TECHNICAL MANUAL
OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, GENERAL SUPPORT AND DEPT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS INFORMATION AND SUPPLEMENTAL MAINTENANCE INSTRUCTIONS) FOR

TRUCK, DUMP, 20 TON, 6 X 4, ON-OFF HIGHWAY 71,000 GVW IHC MODEL F-5070 (CCE) (NSN 3805-00-192-7249)

HEADQUARTERS, DEPARTMENT OF THE ARMY

12 JUNE 1980

TECHNICAL MANUAL

TM 5-3805-254-14&P-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 12 June 1980

Operator's, Organizational, Direct Support,
General Support and Depot Maintenance Manual
(Including Repair Parts Information and Supplemental
Maintenance Instructions)
TRUCK, DUMP, 20 TON, 6 x 4, ON-OFF HIGHWAY
71,000 GVW
IHC MODEL F-5070 (CCE)
(3805-00-192-7249)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Form), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-Automotive Materiel Readiness Command, ATTN: DRSTA-MBS, Warren, Michigan 48090. A reply will be furnished direct to you.

NOTE

Refer to TM 5-3805-254-14&P-1 for Dump Truck Operator's Manual, Special Parts Catalogue, Supplemental Operating, Maintenance and Repair Parts Instructions

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Special Service Manual C-9235

This technical manual is an authentication of the manufacturers' commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

TRUCK SERVICE MANUAL NO. C-9235

INTERNATIONAL TRUCK MODEL F-5070 PAYSTAR SERIES

CONTENTS

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GENERAL

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CLEANING

Clean parts having ground and polished surfaces, such as knuckle pins, knuckle pin sleeves, bearings and spindles, with solvent type cleaners such as emulsion cleaners, or petroleum solvents excluding gasoline. Do not clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthosilicates or phosphates.

DRYING

Parts should be thoroughly dried immediately after cleaning. Use soft, clean, lintless, absorbent paper towels or wiping rags free of abrasive material, such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.

INSPECTION

It is impossible to overstress the importance of careful and thorough inspection of steering knuckle components prior to reassembly. Thorough visual inspection for indications of wear or stress and the replacement of such parts as are necessary will eliminate costly and avoidable front end difficulties.

1. Inspect the steering knuckle thrust bearing, wheel bearing cones and cups. Replace if rollers or cups are worn, pitted or damaged in any way.
2. If wheel bearing cups are to be-replaced, remove from hubs with a suitable puller. Avoid the use of drift and hammers as they may easily mutilate cup bores.
3. Inspect the steering knuckles and replace if indications of weakness or excessive wear is found.
4. Check wear of the knuckle pins; compare with correct specification.
5. Check king pin bushing wear (see Bushing Installation).
6. Check the tightness of the steering connections such as tie rod arms, steering arm, etc.

CORROSION PREVENTION

Parts that have been cleaned, dried, inspected and are to be immediately reassembled should be coated with light oil to prevent corrosion. Spindles, knuckle pins or sleeves that are to be stored for any length of time should be treated with a good rust preventative and wrapped in oiled paper and boxed to keep dry and clean.

REPAIR OF FORGED PARTS

In deciding whether to repair or scrap a damaged part, always keep in mind that we, as manufacturers, never hesitate to scrap any part which is in any way doubtful.

1. Straightening of bent parts should be done cold. Various components are heat-treated and hot straightening would destroy some of the heat treatment.

2. Axle centers (that are bent no more than 1/2") may be straightened cold; if bent more than 1/2" they should be replaced.

   Bent steering arms or knuckles should be replaced rather than straightened.

FRONT WHEEL ALIGNMENT

The alignment of chassis according to the specifications should prevent mis-adjustment, which can affect tire wear, directional stability and steering wheel alignment. Check alignment at regular intervals and particularly after front suspension has been subjected to extremely heavy service or severe impact loads. Before checking and adjusting alignment, components such as wheel bearings, tie rods, steering gear, shock absorbers and tire inflation should be inspected and corrected where necessary.

The procedure for checking and adjusting alignment should be followed; name} checking king pin inclination, camber, caster and toe-in, in the order named. A slight modification in obtaining the proper caster and toe-in has been made and is outlined.

The caster, camber and toe-in dimensions are for vehicle at design load (frame level). If frame is not level on alignment equipment, the frame angle must be considered. This is especially important when making caster check, for the frame angle must be added to or subtracted from the caster angle to obtain a true setting.

CASTER ANGLE

Caster is the amount in degrees the top of the king pin is inclined toward the front or rear of the truck, as viewed from the side of the truck. The caster angle can range from a positive angle to a negative angle.

Positive caster, Fig. 1, is the tilting of the top of the king pin toward the rear of the truck, while negative, or reverse caster, is the tilting of the top of the king pin toward the front of the truck.

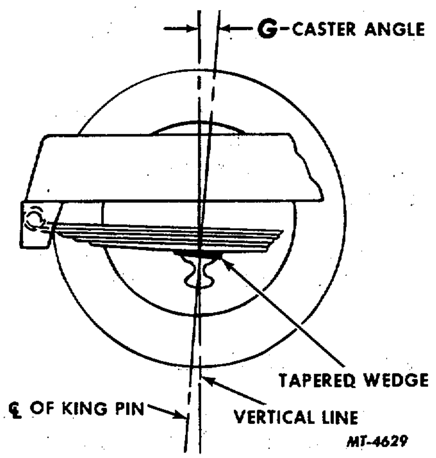


Fig. 1

Positive caster imparts a trailing action to the front wheels, while negative, or reverse caster, causes a leading action. The correct amount of caster helps to keep the front wheels in the straight-ahead position. When in a turn, caster acts as a lever, assisting the driver to return the front wheels to the straight-ahead position.

Caster specifications are based on vehicle design load, which will usually result in a level frame. If the frame is not level when alignment checks are made, this must be considered in determining whether the caster setting is correct.

With the vehicle on a smooth, level surface frame angle should be measured with a bubble protractor placed on the frame rail. See Fig. 2. The degree of tilt from the level frame position is the angle that must be used in determining a correcting caster setting. Positive frame angle is defined as forward tilt (front end down) and negative angle as tilt to rear (front end high).

The measured frame angle should be added or subtracted, as required, from the specified level frame caster setting to obtain the caster that should actually be measured on vehicle.

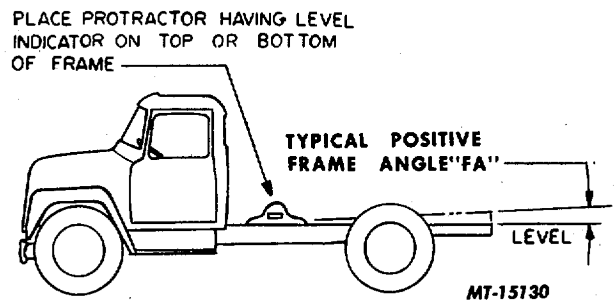


Fig. 2

1. Positive frame angle should be subtracted from specified setting.
2. Negative frame angle should be added to specified setting.

As an example, if the specified caster setting is a positive 10 and it is found that the vehicle has a positive one degree frame angle, then the measured caster should be 0 + 1/20°. This would result in the desired 10 + 1/2° caster angle when the chassis settled to level frame under load.

Possible causes of incorrect caster are sagging springs, bent or twisted axle, or unequally tightened spring U-bolts. In most cases a twisted axle would be the cause if caster varies more than the specified 1/20 between left and right side.

If caster must be corrected, taper shims can be used as required between the springs and axle. Spring U-bolts should be tightened evenly and to specified torque after the addition or removal of shims.

Caster adjustment is made by inserting a wedge between the spring and axle, Fig. 1.

To increase caster, insert the wedge so the thick parts face the rear of the truck (to front for underslung axles).

To decrease caster, place the wedge so that the thick end is toward the front of the truck (to rear for underslung axles).

If an excessively thick wedge is required for a truck that has high mileage, check the contour of the springs and replace springs if necessary. Be sure center bolt drops into I-beam.

The truck will lead to the side which has the most negative caster.

CAMBER ANGLE

Camber is the amount in degrees that the wheel inclines away from the vertical at the top, as viewed from the front of the truck, Fig. 3.

"Positive" camber is an outward tilt or inclination of the wheel at the top.

"Negative" or reverse camber is an inward tilt of the wheel at the top.

The amount of camber, used depends on the amount in degrees the king pin is inclined. An incorrect camber angle causes the side of the tread to wear, resulting in abnormal tire wear.

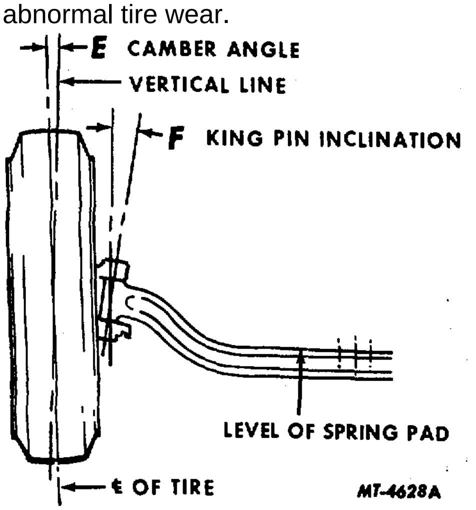


Fig. 3 King Pin Inclination and Camber Angles

Unequal camber in the front wheels will cause the truck to lead to the right-or left. The truck will lead to the side which has the most positive camber.

KING PIN ANGLE (INCLINATION)

King pin inclination (angle) is the amount in degrees that the top of the king pin inclines away from the vertical toward the center of the truck as viewed from the front of the truck, Fig. 3.

King pin inclination working together with the camber angle puts the approximate center of the tire tread in contact with the road. King pin inclination has the effect of reducing steering efforts and improves directional stability in the vehicle.

There is no means of adjusting this angle; therefore, it will not change unless the front axle has been bent. Corrections or changes to this angle are accomplished by replacement of broken, bent or worn parts.

TOE-IN

Toe-in is the amount (in fractions of an inch) that the front wheels are closer together at the front than at the back as viewed from the top of the truck, Fig. 4. With the camber on the front wheels, the left front wheel tries to steer to the left and right front wheel tries to steer to the right. This is due to the wheels wanting to turn in the same direction each wheel leans. To overcome this condition, the wheels are given a certain amount of toe-in.

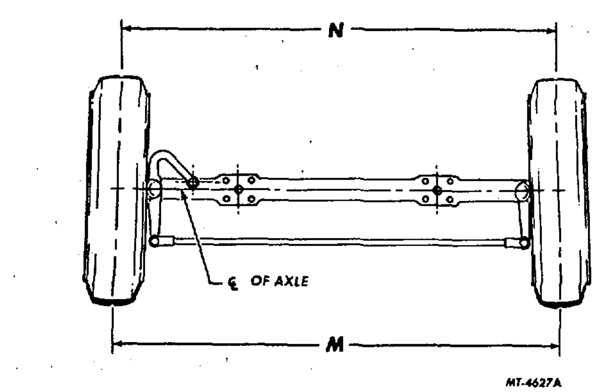


Fig. 4 Toe-In Measurement

Another reason for toe-in and the most familiar, is that when the vehicle is being driven, the forces acting on the front wheels tend to make the wheels toe out.

Incorrect toe-in will result in rapid tire wear. Excessive toe-in will produce a scuffing or "feather-edge" at the inside edge of the tire tread. Toe-out will produce a like wear but at the outside of the tire tread.

When attempting to determine the causes of excessive tire wear, first check king pin inclination, camber and caster and correct, if necessary, in the order named.

No change should be made in toe-in until the other factors of front wheel alignment are known to be within specifications.

Turn the front wheels to the exact straight-ahead position.

When setting toe-in-adjustment, the front suspension must be neutralized; that is, all component parts must be in the same relative position when making the adjustment as they will be in operation. To neutralize the suspension, the vehicle must be rolled forward 12 to 15 feet. By rolling the vehicle forward, all tolerances in the front suspension are taken up and the suspension is then in normal operating position. Neutralizing the front suspension is extremely important, especially if the vehicle has been jacked up in order to scribe the tires; otherwise, the front wheels will not return to the normal operating position due to the tires gripping the floor surface when the vehicle is lowered.

Actual toe-in measurements should be taken at hub height between the two points on the center of the tread at the rear of the tires, Fig. 4.

Mark the point and roll the truck ahead so that the points are in the front at hub height and measure the distance between the same two points on the tire treads.

The difference in the two measurements is the actual toe-in or toe-out.

1. To adjust the toe-in, turn the steeri steering wheel so that the gear is in the mid-position.
2. Loosen the clamping bolts on the tie rod.
3. Turn the tie rod in the direction necessary to bring toe-in within the specified limits.
4. Tighten the clamping bolts on the tie rod.

NOTE: Always recheck toe-in after any change in caster or camber angles or after any alteration in tie rod adjustment.

TURNING ANGLE

Turning angle is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position. Two factors of major importance when adjusting the angle are; tire interference with chassis and steering gear travel.

To avoid tire interference or bottoming of the steering gear, adjustable stop screws are located on the steering knuckles.

To adjust the turning angle, loosen the jam nuts and turn the steering knuckle stop screws in. Position support stands under the front axle so that the wheels are off the floor. Turn the wheels to extreme right turn until the steering gear bottoms or contact of the tire to chassis is made. Then back off the steering wheel 1/4 turn or back off the steering wheel until 1/2" to 1" clearance is obtained between the tire and chassis. Be sure to check both front tires for clearance. When the proper clearance is determined, back the wheel stop screw out and tighten the jam nut.

Repeat the same procedure on the left extreme turn also and adjust the left steering knuckle stop screw.

TURNING RADIUS ANGLE (Toe-Out on Turn)

Turning radius angle is measured in degrees and is the amount one front wheel turns sharper than the other on a turn.

When a vehicle is turned either to the right or left, the inner wheel is required to turn in a smaller circle than the outside wheel, Fig. 5.

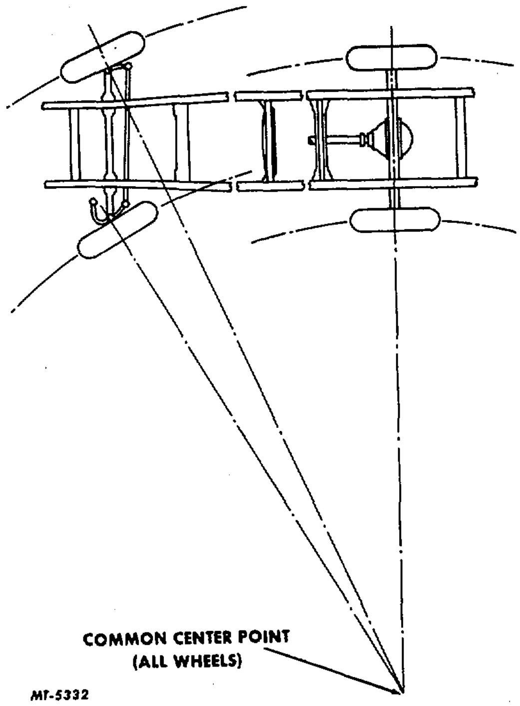


Fig. 5 Inner Wheel Turns in a Smaller Circle Than Outside Wheel

If the inner wheel is not permitted to turn in a smaller circle or greater angle, tire scuffing will result. Therefore, it is necessary for the front wheels to assume a toed-out position during a turn.

Toe-out on turns is accomplished by having the ends-of the steering arms (end at tie rod) closer together than the king pins as shown in Fig. 6. The amount of toe-out depends on the length and angle of the steering arms.

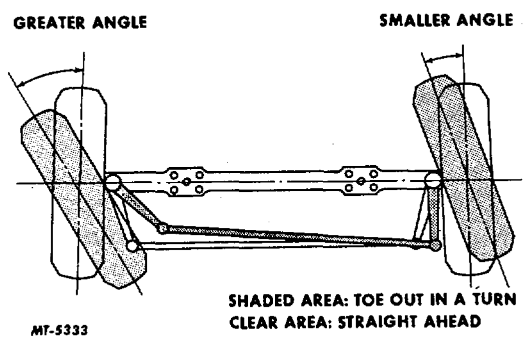


Fig. 6 Inside Wheel Turns at Greater Angle

Even though the toe-in with the wheels in the straight-ahead position may be adjusted correctly, a bent steering arm may cause the toe-out on a turn to be incorrect, causing scuffing of tires.

The turning radius angle is checked using turning radius plates SE-1447-2 or equivalent.

To check the turning radius angle, position the front wheels on the plates and in the straight-ahead position.

After removing the locking pins from each plate, adjust the scale on the edge of the plates so that the pointers read "zero." Turn the wheels to the right until the gauge at the left wheel reads 20°. Then read the angle of the right wheel. The right wheel should then be turned to an angle of 200°. The left wheel should be at the same angle as was the right wheel when the wheels were turned to the left.

STEERING KNUCKLE STOP SCREWS (I-Beam Axles)

Adjustable stop screws in the steering knuckle control the turning angle or limit the movement of the front wheels. This prevents the tires from rubbing against the nearest point on the chassis or the steering gear from bottoming.

STEERING KNUCKLE STOP SCREWS (Driving Front Axles)

There is a stop screw located on each end of the axle housing for the purpose of limiting the amount of the turning angle of the wheels. These screws are not adjusted in accordance with the frame and tire interference as in conventional front axles. Instead, these screws are provided to limit the turning angle of the universal joints in the axles.

TROUBLE SHOOTING

Remember that all alignment angles are so closely related that any change of one will automatically change the others. Because of this fact, it will probably be found that there is more than one cause for the complaint. The following list is not all-encompassing but is representative of the more common causes of difficulty encountered in wheel and axle alignment and should also prove of value in locating and correcting complaints on steering or tire wear.

COMPLAINT	POSSIBLE CAUSE
1. Shimmy (Generally exists at speeds below 30 miles per hour.)	a. Tire pressure incorrect. b. Tires of unequal size or weight. c. Wheel bearings loose. d. Steering arms loose. e. Steering gear loose. f. Too much caster. g. Drag link ends loose. h. Drag link springs weak or broken. i. Spring shackles loose. j. King pins and bushings worn. k. Tie rod ends loose. l. King pins loose in I-beam.
2. High-Speed Wheel Tramp (Generally exists at speeds above 35 miles per hour.)	a. Tire and wheel assemblies out of balance. b. Shock absorbers ineffective.
3. Wander or Weave	a. Tire pressure incorrect. b. Tires of unequal size. c. Bent spindle. d. Wheel bearings loose. e. King pins and bushings worn.. f. King pins bent. g. King pins tight in knuckle. h. Pitman arm loose. i. Steering gear assembly too tight or too loose. j. Too little caster. k. Too much or too little camber. l. Too much or too little toe-in. m. Drag link ends tight. n. Drag link springs weak or broken. o. Tie rod ends too tight or too loose. p. Front axle bent. q. Front axle shifted. r. Springs broken. s. Rear axle shifted. t. Rear axle housing bent. u. Frame diamond shaped.
4. Hard Steering	a. Tire pressure low. b. Wheel spindle bent. c. King pin assembly poor fit. d. Steering assembly too tight. e. Tie rod ends tight. f. Caster excessive. g. Lack of lubrication.

TROUBLE SHOOTING (Continued;

COMPLAINT	POSSIBLE CAUSE
5. Uneven Tire Wear	a. Tire pressure low. b. Excessive camber. c. Wheels out of balance. d. Tires overloaded. e. Eccentric wheels or rims. f. Caster incorrect. g. Toe-in incorrect.

FRONT AXLE

I-BEAM TYPE

CODE 02182

INDEX

SPECIFICATIONS

IH Model	FA-182
IH Code	02182

RUNNING CLEARANCES

Knuckle Pin O.D. (Inch)	1.9980 - 1.9990
Knuckle Pin Bushing I.D. (Inch)	2.0015 - 2.0025

ALIGNMENT

Caster (Degrees) - Level Frame	2 to 3
Camber (Degrees) - At Rim	1
Toe-In (Inch) - Measured from Tread Centers with Camber and Caster to Specifications	1/16
King Pin Inclination (Degrees)	5-1/2
Turning Radius Angle (Degrees) Outer Wheel @ 20 Deg. Inner Wheel Will Be	22-3/4

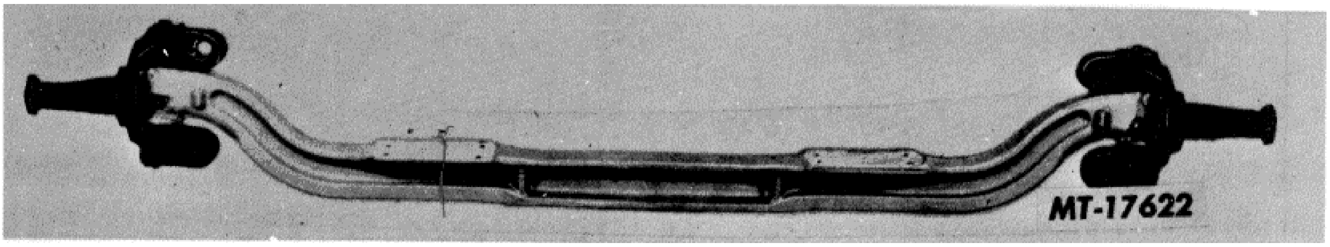


Fig.1

INTRODUCTION

The front axles mentioned herein are the heavy duty I-beam type, Fig. 1.

Construction details for the most part are similar; however, where major variations exist, these are individually explained.

AXLE CENTER SECTION

An "I-beam" type center section machined from heat treated steel forging is used for these axles. Spring pads are integral with the "I-beam".

STEERING KNUCKLE KING PIN

The axles are equipped with straight king pins which employ one or two flats and are held in position by tapered draw keys, Fig. 2.

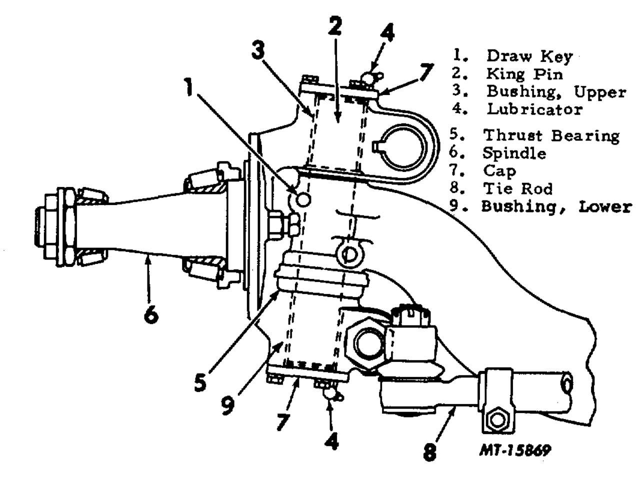


Fig. 2

STEERING KNUCKLE BUSHINGS

Steering knuckles are bushed--in-t-he upper and lower pin bosses to assure turning freely about the pin. Bushings are of bronze or teflon material, although some nylon bushings may be encountered in service. All bushings (EXCEPT TEFLON) contain grooves which allow grease to flow uniformly to high pressure areas. A lubricator is installed in both upper and lower knuckle pin bosses or knuckle pin caps, Fig. 3.

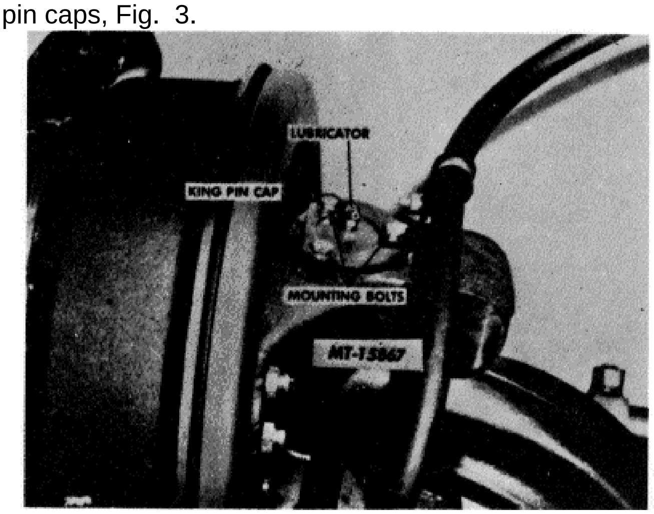


Fig. 3

DISASSEMBLY

<u>Wheel and Hub Removal</u>

1. Raise front end of vehicle so that tires clear floor. Block up securely at this position and remove jacks. (Do not attempt to disassemble or perform knuckle repair with vehicle supported by jacks only.)

2. Two types of wheel bearing adjusting nut lock arrangements are used on the axles covered in this section. Removal of these are as follows:

a. Bend-Over Type Locking Washer

Remove hub cap and gasket. Bend locking washer to release outer lock nut and inner wheel bearing adjusting nut. Remove outer nut, locking washer and inner adjusting nut from steering knuckle spindle. NOTE: Always install new locking washer during reassembly.

b. Dowel and Perforated Ring Type Locking Washer Remove hub cap and gasket.

Remove outer lock nut, locking washer perforated lock ring and doweled wheel bearing adjusting nut from steering knuckle spindle.

3. Remove the outer wheel bearing cone.

4. Remove the wheel and hub assembly.

Steering Knuckle Removal

1. Remove wheel and hub.

2. Disconnect tie rod and drag link.

NOTE: Straight knuckle pins may be removed from the bottom of the knuckle where adequate clearance is provided; however, on some models such as those with riveted backing plates less work is involved by tapping the knuckle pin out the top of knuckle. In either case the adjacent parts, such as air chambers, hydraulic lines or fittings, etc, that might cause an obstruction to the knuckle pin, must be removed first.

3. Remove the snap rings and expansion plug from the bottom of the knuckles where employed. If plug employs no snap ring and is expanded and staked, remove plug by use of a cape chisel and discard.

4. Remove the cap screws or bolts, cover plate, gasket or O-ring from top of knuckle or remove lock ring retainer and seal, depending on model, Fig. 4.

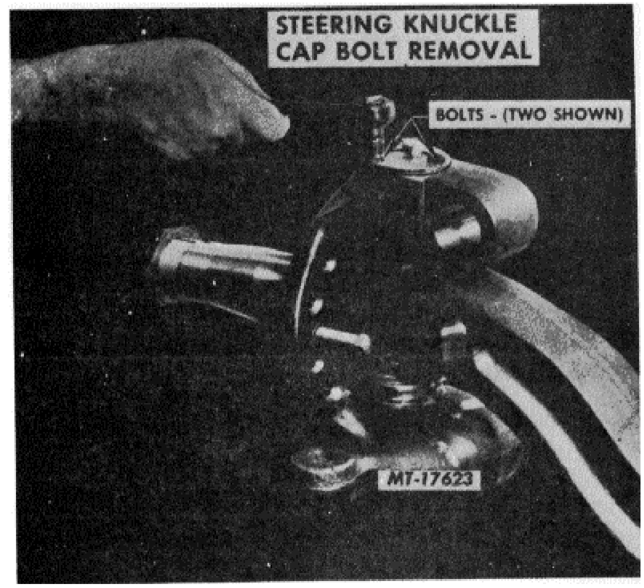


Fig. 4

5. Drive out the knuckle pin draw key (or keys) from the small end using a suitable small slender drift, Fig. 5.

(Older models may employ tapered draw key that is threaded on small end and drawn into place by a nut. On these models, remove the nut and lock washer. Drive the draw key out by use of brass hammer on threaded end.)

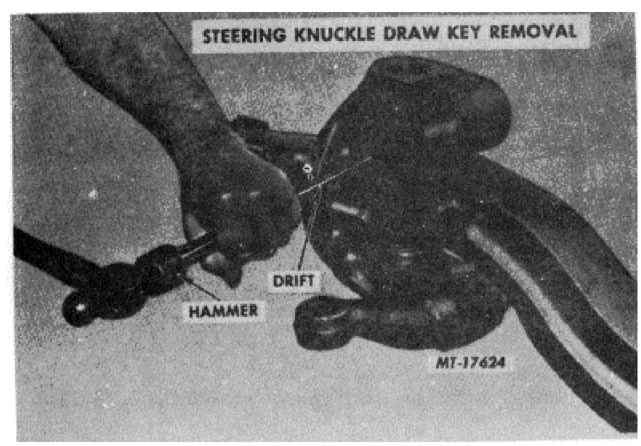


Fig. 5

6. Tap out the knuckle pin by use of a, bronze drift, Fig. 6.

Fig. 6

7. Lift off the knuckle assembly, thrust bearing and spacing washers, Fig. 7.

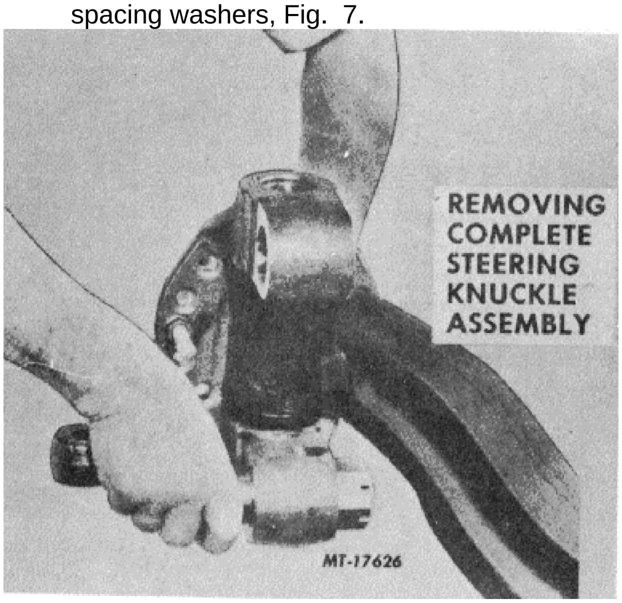


Fig. 7

REASSEMBLY

<u>Steering knuckle Bushings (Nylon and Teflon)</u>

The nylon and teflon bushings are pre sized and can be positioned into the knuckle bore with no additional reaming, burnishing or lapping required. IMPORTANT: Since the I.D. of a nylon or teflon bushing is always smaller than the O.D. of the king pin, the king pin as in bronze bushing applications is a press fit.

King pin looseness on axles equipped with nylon or teflon bushings is checked in the same manner as bronze bushings; however, if the camber changes more than 1/40 the bushing (and king pin, if needed) must be replaced.

To install proceed as follows:

1. Remove present bushing from knuckle.

2. Remove any nicks or burrs from knuckle bushing bore and polish with medium grit abrasive.

3. Place new bushings in knuckle. NOTE: Circular lubricant spreader ring on inside of nylon bushing is always to be positioned toward the I-beam axle (refer to bushing installation diagram, Fig. 8).

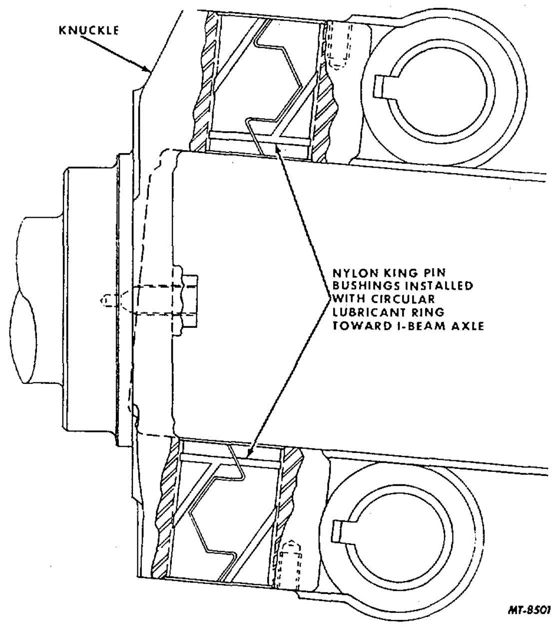


Fig.8

<u>Steering Knuckle Bushing Installation (Bronze)</u>

IMPORTANT: As a means for providing service personnel with the simplest method for checking king pin looseness, it has been determined that the use of camber gauge SE-1417-1 is the most desirable. Instructions for the use of the camber gauge in this particular operation are as follows:

1. Raise the front wheels off the floor and support the axle at outer ends so it cannot rock.

2. Adjust front wheel bearings.

3. Apply brake. Use pedal jack to hold brake application and lock front wheels.

4. Install camber gauge and measure camber while rocking the wheel at top and bottom.

5. If the camber changes 1/40 or more, replace the king pin bushings (and king pin, if needed). Check fit of king pin in "I" beam. Pin must be tight. No looseness is permissible.

Never replace king pins or king pin bushings which are within limits shown in specifications.

To install bronze bushings, proceed as follows:

1. Remove present bushing from knuckle.

2. Remove any nicks or burrs from knuckle bore and polish with medium grit abrasive.

3. Using an arbor press or bushing installing tool, press new bronze bushings into place in knuckle.

IMPORTANT: Since some late production: front axles employ lip type seals in the axle king pin bore to retain lubricant and prevent the entrance of dirt and water, observe the following.

The upper seal can be installed in all upper knuckle king pin bosses (both old and new style axles). NOTE: In Fig. 9 the upper knuckle bushings must be installed in such a manner as to permit installation of the new upper seal. When replacing the bushings the upper bushing should be pressed into the knuckle so that the upper end of the bushing is 1/4" (.20" to .26") from the upper face of the knuckle, This 1/4" dimension at the upper end will assure there is space for installation of the new upper seal.

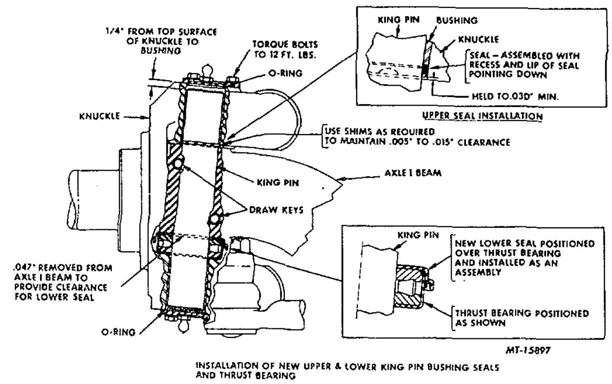


Fig. 9

In most instances the lower seals will be discarded when a new repair kit is being installed on an old axle. When checking the clearance between the upper face of the axle end and lower face of upper steering knuckle pin boss and if this clearance exceeds .015" washers and shims are available in various thickness to take up this clearance. However, if the stack-up of shims is in excess of .047", these shims can be removed and the new lower seal installed and still hold the clearance within the desired .015" tolerance.

Line ream or hone new bushings to size shown in SPECIFICATIONS. An SE-2218 hone may be used to size bushings, Fig. 11.

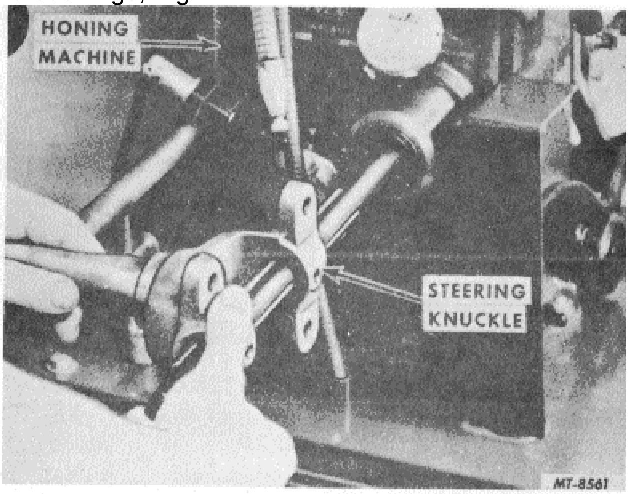


Fig. 11

NOTE: If a reamer is used, it should be equipped to pilot in one bushing, while reaming the remaining one, or be long enough to ream both bushings at the same time, Fig. 12.

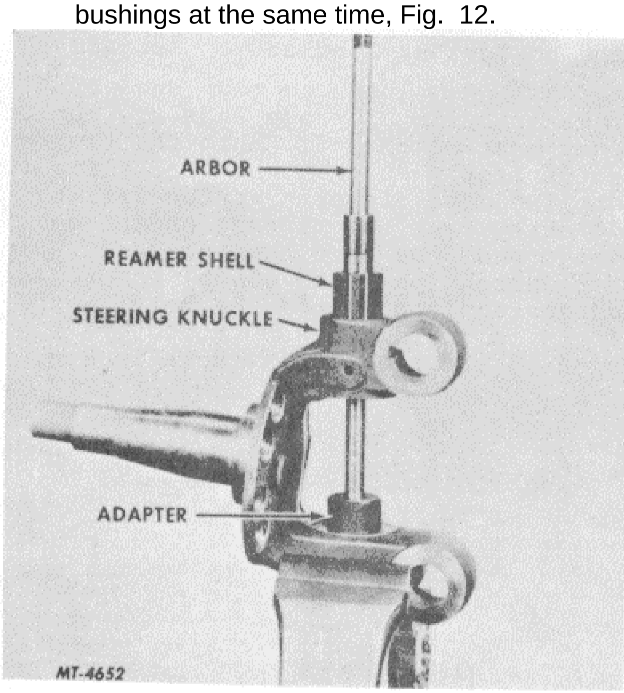


Fig. 12

5. After the reaming or honing operation is completed, the bushings and steering knuckles must be thoroughly cleaned of all dirt and shavings before king pin is installed.

NOTE: For best results, the use of steam cleaning equipment is preferred.

KNUCKLE PIN INSTALLATION

IMPORTANT: Before installing the king pin lubricate inside of bushing and outside of king pin with IH 251H E.P. grease or equivalent NLGI No. 2 multipurpose lithium grease to provide initial lubrication.

1. Make certain that knuckle pin hole in axle center is clean and dry.

2. Position and support the steering knuckle assembly on the axle center.

3. Slide the thrust bearing between the lower face of axle center and lower steering knuckle yoke, Fig. 13. Thrust bearings that are not marked "top" to indicate proper installation position must be positioned with retainer lip down.

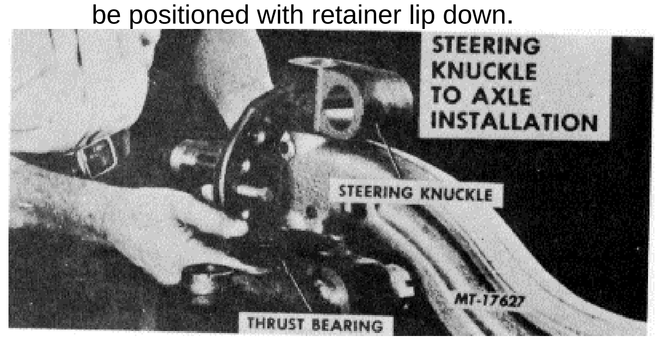


Fig. 13

4. Align the steering knuckle yoke holes with axle center and thrust bearing holes.

5. Place a jack under the lower side of steering knuckle yoke and raise knuckle so that all clearance is taken up between lower yoke, thrust bearing and lower face of axle center end.

6. Check the clearance between the top face of upper axle center end and lower face of upper knuckle pin boss. The clearance must not exceed .015". Washers and shims are available in various thickness to take up this clearance and hold it within the desired .015" tolerance, Fig. 14.

Fig. 14

7. Align flat (or flats) to mate with draw key hole (or holes). Drive knuckle pin through knuckle yoke, axle center and thrust bearing from top or bottom side.

8. Install the draw key (or keys). Drive the draw key with flat side positioned to mate with flat on knuckle pin. Tighten nut to the specified torque.

EXPANSION PLUGS

1. On axles that have grooved holes, install lock rings.

2. On axles not grooved for lock rings, install grease retainer plate and secure in place by staking in four equally spaced places.

3. On units employing grooved knuckle pins that protrude below the knuckle lower yoke, install lock ring in groove.

COVERS, CAPS OR RETAINERS WITH FELTS

1. Install the cover or cap and gasket with cap screws where used.

2. Install the felt, retainer and lock ring on protruding straight pins that are not provided with covers or caps.

Reinstall the tie rod tapered ends into the steering arms and tighten the nuts to the correct torque specification Then install the cotter pin. (Refer to TIE ROD ENDS for replacement of tie rod ends.)

Reinstall brake chambers, connecting the push rods also. Reinstall hydraulic brake cylinder fluid adapter fitting (if removed) on chassis equipped with hydraulic brakes.

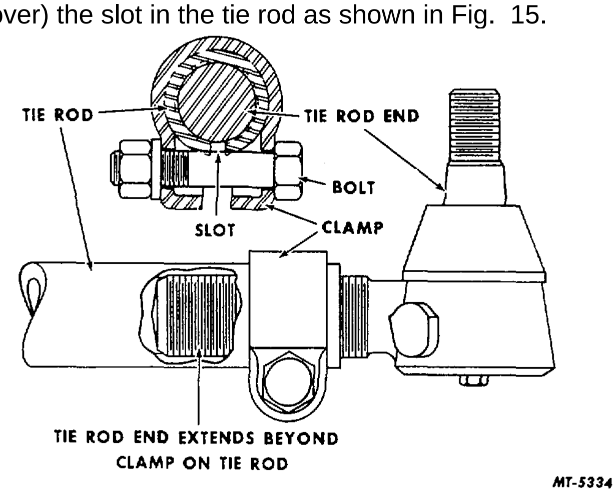
Clean and repack the front wheel bearing. Then install the bearing in the hub assembly using new grease seals, Assemble the hub and bearings on the spindle being careful not to damage the oil seals or bearings. Adjust wheel bearings referring to WHEEL BEARING ADJUSTMENT. Then install wheel grease caps.

TIE ROD ENDS

The tie rods are of three-piece construction, consisting of a tie rod and two rod end assemblies. The ends are threaded to the rod and locked with clamp bolts. Right and left hand threads are provided for toe-in adjustment. Tension on ball stud in the rod ends are self-adjusting and require no attention in service other than periodic inspection to see that the ball studs are tight in the steering knuckle arms.

Fittings are provided for periodic lubrication on some types of tie rod ends. Where no fittings are used, the tie rods have been lubricated at assemble and no further lubrication is necessary.

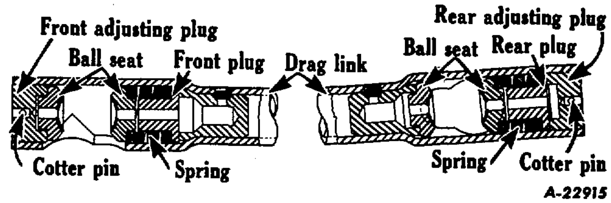
CAUTION: When tie rod, drag link or power steering linkage ends are replaced they must be threaded into the tie rod sufficiently so that when the clamp is applied, the clamping action will be directly over the threads on the ball joint end. Be sure that the end is in far enough (past the clamp) to provide adequate clamping and the bolt in the clamp is installed next to (over) the slot in the tie rod as shown in Fig. 15.



DRAG LINK

This type of drag link requires very little care other than periodical lubrication and occasional inspection to make Figure that it is properly adjusted, Fig. 16.

Adjustment is made by removing cotter pin and turning adjusting plug in the desired direction. To adjust for wear, turn adjusting plug in until it is tight then back off to first cotter pin hole. Insert a new cotter pin of the correct size and bend ends over securely. Drag link should not be adjusted too tightly, otherwise steering will be affected. The spring is merely to accommodate wear and is not intended to act as a cushion against shock.



TORQUE CHART

Location	Diameter	No. Threads	Torque, Ft. Lbs. Minimum	Torque, Ft. Lbs. Maximum
	9/16"	18	50	60
	5/8"	16	60	70
	5/8"	18	60	70
* TIE ROD END NUT	3/4"	16	120	140
	7/8"	14	200	225
	1"	14	300	350
	1-1/8"	12	350	400
	3/8"	24	20	25
	7/16"	20	25	30
TIE ROD CLAMP BOLT	1/2"	20	40	50
	5/8"	18	40	50
	5/16"	24	10	14
	5/8"	16	60	70
	5/8"	18	60	70
* STEERING ARM BALL NUT	3/4"	1	1	140
	3/4"	16	120	140
	7/8"	14	250	300
	7/8"	14	200	225
	1"	14	300	350
* STEERING ARM NUT & TIE ROD ARM NUT	1-1/8"	1	350	400
	1-1/4"	12	400	450
	7/8"	14	165	180
KING PIN NUT	1"	12	250	275
	1-1/8"	12	350	390

* If cotter pin cannot be installed after attaining minimum torque, tighten to next position. Do not back off.

Torque specified is for taper and threads which are clean and oil free.

REAR AXLE

TANDEM DOUBLE REDUCTION
BEVEL INTER-AXLE DIFFERENTIAL

CODE 14368

INDEX

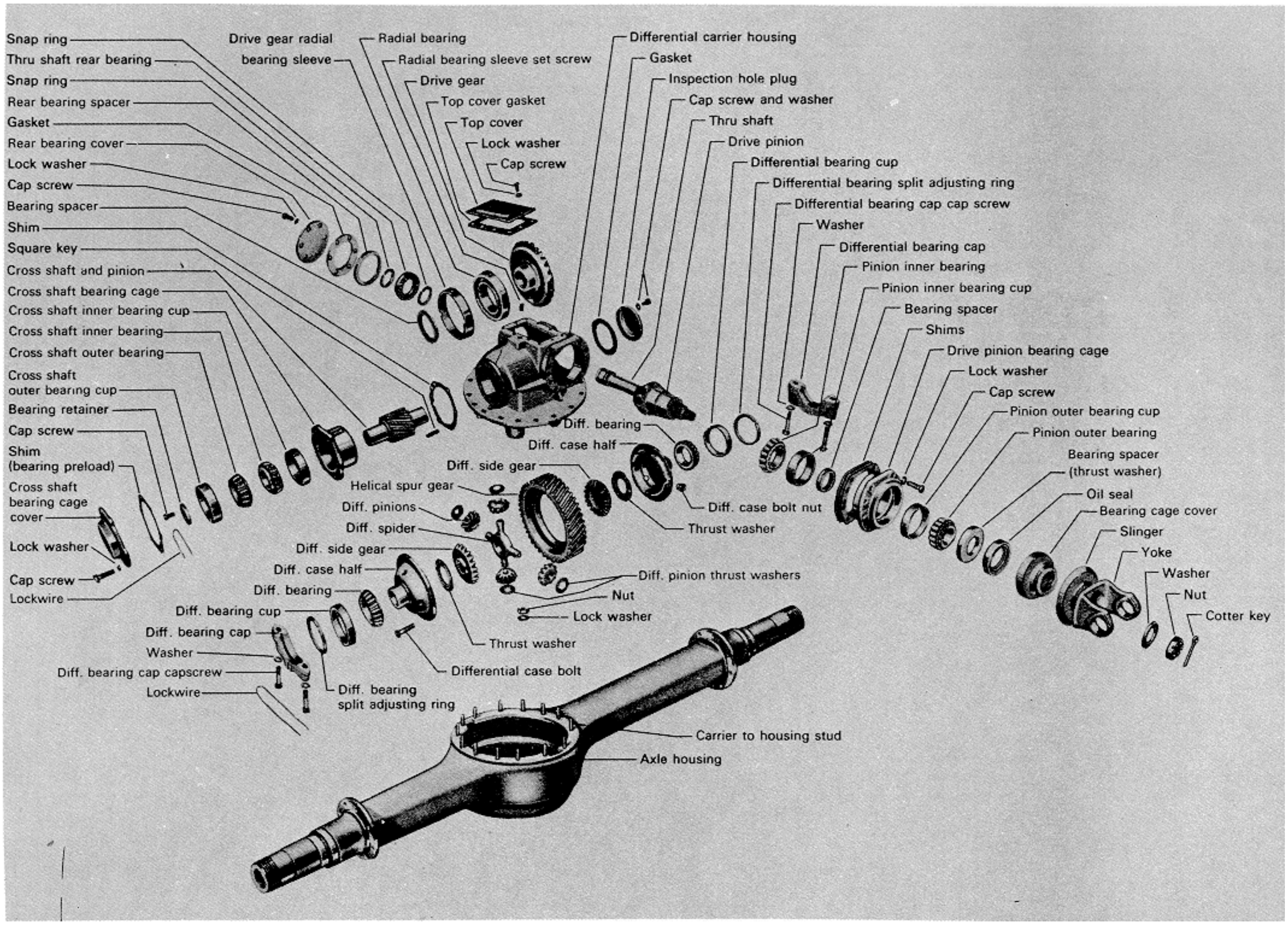
SPECIFICATIONS

IH CODE	14368
MFGR'S MODEL	STDD
TANDEM TYPE	Thru Drive w/Inner Axle Differential
PINION:	
Drive	Hypoid-Helical
Mounting	Straddle
DIFFERENTIAL:	
Type Case	Two Piece
Bearing Preload	1-3/4 - 2-1/2 Notches*
HOUSING	
Type	
Lube Capacity (Pints)	
Forward Axle	30
Rear Axle	28
Inter-Axle Differential	2**
AXLE SHAFTS	
Number of Splines	24
Diameter of Splines (Inch)	2-3/8
INTER-AXLE DIFFERENTIAL	Bevel Pinion & Cage Type

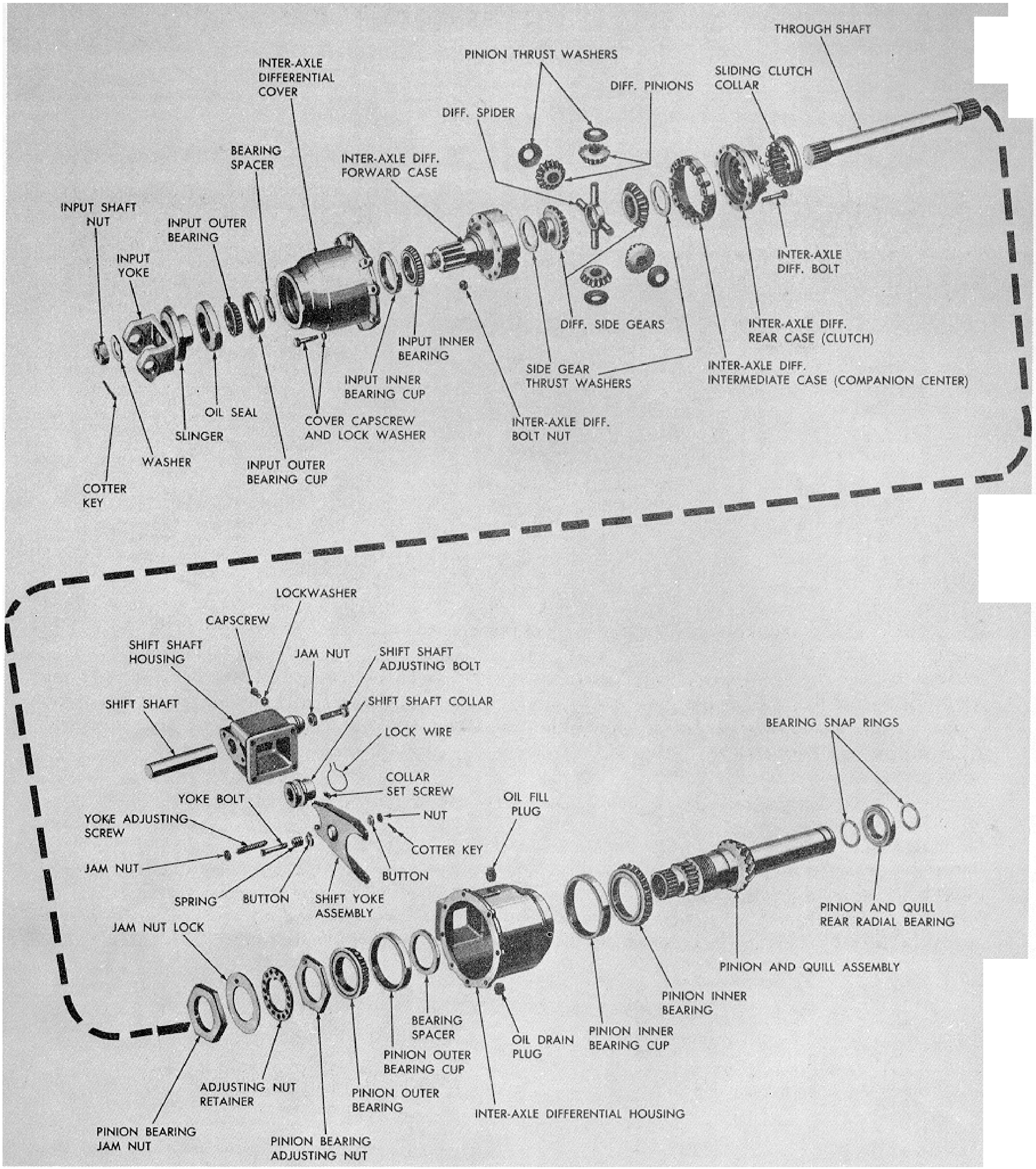
*Total for both nuts

** Add specified amount of lube to inter-axle differential housing when new or reconditioned drive unit is installed.

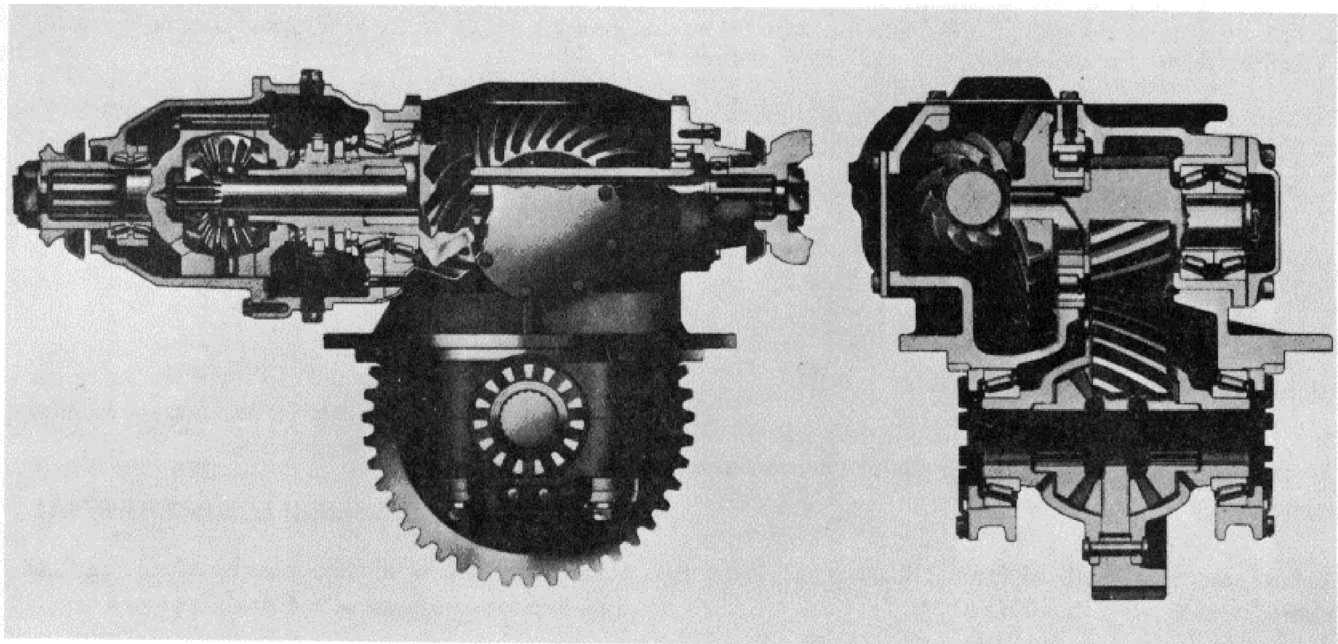
STD and STDD SERIES



INTER-AXLE DIFFERNTIAL



DOUBLE REDUCTION DRIVE UNIT
DESCRIPTION

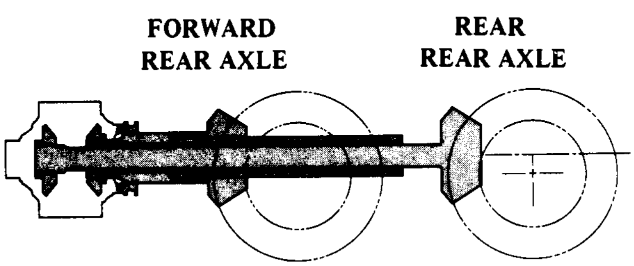


Top-mounted double-education drive units in the SUD and STD Series made by North American Rockwell incorporate hypoid first reduction gears and helical spur gears in the second reduction.

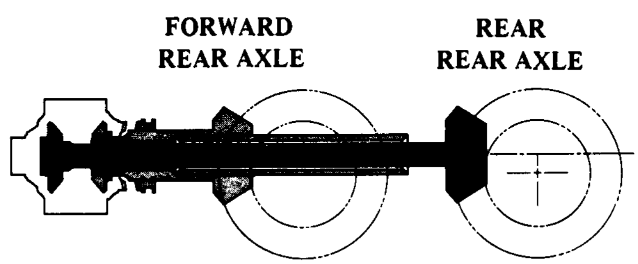
The thru-shafts of the hypoid gear drive units are supported at the forward end by tapered roller bearings in a cage and at the rear end by a ball bearing. Pinion bearing pre-load is adjusted and maintained by a hardened precision spacer between the inner and outer tapered bearings which are held in place on the pinion journal by large nuts. Yokes and flanges are held in place on the thru-shaft by separate thru-shaft nuts.

The inter-axle differential may be either engaged or disengaged by a power actuated shift unit which moves a sliding collar on the pinion quill assembly.

The shift unit is controlled by a selector switch or lever within the cab of the vehicle and may be engaged or disengaged under any normal operating conditions. The inter-axle differential when engaged (unlocked) divides the engine torque between the forward and rear axles, when disengaged (locked) converts the two axles to a through drive type tandem. The following Schematic Drawing illustrates the action of the inter-axle differential assembly.



The single gray tone shows the differential "locked-up," inoperative, with the tandem functioning as a thru-drive assembly.



The double gray tone illustrates the differential operating under normal conditions, distributing equal amounts of torque to the axles.

The rear side gear of the inter-axle differential has splines on the I.D. and engages mating splices of the pinion d and quill assembly, driving the forward axle. The front side gear of the differential also has splines on the I.D. and engages the mating splines of the thru-shaft that extends through the pinion and quill assembly and drives the rear axle.

Hypoid drive units of the thru-drive type have pinions that are separable from the thru-shafts and are serviced with the ' mating gears as matched sets. We assume no responsibility for gears of these types serviced in any manner other than matched sets. The pinion and quill assembly used with the inter-axle differential of the forward hypoid gear topmounted drive units is serviced as an assembly with matched hypoid gears.

REMOVE AND DISASSEMBLE DRIVE UNIT

REMOVE DRIVE UNIT FROM HOUSING

A. Remove plug from bottom of axle housing and drain lubricant.

B. Remove the axle shaft stud nuts, lockwashers and tapered dowels

IMPORTANT: To loosen the dowels, hold a 1% inch diameter brass drift against the center of the axle shaft head, INSIDE THE CIRCULAR DRIVING LUGS. Strike the drift a sharp blow with a 5 to 6 pound hammer or sledge. A 1% inch diameter brass hammer is an excellent and safe drift.

CAUTION: *Do not hit the circular driving lugs on the shaft head this may cause the lugs to shatter and splinter. Do not use chisels or wedges to loosen the shaft or dowels this will damage the hub, shaft and oil seal*

C. Remove the axle shaft from the drive unit and housing.

D. Disconnect the forward and rear propeller shafts.

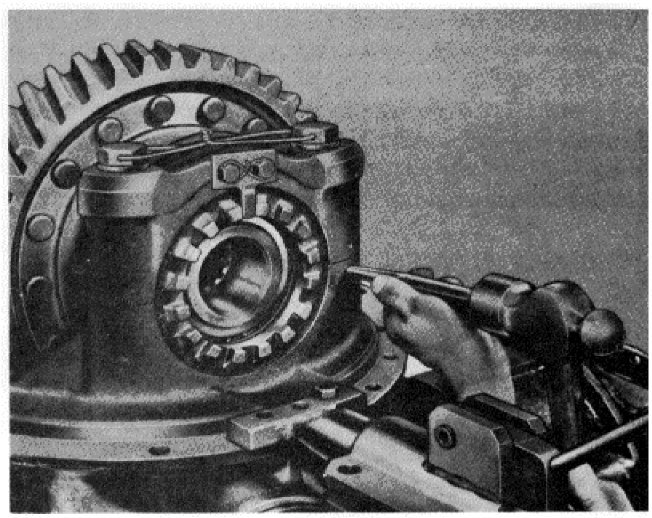
E. Remove carrier to housing stud nuts and washers.

F. Break carrier loose from housing with rawhide mallet and remove tapered dowels. Dowels must be removed. If necessary back out studs.

G. Pull carrier straight out of housing with chain fall, boom or "A" frame. A. small pinch bar may be used to straighten the carrier in the housing bore. However, the end must be rounded to prevent indenting the carrier flange.

REMOVE AND DISASSEMBLE DIFFERENTIAL

A. Mount drive unit in suitable repair stand and cut lock wire. Remove cap screws and adjusting nut locks



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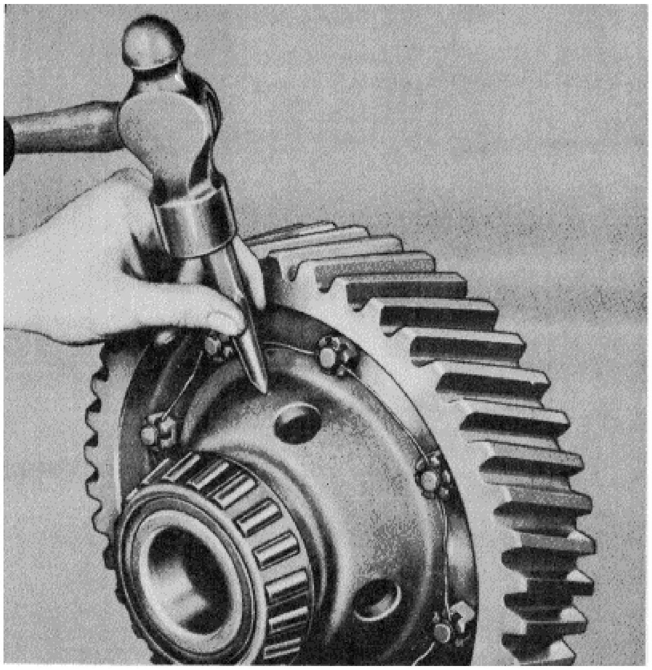
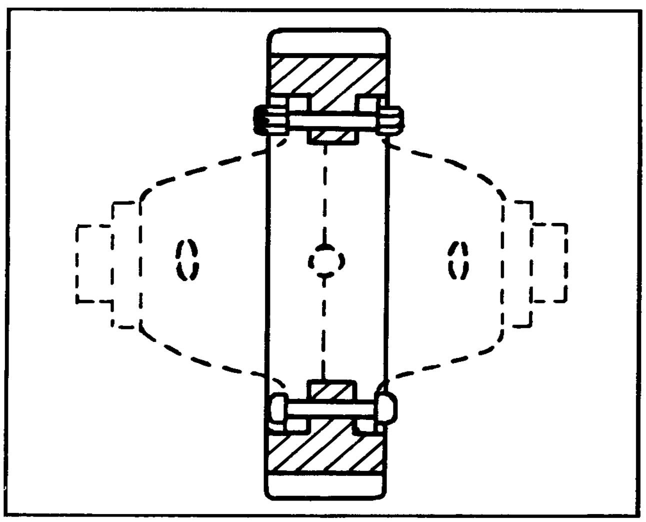
B. Center-punch one differential carrier leg and bearing cap to correctly identify for proper reassembly.

C. Remove bearing cap stud nuts or cap screws, bearing caps and adjusting nuts, split rings (if used), and bearing cups.

D. Lift out differential and gear assembly.



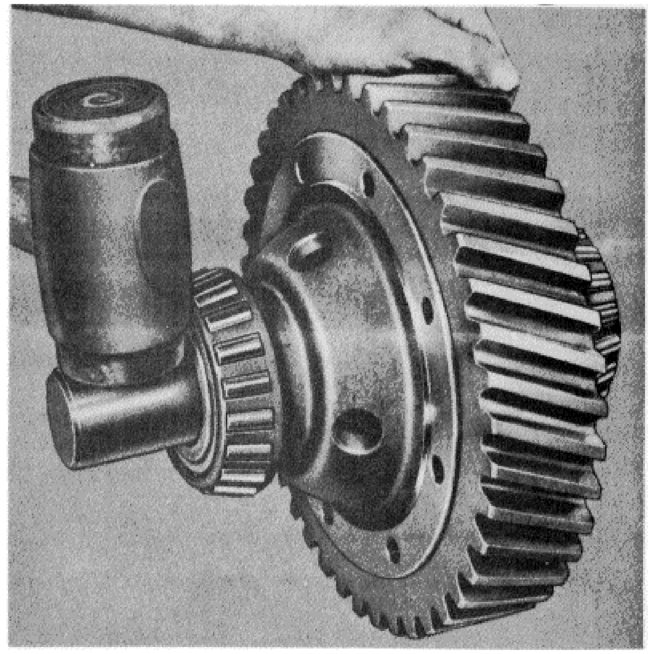
E. If original identification marks are not clear, center-punch case halves for correct alignment during reassembly.



NOTE: Differential may be held together with bolts and nuts or rivets.

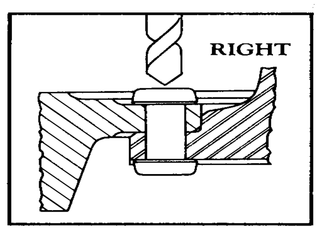
F. When bolts are used, cut lock wire or cotter pins and remove nuts. Drive bolts from case assembly with convenient drift.

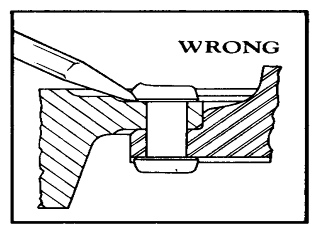
CAUTION: Do not strike these hardened steel pieces directly with a steel hammer.



G. Insert short sleeve in case axle shaft bore and separate assembly by striking sleeve as illustrated.

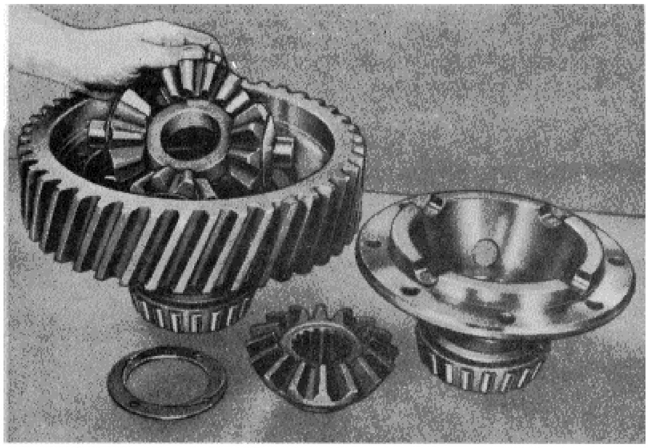
H. When the case assembly is held together with rivets, remove the rivets by drilling out rivet body as illustrated below:



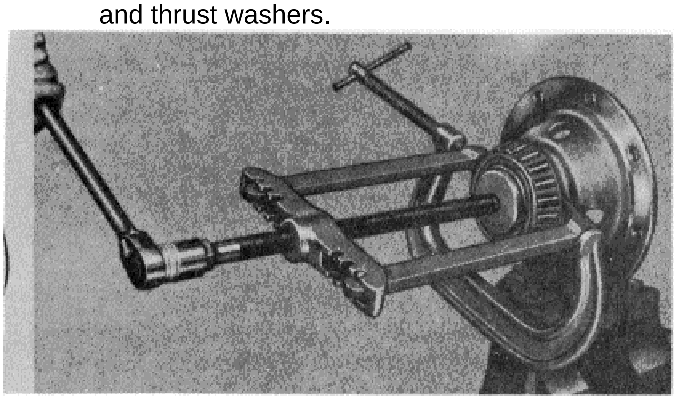


1. Carefully center punch rivets in center of head.
2. Use drill 1/32" smaller than body of rivet to drill through head.
3. Press out rivets.

Note elongated differential case and gear rivet holes that result from cutting rivets with chisel.



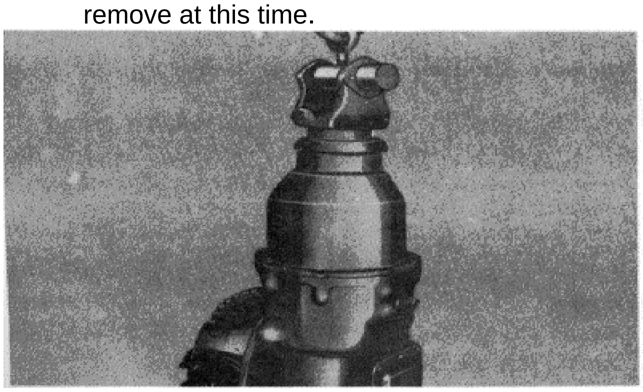
I. Remove side gears, spider and pinion assembly and thrust washers.



J. Remove differential bearings from case halves with suitable puller.

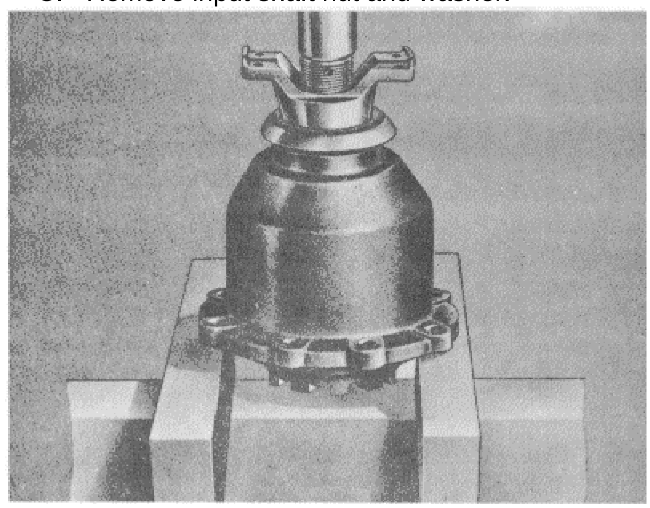
DISASSEMBLE INTERAXLE (3rd) DIFFERENTIAL ASSEMBLY

A. Remove input shaft cotter key using a suitable holder for flange or yoke. Loosen nut, but do not remove at this time.

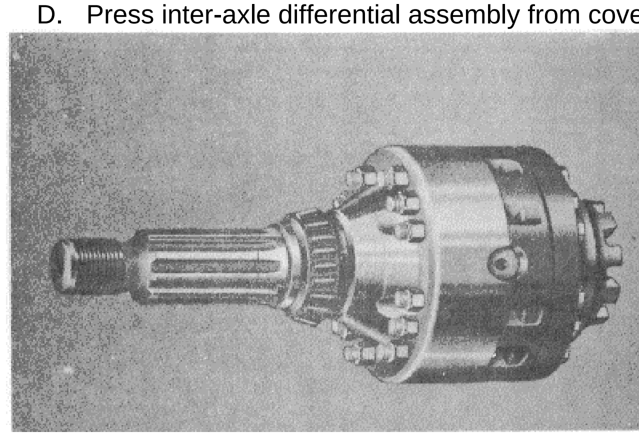


B. Remove the inter-axle differential cover cap screws and lock washers and lift the assembly from the carrier.

C. Remove input shaft nut and washer.



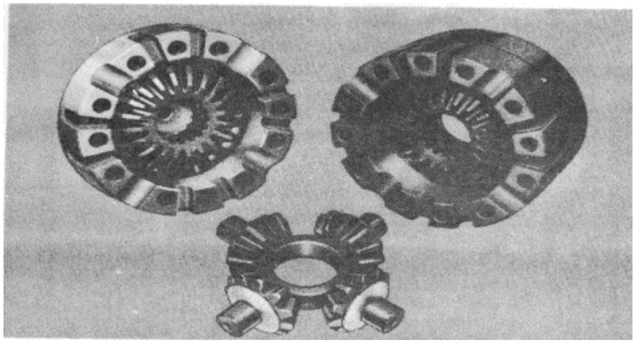
D. Press inter-axle differential assembly from cover.



NOTE: Inner bearing cone and spacer will remain on input shaft. Retain spacer for rebuild.

IMPORTANT: Oil seal assembly and outer bearing will remain in interaxle differential cover. Do not remove unless necessary.

E. If original identification marks are not clear, mark the differential case sections with a punch or chisel for correct alignment during reassembly.



F. Disassemble case sections and remove spider, pinions, side gears and thrust washers. Do not remove the bearing from the case unless replacement is necessary.

G. If it is necessary to replace the outer bearing in the cover, drive the oil seal from the cover and remove bearing.

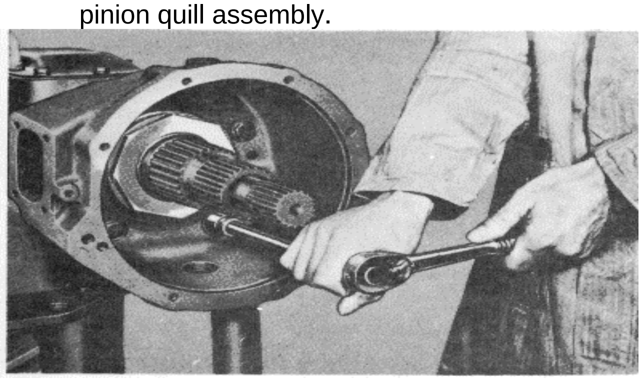
REMOVE AND DISASSEMBLE HYPOID PINION AND QUILL, BEARING AND HOUSING ASSEMBLY

A. Remove shift shaft housing cap screws and lock washers. Remove shift shaft housing assembly.

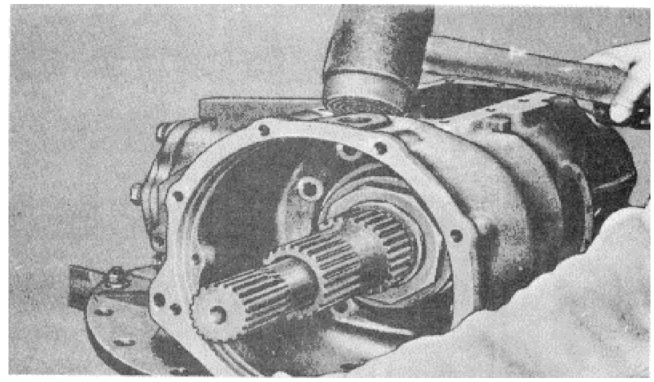
B. Disassemble and remove shift lever attaching nut, button, lever, cup and spring. Body fit bolt should not be removed.

NOTE: Shift unit may be single or double line vacuum, air or electric.

C. Remove inter-axle differential shift collar from pinion quill assembly.



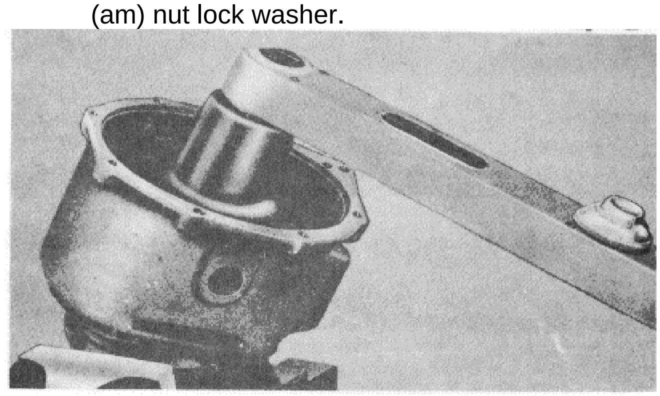
D. Cut housing cap screw or stud nut lock wire. Remove cap screws or stud nuts. Also remove cross shaft cover and carrier inspection cover.



E. Lightly tap on the top edge of housing with a rawhide hammer to loosen it from carrier.

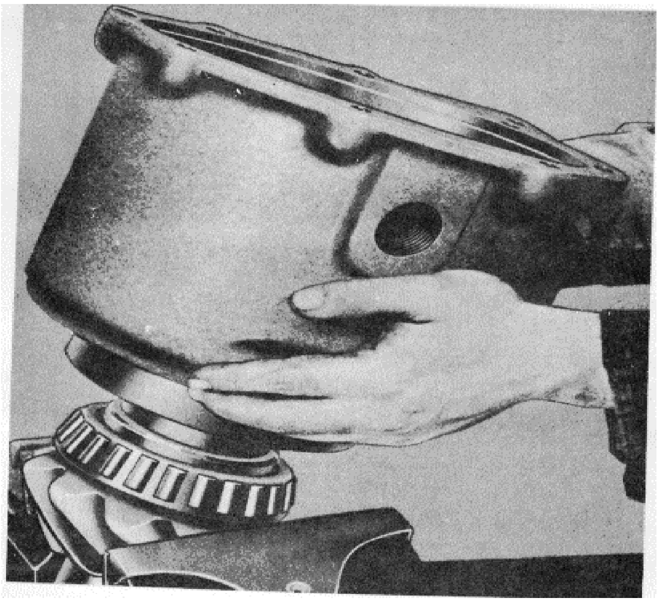
F. Remove housing and pinion quill assembly. Wire shim pack to carrier to aid reassembly.

G. Clamp the pinion and quill assembly in a copper-jawed vise and straighten pinion bearing outer (am) nut lock washer.

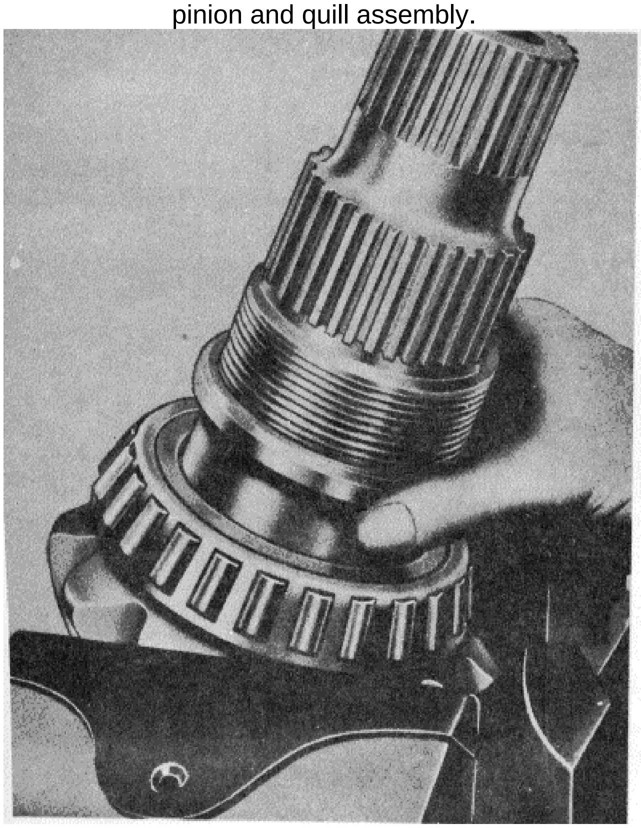


H. Remove the pinion bearing outer nut and lock washer, inner adjusting nut lock and inner adjusting nut.

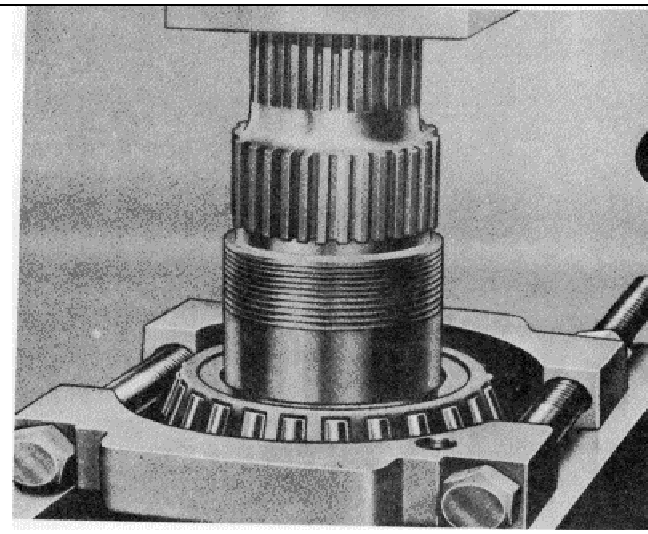
A hard wood wedge inserted between the teeth of the hypoid pinion and hypoid gear will prevent the gears from turning while loosening and tightening the bearing adjusting and jam nuts when the gears are assembled in the carrier.



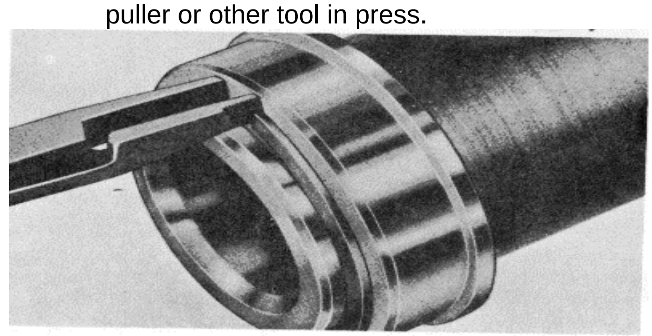
J. Remove housing and outer bearing from the pinion and quill assembly.



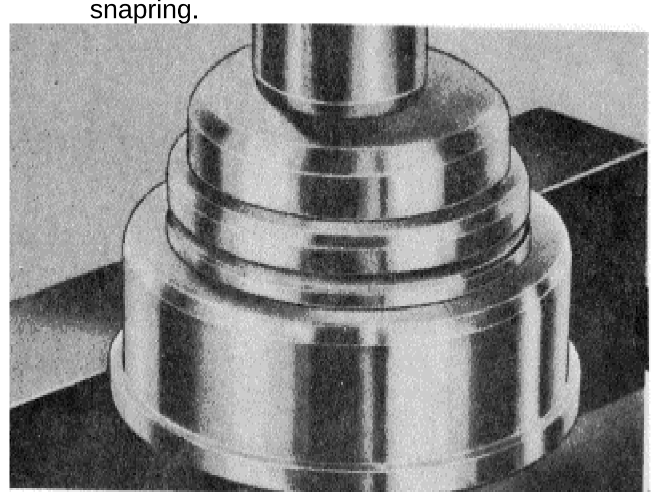
K. Remove the pinion bearing spacer. Note O.D. chamfer i, toward outer bearing.



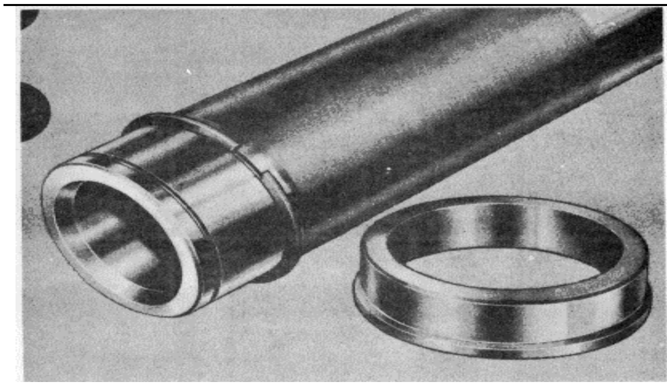
L. Remove the rear pinion bearing using a suitable puller or other tool in press.



M. Remove pinion quill rear bearing inner race outer snapring.



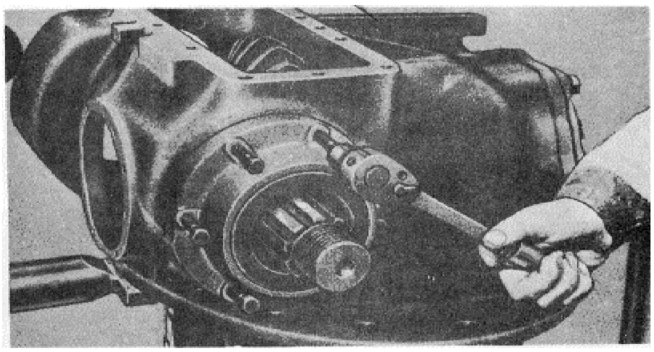
N. Remove the pinion quill rear bearing inner race using a suitable puller or press. Exercise care not to damage inner snapring.



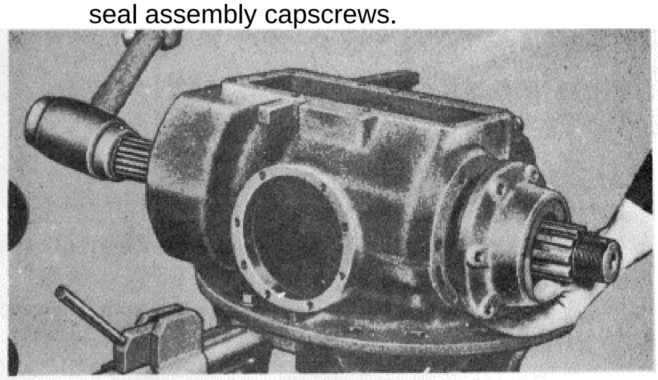
P. Remove rear bearing inner race inner snapring.

Q. Remove pinion bearing cups from housing with suitable puller or with sleeves in press.

REMOVE AND DISASSEMBLE THRUSHAFT ASSEMBLY

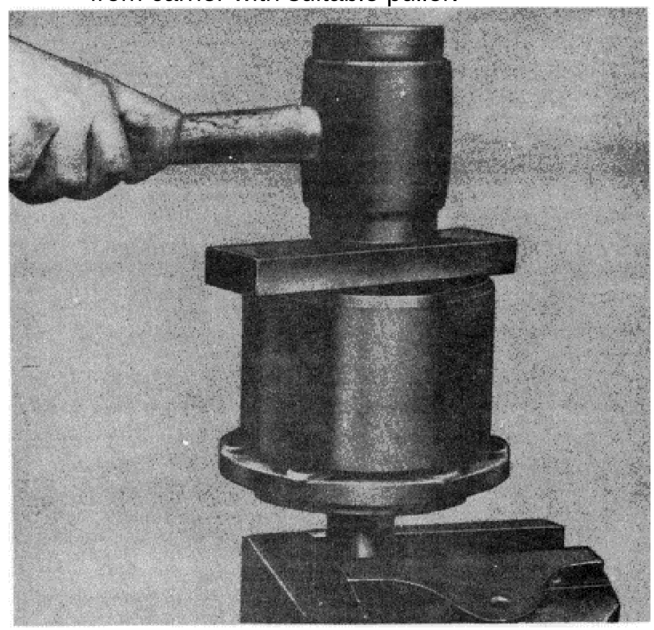


A. Remove the thrushaft bearing cage, cover and seal assembly capscrews.

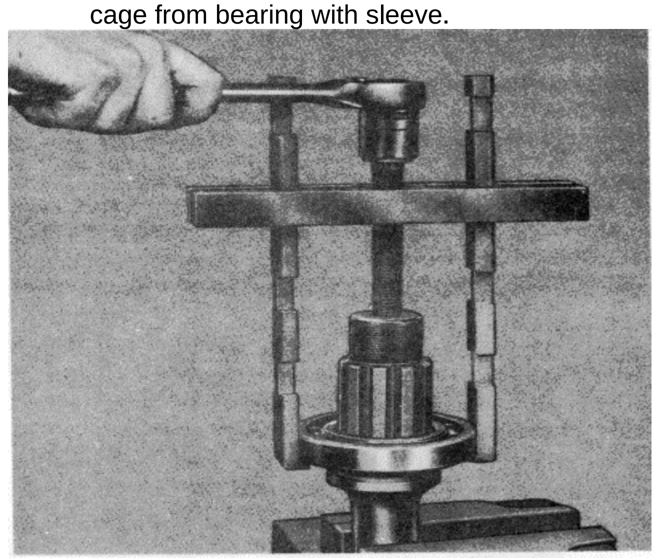


B. Remove the thrushaft assembly by lightly tapping on the forward end with a rawhide hammer.

C. Remove the pinion quill rear bearing from carrier with suitable puller.

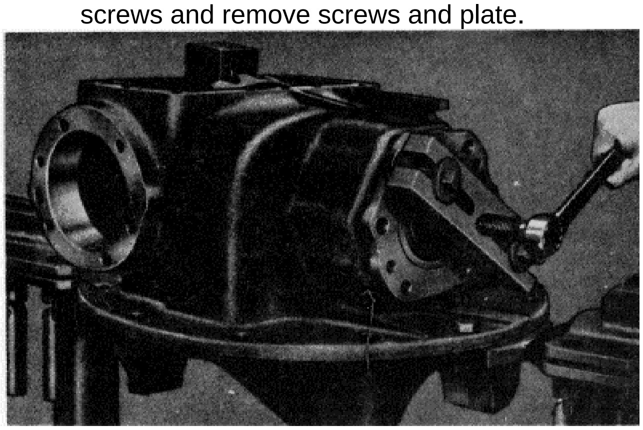


D. Remove snapring and tap thrushaft ball bearing cage from bearing with sleeve.

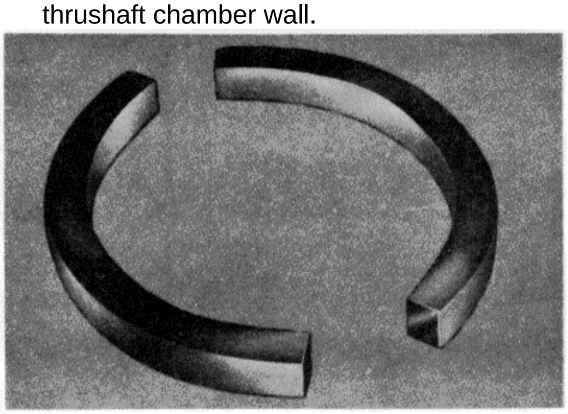


E. Remove thrushaft ball bearing with puller having long fingers that pull against bearing inner race.

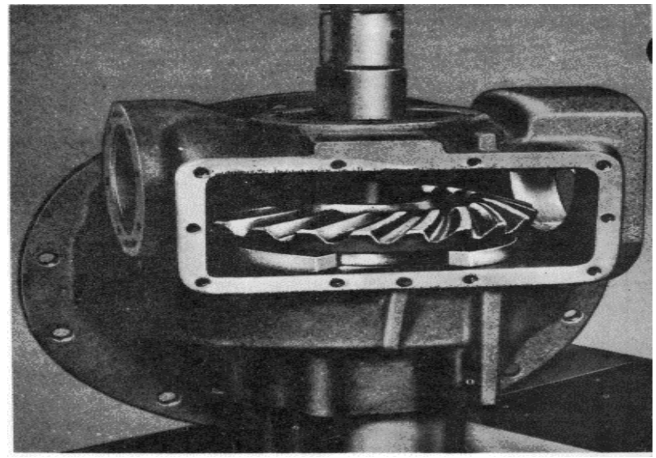
A. Remove cross shaft cover capscrews, lock washers and cover. Attach shim pack, which controls cross shaft bearing preload, to cover. This will facilitate preload adjustment when reassembling drive unit.
B. Cut lock wire from bearing retainer plate cap screws and remove screws and plate.



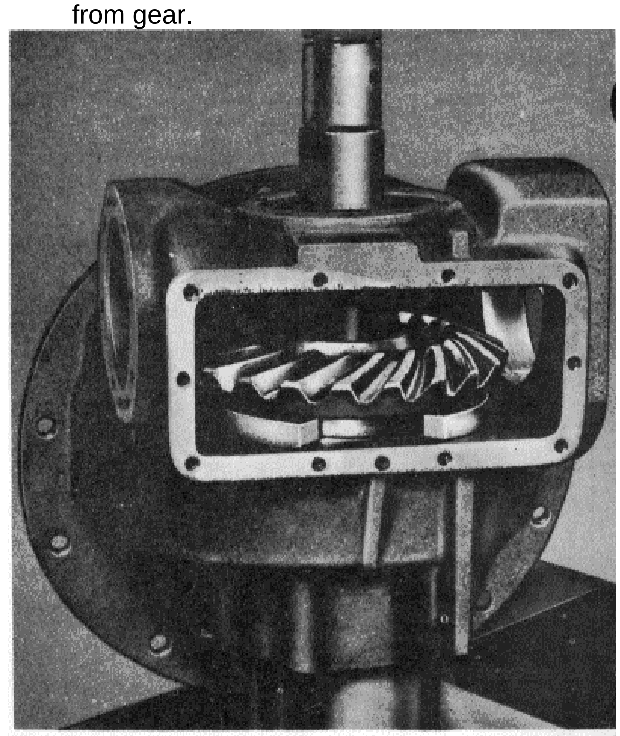
C. Insert hard wood block between end of cross shaft and outer thrushaft chamber wall. Remove bearing cage and tapered bearings with suitable puller, using 3/8"16 puller screws in cage flange tapped holes. Attach shim pack, which controls. gear backlash to cage. This will facilitate adjustment when reassembling drive unit.
D. cross shaft and gear assembly toward thrushaft chamber in carrier, so semicircular blocks can be inserted between back of gear and inner thrushaft chamber wall.



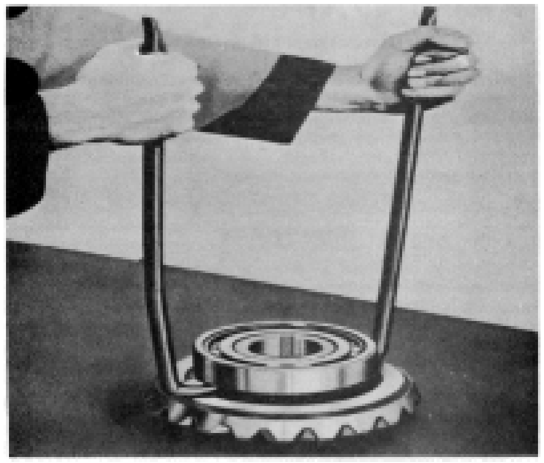
NOTE: Two pieces of %" steel square bar stock, approximately 10" long, bent to form segments of an 18" diameter circle, will facilitate cross shaft removal



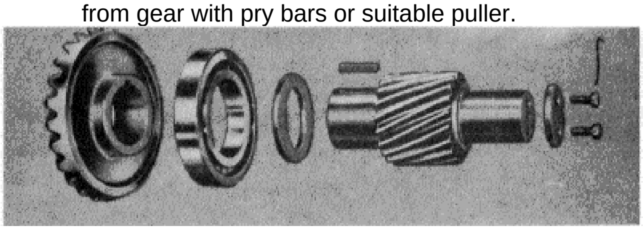
E. Position drive unit in press, thrushaft chamber up, with blocks under gear and press cross shaft from gear.



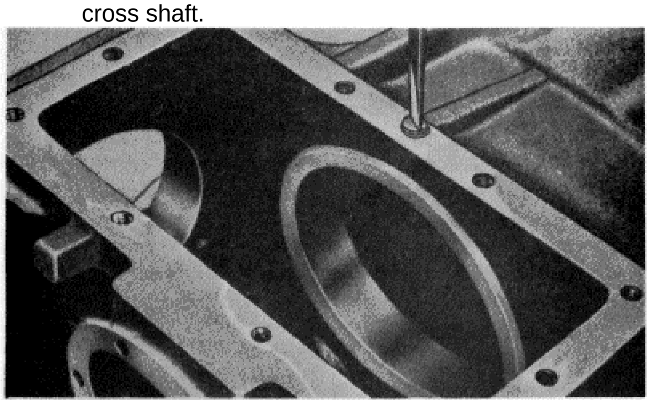
Provide a rigid support on the press bed for the drive unit during this operation. A sleeve with a 3A" or I" wall and I.D. approximately the size of the cross shaft cage O.D. is suitable; or, the drive unit may be supported by a horizontal flat plate 10" x 10" x 1" with a bored hole about the same size as the cross shaft cage O.D. Support ' the horizontal plate on heavy vertical plates of a



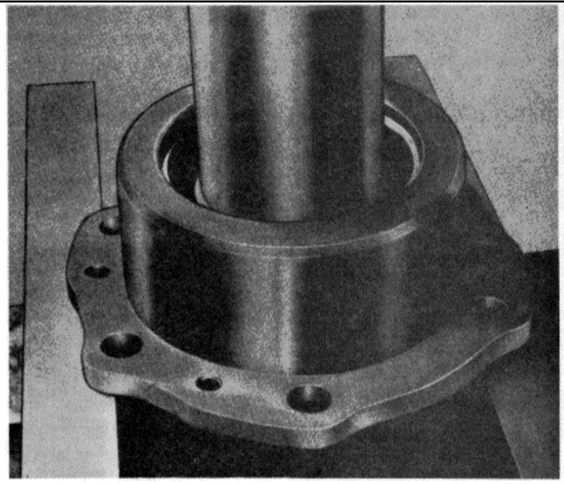
Lift or tap out radial bearing and gear assembly from drive unit; do not lose gear washer. Remove bearing from gear with pry bars or suitable puller.



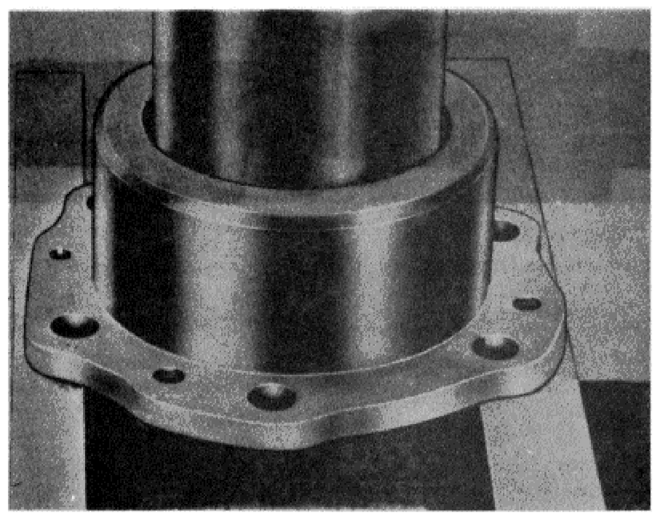
Exploded view of components of cross shaft assembly showing gear, radial bearing, washer, and cross shaft.



G. Do not remove radial bearing sleeve from drive unit unless replacement of sleeve is necessary.



H. Remove cross shaft tapered bearing inner and outer cones and outer cup from cage with suitable puller or with sleeve in press.



J. Remove cage inner cup with suitable puller or with sleeve in press.

CLEAN, INSPECT AND REPAIR

Parts having ground and polished surfaces such as gears, bearings, shafts and collars, should be cleaned in a suitable solvent such as kerosene or diesel fuel oil.

GASOLINE SHOULD BE AVOIDED.

Do NOT clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthosilicates or phosphates

We do NOT recommend steam cleaning assembled drive units after they have been removed from the housing. When this method of cleaning is used, water is trapped in the cored passage of the castings and in the close clearances between parts as well as on the parts. This can lead to corrosion (rust) of critical parts of the assembly and the possibility of circulating rust particles in the lubricant. Premature failure of bearings, gears and other parts can be caused by this practice. Assembled drive units cannot be properly cleaned by steam cleaning, dipping or slushing. Complete drive unit disassembly is a necessary requisite to thorough cleaning.

ROUGH PARTS

Rough parts such as differential carrier castings, cast brackets and some brake parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts are not ground or polished. The parts should remain in the tank long enough to be thoroughly cleaned and heated through. This will aid the evaporation of the rinse water. The parts should be thoroughly rinsed after cleaning to remove all traces of alkali.

CAUTION: Exercise care to avoid skin rashes and inhalation of vapors when using alkali cleaners.

COMPLETE ASSEMBLIES

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all openings are closed. Breathers, vented shift units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

DRYING

Parts should be thoroughly dried immediately after cleaning. Use soft, clean, lintless absorbent paper towels or wiping rags free of abrasive material such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.

CORROSION PREVENTION

Parts that have been cleaned, dried, inspected and are be immediately reassembled should be coated with light. to prevent corrosion. If these parts are to be stored for any length of time, they should be treated with a good RUST PREVENTIVE and wrapped in special paper or other material designed to prevent corrosion.

INSPECT

It is impossible to over stress the importance of careful and thorough inspection of drive unit parts prior to re-assembly. Thorough visual inspection for indications of wear or stress, and the replacement of such parts as are necessary will eliminate costly and avoidable drive unit failure.

A. Inspect all bearings, cups and cones, including those not removed from parts of the drive unit and replace if rollers or cups are pitted or damaged in any way. Remove parts needing replacement with a suitable puller or in a press with sleeves.

   Avoid the use of drifts and hammers. They may easily mutilate or distort component parts.

B. first reduction bevel or hypoid and second reduction spur gears for wear or damage. Gears which are pitted, galled or worn or broken through case hardening should be replaced.

   When necessary to replace the pinion or gear of a spiral bevel or hypoid gear set, the entire gear set should be replaced. We assume no responsibility for gears of these types when replaced in any other manner.

C. Inspect the differential assembly for the following.

   1. Pitted, scored or worn thrust surfaces of differential case halves, thrust washers, spider trunnions and differential gears.
      Thrust washers must be replaced in sets.

      The use of a combination of old and new washers will result in premature failure.

   2. Wear or damage to the differential pinion and side gear teeth.

      Always replace differential pinions and side gears in sets.

D. Spur pinions for wear or damage to teeth.

E. Check end of pinion for indications of brinelling caused by worn splines. Replace the parts if the splines of the pinion and/or thrushaft are worn, permitting movement of the pinion on the thru shaft.

F. Axle shafts for indications of torsional fractures and run out. Axle shafts should be inspected between centers to as certain the amount of run out of the ground surfaces. Run out at the shaft flange and splines should not exceed .005" total indicator reading.

REPAIR

A. all worn or damaged parts. Hex nuts with rounded comers, all lock washers, oil seals and gaskets should be replaced at the time of overhaul.

Use only genuine Rockwell Standard parts for satisfactory service. For example, using gaskets of foreign material generally leads to mechanical trouble due to variations in thickness and the inability of certain materials to withstand compression, oil, etc.

B. Remove nicks, mars and burrs from machined or ground surfaces. Threads must be clean and free to obtain accurate adjustment and correct torque. A fine mill file or India stone is suitable for this purpose. Studs must be tight prior to reassembling parts.

C. All Rockwell Standard bronze bushed axle differential and interaxle differential pinions should be ball burnished after bushing installation. Install the bushing with a small stepped drift. The small O.D. should be .010" smaller than the bushing burnished I.D. and *1l* times bushing length. Always install bushings so end is even with the I.D. chamfer or about 1/16" below the machined surface.

D. When assembling component parts use a press where necessary. Avoid hammering.

E. Tighten all nuts to specified torque. See torque limits following service instructions.

Lock wire must not be brittle; use soft iron wire to prevent possibility of wire breakage.

F. The burrs, caused by lock washers, at the spot face of stud holes of cages and covers should be removed to assure easy re-assembly of these parts. The stud holes are standard sizes (fractions of an inch) and may be reamed with standard size reamers. Start the reamer or drill on side of flange opposite spot face so the tool will have from 3/8" to 1/2" pilot as it cuts the burr from the hole.

REASSEMBLE AND INSTALL DRIVE UNIT

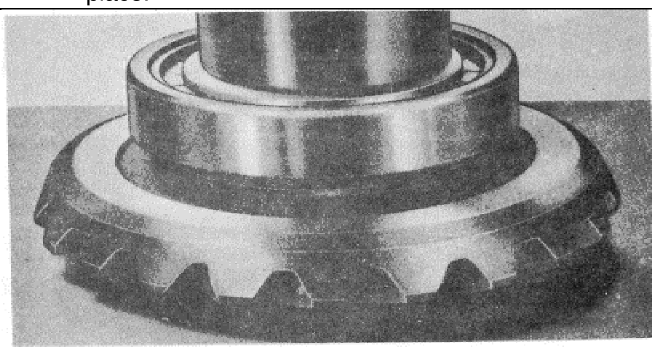
The cross shaft assembly must be installed in the carrier first so cross shaft bearing preload can be established without interference of the thru shaft and pinion assembly. The thru shaft, pinion, bearing and cage may be assembled at the bench and then installed in the carrier.

REASSEMBLE CROSS SHAFT ASSEMBLY

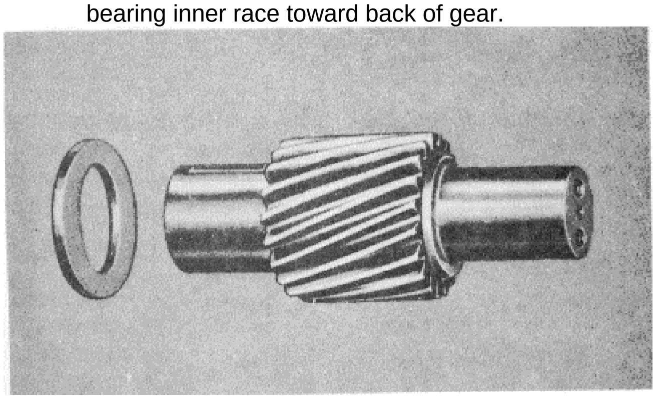
A. Check sleeve I.D. and radial bearing O.D. Replace sleeve and/or bearing if the parts are damaged, or if there is more that .006" clearance between the sleeve and bearing. When these parts are new the sleeve I.D. should be .0024" to .004" larger than the bearing O.D. The radial bearing must be free to float in the sleeve.

Carefully check the I.D. of the bearing bore of older drive units that do not have replaceable sleeves. If the I.D. is more that .006" larger that the bearing O.D., replace the carrier and cap assembly with the newer type carrier and cap assembly that incorporates replaceable sleeves.

B. If radial bearing sleeve is to be replaced, press new sleeve firmly against housing shoulder. Drill hole for lock screw and remove burrs from sleeve. Install lock screw and tighten securely or install pin and stake in place.



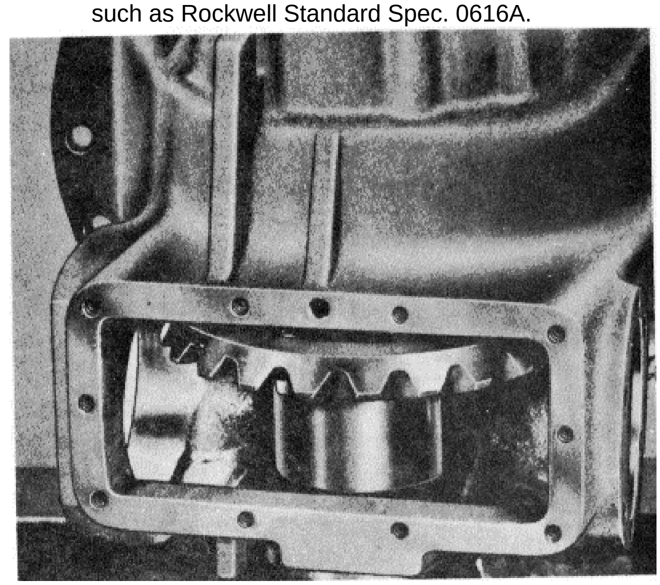
C. Assemble radial bearing on gear hub, large radius of bearing inner race toward back of gear.



D. Install bearing washer on cross shaft with chamfer of spacer away from radial bearing. A large flat washer is 36 used at this location when the O.D. of the pinion teeth is smaller than the I.D. of the radial bearing. (see photo)

E. Coat I.D. or gear with heavy grease such as Rockwell Standard Spec, 0616A. Install gear, and bearing assembly in drive unit sleeve and block up to hold in place.

F. Inspect entering end of cross shaft and remove any nicks or burrs. Coat O.D. of shaft with a heavy grease such as Rockwell Standard Spec. 0616A.

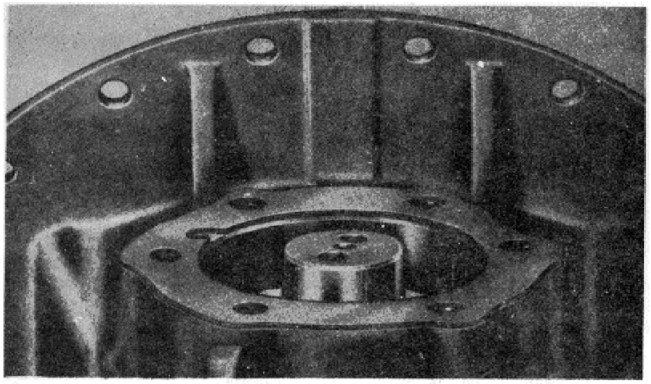


G. Position housing in press, thru shaft chamber down with gear supported on suitable sleeve.

H. Align key in cross shaft (do not drop bearing washer) with keyway in gear and press shaft firmly into gear and bearing. Continue pressing operation, exert 10 to 20 tons pressure in excess of that required for secure assembly.

Begin the assembly operation in the press, making sure the parts are properly aligned. Press the parts together about 4" to 3/8", then relieve the press pressure to permit them to realign themselves to prevent distortion and damage. Continue the pressing operation until the parts are correctly assembled.

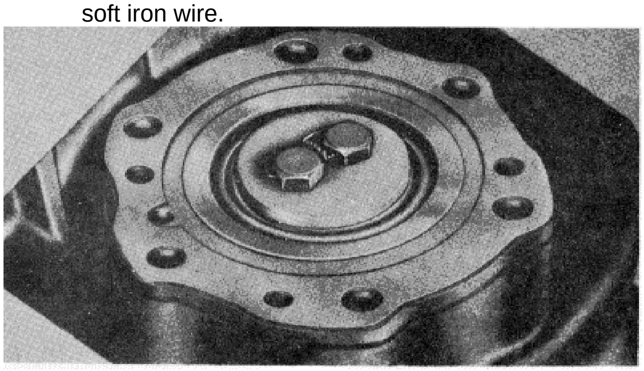
NOTE: If inner tapered bearing cup has been removed from cross shaft cage, reassemble in press using sleeve or the, suitable installation tool. Press cup firmly against cage shoulder.



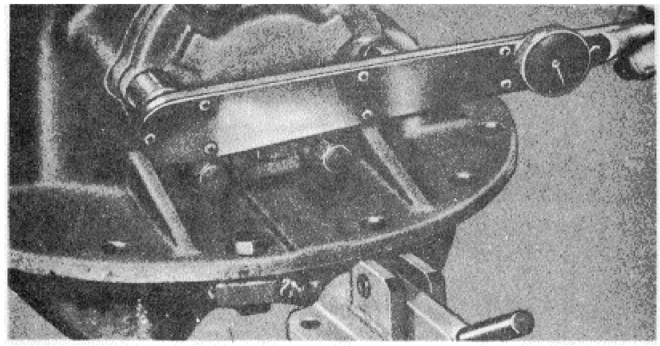
I. Install original shim pack (which controls gear back lash) over cross shaft opening in carrier. Apply colloidal graphite lubricant to cross shaft bearing journal. Place cage in carrier over shim pack, carefully aligning oil holes in cage with oil holes in drive unit. Press bearing cage part way into carrier.

J. Press inner bearing part way onto cross shaft, then install outer bearing and cup onto cross shaft. Use a suitable sleeve and press bearings and cage completely into carrier.

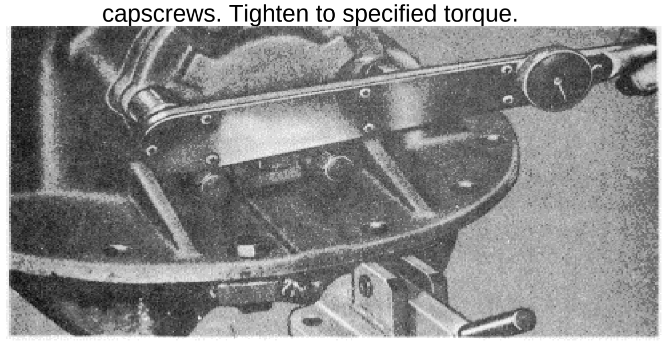
K. Assemble bearing retainer plate with 2 capscrews. Tighten capscrews to specified torque and lock with soft iron wire.



L. Install bearing cage cover original shim pack (which controls tapered bearing preload).



M. Assemble bearing cage cover, lock washers and capscrews. Tighten to specified torque.



N. Measure cross shaft bearing preload torque. Wrap strong cord around spur pinion and pull on horizontal line with pound scale.

The preload torque specification for tapered roller bearings mounted close together in the bearing cage is 5 to 15 pound inches (new and serviceable used bearings).

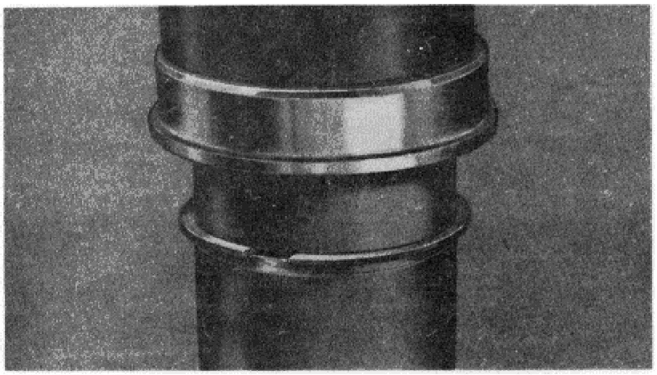
Example: *Assume spur pinion diameter is 4", the radius is 2'; and with 5 pounds pull on the scale, preload torque is 10 pound inches.*

Read rotating pounds pull, not starting pounds pull.

If preload torque is not within 5 to 15 pound inches, add shims between cover and cage to decrease, or remove shims to increase cross shaft bearing preload torque.

If the pinion, quill and through shaft assembly was not disassembled disregard re-assembly section Pagesl8, and 19 and temporarily install the pinion, quill and through shaft into carrier (Page 19, Item H) for tooth contact and backlash check. See backlash and tooth contact section, Pages 21 and 22. Continue re-assembly by installing the shift unit, Page 19. If the pinion, quill and through shaft assembly was disassembled, continue with Item "A" Page 18.

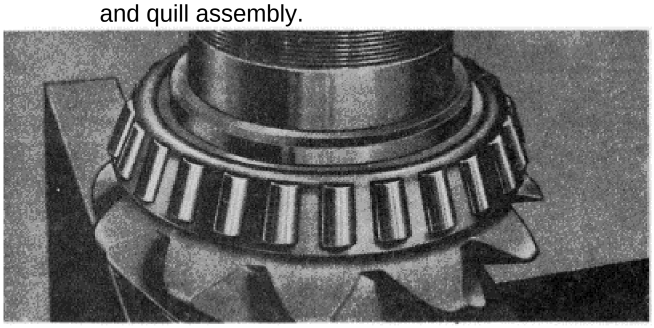
REASSEMBLE AND INSTALL HYPOID PINION AND QUILL, BEARING AND HOUSING ASSEMBLY



A. Press pinion bearing tapered cups firmly in place against housing shoulder. Assemble rear bearing inner race inner snap ring. Coat quill O.D. and race I.D. with heavy grease such as Rockwell Standard Spec. 0-616A and press inner race in place. Install outer snap ring.

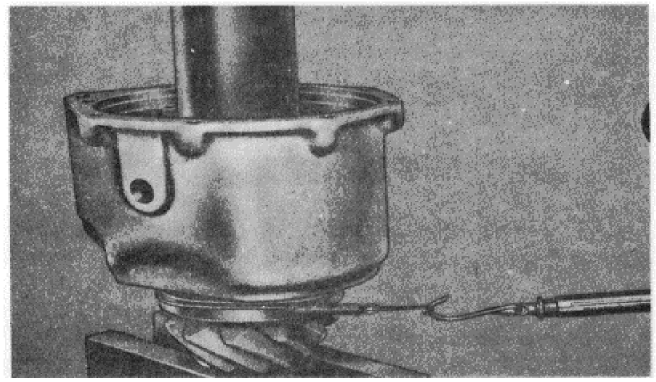
Begin the assembly operation in the press, making sure the parts are properly aligned. Press the parts together about 1/4" to 3/8': then relieve the pressure to permit them to realign themselves to prevent distortion and damage. Continue the pressing operation until the parts are correctly assembled

B. Lubricate all bearing journals only with a few drops of engine oil and firmly press inner bearing on pinion and quill assembly.



C. Install original spacer on inner bearing. O.D. chamfer of spacer must be toward outer (forward) bearing.

D. housing and cup assembly on pinion. Press bearing firmly against selective spacer with suitable sleeve, rotating housing assembly to assure normal bearing contact.

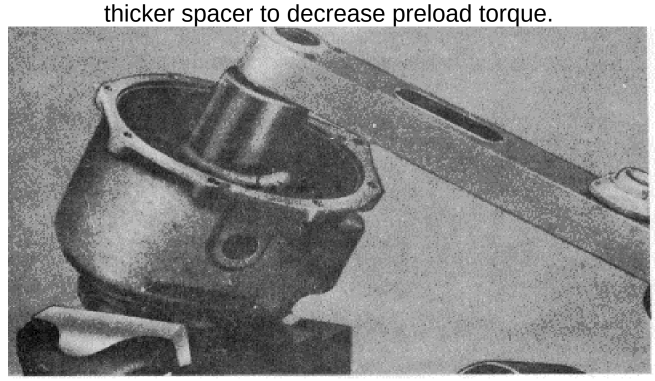


E. Measure pinion bearing preload torque while in press under 9 tons pressure. Wrap strong cord around housing pilot and pull on horizontal line with a pound scale. If a press is not available, the pinion bearing nut may be tightened to the torque noted in "Tabulation of Torque Limits" (back of Manual) and preload torque checked.

The preloae torque specification for tapered roller bearings mounted close together in the bearing cage is 5 to 15 pound inches (new and serviceable used bearings).

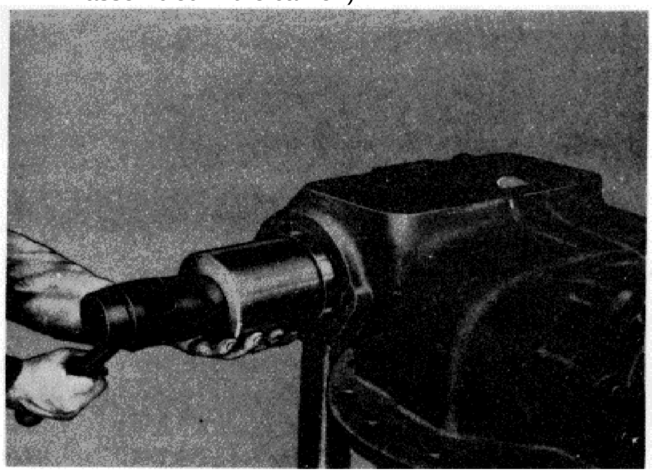
Example: *Assume the housing pilot diameter is 6': the radius is 3" and with 3 pounds pull on the scale, preload torque is 9 pound inches.*

Read rotating pounds pull on scale, not starting pounds pull. If rotating torque is not within 5 to 15 pound inches, use a thinner spacer to increase or a thicker spacer to decrease preload torque.

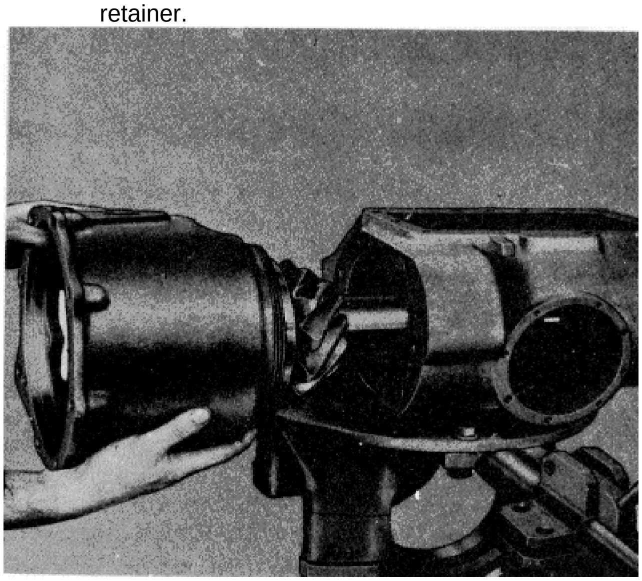


F. Assemble bearing adjusting nut onto pinion and tighten nut to specified torque. Recheck bearing preload. Install , nut lock, flat washer and lock(jam) nut. Bend flat washer over nut flat.

(A hardwood wedge inserted between the teeth of the hypoid pinion and hypoid gear will prevent the gears from turning while loosening and tightening the bearing adjusting and jam nuts when the gears are assembled in the carrier.)



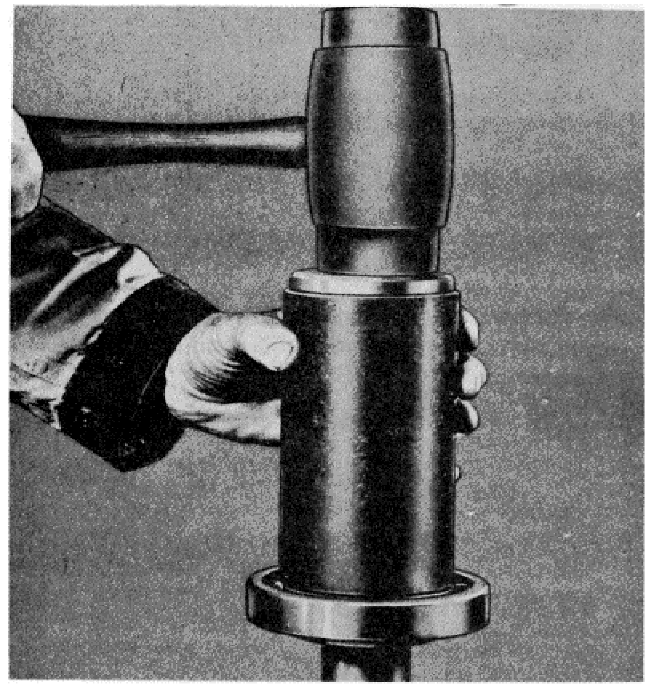
G. Install pinion quill rear bearing in carrier with suitable sleeve. Check location with thru-shaft ball bearing retainer.



H. Loosely install two guide studs in carrier if cap screws are used to hold housing assembly in place. Position original shim pack over studs so oil holes are in correct alignment.

I. Carefully tap pinion, housing and gear assembly in place.

ASSEMBLE AND INSTALL THRU-SHAFT ASSEMBLY



A. Install thru-shaft ball bearing firmly against shaft shoulder and assemble shaft and bearing assembly inter linear.

B. Position gasket over bearing retainer and install shaft, bearing and retainer assembly into carrier.

C. Alternately tighten six evenly spaced capscrews to draw assembly in place. Tighten capscrews to correct torque.

D. seal body and seat with non-hardening sealing compound and install in cover with suitable sleeve. Lubricate sealing element.

E. Install thru-shaft yoke or flange, washer and nut. Tighten nut to specified torque and cotter in place.

SHIFT UNIT INSTALLATION

A. Slide inter-axle differential shift collar onto pinion quill assembly (Dog teeth facing out).

NOTE: Before installing shift unit into carrier, adjust shift fork as follows:

1. Hold shift fork in the "unlocked" position.

2. Turn adjusting screw (at front of unit) in, to contact shift fork.

3. After contact with fork has been made, turn adjusting screw in, 3/4 of a turn.

4. Lock adjusting screw in position with jam nut.

B. Install shift unit into carrier engaging shift collar on pinion quill assembly with shift fork.

C. Assemble shift lever attaching nut, button, lever, cup and spring.

D. Install shift shaft housing assembly, lockwashers and capscrews.

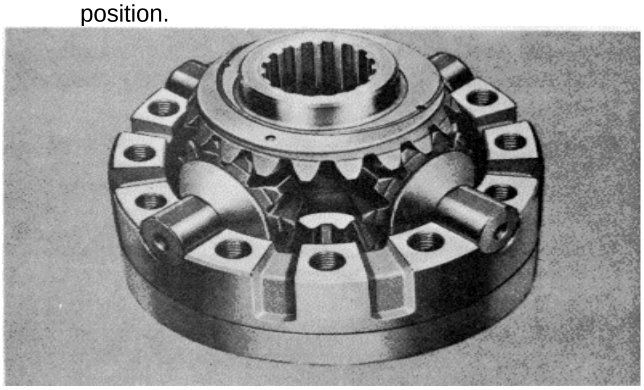
NOTE: Do not adjust shift shaft until interaxle differential has been installed.

ASSEMBLE INTERAXLE DIFFERENTIAL

A. Lubricate differential case walls and all component parts with axle lubricant.

B. Position thrust washer and rear side gear into rear case section and assemble intermediate case section over real case and side gear.

C. Place spider with pinions and thrust washers in position.



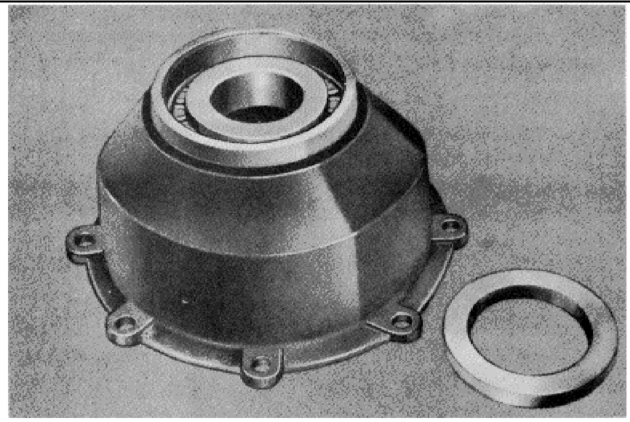
D. Install forward side gear and thrust washer.

NOTE: If inner bearing was removed from forward case (Input shaft), position bearing on shaft and press into position using suitable sleeve. Press bearing flush against case half

E. Align mating marks, of the three case sections.

F. Install the case cap screws, tighten to correct torque and lock wire.

G. Check for free rotation of gears and correct if necessary.



A. If the cover assembly was disassembled, install the forward and read bearing cups.

B. Install the spacer on the input shaft.

C. Place unit in press and position the cover assembly over the input shaft and press outer bearing in cover until the bearing seats against the spacer.

D. Install the cover oil seal with a suitable driver.

BEARING END PLAY CHECK

NOTE: Bearing must be adjusted to .003 to .005 end play which is controlled by the hardened spacer between the bearings. Use the following method:

A. Install gasket and position interaxle differential and cover assembly onto drive unit. Lineup splines of through shaft and pinion with splines of side gears.

B. Install interaxle differential cover to housing capscrews and lockwashers. Tighten capscrew to recommended torque value.

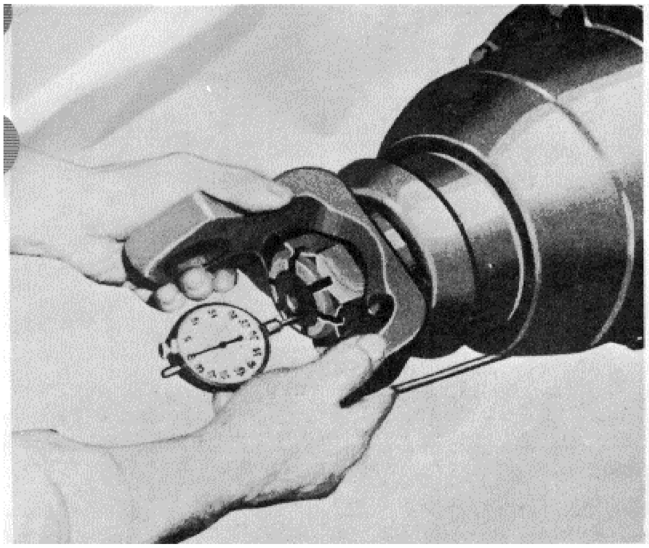
C. Install yoke or flange and hand tighten nut.

D. With rawhide mallet tap input shaft to be certain bearings are properly seated.

ADJUSTMENT:

1. Use a dial indicator with a magnetic base and mount base against cover.

2. Place stem of indicator against end of input shaft



3. While watching the indicator push inward on the flange or yoke and roll it back and forth until the indicator stops changing. Make a note of this reading. In a similar manner, pull outward and roll the flange or yoke until the indicator again stops changing. The difference between this reading and the inward reading is the adjustment condition.

4. Correct to .003 to .005 end play if necessary by using thicker or thinner spacer.

E. Remove yoke or flange and input nut.

F. Install oil slinger if used, reinstall yoke or flange, input washer and nut. Tighten nut to recommended torque value.

SHIFT SHAFT ADJUSTMENT

1. Apply air or vacuum to move shaft to its full travel to "lock" interaxle differential.

2. Turn adjusting screw (in rear of unit) to contact shift shaft.

3. After contact with shaft has been made turn adjusting screw in 3/4 of a turn.

4. Lock adjusting screw in position with jam nut.

ESTABLISH TOOTH CONTACT AND GEAR BACKLASH

Hypoid gear first reduction units have a single shim pack between the pinion cage and carrier or interaxle differential housing and carrier to control pinion position.
A shim pack between the cross shaft bearing cage flange and the carrier controls the position of the first reduction hypoid gear in all top mounted double reduction drive units.

(NEW GEARS)

Tooth contact may be checked by applying a thin even coat of lightly oiled red lead with a small brush to both drive and coast sides of a dozen teeth of the gear. When the pinion is rotated the red lead is squeezed from the gear teeth by pressure of the pinion teeth leaving areas the exact size, shape and location of the contacts. Sharper, better defined areas of contact can be obtained by applying rolling resistance to the gear providing the gear is not forced out of location during the checking operation.

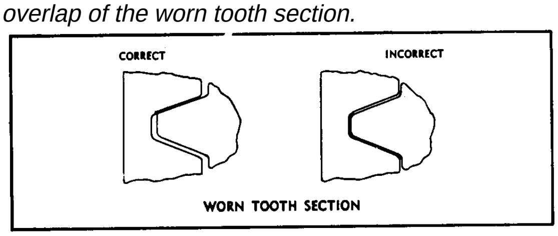
Use the smallest amount of the lead and oil mixture that will render good impressions. The drier the mixture the better the impressions. Clean the material from the gear and pinion teeth when the operation is complete. Always judge tooth contact by noting pattern on the drive side of the gear teeth. The coast side pattern should be correct when the drive side pattern is correct.

IMPORTANT: When backlash amount is not specified, set backlash to the following:

STDD
Forward Rear -.005 to .015
Rear Rear -.005 to .015 SUDD
Forward Rear -.005 to .015
Rear Rear -.020 to .026, however, .010 should be used
for establishing tooth contact pattern, than opened
to .020 to .026.

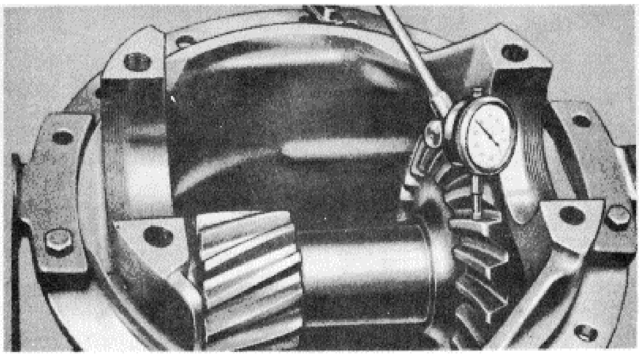
RE-CHECK BACKLASH (USED GEAR SETS)

Generally, if original gears are being re-installed in assembly, red leading of teeth will not indicate the same contact as new gears and can be misleading. Gears that have been in service for long periods form running contacts due to wear of teeth. Therefore, the thickness of the original shim pack plus approximately .015" additional shim stock should be maintained to check gear lash. In the event that gear lash is in excess of maximum tolerance, as stated under gear adjustment, reduce gear lash, only in the amount that will *avoid overlap of the worn tooth section.*



Gear lash can only be reduced to a point of maintaining smooth rotation of bevel gears.

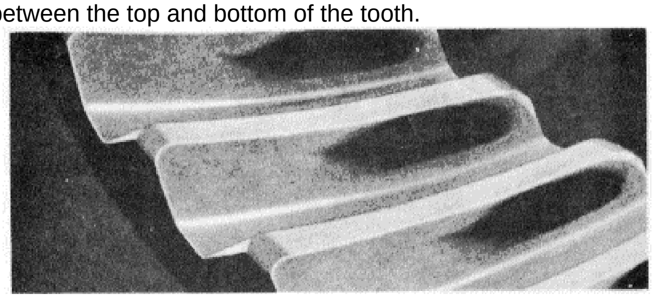
Smoothness or roughness can be noted by rotating bevel gear. If a slight overlap, as illustrated, takes place at worn tooth section, rotation will be rough. Generally with the original gears, tone should be satisfactory.



The actual back lash changes approximately .008" for each .010" movement of the gear.

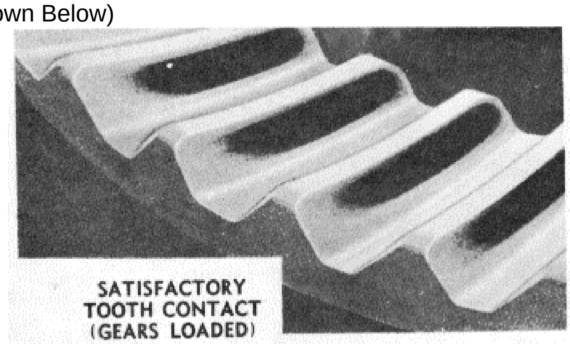
CORRECT TOOTH CONTACT ASSURES LONGER GEAR LIFE

With adjustments properly made (pinion at correct depth and backlash set at .010") the following contacts will be procured. The area of contact favors the toe and is centered between the top and bottom of the tooth.

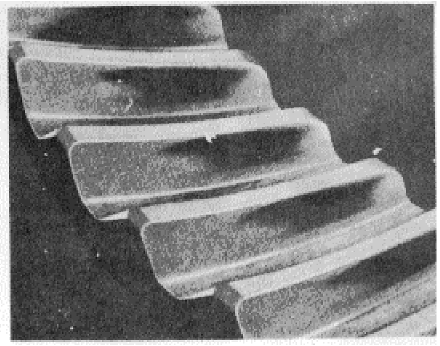


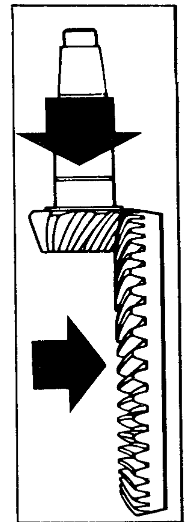
SATISFACTORY TOOTH CONTACT (GEARS UNLOADED)

The hand rolled pattern shown above (gears unloaded) will result in a pattern centered in the length of the tooth when the gears are under load. The loaded pattern will be almost full length and the top of pattern will approach the top of the gear. (Shown Below)

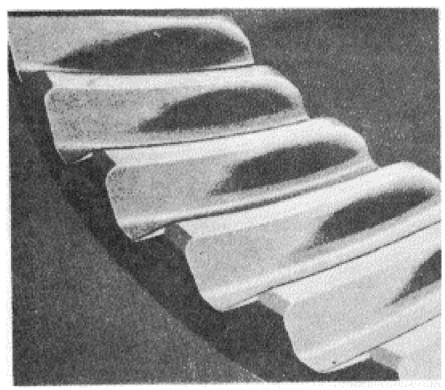


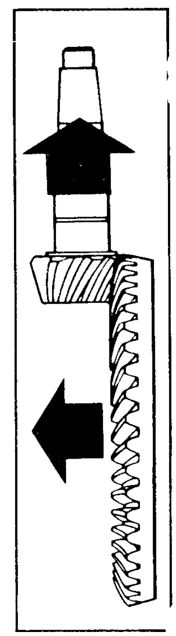
The pattern of the coast side of teeth will appear the same width as the drive side shown above; however, the overall length will be centered between the toe and heel of gear tooth.





A high contact indicates pinion is to far out. Set the pinion to the correct depth by removing shims under the pinion cage. Slight outward movement of hypoid gear may be necessary t maintain correct backlash.



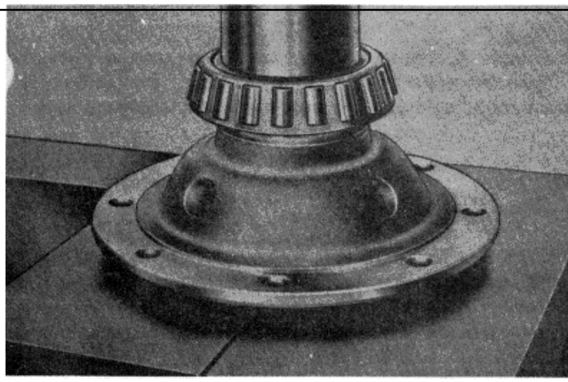


A low contact indicates pinion is to deep. Set the pinion to the correct depth by adding shims under the pinion cage. Slight inward movement of the hypoid gear may be necessary t maintain correct backlash.

A high backlash setting can be used to keep the contact from starting too close to the toe, and a low backlash setting can be used to keep the contact from starting too far away from the toe.*t*

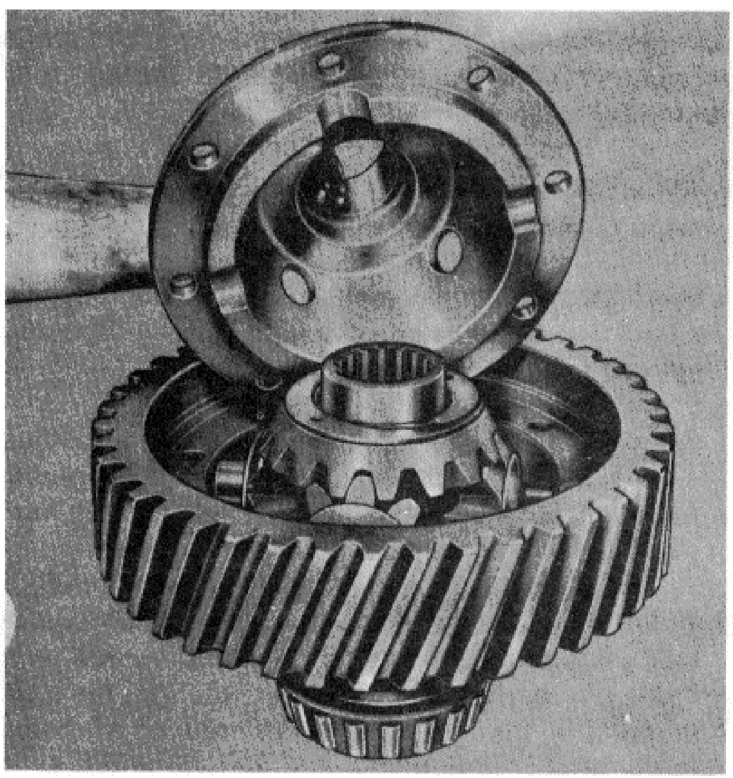
t For further detailed information refer to SAE Paper SP228, Section 2 by W. A. Johnson and R. F. Cornish.

ASSEMBLE AND INSTALL AXLE DIFFERENTIAL

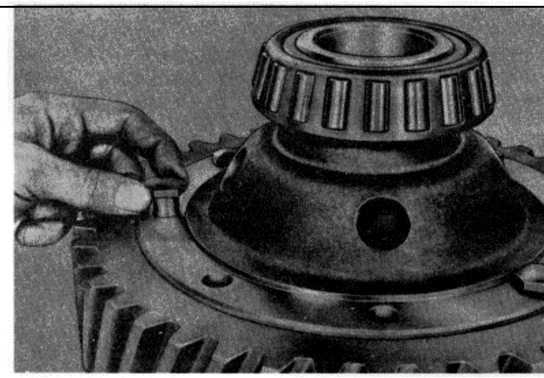


A. Press differential bearings firmly against case shoulders. Coat inside of case and all differential parts with specified rear axle lubricant.

B. Assemble differential case half and gear. Install side gear
thrust washers, side gears and differential pinion gears, thrust washers and spider.



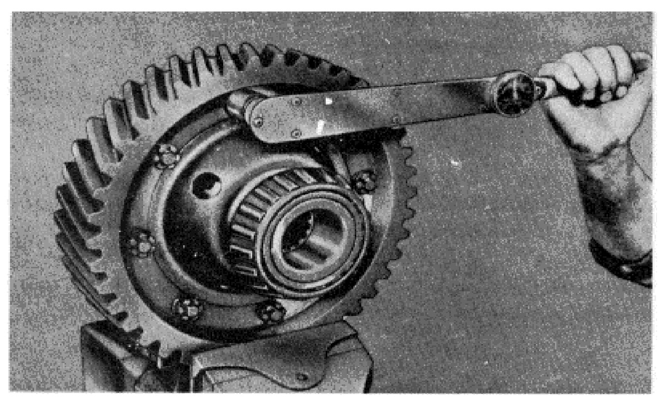
C. Note cast alignment marks and assemble opposite case half. Hold assembly together with 4 bolts and nuts and check for free rotation of parts.



D. Install remaining differential case bolts so heads are locked by machined relief in case half. Be sure case halves are assembled to gear so there is adequate nut clearance. Check clearance in carrier before completing assembly

When a new gear or a new differential case is installed the case holes must be line reamed with the gear in order to assemble the parts using the correct size rivets or bolts. Align the case halves and hold case and gear assembly together with 4 bolts and nuts. Line ream the holes. Thoroughly clean the parts before assembly.

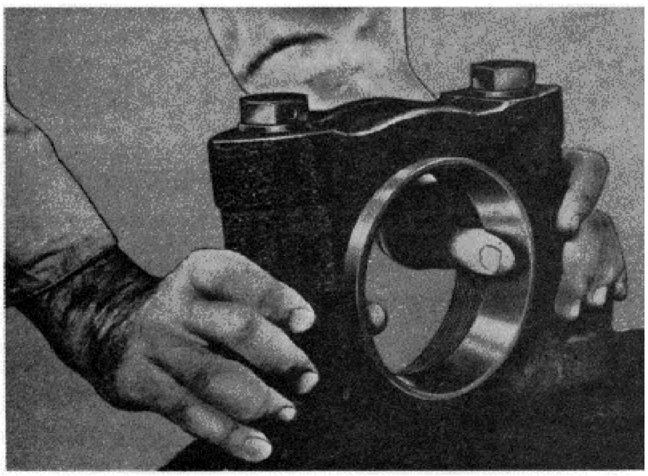
Hold differential case assembly together with 4 bolts when riveting the parts together. Use a rivet set that will shape the formed head 1/8" larger in diameter than the rivet hole. The formed head height should not be more than 1/16" lower than the preformed head. A lower formed head indicates high riveting pressures that may distort the case and cause gear eccentricity.



E. Tighten bolt nuts to specified torque and lock wire or cotter in place

INSTALLATION OF BEARING CUPS IN CARRIER LEG BORES

A. Temporarily install the bearing cups, threaded adjusting rings where employed and bearing caps. Tighten the cap screws to the proper torque.



B. The bearing cups must be of a hand push fit in the bores, otherwise the bores must be reworked with a scraper or some emery cloth until a hand push fit is obtained. Use a blued bearing cup as a gauge and check the fits as work progresses.

This applies to all types of carrier leg bores.

USE THE FOLLOWING PROCEDURE FOR ADJUSTING DIFFERENTIAL BEARINGS ON UNITS EMPLOYING TWO THREADED RINGS:

A. Inspect carrier legs and bearing caps to be sure they are properly relieved at I.D. parting line.

B. Apply Specified axle lubricant to bearing cups and cones. Position cups over cones and install assembly in carrier.

C. Insert differential bearing adjusting nuts and turn hand tight against bearing cups.

D. Position Bearing caps in place over bearing cups and adjusting nuts, making sure they are properly aligned.

Caution; *If bearing caps do not seat easily and correctly, the adjusting nuts may be cross threaded. Forcing caps in place will result in irreparable damage to the differential carrier and caps*.

E. Install and tighten the stud nuts or cap screws to specified torque noted in "Tabulation of Torque Limits" at back of Manual.

F. Alternately loosen one adjusting nut and tighten the opposite adjusting nut while turning the differential assembly to assure normal bearing contact and to keep bearing cups straight in the bores.

G. Either of the following procedures will result in proper differential bearing preload:

1. Establish a zero end play; no-preload condition with a dial indicator. Tighten the adjusting nuts 13A to 2% notches (total for both nuts) tight to correctly preload the bearings; or:

2. Tighten adjusting nuts to spread the differential bearing legs .006"-.010" (total for both legs) as determined by a crescent shaped micrometer held at the level of the leg pilot surfaces and parallel to the carrier mounting flange.

H. Install adjusting nut locks and cap screws. Tighten to specified torque.

I. Lock all parts in place with soft iron wire.

USE THE FOLLOWING PROCEDURE FOR ADJUSTING DIFFERENTIAL BEARINGS ON UNITS EMPLOYING TWO SPLIT RINGS:

A. Temporarily install differential with bearings and cups in carrier housing and center between carrier leg grooves.

B. Insert thin split rings making certain that there is clearance between bearing cup faces and rings. (Do not install bearing caps.)

C. By means of a dial indicator measure end play of differential assembly by shifting the assembly back and forth between the rings with a small pair of pinch bars placed between the carrier legs and the spur gears.

D. Remove and measure the thickness of the rings. To the total thickness of the two thin rings add the end play figure plus another .017" to .022" to obtain the total thickness of the two thicker rings required to obtain proper bearing preload.

E. NOTE: Hardened split rings are ground in increments of. 005

For Example:

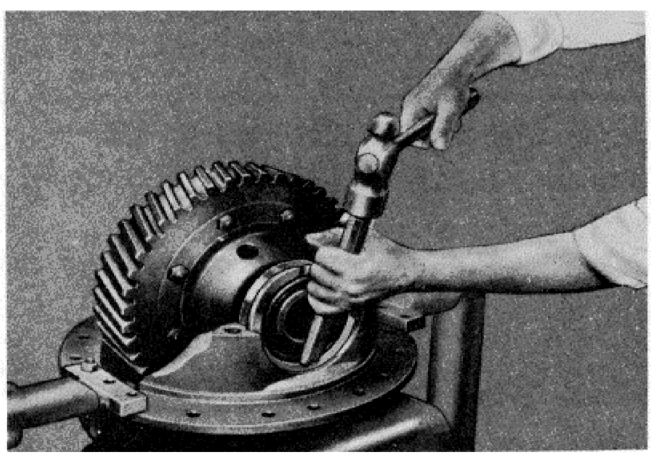
If temporary thin rings used to measure end play were .290" each for a total of .580" and the end play is .005", then .580" plus .005" end play equals .585" (or zero end play).

Here an additional .020" (interference) would be required to preload the bearings or a total of .605" thicker split rings. The total of .605" may be divided between the two rings such as .300" and .305".

F. It should be understood that the .017" to .022" interference of which we speak is not bearing preload torque but that it is the amount of interference required to establish bearing preload torque within the desirable limits.

COMPLETE ASSEMBLY AS FOLLOWS:

A. Insert one split ring in carrier leg groove. Move differential assembly over so that face of bearing cup is held tightly against inserted ring. Rings should be positioned in carrier leg grooves so that split portion will locate in center of cap.



Install opposite split ring by tapping it into the carrier leg groove by use of a blunt end drift, tapping on the I.D. of ring opposite the split portion.

C. Position the differential bearing caps in place making sure they are properly aligned.

D. Install carrier leg cap screws and tighten to specified torque.

COMPLETE DRIVE UNIT ASSEMBLY

A. Apply non-hardening sealer to gaskets under stamped cover and threaded inspection hole plug. Apply sealer to threads of all plugs. Install plugs and tighten securely. Lock thru-shaft chamber plug with soft iron wire.

B. Assemble yokes and flanges, tighten nuts to specified torque.

C. Check flange run out. If run out exceeds .005" total indicator reading, replace flange.

LUBRICATION

Proper lubrication of the axle units is extremely important. The importance of proper lubrication is increased because of greater tooth and bearing pressures and higher speeds in present day vehicles. For this reason we are vitally interested in promoting usage of the best possible lubricants. Incorrect application of lubricants may greatly reduce the maximum service built into the unit. Past experience has shown that a large portion of service problems can be traced to improper lubricant or incorrect lubricant application.

NEW AND RECONDITIONED AXLE SERVICE

The original rear axle lubricant should be drained at the end of the driveway prior to putting the vehicle in regular service, or before the maximum of 3,000 miles. Drain the lubricant initially used in the assembly following reconditioning at the same interval. Completely drain the lubricant while the unit is warm. Flush well with clean flushing oil and thoroughly drain.

Fill axle housings to bottom of level hole with specified lubricant with the vehicle level. Put an additional 2 U.S. pints of specified lubricant in the inter-axle differential housing.

REGULAR AXLE SERVICE

Refer to Motor Truck Operator's Manual, "Lubrication," for recommended service interval. Service the inter-axle differential housing at the same time and in the same manner as the axle housings. Completely drain the lubricant while the unit is warm. Flush well with clean flushing oil and thoroughly drain. Whenever the inter-axle differential housing has been drained, always add an additional 2 U.S. pints of specified lubricant directly to the inter-axle differential housing.

Some newer model axles have a smaller tapped and plugged hole located near and below the housing lubricant level hole. This smaller hole has been provided for the use of a lubricant temperature indicator only and should not be used as a fill or level hole.

Jack up all four wheels of the assembly and run at 25 MP.H. in high transmission gear for five minutes to thoroughly circulate the lubricant throughout the assembly. Be sure brakes are fully released.

TIRES

Measure the rolling radii of all tires. The tires of all wheels must be matched to within 1/8" of the same rolling radius ("' of the same rolling circumference). The 4 largest tires should not be installed on one driving axle and the four smallest tires on the other driving axle of thruadrive type tandems. Such tire mounting will cause inter-axle "fight," unusually high axle lubricant temperatures that result in premature lubricant breakdown and possible costly axle service.

In addition to matching individual tire rolling radii or rolling circumference, we recommend matching, as nearly as possible, the total tire circumference of one driving axle to the total tire circumference of the other driving axle.

This will usually result in satisfactory tandem axle lubricant temperatures that lengthen drive unit service with higher tire mileage.

HOW TO MATCH TANDEM TIRES

The vehicle should be on a level floor, carrying a correctly distributed rated capacity load. Be sure all tires are the same size. Measure new tires to be sure they will be correctly matched.

A. Inflate all tires to the same pressure.

B. Carefully measure the rolling circumference of each tire with a steel tape.'

C. Mark the size on each tire with chalk and arrange them in order of size, largest to smallest.

D. Mount the two largest tires on one side of one axle and mount the two smallest on the opposite side of the same axle.

E. Mount the four other tires on the other axle in the same manner.

F. Test run the vehicle to get accurate rear axle lubricant temperature readings on the two axle lubricant temperature gauges.

G. Vary tire air pressure within the tire manufacturer's recommended range, so the lubricant temperatures r both axles are within 30°F of each other and not i, excess of 2200F. This will usually result in uniform tire loading and good tire life
.

TABULATION OF TORQUE LIMITS

LOCATION	DIAMETER	NO. THREADS	TORQUE LB. FT. MIN	TORQUE LB. FT. MAX.
INTER-AXLE DIFFERENTIAL GROUP				
	1-3/4	12		
Case (Input) Shaft Nut	1-3/4	20	300	400
Cover Capscrews	7/16	14	60	77
Housing to Carrier Capscrews	1/2	13	93	120
Case Bolts and Nuts	1/2	20	105	135
Shift Yoke Adjusting Screw Jam Nut	3/8	24	43	56
Shift Yoke Bolt and Nut	3/8	24	43	56
SHIFT UNIT AND HOUSING GROUP				
Housing Capscrews and Studs	3/8	16	27	35
Shift Shaft Stopscrew Nut	1/2	20	75	96
DRIVE PINION GROUP				
Bearing Adjusting Nut	3-3/8	12	800	1000
Bearing Jam Nut	3-3/8	12	1000	1200
THROUGH SHAFT GROUP				
Rear Bearing Cage Capscrews	3/8	16	38	49
Rear Bearing Cage Cover Capscrews	3/8	16	38	49
Rear (Output) Nut	1-1/2	18	300	400
	1-3/4	12		
CROSS SHAFT GROUP				
Cover (L.H.) Capscrews	3/8	16	27	35
Bearing Cage Cover (R.H.) Capscrews	1/2	13	66	85
	9/16	12	130	170
Bearing Retainer (Washer) Capscrews	7/16	14	60	77
	9/16	12	130	170
MAIN DIFFERENTIAL AND CARRIER GROUP				
Bearing Adjusting Nut Lock Capscrews	5/16	18	16	20
Bearing Cap Capscrews	3/4	10	290	320
	7/8	9	480	520
Case and Gear to Case Bolts and Nuts	9/16	18	148	190
Top Cover Capscrews	3/8	16	38	49

Torques given apply to parts coated with machine oil; for dry (or "as received") parts, increase torques 10%; for parts coated with multi-purpose gear oil, decrease torques 10%. Nuts on studs to use same torque as for driving the stud.

REAR AXLE

LOCKING TYPE DIFFERENTIAL

NO SPIN

INDEX

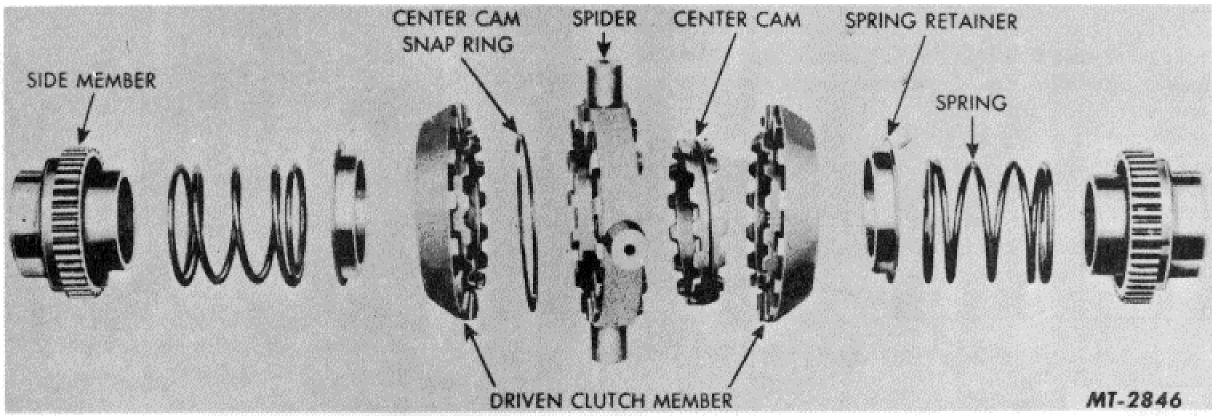


Fig. 1 Internal Spring Design Differential Locking Unit (Exploded View

DESCRIPTION

The No SPIN differential (Figs. 1 and 2) provides equal amounts of drive line torque to each rear driving wheel and also permits differential action for turning corners.

This differential also provides greater operating flexibility than a conventional differential, because the locking type differential overcomes wheel spinning when required to operate in mud, sand, snow and on ice or wet roads. The unit is installed in the differential case in place of the conventional gears, pinion and spider.

The action of the unit is the same for both drive and **coast loads and forward and reverse driving.**

CONSTRUCTION

Two types of No SPIN differentials have been used on IH vehicles; they are (a) Internal Spring Design, Fig. 1 and (b) External Spring Design, Fig. 2.

The difference in the two units is explained in the text; however, the disassembly will cover the internal design locking unit.

The differential locking unit consists of several parts, all assembled around the spider.

<u>Spider and Center Cam Assembly</u>

This assembly consists of the spider, center cam and spider snap ring. The spider has four trunnions projecting radially from a center ring on each side of which are located fixed driving clutch teeth. These teeth vary in number, depending on the size and model of differential. The internal diameter of the spider is uniform. Into it is mounted the center cam. This cam is held in position with a centrally mounted snap ring which permits the center cam to be rotated within the spider but prevents lateral movement. The center cam is symmetric, having the same number of cam lifts on each side as there are clutch teeth on the spider. These lifts or "icams" have uniform contours with rounded surfaces that provide anti-friction ramps for disengaging the driven catch members.

<u>Driven Clutch Members</u>

Two identical driven clutch members are located on either side of the spider and center cam assembly. Each has a set of clutch teeth

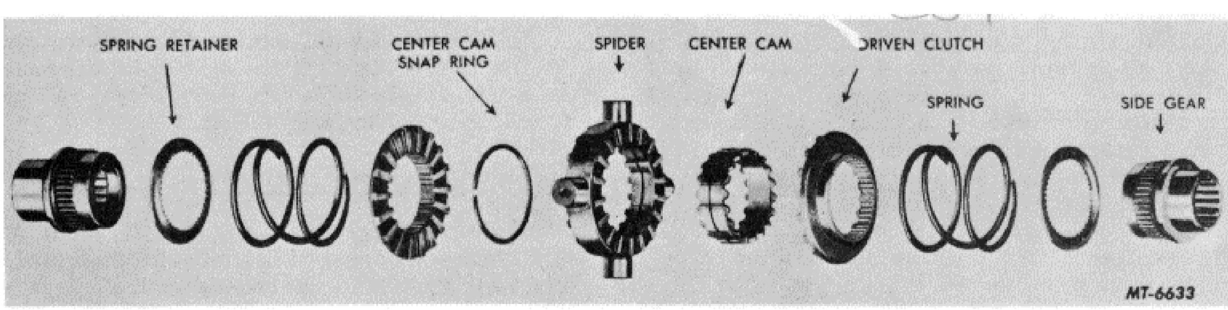


Fig. 2 External Spring Design Differential Locking Unit (Exploded View)

to match the clutch teeth on the spider through which driving torque is transmitted. Radially inward from the driven clutch teeth on models using internal spring are cams which mesh with the cams of the center cam member. These cams have been eliminated on the models using the external spring. The internal diameter of each driven clutch member has splines which engage the external splines of the splined side members.

Spring Retainers and Springs

Models with Internal Springs

Spring retainers are inserted into the outer ends of driven clutch member. The bowl side of these retainers is mounted first through the outer side of the driven clutch members. The flanged portion of the spring retainers pass through the internal splines to rest on the mating flanges of the driven clutch members. The springs are mounted in spring retainers after assembly and thrust against their inner cupped ends.

Models with External Springs

Spring retainers fit over the side gear, passing through external splines to seat against the shoulder on the side gear. Springs fit between the driven clutch and outer flanged surface of the spring retainer.

Splined Members

These two splined side members are splined internally to receive the truck axle shafts. The inner hubs of the splined side members are inserted in the outer ends of the springs. The external splines of the splined side members engage the internal splines of driven clutch members on each side of the completed assembly.

OPERATION

Straight Forward Driving

When a vehicle is being driven in a straight forward direction, the clutch teeth on both sides of the spider assembly are fully engaged with the clutch teeth on each driven clutch member. Likewise, the fixed cams of the driven clutch members are fully meshed with the cam surfaces of the floating center cam ring mounted on the inside diameter of the spider, as described previously.

Engagement of the driving and driven clutch teeth is assured by the pressure of the two springs which force the driven clutch members inwardly against the spider and also by the positive locking action developed by

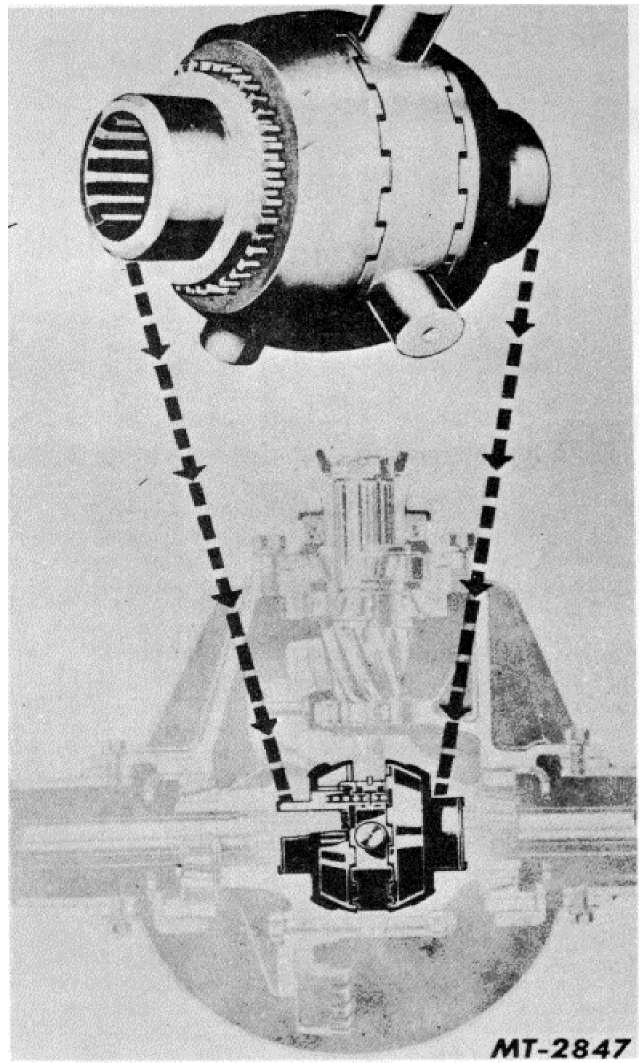


Fig. 3 Typical installation of No Spin, unit (Cross Sectional View)

the mating undercuts on the driving faces of the clutch teeth.

In this condition, both clutches remain fully engaged so that the assembly operates as a solid unit and each rear wheel is driven forward at ring gear speed.

Straight Rearward Driving

When driving a vehicle in a straight rearward direction, both driven clutch members are held in full engagement with the spider and center cam as described for straight forward driving. However, in this case, the spider rotates in the reverse direction and

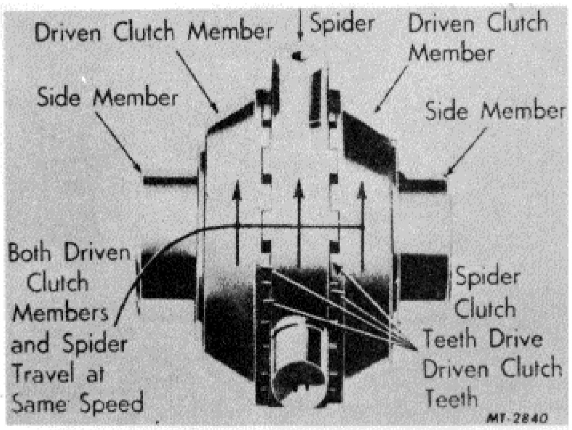


Fig. 4 Straight Forward Driving

shifts the driving force to the opposite set of driving faces on the mating clutch teeth. Again we have the assembly operating as a unit with each wheel being forced to rotate at ring gear speed.

<u>Right Hand Turn--Forward Direction</u>

When making a turn, differential action is required in order to permit the outside wheel to travel a greater distance, and faster, than the inside wheel.

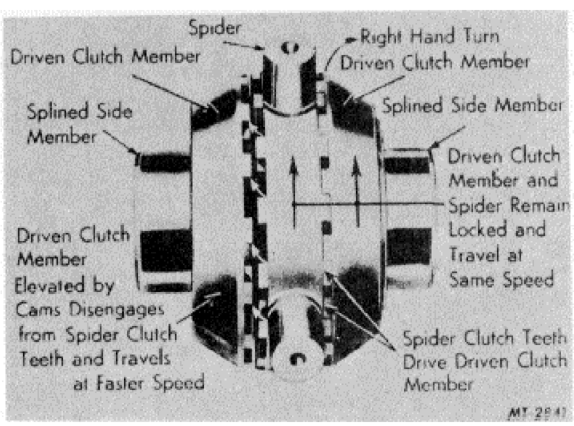


Fig. 5 Right Hand Turn--Forward Direction

A conventional bevel gear type differential permits the outside wheel to turn faster than ring gear speed while the inside wheel turns slower than ring gear speed. The NoSPIN differential allows either wheel to turn faster than the ring gear speed but does not permit either wheel to turn slower than the ring gear speed when power is applied.

When negotiating a right hand turn in a forward direction, the right hand driven clutch member remains fully engaged with the spider clutch teeth and the corresponding cams (see Fig. 5).

The driving clutch teeth of the spider transmit the driving force to the driven clutchmember, which in turn drives the right hand (inside) wheel constantly at ring gear speed, thus propelling the vehicle. The left hand (outside) wheel covers a greater arc than the right hand (inside) wheel and driven by the traction of the road, must turn faster than ring gear speed. Likewise, the left hand driven clutch member must turn faster than the spider. In other words, it permits differences in wheel speeds or differential action. Fig. 6 illustrates how this is accomplished.

The right hand row of cams on the center cam member are meshed securely with the cams on the right hand driven clutch member. With the center cam thus locked in this position so that it cannot rotate with respect to the spider, its came on the left hand side serve as ramps upon which the mating cams on the left hand driven clutch member can rise enabling that driven clutch member to disengage from the spider. The ramps on the center cam are high enough to permit the clutch teeth on the driven clutch member to clear the teeth on the spider and when the crest of the ramp is passed, the teeth of the driven clutch member are forced back by spring pressure into full engagement with the clutch teeth of the spider.

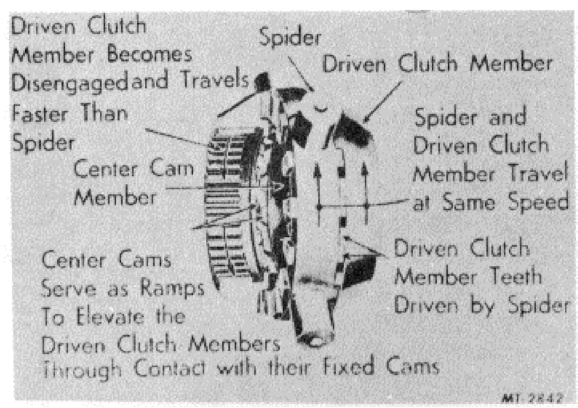


Fig. 6 Forward Right Hand Turn (Cross Sectional View)

This engagement and disengagement or indexing operation continues throughout the turn with a rapidity that is in direct relation to the speed of the overrunning wheel.

As the vehicle completes the turn and is again driven in a straight forward direction, differential action no longer being required, both driven clutch members become fully engaged with the clutch teeth of the spider, then the operation, as described in "Straight Forward Driving" is resumed

.

Forward Right Hand Turn--Braking Condition

In this situation, the vehicle is moving forward, but the direction of torque of the ring gear is reversed because the vehicle is being slowed down by braking action. This reversal of torque is produced by the action of road traction driving the wheels against the torque of the engine. In this condition, when a right hand turn is negotiated, the left hand (outside) wheels rotate at ring gear speed since the left hand driven clutch member remains fully engaged while the right hand (inside) wheels rotate slower than ring gear speed.

The symmetrical design of the differential makes it possible to function in the manner described above which is in effect directly opposite to that described as Right Hand Turns Forward Direction.

It should be noted that if a turn is negotiated in such a manner that power is first applied and then braking action is encountered before the turn is completed, the differential is designed to function without interruption and will automatically take care of such reversal of torque.

Left Hand Turn--Forward Direction

In making a left hand turn with the vehicle driven in a forward direction, the left hand wheel is on the inside of the turn and the power is applied to it so that it must rotate at ring gear speed. The right hand wheel travels through the greater arc, being on the outside of the turn. Its driven clutch member becomes disengaged from the spider clutch teeth, permitting it to be rotated by ground traction faster than the ring gear (See Figs 7 and 8)

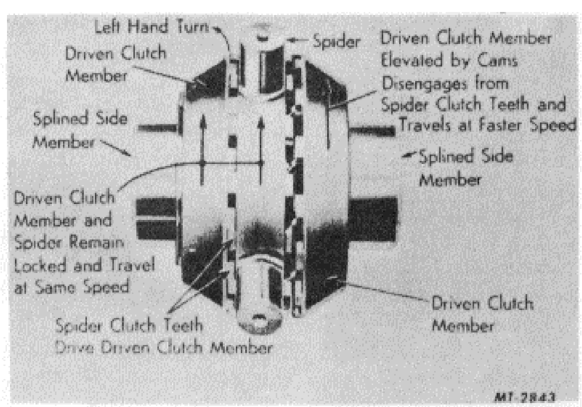


Fig. 7 Left Hand Turn--Forward Direction

The operation of the driven clutch member on the right side of the assembly in the foregoing instance is illustrated above.

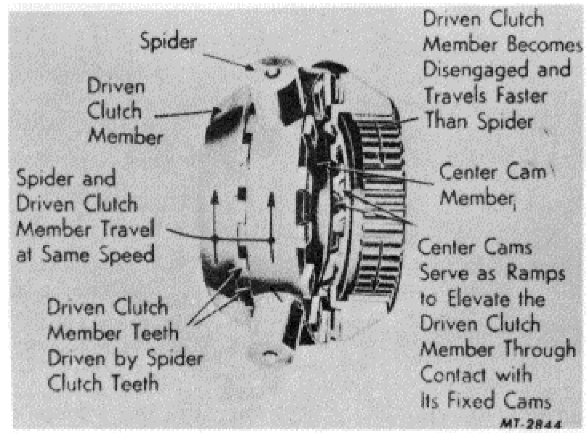


Fig. 8 Forward Left Hand Turn (Cross Sectional View)

Right and Left Hand Turns—Rearward Direction

The operation of the NoSPIN differential when required to make turns while traveling in a rearward direction is identical to that when making turns in a forward direction. When moving rearward in a turn under power, the inside wheel is driven at ring gear speed while the outside wheel is driven by the ground faster than ring gear speed. When the rearward turn is nearing completion and the vehicle is slowing down because of application of the brakes, the outside wheel is driven by the ground at ring gear speed, as its driven clutch member is fully engaged and acts to "brake" against the engine torque. The inside wheel is driven by the ground through the smaller arc of travel and since its driven clutch member is disengaged, it will rotate slower than ring gear speed.

Fig. 9 shows the operation of the differential when a right hand turn in a rearward direction is being negotiated

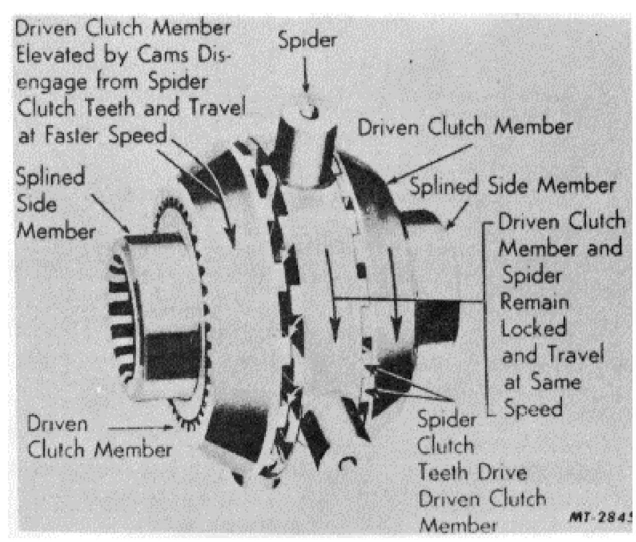


Fig. 9 Right Hand Turn--Rearward Direction

DIFFERENTIAL REMOVAL

The procedure for removing the differential is the same as used for a conventional differential. IMPORTANT PRECAUTION Before disassembling the differential case, insert a bolt through the center of the NoSPIN unit (axle shaft openings) with a flat washer on each end against the side members (Fig. 10).

Thread a nut on the bolt against the flat washer finger tight. This will prevent possible injury caused by the unit flying apart due to the spring pressure within itself during disassembly of the differential case.

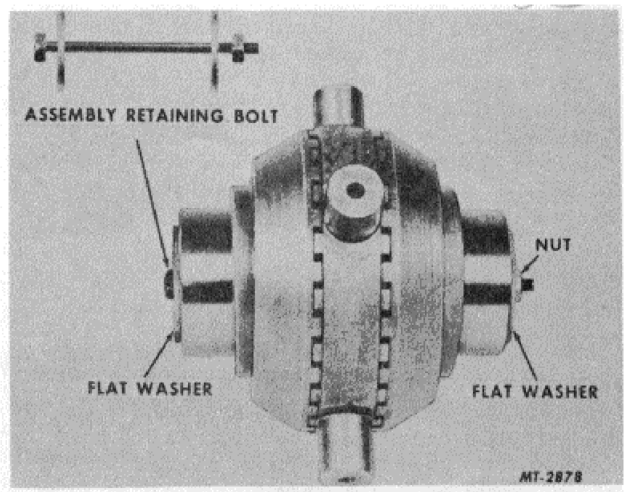


Fig. 10 Inserting Assembly Retaining Bolt

DISASSEMBLY

Remove the bolts from the differential case and lift out the NSPIN unit Mount unit in a small press (Fig. 11).

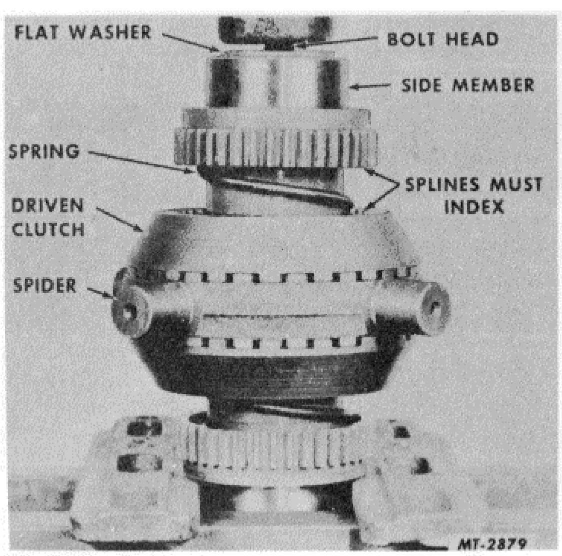


Fig. 11 Release of Spring Pressure

Apply enough pressure on the head of the bolt to release the spring pressure against the nut. Remove the nut and flat washer by reaching underneath the press. Slowly release the press and allow the unit to disassemble itself until the spring pressure is fully released.

Remove unit from press.

Remove side members, springs, spring retainers and driven clutch members. The center cam may be removed from the spider by expanding the snap ring with small screw drivers or wedges.

NOTE : Be careful when removing and reinstalling center cam snap ring to avoid possible injury.

CLEANING, INSPECTION AND REPAIR

Wash all parts thoroughly with a cleaning solvent. Inspect all mating surfaces and teeth for possible wear or damage. Replace all worn or damaged parts before reassembly.

REASSEMBLY

Reassembly is essentially the reverse of disassembly. Lubricate all parts with SAE30 oil during reassembly. Place side member upright and install spring on same. Place spring retainer on spring with flange end toward side member. Install driven clutch member on spring retainer. Place spider on driven clutch member, indexing teeth of same. Install other driven clutch member, spring retainer, spring and side member on spider.

Insert a bolt through the center of the NoSPIN unit with a flat washer against side member. Mount unit in press as shown in Fig. 11. Compress springs by pressing on head of bolt and index splines of side members with those of driven clutch members NOTE : Keep entire unit aligned in press to prevent it from kicking out while springs are being compressed. Compress unit until side member splines are completely indexed and flush with driven clutch member. Install flat washer on bolt against side member and thread nut on bolt, finger tight, so that it has the appearance of Fig. 10 when removed from the press.

Remove unit from press.

Place unit in differential case and install differential case bolts.

Reassembly from this point is the same as for a conventional differential.

TANDEM LOCK

The NoSPIN locking type differential can also be used in place of the conventional interaxle differential and lock-out control in tandem axles, Fig. 12. In this capacity it operates between the axles in the same manner as between the wheels of a single axle. When the "Tandem Lock" (its name for this application) is used in the power divider unit, the need for manual control of the interaxle differential lockout is completely eliminated.

Operation

Inter-axle differential action is required when cornering to permit forward tandem axle to travel farther and faster than rear tandem axle. The tandem lock inter-axle differential, mounted on forward end of thru shaft, allows either drive axle to turn faster than driven speed but does not permit either axle to turn slower than driven speed when power is applied. A right or left turn in a forward direction disengages front driven clutch (b) and side gear (a) from the drive teeth of central driver or spider (c). This results from the wheels on forward tandem axle covering a greater arc than those on rear axle, and driven by traction of road they rotate faster than driven speed.

In like manner the rear driven clutch (d) tries to rotate slower than central driver (c), but design prevents this. Torque is then transmitted through rear side gear (e) of tandem lock unit to rear tandem axle at driven speed to propel the vehicle. This automatic, fulltime power control minimizes tire scuffing and axle shock loads. It also eliminates possible mechanical failure through driver error in the incorrect use of a manual inter-axle lockout.

Maintenance

The disassembly, cleaning, inspection and repair of the tandem lock is the same as covered previously for the single axle unit. For removal and installation of the inter-axle differential, see specific instructions for the conventional unit covered in the Service Manual, Tandem Axle, Section R (CTS-2164).

IMPORTANT PRECAUTION

If a truck is equipped with a NoSPIN differential, power will be transmitted to the opposite rear wheel or axle if one of the rear wheels or axles slips. Both rear wheels or both rear axles must be raised free of ground if it is necessary to operate one rear wheel with truck stationary; otherwise, the wheel or axle that is not raised will pull truck off its support.

LUBRICATION

The NoSPIN unit is lubricated with the same lube used in conventional differentials. Fill differential carrier through filler hole until oil is level with hole. For tandem axles be sure to pour one (1) pint of lube into power divider through hole on top of interaxle differential cover. Check level at each chassis lubrication. Fill as necessary.

Drain differential carrier every 25, 000 miles or once a year.

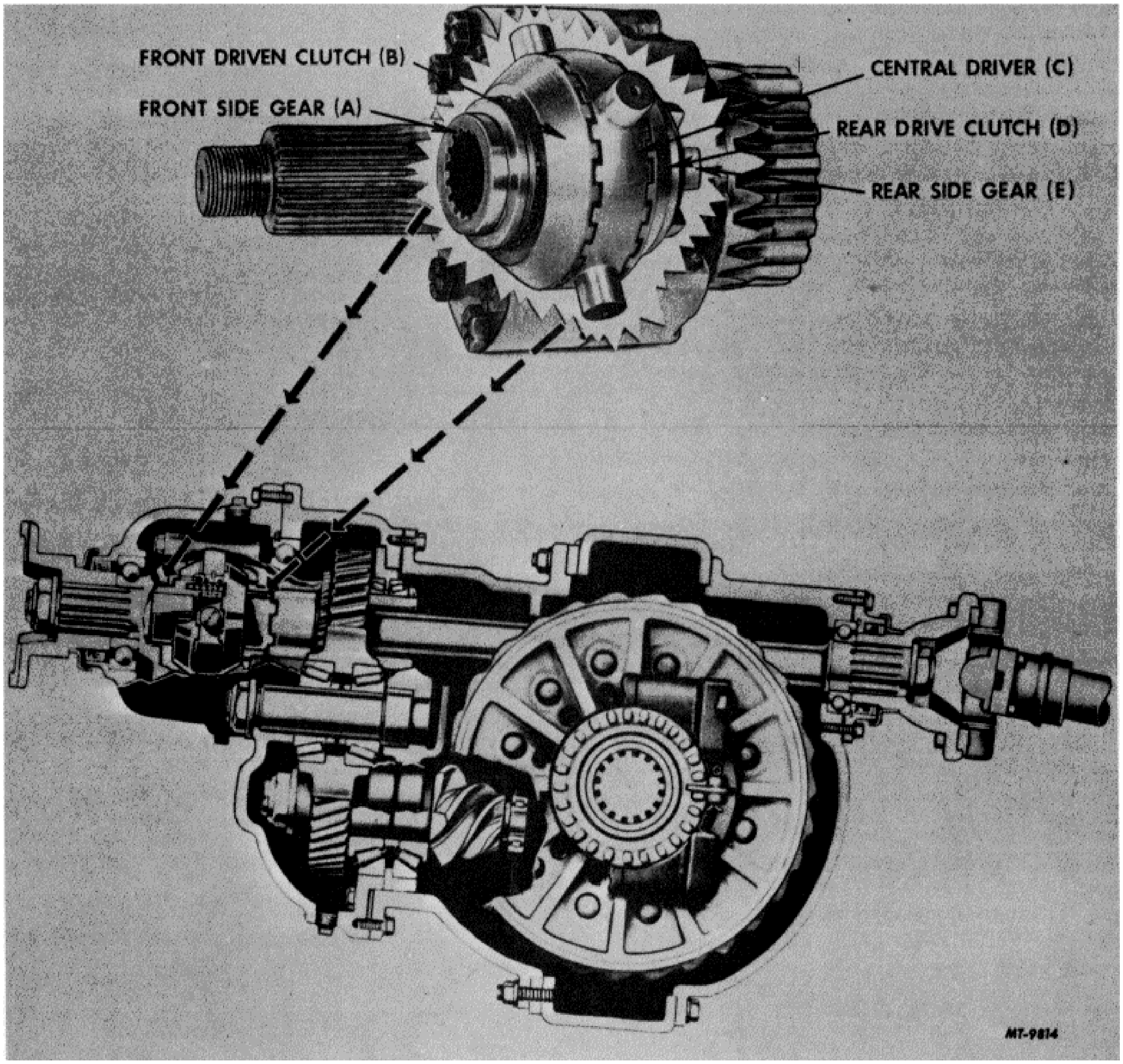


Fig . 12 Cutaway View of Tandem Lock NoSPIN Inter-Axle Differential

FAILURE ANALYSIS

This failure analysis section covers components of the rear axle and will aid in the diagnosis of prematurely failed parts, together with an outline of corrective measures to overcome recurrence of the same type of failures.

This publication has been compiled from actual case histories with unretouched photographs in an effort to record information that will be of assistance in analyzing failures.

Good servicing procedure does not simply imply parts replacement. It requires reassembly of units eliminating the original cause of failure. The application of mechanical skills and knowledge is the mark of the good mechanic.

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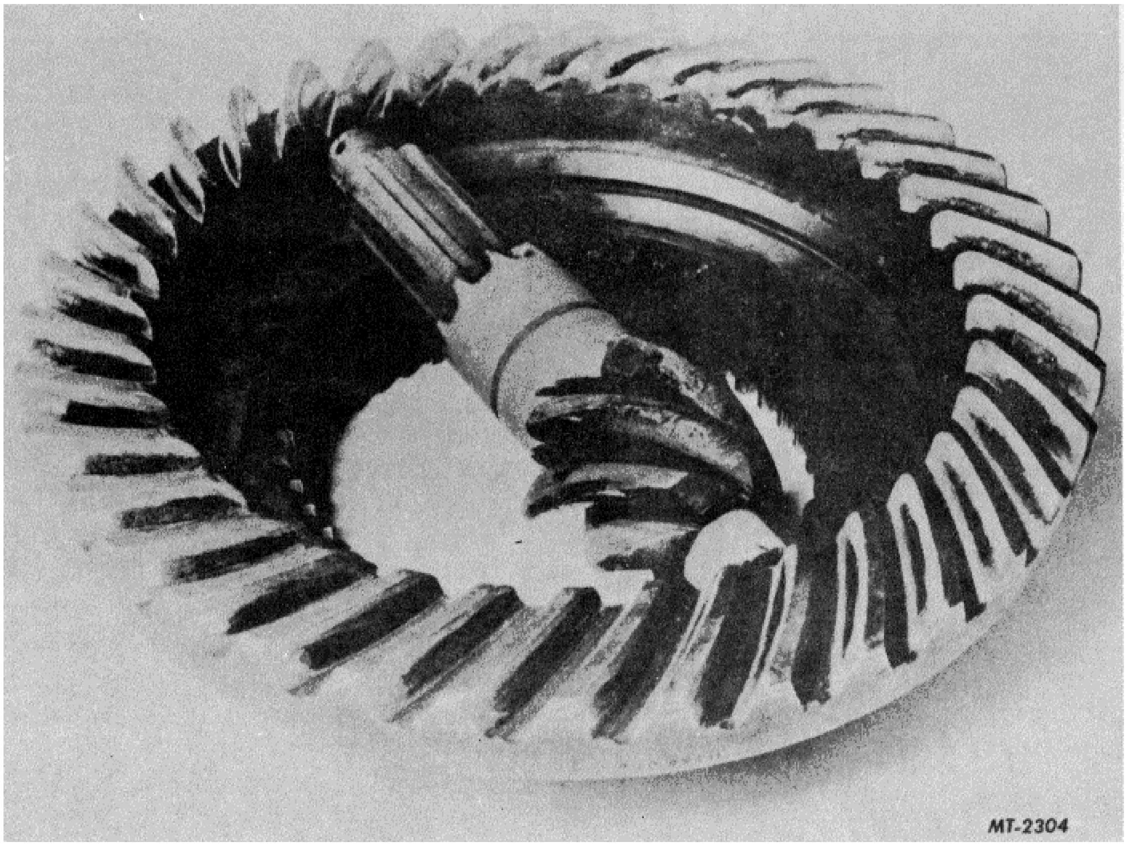


Fig . 1-Scored and Scuffed Gear Teeth .

Scored and scuffed teeth such as those shown in Fig. 1 are the result of running without sufficient lubricating film between the tooth surfaces.

Observe how the scuffed area is spread well over the tooth area. Note the appearance of the scuffed area suggesting the metal had reached the plastic stage and was drawn across the tooth face. This condition is created by the metal-to-metal contact when there is no oil film between the matching teeth.

Excessive torque input can create sufficiently high tooth pressures to cause even the best of lubricants with high film strength to be forced from between bevel teeth resulting in scoring and scuffing.

Good quality recommended lubricant, changed at recommended intervals, when torque input is not excessive, will prevent costly repairs of this kind.

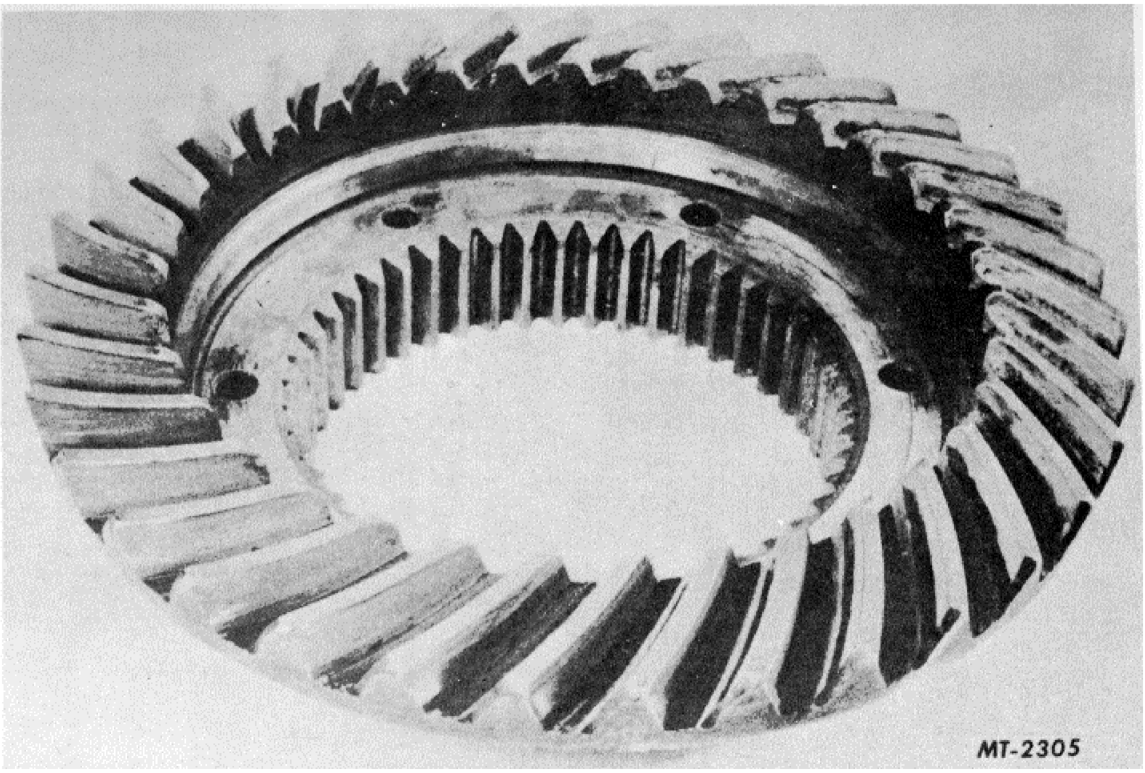


Fig . 2-Scuffed Gear Teeth--Coast Sides Only .

Fig. 2 illustrates how the contact surfaces on the coast sides of the teeth are severely scored and how the drive sides are undamaged. During operation, extreme pressures sufficient to break down the oil film were applied to this gear. The pinion was similar in appearance. Bevel gears in this condition are easily detected, for though they run quietly under load on the pull, they are noisy on the coast or in reverse.

Two separate and entirely different circumstances cause failures of this type. One is worn pinion bearings, allowing end play of the pinion resulting in improper contact between the gear and pinion teeth on the coast sides. The contact areas are localized, and the unit pressures are greater than can be carried by the oil film. When this happens, the friction of metal on metal creates heat and scoring occurs.

The other cause of such failures is abusive driving. This generally comes about when vehicles are operated at high speeds on down grades and snubbing the truck with the clutch to brake the speed. Such operation is particularly detrimental if the transmission is in one of the lower ratios. The best preventive for trouble of this kind is the immediate replacement of worn pinion bearings and good driving procedure.

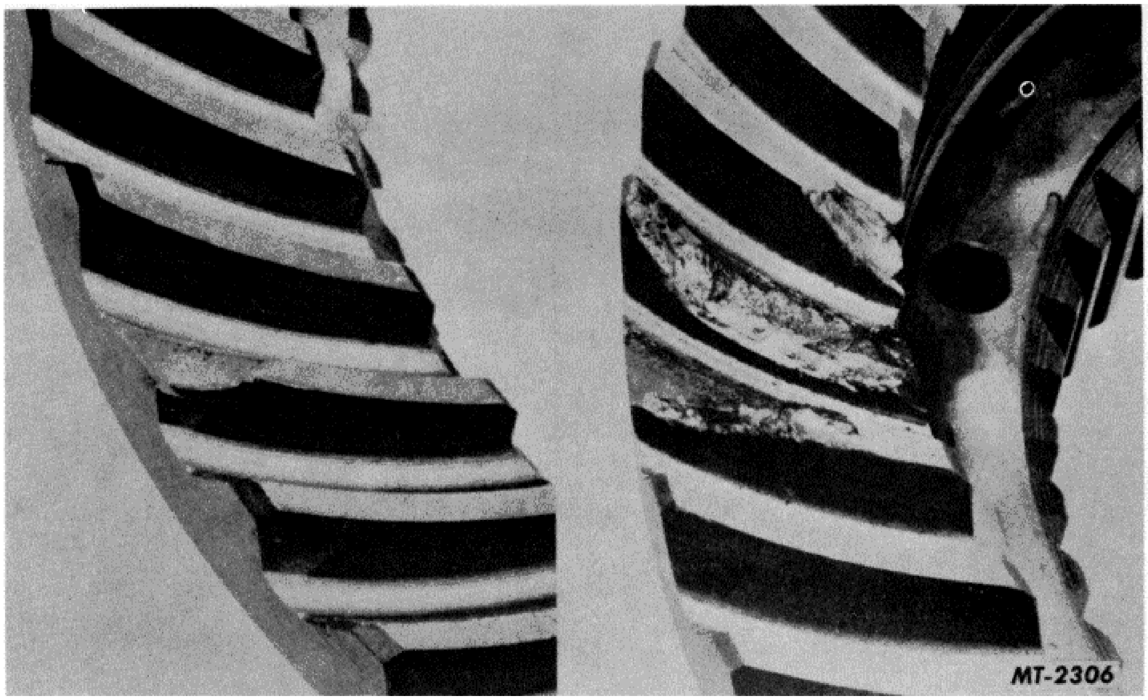


Fig . 3-Fractured Gear Teeth

Fig. 3 illustrates typical examples of fracture to bevel gear teeth due to improper gear adjustment. The photo at the left shows a failure that resulted from concentrated contact area at the heel section of the bevel gear caused by excessive backlash between the bevel gear and pinion. The illustration at the right shows a fractured bevel gear in which backlash between the bevel gear and pinion was not sufficient, thus producing excessive loading on the toe section of the gear.

Bevel gears are carefully matched with the driving pinion before assembly into differential carrier. The gears are then adjusted to satisfy two conditions--best possible contact area position and quiet operation. Readjustment of gears that are believed to be noisy after a period of service, in general, will aggravate the condition rather than eliminate it. Improper adjustment concentrates the contact area on a small portion of the teeth resulting in failures of the type shown above.

Failures of this type can be avoided by correctly adjusting the drive gears, when necessary, according to the specifications outlined in the rear axle section of the CTS-2001 series service manual.

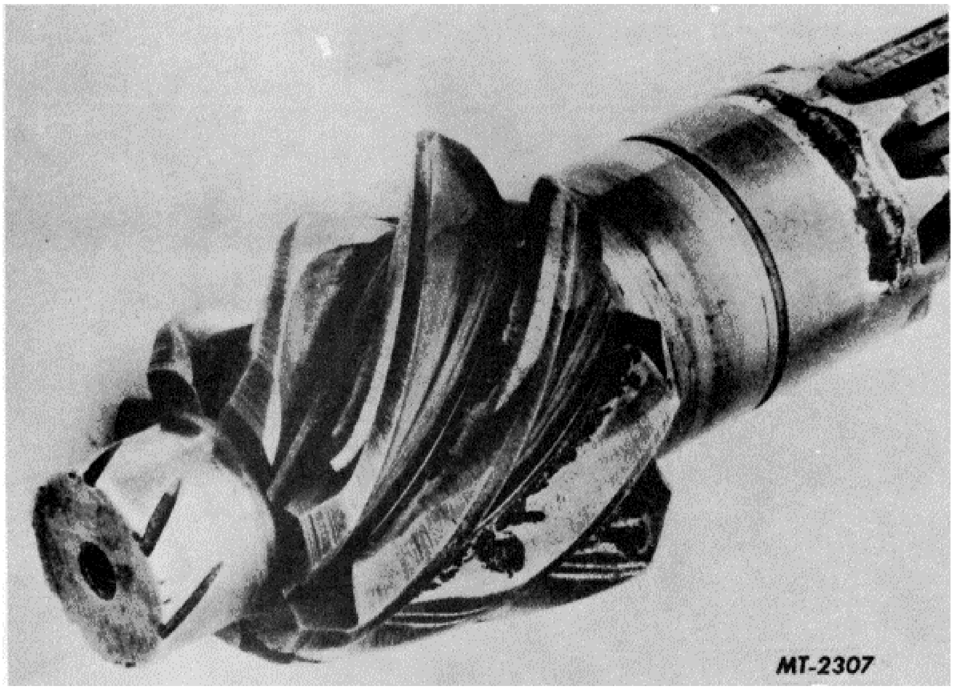


Fig. 4-Pitted Bevel Pinion Teeth

The bevel drive pinion shown in Fig. 4 was in extremely severe service.

Note the pitted areas concentrated at the heel ends of the teeth on the drive sides indicating deflection in the assembly, resulting from abnormal pressures. Normally pressures are quite evenly distributed over the entire faces of the gear and pinion teeth. Under excessive loading, deflection throws the pinion out of its proper position in relation to the ring gear, concentrating the contact areas on the heel ends of the teeth. Unit pressures build up to exceed the strength of the oil film. The teeth contact without benefit of lubrication, the high pressures break down the surfaces and the teeth are pitted.

Occasionally in this type of trouble, the ring gear will appear to be undamaged. The reason for this: each pinion tooth is contacted a number of times for a single contact of a ring gear tooth due to the gear and pinion ratio. Gear damage is not noticeable to the naked eye, but the tooth contour has changed. Running a used gear with a new pinion will cause early failure. Damaged gears should be replaced only in matched sets.

From the above discussion, it will be immediately apparent, the more severe the service, the greater the need for quality lubricants. Use only recommended oils of a known brand and quality.

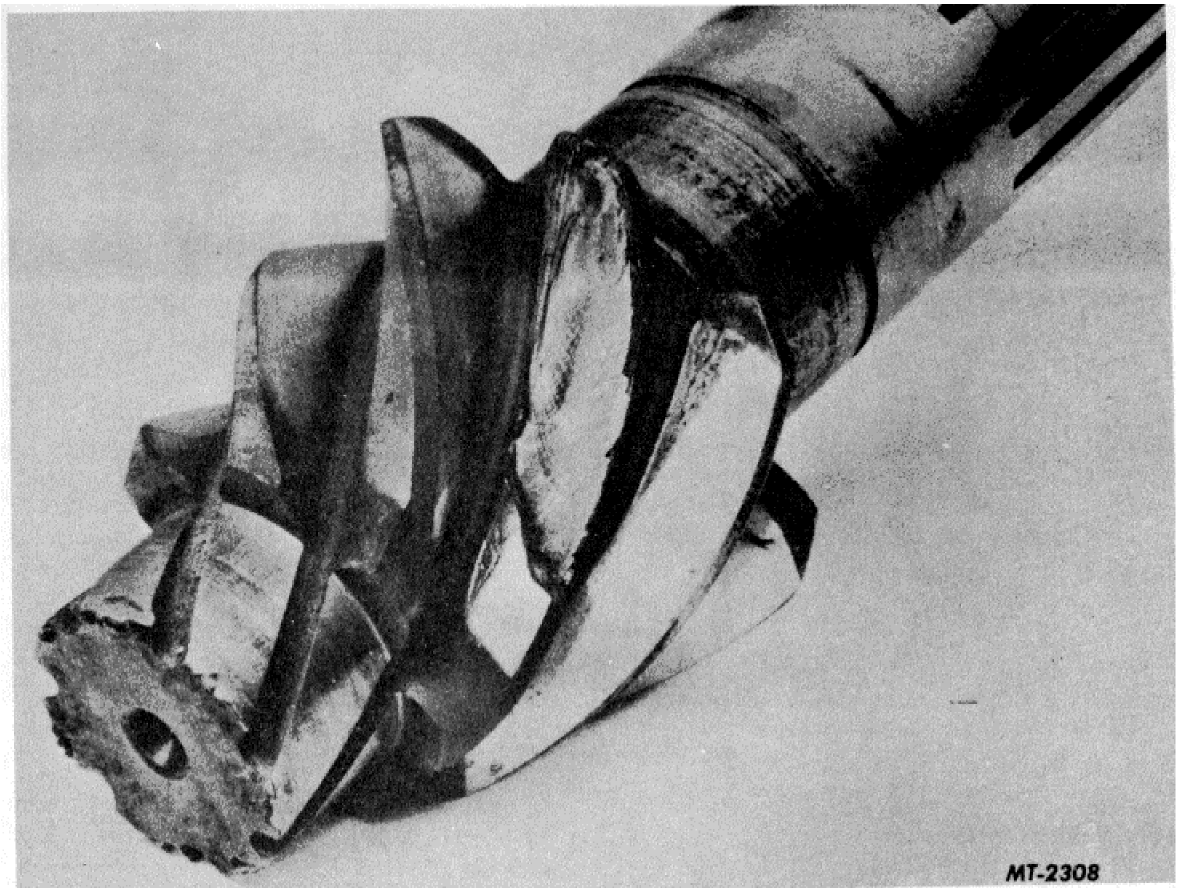


Fig . 5-Fatigue Fracture-Bevel Drive Pinion

The fatigue or progressive fracture develops over a period of time, gradually working through the metal of the tooth section until a point is reached where there is not sufficient strength remaining to carry the load applied. Final failure then occurs and a portion of the tooth is torn out.

Fig. 5 above is a typical fatigue fracture of a bevel drive pinion tooth. The clear cut wavy area identifies the fatigue. It will be found in all failures of this type, making them easily and quickly recognizable.

Continued operation of pitted gears, as described under Fig. 4 will result in fatigue fractures. When part of the area is worn and pitted away the remaining bearing area, decreased in size, must carry the entire load. Unit pressures are increased in an inverse ratio. The concentration of stresses starts fatigue resulting in final and complete failure.

Momentary excessive stresses applied through the gears, such as "bucking" to start an overload, or "frogging" to pull out of a bad spot, will frequently crack tooth surfaces. This crack becomes a focal point for the stress and fatigue fracture is the result. Abnormal axid abusive operations most frequently are the direct causes of this kind of trouble.

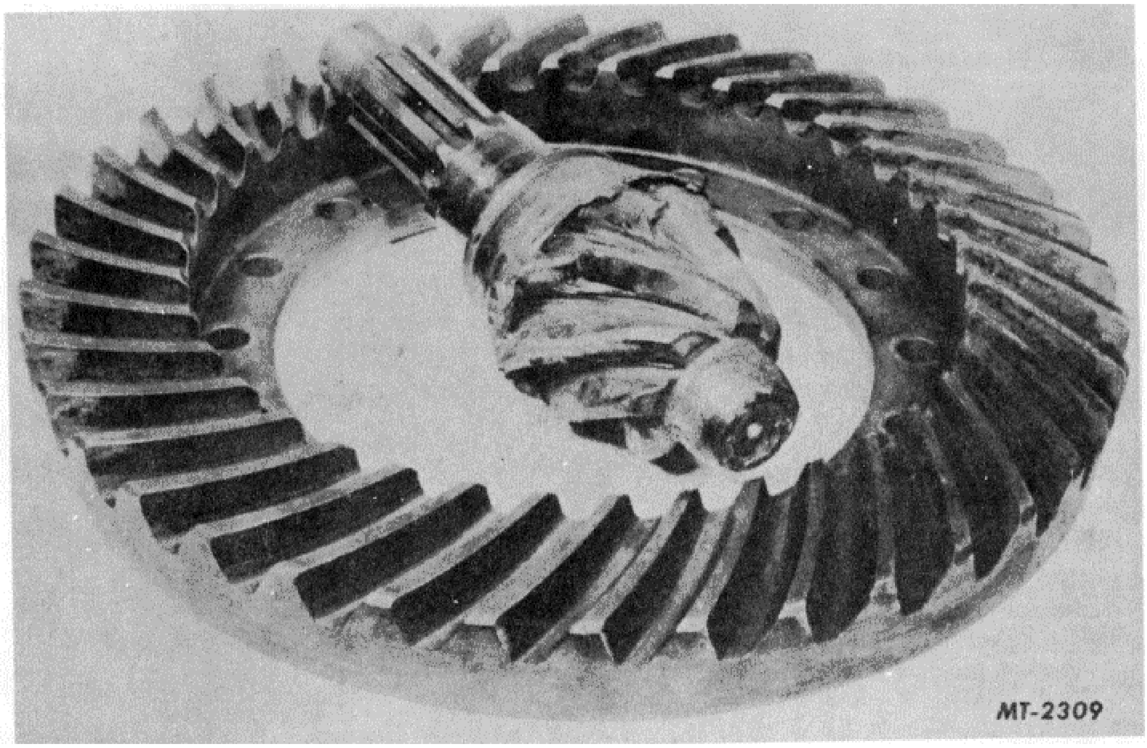


Fig . 6-Overheated Gear Set .

A typical example of a ring gear and pinion subjected to prolonged excessively high temperatures is seen in Fig. 6. Note that the pinion bearing fused to the pinion. The ring gear teeth will show definite discoloration due to the heat generated. Metal-to-metal contact is very evident by the distorted condition of the pinion.

Actual experience has shown that this type of failure is caused by one of three circumstances or a combination of them. They are: improper lubricant, low lubricant level, and infrequent lubricant change. When one or more of these conditions are present, the proper lubrication film between contacting metal surfaces is not available, thus causing the surfaces to overheat because of excessive friction.

A good quality lubricant would provide the proper oil film under heavy loads to prevent excessive overheating. A result of using contaminated lubricants may be seen by the evident end roll at the pinion pilot bearing. This condition developed because the lubricant could not withstand the heat generated by heavy loadings at the pinion.

From the above discussion, it is evident that proper lubrication maintenance is one of the essentials for proper gear set life.

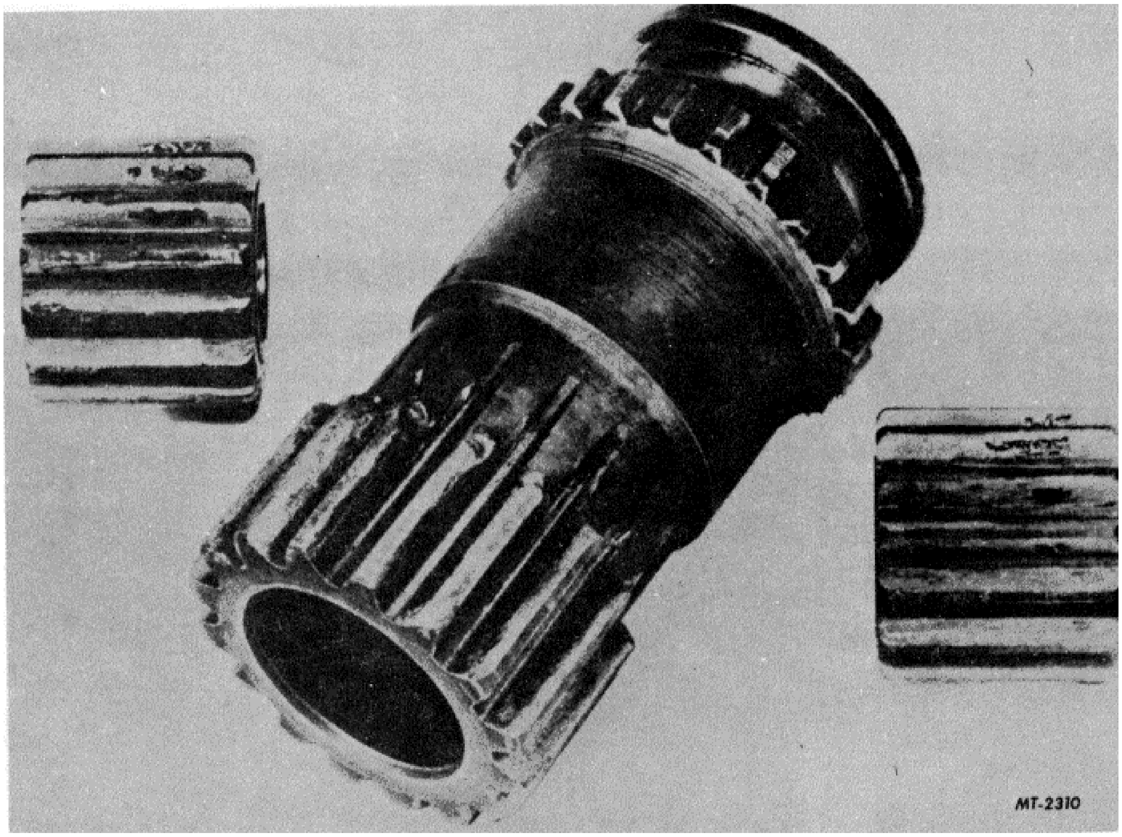


Fig . 7-Pitted Planetary Gear Teeth .

Here are idler pinions and a sliding clutch gea2 damaged by abnormal pressures. Observe the pitted areas on the idler pinion teeth near one end and the corresponding mutilated areas on the gear. Excessive loading created deflection in the assembly and the contact areas or bearing areas were concentrated at one end of the teeth. Consequently, pressures were sufficiently high to break through the protecting oil film, permit metal-to-metal contact, and break down the tooth surfaces. Close inspection of Fig. 7 will reveal some of the teeth have larger pitted areas than others. Merely because some of these teeth happened to be in contact more frequently at the instant of clutch ing and pressure application, they were most affected.

Examination of all these gears definitely proved they had been correctly heat treated to sufficient hardness and strength to withstand all normal pressures. It is therefore evident, normal pressures were greatly exceeded in operation and the failure may be readily traced to abusive service. Very frequently when damage of this kind occurs, other parts of the unit will be worn to a point requiring replacement. Thorough examination and a complete tear down is the only way a lasting, satisfactory repair job may be assured. Look for bearing wear, damaged bevel gears, mutilated differential gears and scored idler pinion pins.

Failures of this type may be easily avoided by loading within the capacity of the vehicle in consideration of the working conditions, and putting the trucks under the control of only capable drivers.

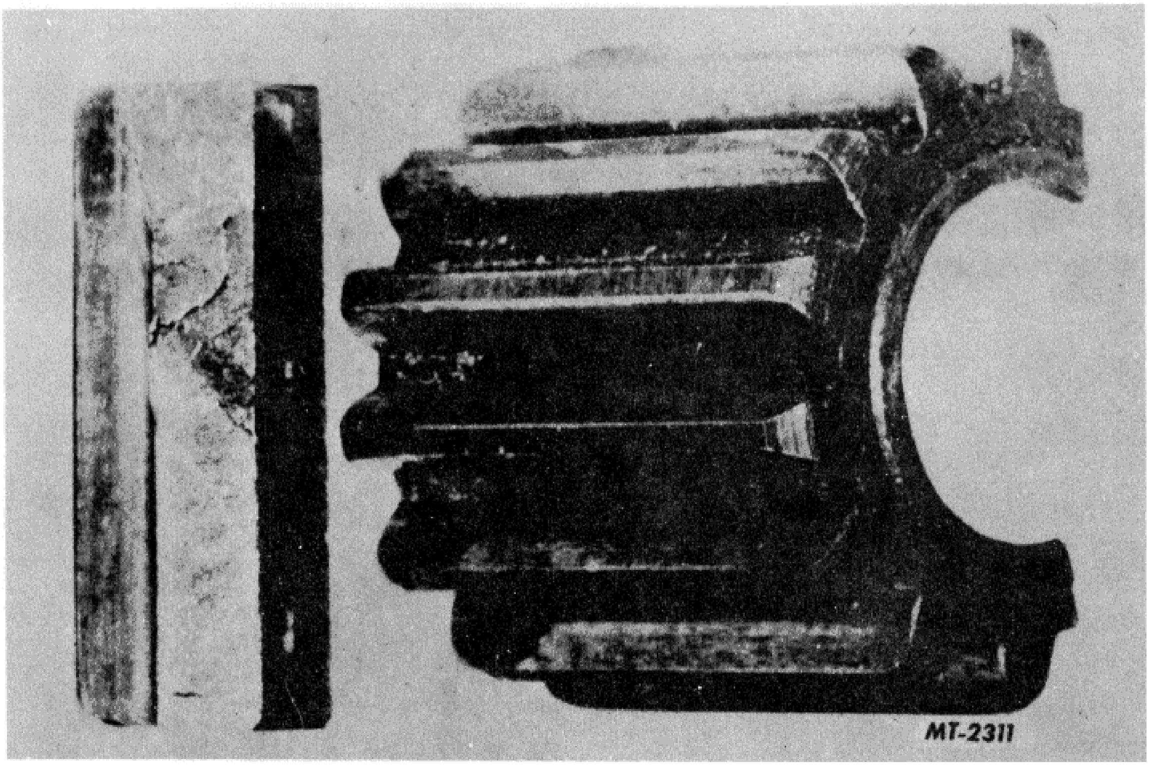


Fig. 8-Shock Fracture.

When shock loads greater than the maximum strength of the gears are applied to the planetary unit, failure such as that shown in Fig. 8 is the result.

Note the grainy appearance of the break in the idler gear, without any of the progression found in fatigue failures. This indicates the part was sufficiently stressed by an instantaneous load to cause immediate fracture. In this case the other planetary parts should be very carefully checked, as they have been damaged by the high stresses and may have small cracks in them that are almost impossible to see with the eye. If any of the four idlers have broken, it is indeed advisable to replace all, as small cracks may be obscured by oil film or be small enough to pass unnoticed.

Shock fractures of planetary gears occur most frequently in severe operations such as construction work, oil field hauls and logging service. Many times abusive handling is responsible rather than payload or operating conditions. The two-speed axle equipped vehicle does not need to be "frogged" or "bucked" when handling heavy loads. There is sufficient power in the low range to move the truck under almost any condition without such abuse.

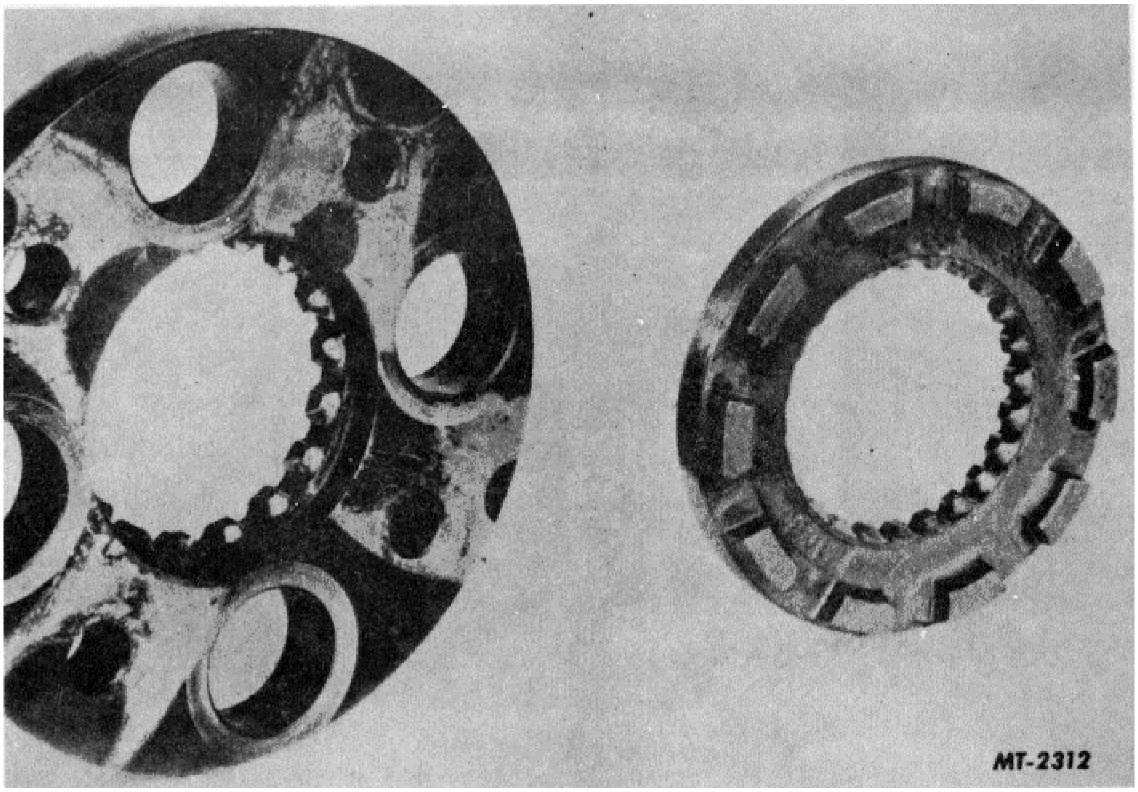


Fig. 9-Worn High Speed Clutch Plate and Differential Bearing Adjuster

The high speed clutch plate and differential bearing adjuster illustrated in Fig. 9 shows very good examples of severe wear of the internal teeth. This was due to excessive rotation of the sliding clutch gear before meshing with the internal teeth. Failures of this type are indicative of improper shifting procedure in two-speed axle operation.

Excessive wear on the differential bearing adjuster resulted from shifting an axle from high range to low range too slowly. The low speed side of the sliding clutch gear teeth then clash against the differential bearing adjuster internal teeth. On the other hand, shifting too rapidly from low range to high range, without sufficient pre-select time or improper throttle action, produced the wear condition shown on the high speed clutch plate. The sliding clutch gear teeth, in this case, clash against the high speed clutch plate teeth.

When failures of this type occur, a thorough examination of the sliding clutch gear teeth should be made. The clash teeth wear may be so excessive that replacement of the sliding clutch gear is necessary.

In two-speed axle operation, it is essential that drivers be aware of the effect that varying transmission ratios in combination with gas or diesel engines have on the shifting procedure. Truck operators can adjust their two-speed axle shifting technique to obtain optimum road performance with minimum abuse to the axle.

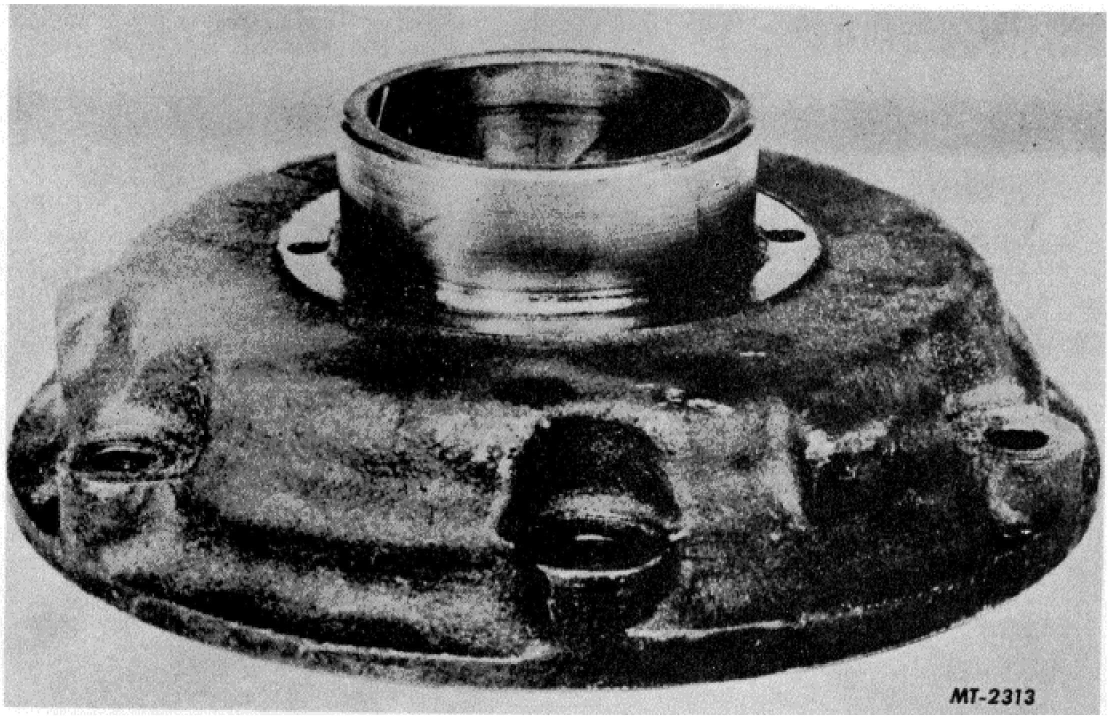


Fig. 10-Worn Support Case Hub.

Differential bearing hubs in axles that have been in severe service are apt to be worn undersize as is the one shown in Fig. 10.

When a truck is heavily overloaded, or subjected to excessive clutching, the pressures between the inner race of the differential bearing and the case hub are exceedingly high. The bearings are forced to carry a load greater than the capacity for which they were designed.

Consequently the hub is compressed and the race turns, wearing away the metal of the hub with increasing rapidity. At this point the bearing no longer functions properly as the inner race is moving on the hub.

A similar condition of wear may be the result of contaminated lubricant. If chips from broken parts are left in an axle housing after a repair job, they will likely be picked up by the circulating lubricant and carried into the bearings. Foreign matter in the lubricant will temporarily lock the rolls of the bearing, forcing the inner race to turn and wear the hub. The latter reason is by far the less common of the two; and when it is, the evidence of contaminated lubricant is generally present on other axle parts.

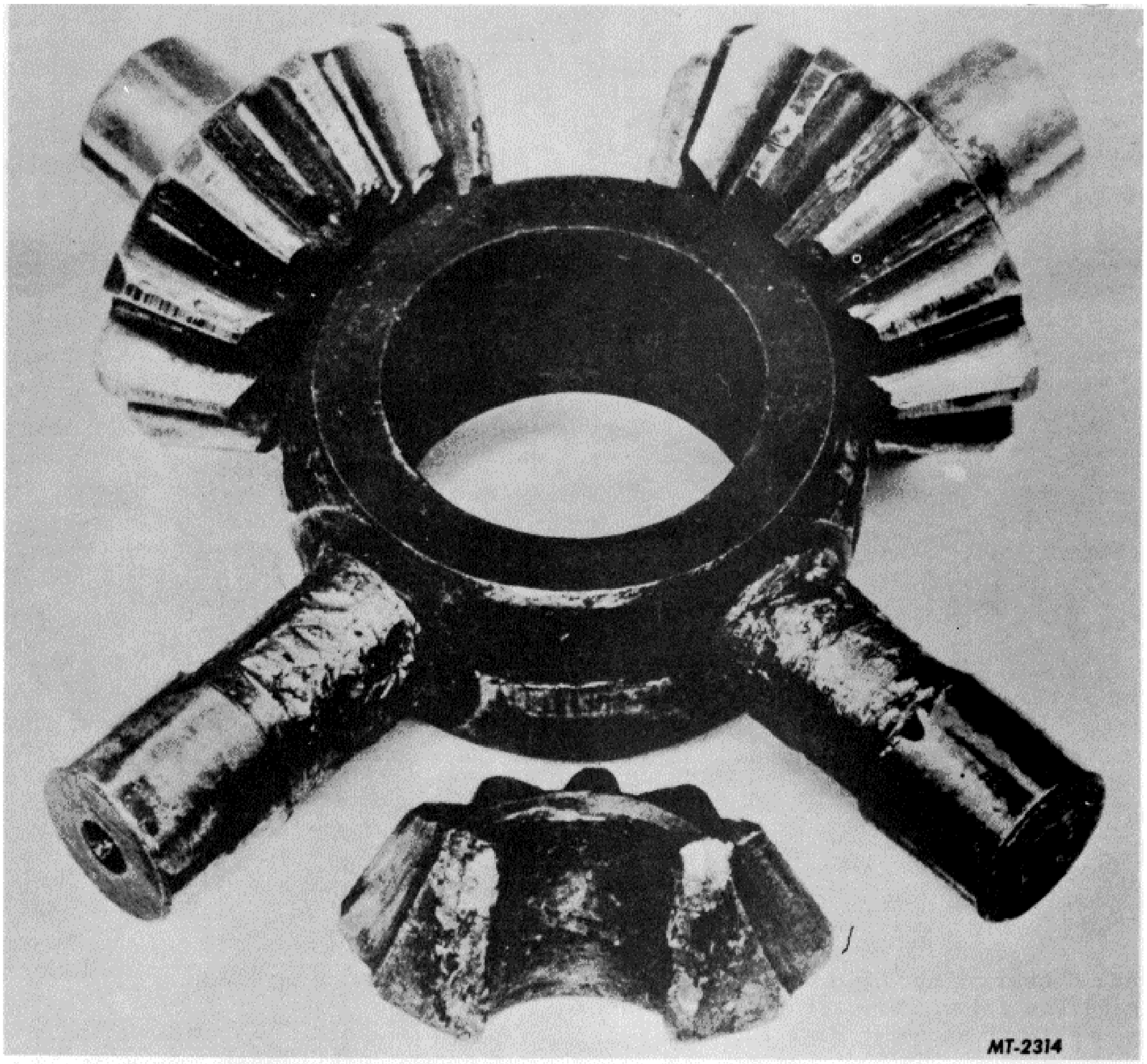


Fig. 11-Scoring and Seizure of Spider and Pinions

A typical example of seizure in the differential is seen in Fig. 11. This unit operated for some time after scoring first started and the spider arms as well as the differential pinions were badly discolored by the heat generated. The fact that there was metal-to-metal contact is clearly evident.

Actual experience has proved failures of this kind are caused by one of three circumstances or a combination of them. Relative to frequency of occurrence, they are wheel spinning, inadequate lubrication, and overstress. All have a common factor in the loss of lubricating film between the adjacent surfaces. Without oil protection, friction causes the hardened areas to overheat, score and finally, if running is continued, to seize.

Off-the-highway service such as logging, oil field hauling and construction work, produces most failures of this kind, although they are also found in highway work during the winter months when roads, are spotted with ice.

Good quality recommended lubricants will go a long way toward eliminating differential seizures but will not prevent them in cases of excessive wheel spinning. Overloading where ground conditions are bad is especially conducive to wheel spinning. It is well in analyzing differential failures to check payloads and operating conditions.

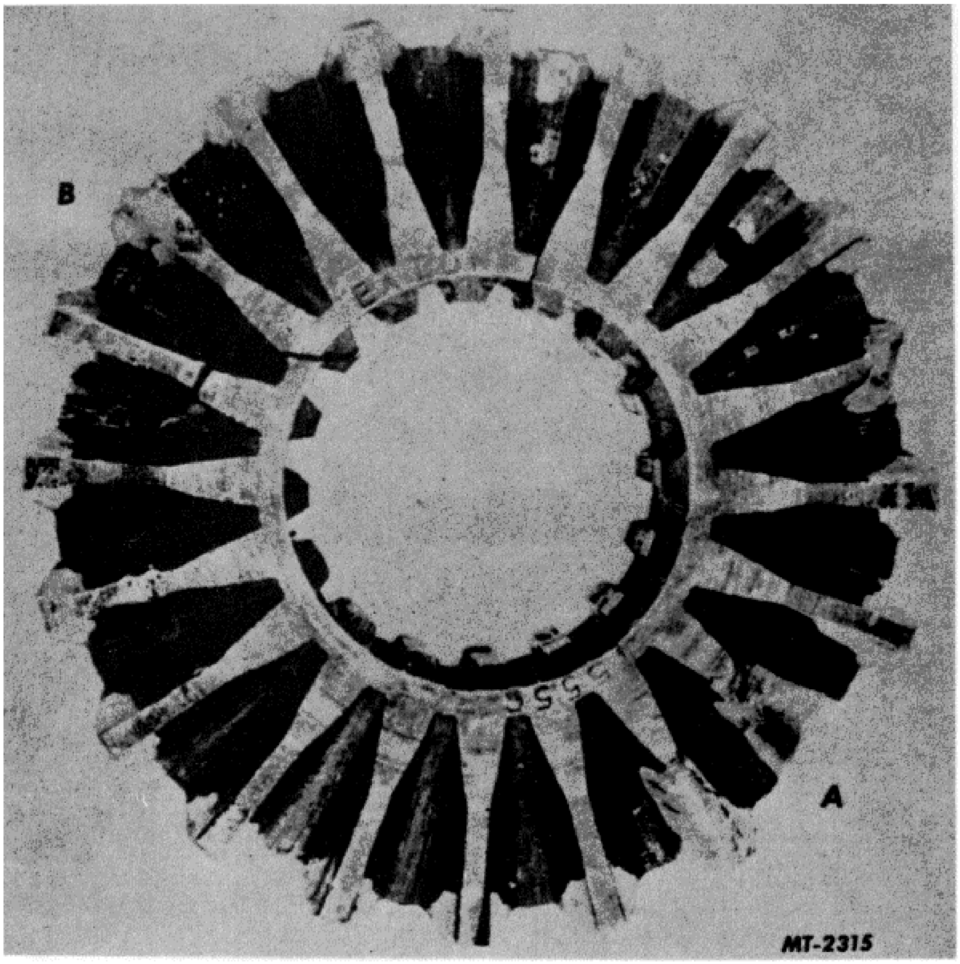


Fig. 12-Fatigue Fracture-Differential Side Gears

Repeated stresses reaching the maximum strength of differential side gears, causes progressive failures of the type shown in Fig. 1; Applied forces were not sufficiently high to cause immediate complete rupture at first, b continued applications further opened the original fracture until there was not sufficient strength to carry the load in the remaining section. Portions of the gear teeth were then broken out fully. Fatigue or progressive fracture is most clearly seen at points A and B.

"Frogging" or "bucking" the truck will tend to produce the fatigue fracture. Many times it not payload or working conditions of the job alone, but lack of knowledge on the driver regarding two-speed axle operation. Education of the driver plays a very important part in the prevention and elimination of failures like this. Abusive handling of equipment is usually unnecessary and must be stopped if long life and trouble-free service are to be expected.

When repairing a job of this kind, give attention to all differential gears and pinions. Although they may not have ruptured completely, they may be cracked and on their way toward failure. Careful repair work and the replacement of questionable parts is in the end the least expensive way.

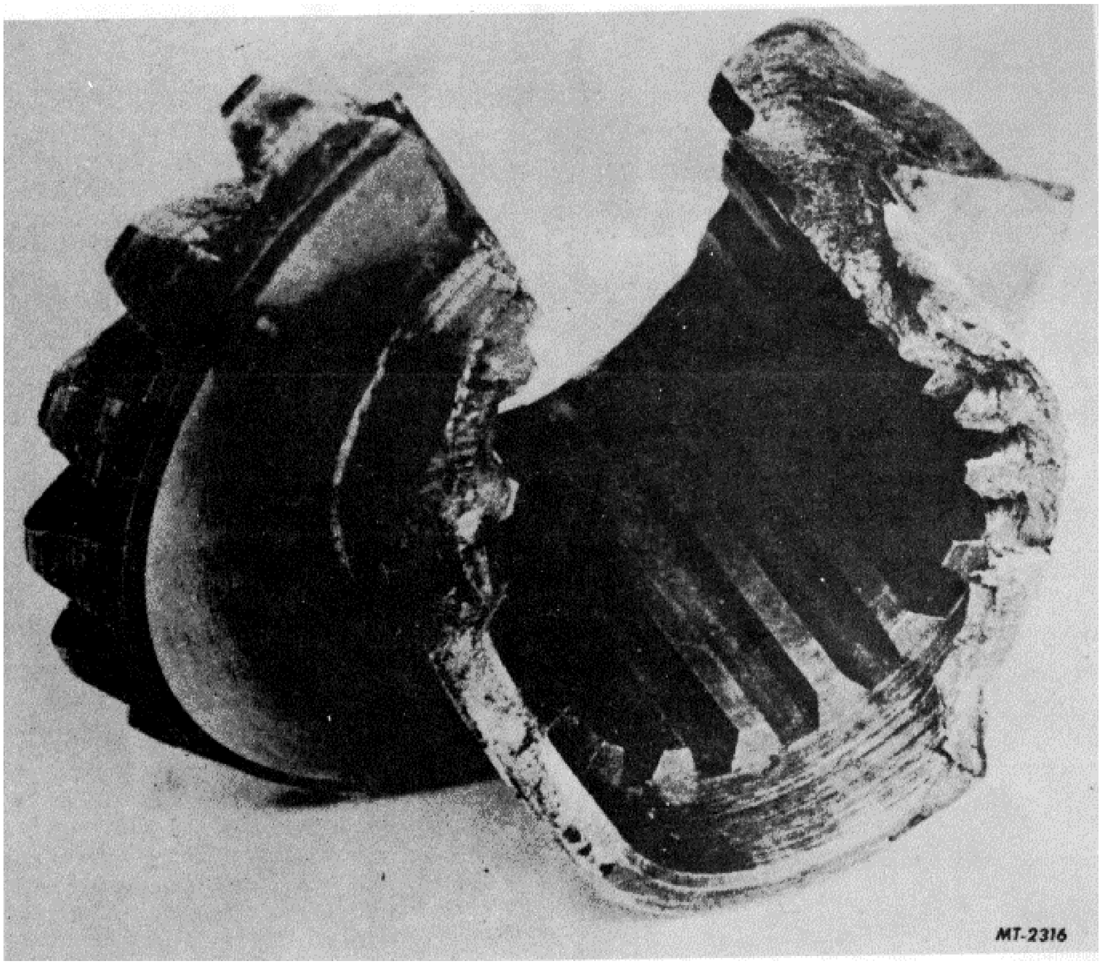


Fig. 13-Fatigue Fracture-Misalignment.

The side gear shown in Fig. 13 is a very good example of failure resulting from misalignment in axle shafts. The same kind of failure is also frequently the result of an axle shaft breaking. If sprung or twisted and bent shafts are not soon replaced after they have been damaged, the side gears may become mutilated adding considerable parts cost to the repair job.

Housings bent by accident or overload, through misalignment carried to the differential, also cause failures similar to the one shown.

The reason side gears fail in the manner seen above is that stresses are concentrated to localized areas. The design and the computed strength of the gears are based on the assumption that there will be no misalignment and the stresses to be carried will be spread over the entire splined area. When this is not true, the maximum strength of the material is exceeded and failure must take place. In most cases, the failure is not instantaneous, but occurs over a period of time and is of the progressive fatigue type. It may be attributed to abusive operation and overloads.

Generally a check of the conditions under which the truck has been operated will very readily reveal the exact circumstances causing the troubles.

It is not unusual for an axle shaft on the opposite side of the vehicle to be damaged, bent, or sprung when one has failed. To eliminate the possibility of recurrent failures of the kind described and pictured here, it is always advisable to make sure both axle shafts are examined and the housing is checked for correct alignment.

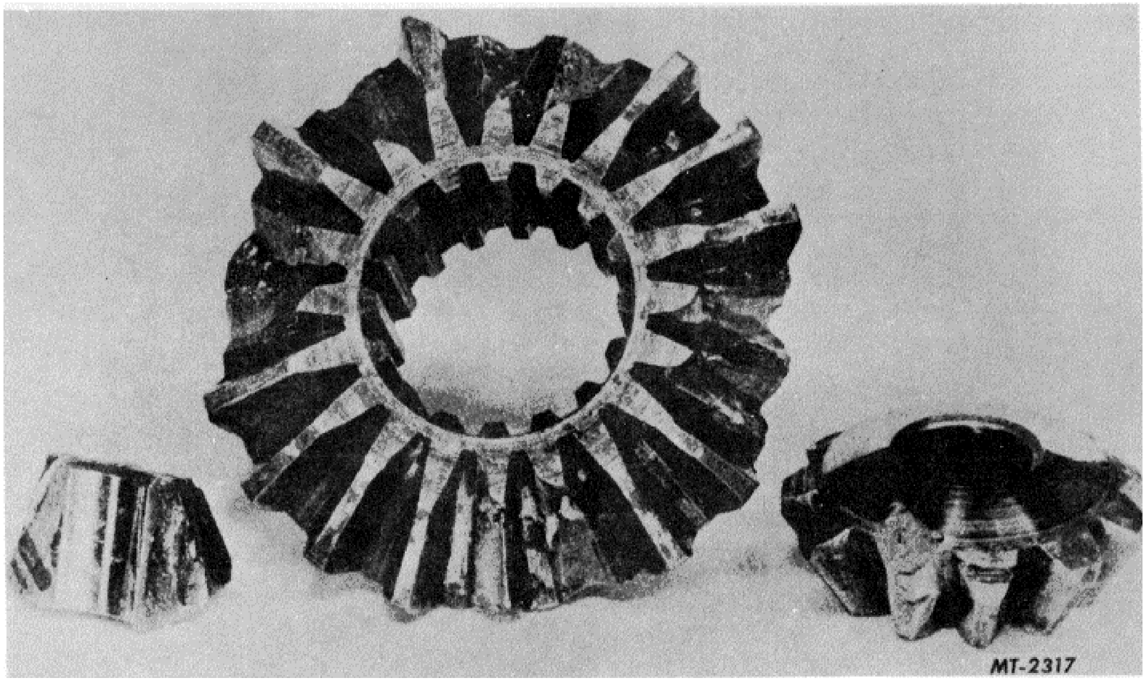


Fig. 14-Shock Fracture

Excessive clutching--commonly known as "bucking" or "frogging"--will very frequently cause differential side gears and side pinions to fail in the manner shown in Fig. 14. The fractures are of the shock type--produced by stresses greater than the maximum strength of the parts. The break occurs at once when the. high abnormal pressures are applied. For this reason, the failure is known as a shock fracture.

In the above illustration, the grainy structure characteristic of all shock fractures is clear. Note how teeth from the side gear were broken out about 900 apart where each of the side pinions meshed. One of the side pinions shown received sufficient shock load to cause it to split.

With failures of this kind, it is not at all unusual to find that secondary failures also occurred, such as broken axle shafts or cracked bevel gear teeth. If the truck continued in operation after the differential broke up, damaged cases, battered idlers, and ruined bearings would most likely be found.

During the winter months when trucks are operating on icy pavements, trouble of this nature is not unusual. Wheels spinning under load and suddenly breaking through ice to stop against high traction pavement, subject differential gears to fracture creating shocks. Severe operations such as construction work and logging are apt to develop numerous failures of this kind when ground or working conditions are poor. Lightened loads are often all that is necessary to eliminate them entirely.

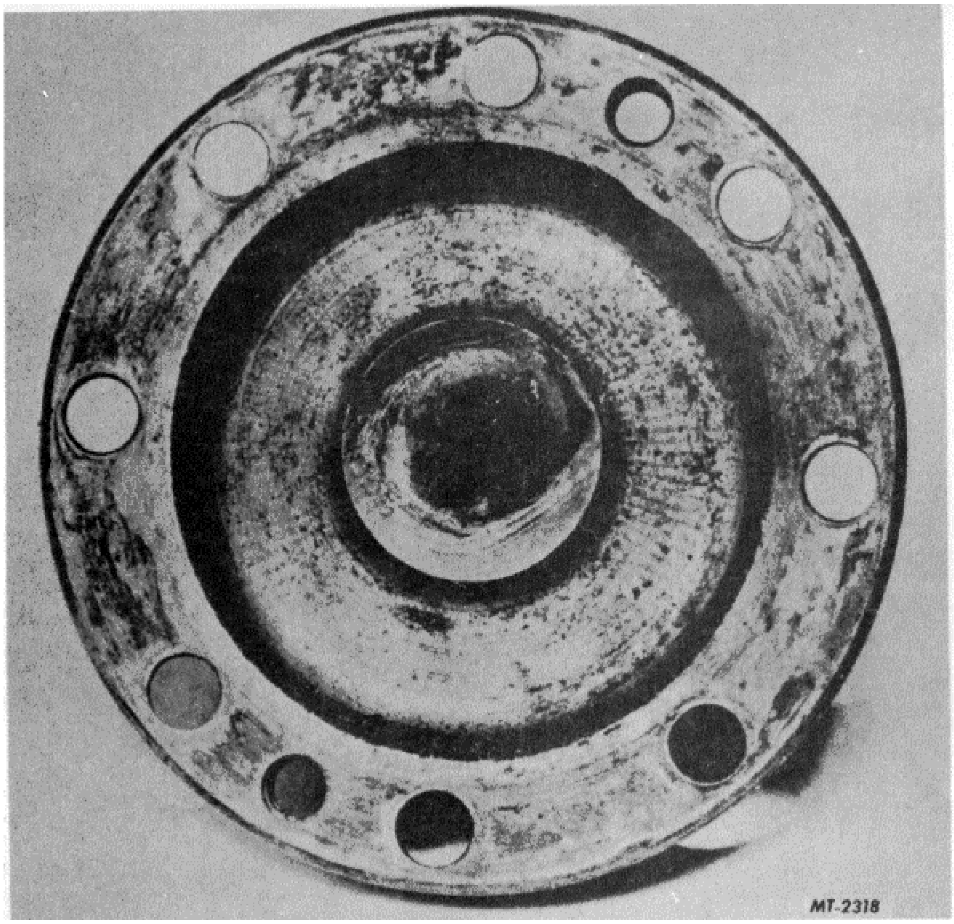


Fig. 15-Fatigue-At Axle Shaft Flange

Worn wheel bearings caused the failure of the axle shaft shown in Fig. 15.

Looseness in wheel bearing adjustment, causing misalignment, if not immediately correcte4 will almost invariably result in a fracture of this kind. Misalignment between the differential and the hub, such as that caused by a bent axle housing, will also create such failures. It is to be noted that housings may deflect sufficiently under heavy load to create a temporary misalignment that will be in effect the same as a sprung or bent unit. Not necessarily will it follow that the housing when not carrying load will remain sprung.

Fractures from such conditions are of the fatigue type and are readily identified. Refer ring to Fig. 15, the fatigue or progressive fracture is clearly seen extending from the outside diameter about a third of the distance in toward the center of the shaft. This failure worked in slowly until the body was so reduced in size that it would no longer carry the load. The remaining portion was then broken through in a single action. This last area to fracture is darker in color and rougher in texture. In cases of this kind, it is not uncommon for final rupture to occur when a truck is moving unloaded on excellent surface conditions. The failure may have started many miles previous to that time.

The best preventive measure against such failures is correct lubrication and proper adjustment of wheel bearings.

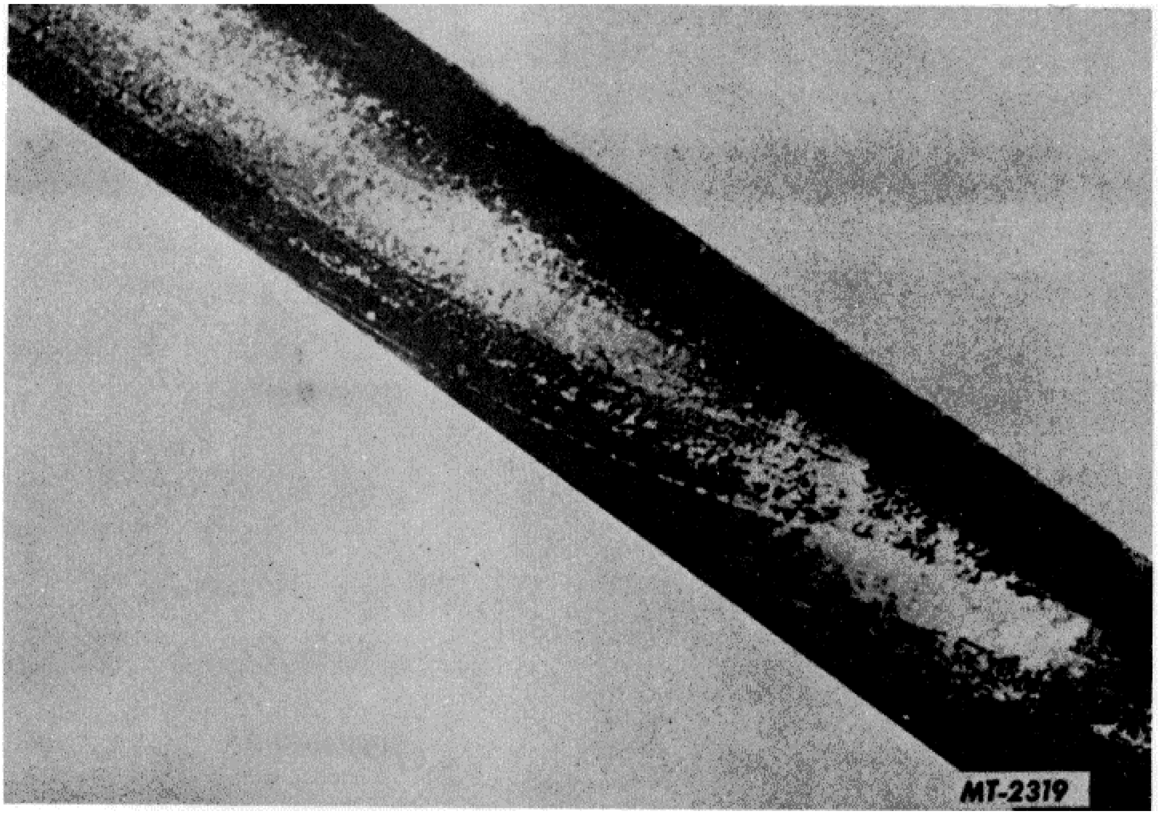


Fig. 16-Twisted Shaft

Fig. 16 illustrates a portion of a twisted axle shaft caused by abusive or very severe operation.

This is a preliminary failure stage where the shaft has twisted and alignment was destroyed, but no signs of fracture are in evidence. The shaft has passed its period of usefulness and should be replaced. If it is not, it will continue to twist until an ultimate fracture will occur. With complete failure, other axle parts may be damaged with consequent substantial increase in repairs cost. The lubricant should be changed and the axle well cleaned after such shaft breakage to eliminate all possibility that pieces might remain in the unit to cause later damage. The shaft on the opposite side of the truck should be very carefully examined.

Such parts condition is produced by severe operations frequently in combination with abusive handling of equipment. Usually investigation will disclose the vehicles are overloaded or the drivers are improperly using the equipment.

Technically the damage is the result of a series of torque or stress applications greater than the strength of the metal. Most always these are in both directions and applied thru low and reverse transmission gears. A twisted shaft that has fractured is sometimes thought, by persons not experienced in metal fractures, to be evidence of seams in the steel It is not, for the small noticeable cracks are caused by fatigue.

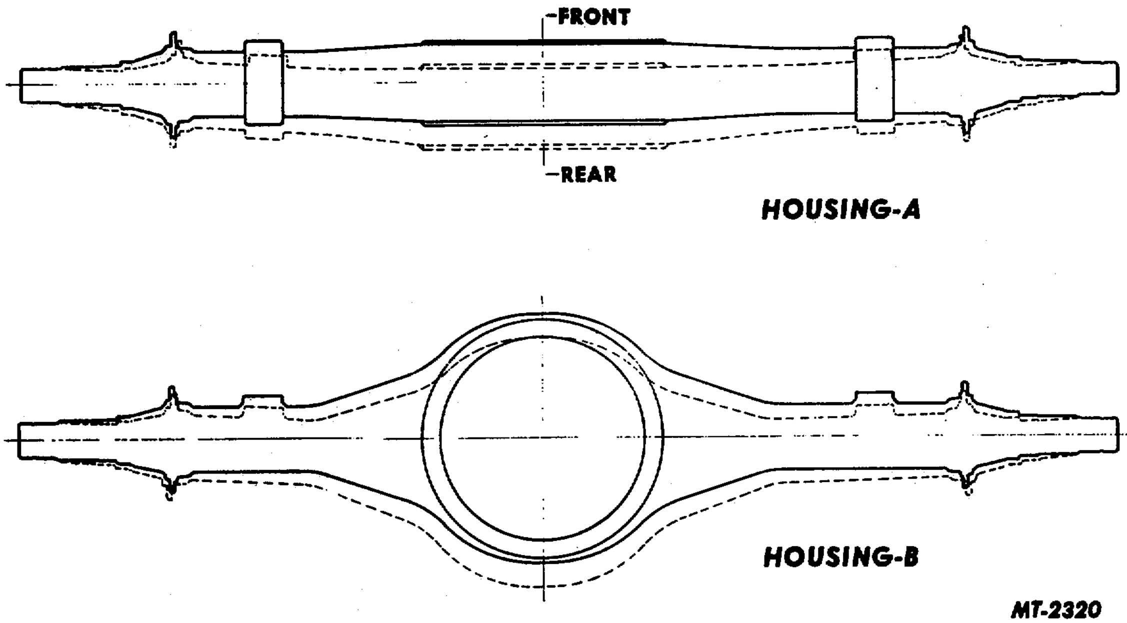


Fig. 17-Bent Housing

Housing "A" shown in Fig. 17 is a diagrammatic sketch of a housing bent or sprung through accident. The differential carrier face was moved back from its original position shown by the dotted line. This change in alignment was the result of contact by an obstruction with sufficient force to bend the housing. Housings like this will be responsible for repeated axle shaft or differential failures. The misalignment must be corrected. This may sometimes be accomplished by straightening; however, unless properly done by an experienced worker, the spring may come in again.

Housing "B" shown in Fig. 17 was bent by excessive loading. Note how the center, as shown by the dotted line, was sprung from its original position. Repeated axle shaft failures and excessive tire wear will occur with housings in this condition. Bent in this direction, they cannot be satisfactorily straightened, but must be replaced.

Overloading causes housing deflection. Since housings will recover from a certain amount of deflection, if it is not sufficient to produce a permanent set, trucks frequently operate with a temporary spring in the housing which will be enough to create axle shaft failure. The same part checked unloaded will seem to be in proper alignment.

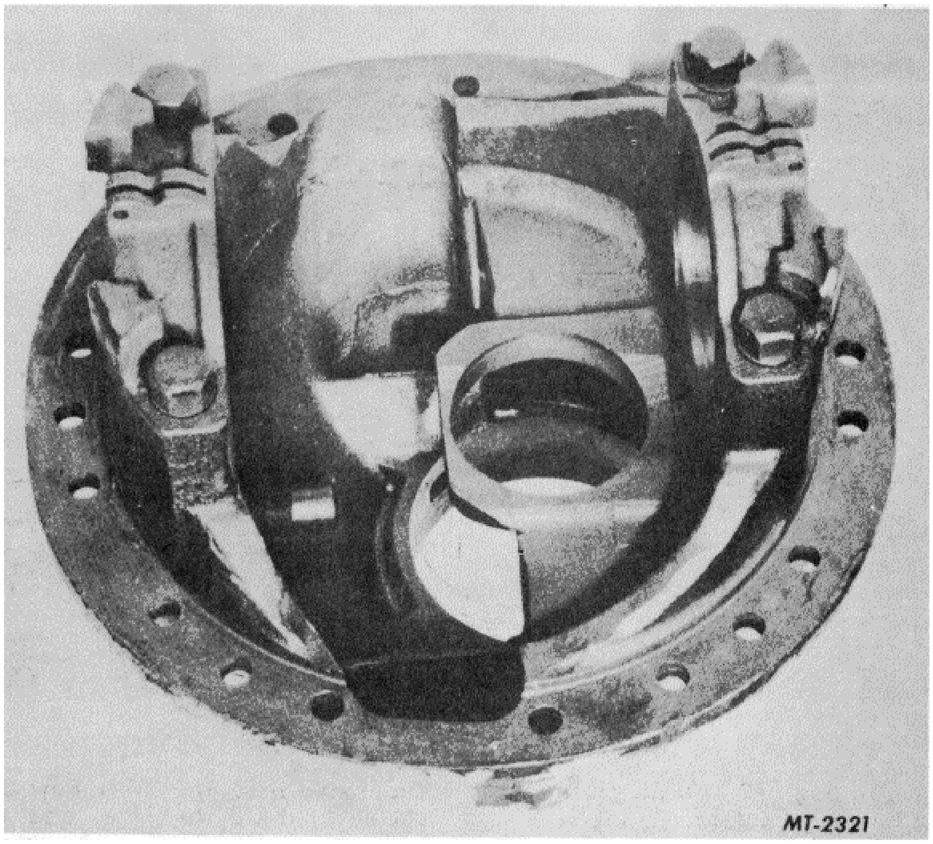


Fig. 18-Wear—Inner Bearing Bore.

Differential carriers worn oversize at the inner pinion bearing bore as shown in Fig. 18 are occasionally encountered. Ordinarily this condition is found along with other damage to the axle such as bearing failure, mutilated bevel gears and pitted planetary gears. It is a result of overloading often increased by end play in the outer bearings. Inner bearing failure will frequently mutilate this bore causing it to be over size.

Carriers damaged in this way must be replaced. If not, they will allow misalignment of the bevel gears resulting in noise, and in all probability, ruining the gears to such an extent that they will require replacement. Satisfactory life for a repair job cannot be anticipated if a worn carrier is used.

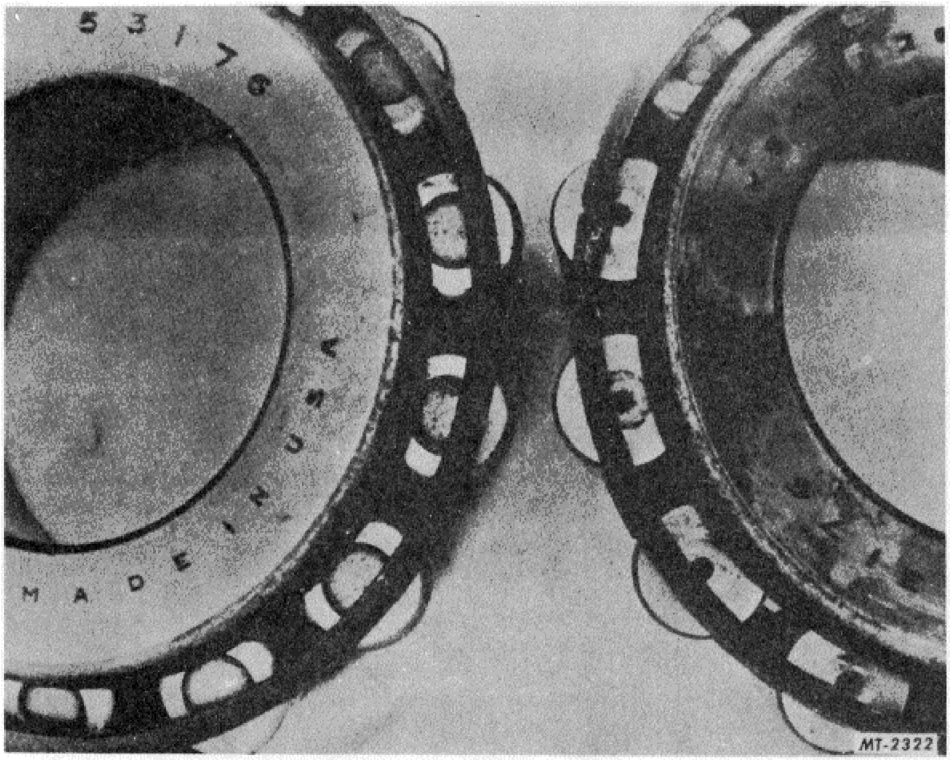


Fig. 19-Roller Bearing End Wear.

The taper bearing shown on the left in Fig. 19 is a new bearing. Close examination will reveal the raised ground and polished shoulder on the roll ends that contact a matching shoulder on the inner race. The dark center area is considerably lower than the roll end shoulder.

The bearing shown in on the right in Fig. 19 has been removed from a unit after a period of service. The bevel gears were noisy and required replacement. Comparing the roll ends of this bearing with those of the new one, the difference is immediately apparent. Here the shoulder has worn completely away and below the original height of the center recessed area.

The lapping and wear of the roll ends were caused by foreign substance in the lubricant.
As a result of this wear, the pinion was no longer held in proper position relative to the ring gear. The gears were "out of adjustment. " Continued operation, with end play in the pinion damaged the contact area of the bevel teeth which created noise.

The use of recommended lubricants changed at reasonably regular intervals will prevent the majority of such failures.

Readjustment of bearings damaged in this manner will not give a satisfactory repair job, as they will continue to wear rapidly--they should be replaced.

New bearing assemblies should always be installed along with new gear sets.

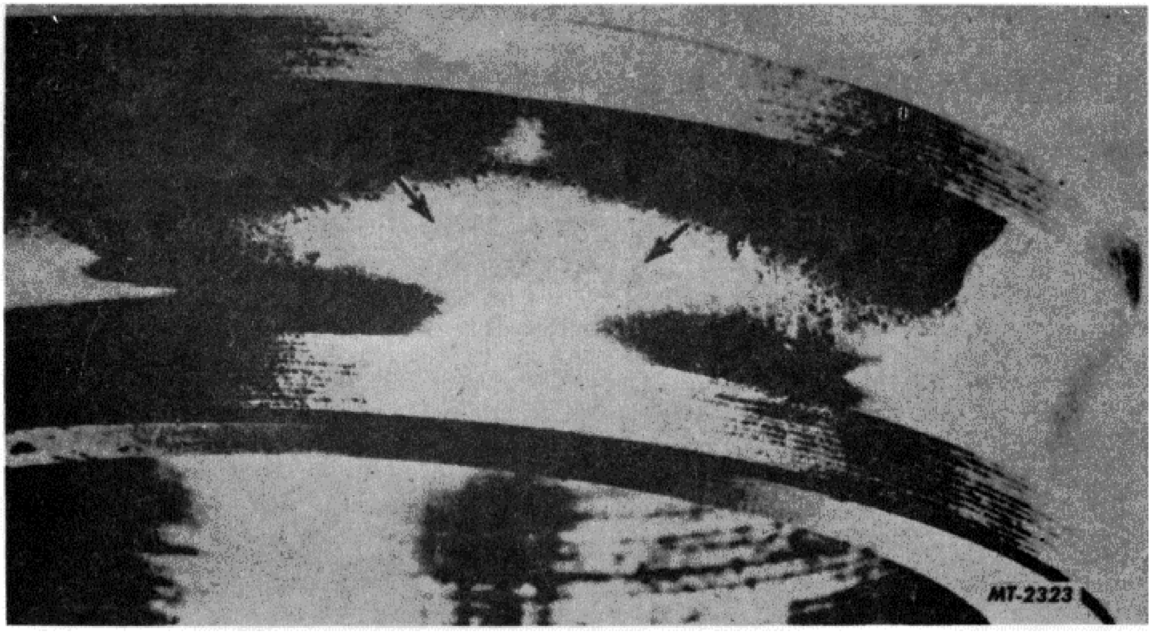


Fig. 20 - Ball Inner Race Damaged From Circulation of Abrasive Material.

During the course of operation, the unit breathes in much the same manner as the engine. As the hot unit coals, it pulls air into the gear inclosure through the breather. Dust, grit, and other abrasive materials suspended in the air are drawn into the case and deposited in the lubricant. In addition, pieces of material broken from the gear teeth are also deposited in the lubricant. All of this material circulating in the case will lap the bearings and increase the radical and axial clearance originally built in these parts, Figs. 20 and 21.

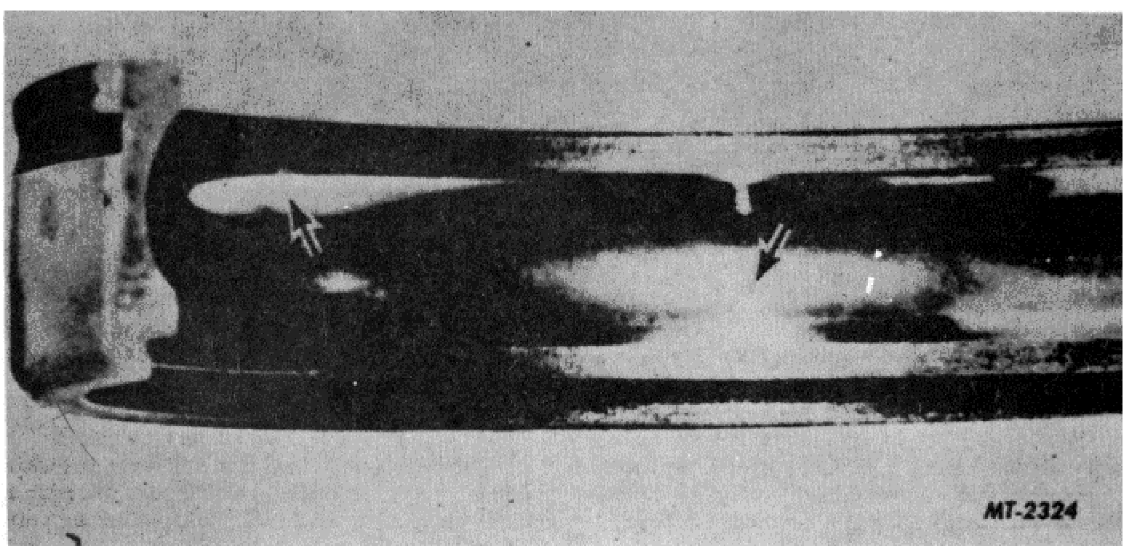


Fig. 21-Ball Bearing Outer Race Lapped From Circulation of Abrasive Material.

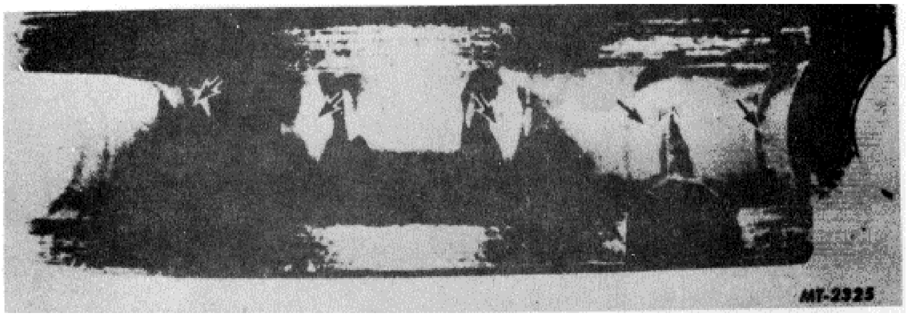


Fig. 22 - Ball Bearing Inner Race Marked From False Brinelling.

False brinelling resulting from vibration without relative rotation of the inner and outer races, Fig. 22. With the inner and outer races stationary and the entire bearing subject to vibration, the balls will rotate and indent the inner and outer races. Exposure of the bearing surface to air will oxidize the microscopic metal particles freed by the vibrating movement. These oxides in turn form an abrasive which deepens the indentation further.

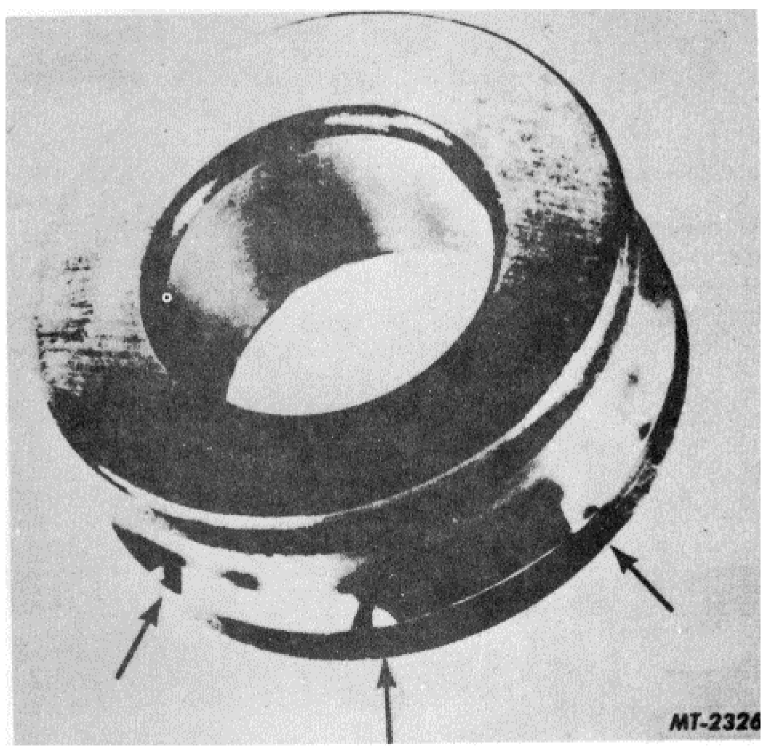


Fig. 23 - Ball Depressions Produced By an Off-Center Blow in Mounting.

True brinelling is caused by an off-center blow during the mounting process. In the example shown, only three balls produced depressions, Fig. 23. Shallower marks frequently go unnoticed because the edges of the brinelled depression are not clearly marked and no change appears in the surface of the raceway. Brinell marks of this nature are difficult to see under a microscope. Bearings marked in this fashion frequently go unnoticed in operation because the load does not cause the ball path to reach the brinell marks on the edges of the races. The balls, however, acquire similar depressions and will make the bearing sound noisy or "catchy" as if it had several small pieces of foreign material lodged in it. Failure of the bearing may result because of the flat spots on the balls or on the races.

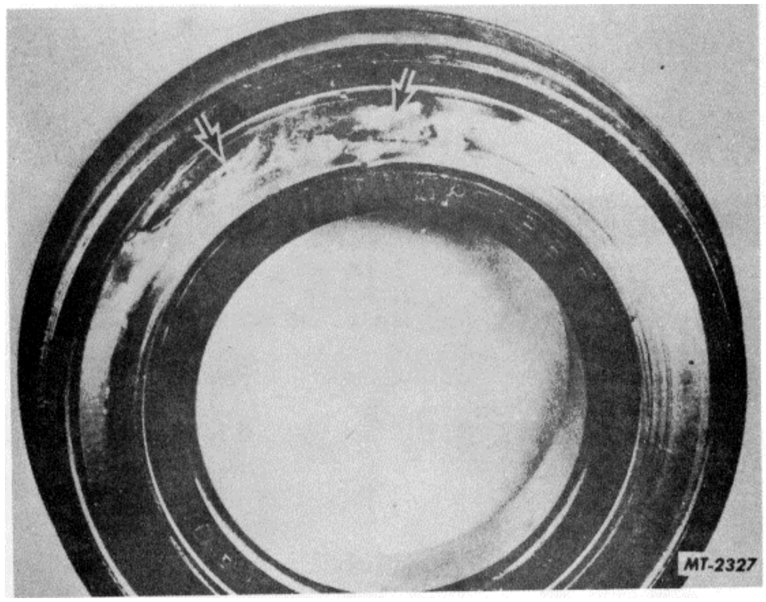


Fig. 24-Bearing Shield Damaged From Removal With Punch.

A very common cause of bearing damage results from the use of the conventional two-piece puller--a hammer and punch, Figs. 24 and 25. These particular illustrations show a damage shield resulting from the use of the punch. In a conventional bearing without shield, the separators would have been damaged.

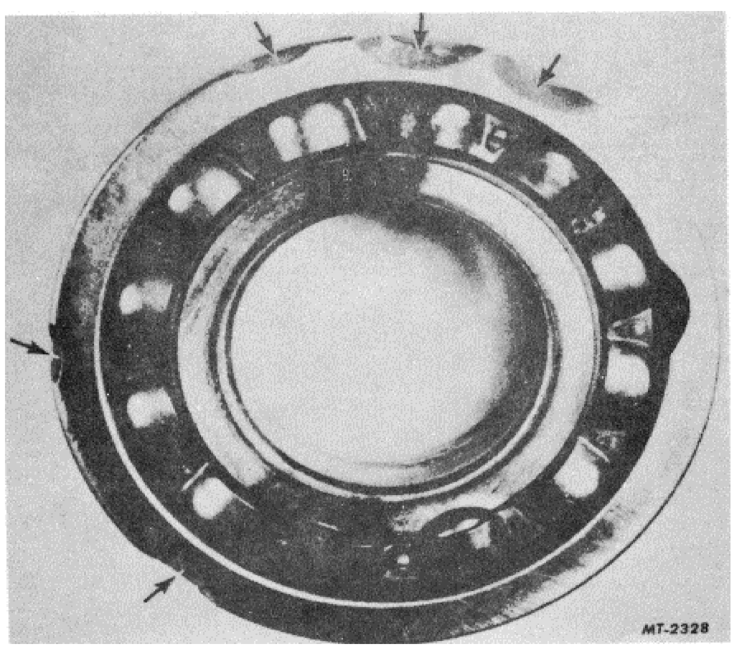


Fig. 25 - Section of Outer Race Adjacent to Snap Ring Groove Damaged From Removal With Chisel.

Bearing damage of the type shown in Fig. 25 can be eliminated by using bearing pullers on all occasions.

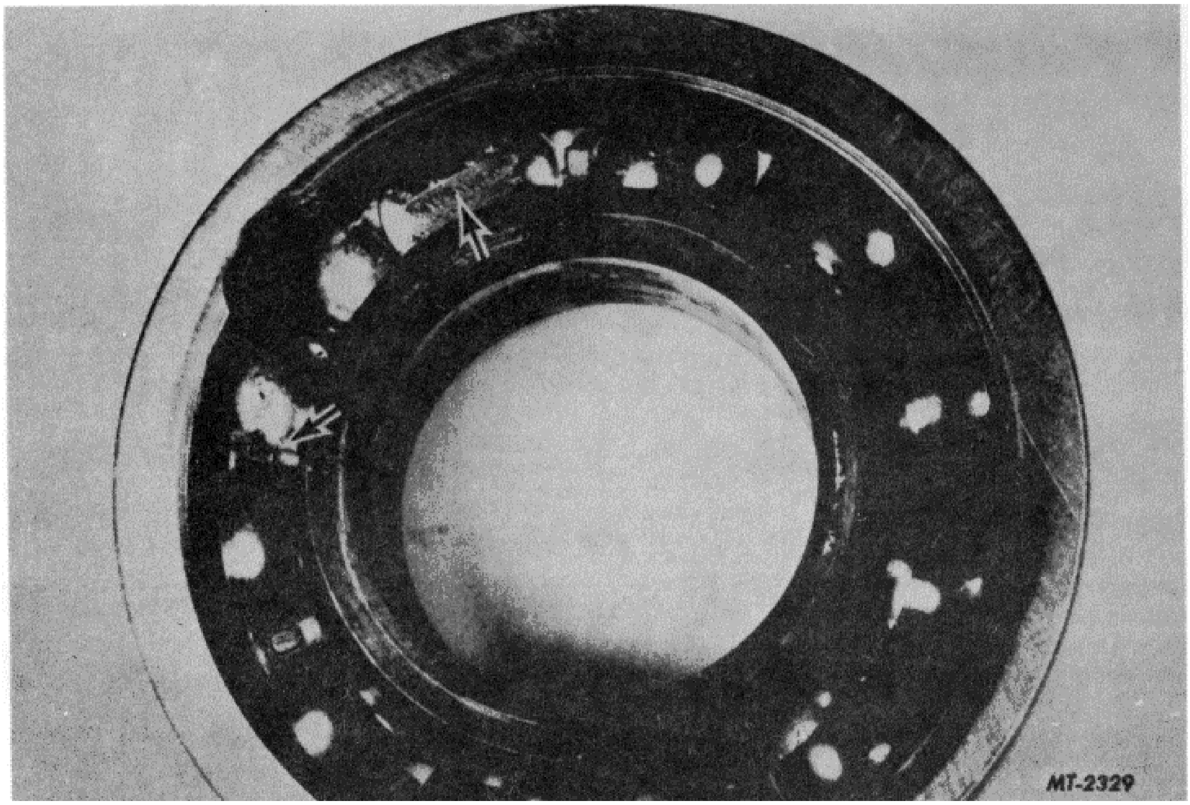


Fig. 26 - Failure of Ball Separator As Result of Misalignment

Ball separators worn from contact either with outer race or inner race are indicative of misalignment, Fig. 26. In the transmission this condition occurs most frequently at the maindrive gear position and is the result of the transmission being eccentrically with the pilot bearing bore in the flywheel.

BODIES AND CABS
CONVENTIONAL RIVETED CAB
INDEX

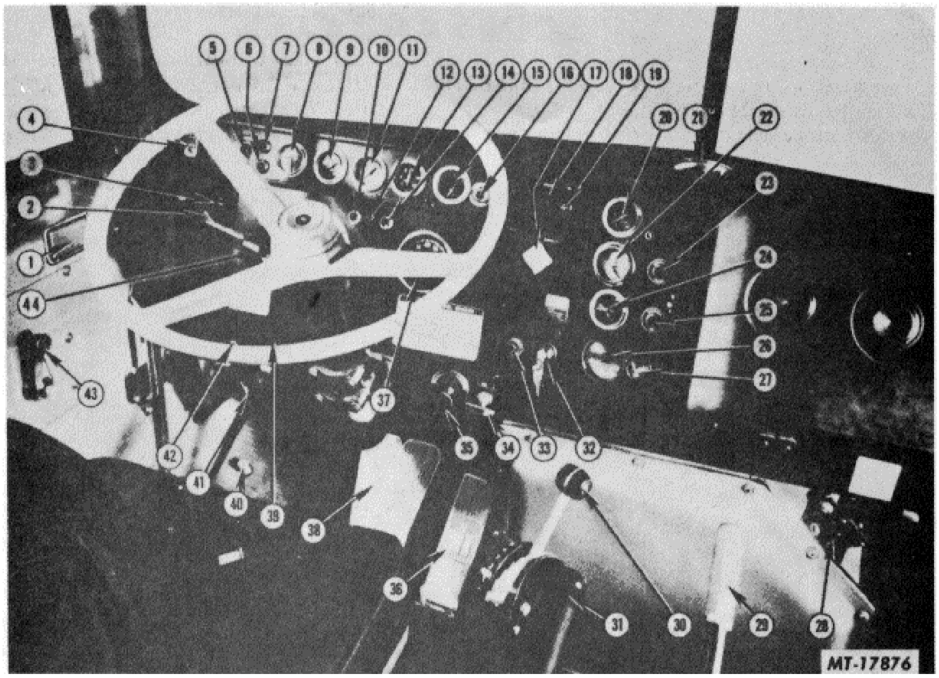


Fig. 1. Instrument Panel Gauges and Controls

Legend for Fig.1

Key	Description	Key	Description
1.	Door Control	23.	Transmission Oil Pressure Indicator Light
2.	Turn Indicator Control	24.	Transmission Oil Temperature Gauge
3.	Power Divider Lock Control	25.	Transmission Oil Temperature Indicator Light
4.	Exhaust Brake Switch	26.	Air Cleaner Restriction Gauge
5.	Glow Plug Switch	27.	Cigarette Lighter
6.	Oil-Water Temperature Indicator Light	28.	Circuit Breaker Switch-Start-Run
7.	Glow Plug Indicator Light	29.	Dump Body Control
8.	Battery-Generating System Indicator Gauge	30.	Automatic Transmission Control
9.	Water Temperature Gauge	31.	Auxiliary Transmission Control
10.	Left Turn Indicator Light	32	Starting Switch Key
11.	Oil Pressure Gauge, Engine	33.	Starting Button
12	Headlight High Beam Indicator Light	34.	Throttle Control
13.	Air Pressure Gauge	35.	Emergency Brake Release
14.	Right Turn Indicator Light	36.	Accelerator Pedal
15.	Fuel Level Gauge	37.	Speedometer and Odometer
16.	Low Air Pressure Light	38.	Brake Pedal
17.	Parking Brake Control	39.	Front Wheel Brake Limiting Valve
18.	Dome and Panel Lights	40.	Headlight Beam Selector
19.	Headlights	41.	Power Take Off Control
20.	Fuel Pressure Gauge	42.	Fuel Primer Pump
21.	Ash Receptacle	43.	Window Regulator
22.	Transmission Oil Pressure Gauge	44.	Tachometer

CONTROLS

The instrument gauges and instrument panel controls, Fig. 1, are all conveniently located within sight and easy reach of the operator.

DESCRIPTION

The four-point mounted riveted cab is available in either steel or aluminum construction. Various panels are riveted together, providing easier replacement of damaged areas. Some models utilize a fiberglass tilt hood and fender assembly, while others have steel front end sheet metal with a butterfly type hood.

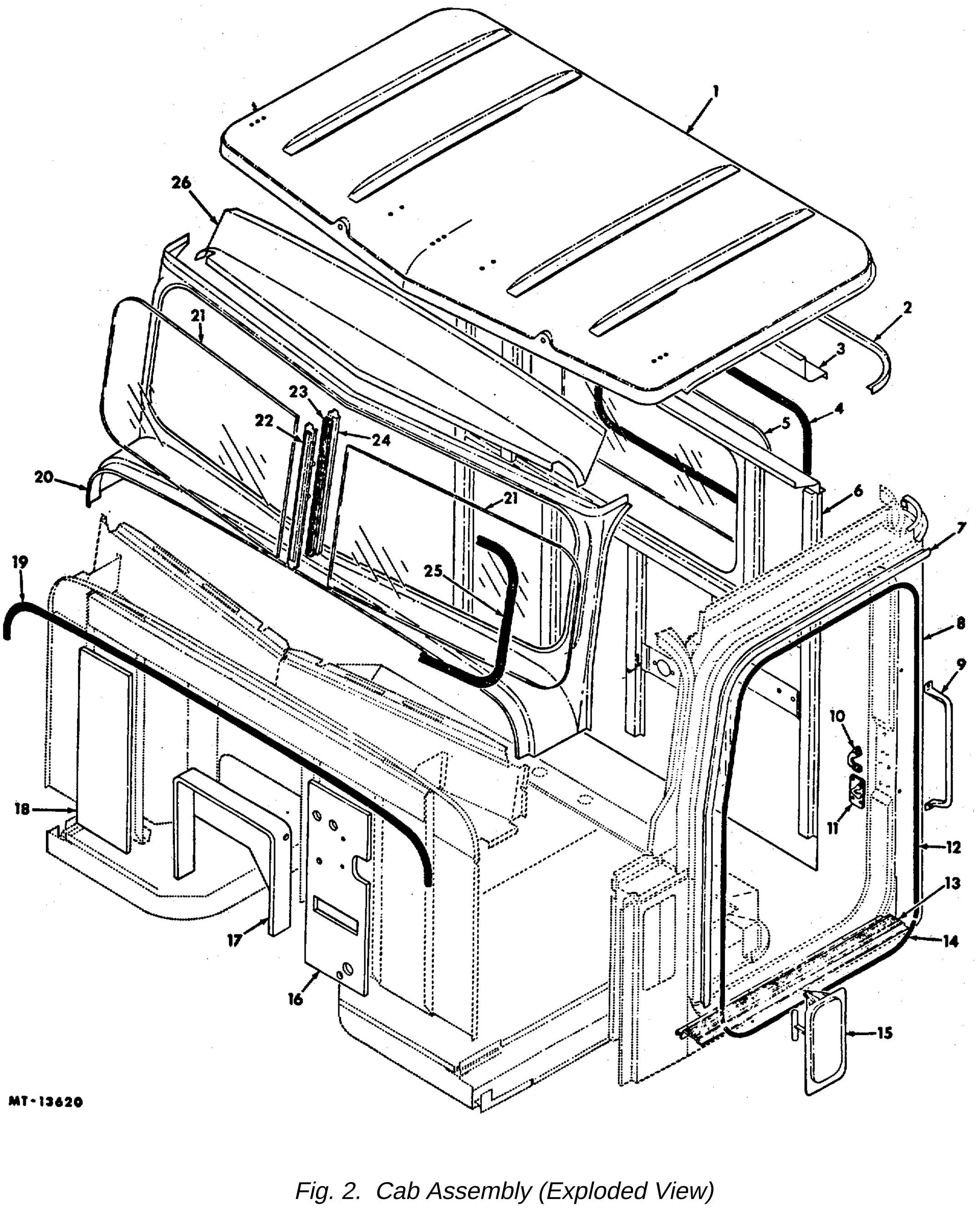


Fig. 2. Cab Assembly (Exploded View)

Legend for Fig. 2

Key	Description
1	PANEL, Roof
2	MOULDING, Rear Drip
3	MOULDING, Rear Window
4	SEAL, Back Panel Glass
5	GLASS, Back Panel
6	PANEL, Back, Assembly
7	MOULDING, Left Drip
8	PANEL, Rear Corner
9	HANDLE, Grab
10	PLATE, Door Lock Striker, Assembly
11	DOVETAIL, Door, Female, Assembly
12	SEAL, Door, Weather
13	PLATE, Scuff
14	SEAL, Door Lower Outer Weather
15	VENTILATOR, Cowl
16	INSULATOR, Dash Left
17	INSULATOR, Dash Center
18	INSULATOR, Dash Right
19	SEAL, Cowl Hood
20	PANEL, Cowl Top
21	GLASS, Windshield
22	BAR, Windshield Outer Dividing
23	SEAL, Windshield Dividing Weather
24	BAR, Windshield Inner Dividing
25	SEAL, Windshield Weather
26	HEADER, Windshield Opening

CAB DOOR AND HINGE

To Remove the Cab Door::

1. Remove two screws securing door check strap to door panel.
2. Remove ten capscrews securing door to door hinge.
3. Remove door assembly.
4. If desired, cab door hinge may be removed from cab by taking out the nine capscrews securing it to the cab.

To Install:

Reverse the foregoing procedure for cab door and hinge installation.

CAB DOOR GLASS

The replacement of cab door glass is a simple operation if the following instructions are carried out.

To Remove:

1. Remove window regulator handle, grab handle and door check from door panel.
2. Remove the retaining screws from door lower opening cover panel, Fig. 4.
3. Remove door lower cover panel.
4. Reinstall door check to prevent door from becoming damaged when fully open.
5. Remove upper retaining screw from window run channel, Fig. 5.

Legend for Fig. 3

Key	Description
1	WINDOW, Door Vent
2	SEAL Window Opening
3	RETAINER, Glass Run Channel
4	GLASS, Door
5	CHANNEL, Glass Run
6	SEAL, Glass
7	FILLER, Side Door Lock
8	DOVETAIL, Door, Male
9	KNOB, Lock Control
10	BUSHING, Control Knob
11	ROD, Lock Control, **Inner**
12	ROD, Door Lock Knob
13	LOCK, Door
14	RETAINER, Lock Rod
15	ROD, Lock Cylinder Contr'4
16	ROD, Lock Control Outer
17	REST, Arm
18	POCKET, Manifest
19	SCREW, Socket Head
20	HANDLE, Window Regulator
21	WASHER, Regulator Handle
22	HANDLE, Grab
23	HANDLE, Door Pull
24	HANDLE, Left Door Remote
25	PANEL, Left Door Inner
26	REGULATOR, Left Window
27	CLIP, Regulator Arm Retaining
28	CHANNEL, Left Door Glass
29	HANDLE, Left Door Outer
30	BRACKET, Left Channel Retainer
31	RETAINER, Left Glass Channel
32	BUMPER, Window Stop
33	BRACKET, Dovetail Mounting
34	RETAINER, Glass Channel Rear
35	GLASS, Right Door View
36	SEAL, View Glass
37	HINGE, Door

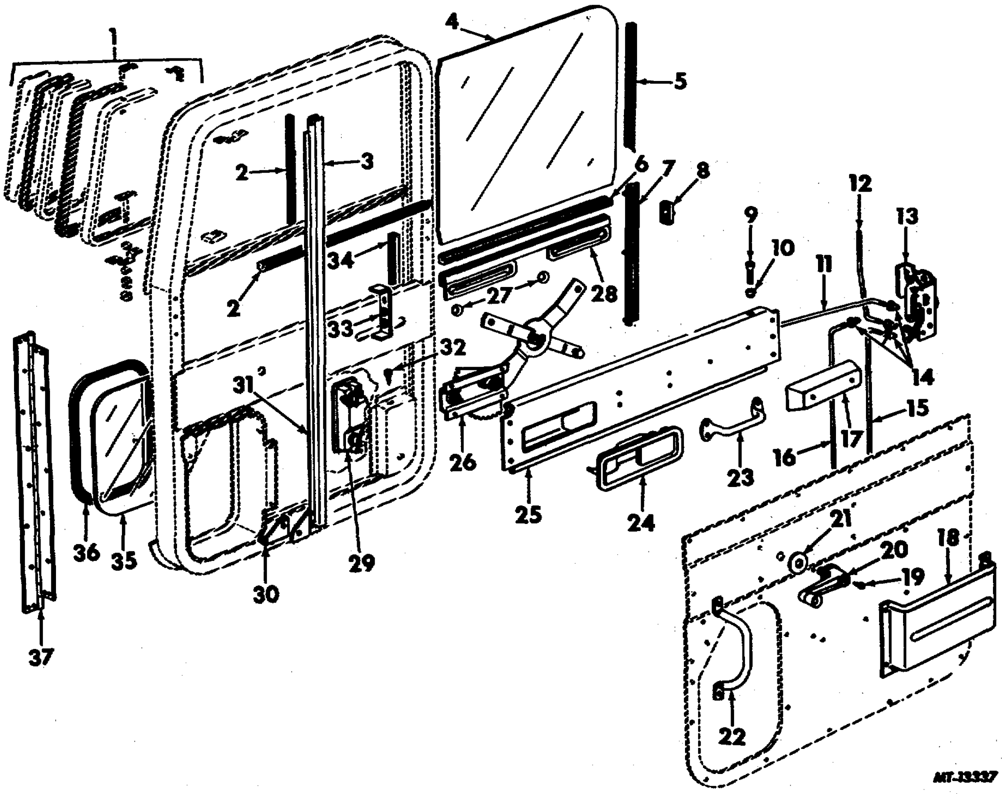


Fig. 3. Cab Door Window and Vent Assembly (Exploded View)

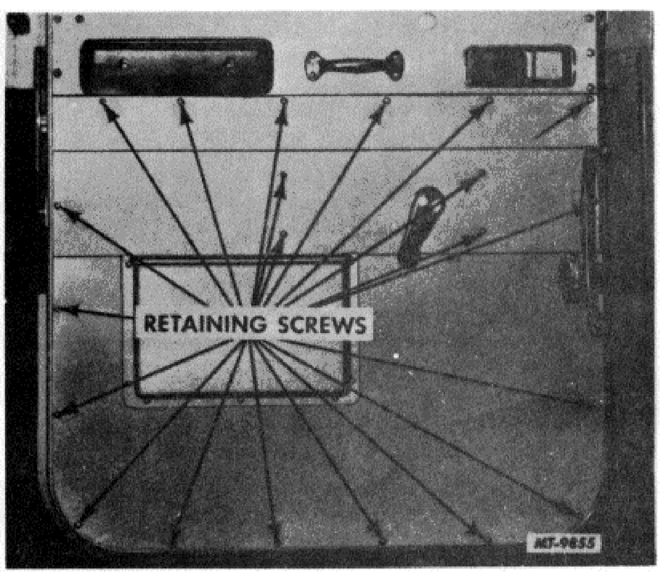


Fig. 4

Fig. 5

6. Remove door lock push button and take out retaining screws from door upper cover panel, Fig. 6.

7. Remove the remote control arm from door handle, Fig. 7.

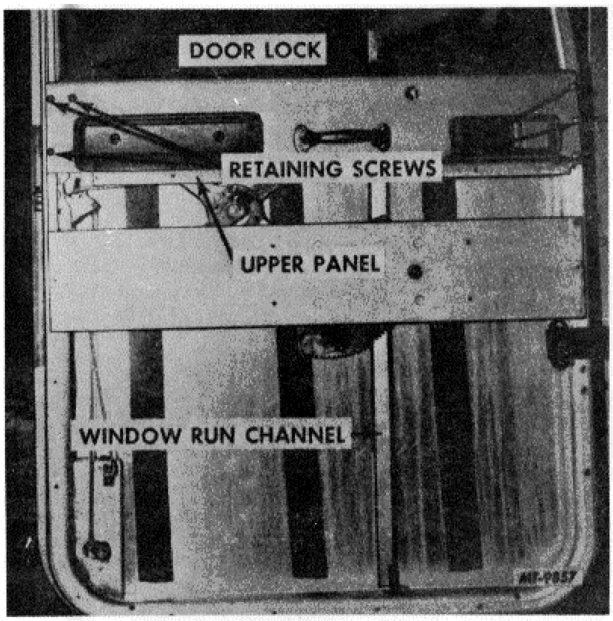


Fig. 6

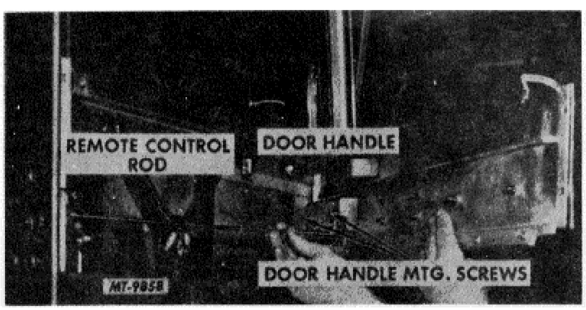


Fig. 7

Fig. 8

8. Remove door upper cover panel.
9. Remove lower retaining screw from window run channel. Position window run channel to the right of the window run channel mounting bracket, Fig. 8.
10. Remove retaining clip from regulator arms, Fig. 9

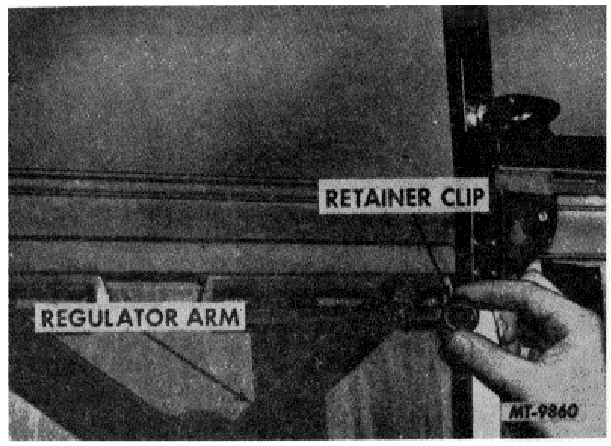


Fig. 9

11. Remove regulator arms from door glass channel slides. Fig. 10.

Fig. 10

12. Raise regulator arms to extreme upper position to permit door glass removal.
13. Lift door glass out of door lower opening, Fig. 11.

To Install:

Door glass installation is accomplished by reversing the foregoing removal procedure.

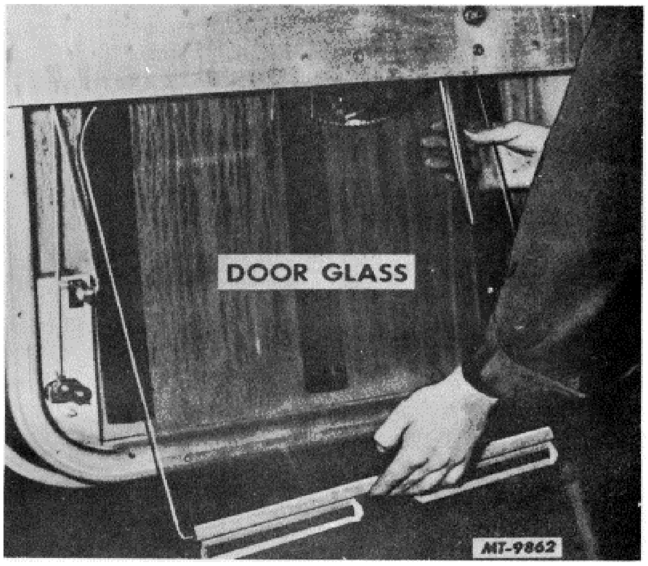


Fig. 11

WINDOW REGULATOR

To remove cab door window regulator, proceed as follows:

<u>To Remove:</u>

1. Remove door glass as outlined under "CAB DOOR GLASS REMOVAL AND INSTALLATION.
2. Remove window regulator retaining screws, Fig. 12.

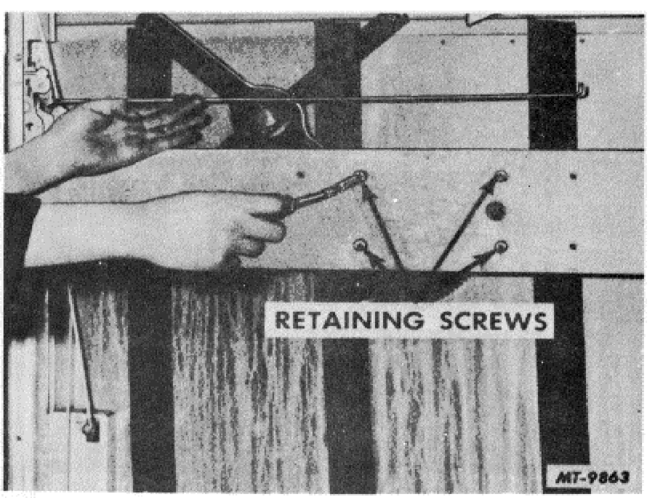


Fig. 12

3. Remove window regulator through cab door lower opening, Fig. 13.

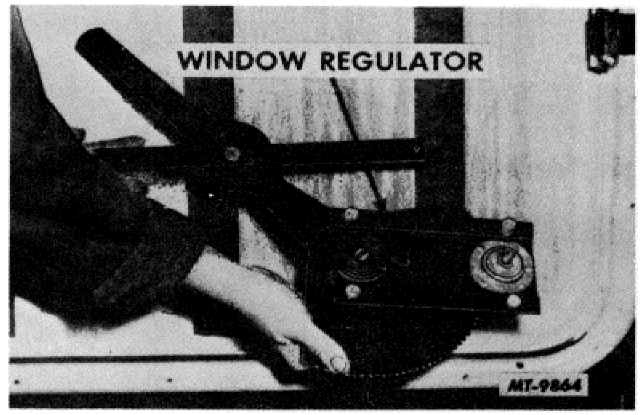


Fig. 13

<u>To Install:</u>

Cab door window regulator installation is accomplished by reversing the foregoing removal procedure.

After window regulator installation, apply Lubriplate 110 or equivalent to window channel slides, Fig. 14.

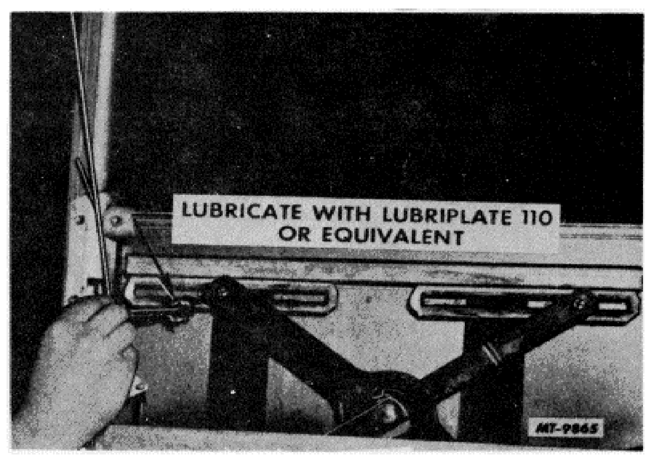


Fig. 14

DOOR GLASS WINDOW CHANNEL

1. Remove cab door glass as outlined under "CAB DOOR GLASS REMOVAL AND INSTALLATION."
2. Remove door glass rear run channel retainer, Fig. 15.

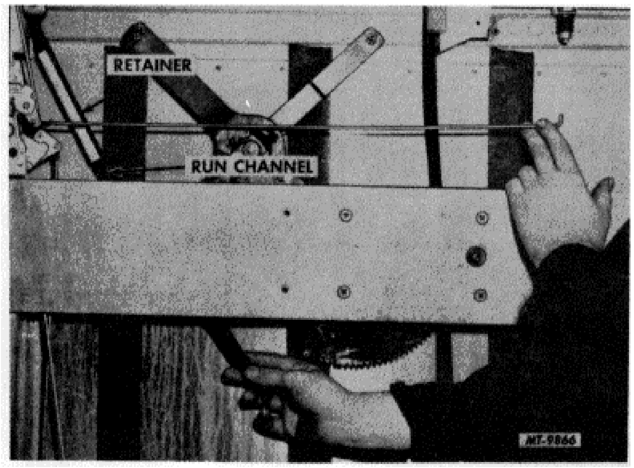


Fig. 15

3. Pull door glass rear run and front run channels from door, Fig. 16.

Fig. 16

VENT WINDOW

<u>To Remove:</u>

1. Pull out door vent glass window weatherseal far enough to expose vent window frame to cab door retaining screws, Fig. 17.
2. Remove four door vent window retaining screws, Fig. 17.

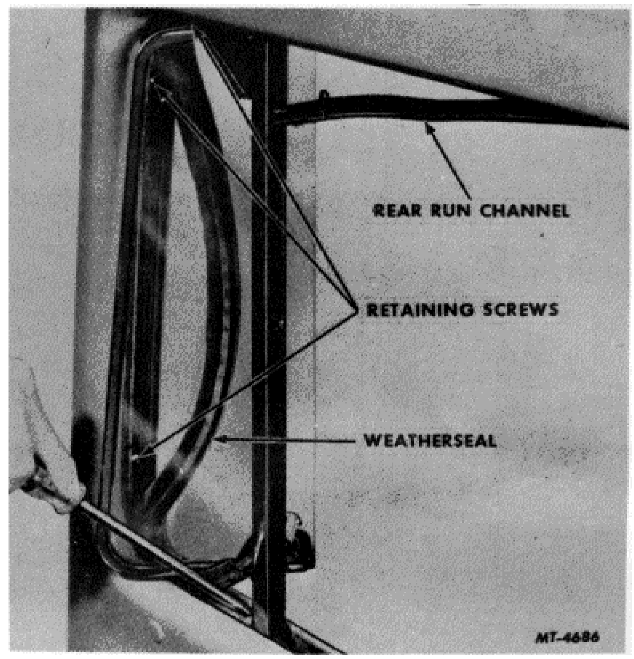


Fig. 17

3. Slide top of door glass vent window toward rear of door and remove vent window and front channel from cab door, Fig. 18.
4. Loosen retaining screw from door vent glass window tension spring clip.

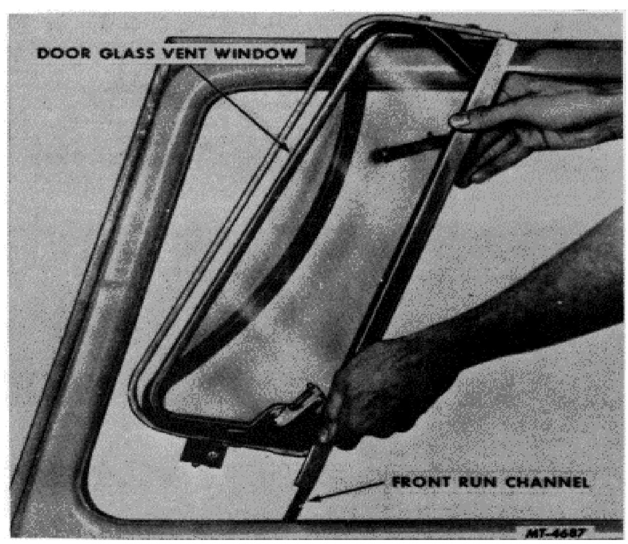


Fig. 18

5. Remove door glass vent window upper pivot screw and lock washer from vent window cradle.

6. Remove door vent wing and glass from cradle.

7. Remove door vent glass window weatherseal.

8. Center punch four rivet heads inside front run channel, Fig. 19.

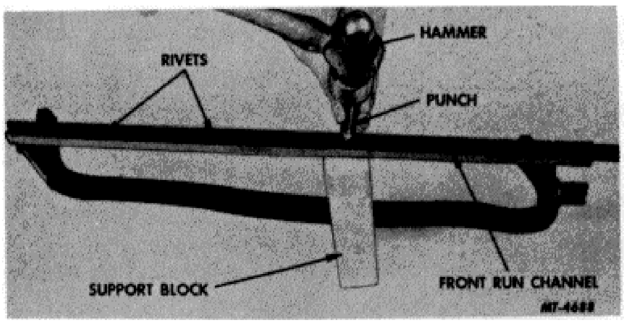


Fig. 19

9. Remove the four rivet heads using a 1/8 inch drill, Fig. 20.

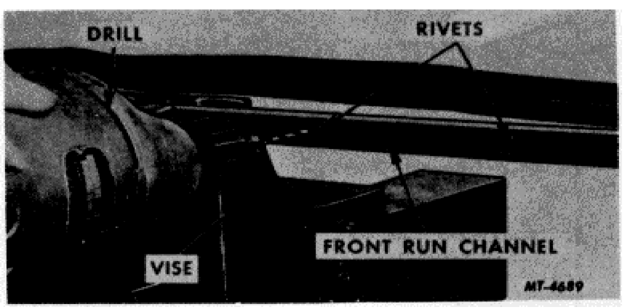


Fig. 20

10. Remove front run channel and weatherstrip from vent glass window frame.

To Install:

Position the front run channel and weatherstrip into vent glass window frame and secure with four rivets.

Door vent glass window and front run channel installation is accomplished by reversing the foregoing removal procedure.

NOTE

To assist in installing the vent glass window weatherseal, coat the seal channel with soap solution.

CAB DOOR LOCK AND REMOTE CONTROL

The cab door lock and remote control assembly must be removed and installed as a unit.

To Remove:

1. Remove 3 screws securing door lock assembly to door, Fig. 21.

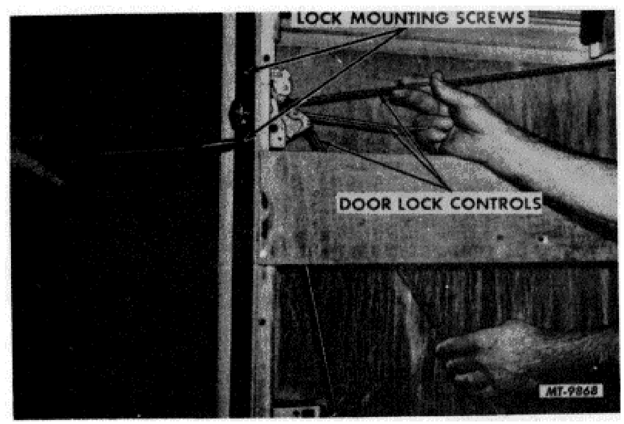


Fig. 21

2. Disconnect door lock remote control rods from outside door handle, Fig. 22.

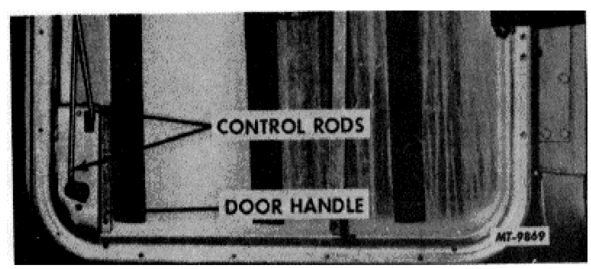


Fig. 22

3. Remove door lock assembly from door.

To Install:

Reverse the foregoing procedure for installation.

CAB DOOR HANDLES To remove the/cab outside door handle, proceed as follows:

1. Remove door lower panel as previously outlined under "CAB DOOR GLASS REMOVAL AND INSTALLATION."

2. Remove door lock remote control rods from door handle, Fig. 22.

3. Remove two nuts and washers securing outside door handle to mounting bracket, Fig. 22.
4. Pull door handle assembly out of door.

To Remove Cab Inside Door Handle:

1. Remove cab door upper panel as outlined under "CAB DOOR GLASS REMOVAL AND INSTA LLA TION."
2. Disconnect door lock remote control rod from inside door handle, Fig. 7.
3. Remove two nuts and washers securing door handle to mounting bracket, Fig. 7.
4. Remove door handle.

To Install:

Reverse the foregoing procedures for inside and outside door handle installation.

CAB DOOR LOCK CYLINDER

To remove the lock cylinder from the lock case, the lock case and shaft assembly must be removed from the door before the lock cylinder can be removed.

To Remove:

1. Remove outside door handle as outlined under "CAB DOOR HANDLES."
2. Remove lock cylinder case from door handle.
3. Place key in lock cylinder and insert a thin knife blade in the small hole in the side of the lock case. Lift up on lock cylinder retaining spring with knife blade, turn cylinder slightly to left and pull out.

To Install:

Reverse the foregoing procedure for lock cylinder installation.

CAB DOOR OPENING WEATHERSEALS

Rubber weatherseals are cemented to the cab door opening flange and form a weathertight seal around door opening when the door is closed.

To Remove:

1. Pull old upper weatherseal from cab door opening flange.
2. Remove door sill plate and remove door lower weatherseal.

To Install:

1. The cab door opening flange and outer edge of front floor panel must be cleaned free of all old cement or dirt before installing new seals.
2. Coat door opening flange with rubber cement.
3. Press new upper weatherseal into place on door opening flange.
4. Coat outer edge of floor panel with rubber cement.
5. Press new lower weatherseal into place on edge of floor panel.
6. Reinstall door sill plate.

SUN VISOR

To remove the sun visor, take out the three screws securing the visor support bracket to the cab header.

WINDSHIELD

The windshield is of two-piece construction and the glasses are formed to fit the windshield opening in the cab. A one-piece moulded weatherseal (weatherstrip) fits around the edge of both glasses and secures the glass to the cab windshield opening. The windshield is installed from the front of the cab. In replacing the windshield it is recommended that a new weatherseal be used at all times. A used weatherseal is apt to be stretched or deteriorated and should not be reused when installing new windshield.

To Remove:

If the windshield is not damaged and it is desired to replace the weatherseal only, it is advisable to first cut away the portion of the seal which is moulded around the flange in the cab, Fig. 23.

Cutting away the windshield weatherseal will allow easier removal of the windshield and lessen the possibility of breaking or cracking the glass being removed. NOTE: Before removing windshield, it will be necessary to remove both windshield wiper arms and blades. When replacing the cab windshield glass, the flange at the windshield opening in the cab must be cleaned free of all old sealing compound or dirt before installing a new windshield.

NOTE : To assist in installing the cab windshield glass, coat weatherseal with a soap solution.

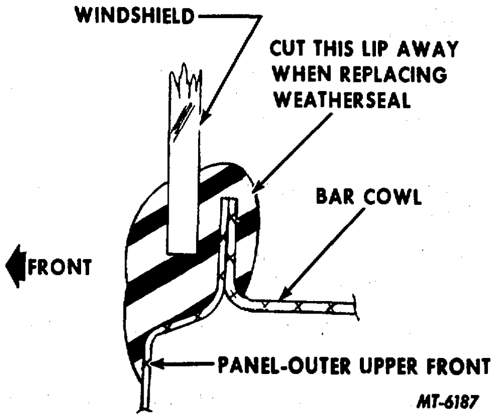


Fig. 23

To Install:

1. Carefully place the moulded weatherseal (weatherstrip) around the edge of the glass as shown in Fig. 24.

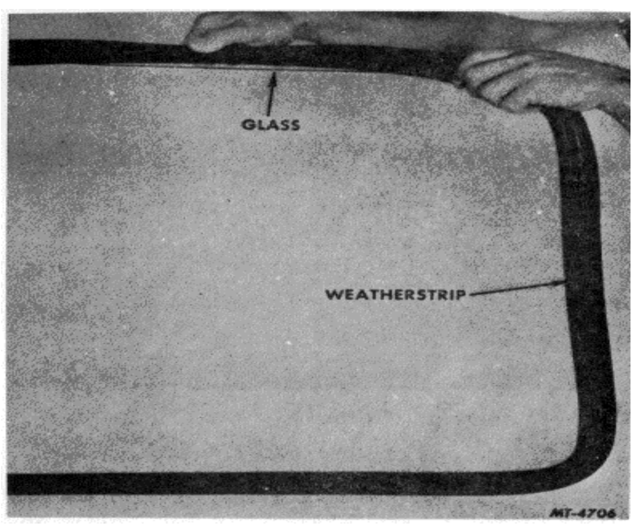
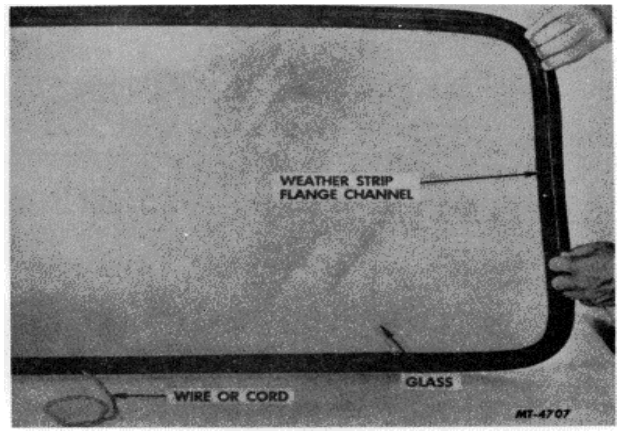


Fig. 24

2. Place a chalk line cord in the weatherseal flange channel. Work the cord into the weatherseal, being careful to keep the cord straight and free of kinks, Fig. 25.
3. With an assistant, carefully place the windshield, with weatherseal attached, in position in the cab opening. The cord used for installing the glass must be installed in the seal with the ends at the bottom of the glass.



4. With one man working from inside the cab and the other serving to press the glass inward, grasp the end of the cord (either end of cord) as shown in Fig. 26.

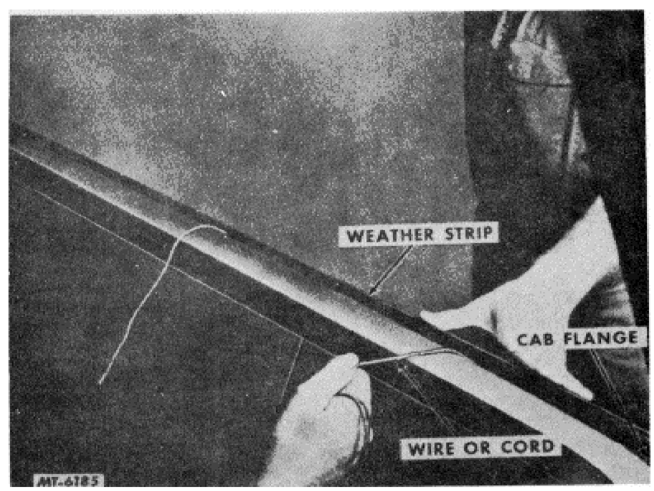


Fig. 26

5. Carefully draw the cord from the flange channel in the weatherseal; bring the lip on the channel over the cab flange. Draw one side of the cord out of the weatherseal until the cord has traveled completely around to the top center of the glass. It is not important which side of the weatherseal is drawn over the cab flange first, Fig. 27.
6. Leave the one end of the cord at the top center of the glass, then grasp the opposite end of the cord to complete the drawing operation around the opposite side of the glass to within approximately 12" of completing the drawing operation, Fig. 28.

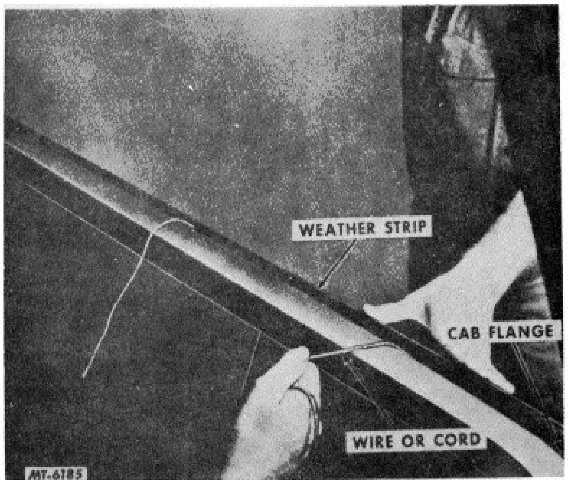


Fig. 27

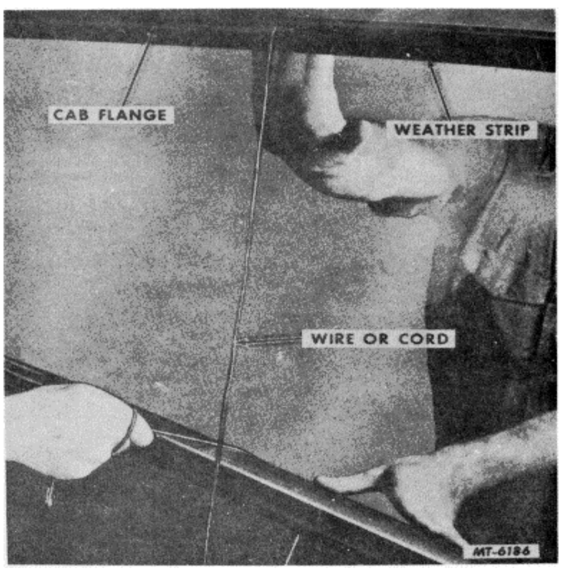


Fig. 28

7. Before completing the drawing operation at the top of the windshield weatherseal, hold the cord which was first pulled around the edge of the glass in one hand to prevent its being drawn out of position; then carefully pull the opposite end of the cord to complete the drawing operation, Fig. 29. During the drawing operation the man outside the cab must carefully press inward.

8. Upon completion of the drawing operation press the weatherseal firmly against the cab flange to bring the seal to its seat in the cab

opening. If the weatherseal does not fully engage the contour of the cab opening, a small amount of nonhardening sealing compound can be injected between the weatherseal and the cab. Be sure to wipe away excess sealing compound before it becomes set, Fig. 30.

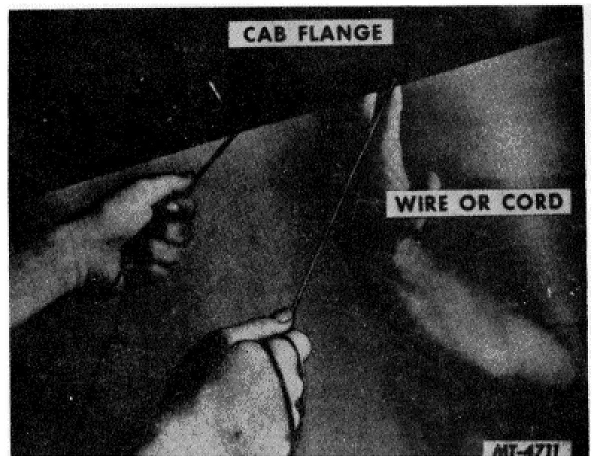


Fig. 29

Fig. 30

CAB REAR WINDOW GLASS

The cab rear window glass is secured to the cab with a onepiece weatherseal. The weatherseal fits around the edge of the glass and ie so moulded that it secures the glass to the cab window opening by fitting over a flange located in the window opening on the cab.

The rear window glass is installed from the inside of the cab. When replacing the glass, a new weatherseal should be used. Old weatherseals are apt to be stretched or deteriorated and should not be reused when installing new window glass.

If the glass is not damaged and it is desired to replace the weatherseal only, it is advisable first to cut away the portion of the weatherseal which is moulded around the flange in the cab.

The operation of cutting away the rear window weatherseal will allow easier removal of the window and lessen the possibility of breaking or cracking the glass being removed.

When replacing the window glass, the flange at the window glass opening in the cab must be cleaned before installing a new glass.

> **NOTE**: To assist in installing the rear window glass, coat the weatherseal with a soap s olution.

CAB REAR WINDOW GLASS INSTALLATION

Procedure for installing rear window glass is as follows:

1. Carefully place the moulded weatherseal around the edge of the glass.
2. Place a chalk line cord in the weatherseal flange channel, working the cord into the channel around the full length of the weatherseal. Be careful to keep the cord straight and free of kinks. Fig. 31.

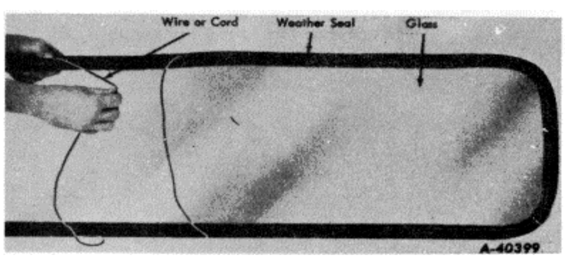


Fig. 31

3. With an assistant carefully place the window glass, with weatherseal attached, in position in the cab opening. The illustration shows the cord used for installing the glass terminating at the top of the glass. The cord may be installed with the ends at the bottom of the glass, Fig. 32.
4. With one man working outside the cab and the other serving to press the glass outward and to steady the glass from the inside, grasp the end of the cord (either end of the cord) as shown in Fig. 33.
5. Carefully draw the cord from the flange channel in the weatherseal, bringing the lip of the channel over the cab flange. Draw the cord out of the weatherseal until the cord has traveled around the glass to within approximately 10" of completing the drawing operation.

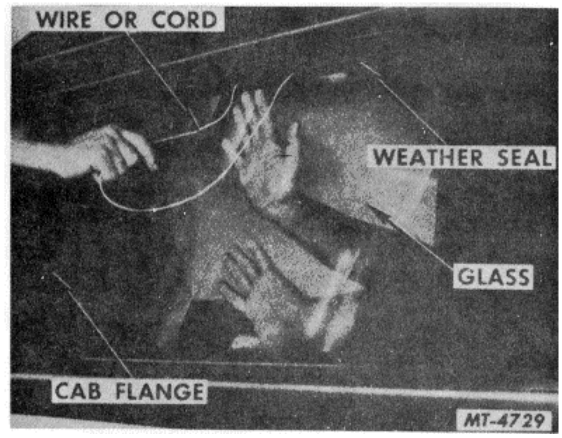


Fig. 32

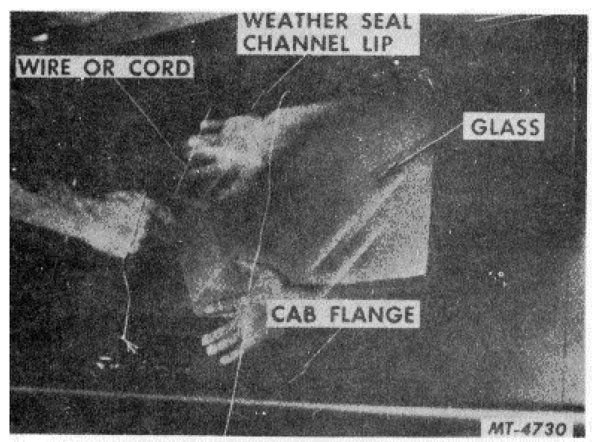


Fig. 33

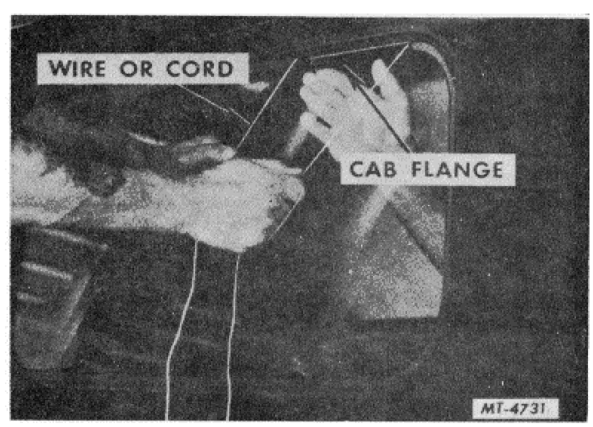


Fig. 34

6. Before completing the drawing operation of the rear window weatherseal, hold the cord which was pulled around the edge of the glass in one hand to prevent its being drawn out of position, then carefully pull the opposite end of the cord to complete the drawing operation, Fig. 34.
7. Upon completion of the drawing operation, press the weatherseal firmly against the cab flange to bring the weatherseal to its seat in the cab opening. If the weatherseal does not fully engage the contour of the cab opening, a small amount of nonhardening sealing compound can be injected between the weatherseal and the cab.

WINDSHIELD WIPER MOTOR

<u>To Remove:</u>

1. Remove the six wiper motor access panel retaining screws, Fig. 35.

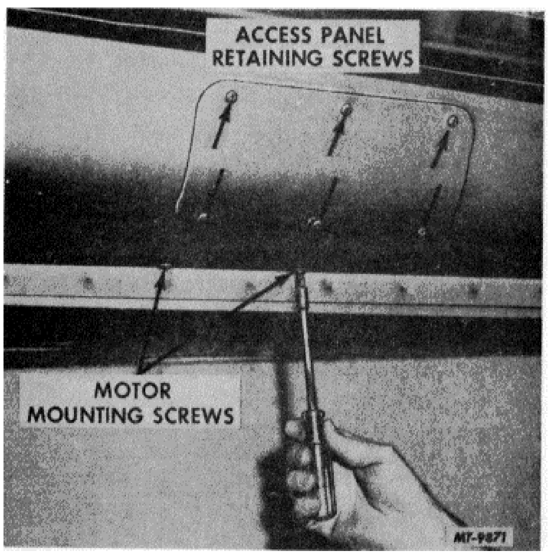


Fig. 35

2. Remove two wiper motor mounting screws, Fig. 35.
3. Disconnect air lines from wiper motor, Fig. 36.
4. Remove arm retaining clip and disconnect arm from motor.
5. Remove wiper motor assembly from cab header, Fig. 37.

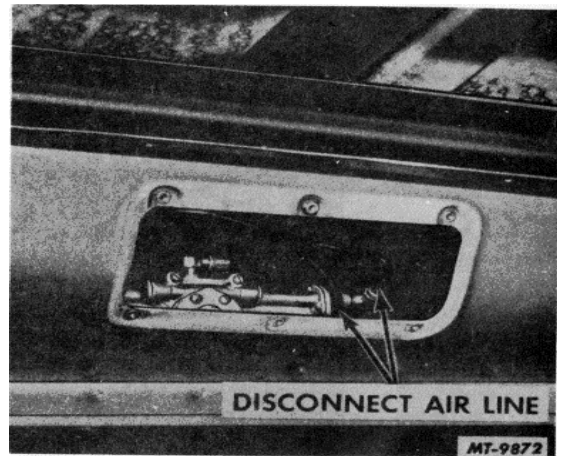


Fig. 36

Fig. 37

<u>To Install:</u>

To install windshield wiper motor in cab, reverse the foregoing procedure.

WINDSHIELD WASHER AND WIPER MOTOR CONTROLS

To remove the wiper motor or windshield washer controls:

1. Remove six screws securing access panel to cab header panel, Fig. 38.

Fig. 38

2. Remove windshield wiper control knob.
3. Remove hex nuts securing wiper motor con trol and/or windshield washer control to access panel.
4. Disconnect air lines from wiper control.
5. Disconnect electrical wiring or air line and fluid hose from washer control, whichever is applicable.
6. Remove wiper motor control and/or washer control.

To Install:

Reverse the foregoing procedure for installation of wiper motor or windshield washer controls.

COWL VENTILATOR

To Remove:

1. Drill out rivets securing vent assembly cab.
2. Remove vent assembly.

To Install:

Position vent assembly and secure with new rivets.

CAB AIR INTAKE

To remove the cab air intake located on right side cowl, take out the seven screws securing it to the cowl panel.

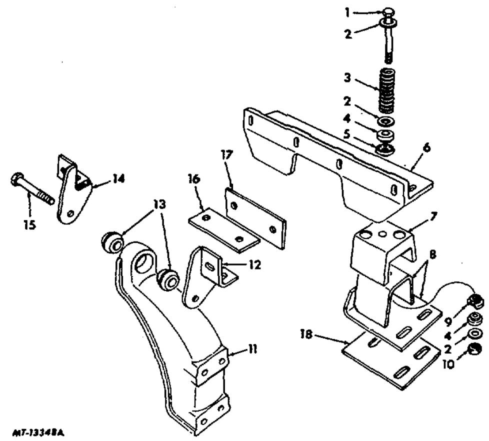


Fig. 41 Cab Mounting (Exploded View)

Legend for Fig. 41

Key Description

1. BOLT, Hex Head
2. WASHER, Flat
3. SPRING, Mounting
4. INSULATOR, Rear Mounting Rebound
5. RETAINER, Rebound Pad
6. BRACKET, Rear Upper Cab
7. INSULATOR, Mounting
8. BRACKET, Rear Cab
9. RETAINER, Rebound Pad
10. NUT, Hex
11. BRACKET, Front Cab Mounting
12. BRACKET, Left Front Body Mounting
13. BUSHING, Front Mounting
14. BRACKET, Right Front Body Mounting
15. BOLT, Hex Head
16. SPACER, Lower Body Mounting
17. SPACER, Upper Body Mounting
18. SPACER, Cab Mounting

Legend for Fig. 42

Key	Description	Metal Thickness	Alloy Spec.
1.	REINFORCEMENT, Side Header	.063	5052-H34
2.	EXTENSION, Reinforcement Upper	.080	.5052-H34
3.	REINFORCEMENT, Rear Header	.080	5052-H34
4.	STRAINER, Back Panel Outer	.080	6061-T6
5.	STRAINER, Back Panel Upper	.080	6061-T6
6.	STRAINER, Horizontal Back Panel	.080	6061-T6
7.	EXTENSION, Header Reinforcement Upper	.080	5052-H34
8.	STRAINER, Back Panel Lower	.080	6061-T6
9.	BRACKET, Socket Mounting	.080	5052-H34
10.	PANEL, Side	.050	3030-0
11.	BRACKET, Socket Mounting	.080	5052-H34
12.	GUSSET, Back Strainer	.090	5052-H34
13.	REINFORCEMENT, Rear Sill	.125	6061-T6
14.	INSERT, Door Opening, Upper	.080	5052-H34
15.	HEADER, Windshield Opening	.080	3030-0
16.	REINFORCEMENT, Windshield Header, Right	.080	5052-H34
17.	BAR, Cowl, Right	.080	5052-H34
18.	PANEL, Assembly Floor, Right	.063	5052-H34
19.	PANEL, Assembly Floor, Center	.063	5052-H34
20.	PANEL, Assembly Floor, Left	.063	5052-H34
21.	CHANNEL, Assembly, Right	.125	6061-T6
22.	REINFORCEMENT, Side Header, Left	.080	5052-H34
23.	REINFORCEMENT, Windshield Header, Left	.080	5052-H34
24.	SUPPORT, Assembly, Muffler Mounting	.100	5052-H34
25.	REINFORCEMENT, Plage Upper, Left	.080	5052-H34
26.	PANEL, Cowl, Outer	.050	5052-H34
27.	PANEL, Sill Side Outer Left	.080	5052-H34
28.	BAR, Cowl Left	.080	5052-H34
29.	INSERT, Door Opening, Lower	.080	6061-T6

Legend for Fig. 42 (Continued)

Key	Description	Metal Thickness	Alloy Spec.
30	PANEL, Dash Upper	.063	5052-H34
31	PANEL, Dash Lower	.063	5052-H34
32	SUPPORT, Assembly, Front Body Mounting Right	.190	5052-H34
33	PANEL, Assembly, Dash Lower Center	.063	5052-H34
34	SUPPORT, Assembly, Front Body Mounting Left	.190	5052-H34
35	PANEL, Dash Lower Left	.063	5052-H34
36	REINFORCEMENT, Dash Assembly Upper	.090	6061-T6
37	PANEL, Lock Pillar, Inner	.050	5052-H34
38	PANEL, Assembly, Side Header Inner	.063	5052-H34
39	PANEL, Windshield Side Inner	.063	5052-H34

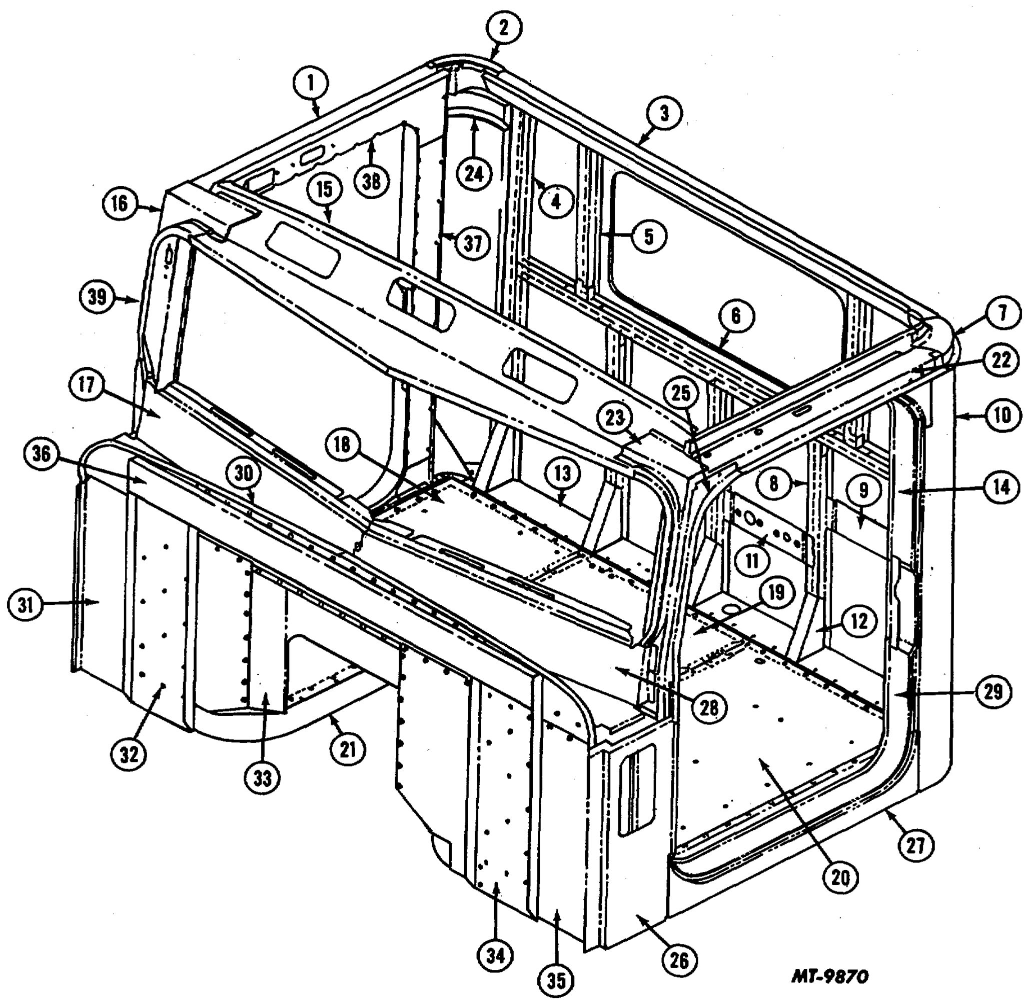


Fig. 42. Cab Structure Sections

CAB MOUNTING

The cab has a four- point mounting. It is secured to the frame at each front corner by brackets and rubber bushing. The rear of the cab is secured in the center at two places to a crossmember with brackets, rubber bushings and rubber insulators. Fig. 41 shows details of the cab front and rear mountings.

CAB REMOVAL

To remove the cab assembly from the chassis, proceed as follows:

1. Disconnect:
    a. Frame-to-cab ground wire.
    b. Air lines at brake valve.
    c. Clutch linkage.
    d. Electrical connections.
    f. Luberfiner hose.
    g. Heater hose.
    h. Speedometer drive cable.
    i. Tachometer drive cable.
    j. Exhaust system.
    k. Throttle linkage.
    m. Steering shaft at gear.

2. Remove:
    a. Gear shift lever from transmission.
    b. Cab mounting bolts.

3. Carefully lift cab from chassis. NOTE: Be certain all items are disconnected.

CAB FLOOR SUBSTRUCTURE

Fig. 42 shows the various parts of the cab structure and the legend provides alloy and material thickness data which will be helpful in the event weld repair is necessary.

There are sections of the cab understructure that, once damaged, must be replaced as a complete assembly. The cab floor substructure, Fig. 43, should be completely replaced should major damage occur. In some cases where the sections are only slightly bent, the parts can be bent back into position or straightened. Where parts are torn, then complete replacement should be made.

Do not heat to straighten any section of the cab understructure. To do so may destroy the strength of the members, resulting in early failure. If these areas cannot be satisfactorily cold straightened, then replacement is required.

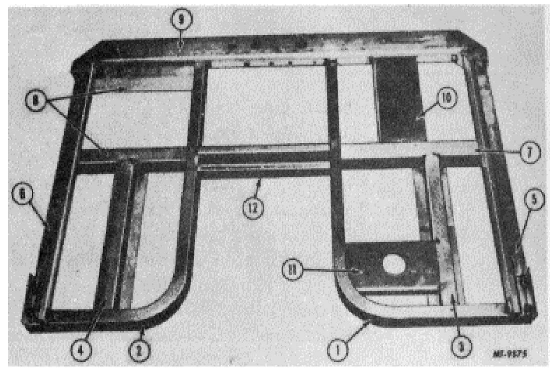


Fig. 43 Cab Floor Substructure

Legend for Fig. 43

Key	Description
1	CHANNEL, Underbody Inner, Left
2	CHANNEL, Underbody Inner, Right
3	SUPPORT, Floor Panel Front, Left
4	SUPPORT, Floor Panel Front, Right
5	SILL, Underbody Side, Left
6	SILL, Underbody Side, Right
7	SUPPORT, Floor Panel, Left
8	SUPPORT, Floor Panel, Right
9	SILL, Underbody Rear
10	SUPPORT, Driver's Seat
11	SUPPORT, Brake Valve
12	CROSSMEMBER, Center

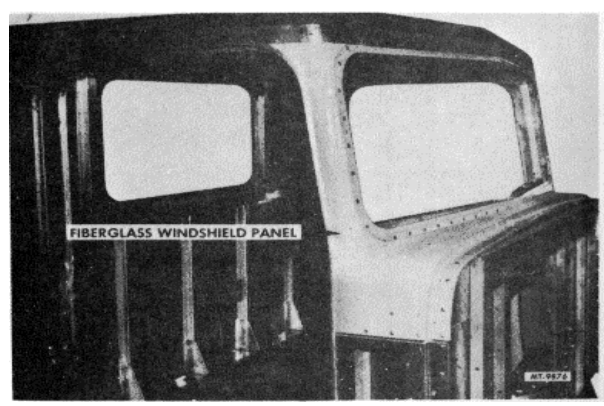


Fig. 44

CAB STRUCTURE

Figs. 44, 45 and 46 show various cab panels and sections and the construction details of them.

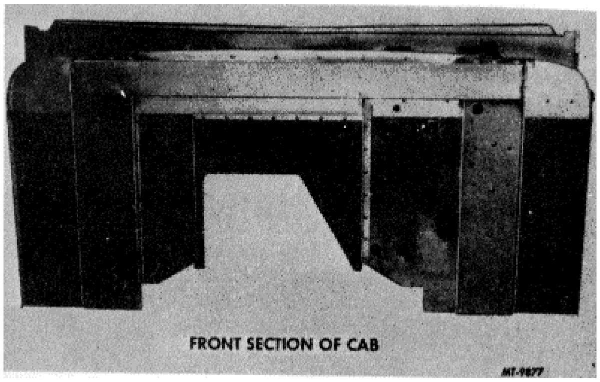


Fig. 45

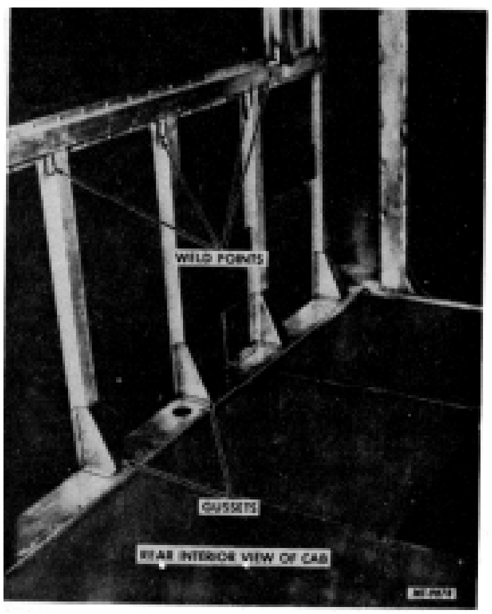


Fig. 46

ADJUSTMENTS

Cab Door Hinge:

T he mounting holes in the cab hinge pillar are oversize to permit adjustment of the door to the door opening.

The door lock striker plate mounting holes in the body are oversize so that the striker plate can be moved in or out to adjust the door to the door opening seal.

Door Vent Glass Tension Adjustment:

1. Remove button plug on inside of door.

2. Working through opening with screwdriver tighten or loosen adjusting screw to provide slight drag on vent window pivot pin.

Cab Door Dovetail:

The cab door dovetail can be adjusted for proper door alignment by loosening the attaching screws.

BODY MOUNTINGS

When mounting bodies on frames, always place tight-fitting spacer blocks inside the frame channels at points where the U-bolts are to be installed. These filler blocks will support the frame flanges and prevent bending by the U-bolt.

The filler blocks should be so constructed that they will be form fitting in the channel and so constructed that the body U-bolt will rest in a recess in the block to prevent its loss should the bolt become loose. Fig. 47 illustrates the construction of such a block.

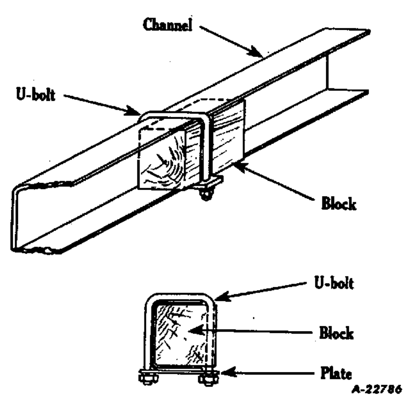


Fig. 47

Well-seasoned wood should be used for filler block construction.

LUBRICATION

There are a number of points on the cab where periodic application of lubricant will increase the service life of the parts as well as eliminate objectionable squeaking.

New vehicles are properly lubricated at the factory and before they are delivered to the customer. After the vehicle is placed in operation, regular lubricant intervals based on type of service and road conditions should be established. Thorough lubrication at definite intervals will add greatly to the service life of the vehicle and will reduce the overall operating expense of the vehicle.

Following are points on the cab to be lubricated and the type of lubricant to use. Wipe off all lubrication points before applying new lubricant. When lubricating the points, apply lubricant sparingly so as not to allow excess lubricant to get on the operator's clothing.

LUBRICANT POINT	LUBRICANT
Door Dovetail	Lubricate with Stick Lubricant
Door Hinge Pins	Light Engine Oil
Door Lock Assembly and Remote Control	Lubriplate 110 or Equivalent
Door Latch Striker Plate	Lubricate with Stick Lubricant
Door Lock Cylinder	Lock Oil
Door Window Regulator, Gear Teeth, Arm Pin and Slide	Lubriplate 110 or Equivalent
Seat Adjuster	Lubriplate 110 or Equivalent
Hood Pivot Bar	Lithium 12- Hydroxy Stearate EP Grease
Butterfly Type Hood Hinge,	Light Engine Oil

FRONT END SHEET METAL

Fender

To Remove:

1. Disconnect headlight and directional light wiring.
2. Remove fourteen bolts, lockwashers and nuts securing fender to chassis.
3. Lift off fender.

To Install:

To install fender, reverse the foregoing procedure.

Fender and Splash Panel Assembly

To Remove:

1. Raise hood.
2. Remove four nuts securing wiring harness clips to splash panel.
3. Disconnect headlight and directional light wiring.
4. Disconnect horn wire.
5. Remove fender grommet.
6. Pull headlight wiring through grommet opening.
7. Remove bolts securing fender to front and rear support braces.
8. Lift off fender and splash panel as an assembly.

To Install:

Reverse the foregoing procedure for fender and splash panel installation.

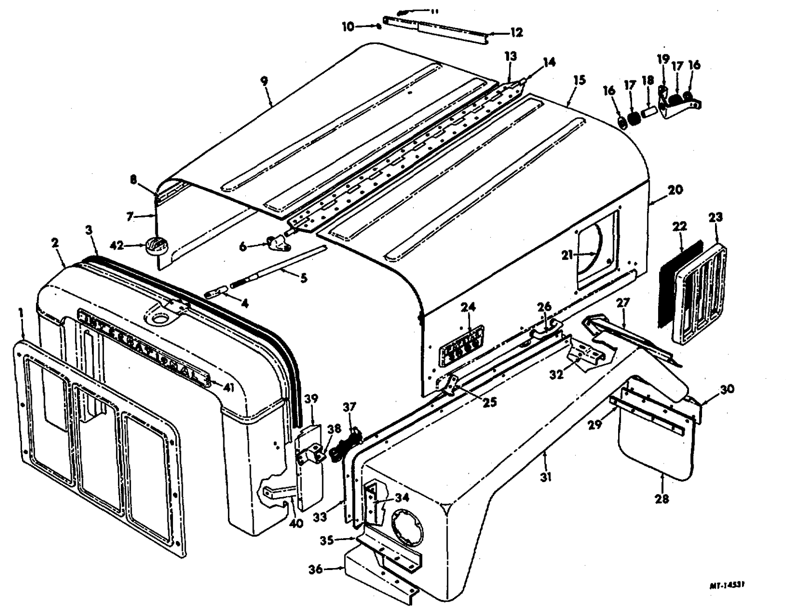


Fig . 48. Exploded View of Front End Sheet Metal Leg

Legend for Fig. 48

<u>Key Description</u>

1. Grille, Radiator
2. Shell, Radiator
3. Seal
4. Eye, Rod End
5. Rod, Radiator Stay
6. Retainer, Center Hood Rod
7. Panel, Hood Side Right
8. Pin, Hood Side
9. Panel, W/Top and Side Hinges, Hood Right
10. Washer, Spring
11. Bolt, Shoulder
12. Prop, Hood Assembly
13. Hinge
14. Pin, Hood Center Hinge
15. Panel, W/Top and Side Hinges, Hood Left
16. Washer, Flat
17. Insulator, Stay Rod Bracket
18. Spacer, Rod
19. Bracket, Stay Rod
20. Panel, Hood Side Left
21. Plate, Air Cleaner Intake Cover

<u>Key Description</u>

22. Screen (Make Locally)
23. Deflector, Air Intake
24. Plate, Name
25. Bracket, Hood
26. Handle, Hood Lift
27. Support, Fender Rear Mounting
28. Guard, Mud Flap
29. Bar, Reinf.
30. Bracket, Flap Mounting
31. Panel, Fender
32. Channel, Fender Rear
33. Panel, Splash
34. Reinf., Splash Panel to Fender
35. Angel, Fender Front Mounting
36. Support, Fender Front Left
37. Latch, Hood Hook
38. Bracket, Latch
39. Panel, Filler
40. Brace, Hood Filler Panel
41. Plate, International
42. Cap, Radiator

Grille

To remove grille, take out six machine screws and lift off grille.

Hood

To Remove:

1. Raise hood.
2. Remove two machine screws securing either front or rear hood bracket.
3. Remove one bolt each securing right and left hood support brace to hood.
4. Pull hood hinge rod out of remaining bracket.
5. Lift off hood assembly.
6. If necessary, hood can be separated into four pieces by pulling out piano hinge rods.

To Install:

Reverse the foregoing procedure for hood installation.

Radiator Sheet Metal Shell

The most practical method of replacing the radiator sheet metal shell is by removing the grille, radiator shell, radiator, shutters and fan shroud together as an assembly.

To Remove:

1. Drain radiator.
2. Remove hood (see hood removal). Remove fan assembly.
3. Disconnect shutter linkage at bottom of shutter assembly.
4. Disconnect horn wire.
5. Disconnect radiator upper and lower hose.
6. Disconnect water filter assembly.
7. Remove power steering reservoir.
8. Disconnect air bleed and deaeration hoses.
9. Remove bolts securing radiator upper stay rods to radiator.
10. Remove bolts securing radiator lower stay rod brackets to radiator.
11. Remove two radiator lower mounting bolts.
12. Remove radiator and shell assembly.

To Install:

To install radiator and shell assembly, reverse the foregoing procedure.

Separation of Radiator Core, Shell and Related Components

1. Remove six machine screws and take out grille.
2. Remove eight capscrews and lift off shutter assembly.
3. Remove eight capscrews securing fan shroud.
4. Take out eight capscrews and remove radiator core from sheet metal shell.

To reassemble radiator, shell and related components, reverse the foregoing disassembly procedure.

PROCEDURES AND INSTRUCTIONS FOR WELDING ALUMINUM CABS, BODIES AND STRUCTURES

INDEX

WELDING PROCEDURES, INSTRUCTIONS

AND SAFETY PRECAUTIONS

With the introduction of aluminum into the manufacturing of truck cabs, bodies and cab under structures, it becomes necessary for the operator of welding equipment to understand a few special precautions in order to assure satisfactory work when it becomes necessary to perform any welding on aluminum.

Generally, the operator of conventional steel welding equipment will not find it difficult to handle the welding of aluminum, providing he becomes familiar with the metal-arc inert gas (MIG) method of welding. This manual covers basic principles in making repairs on aluminum equipment using the SE-2165 Linde SWM-15 Short Arc Welder, While similar welders are available from other manufacturers, the SE-2165 (Fig. 1) welder is illustrated herein. NOTE The gas containers shown in Fig. 1 are not included with the SE-2165 but are obtained locally.

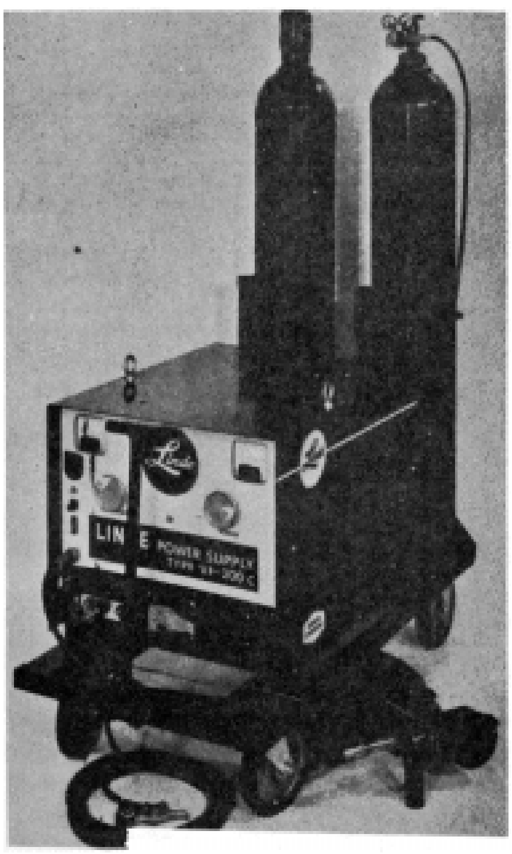


Fig. 1. Typical Arc Welder
(SE-2165 Linde VI-200C Unit Shown)

MIG welding is a process in which a consumable bare electrode is fed into a weld at a controlled rate while a continuous blanket of inert gas shields the weld zone from contamination by the atmosphere. (Fig. 2) MIG welding produces high-quality welds, at high welding speeds, without the use of flux.

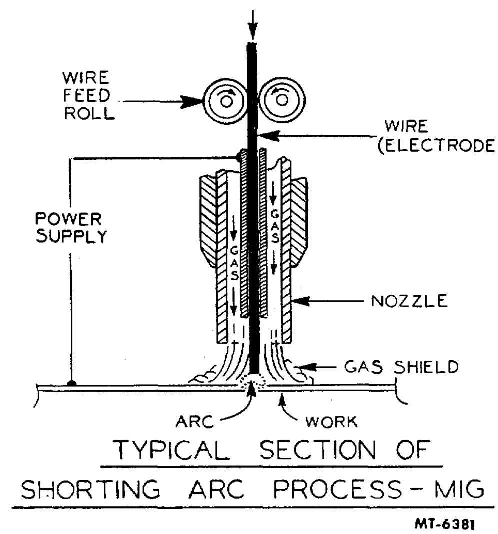


Fig. 2. Diagram Showing Details of Shorting Arc Process and the Inert Gas Shielding

The MIG process includes two distinctive techniques or process variations, known as shorting arc and spray arc welding. Shorting arc welding operates on generally lower arc voltages and amperages than spray arc, pinpoints the arc heat and produces a small fast freezing weld puddle. The spray arc process provides an intensely hot, higher voltage arc and higher deposition rates.

TYPICAL SHORTING ARC WELDING CONDITIONS

Plate Thickness (inches)	Type of Joint	Wire Diam. (inches)	Argon Flow (cfh)	Amperes (DCRP)	Voltage (Volts)	Approximate Wire Feed Speed (IPM)
0.040	Fillet or Tight Butt	0.030	30	40	15	240
0.050	Fillet or Tight Butt	0.030	15	50	15	290
0.063	Fillet or Tight Butt	0.030	15	60	15	340
0.093	Fillet or Tight Butt	0.030	15	90	15	410

MIG shorting arc welding employs low cur-rents, low voltages and small diameter wires. The wire short circuits to the workpiece an average of 100 times a second. Metal is trans-ferred with each short circuit (arc outage) and not across the arc.

The MIG shorting arc technique with its low heat input minimizes distortion and is particularly useful for welding thin gauge materials in all positions. Shorting arc welding will tolerate relatively poor fit-up.

When the spray arc welding technique is used, the principal requirement for the mechanical transfer of metal from the wire to the work is a high current density. Spray arc welding is a high deposition rate technique as compared to the shorting arc technique. It is recommended for 1/8 inch and thicker sections requiring heavy, single or multi-pass welds or for any filler pass application where speed is advantageous.

PREPARATION FOR REPAIRS

Surface Preparation (Cleaning)

Sound welding requires that all foreign material be removed from the areas to be welded. This includes dirt, loose metal particles, moisture, paint, heavy oxide coatings and particularly grease and oil.

Loose materials such as dirt and metal particles can be removed by washing and scrubbing with water. Drying is important to insure that no water or condensed moisture is pre-sent in the area to be welded. Both sides of the surface to be welded must be cleaned.

All paint should be removed from the weld area and 6 inches to both sides to allow full visual inspection of the extent of the failure. This will insure that the heat of welding will not cause decomposition of the paint and create a toxic atmosphere or interfere with making a good weld.

TYPICAL SPRAY-ARC WELDING CONDITIONS

Plate Thickness	Preparation	Wire Diameter (in.)	Argon Flow (cfh)	Amperes DCRP	Voltage
.250	Single Vee Butt (60° included angle) Sharp nose Backup strip used	3/64	35	180	24
	Square Butt with backup strip	3/64	40	250	26
	Square Butt with no backup strip	3/64	35	220	24

Removal of grease and oil is best accomplished by using a suitable solvent. Butyl alcohol is a good degreasing agent since it evaporates quickly and leaves little residue. Slightly more residue is left by "per-Trolene, Solvent M-2"1 (John D. Moore, Nutley, N.J.), but this solvent has the advantage of a relatively high flash point.

Both removal of oil residues and the removal of aluminum oxides may be obtained by employing butyl alcohol-phosphoric acid type solutions such as "Deoxidine 126, 526 and 670 (American Chemical Paint Co.), "Met-l-Prep No. 10" (Nielson Chemical Co.), "Ferrotone" (Penetone Co.), "Rusticide No. 50" (Rusticide Products Co.), and "'Turco - W.O. No. 1" (Turco Products, Inc.).

The use of solvents requires good ventilation and the use of those containing phosphoric acid requires rinsing with water. Solvents should never be used where evaporation is hindered or residue entrapped by the joint to be welded.

An example would be the solvent cleaning of the edges of two abutting plates. Here, the plate edges and surfaces would be cleaned prior to positioning for welding. No solvent would be used after the plates are placed in fixtures.

Reduction of the aluminum surface oxide to a minimum by means of a wire brush or steel wool will increase the welding arc stability and allow improved metal flow and coalescence of the weld pool. Manual wire brushing is preferable, but machine brushing can be used providing the operator uses light pressure. In any case, a stainless steel brush must be used to prevent contamination of the aluminum surfaces. Machine brushing with heavy pressure between the brush and work piece can result in imbedding foreign material into the surface. The wire brush should be free from oil, grease and rust and have sharp bristles. Remove grease and oil from the weld area by solvent cleaning before wire brushing.

Chipping

Chipping provides a rapid method for removal of flaws and excess weld material and for grooving the backside of the two-side weld (Fig. 3). Chisels should be shaped much as those used in woodworking, coming to a sharp knife edge. The knife edge and smooth heel of the chisel allow rapid removal of metal, leaving a smooth surface finish. The long, curved heel of the chisel affords the operator a means of controlling the depth of cut.

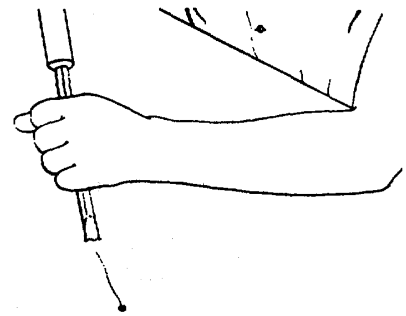


Fig. 3. Chipping Along Length of Crack. Chipping is not necessary on Sheet Aluminum.

Grooves are chipped and fillet welds removed by means of round gouges of proper radius so that the prepared joint will have no sharp corners. A further benefit of the knife-edged chisels becomes apparent when back-chipping a weld. The metal chip will split into a "ram's horn" until fused metal depth is reached. The chipping procedure is usually applied where the aluminum is heavy enough to withstand the operation.

Removal of Dinges and Dents

Reshaping of aluminum parts may be accomplished by means of rubber or wood mal-lets. Steel hammers and hydraulic jacks should be used with wood blocks. Avoid local thinning from heavy steel mauls or hammers. Final operations may consist of planishing with smooth, polished steel tools such as those used in auto body repair work.

Heating by gas torch up to but not exceeding 400°F will make straightening much easier. Temperatures in excess of 400°F are unnecessary and can lead to overheating. Ignition of, an ordinary kitchen match occurs below 400°F. A more accurate means of tempera-ture indication is to use "Tempilstiks" which mark only when the temperature of the material exceeds the 350°, 375° or 400°F value designated on the crayon.

Fiber Glass Repairs—Dents etc.

In areas of the cab surfaces where minor dents occur or where the skin has not been ruptured or torn, the use of plastic putty or fiber glass and resin can be considered. Where the cab skin is cracked and requires welding, the fiber glass repairs can also be used to minimize sheet metal work in order to obtain finished surfaces. The welded repair is first made to assure restoration of the skin strength. After welding, the weld area is depressed below the surface of the surrounding area and the depression then filled with fiber glass or plastic putty.

ALUMINUM ALLOYS
Sheet Alloys (Skin),

Aluminum, like many metals, is not generally used in a "pure" form. In order to achieve certain desirable properties, it is alloyed with other metals. In some applications, specifications call for a class of aluminum alloys containing magnesium as the principal alloying ingredient. Those commonly used in sheet form are 5052, 5154, 5086, 5454; while alloys 5154, 5356 and 5554 are the commonly used welding electrodes.

Structural Alloys
Rolled and extruded structural shapes used in underframing and other applications may be alloy 6061, 6062 or 6063. These are heat treatable alloys having both magnesium and silicon as alloying ingredients. They are readily weldable to each other and to the aluminum-magnesium series of alloys with 5154 and 5356 welding electrode and wire.

Crack Repair
Where cracks are to be repaired in the aluminum sheet or skin, they must be prepared properly before welding; however, it should be determined before making the repair whether some additional reinforcement in the crack area is required to prevent further problems. Simple crack repair is as follows:

1. Locate the extent of the crack area or length. Often the fine line of the entire crack length is not visible. Use a dye penetrant to aid in locating the crack length. Brush a small amount of the dye over the suspected crack area. The dye will expose the crack. If the SE-2127 Portable White Line Magnetic Inspection Tool is available, it can be used to expose cracks in aluminum. This tool utilizes a magnetic field in conjunction with a white powder to indicate the crack. Complete detailed instructions for operating the SE-2127 are included with the tool (Fig. 4).
2. After locating the crack and its extent, drill one 1/8" hole at each end of the crack to prevent further progress of the crack. (Fig. 5).
3. Using a thin chisel, open the crack a small amount by driving down against the crack along its full length. Do not widen the crack excessively. About 1/16" width will suffice. Do not run the chisel past the drilled holes at the crack ends (Fig. 3).

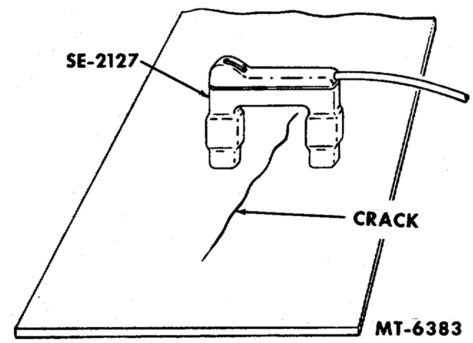


Fig. 4. Showing use of SE-2127 Portable White Line Magnetic Inspection Tool. The crack area is dusted with a special white powder which clearly indicates the crack length when the magnetic field across the crack is generated.

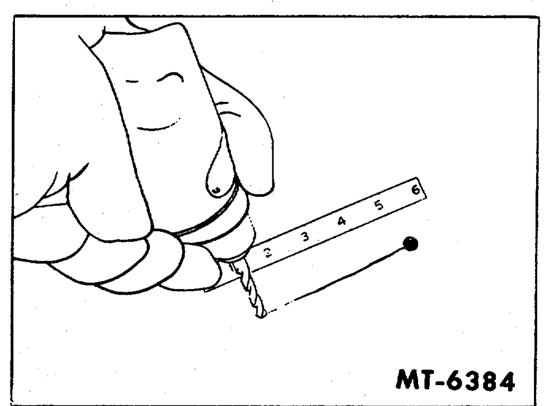


Fig. 5. Drilling at the crack ends to stop further cracking.

4. After the crack is widened, the work must be cleaned on both sides if possible. Use a stainless steel brush and make certain that all dirt, grease or paint has been removed.

5. Apply the weld to the prepared area by

making a short run of weld at one end of the crack, starting at the drilled hole. This weld should be about one inch (1") long. The purpose of this short weld is to prevent the forming of a crater in the metal surface when the welding is completed (Fig. 6).

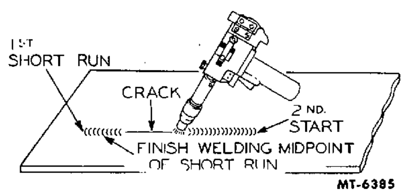


Fig. 6. Showing method of applying short run of weld.

6. Having completed the short weld, working at the opposite end of the crack start the final weld run at the drilled hole and carry this weld run up onto the short run section previously applied. Stop the final weld midway on the short run section. This procedure will prevent the leaving of a crater in the metal surface as indicated above. A crater in the skin surface could cause cracking. Tilt the torch or welding gun away from the direction of travel as shown in Fig. 7. If the crack repair is not exposed and is not to be painted, no further work is required.

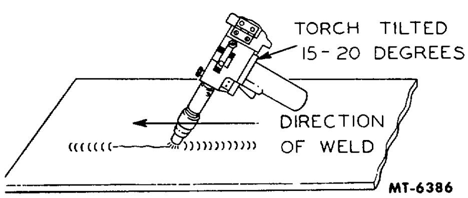


Fig. 7. Direction of weld and tilting torch.

Where the weld is to be finished and painted, proceed as follows:

<u>Finishing Weld Repairs</u>

To minimize working of the sheet metal surfaces, avoiding grinding and other metal work, the repaired crack or section of the cab or panel skin can be finished as follows:

1. Using a suitable driving tool, work the weld down below the surface of the surrounding area, Fig. 8. The weld should be depressed or recessed only enough so that it can be covered with plastic or fiber glass material.
2. Thoroughly clean the welded area using a stainless steel brush.
3. Proceed with the repair as outlined under "Plastic Putty Repair", or, if necessary, use the procedure covered under "Fiber Glass Repair".

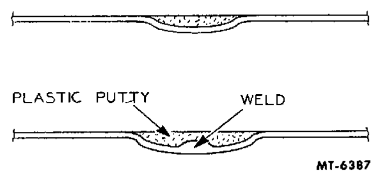


Fig. 8. Application of Plastic Putty

NOTE: When drilling in aluminum, use sharp drills in good condition. Avoid the use of files.

FIBER GLASS AND PLASTIC PUTTY REPAIRS

The use of plastic putty or fiber glass repairs on aluminum cab surfaces can be considered when the repair is made to surfaces that are not under strain. Generally, these are the flat surfaces of cab sections. Also, small holes in the cab skin (under 1/4" in diameter) may be filled with plastic putty or fiber glass materials. (Fig. 9). The use of plastic putty and fiber glass will minimize sheet metal work on the aluminum surfaces and reduce the possibility of further unsightly damage.

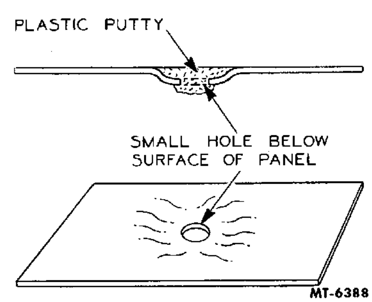


Fig. 9. Repair of small hole in aluminum sheet

In all aluminum cab surface repairs, the use of emery wheels to smooth surfaces should be kept to a minimum to prevent grinding the material to the extent that the skin is thinned down excessively. To minimize grinding, the plastic putty or fiber glass patch or fill can be smoothed very nearly to the surrounding metal surface level. The use of polyethylene sheeting over the new patch will impart a smooth surface to the plastic or fiber glass. Apply the patch or filler as follows:

Plastic Putty Repairs

1. Remove all old paint from the area to be repaired. Use paint remover or fine sandpaper. Avoid the use of a power driven emery wheel or disc. Do not use files on the aluminum surfaces.
2. Clean the area to be filled. Wipe off loose paint or dust.
3. Apply a sufficient amount of plastic putty to fill the dent or depression.
4. Place a piece of plastic sheet (polyethylene) over the plastic putty.
5. Using a straight edge or edge bent to match the surface surrounding the repair, strike off the filler. Use a light pressure on the straight edge working the filler down to the level of the surrounding surface. The polyethylene sheet between the straight edge and filler material can be left in place until the filler hardens.
6. After the repair hardens, lightly sand the repair to a feather edge and paint.

Fiber Glass Repair

Where larger dents are to be filled, fiber glass cloth or fiber glass mat can be used. If this is required, proceed as follows:

1. Remove paint from area to be repaired.

The paint must be removed well back from the area to be covered with fiber glass since fiber glass will not stick to painted surfaces.

2. Wipe the area to be repaired with clean cloth to remove loose paint or dust.
3. Prepare the resin mix according to instructions furnished with the fiber glass kits.
4. Cut a piece of plastic sheet (polyethylene) considerably larger than the repair area.
5. Prepare a patch consisting of fiber glass cloth or mat saturated with resin and of sufficient quantity to nearly fill the repair.
6. Place the patch mixture on the plastic sheet and position the mix over the indented area.
7. Using a straight edge, smooth the patch mix to fill the depression. Leave the plastic sheet in position until the fiber glass hardens.
8. After the repair hardens, remove the plastic sheet and where necessary, apply plastic putty to bring the repair up to the level of surrounding surfaces. Follow the instructions under "Plastic Putty Repair" when using the plastic putty.
9. Lightly sand the area repaired--then paint as required.

NOTE: Avoid the excessive use of power driven grinding discs or wheels on aluminum cab surfaces. Careless use of these tools can quickly cut through or thin down the cab skin.

PREPARATION OF ALUMINUM FOR PAINTING

Cleaning and Painting

The most important step in obtaining satisfactory paint adhesion is that of proper surface preparation. In every case, the surface to be primed or painted should be cleaned free from all oxide, scale, dirt, grease, oil and moisture. Prepare unpainted aluminum surfaces as follows:

1. The chemicals used in this process may discolor top coat enamels. All adjacent enamel finish should be protected from direct exposure to the chemicals by masking with paper or polyethylene sheeting.
2. Dilute "Alumiprep #33" with Z parts of water before using. Use a plastic, porcelain or glass vessel.
3. Freely apply the diluted Alumiprep #33 to the aluminum surface by swabbing with a brush, mop, or cloth, Swab surface for about 30 seconds, Re-apply Alumiprep and swab for an additional 30 seconds.

Flush away the spent Alumrniprep with clean water or wipe with a clean wet cloth.

Wring cloth free of clean water and rewipe. Then wipe with a clean dry cloth.

4. Apply undiluted "Brush-On Alodine #1201" to the metal surface, brushing or swabbing the surface for about 30 seconds. Re-apply Alidone #1201 liberally and allow to remain for a minimum of 2 minutes. DO NOT ALLOW THIS MATERIAL TO DRY ON THE METAL SURFACE. Flush the surface with cold water or mop with a clean wet cloth.
5. Allow the surface to air dry. DO NOT WIPE DRY. The treated aluminum surface should now have a gold hue.
6. Apply one light coat of zinc chromate primer. The first coat of primer may be lightly sanded if a second coat is to be applied.

CAUTION

1. The processing materials are acidic.

Rubber gloves and eye protection should be used.

2. The cloths and masking materials should be rinsed in water before disposal. Spontaneous combustion may occur if the chemicals are allowed to dry in cloths or paper.

   NOTE: The Alumiprep #33 and the Brush On Alodine #1201 are both proprietary compounds marketed by the Amchem Products, Inc. The Amchem Products General Offices are at Ambler, Pennsylvania with operations at Ferndale, Michigan and Fremont, California. Generally these products may be purchased from the same sources which handle the Lithoform #2 required for zinc coated steel.

Undercoating

Undercoating materials must not be used as a substitute for priming or painting but must be applied over a primed and painted surface.

Surfaces must be clean, dry and free from oil or grease film. The material may be sprayed on, using 20 to 50 psi fluid pressure and 50 to 70 psi for atomization.

ATTACHING UNLIKE MATERIALS TO ALUMINUM

Bolts and Self-Tapping Screws

All bolts and self-tapping screws must be zinc or cadmium plated. Where bolts, washers, nuts, etc. are used in locations subject to high moisture conditions--as in an insulated body or below the floor line where road splash, mud, etc. can be trapped for a length of time, extra precautions should be taken, such as using a 52S aluminum washer under the bolt head and nut and the entire fastener covered over with a 3M underseal material or some similar material. Machine or self-tapping, countersunk screws through floors should be generously covered with zinc chromate paste sealer before being driven.

Steel (and Brass)

Steel that joins aluminum should be zinc or cadmium plated or completely painted over with primer prior to assembly.

Gasket Materials.

There are a wide variety of rubber, vinyl, fabric, etc. tapes and gasket materials that have been developed particularly to minimize galvanic corrosion. Proper design calls for the use of non-absorbent tapes, gaskets, or sealing compounds in joints with 1/8',' to ¼" overlap necessary to prevent bridging of salt solutions.

Wood

An aluminum to wood joint should be treated in the same manner as a steel joint since certain mild acids are present in the wood which will produce an attack on the metal. The wood should be painted with two or three coats of aluminum paint.

Plug Welding

Plug welding is a method of attaching two sheets or sections by welding one part to another through holes punched or drilled through one or another of the sections. The holes, which should vary in size according to the thickness of the material, are filled with weld metal to bond the two pieces together. Hole sizes for aluminum skin or sheet should range between 3/8" to 1/Z". A sufficient number of weld points should be made to assure firm attachment of the sections, (Fig. 10).

When plug welding material over 1/8" thick, the edges of the holes should be chamfered. Plug' welding should not be applied where the aluminum is under strain or the parts are supporting members.

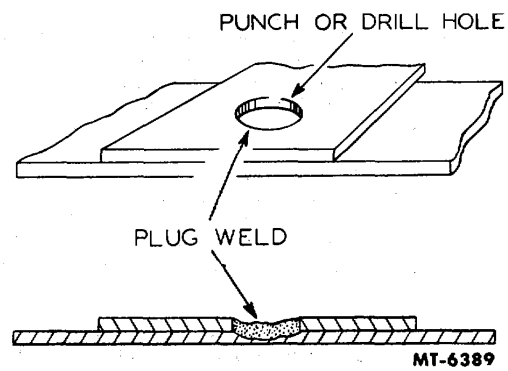


Fig. 10. Details of the plug weld.

WELDING WIRE CARE

Unsound welds will result if the welding material or wire is not clean. Wire that is contaminated with oil, grease, dust or shop fumes can cause numerous difficulties.

The welding wire should be stored in a dry, warm area and kept under cover. When the welder is out of use for any length of time, the wire should be removed from the torch and placed in the original carton to safeguard against possible contamination.

Wire that is kinked or has sharp bends will cause faulty welds and prevent even feed to the work. Protect weld wire from damage at all times.

SAFE PRACTICES AND PRECAUTIONS

While the various types of electric welding are not considered particularly hazardous, it is necessary to observe sound, common sense procedures to safeguard against personal injury and to attain the best possible efficiency. The operator of welding equipment should become familiar with the operation before starting the work. The IHC Safety

Manual, IR-50, should be reviewed and the safety precautions covered therein observed. The instructions provided with the MIG equip-ment (SE-2165) should also be studied to as-sure the proper operation and care of this type of welder.

The welding of aluminum requires a few additional precautions to be observed as follows:

1. First and foremost in the list of instructions in welding aluminum is the need for cleanliness. The surfaces to be welded must be clean or the weld will be unsound and otherwise unsatisfactory. Both sides of the work must be clean.
2. Wear safety goggles under the welding helmet or hand shield. Lens shade #8 is considered satisfactory when 75 amp settings are used. Lens shade #10 is best suited to 75-100 amp settings.
3. Open containers of chlorinated solvents such as carbon tetrachloride should not be left anywhere near the welding area. Ultra-violet rays from the welding arc can cause the formation of toxic gas when they come in contact with chlorinated solvents.
4. Make certain that you are properly protected before starting to weld. Leather gloves, aprons and caps are considered the best possible protection from weld splatter, sparks or other exposure to welding hazards.
5. Ventilation is important in the welding area; however, excessive drafts or blasts of air should be avoided when using the inert-gas welding equipment. The flow of argon gas around the welding nozzle must not be disturbed by air blasts, otherwise the effects of shielding the work will be lost.
6. Use grinding or sanding discs sparingly.

These high speed tools can quickly cut through the aluminum sheeting. Do not use files which would leave minute surface notches where cracks can start.

7. Do not weld closed containers or fuel tanks. Welding on containers which previously have held flammable materials is extremely dangerous.
8. Do not weld around wet surfaces or on wet floors. Make certain that ground circuits are securely attached. Ground connections at the work should be attached to the heavier sections of the aluminum structure not on the cab skin or other thin sections.
9. Review the welding machine instructions periodically to assure familiarity with the features of the MIG welder. Good practice would be to make trial. welds on scrap aluminum before starting the work.
10. Keep the SE-2165 welder in good, clean operating condition.
11. All IHC vehicles using aluminum in the cab or body structure have been designed and engineered to provide the best possible service life. Do not make changes in the structure design unless the changes have been approved as acceptable.

PROPERTIES OF ALUMINUM

The following information will be of value in order to clarify some of the peculiarities of which to be aware when welding aluminum:

1. Pure aluminum melts at 12200F. Commercial aluminum alloys generally start to melt at 1050°F.
2. There is no color change in aluminum during heating. Weld temperature is indicated when the aluminum develops a glossy appearance.
3. Aluminum conducts heat three times faster than iron.
4. Aluminum welds decrease (shrink) about six percent in volume when solidifying from the molten state.
5. Thermal expansion of aluminum is approximately twice that of steel.
6. Speed of welding aluminum is an important factor in preventing distortion due to heating.
7. Aluminum alloys loose characteristics of increased hardness and strength when re-heated to high temperatures. Welding causes some annealing of the parent metal.
8. In MIG welding, preheating of the weld area is not required regardless of material thickness.
9. Aluminum rapidly develops air oxide film upon exposure to air. This oxide has a melting point above the melting point of pure aluminum. (This is one of the import-ant reasons for cleaning before welding.)
10. The cleaning of aluminum surfaces before welding is of major importance. <u>Cleanliness cannot be over-emphasized.</u>

WELDING TERMS

Arc Welding: A group of welding processes wherein coalescence is produced by heating with an electric arc or arcs, with or without the application of pressure and with or without the use of filler metal.

Backing: Material (metal, weld metal, asbestos, carbon, granular flux, etc.) backing up the joint during welding to facilitate obtaining a sound weld at the root.

Backing Strip: Backing in the form of a strip.

Base Metal: The metal to be welded or cut.

Bead Weld: A type of weld composed of one or more string or weave beads deposited on an unbroken surface.

Bevel: A type of edge preparation.

Beveling: A type of chamfering.

Butt Weld: A weld in a butt joint.

Chamfering: The preparation of a contour, other than for a square groove weld, on the edge of a member for welding.

Chipping: Cut away, break off.

Coalescence: Combine, join together.

Consumable electrode: Welding operation in which the electrode serves as the current carrier and becomes part of the weld pool.

Continuous Weld: A weld which extends without interruption for its entire length.

Cover Glass: A clear glass used in goggles, hand shields and helmets to protect the filter glass from spattering material.

Crater: A depression at the termination of a weld bead.

Crater Crack: A crack in the crater of a weld bead.

Cylinder: A portable cylindrical container used for transportation and storage of a compressed gas.

Deposition Rate: The weight of metal deposited in a unit of time.

Depth of Fusion: The distance that fusion extends into the base metal from the surface melted during welding.

Face of Weld: The exposed surface of a weld, made by an arc-or gas-welding process, on the side from which welding was done.

Filler Metal: Metal to be added in making a weld.

Fillet Weld: A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other in a lap joint, tee joint or corner joint.

Filter Glass: A glass, usually colored, used in goggles, helmets and hand shields to exclude harmful light rays.

Full Fillet Weld: A fillet weld whose size is equal to the thickness of the thinner member joined.

Fusion: The melting together of filler metal and base metal, or of base metal only, which results in coalescence.

Gas Pocket: A weld cavity caused by entrapped gas.

Groove: The opening provided for a groove weld.

Hand Shield: A protective device, used in arc welding, for shielding the face and neck. A hand shield is equipped with a suitable filter glass and is designed to be held by hand.

Helmet: A protective device, used in arc welding, for shielding the face and neck. A helmet is equipped with a suitable filter glass and is designed to be worn on the head.

Inert-Gas Metal-Arc Welding: An arc welding process wherein coalescence is produced by heat-ing with an electric arc between a metal electrode and the work. Shielding is obtained from an inert gas such as helium or argon. Pressure may or may not be used and filler metal may or may not be used.

Joint Penetration: The minimum depth a groove weld extends from its face into a joint, exclusive of reinforcement.

Lap Joint: A joint between two overlapping members.

Manual Welding: Welding wherein the entire welding operation is performed and controlled by hand.

Metal Electrode: A filler- or non-filler-metal electrode, used in arc welding, consisting of a metal wire, with or without a covering or coating.

Nugget: The weld metal joining the parts in spot seam or projection welds.

Pass: A single longitudinal progression of a welding operation along a joint or weld deposit. The result of a pass is a weld bead.

Planishing: Make smooth, to toughen and polish by hammering lightly.

Plug Weld: A circular weld made by either arc or gas welding through one member of a lap or tee joint joining that member to the other. The weld may or may not be made through a hole in the first member. If a hole is used, the walls may or may not be parallel and the hole may be partially or completely filled with weld metal. (A fillet-welded hole or a spot weld should not be construed as conforming to this definition.)

Regulator: A device for controlling the delivery of gas at some substantially constant pressure regardless of variation in the higher pressure at the source.

Root Crack: A crack in the weld or base metal occurring at the root of a weld.

Spatter: In arc and gas welding, the metal particles expelled during welding and which do not form a part of the weld.

Tack Weld: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

Tungsten Electrode: A non-filler-metal electrode, used in arc welding, consisting of a tungsten wire.

Voltage Regulator: An automatic electrical control device for maintaining a constant voltage supply to the primary of a welding transformer.

Weld: A localized coalescence of metal wherein coalescence is produced by heating to suitable temperatures, with or without the application of pressure, and with or without the use of filler metal.

Weld Crack: A crack in weld metal.

Weld Metal: That portion of a weld which has been melted during welding.

<u>Welding Goggles</u>: Goggles with tinted lenses used during welding or oxygen cutting, which protect the eyes from harmful radiation and flying particles.

<u>Welding Rod</u>: Filler metal, in wire or rod form used in gas welding and brazing processes and those arc welding processes wherein the electrode does not furnish the filler metal.

BODIES AND CABS

FIBERGLASS REPAIR INSTRUCTIONS

INDEX

GENERAL

The information contained in this manual section has been prepared to provide service personnel with a ready reference to step-by step procedures for repair or replacement of fiberglass components.

Instructions for making fiberglass repairs to sheet metal are also covered in this section.

A fiberglass reinforced plastic repair kit (Fig. 1) has been made available which contains the material needed to repair either fiberglass or sheet metal components. This kit may be obtained through regular Service Part channels.

The mixing directions for the resin mixture and plastic putty are found on the cans.

CAUTION: Do not put mixed material back into cans.

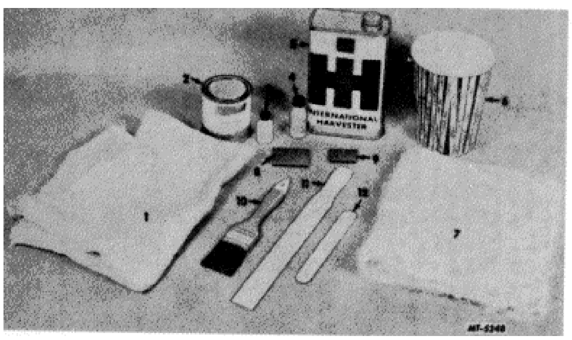


Fig. 1. Fiberglass Repair Kit

Legend for Fig. 1

Key	Description
1	CLOTH
2	PLASTIC FILLER
3	PLASTIC ACTIVATOR
4	RESIN ACTIVATOR
5	RESIN
6	MIXING CUP (3)
7	MAT
8	SQUEEGEE (1-1/2" x 2")
9	SQUEEGEE (1-1/2" x 1")
10	PAINT BRUSH
11	STIRRING STICK
12	STIRRING STICK

DESCRIPTION

Fiberglass is manufactured from filaments of pure glass spun into yarn then either woven into a fabric (cloth) or a loosely bound mat. The cloth or mat is then saturated with a resin. When the resin cures (hardens) it acts as a binder to hold the fiberglass together, thus forming a solid panel.

Fiberglass components, such as the hood with fenders assembly,' are formed from laminated sheets of fiberglass mats held together with a synthetic resin. When the liquid resin mix cures (hardens) it binds the filaments of glass in the fiberglass mats and creates a solid panel. The glass fiber provides the strength in the panel while the resin bonds the glass fibers together and supplies only a limited additional amount of strength. Therefore when repairing a section, be sure to cover more than Just the hole where the damaged material has been removed. Always overlap the undamaged portion with fiberglass patches, so that a more continuous sheet of reinforced fiber-glass results.

Since the material hardens by a chemical action, a hard surface indicates a hard interior, ready for finishing. The mixture be-comes hot before reaching setting temperature and then it begins to harden. It reaches full hardness after 48 hours. It can however be sanded and finished before then.

To hasten the curing action or if the working temperature is below 60 degrees F, hold a heat lamp approximately 18" from work. **NOTE**: 250 degree F to 275 degree F is the high limit for material and to go higher might distort the fiberglass form you are patching. Therefore, keep a close control over the external heat supply. Cooler temperature increases the working time and hardening time.

The paint refinishing method is the same as that recommended for metal parts with the exception that the temperature must be kept below 250 degree F, which means the air dry process is the most practical method. Either enamels or lacquers may be used to paint the fiberglass.

TOOLS AND EQUIPMENT NEEDED

Tools and equipment necessary to make repairs on fiberglass are as follows:

- IH Repair Kit (Fig. 1)
- Putty Knife
- Electrical Drill and Bits
- Electrical Grinder or Sander
- Respirator
- "C" Clamps
- Hacksaw Blades and Holder
- Files

Acetone or Lacquer Thinner
Scissors
Polyethylene (Plastic Container Bag Material) or Cellophane Sheets
Assorted Bolts, Nuts and Rivets.

SAFETY PRECAUTIONS

Observe The Following When Making Repairs With Fiberglass

1. Avoid spilling the resin or hardener on skin or clothing. If this occurs, remove with paint thinner or denatured alcohol. Then wash with soap and water. If the mixture contacts the eyes, flush thorough-ly with water immediately. Continue flushing for at least 15 minutes and con-tact physician as soon as possible.
2. In some cases, some individuals may have skin sensitivity to the use of these materials. Because of this, protective creams can be applied to the hands to guard against irritation.
3. When protective creams are not available, rubber gloves may be used to protect the hands. The gloves can be removed quick-ly leaving the hands clean for other work.
4. When working with fiberglass always work in a well ventilated area. DO NOT SMOKE OR EXPOSE FLAME WHERE KITS ARE BEING USED OR STORED. If possible, obtain a kit of material large enough to accommodate only one or two jobs to avoid storing any quantity of this material. Resin liquid must be kept in a metal container or cabinet when not being used.
5. Repairs must be ground or sanded to match surrounding contours. When grinding or sanding, it is advisable to use an approved type respirator during the opera-tion. Suitable respirators are available under equipment number SE-1798 and SE-1799. The ground dust or particles of resin or fiberglass must not be inhaled, otherwise irritation may occur.

REPAIRING FIBERGLASS

Small Holes (Under 3” Diameter):

1. Remove damaged material such as loose fiberglass and bevel the edges (approximately 20 degree). See Fig. 2.
2. Remove paint from outside surface with sandpaper. Clean inner surface (if accessible).

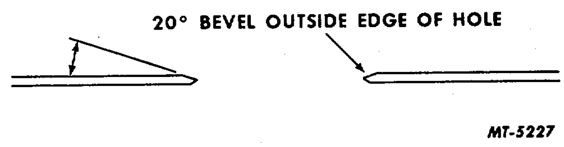


Fig 2.

3. Cut a piece of cloth and a piece of mat so that the patches will extend past the edges of the hole about 2”.
4. Coat both inner and outer with resin mixture and saturate both the mat and cloth.
5. When tacky, apply the mat on the inner surface and the cloth to the outer surface. Press the two patches together using polyethylene. A saucer-like depression should be made. See Fig. 3.

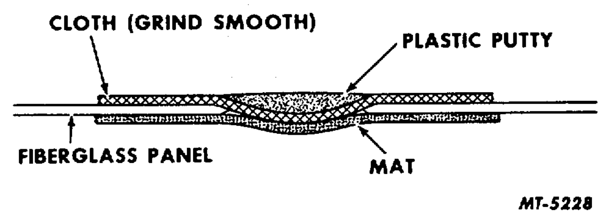


Fig. 3

6. Allow the material to cure. This is a chemical action and not a drying action. A hard surface indicates a hard interior. To hasten curing action, heat lamps may be used about 18” from work. Then smooth the outside surface. Additional coats of resin mixture may be added if necessary.
7. Apply plastic putty to fill the low spots, allow time for the putty to cure, then smooth the outside surface.

Large Holes (Over 3” Diameter):

1. Remove damaged material such as loose fiberglass and bevel the edges (approximately 20 degree). See Fig 2.
2. Remove paint from the outside surface with sandpaper. Clean the inner surface also if it is accessible.
3. On a piece of polyethylene place a piece of cloth cut larger than hole being repaired. Saturate with resin mixture. Obtain a layer of mat cut larger than the hole being repaired

and position it on the cloth. Saturate mat also with the resin mixture.

4. Coat the inner surface of area being repaired with the resin mixture. When tacky, apply the patch prepared in item 3. Using the polyethylene sheet, press out air pockets and allow patch to cure.

5. On a piece of polyethylene, place another piece of cloth larger than hole being repaired. Saturate with resin mixture. Apply two layers of mat (Fig. 4), saturating both with the resin mixture. Coat the outer surface of area being repaired with the resin mixture. When tacky, position the entire patch on the prepared surface and press into position. Allow the patch to cure.

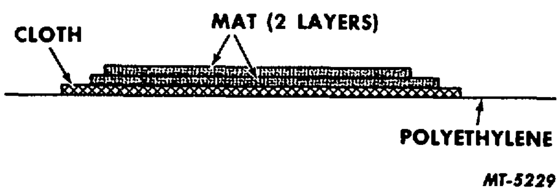


Fig. 4

6. After the inner and outer patches have cured, peel off the polyethylene and smooth the outer surface. Any of the polyethylene material left on patch will be removed when sanded.

7. In the resulting low spots, apply plastic putty. Then over the putty place another sheet of polyethylene and squeeze well to remove all air. When putty has cured, remove polyethylene and sand down to a feather edge.

<u>Crack or Split:</u>

1. Remove loose material and grind to a broad "V" (Fig. 5). Clean inner panel also.

2. Align parts. A nut and bolt with large flat washers may be used to draw parts together. See Fig. 6.

3. Cut one or two pieces of mat and apply to inner surface with resin mixture. (On cracks where excessive stresses may occur apply two pies of mat). Apply a piece of cloth with the resin mixture to the inner surface also. Extend patches beyond break about 2".

Press the patches firmly into place and allow to cure. **NOTE** : It is a recommended procedure to leave the washer and nut (if used) in the patch if the mat and cloth were applied over them.

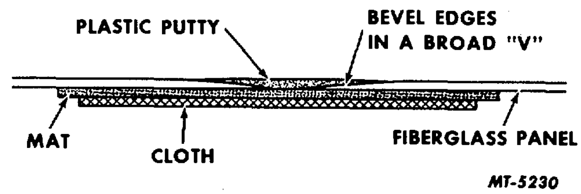


Fig. 5

4. Mix a fresh supply of plastic putty and apply over the outside surface filling the large "V" like valley (Fig. 5). Before the plastic putty cures, remove the bolt and washer (if used) from the outside and fill the hole with putty and allow to cure.

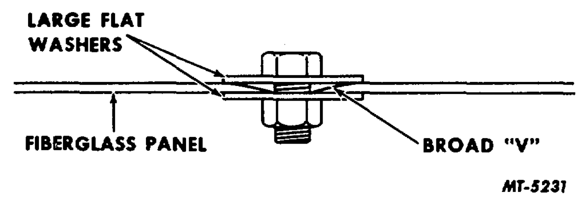


Fig. 6

5. After the putty has cured, sand down to the exposed surface.

<u>Small Scratches or Chipped Area:</u>
(No damage to basic fiberglass structure)

Remove paint from area being repaired and fill damaged area with a plastic putty mixture. After area has cured, sand smooth.

BOSTROM 'AIR VIKING' SEAT

DESCRIPTION

The "Air Viking" seat can be adjusted to each driver's weight and size.

An easy-to-operate push-pull air valve (Fig. 2) regulates the seat to the most comfortable position and weight adjustment.

Fig . 1. "Air Viking" Suspension Seat

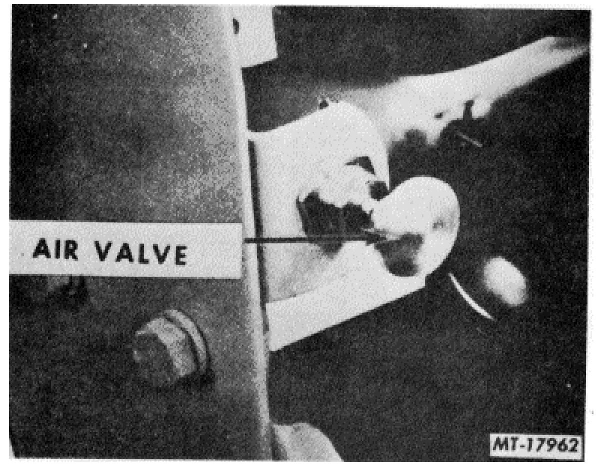


Fig. 2 Air Valve

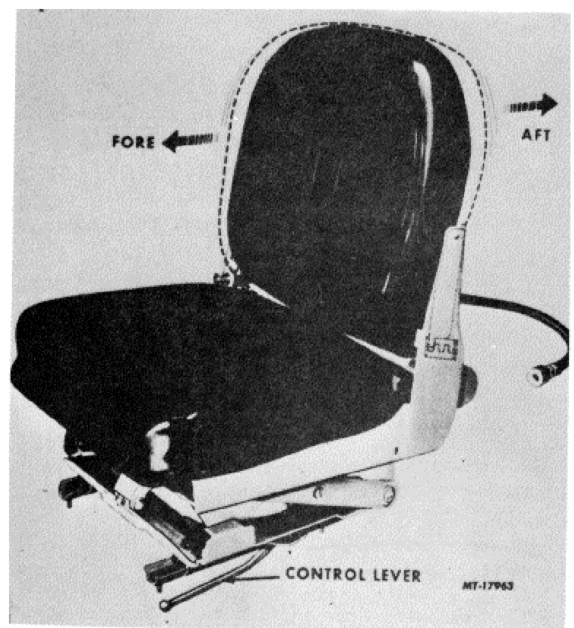


Fig. 3

ADJUSTMENTS

Fore-Aft

The seat assembly moves forward or rearward four (4") inches along ball bearing slides to suit length of the driver's legs (Fig. 3).

Back Angle

The back rest angle has three (3) positions to accommodate the driver's preference (Fig. 4).

Ride Level Indicator

The indicator located inside the left panel (Fig. 5) provides positive assurance that the seat is properly adjusted for the driver's weight.

1. If there is too much air pressure, the indicator (1) will be forward of the panel edge.
2. If insufficient air exists, the indicator (2) will remain behind panel edge.
3. Adjust air pressure until indicator (3) is even with the panel edge.

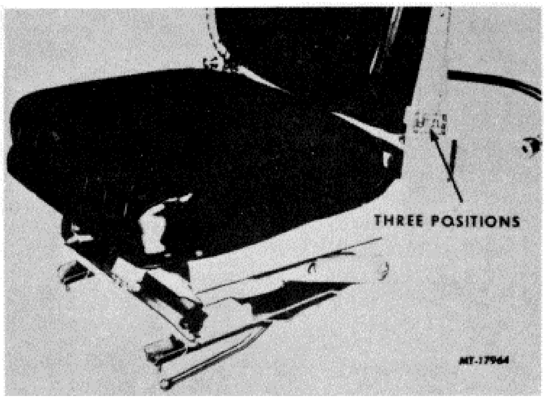


Fig . 4

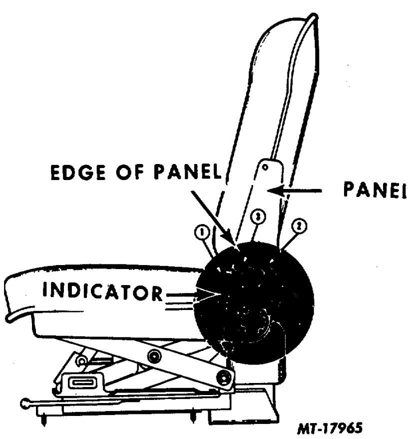


Fig. 5

LUBRICATION

Lubricate the air suspension seat at locations shown in Fig. 6 using IH 251H EP grease or equivalent NLGI #2 multi-purpose lithium grease.

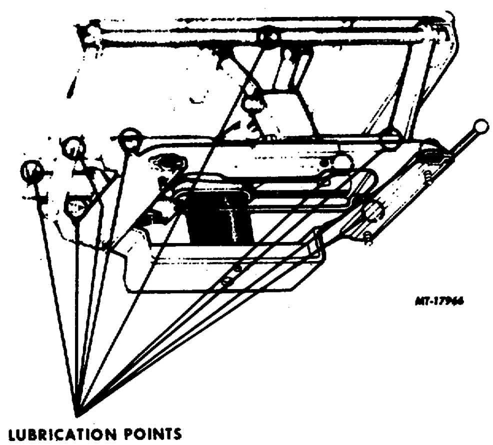


Fig . 6

REMOVAL

CAUTION: Release air pressure by pulling button on control valve out, before performing any service.

AIR SUSPENSION SYSTEM

1. Disconnect air supply.

2. Wedge upper seat in top position by using a wood shim under tube located under front of seat cushion or by shim under tube located below back of cushion.
3. Release air spring assembly from seat base assembly by removing machine screw and lock washer. This may necessitate removing entire seat from vehicle.
4. Disengage air reservoir from seat, right and left side panels by removing capscrews and lock washers. This permits entire air suspension system to be removed as a unit as shown in Fig. 7.

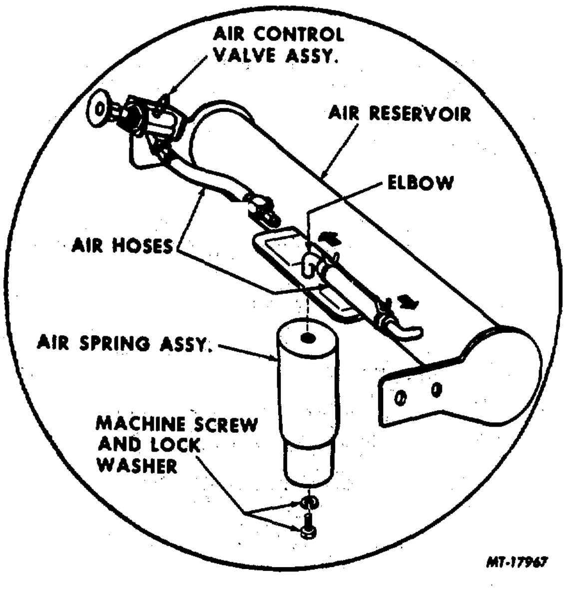


Fig. 7. Air Suspension System

AIR SPRING ASSEMBLY

1. Release air spring assembly from seat base assembly by removing machine screw and lock washer (Fig. 8). To perform this operation, removal of entire seat assembly may be required.

2. Grasp air spring bag at top and unscrew (counter clockwise) from elbow.

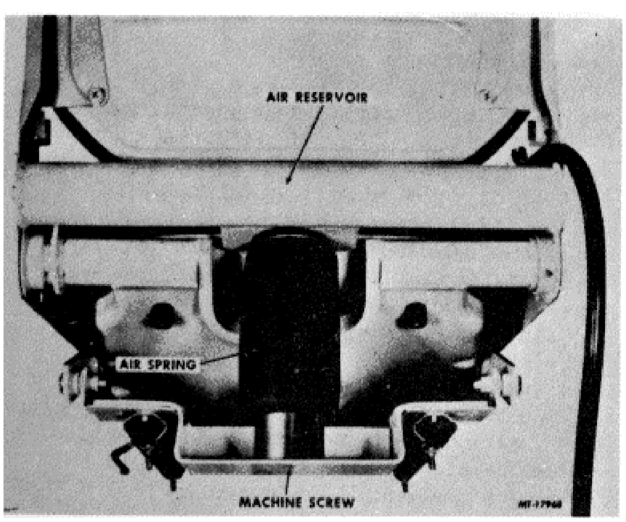


Fig. 8. Air Spring Assembly

AIR VALVE ASSEMBLY

1. Use a pair of pliers to free hose at valve fitting.

2. Loosen lock nut holding valve in support bracket. Use a screw driver to pry valve free of bracket.

AIR HOSE ASSEMBLIES

1. Disconnect air supply.

2. Disengage seat cushion from assembly by removing nuts, lock washers and washers. Move seat cushion forward to free nylon rollers from housing under seat cushion.

3. Hose from control valve to reservoir can be removed by using pliers and pulling away from hose fittings. The hose from reservoir to air spring can be removed using a pliers, release hose clamps and slide off ends of hose in direction of arrows (Fig. 7). Hose can then be removed from fittings.

SHOCK ABSORBER

1. Wedge seat in upper position by using wood shim under tube located under front of seat cushion or by shim under tube below back of cushion.

2. Release air pressure from air spring bag by pulling out air control valve button

3. Remove seat cushion by removing nuts, lock washers and washers. Move seat forward to free nylon rollers from housing under seat cushion.

4. Secure seat side panel assemblies with wire, across front of seat to retain their position.

5. Remove left snap ring from end of hinge shaft at front of shock absorber (Fig. 9).

6. Remove hinge shaft by tapping shaft from left to right side. This will free the two washers on end of shaft. Washers are not illustrated in Fig. 9.

7. Use a small diameter punch to remove one of the roll pins from hinge shaft at rear of shock absorber, (Fig. 9).

8. Remove rear hinge shaft at rear of shock absorber freeing the shock.

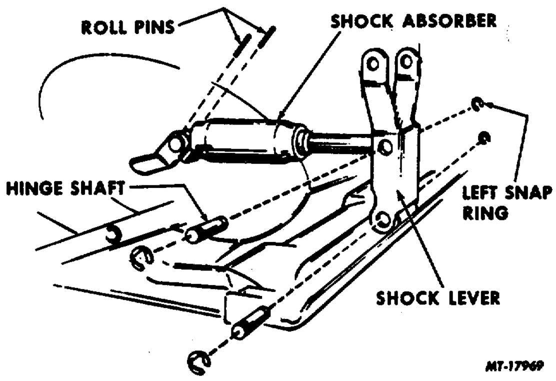


Fig. 9. Shock Absorber Removal

REINSTALL

Installation of Air Suspension System, Air Spring Assembly, Air Valve Assembly, and Air Hoses are reinstalled by reversing the removal procedures.

SHOCK ABSORBER

1. With the shock absorber in proper posi-tion, replace rear hinge shaft at rear of shock.

2. Replace roll pin in hinge shaft, locking roll pin on right hand side in nibs in bent-up ear.

3. Replace hinge shaft at front of shock absorber, driving shaft from right hand to left side. Serrated end of shaft to enter shock lever last. Drive shaft through two (2) washers and through shock absorber loop.

4. Replace snap ring at end of front hinge shaft.

5. Line up left and right seat side panels maintaining the 20” dimension over the side panels.

6. Reassemble the seat cushion.

7. Inflate air spring assembly by pushing in on control valve and then remove shim.

Legend for Fig 10

Key	Description	Key	Description
1	CUSHION, Seat Assembly	15	ROLLER, W/Bushing
2	CUSHION, Back Assembly	16	PIN, Roller
3	CLIP, Covering	17	BUSHING, Shock Absorber
4	SPRING, Air	18	ABSORBER, W/Pin, Shock
5	RESERVOIR, Air	19	LEVER
6	VALVE, W/Hoses, Air	20	PIN, Seat Lever Drive
7	PANEL, Seat, Right	21	BUSHING, Seat Adjusting Lever
8	PANEL, Seat, Left	22	LEVER, W/Pins, Seat Adjuster
9	BUSHING, Seat Lever, Left	23	ROLLER, W/Bushing, Seat
10	INDICATOR, Ride	24	PIN, Hinge
11	BUMPER, Rubber	25	LEVER, W/Pins, Shock Absorber
12	BUSHING, Seat Lever, Right	26	BASE, W/Bushings, Seat
13	PIN, Roll	27	RISER, Seat
14	PIN, Shock Absorber	28	BUSHING, Seat Stabilizer

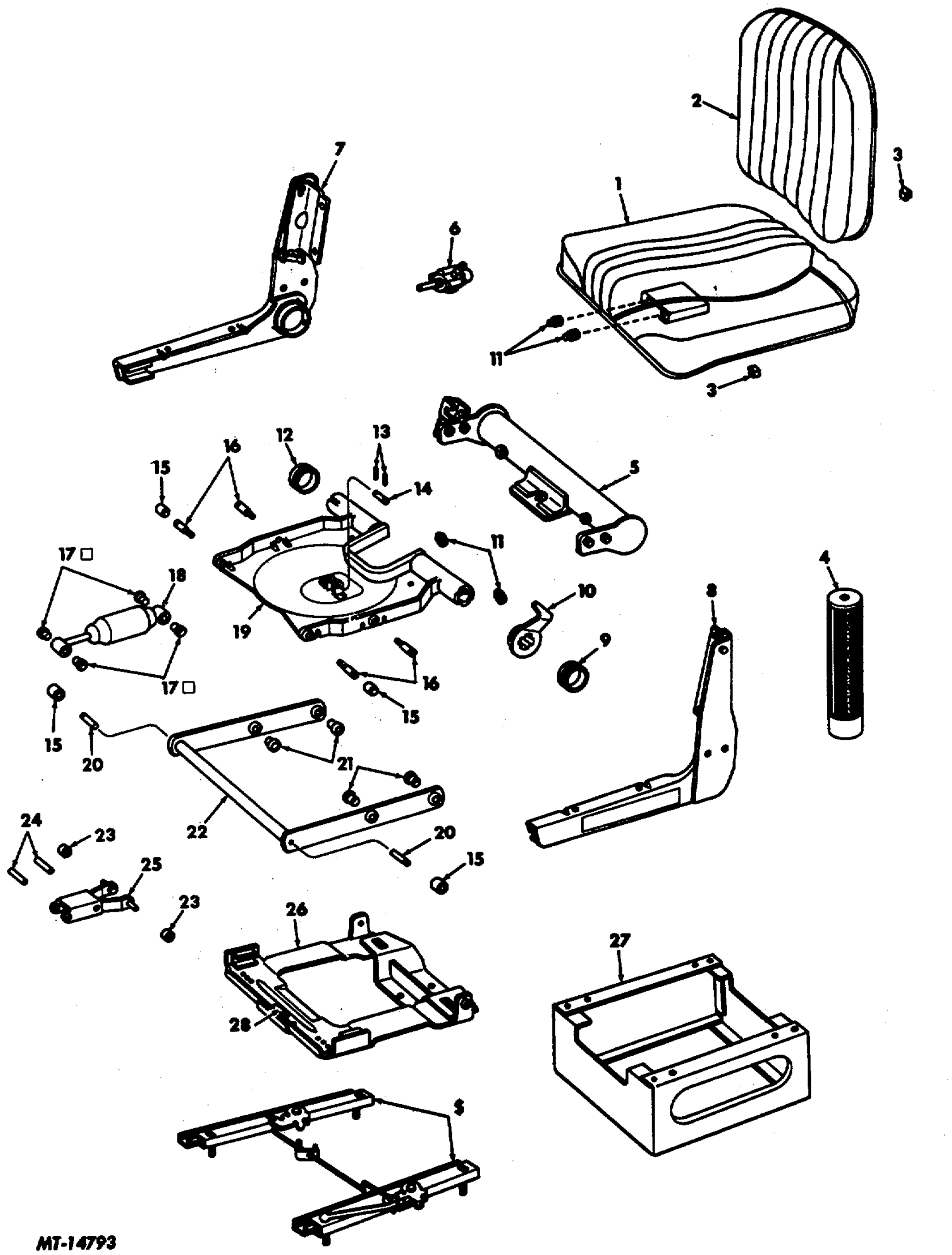


Fig. 10. Exploded View of Air Suspension Seat

AIR COMPRESSOR

BENDIX WESTINGHOUSE

500 TU-FLO

INDEX

SPECIFICATIONS

(AIR COMPRESSOR)

MODEL	Tu-Flo 500
Number of Cylinders	2
Capacity (cfm) (at 1250 RPM)	12
Bore (Inches)	2-1/2
Stroke (Inches)	1-11/16
Maximum Speed for Compressor (RPM)	3000
Cooling Water	
Piston-to-Cylinder Bore Clearance (In.)	.002-.004
Number of Rings Used on Each Piston	5
Ring Gap in Cylinder Bore (Inch)	.005-.015
Ring Fit in Grooves (Inch):	
Top	.002-.004
2nd	.002-.004
3rd	.035-.055
4th	.002-.004
5th	.035-.055
Wrist Pin-to-Connecting Rod Bushing Clearance (Inch)	.0001-.0006
Connecting Rod Bearing Clearance (In.)	.0003-.0021
Discharge Valve Lift (Inch)	.056-.070
Inlet Valve Seat (Dimension from Top of Block)	
Not to Exceed	.145
Not less Than	.101

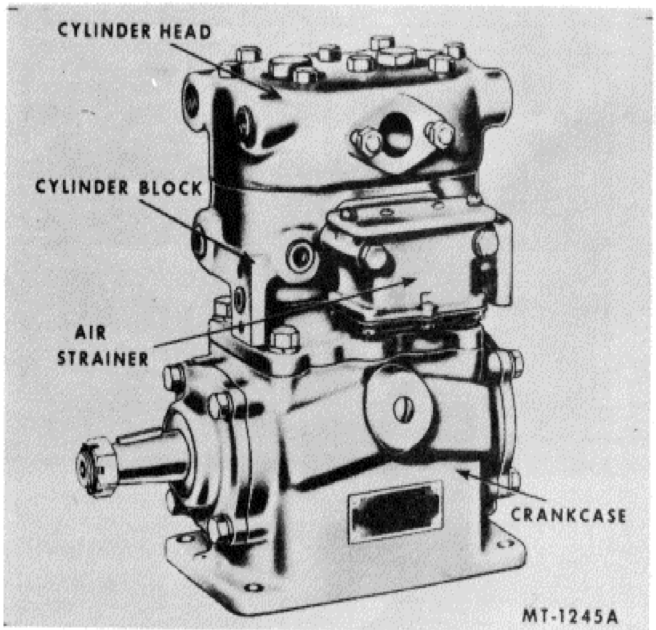


Fig . 1 Exterior View of TuFlo 400 and 5 Compressor

DESCRIPTION

The TuFlo 500 compressors are single acting reciprocating piston type compressors. The rated capacity of a compressor is based on the piston displacement in cubic feet per minute when operating at 1250 RPM.

The capacity of the TuFlo 500 is 12 cubic feet per minute.

The TuFlo 500 and 600 compressors have water-cooled cylinder heads and water-cooled cylinder blocks. Various mounting and drive adaptations are used depending on design of the engine.

Engine lubricated compressors are dependent on the vehicle engine for oil and oil pressure, Fig. Z. In these compressors oil from the vehicle engine enters the compressor through a passage in the compressor end cover and is fed to the connecting rod bearings through drilled holes in the crankshaft. The wrist pins are lubricated through holes in the top of the connecting rod wrist pin bearing and bushing by means of oil dripping from a drip boss on the piston. The main bearings are splash lubricated. Surplus oil returns to the engine crankcase through the open compressor base.

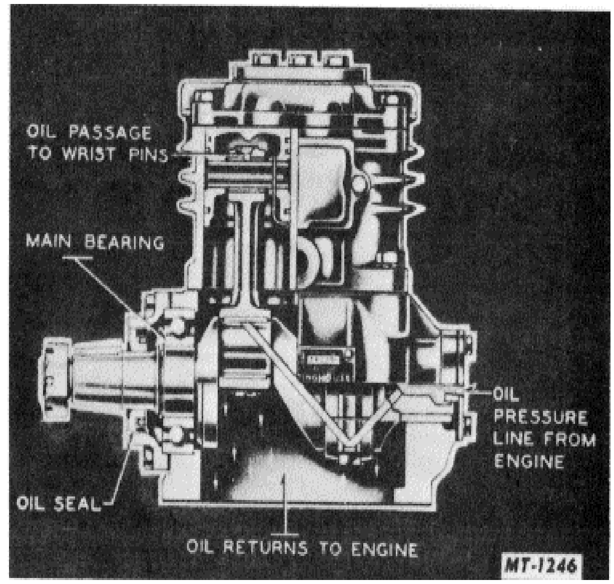


Fig . 2 Sectional View of Compressor Oiling System

OPERATION

The compressors run continuously while the engine is running, but the actual compression of air is controlled by the governor, which, acting in conjunction with the unloading mechanism in the compressor cylinder block, starts or stops the compression of air by loading or unloading the compressor when the pressure in the air brake system reaches the 'desired minimum (8085 p. s. i.) or maximum (100105 p.s. i.).

<u>Compressing Air (Loaded)</u>

During the down stroke of each piston a partial vacuum is created above the piston which unseals the inlet valve, allowing air drawn through the intake strainer to enter the cylinder above the piston, Fig. 3. As the piston starts the upward stroke, the air pressure on top of the inlet valves plus the inlet valve return spring force closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir, Fig. 4. As each piston starts its down stroke the discharge valve above it returns to its seat, preventing the compressed air from returning to the cylinder, and the same cycle is repeated.

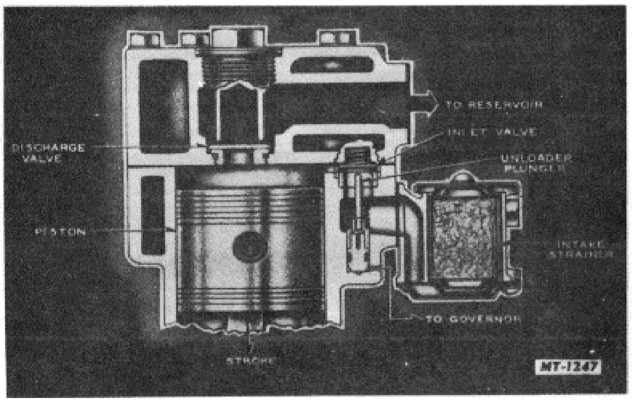


Fig. 3 Intake of Air

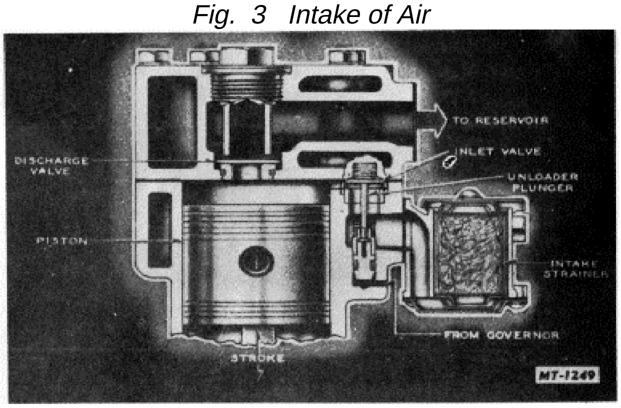


Fig. 4 Compression of Air

<u>Not Compressing Air (Unlogded)</u>

When the air pressure in the reservoir reaches the maximum setting of the governor (100105 p. s. i.), compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. This air pressure lifts the unloading pistons, which, in turn, lift the inlet valves off their seats, Fig. 5.

<u>Passage of Air During Noncompression</u>

With the inlet valves held off their seats the air during each upstroke of the piston is forced through the air inlet cavity and to the other cylinder where the piston is on the down stroke.

When the air pressure in the reservoir is reduced to the minimum setting of the governor (8085 p. s. i.), the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the pistons down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

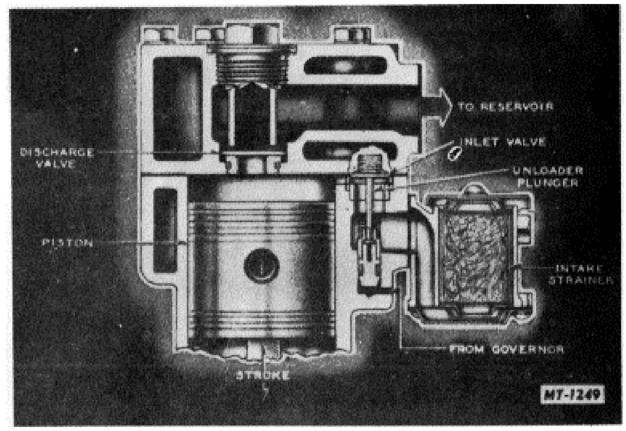


Fig. 5 Compressor Unloading Mechanism

REMOVE

1. Drain air brake system.
2. Drain engine cooling system, compressor cylinder head and compressor cylinder block.
3. Disconnect all air, water and oil lines connected to compressor.
4. Remove compressor drive belt.
5. Remove compressor mounting bolts and remove compressor from engine.
6. Use a suitable puller to remove the pulley from the compressor crankshaft after removing the crankshaft nut.

DISASSEMB LY

Remove grease or dirt from the exterior of the compressor by scraping, if necessary, followed by the use of cleaning solvent and a brush.

TuFlo compressors should have the following items marked showing proper relationships prior to disassembly. Center punch marks can be used if desired.

1. Position of cylinder block in relation to crankcase.
2. Position of end covers in relation to the crankcase.
3. Position of crankshaft in relation to crankcase.

Removing and Disassembling Cylinder Head

Remove capscrews or nuts from studs attaching cylinder head and lift off cylinder head.
’he cylinder may have to be tapped with a raw hide hammer to break gasket joint.
Remove cylinder head gasket and scrape off any gasket material that may remain on cylinder head and block.
Remove discharge valve cap nuts and lift out discharge valve springs and discharge valves.

Removing and Disassembling Piston and Connecting Rod Assemblies

Straighten prongs of connecting rod bolts and remove bolts and bearing caps. Then push pistons with connecting rods attached out the top of the cylinder block. Replace caps on each connecting rod to avoid damage to bearings. Connecting rod caps and connecting rods are already marked with center punch marks to show the proper position of the caps on the rods.

Remove piston rings from each piston. If pistons are to be removed from connecting rods, remove wrist pin lock wires from wrist pins and press pins from pistons and connecting rods.

Removing Crankshaft

Remove capscrews or nuts from studs, securing end cover to crankcase at drive end of crankshaft.

Remove end cover with oil seal and gasket. If oil seal needs replacing, remove it from end cover.
Remove capscrews or nuts from studs, holding opposite end cover to crankcase. Remove end cover and gasket.

Some crankcases are fitted with a shoulder to position the crankshaft in the crankcase. In such cases the crankshaft may be removed only through one end of the crankcase. Press crankshaft and ball bearings out of crankcase.

Removing Cylinder Block

When cylinder head is removed from cylinder block, the inlet valve springs and inlet valves should be removed.

If compressor is fitted with an air strainer, remove screws and lock washers securing air strainer in place and remove air strainer and air strainer gasket.

If compressor has a Type D or D2 governor mounted on cylinder block, remove governor and gasket. Remove capscrews or nuts securing cylinder block to crankcase and remove cylinder block and cylinder block gasket.

Remove unloader spring and unloader spring seat.

Remove unloader spring saddle, unloader plunger and unloader pistons. Remove unloader piston grommets. Remove inlet valve seat bushings only if seats are worn or damaged.

CLEANING AND INSPECTION OF PARTS

Clean all parts using cleaning solvent to remove all traces of dirt, oil and grease before inspection.

Cylinder Head and Components

Put cylinder head body through a cleaning solution to remove all carbon from discharge valve cavities and to remove all rust and scale from water cavities. Use air pressure to blow dirt out of all cavities. Scrape carbon, dirt, and particles of old gaskets from all surfaces.

Clean discharge valves not damaged or worn excessively by lapping them on a piece of crocus cloth on a flat surface.

Oil Passages

Clean thoroughly all oil passages through crankshaft, connecting rods, crankcase and end covers. If necessary, probe oil passages with wire and flush with cleaning solvent.

Cylinder Block

Put cylinder block through a cleaning solution to remove all carbon and dirt from inlet passages and unloader passages so as to remove rust and scale from water cavity.

Clean inlet valves that are not damaged or worn excessively by lapping them on a piece of crocus cloth on a flat surface.

Scrape particles of old gaskets from all surfaces.

Air Strainer

Wash curled hair from air strainer in cleaning solution and then saturate it with clean oil, squeezing out excess oil before replacing it in air strainer.

Ball Bearings

All ball bearings must be cleaned thoroughly in cleaning solvent.

INSPECTION OF PARTS

Cylinder Head Body

I Inspect cylinder head body for cracks or breaks. Replace if any defects are found.

Water Passages

Test water jacket of cylinder head and cylinder block for leakage, using air pressure. Replace unit if leakage is found. Discharge Valve Springs

Discard all used discharge valve springs and replace with new springs.

Discharge Valves and Seats

Inspect condition of discharge valves and discharge valve seats. If discharge valves are grooved deeper than . 003" where they contact the seats, they should be replaced. If the discharge valve seats are worn excessively so there is no longer sufficient metal left to reclaim the seat by using a lapping stone, the seats should be replaced.

Crankcase and End Covers

Check crankcase and end covers for cracks and broken lugs. Replace if any damage is found.

End Covers

If an oil seal ring is used in the end cover, check fit of ring in the ring groove and have .008" to .015" clearance at the gap when placed in the end bore of the crankshaft. Check oil seal ring for wear. If worn thin or damaged, the oil seal ring must be replaced. Inspect oil ring groove in end cover. If ring wear has formed a step pattern in groove, replace end cover or machine groove for next oversize oil seal ring.

Crankcase Bearing Bores

Check fit of ball bearings in crankcase. Bearings must be a finger press fit. If crank-case bearing bores are worn or damaged, the crankcase should be replaced. Cylinder Block Check for cracks or broken lugs on cylinder block. Also check unloader bore bushings to be sure they are not worn, rusted or damaged. If these bushings are to be replaced, they can be removed by running a 1/8" pipe thread tap inside the bushing, then inserting a 1/8" pipe threaded rod and pulling the bushing straight up and out. Do not use an easy-out for removing these bushings.

Inlet Valve and Seats

Inspect condition of inlet valves and seats.
If inlet valves are grooved deeper than .003" where they contact the seat, they should be replaced. If the inlet valve seats are worn or damaged so that they cannot be reclaimed by facing or lapping, seats should be replaced.

Cylinder Bores

Check cylinder bores for evidence of excessive wear, out of round, or scoring. Cylinder bores which are scored or out of round more than . 002", Fig. 6, or tapered more than . 003", as should be re-bored or honed oversize. Oversize pistons are available in .010", .020" or. 030" oversize. Cylinder bores must be smooth, straight and round. Refer to specifications for proper clearance between piston and cylinder bore. Aluminum pistons are cam ground.

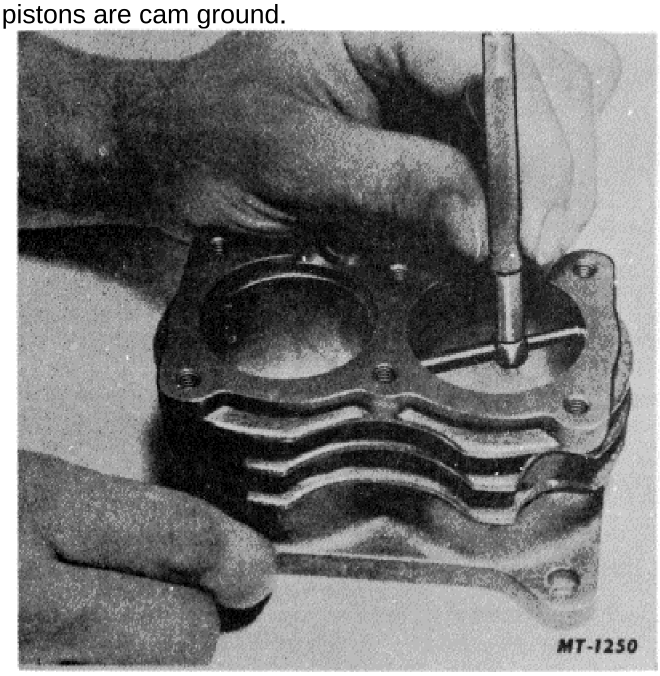


Fig. 6 Measuring Cylinder Bore Diameter

Pistons

Inspect pistons for scores, cracks or damage. If scores or cracks are found, replace the piston. Check each piston with a micrometer, Fig. 7, in relation to the cylinder bore diameter to be sure the proper clearance is obtained as outlined in the specifications.

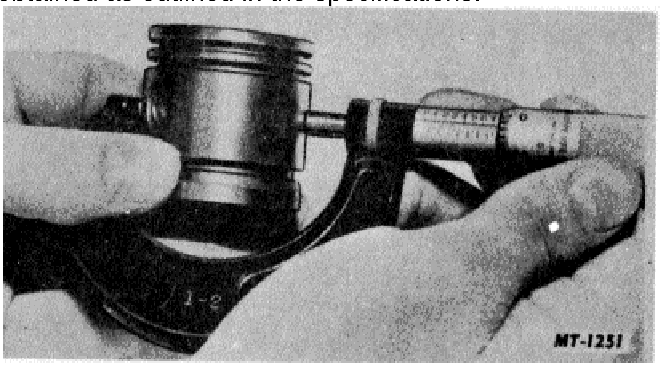


Fig. 7 Measuring Piston Diameter

Piston Rings

Check fit of piston rings in the ring grooves. Also check ring gap with rings installed in cylinder bores, Fig. 8. Refer to specifications for correct ring gap and groove clearance.

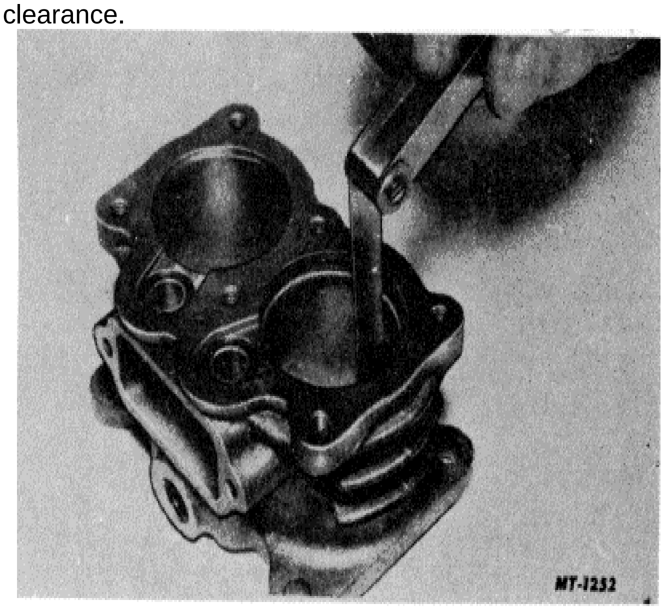


Fig. 8 Measuring Ring Gap

Wrist Pins

Check fit of wrist pins in pistons and connecting rods. Wrist pins must be a light press fit in piston. If wrist pin is a loose fit in the piston, the wrist pin, piston or both must be replaced. Check fit of wrist pin in connecting rod bushing by rocking the piston. Clearance of wrist pin to connecting rod bushing should not exceed . 0015". If excessive clearance is apparent, replace wrist pin bushing in connecting rod. Wrist pin bushings should be reamed after being pressed in place. Discard all used wrist pin lock wires and replace with new.

Connecting Rod Bearings

Inspect connecting rod bearings for proper fit on crankshaft journals. Also check connecting rod bearings for wear. If worn, cracked, or broken, the inserts must be replaced. Connecting rod caps are not interchangeable. Position the caps so that the two locking slots are both located adjacent to the same capscrew.

Refer to specifications for proper connecting rod bearing clearance.

Crankshaft

Crankshaft journals which are more than .001" out of round or scored must be reground.

When regrinding, the fillets at the ends of the journals must be maintained. Connecting rod bearing inserts are available in .010", .020" and .030" undersize for reground crankshafts.

Screw threads, key ways, tapered ends and all ground and machined surfaces of the crankshaft must not be mutilated or worn excessively.

Main bearing journals must not be worn sufficiently to prevent the ball bearings being a press fit. The oil seal ring groove in crankshafts fitted with oil seal rings must not be worn sufficiently to prevent a good fit on the oil seal ring. Walls of the oil seal ring grooves must be square and have a good finish.

Main Bearings

Check for wear or flat spots; if damaged, the bearings must be replaced. If sleeve bearing type, the bearing should be checked for scores or wear and replaced if necessary.

REPAIRS

Discharge Valves and Seats

If discharge valve seats merely show signs of slight scratches, they can be reclaimed by using a lapping stone and grinding compound. If seats cannot be reclaimed, install new seats. After installing new discharge valves, discharge valve springs and discharge valve cap nuts, the discharge valve travel should be checked. This can be accomplished from the bottom side of cylinder head by measuring the movement of discharge valve from its seat. Refer to specifications for correct valve travel.

To test for leakage, apply 100 p. s. i. air pressure through the discharge port of the cylinder head and apply soap suds to the discharge valve openings in the floor of the cylinder head. Leakage should not exceed a one inch soap bubble in not less than five seconds.

If excessive leakage is found, leave the air pressure applied and using a fiber or hardwood dowel and light hammer, tap the discharge valves off their seats several times to improve the seal between the valves and their seats. If the valves and valve seats have been reconditioned properly, this will reduce the leakage.

Leakage tests must also be made by applying soap suds around the discharge valve cap nuts with air pressure applied as above. Leakage at cap nuts is not permissible.

Inlet Valves and Seats

If inlet valve seats show signs of slight scratches or wear, they can be reclaimed by using a lapping stone and grinding compound. If the seats cannot be reclaimed in this manner, they should be replaced. Install new inlet valve seats by pressing them into cylinder block to dimensions shown in the specifications.

Inlet valves not worn excessively or damaged can be reclaimed by lapping them on a piece of crocus cloth on a flat surface.

REASSEMBLY

Installing Cylinder Block

Place new cylinder block gasket in position on crankcase studs. Position cylinder block on crankcase in accordance with markings made before disassembly. Install nuts and lock washers securing cylinder block to crankcase.

Installing Cranks haft

If the crankshaft is fitted with oil seal rings, install rings. Position ball bearings and crankshaft in crankcase, being sure the drive end of the crankshaft is positioned as marked before disassembly. If one end of the crankcase is counter bored for holding bearing, be sure the crankshaft is installed through the correct end of the crankcase. Carefully press crankshaft and bearings into crankcase using arbor press.

Place a new rear end cover gasket in position over studs on rear end of crankcase being ¾ sure the oil hole in the gasket lines up with the oil hole in the crankcase. If end cover includes an oil seal ring, install oil ring. Position end cover over studs in crankcase being sure oil holes in end cover line up with oil A holes in gasket and crankcase. Install capscrews or nuts securing end cover in place.
Install pipe plugs in end cover oil openings which are not in use.

If opposite end cover includes an oil seal and the seal has been removed, press a new seal in the end cover. Install a new end cover gasket. Carefully position the end cover to avoid damage to oil seal and install capscrews or nuts securing end cover in place, Fig. 9.

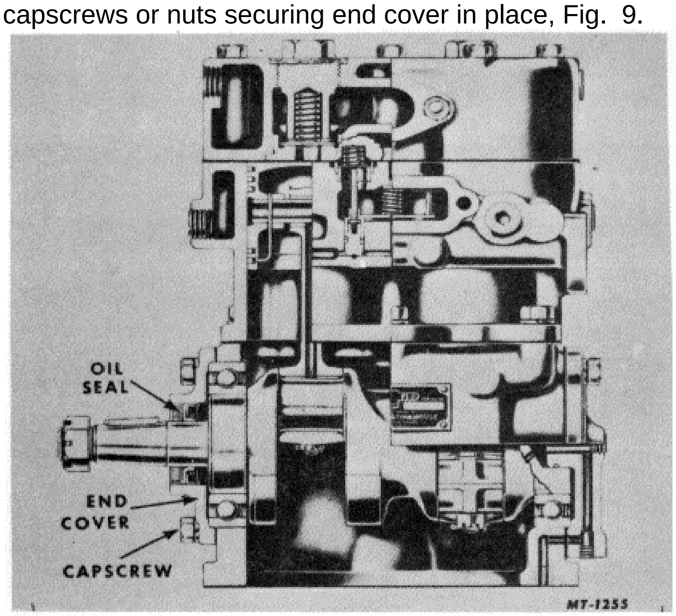


Fig . 9 Sectional View of Block and Crankcase

Assembling Pistons and Connecting Rods

If wrist pin bushings have been removed from connecting rods, press new bushings into place making sure that the oil holes in the bushings line up with the oil hole in the connecting rods. Bushing must then be reamed, honed or bored to provide the proper running clearance on the wrist pin as shown in the specifications. Position connecting rod in piston and press wrist pin into position with lock wire holes in pin aligned with lock wire hole in piston. Install new wrist pin lock wire in wrist pin so that the long end extends through piston and wrist pin and short end can be snapped into the lock wire hole near the bottom of the piston skirt, Fig. 10. Do not use pistons in which the wrist pin is loose.

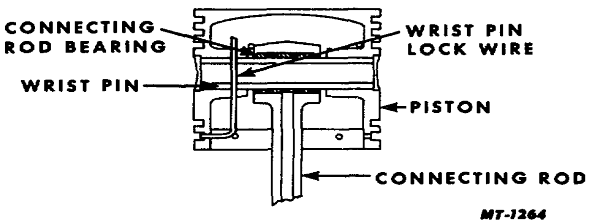


Fig. 10 Installing Wrist Pin Lock Wire

Install piston rings by hand, Fig. 11. Particular care must be taken when installing piston rings so that the pip mark on the ring is toward the top of the piston. Stagger the position of the ring gaps.

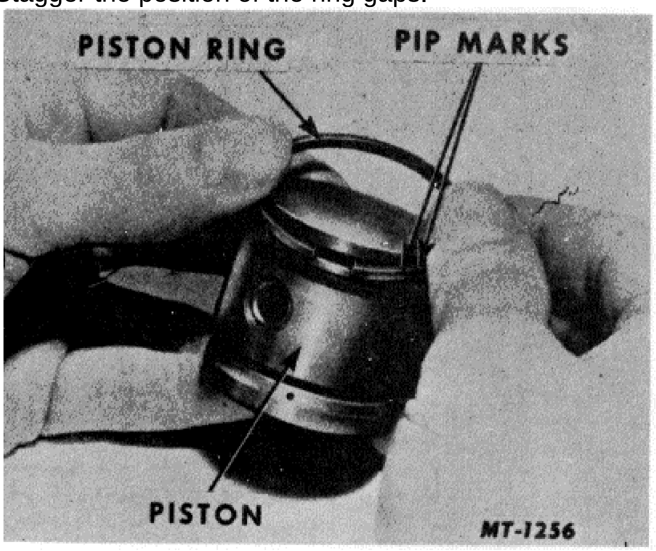


Fig. 11 Installing Piston Rings

Installing Pistons and Connecting Rods

Before installing pistons and connecting rods, thoroughly lubricate pistons, piston rings, wrist pin bearings and connecting rod bearings with clean engine oil.

Turn crankshaft so as to position one crankshaft journal downward. Remove bearing cap from connecting rod.

Insert the connecting rod and piston through top of number one cylinder so that the connecting rod bearing makes contact with the crankshaft journal. Position and attach bearing cap to rod. The cap is in the correct position when the two locking slots in the bearing inserts and in the rod and cap are both located adjacent to the same connecting rod bolt. Then install the lock wire through both capscrew heads and secure. Install the two capscrews and slotted nuts. Then install cotter pins in the capscrews.

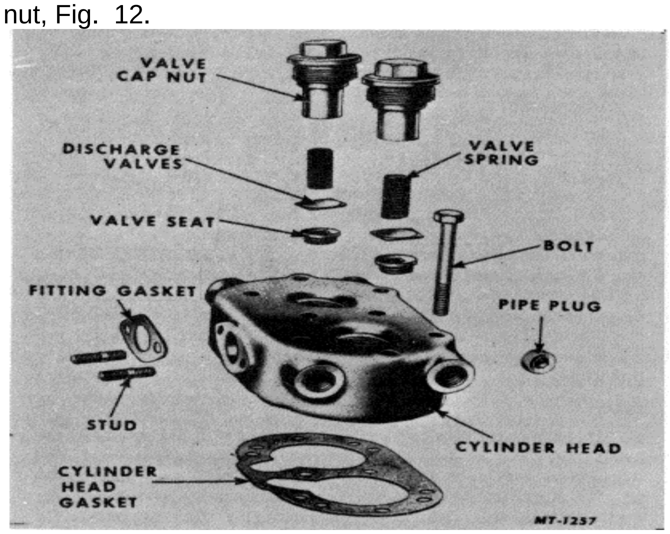
Turn crankshaft until other journal is downward and install second connecting rod and piston in same manner.

Assembling and Installing Unloader Pistons

Lubricate the unloader piston bores in the cylinder block and also the unloader piston and unloader piston grommet with clean engine oil. If new unloader kits are being installed, the pistons in the kit are prelubricated. Install unloader piston grommet on unloader piston. Install unloader pistons and unloader plungers through the top of the cylinder block taking care to avoid cutting the unloader piston grommets on the block. Install unloader spring saddle on unloader plungers. Install spring seat in top of cylinder block strainer opening and place unloader spring between spring guide and spring saddle. Install inlet valve guides if they have been previously removed.

Assembling and Installing Cylinder Heads

Install discharge valve in the cylinder head. Install discharge valve spring and discharge valve cap nut, Fig. 12.



Fig, 12 Exploded View of Cylinder Head

Install inlet valves and inlet valve springs in cylinder block. Place new cylinder head gasket on block. Carefully align inlet valve springs with inlet valve guides in cylinder head and secure head to block by tightening cylinder head nuts evenly.

Assembling and Installing Air Strainer

If compressor assembly includes an air strainer, assemble air strainer, Fig. 13.
Using a new gasket, position and install strainer on cylinder block.

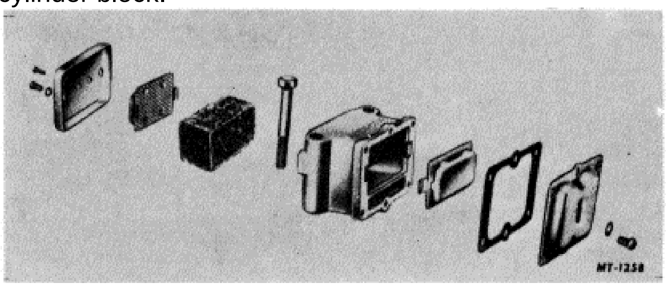


Fig. 13 Exploded View of Air Strainer

REINSTALL

Clean oil supply line so that oil will flow freely through the line.

Be sure oil return line or passages through brackets are clean and unrestricted so that oil can return to engine. Always use a new mounting gasket and be sure oil hole in gasket and compressor is properly aligned with oil supply line.

Inspect drive pulley or gear for wear or damage. They must have a neat fit on crankshaft making sure it properly contacts the shaft and not ride the key. Tighten nut securely and install cotter pin. Be sure air cleaner is clean and properly installed. If air intake is connected to engine air cleaner or supercharger, these connections must be tight with no leakage.

Clean or replace any damaged or dirty air or water lines which may be corroded before connecting them to the compressor. Use a new discharge fitting gasket.

Align compressor drive and adjust to proper belt tension. Tighten mounting bolts securely and evenly.

After compressor is installed, operate it and check for air, oil or water leaks at connections. Be sure to check for noisy operation.

TESTING COMPRESSOR

A compressor efficiency or buildup test can be run which is not too difficult. Before the test the crankcase of a self lubricated type compressor should be properly filled with lubricating oil. An engine lubricated compressor must be connected to an oil supply line of at least 15 pounds pressure during the test and an oil return line must be installed to keep the crankcase drained. The compressor (when tested) should be tested without a strainer.

To the discharge port of the compressor connect a reservoir or reservoirs whose volume plus the volume of the connecting line equals 1300 cubic inches. Run the compressor between 1700 and 1750 RPM. Elapsed time that the compressor takes to build up from 0 to 100 psi depends on the type compressor as follows:

Type Compressor	Build-Up Time 0 to 100 PSI
Tu Flo 500	30 Seconds Maximum

During the above test the compressor should be checked for oil leakage and noisy operation.

MAINTENAN CE

It is good practice to follow a preventive maintenance schedule at regular mileage intervals to extend the service life of the air compressor. These mileage intervals represent requirements for normal conditions. For severe service or unusual operating conditions the intervals should be reduced accordingly.

Daily:

If the compressor is a self lubricated type, its oil level should be checked at the same time the engine oil level is checked. The oil level should be kept between the bottom of the dip stick threads and the bottom of the dip stick. The oil should be changed often enough to keep it nonabrasive and noncorrosive.

IMPORTANT: Should it be necessary to drain the engine cooling system to prevent damage from freezing, water-cooled compressors must be drained, as both cylinder block and cylinder head are water cooled.
Use drain cock or remove head and/or block pipe plugs.

3,000 Miles:

Service compressor air strainer. Remove and wash all parts including curled hair in 'leaning solvent. Saturate curled hair with clean engine oil and squeeze dry before replacing it in the strainer.

Check compressor mounting and drive for alignment, belt tension, etc. Adjust if necessary.

10, 000 Miles:

If compressor is self lubricated type, the oil should be drained and the compressor crankcase flushed and refilled with clean engine oil.

35,000 Miles:

Remove compressor discharge valve cap nuts and check for presence of excessive carbon deposits. Also, check the discharge line for carbon. If excessive carbon is found in either check, the cylinder head or discharge line should be cleaned or replaced.

If compressor is self lubricated type, service crankcase breather. Clean and wash breather in cleaning solvent.

If the compressor is lubricated from the engine, clean oil supply line to compressor. Also clean oil return line to engine crankcase if chassis is so equipped.

100,000 Miles:

Depending upon operating conditions and experience, disassemble compressor, clean and inspect all parts thoroughly. Repair or replace all worn or damaged parts.

TROUBLE SHOOTING

Compressor Fails to Maintain Adequate pressure in the Air Brake System

1. Dirty intake strainer.
2. Excessive carbon in compressor cylinder head or discharge line.
3. Discharge valves leaking.
4. Excessive wear.
5. Drive belt slipping.
6. Inlet valves stuck open.
7. Excessive leakage of inlet valves.

Noisy Operation

1. Loose drive pulley.
2. Excessive carbon in cylinder head or damaged line.
3. Worn or burnout bearings.
4. Excessive wear.

Compressor Passes Excessive Oil

1. Excessive wear.
2. Dirty air strainer.
3. Excessive oil pressure.
4. Oil return line or passage to engine compressor crankcase flooded.
5. Oil seal ring in end cover excessively worn.
6. Back pressure from engine crankcase.
7. Piston rings improperly installed.

Compressor Does Not Unload

1. Defective unloading piston grommet.
2. Unloading cavity plugged with carbon.
3. Unloading mechanism binding or stuck.

AIR BRAKE COMPONENTS

CONTENTS

GENERAL

GENERAL INSTRUCTIONS

Air brake equipment on trucks and truck tractors provides a means of controlling the brakes through the medium of compressed air.
Air brake equipment consists of a group of devices; some maintain a supply of compressed air, some direct and control the flow of the compressed air and others transfer the energy of compressed air into the mechanical force and motion necessary to apply the brakes. Different types and sizes of devices are in use on different types of vehicles to meet operating requirements.

The components used to make up a typical dual air system on a chassis are listed in this section with a brief description, operation, service checks and maintenance procedures.
Disassembly and reassembly instructions are provided for some components.

> CAUTION: Whenever any component is serviced or removed from the air system, be sure to set the parking brake and/or block the vehicle to prevent it from moving while the service is being performed.

LUBRICANT SPECIFICATIONS

Throughout the text whenever a particular lubrication note and a particular item number is made, refer to the following list of item numbers and use the lubricant specified.

Item 1

IH 251H EP grease or equivalent to NLGI #2 multipurpose lithium grease (same as BW 226M and 204M lubricant).

Item 2

Bendix Westinghouse 239 377 (2 oz.) molybdenum disulfide lubricant in liquid carrier. A lubricant suited for O ring powder suspended in synthetic lubricant (polyalkylene glycol derivative) and rubber parts as well as metal lubrication, especially at low temperatures.

Item 3

Bendix Westinghouse 291 126 (1/4 oz.) or BW 191 127 (2 oz.) silicone grease intended primarily for dynamic lubrication between oil resistant rubber seals and metal parts. Meets ' MILL4343A requirements. Can be used in serviceable range of 65 degrees F to +800 degrees F. Causes less swelling and hardness change of rubber parts than normally encountered with petroleum, based lubricants (approved source:
Dow Corning Corporation DC55 pneumatic grease).

LEAKAGE TESTS

In most cases where leakage tests are performed on various components, a soap bubble test can be made to determine if the items need repairs. However, to assist in locating any leakage at connections or at any components, we suggest that a Leak Detector Tester (SE2326) be used to locate any air leaks.

With special attachments contained in the tester a very small air leak can be detected easily; for example, in a confined area where a brush with soap is obstructed.

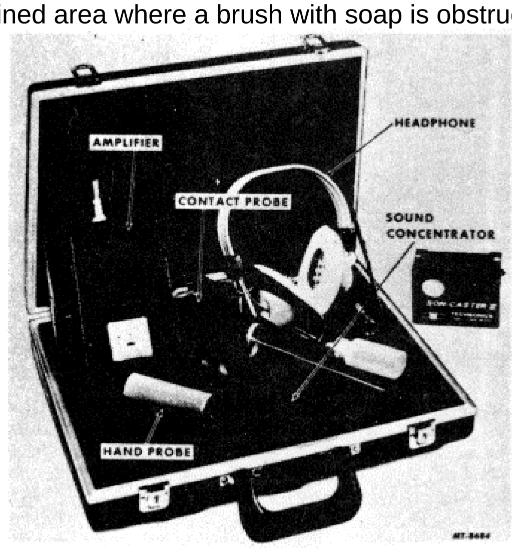


Fig. 1 Leak Detector Tester (SE2326)

CHAPTER I
GOVERNOR

BENDIX-WESTINGHOUSE D-2 TYPE

DESCRIPTION

The air compressor governor along with the compressor unloader mechanism automatically limits system pressure to a predetermined range by opening unloading valves and stopping compression when system pressure has been built up to maximum pressure limit and by closing unloading valves and starting compression when system pressure has dropped to minimum pressure limit.

The D2 governor has a piston upon which air pressure acts to overcome the pressure setting spring and control the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

Type D2 governors can be attached hed to the compressor or mounted remotely. They are adaptable to either mounting. Connections in this system are to the reservoir and compressor unloading ports. They also have an exhaust port.

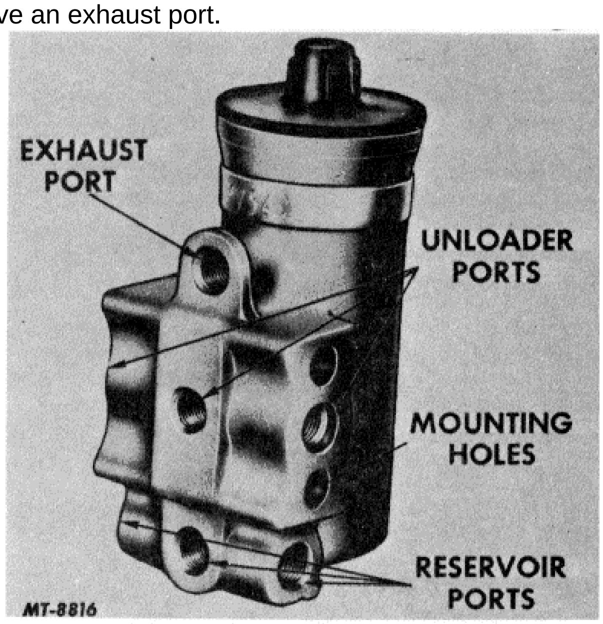


Fig . 1 Type D2 Governor

OPERATION (Fig. 2)

Reservoir air pressure enters the governor at ,one of its reservoir ports and acts on the area of the piston and beneath the inlet and exhaust valve. As the air pressure builds up, the

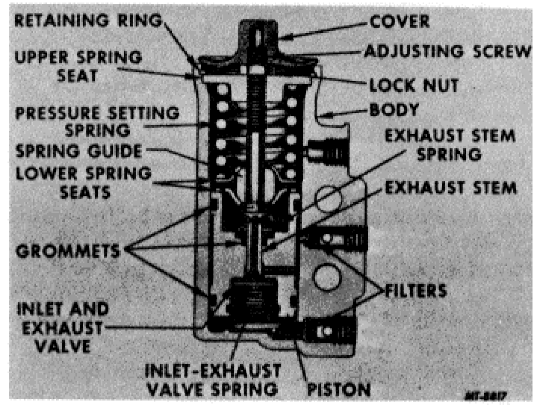


Fig . 2 Sectional View of type d-2 Governor

piston moves against the resistance of the pressure setting spring. The piston and inlet and exhaust valve move up when the reservoir air pressure valve move cutout setting the governor. aivernor.

The exhaust stem seats on the inlet and exhaust valve and then the inlet passage opens.

Reservoir air pressure then flows by the open inlet valve, through the passage in the piston and out the unloader port to the compressor unloading mechanism. The air, besides flowing to the compressor unloading mechanism, also flows around the piston and acts on the additional area of the piston, assuring positive action and fully opening the inlet valve.

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.

SERVICE CHECKS

Operating Tests

Start the vehicle engine and build up air pressure in the air brake system and check the pressure registered by a dash or test gauge at the time the governor cuts out, stopping the compression of air by the compressor. The cutout pressure should be in accordance with the piece number of the governor. The more common cutout pressures vary between 105125 psi.

With the engine still running make a series of brake applications to reduce the air pressure and observe at which pressure the governor cuts in the compressor. As in the case of the cutout pressure, the cut-in pressure should be in accordance with the governor piece number. Common cut-in pressures vary between 80100 psi. Never condemn or adjust the governor pressure settings unless they are checked with an accurate test gauge or a dash gauge that is registering accurately. If the pressure settings of the governor are inaccurate or it is necessary that they be changed, procedure is as follows.

First, unscrew the cover at the top of the governor. Next, loosen the adjusting screw lock nut. With a screwdriver the adjusting screw is turned counterclockwise to raise the pressure setting and the screw is turned clockwise to lower the pressure setting. After the adjustment is completed, the adjusting screw lock nut should be tightened to lock this adjustment.

Leakage Tests

Leakage checks on the D2 governor are made at its exhaust port in both cut-in and cutout positions. In the cut-in position check exhaust port for inlet valve leakage by applying a soap solution at the port. Leakage could also be past the bottom piston grommet. In the cutout position check the exhaust port to determine leakage at the exhaust valve seat or stem grommet. In this position leakage could also be past the upper piston grommet.

Leakage in excess of a 1" soap bubble in 3 seconds is not permissible in either of the foregoing tests. If excess leakage is found, the governor must be repaired or replaced.

REMOVE

Block and hold vehicle by means other than air brakes.

Drain air brake system.

If governor is compressor mounted type, disconnect reservoir air line. If remote mounted governor, disconnect both the unloader and reservoir air lines.

Remove governor mounting bolts, then governor.

INSTALL

If compressor mounted type governor, clean mounting pad on both compressor and governor block. Clean connecting line or lines. Also be sure compressor unloading port is clear and clean.

If the governor is being mounted remotely, it should be positioned so that its exhaust port points down. It should be mounted higher than the compressor so that its connecting lines will drain away from the governor.

Install governor.

If compressor-mounted type, use a new governor mounting gasket.

Connect air lines to governor. Test governor as outlined under SERVICE CHECKS.

DISASSEMBLY

Clean governor exterior of road dirt and grease using a good cleaning solvent and brush.

Unscrew the top cover.

With a pair of retaining ring pliers remove the spring assembly retaining ring.

Remove the adjusting screw and spring assembly.

Remove the lock nut, then the hex-shaped upper spring seat from the adjusting screw.

Remove the pressure setting spring, lower spring seat, spring guide and the other lower spring seat from the adjusting screw.

Remove the exhaust stem and its spring from the top of the piston.

With the body in the inverted position tap it lightly and the piston should fall out.

Remove the inlet and exhaust valve spring and the valve from the piston.

Remove the two piston grommets and with a hooked wire remove the exhaust stem grommet.

Clean or remove the unloader and reservoir port filters.

CLEANING AND INSPECTION

Clean all metal parts in a good cleaning solvent.

Wipe rubber parts dry.

Inspect body for cracks or other damage. Be particularly careful that the body air passages, the filters, exhaust stem and piston are not obstructed.

Check springs for cracks, distortion or corrosion.

Replace all parts not considered serviceable during these inspections.

ASSEMBLY, ADJUST AND TEST

Prior to assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston grommets, a piston setting spring guide and adjust screw using Item 1 in LUBRICANT SPECIFICATIONS.

Install the exhaust stem grommet in its groove in the stem bore of the piston.

Drop the inlet and exhaust valve into place at the bottom of the piston.

Install the inlet valve spring with its narrow end against the valve. Press the spring down until the large coiled end snaps into the groove inside the piston.

Position the exhaust stem spring over the exhaust stem. Then carefully press the stem into the stem bore of the piston.

Install the piston in the body.

Install one lower spring seat, spring guide, the other lower spring seat, pressure setting spring and the hex-shaped upper spring seat on the adjusting screw, in that order. Screw the upper spring seat down until the dimension from the top of the seat to the bottom of the stem head is approximately 17/8".

Install the lock nut.

Before placing the adjusting screw and stem assembly in the governor body, check to be sure the exhaust stem and its spring are in place in the piston.

Install the adjusting screw and spring assembly retaining ring.

At this point make the adjustment as outlined under SERVICE CHECKS.

After the adjustment is made, the top cover should be screwed on tightly until it seals the body against the entrance of any foreign matter.

If necessary, install new filters in the reservoir and unloader ports. These cup shaped filters can be installed with head of a pencil.

Perform operating and leakage tests as outlined in SERVICE CHECKS section when checking rebuilt governor.

MAINTENANCE

15,000 Miles

Clean or replace governor filters. If cleaning use a cleaning solvent which is known to have no detrimental effect on metal or rubber material.

100,000 Miles

Disassemble the governor and clean and inspect all parts.

CHAPTER II
RESERVOIR DRAIN COCK SAFETY VALVE
PRESSURE GAUGE - LOW PRESSURE INDICATOR - STOP LIGHT SWITCH

RESERVOIR

DESCRIPTION

The air reservoir (air tank) function is to provide a volume of compressed air used in braking the vehicle.

Another function of a reservoir is to provide a place where the air, heated during compression, may cool and cause the oil and water vapors to condense.

The combined volume of all service reservoirs and supply reservoirs are 12 times the combined volume of all service brake chambers at maximum travel of the pistons or diaphragms. The size of air tanks should never be altered without IH Engineering approval.

The reservoirs should be completely drained daily. If an automatic drain device is used, the automatic drain should be checked periodically to determine if it is functioning properly. When manually draining tanks, satisfactory draining is only accomplished by leaving the drain cocks open after all air has escaped and all drainage has stopped.

Reservoirs are tested against a 300 pound pressure and treated on the inside with a rust preventive.

SERVICE CHECKS

1. Leakage Tests. With the air brake system charged, use Leak Detector Tester (SE2326) to check for leakage on outside surfaces of reservoirs. If any leakage is found, replace the reservoir.

2. Inspection. Inspect inside and outside surfaces for damage or corrosion. A small flashlight is helpful when inspecting the interior. If damage or corrosion is found that would weaken the reservoir, replace the reservoir.

3. Moisture taken in with the air through the compressor inlet valve collects in the reservoirs and necessitates draining the reservoirs daily in cold weather and every week in warm weather by opening the drain cock located on the bottom. Be sure to close the drain cocks after all moisture has been removed.

MAINTENANCE

Drain air reservoirs regularly as required. Local conditions govern frequency. In dry climates, for example, once a month may be sufficient, while in humid areas it may be necessary to drain reservoirs daily.

When draining the air reservoirs, open the drain cock and let the air bleed off. Be sure to leave the cock open until all drainage stops.

DRAIN COCK

DESCRIPTION

Drain cocks have a brass body fitted with a tapered brass key. The drain cock is open when the handle is parallel to the body and closed when the handle is at right angles to the body.

Drain cocks are installed in the bottom of each reservoir (Fig. 1) in the air brake system to provide a convenient means of draining the condensation which normally collects in the reservoirs.

Always open a drain cock by hand. Never strike the handle with a hammer or any other instrument, as the cock will be damaged and leakage will develop.

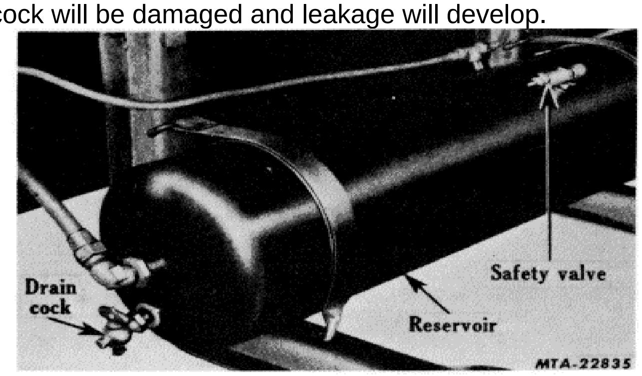


Fig. 1 Reservoir, Safety Valve and Drain Cock

SERVICE CHECKS

1. With air brake system charged, test with soap suds for leakage past the key. Also check for leakage through the body by coating the outside of the drain cock with soap suds. Leakage in excess of a 3" soap bubble in 3 seconds is not permissible.
2. Leakage is caused by dirty or scored key or body. Leakage due to dirt is corrected by cleaning parts and applying a thin coating of Item 1 in LUBRICANT SPECIFICATIONS on the key. Leakage due to a scored key or body cannot be repaired and the drain cock must be replaced.

SAFETY VALVE

DESCRIPTION

The purpose of the safety valve is to protect the air brake system against excessive air pressure. Should the air pressure in the air brake system rise above the setting of the safety valve at 150 pounds, the valve opens and permits pressure above 150 pounds to be exhausted.
It is located on the supply reservoir.

The safety valve is a piston type valve (Fig. 2). The piston is equipped with an O ring type seal which seats in the body of the valve.

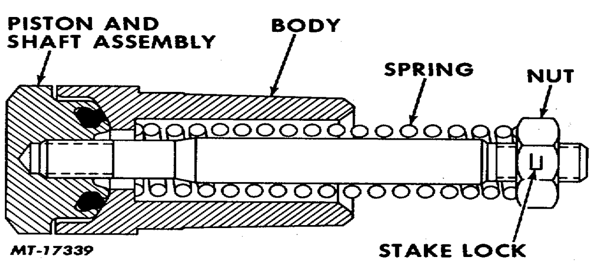


Fig. 2 Sectional View of Piston Type Safety Valve

MAINTENANCE

Once each year or every 100,000 miles the safety valve should be removed and thoroughly cleaned.

SERVICE CHECKS

Operating Test

The safety valve may be tested to be sure it is operative by pulling the exposed end of the piston. This removes the spring load from the piston and permits the valve to exhaust.

Leakage Test

Leakage at the piston in the body should not exceed a 3" soap bubble in 3 seconds. If air leakage is excessive the valve must be replaced since it is only serviced as a complete component.

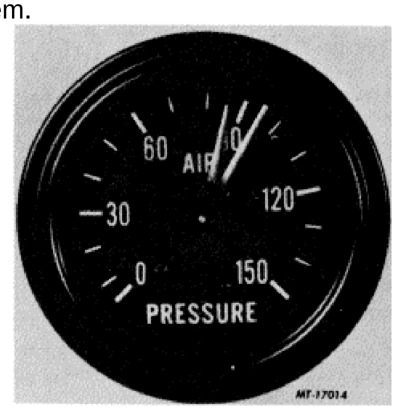
The safety valve should be set to "blow off" at approximately 150 pounds. The pressure setting may be adjusted by turning the adjusting nut clockwise to raise the pressure setting and turning the adjusting nut counterclockwise to lower the pressure setting.

Since the safety valve must be removed to perform any adjustments, it is suggested that the valve be replaced when any defect is detected.
CAUTION: When replacing the safety valve be sure to drain all air from the supply reservoir. Draining the primary and secondary reservoirs are not required since they are protected by check valves.

AIR PRESSURE GAUGE

DESCRIPTION

The purpose of the air pressure gauge is to register the amount of reservoir air pressure in the air system. While air pressure gauges of this type are commercially accurate, they must never be confused with or substituted for test air gauges, which are intended primarily for accurately checking air pressure in the air brake system.



Only test gauges known to be accurate are to be used for checking brake valve delivery pressures, governor pressure settings and other tests. Test gauges differ from ordinary dash gauges in respect to material and workmanship. Due to these differences they are more accurate over entire range and maintain their accuracy over longer periods.

After initial starting of engine, if air gauge shows that one circuit has no air pressure nor a noticeable increase in air pressure within a reasonable length of time (30 to 60 seconds) and the low pressure switch and low pressure light will not shut off, this indicates an open drain cock or a failure in the brake system.

NOTE: It is not compulsory but it is advisable that vehicles be inspected to be sure that the air gauges are properly connected. The primary system should be connected to the green needle and secondary system to red needle. This can easily be checked by charging the air system, bleeding off the primary system (rear brake reservoir) and the green needle should drop. If the green needle does not drop the air lines on the gauge should be changed. Al chassis would be assured that they are connected in the same manner and identification of both systems will be uniform.

SERVICE CHECKS

1. Check the air gauge for accuracy. The simplest way to do this is to compare the pressures registered by the gauge over its normal pressure range with the pressure registered by a test gauge know to be accurate.
2. A gauge which loses its accuracy must be replaced. The continued use of a dash gauge showing an error of more than 5 pounds is not recommended.

LOW PRESSURE INDICATOR (LP3 Type)

DESCRIPTION

The low pressure indicator (Fig. 4) is a safety device designed to give an automatic warning whenever the air pressure in the primary or secondary air brake system is below approximately 70 pounds. Operating as an air controlled switch of an electrical circuit, the low pressure indicator automatically sounds a buzzer when the air pressure drops too low. The warning will be both visible (light) and audible (buzzer).

The nominal pressure setting of 70 pounds is subject to a tolerance of plus or minus 6 pounds so that the actual operating pressure of the low pressure indicator may vary between 76 pounds maximum and 64 pounds minimum.

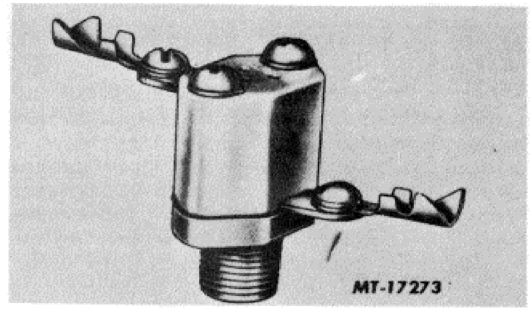


Fig. 4 Exterior View of Low Pressure Indicator

OPERATION (Fig. 5)

To describe the operation, we shall assume the Low Pressure Indicator is set for 70 psi. Setting of indicator is marked on a label on valve body. When air pressure at supply port and under the diaphragm is above 70 psi, electrical contacts remain open because the force exerted by air pressure underneath the diaphragm overcomes force exerted by the spring above the diaphragm.

When air pressure below the diaphragm drops below 70 psi, the spring exerts a force which is greater than the force exerted by the air pressure below the diaphragm. This causes the piston to move and allow the electrical contacts to close. This completes or closes electrical circuit to warning device, warning driver of low air pressure in the system .

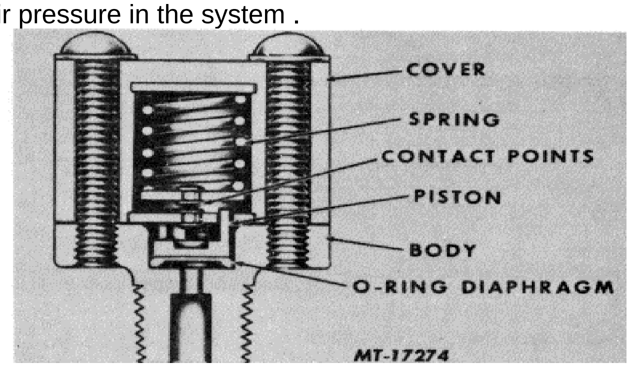


Fig. 5 Cross Sectional View of Low Pressure Indicator

MAINTENANCE

Once a month or after 10,000 miles, check electrical connections.

Every year or 100,000 miles, perform SERVICE CHECKS. If diaphragm is ruptured, replace complete assembly.

SERVICE CHECKS
Operating Test

Operation of the low pressure indicator may be checked with ignition switch on, then by reducing the reservoir pressure and being sure that the contacts close when the reservoir pressure is between 76 pounds maximum and 64 pounds minimum. The contacts will be closed when the warning light or electrical buzzer operates.

Leakage Test

A small vent hole is provided in the cover of the low pressure indicator to check the condition of the diaphragm. Cover the vent hole with soap suds or use Leak Detector (SE2326); if a leak is indicated, it signifies a ruptured diaphragm. Replace complete assembly.

REMOVE
1. The ignition switch should be in the "off" position.
2. Drain the air from the system.
3. Disconnect the electrical connections at the Low Pressure Indicator.
4. Remove the Indicator from fitting.

REINSTALL
1. Install indicator in fitting where old indicator was removed.
2. Connect electrical connections.
3. Charge air system and perform Leakage Test.

NOTE: Disassembly and reassembly of Low Pressure Indicator is not recommended since it is only serviced as a complete assembly.

STOP LIGHT SWITCH

DESCRIPTION

The stop light switch (Fig. 6) is an electropneumatic switch which operates in conjunction with the brake valve and stop lights by completing the electrical circuit when a brake application of 5 psi or more is made.

Both the primary and secondary brake systems are equipped with a stop light switch on a straight truck. If a failure should occur in either the primary or secondary systems, the system which is functioning properly will provide stop lights when the brakes are applied.

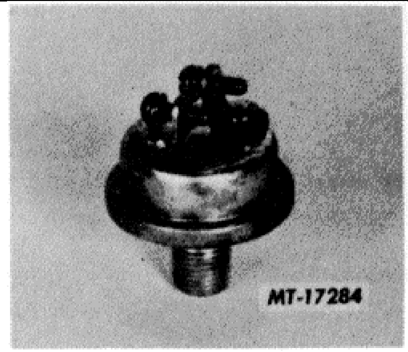


Fig. 6 Stop Light Switch

MAINTENANCE

Every month or every 10,000 miles check all electrical connections.

Every year or 100,000 miles the stop light switches should be replaced.

SERVICE CHECKS
Operating Tests

1. Both stop light switches must be checked in-

dependently on a straight truck to be sure both are functioning. Disconnect one switch.

2. Apply brake valve and note that with first downward movement of pedal or treadle that the stop lights go on immediately.
3. Release brake valve and note that stop lights of off.
4. If lights fail to go on use a test light at stop light connections. Test both terminals to determine if an electrical supply is available at switch; then "bypass" the switch with test light or jumper wire. Lights should go on. If not, a failure in the electrical circuit is the problem. However, if lights work, replace stop light switch.

Leakage Test

With brakes applied there should be no air leakage at stop light switch.

REMOVE

1. Disconnect electrical connections. Be sure to keep electrical connections from frame, etc. Tape them.
2. Remove switch from air fitting.

INSTALL

1. Install stop light switch in air fitting.
2. Install electrical connections.
3. After stop light switch is reinstalled, perform SERVICE CHECKS.

AUTOMATIC RESERVOIR DRAIN VALVE

DESCRIPTION

The DV2 Automatic Reservoir Drain Valve ejects moisture and contaminants from the reservoir in which it is connected. It operates automatically and requires no manual assistance or control lines from other sources.

The automatic reservoir drain valve has a die cast aluminum body and cover and is normally mounted either in the bottom of the reservoir using the top port of the drain valve or in the end of an end drain reservoir using the side port of the valve.

For vehicles operating in subfreezing temperatures, the valve is also available with a heater and thermostat cast into the cover.

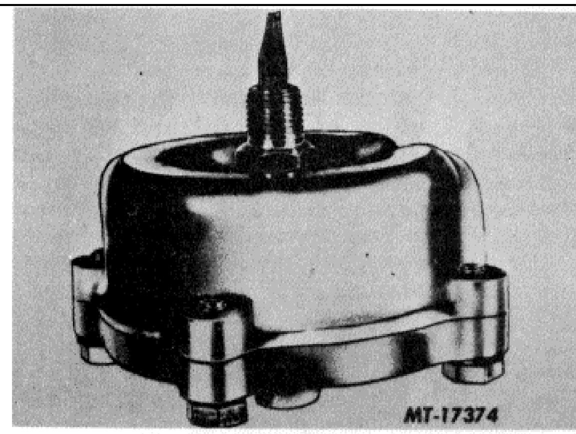


Fig . 8 Automatic Reservoir Drain Valve

OPERATION

With no air pressure in air system, the inlet and exhaust valves are closed (Fig. 9).

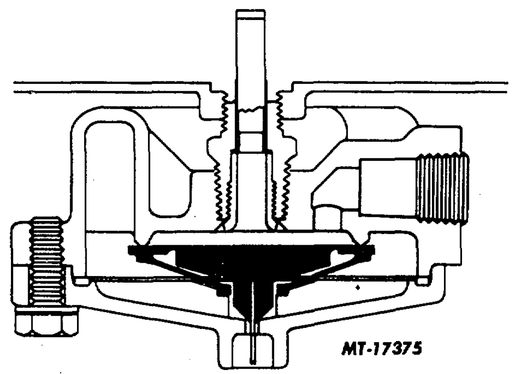


Fig . 9

When charging the air system, a slight pressure opens the inlet valve which permits air and contaminants to collect in sump (Fig. 10).

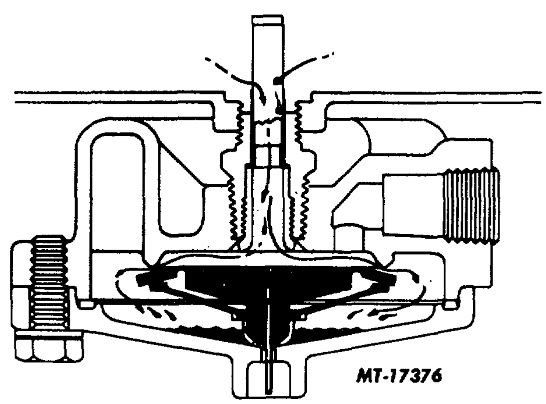


Fig . 10

The inlet valve remains open while pressure ascends in the system until maximum governor cutout pressure is reached. The spring action of valve guide in sump cavity closes the inlet. The inlet valve and exhaust valve are now closed (Fig. 11)

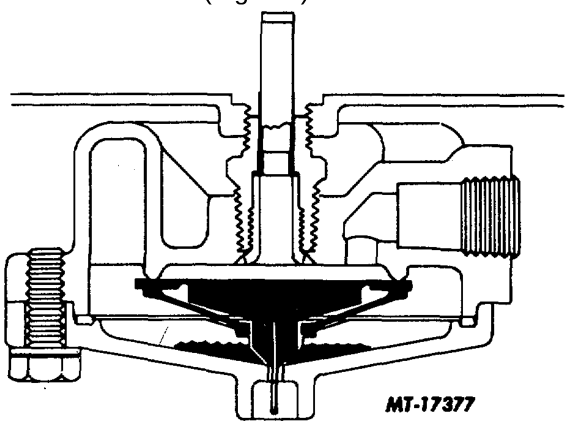


Fig . 11

When reservoir pressure drops slightly (approximately 2 psi), air pressure in the sump cavity opens exhaust valve allowing moisture and contaminants to be ejected from sump cavity until pressure in sump cavity drops sufficiently to close the exhaust valve. The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and reservoir pressure drop that occurs each time air is used from the system.

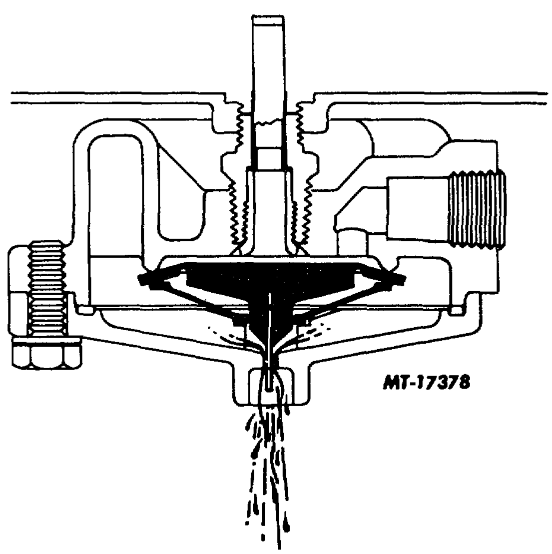


Fig . 12

Manual draining can be accomplished by inserting a tool in the exhaust port so that the wire in the port may be moved up and held until draining is completed.

The heated automatic drain valve will activate the heating element when the valve body is warmed to 85 degrees F.

MAINTENANCE

Once each year or every 100,000 miles the automatic drain valve should be removed, disassembled, cleaned and lubricated. Parts showing signs of wear or deterioration should be replaced.

Special attention should be given to the filter when the maintenance check is made. The filter must be clean and should be cleaned or replaced if clogged or damaged.

Under no conditions should valve be installed without a filter installed in the adapter.

SERVICE CHECKS

Operating Test

With system charged, make several foot valve applications and note each time an application is made if an exhaust of air occurs at exhaust port of the drain valve. If no air comes out, push the wire stem. If no air comes out, the filter is plugged and valve should be removed and cleaned.

Leakage Test

With system charged and pressure stabilized in system, there should be no leaks at the drain valve exhaust. A constant slight exhaust of air at the drain valve exhaust could be caused by excessive leakage in the air brake system.

If the automatic drain valve does not function as described or if leakage is excessive, it is recommended that it be removed and repaired or replaced.

REMOVE

1. Block and hold vehicle by means other than air brakes.
2. Drain air system.
3. Disconnect heater wire if valve is so equipped.
4. Remove automatic reservoir drain valve.

INSTALL

1. Block and hold vehicle by means other than air brakes.

2. Drain air system.

3. To prevent early plugging of the filter, thoroughly flush and clean reservoir before installing drain valve.

4. Aerate any tank thoroughly if any solvents have been used in the cleaning process.

NOTE: When installing the automatic reservoir drain valve equipped with a heater and thermostat, first determine if the vehicle electrical system is 12volt or 24volt and that the heater/thermostat unit is of the same voltage. The #14 gauge lead wire on the valve should be connected to the "on" position of the engine control or ignition switch. Use an 8amp fuse for one valve, a 15amp fuse for two valves and a 20amp fuse for three valves. All electrical connections must be waterproof.

DISASSEMBLY

Refer to Fig. 13 for disassembly of valve and proceed as follows:

1. Remove 4 capscrews and lockwashers.

2. Remove cover and sealing ring.

NOTE: If the heater or thermostat has failed, the entire cover must be replaced. Do not remove the thermostat cover plate. It is moisture sealed and removal could result in early thermostat failure.

3. Remove valve guide.

4. Remove inlet and exhaust valve.

5. Remove adapter and filter assembly.

6. Remove filter retainer.

7. Remove filter.

CLEANING AND INSPECTION

1. Cleaning solvent may be used on metal parts.
2. Rubber parts should be wiped clean.

3. Inspect all parts for wear or deterioration.

4. Clean and inspect filter and replace if clogged.

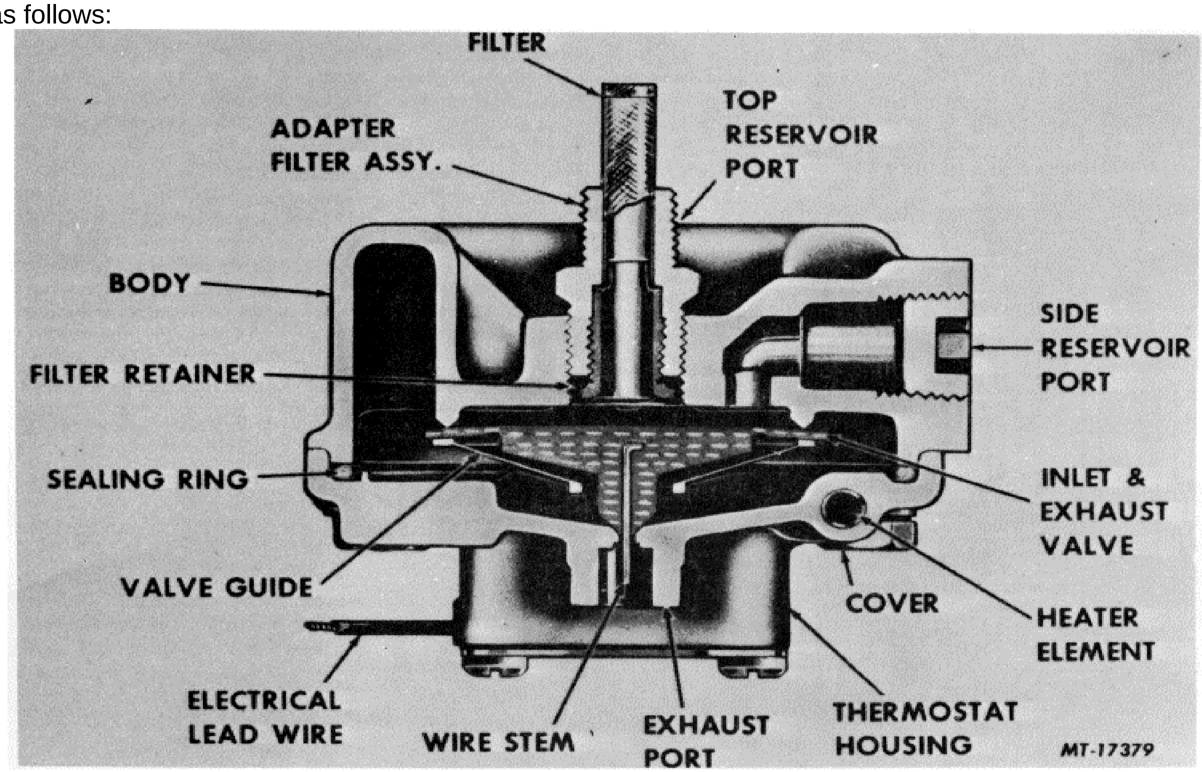


Fig. 13 Sectional View of Automatic Reservoir Drain Value

NOTE It is important that filter be in good condition. Do not put valve back into service without a clean filter.

Replace all parts not considered serviceable during these inspections.

ASSEMBLY

For the assembly of valve, refer to Fig. 13 and proceed as follows:

Before assembling the valve, apply a light film of grease on inlet valve seat. Do not apply oil to the inlet and exhaust valves.

1. Place sealing ring in groove of cover.

2. Place valve guide over inlet and exhaust valves.

3. Place valve guide and inlet and exhaust assembly into cover (wire will project through exhaust port).

4. Place body on cover and install capscrews and lockwashers.

5. Install filter and adapter and screw in filter retainer.

6. Install adapter and filter assembly in body and tighten.

7. Install drain valve in reservoir and reconnect heater wire if drain valve is so equipped.

NOTE Covers on the standard and heated drain valves can be interchanged.

Before returning the vehicle back to service perform SERVICE CHECKS as outlined.

CHAPTER III
CHECK VALVES

ONE-WAY CHECK VALVE

DESCRIPTION

The one-way check valve (Fig. 1) is used to permit passage of air pressure through the valve in one direction only as indicated by the arrow on the side of the valve. They are installed in both primary and secondary reservoirs to maintain the air supply in both reservoirs if an air loss should occur ahead of the valve.

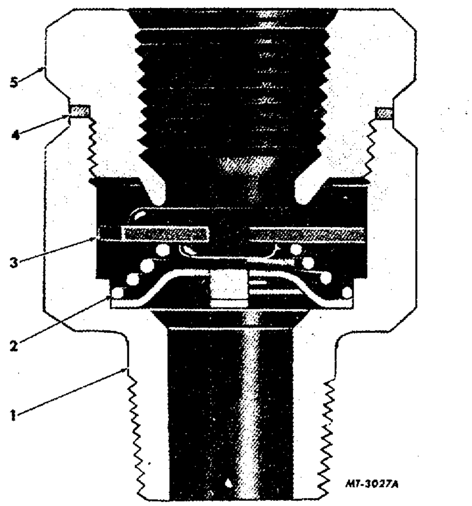


Fig. 1 Cross Sectional View of One-Way Check Valve

Legend for Fig. 1

Key	Description
1	BODY, Valve
2	SPRING
3	SEAL, Assembly
4	WASHER, Cap-to-Body
5	CAP, Valve

OPERATION

Air flow in direction of arrow moves the seal from its seat and the air flow is unobstructed. Flow in reverse direction is prevented by seating of the seal by the upstream air pressure and assistance of spring.

MAINTENANCE

Once each year or every 100, 000 miles check operation (see SERVICE CHECKS).

SERVICE CHECKS

Depending upon installation, it may be easier or necessary to completely remove check valve so that the following checks may be made. If checking valves at primary and secondary reservoirs, bleed air supply reservoir and disconnect air inlet to valve and proceed as follows.

CAUTION: Be sure to block or hold vehicle to prevent it from moving.

With air pressure present at outlet side of check valve and inlet open to atmosphere, use leak detector tester to test for leakage. A slight leakage is permitted. However, if valve leaks excessively, the valve should be replaced.

REMOVE

1. Block or hold vehicle by means other than air brakes.

2. Drain all air reservoirs.

3. Disconnect air lines and remove check valve.

INSTALL

1. Check and, if required, clean or replace air line to valve.
2. Install valve making certain that it is installed correctly. Arrow on outside of body indicates direction of air flow through valve.
3. Check valve for leakage.

CHAPTER IV

MIDLAND ROSS

Description (Fig. 1)

The foot-operated brake valve is the main air control device of the air brake system. While some different models or types may be encountered, all brake valves are similar in construction and are operated by either a brake treadle or pedal.

Movement of the treadle or pedal controls the movement of an inlet and exhaust valve which controls the air pressure delivered to or exhausted from the brake chambers.

Full depression of the treadle or pedal results in a full brake application, partial movement of the treadle or pedal results in correspondingly less braking force.

At any time, the brakes may be partially released by the driver permitting a partial return of the treadle or pedal to release position.

The amount of force being applied to the brakes is always proportional to pedal pressure applied by the driver.

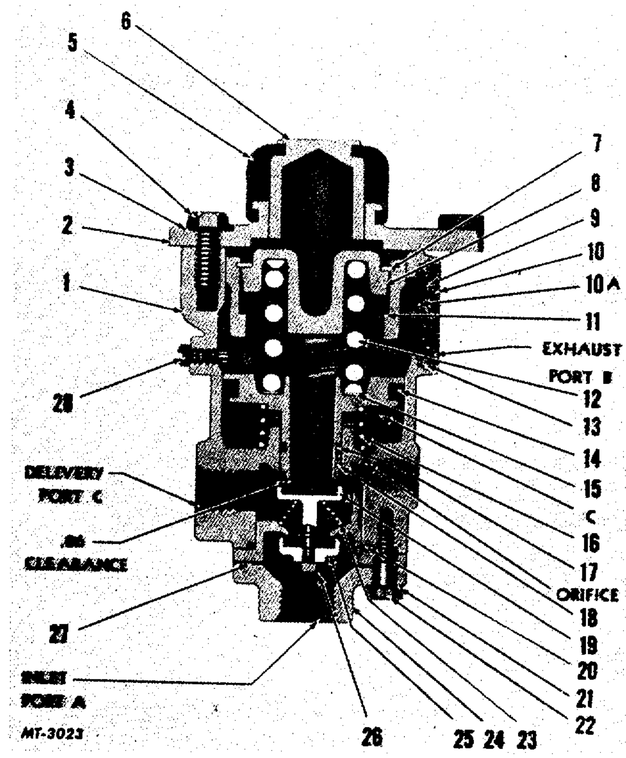
Operation (Fig. 1)

As the driver depresses the treadle or pedal, pressure is exerted against the plunger which moves the piston down to close the exhaust valve and open the inlet valve. This permits air pressure at the inlet port (A) to flow past the inlet valve and out the delivery port (C) to the brake chambers to apply the brakes.

Reservoir air pressure also passes through to a small orifice to cavity (C). When this pressure is equal to the mechanical force applied by the treadle, the piston moves up to close the inlet valve cutting off further supply of air pressure to the brakes. The exhaust valve remains closed preventing any loss of air pressure. In this position, the brake valve is in the lap position and instantly responsive to any movement of the treadle to increase or decrease air pressure being delivered to the brake chambers.

When the driver returns the treadle or pedal to its full release position, the piston completes its upward movement to unseat the exhaust valve. All pressure in the service line, not exhausted through a quick release valve, is released through the center of the piston and the brake valve exhaust port (B).

BRAKE VALVE



Legend for Fig. 1

Key	Description	Key	Description
1.	Body	15.	Washer, shim
2.	Plate, mounting	16.	Spring
3.	Washer, lock	17.	"O"-ring
4.	Screw, cap	18.	Piston
5.	Boot	19.	Valve, exhaust
6.	Plunger	20.	"O"-ring
7.	Ring, snap	21.	Washer, lock
8.	Guide spring	22.	Screw, cap
9.	Cleaner, air	23.	Spring, valve
10.	Cap	24.	Cap, end
10A.	Screen	25.	Valve, inlet
11.	Washer, shim	26.	Nut
12.	Spring	27.	Gasket
13.	Ring, snap	28.	Screw
14.	Seal, vee-block		

Disassembly (Fig. 1)

1. Scratch mark end cap, cage, body and mounting plate to assist in correct positioning for assembly.
2. Remove boot (5).
3. Remove three cap screws (4), lock washers (3) and mounting plate (2).

4. Remove screw (28) from body (1).
5. Remove piston assembly (18) and spring (16) from body.
6. Remove snap ring (7), spring guide (8), spring (12), and shim washers (15).
7. Remove spring (16).
8. Remove "O"-ring (17) and vee-block seal (14).
9. Remove cap screws (22), lock washers (21), end cap (24) and gasket (27).
10. Remove cage assembly and "O"-ring (20) from body.
11. Hold exhaust valve (10), unscrew nut (26) and remove exhaust valve spring (23) and inlet valve (25) from cage assembly.
12. Remove snap ring (13), cap (10), air cleaner (9) and screen (10A).

Inspection and Cleaning

1. Wash all metal parts in mineral spirits or cleaning fluid.
2. Scrape old gasket material from mating surfaces of end cap (24) and cage assembly.
3. Clean and wipe dry inlet valve (25) and exhaust valve (19). They must be replaced if nicked or worn.
4. Examine inlet valve seat in cage assembly and exhaust valve seat on piston (18). They must be free of nicks. Crocus cloth may be used to smooth off slight nicks; if nicks are too deep, replace piston or cage.
5. Replace boot if cracked or deteriorated.

Assembly

1. Place spring (23) on stem of exhaust valve (19) and install in cage with inlet valve (25) and nut (26). Tighten securely.
2. Install new "O"-ring (20) in body (1).
3. Use scratch marks to position gasket (27) and cage *assembly,* install *lock* washers (21), cap screws (22) and tighten securely.
4. Install new "O"-ring (17) and vee-block (14) on piston (18).
5. Install shim washers (15) in piston (four normally required) spring (12) shim washers (11) (two normally required) and secure in place with snap ring (7).
6. Apply light lubricant to inside bores of body. Install piston assembly in body.
7. Install screw (28) with head of screw tight against body.
8. Install plunger (6) in mounting plate (2), position mounting plate on body and secure in place with three lock washers (3) and cap screws(4). Tighten securely.
9. Install boot (5) in grooves in mounting plate.

NOTE: The gap between the exhaust valve and seat must be .06" minimum. This may be checked by inserting a feeler gauge through a delivery port.

Test

Released Position

Plug all cylinder ports. Connect air supply and air gauge to inlet port. Check exhaust port with soapy water. No leakage allowed.

Applied Position

Connect air *supply* and air gauge to one cylinder port. Depress treadle or piston to allow 5 to 10 psi air pressure to register on gauge in cylinder port. Check exhaust port with soapy water; a one inch soap bubble in three seconds permissible.

Depress plunger of brake valve slowly so that brake valve piston movement is also slight. Note that pressure gauge reading at cylinder port builds up in proportion to pressure gauge reading at inlet port. (The pressure reading at cylinder port should become greater as plunger is further depressed.) With plunger fully depressed, both gauges should read alike. While plunger is depressed in this holding position, a one inch soap bubble in three seconds at exhaust port is permissible.

Coat the entire valve with soapy water especially around gaskets, assembly screws, and tubing fittings. With brakes released or applied, no leaks are permitted. If tightening the assembly screws or fittings does not eliminate air loss, the brake valve must be disassembled and reassembled correctly.

When tests determine that brake valve is satisfactory, remove test gauges and air lines from valve. Prevent the entrance of dirt in valve by plugging all ports until valve can be reinstalled in air system.

QUICK RELEASE VALVE, LIMITING AND QUICK RELEASE VALVE COMBINATION

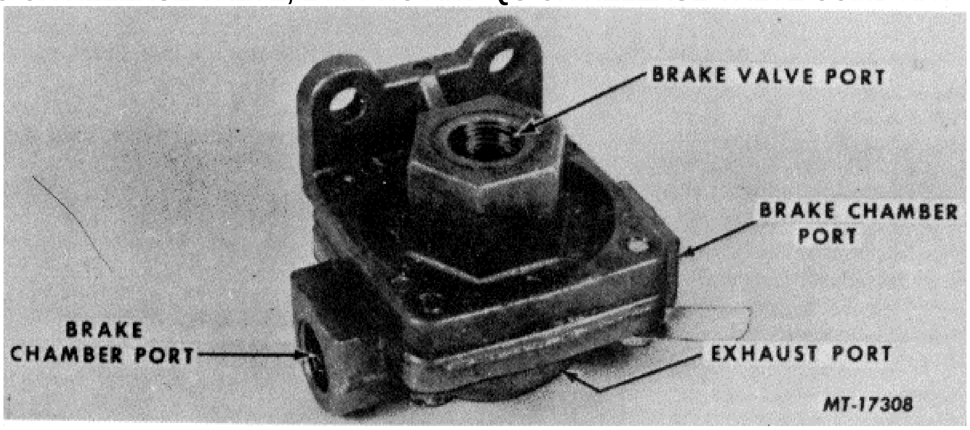


Fig. 1. Quick Release Valve

QUICK RELEASE VALVE

DESCRIPTION

The purpose of the quick release valve is to reduce the time required to release the brakes by hastening the exhaust of air pressure from the brake chambers. When a brake valve application is released, the exhaust of the quick release valve opens and the air pressure accumulated in the brake chamber is exhausted through the quick release valve, rather hastening than exhausting back through the brake valve .

The quick release valve opens amounted on the frame close to the brake chambers it controls. The line connected through to the quick release port is the delivery line from the brake valve. The two side ports are the brake chamber connections, and the bottom port is the exhaust.

> NOTE: In some special applications a spring and spring seat will be found in quick release valves.

OPERATION

When a brake valve application is made air pressure enters the top (brake valve) port of the QR-1 valve, moves the diaphragm down and flows into the brake chambers.

As soon as the brake chamber pressure beneath the diaphragm equals the air pressure being delivered in the brake valve, the outer edges of the diaphragm will seal against the cover seat. The exhaust port is still sealed by the center portion of the diaphragm. When the brake valve is released, air pressure above the diaphragm is exhausted, allowing the diaphragm to raise, opening the exhaust port and allowing brake chamber pressure to release.

MAINTENANCE

Every year or 100, 000 miles remove the quick release valve, dismantle it and clean all parts.

The diaphragm should be replaced if worn or deteriorated.

SERVICE CHECKS

Operating Tests

Apply the brakes and observe that when the brakes are released, air pressure is quickly exhausted through the exhaust port of the valve. Be sure the exhaust port is not restricted in any way.

Leakage Test

The valve must be tested at regular intervals for leakage using Leak Detector Tester (SE-2326) at exhaust port with the brakes applied. On releasing the brakes see that the valve releases immediately with the corresponding return movement of the foot pedal. Leakage may be caused by dirt in the valve or a defective diaphragm. Leakage in excess of a 1" soap bubble in 1 second is not permissible. If excessive leakage is found, the relay valve must be repaired or replaced.

REMOVE

1. Disconnect air lines from quick release valve.

2. Remove mounting bolts and valve.

INSTALL

1. Mount quick release valve with mounting bolts and lock washers with its exhaust port pointing down.

2. Connect brake valve to top port and brake chamber lines to side ports.

3. Make sure exhaust port is not restricted.

4. After the new or rebuilt valve is installed, perform tests as outlined under SERVICE CHECKS.

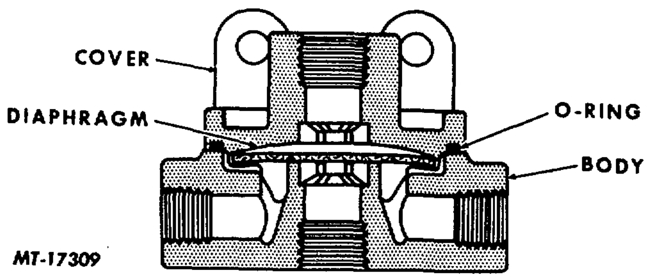


Fig. 2. Sectional View of Quick Release valve

DISASSEMBLY

1. Remove four screws.

2. Remove spring and spring seat if so equipped.

3. Remove diaphragm.

4. Remove cover O-ring.

CLEANING AND INSPECTION

1. Clean all parts in good cleaning solvent.

2. Inspect diaphragm, especially the *lower* part that contacts the exhaust seat and cover O-ring, for wear or deterioration. Replace if necessary.

3. Check the cover exhaust seat for pitting or nicks. This seat should be smooth and sharp. If not, use a fine piece of emery cloth to dress the seat.

4. Check the spring and spring seat(if valve so equipped) for wear or corrosion.

5. Clean or replace as necessary.

REASSEMBLY

1. If valve is equipped with spring and spring seat, position spring in body.

2. Position diaphragm over spring seat.

3. Place O-ring in groove.

4. Assemble cover and body.

5. Install four screws and tighten evenly.

LIMITING AND QUICK RELEASE VALVE COMBINATION

DESCRIPTION

The limiting quick release valve and two-way valve are used as a combination in air brake systems of trucks, buses and tractors. This combination permits full brake valve delivery pressure to the front wheel brakes when on dry roads, or, at the option of the driver, limits the pressure to the front wheel brakes 50 percent of the brake valve delivery pressure when on slippery roads.

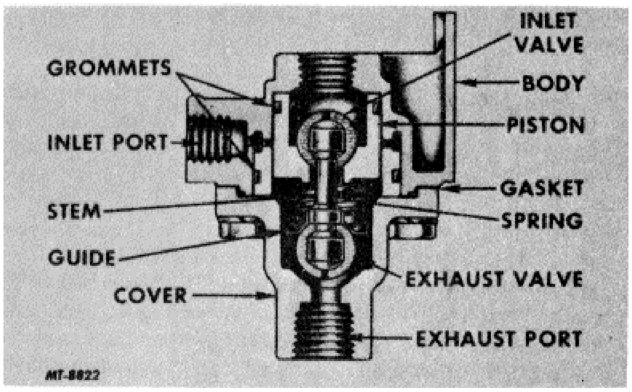


Fig. 3 Limiting and Quick Release Valve Combination

The two-way control valve (See Chapter IX) is mounted on the instrument -panel within reach of the driver.

Both the limiting quick release valve and the two-way valve are connected to a delivery port of the foot brake valve. One air line is connected to the inlet port on top of the limiting and quick release valve. Another enters the inlet port of the two-way control valve. A third air line is connected between one of the delivery ports of the two-way valve to the uppermost side port of the limiting quick release valve. There are two brake chamber delivery ports and an exhaust port located in the bottom cover of the limiting and quick release valve.

The limiting quick release valve, besides providing for a 50 percent reduction of front wheel braking pressures, also serves as a quick release valve upon release of brakes.

OPERATION

Dry Road Position

When the handle of the two-way valve is in the dry road position, the valve is "on" its inlet valve is off its seat, and the exhaust is closed. In this position, air has free passage through the valve.

If a foot brake valve application is made, air passes through the two-way valve and enters the side inlet port of the limiting and quick release valve. At the same time air also enters the top inlet port; therefore, pressure acts on the top and side areas of the piston. The piston moves down and the exhaust valve seats, closing the exhaust port. At the same time, the inlet valve opens and air passes through and out to the brake chambers.

When the air pressure beneath the piston and in the brake chambers equals the air pressure being delivered to the limiting quick release valve by the foot valve, the piston raises slightly and closes the inlet valve. Then when the foot valve application is released, the air on the top and side areas of the piston is exhausted through the foot valve. Now the air pressure beneath the piston raises it and the exhaust valve opens and the air in the brake chambers is exhausted out the limiting and quick release valve exhaust port.

Slippery Road Position

When the handle of the two-way valve is in the slippery road position, the valve is "off". Its inlet valve is seated and the exhaust is open. Air is stopped from passing through the valve.

If a foot brake valve application is made, air enters the limiting and quick release valve only at the top inlet port and not its side port, because air is stopped at the two-way control valve. Air pressure is only on the upper inner area of the piston. The piston moves down, the exhaust valve seats, and the inlet valve opens. Air pressure enters the brake chambers and also acts on the lower area of the piston. This lower area of the piston is about twice the size of the upper inner area of the piston, so when the pressure acting on the lower area is about half of the brake valve delivered pressure, the piston lifts and closes the inlet. In this position the air pressure in the brake chambers is approximately one-half the brake valve application pressure.

MAINTENANCE

Once each year the limiting and quick release valve and two-way valve should be disassembled and cleaned. The inlet and exhaust valve boots and piston grommets should be checked and replaced.

SERVICE CHECKS

Operation Test

With two test gauges you know to be accurate, disconnect one of the front brake chamber lines or remove the plug from the unused brake chamber inlet port, if this type, and install one of the test gauges. The other test gauge should be installed in a foot brake valve delivery line. Place the handle of the two-way valve in the dry road position and make a foot valve application. Readings on both test gauges should be the same. Release the foot application and note that the air is exhausted promptly at the exhaust port of the limiting and quick release valve.

Place the handle of the two-way valve in the slippery road position and apply the foot valve. The reading on the test gauge connected in the brake chamber or line should be about one-half the reading on the test gauge connected to the brake valve delivery line.

Leakage Test

With the two-way valve handle in the dry road position, make and hold a foot valve application. Check the exhausts of both the two-way and limiting and quick release valves for leakage.

Place the handle of the two-way valve in the slippery road position. Make a foot valve application and check the exhaust of the two-way valve for leakage.

If the limiting and quick release valve or two-way valve does not function as noted above or if leakage is excessive, it is recommended that they be reconditioned or replaced.

REMOVE AND REINSTALL.

Remove

To remove the limiting and quick release valve assembly, disconnect all air lines at valve and remove mounting bolts.

Install

Install valve in same location where removed using same mounting bolts. Connect brake chamber lines to delivery ports of valve and brake valve delivery line to top of inlet port and line from two-way valve to side inlet port. The perform the tests listed in "SERVICE CHECKS".

DISASSEMBLE

Remove the four capscrews that hold the valve cover to the body. Separate cover, gasket and body. Push piston assembly out of body. If necessary, the piston assembly can be dismantled and its component parts serviced. To disassemble the piston assembly, first remove the piston grommets.

The boot type inlet and exhaust valves are removable and serviceable. They can either be cut or pryed off the stem.

Remove the exhaust valve, valve guide and spring.

Pull the valve stem through the piston and remove the inlet valve from its stem.

CLEANING AND INSPECTION

Clean all metal parts of both valves in good cleaning solvent and dry thoroughly. All rubber parts will be replaced. Check all metal seats for scratches or scores. Polish seats with fine crocus cloth when they are nicked or corroded. Inspect all springs for cracks, distortion and corrosion and replace where necessary.

REASSEMBLE

If an arbor press is available, the inlet and exhaust valve boots should be pressed on the stem dry. Without an arbor press a little soap or water will make it easier to press on the stem.

Install inlet valve boot on stem and insert in piston.

Position spring and valve guide over stem and press exhaust valve boot on stem.

Lubricate body and cover bores, grommet and grommet grooves and other areas of the piston with a lubricant comparable to that listed in "LUBRICATION SPECIFICATIONS" item 1.

Press piston assembly in body but with caution so piston grommets are not damaged.

Position gasket and cover on body and install four capscrews with lock washers.

CHAPTER VI
RELAY VALVE

DESCRIPTION

The relay valve (Fig. 1) is used to operate the brakes on the rear axle of six wheel tractors, trucks or long wheelbase trucks.

It is operated by air pressure from the foot brake valve. The air pressure delivered to the brake chambers is the same as the pressure delivered to the relay valve.

With a direct air supply from the reservoir, the relay acts as a remote brake valve to speed up the application and release of brakes.

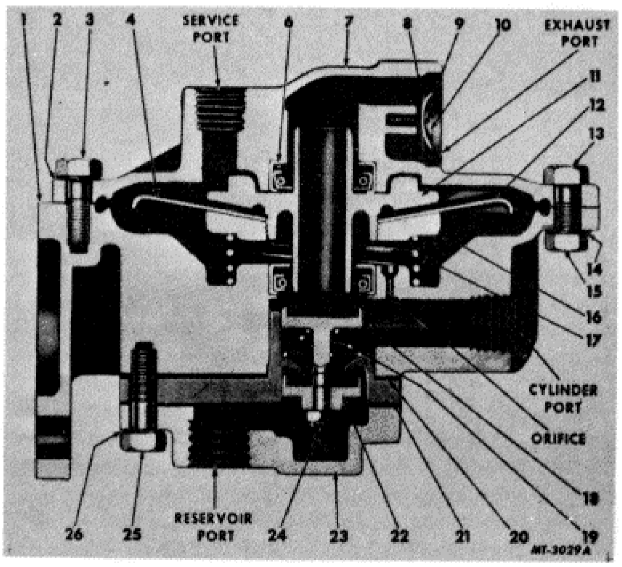


Fig. Cross Sectional View of Relay Valve

Key	Description	Key	Description
1	Body, Relay Valve	13	Bolt
2	Washer, Lock	14	Washer, Lock
3	Screw, Cap	15	Nut
4	Plate, Retainer	16	Nut, Diaphragm
5	Not Used Ret.		
6	Seal	17	Spring, Diaphragm
7	Cap	18	Valve, Exhaust
8	Diaphragm, Relay Valve	19	Bolt
9	Screw	20	Gasket
10	Retainer, Diaphragm	21	Cage, Body
		22	Valve, Inlet
11	Plunger	23	Cap
12	Diaphragm, Asm	24	Nut, Valve Stem
		25	Screw, Cap
		26	Washer, Lock

OPERATION

When the brake valve is applied, air pressure from the brake valve passes into the service port to fill the small cavity above the diaphragm in the relay valve. This pressure acting against diaphragm assembly (12) forces the plunger assembly down to close exhaust valve (18) and open inlet valve (22) allowing air pressure from the reservoir port and lower cavity of the relay valve to pass through the cylinder ports to the brake chambers. At the same time, air pressure from the lower cavity passes through a small orifice to the cavity below the diaphragm.

When this pressure builds up to equal the pressure at the service port, spring (17) moves the diaphragm upward, to close inlet valve. The relay valve is now in Lap position and instantly responsive to any movement of the brake valve to increase or decrease the brake application .

When the brake valve is released, air pressure at the service port exhausts thru the foot brake valve, spring (17) moves diaphragm assembly (12) to full upward position. Exhaust valve (18) opens to permit air from the brake chambers to pass through the hollow section of the diaphragm and plunger assembly and the exhaust port of the relay.

DISASSEMBLY

1. Remove three capscrews (3), lock washers (2), and five nuts (15), lock washers(14), and bolts (13).
2. Remove cover (7), diaphragm and plunger assembly, and spring (17) from body (1).
3. Remove screw (9), retainer (10), and diaphragm (8).
4. Remove diaphragm retainer nut (16), retainer plate (4), diaphragm (12), from plunger (11).
5. Remove five capscrews (25), lock washers (26) to remove end cap (23).
6. Remove cage assembly (21) and two gaskets (20).
7. To disassembly cage assembly, remove nut (24), inlet valve (22) from exhaust valve stem (18). Remove exhaust valve (18) and spring (19).

CLEANING AND INSPECTION

1. Wash all metal parts in mineral spirits or cleaning fluid.

2. Inspect inlet valve seat in cage assembly. It must be smooth and free from nicks.

3. Inspect rubber face of inlet valve (22) and exhaust valve (18). Wipe clean. Replace if worn, nicked or distorted.

4. Inspect lower end of plunger (11), it must be perfectly smooth.

5. Inspect two seals (6). If they are worn, press out of body (1) and replace.

6. Scrape all traces of old gaskets (20) from mating surfaces of cage assembly (21) and cap (23) and body (1).

7. Orifice in body must be free of dirt.

ASSEMBLY

1. Install spring (19) on exhaust valve stem (18) and install in body cage (21). Apply inlet valve (22), nut (24), and tighten securely.

2. Install new gaskets (20) on body cage. Install cage assembly in body (1) with five lock washers (26) and cap screws (25). Tighten securely.

3. Hold plunger (11) with threads facing upward, install diaphragm (12) with bead facing down, retainer plate (4) and tighten nut (16).

4. Apply light lubricant to outside of diaphragm and plunger assembly (11) and install in body.

5. Install diaphragm (8), retainer (10) and screw (9) in cap (7).

6. Locate cap on body and install three cap screws (3) with lock washers (2). Install five bolts and apply lock washers (14) and nuts (15). Tighten all cover bolts securely.

7. Use thread protectors in all pipe ports to prevent dirt entering the valve assembly.

TEST

1. Connect 100 psi air pressure to reservoir port.

2. Install air gauge in cylinder port. No leak allowed at exhaust port or around cage and cover gaskets.

3. Apply pressure to service port. No leak allowed at exhaust port or at assembly bolts.

CHAPTER IX
SPRING BRAKE AND TWO-WAY CONTROL VALVE

SPRING BRAKE CONTROL VALVE
(MIDLAND ROSS)

DESCRIPTION

The spring brake control valve is a manually operated valve of push-pull type. When the valve is pushed "in" the valve is open to supply air. The "out" position closes off supply air and allows delivered air to exhaust to atmosphere, applying the spring brakes. Valve also features a plunger pressure sensing arrangement which provides automatic return to "out" position when brake system air pressure approaches low energy levels.

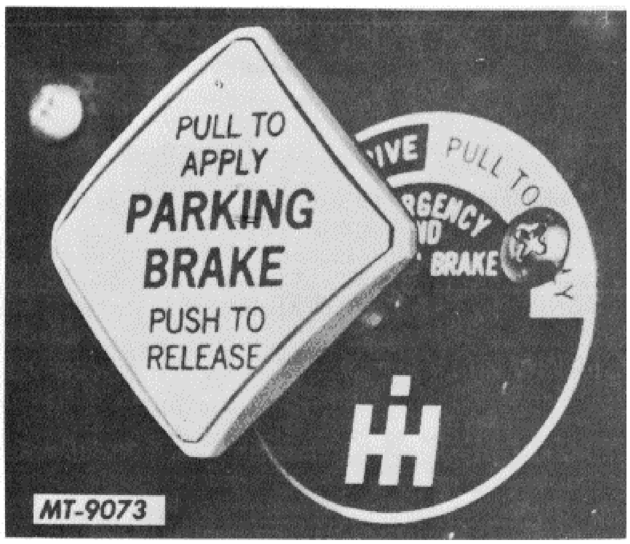


Fig. 1. Spring Brake Control Valve

OPERATION

The spring brake control valve serves to app and release the spring actuated parking brakes The valve is in the "in" position under normal operation on either a straight truck or tractor-trailer. Air supply passes through the valve delivering system pressure to retract and hold parking brakes in released position. Manual pull "out" closes off air supply and vents delivered air to atmosphere, applying the parking brakes.

When valve is pushed "in" it will remain in this position as long as supply line is 45 psi o0 more. If air pressure should drop to 28-35 psi during normal operation the air control valve will automatically apply, moving "out." The automatic application will result when both primary and secondary systems have depleted air supply to the 28-35 psi.

Refer to Fig. 2 for following operational description. Fig. 2 illustrates valve in applied (out) position.

Pushing piston in moves valve assembly off body seat until contacting end cap seat. Air pressure at inlet has free passage to outlet and is blocked from exhausting to atmosphere.

Pulling piston out moves valve assembly away from end cap seat and contacts body seat. Air pressure at inlet is blocked from entering either outlet or exhaust passages. Air pressure in outlet has free passage to exhaust to atmosphere.

The spring in the valve assists to move piston out automatically if inlet pressure drops and effective opposing force across the valve seat is overcome.

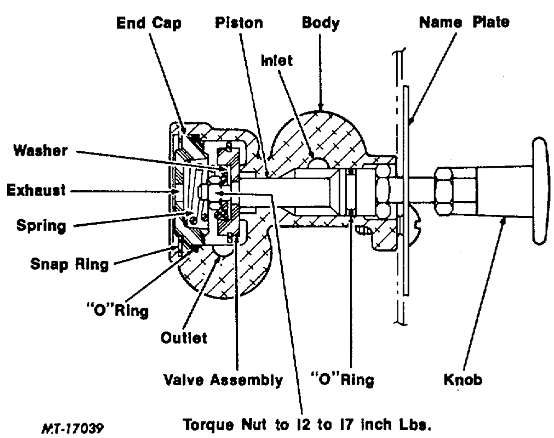


Fig. 2. Cross Section of Spring Brake Control Valve

MAINTENANCE

Once each year or every 100, 000 miles the valve should be removed, disassembled and a repair kit installed.

SERVICE CHECKS

<u>Leakage Test</u>

Use air pressure source equipped with in-line manual shut-off valve, air gauge known to be accurate and connection. Connect air source to inlet port. Also connect a manifold with an air gauge and close manual shut-off valve to outlet. With air control valve in "out" position, open manual valve to build up 100-125 psi to inlet port. Shut off manual valve. No air leakage is allowed around piston or through casting surfaces. Permissible leakage at exhaust port is a 1" soap bubble in 6 seconds.

Push control valve in and build up 100-125 psi at both inlet and outlet. Shut off manual valve and repeat above leakage test.

Pull control valve out. Outlet port pressure should exhaust to zero through valve.

Operation Test

Begin with zero pressure at inlet and outlet. Hold control valve "in" and open manual valve to allow 45 psi pressure to build up at both inlet and outlet. Control of valve should remain "in" at 45 psi and above.

Second check is accomplished with 100-125 psi in both inlet and outlet ports and both manual shut-off valves closed. Slowly open manual valve at outlet to bleed down pressure. The spring brake control should automatically move "out" when air pressure at inlet port reaches 28-35 psi.

If spring brake control valve does not perform as described it should be repaired or replaced.

DISASSEMBLY (Fig. 2) NOTE

Note: Before moving spring brake control valve from vehicle drain all air from all reservoirs,

1. After valve is removed from vehicle, inspect it for damage. If casting is broken or shows fractures replace valve assembly.
2. Carefully remove end cap snap ring.
3. End cap, O-ring and spring can be removed now.
4. Remove nut, washer and valve assembly.
5. Pull piston with the knob out end of body and remove O-ring from piston.

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent. Inspect body and end cap seats. Face of seats must be flat and smooth with no cracks or nicks.

Use new parts supplied in repair kit.

ASSEMBLY (Fig. 2)

Lubricate O-rings, O-ring sealing surfaces and piston-to-body surfaces with Item 3 of LUBRICANT SPECIFICATIONS.

1. Install O-ring on piston and insert piston into body, aligning hex on piston to hex on body.
2. Position valve assembly over end of piston, then position washer over piston stud end against metal face of valve.
3. Install nut and torque as specified on Fig.
2. Piston should move smoothly back and forth in body.
4. Install spring with small end against valve disc.
5. Position O-ring over end cap. Align end cap over spring and push end cap into body Hold end cap to prevent spring pushing end cap out.
6. Install snap ring in valve body groove.

Plunger should move in and out by applying force to move plunger in and releasing it.

Before releasing vehicle for service perform SERVICE CHECKS as outlined.

TWO-WAY CONTROL VALVE
(WAGNER ELECTRIC TYPE PB)

DESCRIPTION

The type PB control valve is a push-pull air valve, providing on-off manual control when an air system requires a simple non-metered application and exhaust of air pressure. It is used as the Trailer Emergency Brake Valve (control valve for the tractor protection valve) in a combination vehicle protection system to change the system for normal operation with trailer connected and to discharge the system in an emergency or bob-tailed tractor operation.

OPERATION

Applied Position

Valve knob will be pushed in to release trailer emergency. The reservoir port is open and exhaust port is sealed. The delivery port is always open and air flows from reservoir into system.

Released Position

Valve knob is pulled out to apply trailer emergency system or operate tractor without trailer. The reservoir port is sealed and exhaust port is open. Pressure in the emergency system at delivery now flows through exhaust port.

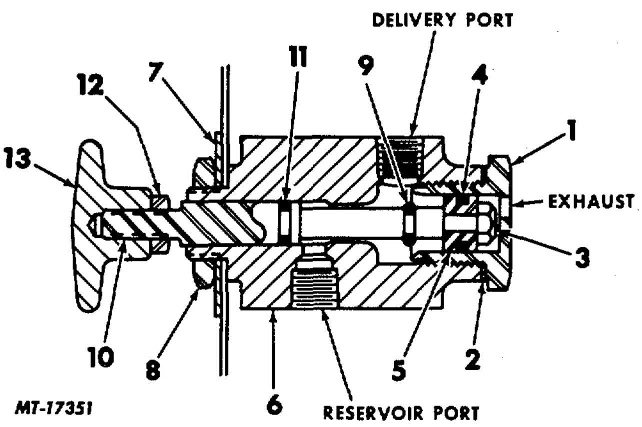


Fig. 4. Sectional View of Type PB Two-Way Control Valve

Legend for Fig. 4

Key	Description	Key	Description
1	CAP, Valve End	8	NUT, Mounting
2	GASKET, End Cap	9	O-RING STEM, Center (5/16" or
3	NUT, Valve Stem		
4	O-RING, Piston (1/2" OD)	10	STEM, Valve
		11	O-RING STEM, Front (3/8" OD)
5	PISTON		
6	BODY	12	NUT, Lock
7	PLATE, Name	13	KNOB

MAINTENANCE

Once each year or every 100, 000 miles the valve should be removed, disassembled and repair kit installed.

SERVICE CHECKS

Normal usage tests will provide good checks for valve. However, it should be checked periodically as follows.

Air leaks (disregarding normal exhaust) may appear at exhaust port. Nominal leakage of slow bubbling of soap will have little consequence in most systems. A leak at exhaust port when valve is applied indicates exhaust seal leaking.

If leakage occurs at stem end (at control knob) of valve, stem seal is leaking. If leakage is noted the valve must be removed and either replaced or repaired

REMOVE

Refer to Fig. 4 for numbers in parenthesis.

1. Loosen lock nut (12) and remove knob (13). Lock nut can now be removed.
2. Disconnect air lines at valve.
3. Loosen and remove valve mounting nut (8); then name plate (7); then remove valve.

INSTALL

1. Position valve through instrument panel.
2. Install name plate and mounting nut.
3. Connect air lines; then install control knob lock nut and knob. Tighten lock nut against knob to secure it.

NOTE: Prior to returning vehicle to service, perform SERVICE CHECKS as outlined.

DISASSEMBLY

Refer to Fig. 4 for numbers in parenthesis.

1. Remove end cap (1) and gasket (2).
2. Remove valve stem nut (3). To remove nut install two nuts on opposite end of stem (10) locking stem. Use a wrench at each end of stem to loosen stem nut (3).
3. Pull stem (10) from body (6).
4. Remove piston (5) from body.

CLEANING AND INSPECTION

Wash all metal parts in good cleaning solvent. Inspect body for nicks or burrs in bore of valve., Replace complete valve assembly if body is not considered serviceable.

Use new parts supplied in repair kit.

REASSEMBLY

Lubricate O-rings, O-ring sealing surfaces and stem with Item 3 of LUBRICANT SPECIFICATIONS (refer to Fig. 4 for numbers in parenthesis).

1. Install new O-rings on stem (10) and piston (5).
2. Insert stem in valve body; then position piston (5) in valve body over stem.
3. Install stem nut (3).
4. Install valve end cap (1) and new gasket (2).

Before vehicle is returned to service, perform SERVICE CHECKS on valve as outlined.

TWO-WAY CONTROL VALVE
(BENDIX-WESTINGHOUSE TYPE TW-1)

DESCRIPTION

The TW-1 two-way control valve, which is an off-on valve, is mounted on the instrument panel and is primarily used in conjunction with various other air devices in vehicle air systems. The systems in which these valves may be used are: transmission air control valve, quick release valve, two-speed shift cylinders, manually operated tractor protection valve and power divider lock-out system.

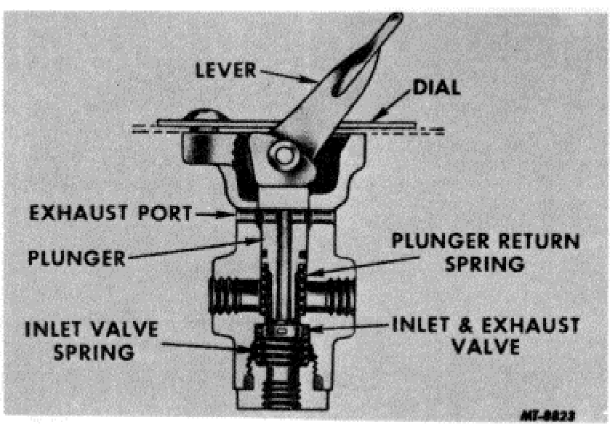


Fig. 5 Lever-Operated Two-Way Control Valve

OPERATION

Applying
When the lever is actuated in the delivery position, the hollow plunger of the valve is depressed and makes contact with the inlet valve and unseats it. In this position the exhaust passage through the hollow plunger is closed and air from the inlet port has free passage through the two-way valve and out the delivery port to the device being operated.

Releasing
When the lever is released, the plunger is raised by the plunger spring and the inlet valve moves to its seat and is held closed by the inlet ¼ valve spring and inlet air pressure. Any air pressure in line or lines connecting the two-way valve with the device being operated will be exhausted through the hollow plunger and exhaust opening near the top of the valve.

MAINTENANCE

Once each year or every 100, 000 miles the two-way valve should be disassembled and thoroughly cleaned. Replace all grommets and inlet valves worn or damaged in any way.

SERVICE CHECKS

Operation Test
Plug one delivery port and install an air pressure test gauge in remaining port. Install second air pressure gauge in the air inlet line. With air connected to the inlet port, place the lever in applied position. The air gauge in the delivery port should read the same as the gauge installed in air inlet line.

Leakage Test
With air supplied to the inlet port of the two-way valve and the lever in released position, use Leak Detector Tester (SE-2326) at exhaust opening at top of the valve (where lever enters valve) to locate any leak.

Move lever or button to applied position and check exhaust opening with Leak Detector Tester (SE-2326) to locate leakage past exhaust plunger.

REMOVE

1. Disconnect air lines at two-way valve.
2. Remove machine screws securing control valve in place and remove valve.

INSTALL

1. Install valve using the machine screws. Position lever-operated or push button-operated two-way valve on instrument panel with body of valve behind instrument panel and dial or instrument panel plate showing on front of panel.
2. Connect all air lines and perform tests outlined in SERVICE CHECKS.

DISASSEMBLY

1. Press out lever or plunger roll pin.
2. If valve is of the push-pull type, loosen jam nut at control button, then remove button and jam nut.
3. Remove plunger and plunger return spring from body.
4. Unscrew cap nut at inlet port and remove valve spring and valve from body.
5. Remove grommets from plunger and cap nut.

CLEANING AND INSPECTION

1. Wash all metal parts in cleaning solvent.
2. Check plungers for damage. Hollow hole plunger must be clean and free of all foreign material.
3. Inspect small end (exhaust seat) of plunger carefully; if chipped, worn or distorted, replace.
4. Check plunger retainer spring and valve spring for damage.
5. Valve body must be replaced if seat is worn excessively or damaged.

ASSEMBLY

1. Install new grommet on plunger.
2. Apply a small amount of the lubricant listed in LUBRICANT SPECIFICATIONS, Item 1, on the plunger and insert plunger return spring and plunger in the body. Plunger must move freely with only a slight drag due to grommet. Depress plunger and then release; plunger spring must return plunger.
3. Apply a lubricant comparable to that listed in LUBRICANT SPECIFICATIONS, Item 1, to cap nut grommet and position grommet on cap nut.
4. Position valve and valve spring in valve body.
5. Install cap nut in valve body.
6. Position lever on top of plunger and align hole in lever with hole in body.
7. Install lever pin and stake edge of hole.
8. Install jam nut and button on push-pull type valve. Install bracket on remote control (cable-operated) type valve.

CHAPTER XII
FLEXIBLE HOSE, NYLON TUBING, RIGID PIPING AND FITTINGS

DESCRIPTION

Rigid (copper) tubing and fittings of different sizes have been used to connect different air devices in the air system. However, flexible hoses and nylon tubing is gaining increasingly wide usage in place of copper piping on IH vehicles.

FLEXIBLE HOSE

Any size or length of hose can now be made locally for service requirements.

The hose is constructed of a seamless synthetic rubber lining or tube reinforced with one fabric braid of high tensile steel wire which is covered with a synthetic rubber-impregnated oil-resistant fabric braid.

These hoses can be used for air systems and air brake systems, except air line from air compressor to air reservoir, where the temperature will exceed 300 degrees F.

The fittings used at the ends of the flexible hose are of the swivel type, such as that shown in Fig. 1. The swivel end permits one end of the hose to be disconnected and not disturb the complete hose.

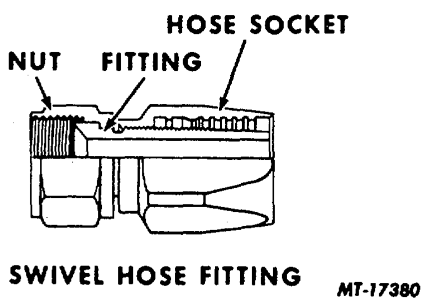


Fig. 1. Flexible Hose Fitting

CAUTION: Do not try to mix different type hoses and hose fittings. In some cases the hose and hose fittings may seem to fit, but the ends may not hold up under pressure. <u>If in doubt as to the identification of the hose and/or fittings which are being repaired, use new IH components to make up a new hose assembly.</u>

<u>Hose Assembly Instructions</u>

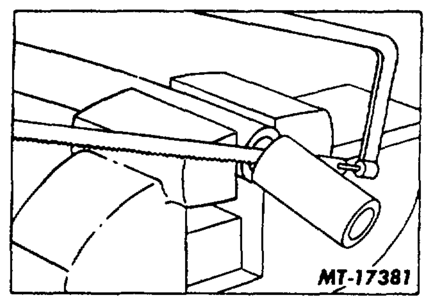
When the assembly procedure in making up a hose is being performed, each step should be finished carefully to assure proper connections at the hose ends.

1. Remove the hose fitting and nut from socket and hose. Fig. 1 illustrates the swivel hose fitting. So that the swivel nut and fitting can be removed from the hose and socket assembly, install a pipe adapter in the swivel nut and tighten it, locking the swivel joint assembly (nut and fitting). The swivel nut and fitting can now be turned out of the hose using a wrench.

2. Separate the hose from the socket.

3. Repeat steps 1 and 2 for the removal of second end.

4. Use a fine-tooth hack saw to cut hose to desired length (Fig. 2). Use care in supporting the hose so as not to crush or damage the hose during the cutting operation.



5. Lightly clamp the hose socket in a vise.

6. Screw end of new hose into socket until hose bottoms in fitting (turn hose counterclockwise). Then back off hose 1/4 turn (Fig. 3).

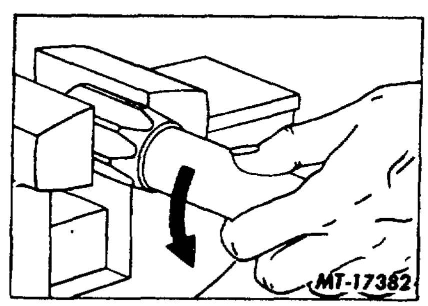


Fig. 3

7. Reposition hose and socket in the vise as shown in Fig. 4. Lubricate hose socket and fitting threads.

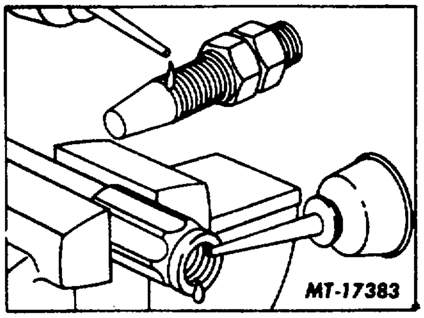


Fig. 4

8. Position hose socket in swivel nut and reassemble pipe adapter (if removed) to lock swivel nut on the fitting. Thread the fitting and swivel nut (with pipe adapter) assembly into the hose as shown in Fig. 5 leaving 1/32" to 1/16" clearance between nut and socket so that the nut can swivel freely.

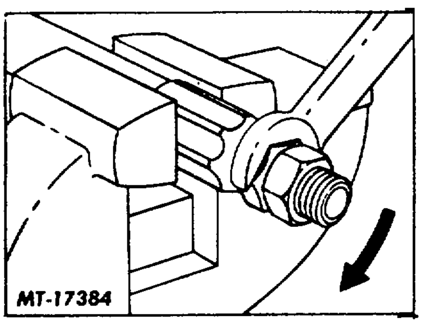


Fig. 5

9. Repeat steps 5, 6, 7 and 8 on opposite end of hose to install the remaining nut and fitting.

10. Lubricate the threads of the hose assembly when connecting the lines (use light engine oil sparingly).

11. When installing the new hose assembly on the vehicle be sure to check for possible leakage and correct any leaks if leaks are present.

<u>Hose Assembly Special Instructions</u>

Installation and routing of these hoses is just as important as special attention given to the installation of the ends. Common problems encountered with installation and routing which will result in short service life of these hoses are:

1. High external temperatures will shorten the life of a hose. Route hoses away from hot manifolds and exhaust systems.
2. Abrasion of hoses will cause outer surfaces to wear and weaken the hose. When installing these flexible hoses avoid contact or crisscrossing, sharp surfaces and contact of moving parts (shift levers and pedals). Clip hoses in place to prevent vibration, abrasion; route hoses together and parallel. If the hose cannot be clipped adequately, the hose must be equipped with a protective conduit (cover). If the hose being replaced has a protective conduit, be sure to use a cover on new hose.
3. Flexing of short hoses should not be allowed, since this will tend to wear the hoses at the fittings. If the hose must move, do not permit the hose to twist; keep the bend in the hose in the same plane as the movement where the hose is connected. Provide enough hose to permit any movement which may be required. Avoid sharp bends or turns in the hoses.

<u>NYLON TUBING</u>

In past years nylon tubing of varying construction has been used in such diverse applications as rear axle shift control lines, windshield wiper motor supply lines, transmission shift control lines and engine governor control lines.

With production of nylon tubing as a replacement for certain copper tubing in chassis <u>air brake system</u> applications, a superior nylon tubing which is suitable for all of the above applications as well as air brake system applications is now being provided for field service use.

<u>Nylon Tubing Assembly Instructions</u>

For the most part nylon tubing in air brake systems is assembled much like copper tubing. The same fittings, sleeves and nuts used with copper tubing can be used with nylon tubing. Long or short tube nuts may be found on chassis in service with nylon tubing (Figs. 6 and 7). Either nut may be satisfactorily used on the nylon lines.

> NOTE: If copper tubing is being substituted for nylon tubing, the short tube nut shown in Fig. 7 <u>must not</u> be used. Either the short tube nut or the long tube nut may be used satisfactorily with nylon tubing.

A tube support or insert will be used in all applications of the nylon tubing in air brake systems. The insert provides a stiff or rigid area for the sleeve to be crimped or compressed on the tubing and prevents collapsing the tubing when the nut is tightened. The parts listing notes that there are some sizes of tubing that are used only in accessory piping systems in repairing accessory piping systems tube supports are needed with all sizes of tubing except 1/8" O.D. if compression-type fittings are used.

Once the tubing has been connected and tightened the sleeve has been crimped on the tubing and insert. Since the sleeve has been compressed and distortion of the insert may have resulted, <u>the sleeve and inserts should never be used the second time.</u>

To assemble tubing ends for use with compression-type fittings, the following steps should be followed carefully.

1. Loosen and remove nut from fitting.
2. Pull tubing from fitting.
3. Repeat the same operations at other end of tubing. If only one end of line needs repairing, second end need not be disconnected if line is long enough to permit repairing.
4. Cut the selected size of tubing to length. Be sure to make smooth, square cuts. Either a sharp knife or hack saw may be used.
5. Position nut on tube.
6. Position compression sleeve on tube.

*7. Insert tube support into tube.

*8. Position the tube, support and sleeve in the fitting. Push tube in fitting until it bottoms.

9. Then install and tighten tube nut to secure sleeve on tubing.
10. Inspect tubing connections for air leakage. With the tubing. and associated fittings charged to full system air pressure coat tubing lines and fittings with soap suds to check for leakage. No leakage is permissible. Leakage at a tubing fitting is sometimes corrected by tightening the tubing fitting nut. If this fails to correct the leakage, replace the tubing fitting, tubing, or both.

* No tube support is used with 1/8" O.D. tubing. Certain fittings used in accessory piping systems have the tube support as an integral part of the fitting body. These fittings may be reused if no distortion of the tube support has occurred.

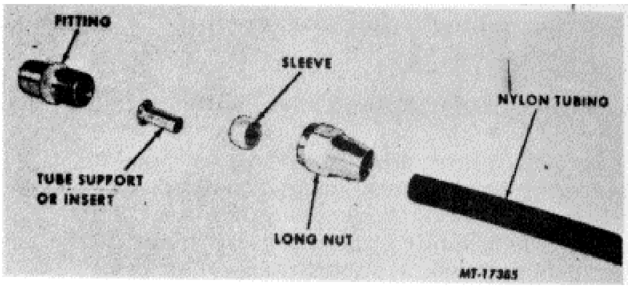


Fig. 6. Nylon Tubing assembly with Long nut

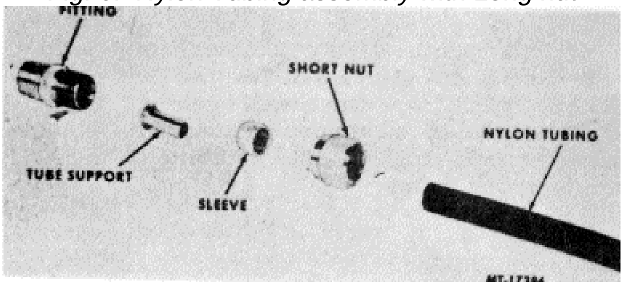


Fig. 7. Nylon Tubing assembly with Short nut

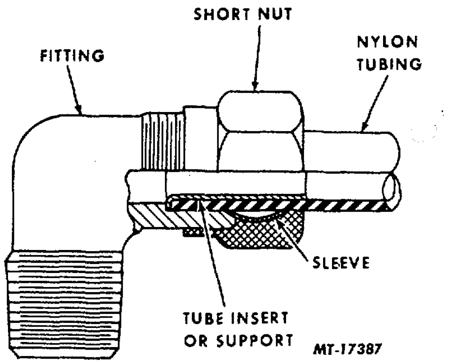


Fig. 8. Nylon Tubing Assembly Cross Section

<u>Nylon Tubing Special Instructions</u>

For the present this nylon tubing should not be substituted in the field for any metallic tubing. In addition, the following precautions must be taken in the use of nylon tubing.

1. Do not use nylon tubing for any application which would cause it to be exposed to temperatures <u>below -40 degrees F or above +200 degrees F.</u>

2. Do not subject nylon tubing to working pressure in excess of 150 psi.

3. Do not use nylon tubing for frame-to-axle, tractor-to-trailer or any similar line where a high degree of flexibility is required.

4. Observe extreme care when welding near nylon tubing. Hot slag or spark will damage the tubing.

5. Protect nylon tubing from battery acid.

The service nylon tubing will be marked at regular intervals with name, number, type, size and manufacturing code designations. This marking is intended to positively identify the tubing and prevent substitution of inferior quality tubing.

MAINTENANCE

Every six months all air connections should be checked and tightened if leaking (refer to SERVICE CHECKS). Once each year all tubing and hoses should be inspected for dents, kinks, chafing or crimping. Replace tubing if these conditions are found.

SERVICE CHECKS

Operating Tests

If any evidence is found that an air line is restricted, remove and blow out through it in both directions to be sure the passage through the tubing is not obstructed in any way. Inspect piping for partial restrictions such as may be caused by dents or kinks. Damaged pipes must be replaced.

Leakage Tests

With the air system fully charged, the governor cut out and brakes applied, use SE-2326 Leak Detector Tester at air lines and fittings to check for leakage. No leakage is permissible. Leakage at a tubing fitting is sometimes corrected by tightening the fitting nut. If this fails to correct the leakage, replace the tubing, sleeve or fitting, the tubing or hose.

CHAPTER XIII
ALCOHOL EVAPORATOR

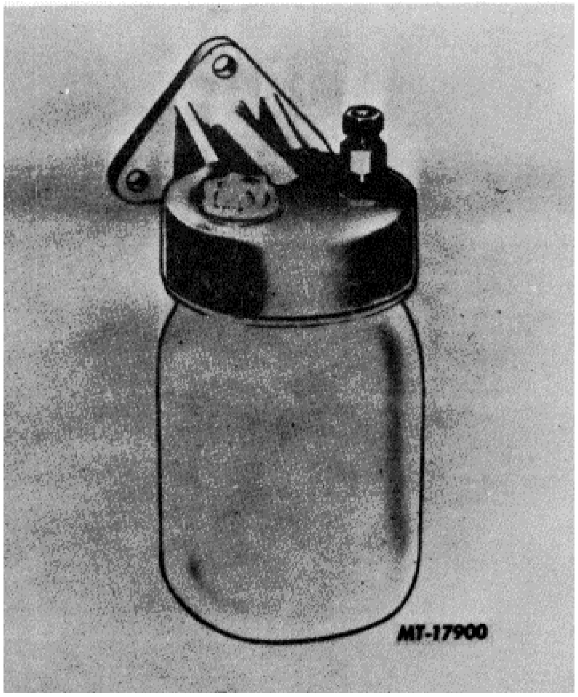


Fig. 1. AE-1 Alcohol Evaporator

BENDIX-WESTINGHOUSE-AE-1

DESCRIPTION

The alcohol evaporator is designed to permit vaporized alcohol to be drawn into the air brake system to overcome possible freezing of any moisture in the air brake system.

NOTE: The installation of an alcohol evaporator does not mean that daily draining of all air reservoirs is not required. In a moisture-laden atmospheric air system, a properly installed and maintained alcohol evaporator and daily draining of all reservoirs will be very effective in preventing air system freeze-ups.

The AE-1 alcohol evaporator (Fig. 1) has a die cast body which houses the filter, filter cap and evaporator tube. The die cast body also serves as a mounting bracket. The container can either be glass, plastic or metal and may also either be a pint, quart or two-quart size.

Some installations require the use of a check valve to prevent alcohol entering the engine induction system.

OPERATION

When the air compressor is in the compressing cycle, a partial vacuum is present at the compressor intake. A line from the evaporator is connected to the compressor intake, therefore a vacuum is created above the alcohol in the alcohol reservoir. Air at atmospheric pressure or greater, depending upon the type of installation, enters the evaporator and passes through the tube which is immersed in the alcohol. This air passing through the alcohol causes the alcohol to bubble and the vapor formed by the bubbling is induced into the compressor intake and on into the air system.

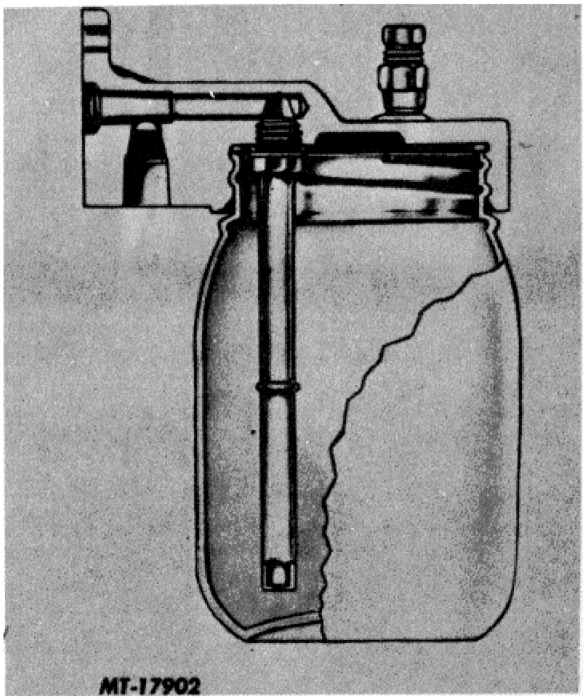


Fig. 3. Cutaway View of AE-1 Alcohol Evaporator

CONSUMPTION OF ALCOHOL

Complaints of inoperative alcohol evaporator or excessive use of alcohol can be traced to either a wrong kit being installed or an incorrect installation of a kit. For that reason the correct selection of a kit is very important.

The consumption of alcohol will vary on different vehicles. The main determining factor on properly installed and maintained units is the percentage of time the air compressor is in its loaded (compressing) cycle. Since the alcohol is only used when the compressor is compressing air, good maintenance practice should be followed by keeping air leakage in the system to a minimum and keeping the brakes adjusted.

It is difficult to estimate the amount of alcohol a vehicle will use. A guide to determine if the alcohol evaporator is working properly is:

Alcohol Usage = 30 cc to 70 cc (1 oz to 2 ozs) per hour if compressor is continuously pumping.

Example: If a compressor on a tractor-trailer will be loaded (compressing air) 20% of the total operating time of 12 hours (or roughly 2-1/2 hours), consumption of alcohol can be calculated by multiplying 70 cc of alcohol (maximum usage) by 2.5 hours, or approximately 175 cc of alcohol (1/3 to 1/2 pint) in 12 hours. Additional calculations reveal that if a compressor operates a greater percentage of time, more alcohol will be used.

TYPE OF ALCOHOL TO BE USED

It is recommended that only pure methanol alcohol be used in the air brake system. Certain types of alcohol and antifreeze solutions contain ingredients which leave residue or deteriorate parts in the air system.

Bendix Heavy Vehicle System Group markets alcohol under the name "Air Guard."

1 Qt. Can Part No. 242100

1 Gal. Can Part No. 246972

MAINTENANCE

40, 000 km or 25, 000 Miles

Make sure all fittings are tight and bubbles are present in alcohol when compressor is compressing air. Refer to Trouble Shooting Guide if evaporator assembly is not operating properly.

80, 000 km or 50, 000 Miles

If strainer is present, check to be sure it is clear. Clean or replace if necessary.

160, 000 km or 100, 000 Miles

Disassemble evaporator and check valve (if equipped); clean all parts, replacing all gaskets and rubber parts.

FILLING

1. Always use the filler plug on AE-1 evaporator. Frequent removal of alcohol reservoir will cause possible deterioration of gasket which will allow leakage and affect performance.

2. Fill reservoir 2/3 full. Be certain proper alcohol is used.

DISASSEMBLY, CLEANING AND INSPECTION, REASSEMBLY

1. Carefully disassemble, noting order of removal of parts.

2. Wash all metal parts in solvent; wipe all rubber parts clean.

3. Inspect all parts and replace all parts not considered serviceable.

4. Assemble parts, making sure new gaskets and rubber parts are properly installed.

TESTING FOR SERVICEABILITY

With compressor in compressing cycle, bubbles should be evident in alcohol. If air bubbles are not present, check Trouble Shooting Guide.

TROUBLE SHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	REMEDY
Alcohol Evaporator Does Not Operate (NOTE: See below)		
	Lines restricted (foreign material, kinked, etc.)	Clean or replace lines.
	Alcohol evaporator filter clogged	Clean or replace filter material.
	Leaky fittings, lines, jar cover gasket or filler cap gasket.	Tighten or replace necessary parts.
	3/16” line from compressor to alcohol evaporator longer than five (5) feet.	Line from compressor to alcohol evaporator should not be longer than 1.52 m (5').
	Compressor not in loaded (compressing air) cycle.	By observing dash gauge, make certain compressor is in loaded (compressing air) cycle.
	Check valve stuck in closed position.	Replace necessary parts or complete check valve.

NOTE: Proof that evaporator is functioning can be determined by:

1. If a glass jar is being used, alcohol should bubble when engine is revved (compressor loaded).
2. If a plastic jar or metal can is used, check exhaust of devices or reservoir drain for odor of alcohol.

PROBLEM	POSSIBLE CAUSE	REMEDY
Excessive Use of Alcohol		
	Leaky compressor unloaders (supercharge and turbochargers induction only). Leaky unloaders can cause alcohol to be "blown" into the engine intake.	Replace compressor unload-
	Evaporator is subjected to excessive temperature (greater than 490 C, 1200 F).	Relocate alcohol evaporator.
	Check valve leaking or inoperative (Engine Air Cleaner Inductiononly).	Replace necessary parts or complete check valve.
	Excessive system leakage (causing compressor to be in loaded compressing air cycle in excess of normal).	Check system leakage. Leakage should not be greater than 2 psi in one minute for single vehicles
		(with brakes released).
	Choke fitting, B.W. part No. 245103, not used (supercharged and turbocharged induction only).	Install choke fitting (B.W. 245103) at compressor inlet.
	Clogged air strainer (will cause excessive intake vacuum).	Clean or replace air strainer element.
Deposit of Residue in Valves from Alcohol	Wrong alcohol being used. cohol, Bendix-Westinghouse "	Use only pure methanol al- Air Guard" or equivalent.

CHAPTER XIV

AIR DRYER

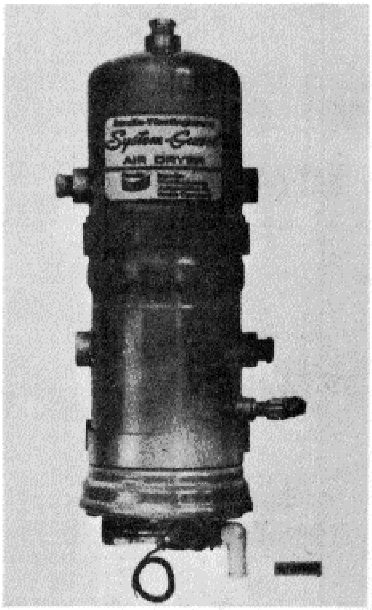


Fig. 1. AD-1 Air Dryer

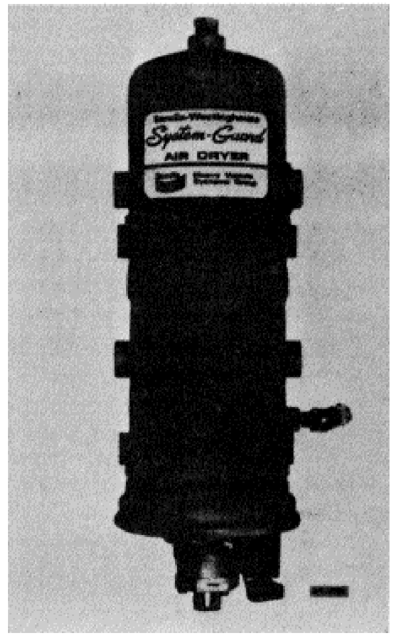


Fig . 2 . AD-2 Air Dryer

DESCRIPTION

The air dryer function is to collect and remove moisture and contaminants before air reaches the first reservoir, thus providing "super dry" air for the air brake system. Daily draining of the air system reservoirs is no longer necessary with an air dryer and air brake system maintenance is considerably reduced when compared to an air brake system without an air dryer.

The air dryer is installed in the discharge line between the air compressor and supply reservoir. The unit is mounted vertically, usually on the frame of the vehicle.

The housing assembly consists of two cylindrical steel stampings welded together. The housing on the AD-2 Air Dryer incorporates two inlet ports, one reservoir port and one purge volume port. The side outlet port of the AD-2 has an integral single check valve with the top port used for the addition of purge volume.

The AD-1 Air Dryer has two inlet and three outlet ports, but is not equipped with a single check valve in any of the three outlet ports.

The safety valve protects against excessive pressure buildup within the housing.

The desiccant sealing plate is located midway in the housing assembly and houses a replaceable single type check ball and a purge orifice. The desiccant cartridge and paper pleated oil filter are removable and comprise a complete serviceable unit.

The desiccant beads, referred to as the "drying bed, " are a drying substance which has the unique property of exposing a tremendous surface area in proportion to its bulk. Desiccant beads weighing .454 km (1 lb.) have about 186, 000 $_{m2}$ (two million square feet) of absorptive area made up of a large number of submicroscopic cavities in each bead. Each bead absorbs or extracts moisture from the compressed air.

The desiccant beads are held in place in the cartridge with steel perforated plates and filter cloths. The top plate is held in place by a spring, while the bottom plate rests on a shoulder about 3 mm (1/8") from the bottom of cartridge housing.

The end cover assembly is retained by

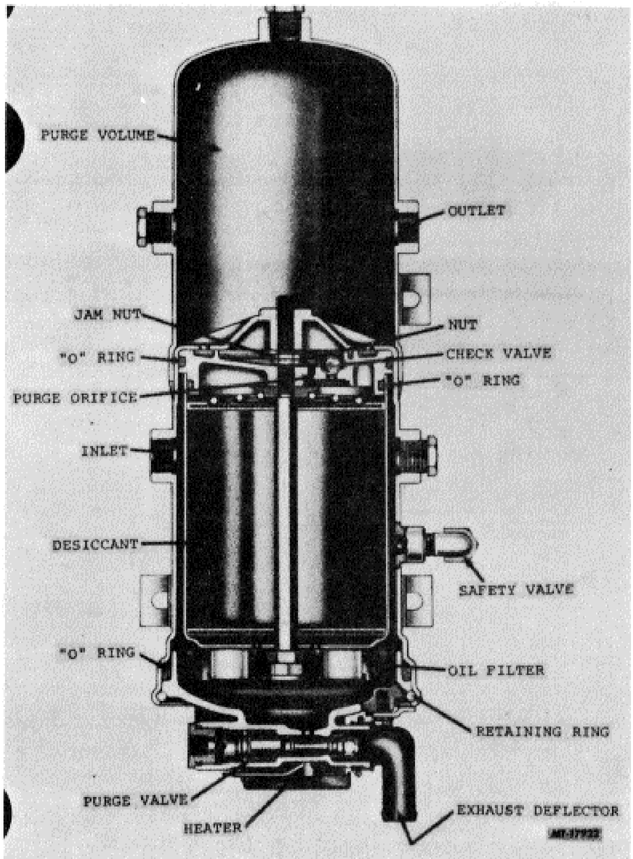


Fig . 3 . Sectional View of AD-1 Air Dryer

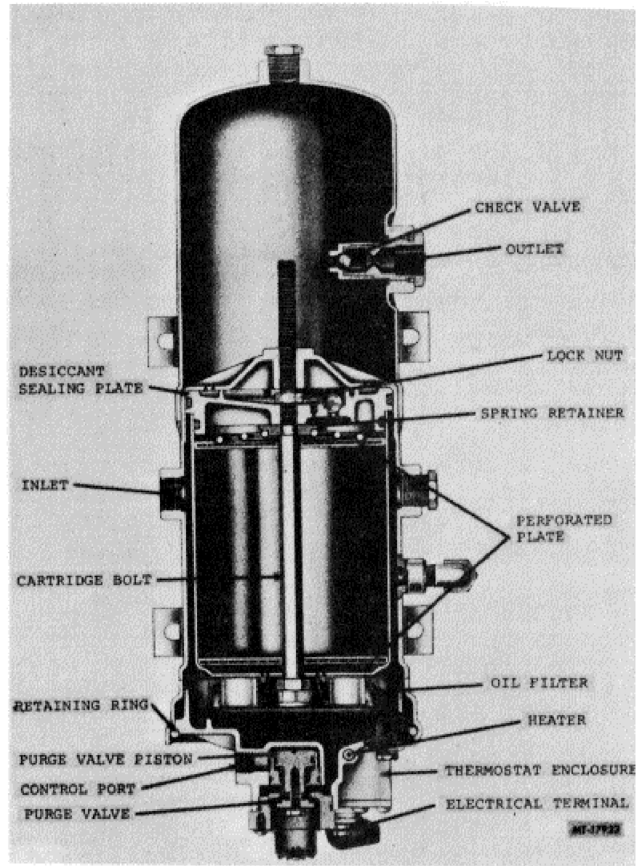


Fig. 4. Sectional View of AD-2 Air Dryer

a lock (retaining) ring, capscrews and retainers, and houses the purge valve and heater assembly if so equipped.

The heater and thermostat assembly prevent freeze-up in the purge drain valve when the dryer is used in severe winter conditions. The heater and thermostat assembly is standard in the AD-2 and was optional equipment for the AD-1. The 60 watt, 12 or 24 volt DC heater and thermostat assembly has an operating range between 100 C and 320 C (500 F and 850 F).

OPERATION

The operation of the air dryer can , best be described by separating the operation into two cycles; the charge cycle and the purge cycle.

Charge Cycle (Fig. 5)

With the compressor in its "loaded" or compressing cycle, air from the compressor enters the air dryer through the

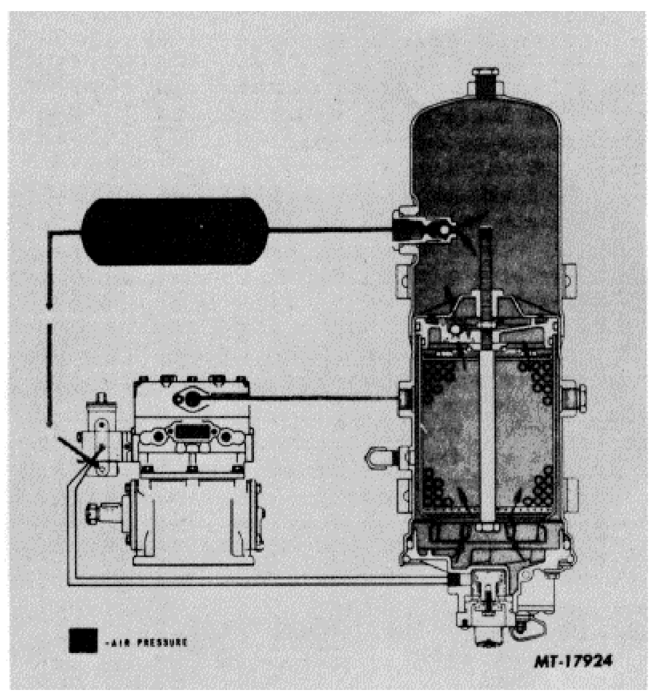


Fig. 5. AD-2 Operational Charge Cycle

discharge line. When the air along with the water and contaminants enter the air dryer, the velocity or speed of the air reduces substantially and much of the entrained liquid drops to the bottom or sump of the air dryer. The initial air flow is toward the bottom of the dryer, but air flow direction changes 180 degrees at the bottom of the air dryer dropping some water and oil.

The air now passes through the oil filter which removes some oil and foreign material but does not remove water vapor. At this point, the air remains saturated with water.

The filtered air and vapors penetrate the desiccant drying bed and the adsorption process begins. Water vapor is removed from the air by the desiccant.

The unsaturated "dry air" passes through the ball check valve and purge orifice into the purge volume. From the purge volume air flows through a check valve and into the first reservoir.

NOTE: The AD-1 Air Dryer does not incorporate an integral check valve. The single check valve in an AD-1 installation would be located in the line between the AD-1 outlet port and the first reservoir.

Purge Cycle (Fig. 6)

When desired system pressure is reached the governor cuts out, pressurizing the unloader cavity of the compressor which unloads the compressor (non-compressing cycle). The line connecting the governor unloader port to the end cover purge valve port (bottom of the air dryer) is also pressurized, opening the exhaust of the purge valve to atmosphere. With the exhaust of the purge valve open, contaminants in the discharge line and dryer sump are purged or forced past the open exhaust out to atmosphere.

The reverse air flows across the desiccant and starts the removal process of moisture from the desiccant surface. Dry air flowing from the purge volume through the purge orifice and across the drying bed further dries the desiccant.

The combination of these reverse flows strips the water vapor from the desiccant (drying bed). This normally takes between 12-15 seconds.

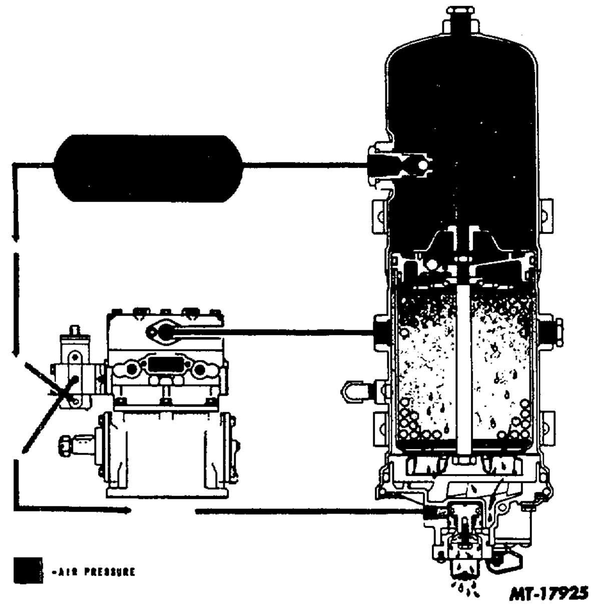


Fig. 6. Operational Purge Cycle

The desiccant becomes activated from this cycle and is now ready for another charge cycle, which occurs when the compressor returns to the compressing cycle. It is for this reason the air dryer must be purged for 20 seconds after receiving moisture saturated air for a maximum of 60 seconds from a 1.2 $_{m2}$ (12 CFM) compressor.

MAINTENANCE & CHECKING SERVICEABILITY

Every 37, 000 km (23, 000 miles) or every three months:

1. Inspect for moisture in the air system by opening reservoirs, drain cocks or valves and checking for presence of water. In areas where more than approximately a 170 C (300 F) range of temperature is common, small amounts of water can accumulate in the air brake system due to condensation. The presence of small amounts of water due to condensation is normal and should not be considered as an indication that the dryer is not performing properly.

   The desiccant cartridge should be replaced or rebuilt when it has been determined that the desiccant is contaminated and does not have adequate water adsorption capacity. However, the following checks should be made before replacing the desiccant cart ridge to ascertain that the water accumulation is not related to the following listed items:

a. An outside air source has been used to charge the system. This air did not pass through the drying bed.

b. Air usage exceptionally high and not normal for a highway vehicle. This may be due to accessory air demands or some unusual air requirement that does not allow the compressor to load and unload (compressing and non-compressing cycle) in a normal fashion. Check for high air system leakage.

c. The air dryer has been installed in a system that has been previously used without an air dryer. This type system will be saturated with moisture and several weeks of operation may be required to dry it out.

d. Location of the air dryer is too close to the air compressor. Refer to "Installation" section.

2. Check mounting bolts for tightness. Check all air and electrical connections.

3. Check the operation of the integral single check valve in the AD-2 or the "in-line" check valve used with AD-1. Build the air system, to governor cutout and observe the test air gauge installed in the supply reservoir. A rapid loss of pressure could indicate a failed check valve. This can be confirmed by checking at the purge valve exhaust.

   NOTE: Purge valve will be open when governor cut-out pressure is reached. Allow two minutes for purge cycle before testing the check valve.

4. Check for excessive leakage at the purge valve by coating the exhaust with a soap solution while the compressor is loaded (compressing air).

5. Check the operation of the safety valve by pulling the exposed stem while the compressor is loaded (compressing air). There must be an exhaust of air while the stem is held and the valve should reseat when the stem is released.

6. Check all lines and fittings leading to and from the air dryer for leakage and integrity.

7. Check the operation of the heater and thermostat during cold weather operation. This can be done by allowing the end cover assembly to cool below 100 C (500 F) and feeling the end cover when the ignition is turned on. The end cover should be warm to the touch within a few moments. Warming should cease at about 300 C (850 F).

The desiccant change interval may vary; however, it is generally recommended that the desiccant be replaced every 12 months (yearly). If experience has shown that extended or shortened life has resulted for a particular installation, then the yearly interval can be increased or reduced accordingly.

REMOVAL OF DESICCANT CARTRIDGE AD-1 & AD-2

1. Make certain the vehicle is safely parked. Block the wheels if necessary.

2. Drain the air system completely being sure that the lines leading into and out of the air dryer are at atmospheric pressure.

3. Disconnect the air line from the end cover and mark location of this port on the dryer.

4. Disconnect the heater wire.

5. Loosen the three capscrews on the end cover and turn the retaining clamps aside (capscrews may be left finger tight).

6. Locate the notch in the dryer shell. While pushing the end cover up into the dryer, insert the blade of a screwdriver in the notch and slowly pry out the retainer ring. Remove the end cover assembly and set it aside temporarily.

7. Using a 3/4" socket wrench, remove the cartridge and desiccant sealing plate assembly.

   NOTE: Be certain the desiccant sealing plate assembly comes out with the cartridge.

REMOVING AND REBUILDING DESICCANT SEALING PLATE

Before the desiccant cartridge can be replaced or rebuilt the desiccant sealing plate must be removed. It is recommended that all non-metallic parts be replaced when the plate is removed. In the past, three methods have been employed to secure the desiccant sealing plate to the desiccant cartridge; a Tru Arc retaining ring, two special thin nuts and the latest method a single hex lock nut. Removing the securing device will permit the desiccant plate to be separated from the desiccant cartridge. After removing the desiccant cartridge:

1. Remove the two o-rings from the desiccant plate and discard them.

2. Remove the ball check valve retaining clip and remove and discard the rubber ball valve.

3. Clean the desiccant plate thoroughly using a quality commercial solvent making sure the purge orifice and check valve seat are clean.

4. Install new ball check valve and replace the retaining clip and screw (Fig. 7)

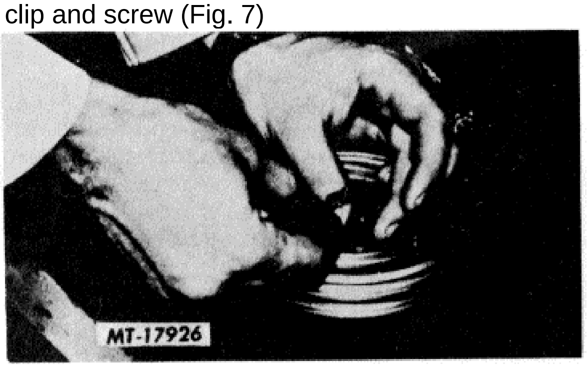


Fig. 7 Installing Check Valve

5. Thoroughly lubricate the two new orings and install them in their respective grooves in the purge plate (Fig. 8).

6. Set the desiccant sealing plate aside for reinstallation on the desiccant cartridge.

REPLACING DESICCANT CARTRIDGE

If the desiccant cartridge is to be replaced as an assembly rather than rebuilt (see desiccant cartridge rebuild-

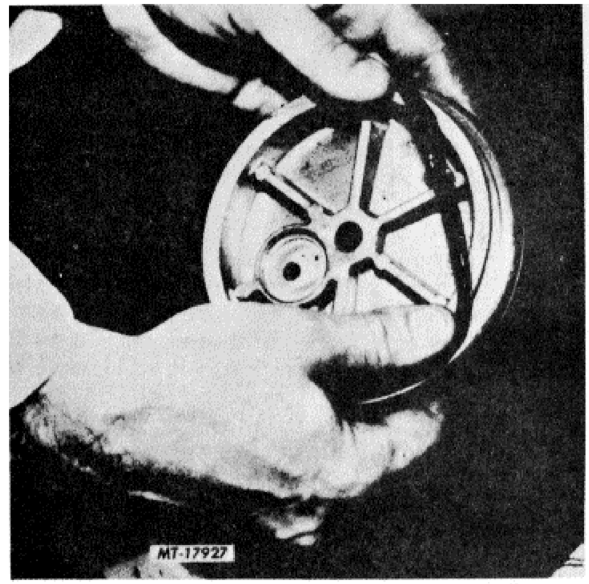


Fig. 8. Installing O-Rings

ing instructions), the cartridge removed from the air dryer may be discarded after the desiccant sealing plate is removed.

The current revision replacement desiccant cartridge is shown in Fig. 9. All prior revisions of the cartridge with interchange with no modifications to either air dryer.

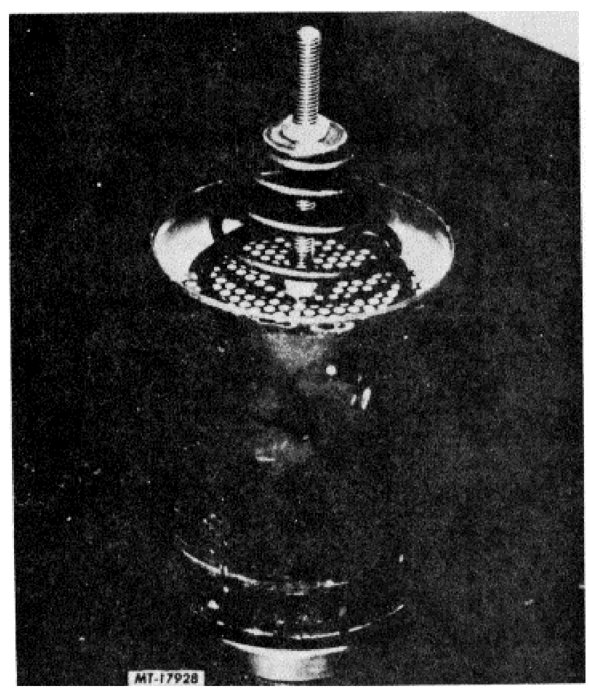


Fig. 9 Replacement Desiccant Cartridge

Prior to installing the new replacement cartridge in the air dryer, the following steps must be follows:

1. Carefully remove the lock nut from the cartridge bolt using an 11/16" open end or box wrench.

   IMPORTANT: Care must be taken not to allow the cartridge bolt to slip out of the cartridge when the lock nut is removed. Loss of desiccant material will occur should this happen.

2. Install the previously rebuilt desiccant sealing plate on the cartridge bolt so that the ball check retaining clip remains visible (see Fig. 7).

3. While holding the cartridge bolt, reinstall the lock nut on the cartridge bolt.

   IMPORTANT: Before tightening the lock nut down make certain that the shoulder (unthreaded portion) of the cartridge bolt extends slightly above the perforated desiccant plate (see Fig. 14).

4. By tightening the lock nut, draw the desiccant sealing plate down into the desiccant cartridge until the shoulder of the desiccant sealing plate is against the cartridge shell.

REBUILDING DESICCANT CARTRIDGE

IMPORTANT: Only the current revision desiccant cartridges (see Fig. 9) can be rebuilt. Currently revised desiccant cartridges are identified positively by the Bendix trademark BW stamped in the hex head of the cartridge bolt and by the letters and number AD-2 displayed on the bottom face of the oil filter. <u>If an old revision desiccant cartridge is removed from the air dryer, it should be replaced with a complete currently revised desiccant cartridge.</u>

<u>Disassembly of Desiccant Cartridge</u>

1. Carefully remove the lock nut on top of the desiccant sealing plate. (The plate is spring loaded; however, the spring load is completely relieved when the nut is removed.)

2. Remove the desiccant sealing plate and rebuild it as outlined in "Removing & Rebuilding the Desiccant Sealing Plate."

3. Remove and retain the spring, spring seat, bolt and cartridge shell. Discard the oil separator filter, the two perforated plates and desiccant material.

<u>Assembly of Desiccant Cartridge</u>

1. Insert one of the perforated plates into the cartridge, felt cloth up, and tap it firmly to the bottom. Felt always faces desiccant material (see Fig. 10).

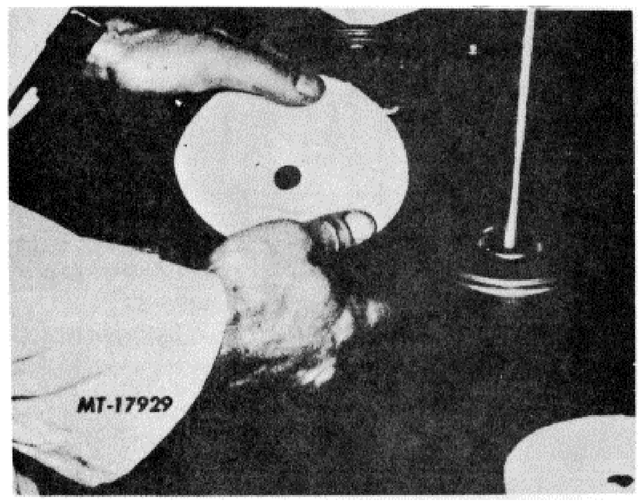


Fig. 10 Installing Felt Cloth in Cartridge

2. Slide oil filter separator over the cartridge bolt with the gasket surface next to the shell (Fig. 11).

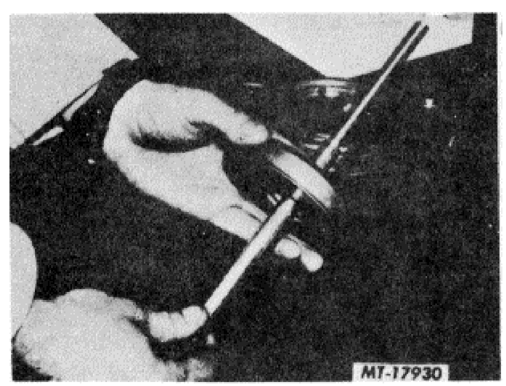


Fig. 11 Installing Oil Filter Separator

3. Install the bolt with the oil separator into the bottom of the shell and through center hole of the perforated plate in the bottom of the shell (Fig. 12).

Fig. 12 Installing Cartridge Bolt

4. Pour the entire package of desiccant material into the shell making sure none is lost. Handle shell carefully so that the bolt does not fall out (Fig. 13).

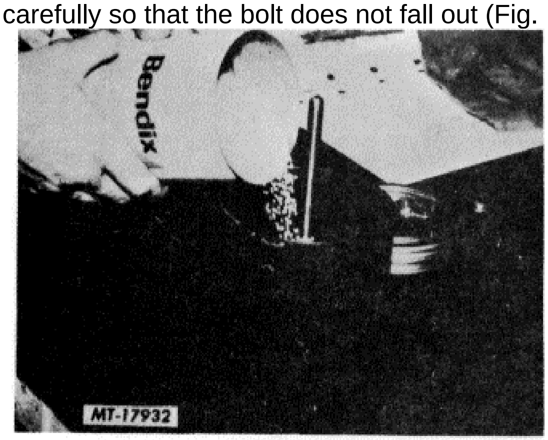


Fig. 13 Installing Desiccant

5. Level the desiccant material and install second perforated plate, felt cloth down. Make sure the shoulder of the bolt is centered and extends slightly above the top of the perforated plate (Fig. 14).

NOTE: If the shoulder of the bolt does not extend above the perforated plate, tap the side of the desiccant container.

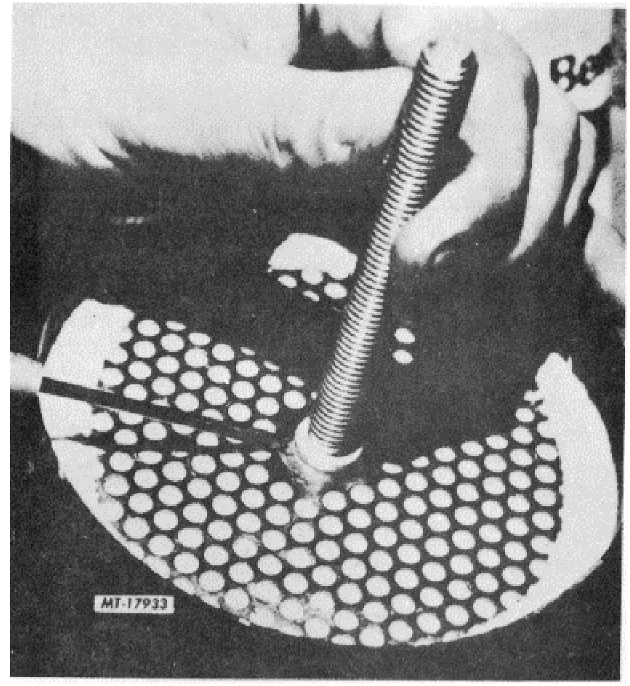


Fig 14 Installing Second Perforated Plate

6. Set the conical spring on top of the perforated plate (large diameter down; small diameter up).

7. Place the spring retainer on top of the spring (Fig. 15).

Fig. 15 Positioning Spring Retainer On Spring

8. Install the previously rebuilt descant sealing plate on the cartridge bolt so that the ball check retain: clip can be seen.

9. Using the lock nut draw the assembly together to approximately half of spring's free height. While slowl5 turning the cartridge, tap the side of the shell with a plastic mallet (Fig. 16). This allows the desicants material to settle properly into place. Continue to tighten the nut making sure all items are properly aligned. Tighten nut firmly using an 11/16" socket or box wrench.

Fig. 16

REBUILDING AD-1 END COVER ASSEMBLY

To remove the end cover assembly fl the air dryer follow Steps 1 through under "Removal of Desiccant Cartridge AD-1 & AD-2." Before rebuilding the E cover, clean the exterior thoroughly using a quality commercial solvent.

Disassembly

1. Remove and discard the large O-ring around the end cover.

2. Remove the exhaust elbow and clamp 3. Remove the cap nut and discard the cap nut O-ring.

4. Place the handle of a large screwdriver in a vise and secure it.

5. Place the slot in the plunger (cap nut end) over the blade of the screw driver, hold it securely and remove the nut from the plunger using a 1/2" socket wrench.

6. Remove the plunger, spring and valve; discard the valve.

7. Clean and inspect the plunger bore and the valve seat.

8. Remove and discard the three O-rings from the plunger; clean the plunger.

NOTE: If during the serviceability checks it was determined that the heater and thermostat were defective, replace end cover as an assembly.

Assembly

1. Using Item 1 of LUBRICATION SPECIFICATIONS, lubricate and install 0rings on the plunger and cap nut.

2. Lubricate the plunger bore and install the spring and plunger (through the cap nut end).

3. Install the valve on the plunger making certain the chamfered end of the valve is in contact with the metal seat of the body.

4. Using the screwdriver held in the vise, as described in Steps 4 and 5, compress the plunger into the bore while installing and tightening the nut.

5. Install the cap nut and tighten it.

6. Lubricate and install the large diameter O-ring around the end cover assembly with Item 1 of LUBRICANT SPECIFICATIONS.

REBUILDING AD-2 END COVER ASSEMBLY

To remove the end cover assembly from the air dryer, follow Steps 1 through 6 under "Removal of Desiccant Cartridge AD-1 & AD-2." Before rebuilding the end cover, clean the exterior thoroughly using a quality commercial solvent.

Disassembly

1. Remove and discard the large O-ring around the end cover assembly.

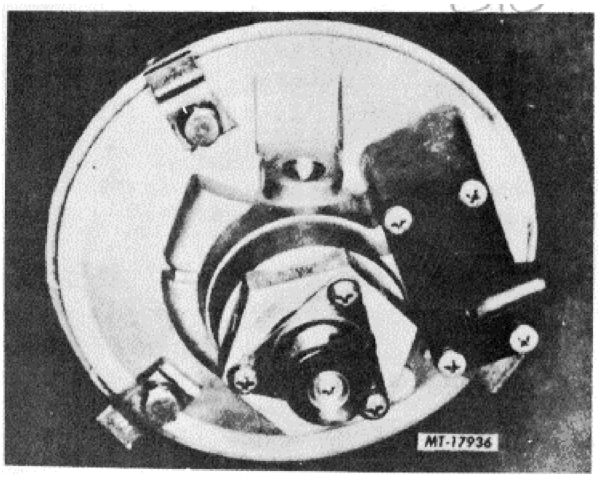


Fig. 17 AD-2 End Cover Assembly

2. Remove the single 6-32 screw securing the exhaust diaphragm and separate the diaphragm, washer and screw. Discard the diaphragm.

3. Remove the three No. 6-32 screws securing the exhaust cover and remove the exhaust cover.

4. Remove the purge valve assembly, the large hex cap nut from the end cover and discard both O-rings around the cap nut.

5. Using a 7/16" socket wrench and a large screwdriver, remove the 1/4"20 hex head cap screw which holds the assembly together.

6. Separate capscrew, purge valve, purge valve piston and the piston return spring.

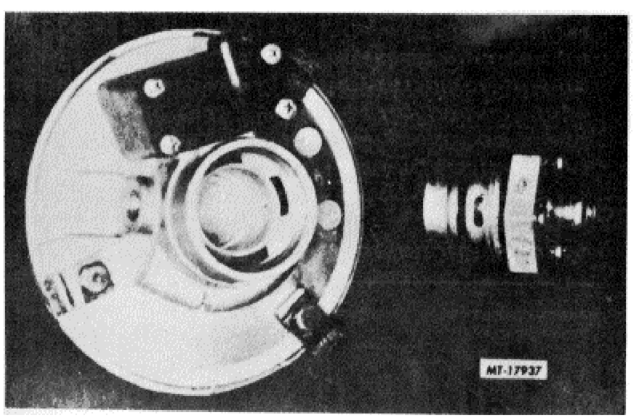


Fig. 18 AD-2 End Cover Assembly with Purge Valve Assembly

7. Discard the piston O-ring, the purge valve and the piston return spring.

8. Wash all remaining parts in a commercial solvent making sure all surfaces, bores, ports and passages are clean and dry before reassembly.

NOTE: The heater and thermostat assembly in the AD-2 end cover are non-serviceable. Do not remove the thermostat cover. Should this assembly become defective, the end cover must be replaced.

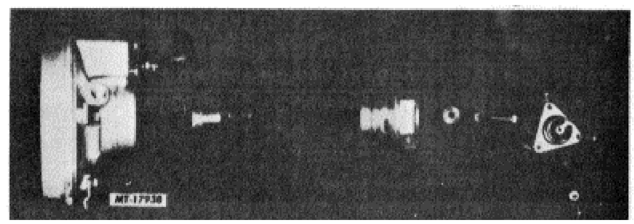


Fig. 19 Purge Valve Assembly Disassembled

Reassembly

1. Lubricate the piston O-ring and install it on the piston.

2. Lubricate the piston bore and install the piston.

3. Install the purge piston return spring and piston.

4. Install the purge valve in the large cap nut so that the rubber portion rests on the metal seat of the cap nut.

5. Secure the valve to the piston using the 1/4"-20 capscrew and lockwasher and torque to 5.5 N.m (50 in. lbs.).

6. Lubricate and install the two cap nut O-rings.

7. Lubricate the cap nut threads and the cap nut bore of the end cover and install the cap nut; torque it to 19.8 27.5 N.m (180 250 in. lbs.).

8. Secure the exhaust diaphragm to the exhaust cover using the No. 6-32 phillips head screw and diaphragm washer.

9. Secure the exhaust cover to the purge valve hex head cap nut using the

No. 6-32 phillips head screws.

10. Lubricate and install the large diameter O-ring around the end cover assembly.

OUTLET PORT CHECK VALVE ON AD-2

The one-way check valve located in the outlet port of the AD-2 dryer assembly is replaced as a complete assembly. The removal and installation procedure is as follows (Refer to Fig. 20).

1. Set parking brake by applying the control valve.
2. Bleed air from main air reservoir.
3. Locate outlet port on air dryer assembly which is the air supply to main air reservoir. Then disconnect the air supply line or hose.
4. After hose is disconnected, the elbow and check valve assembly can then be removed separately.
5. Install new check valve assembly and seal.
6. Reinstall elbow and connect hose.
7. After air supply is restored check connection for air leaks.

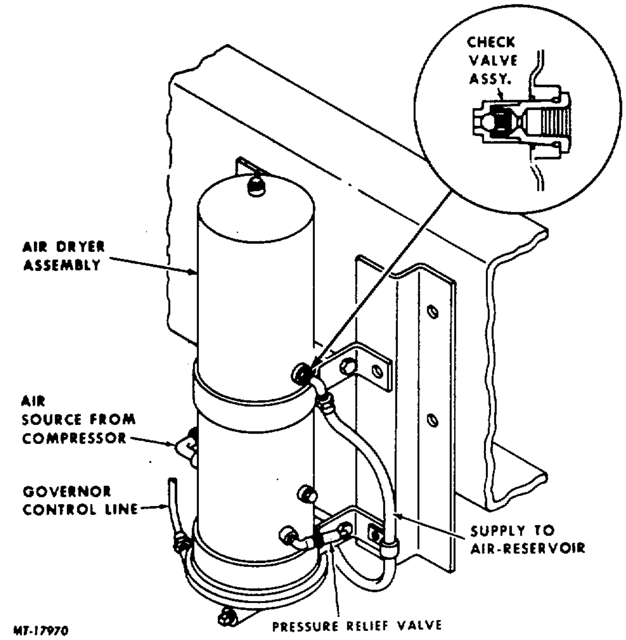


Fig. 20 Typical Air Dryer Installation

FOUNDATION BRAKE - AIR

CAM-ACTUATED TYPE

INDEX

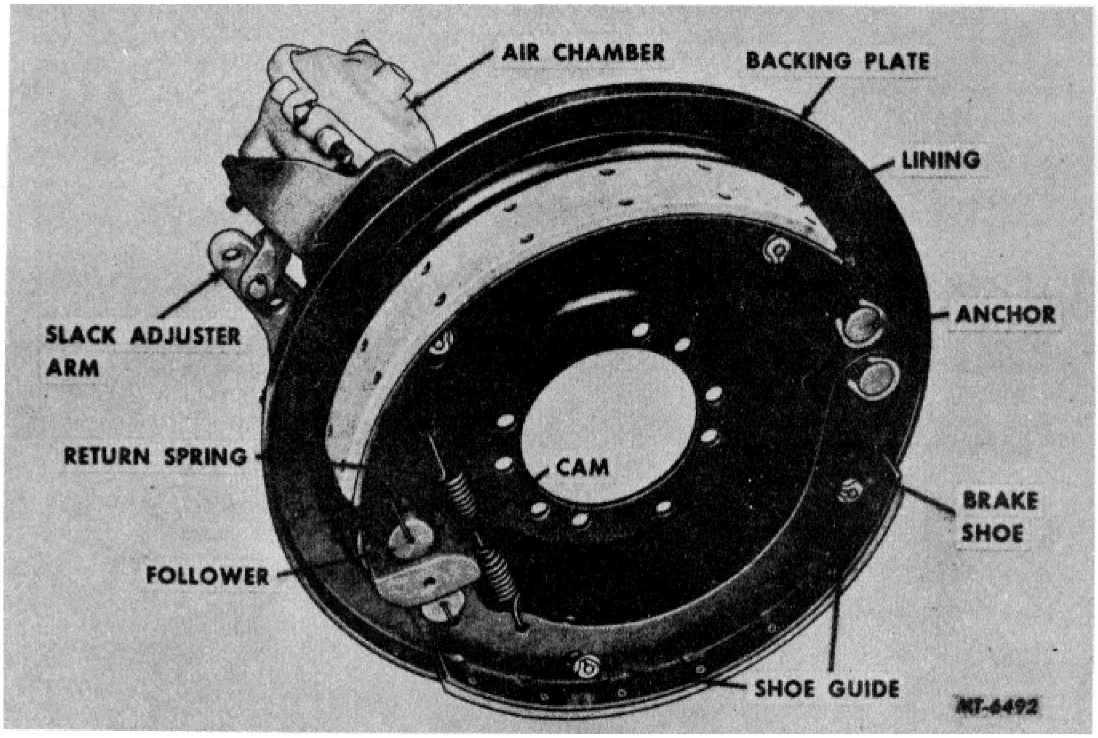


Fig. 1 Foundation Brake Assembly

DESCRIPTION

The foundation brake is where the real work in stopping a vehicle takes place. To provide adequate brakes on a vehicle, every square inch of brake lining-to-drum contact is needed as well as overall condition of the frictional surface of the drum.

The term foundation brake is given to those components at wheels which actually do the braking. This includes such items as brake shoes, lining, anchors, drums and spider or backing plate, Fig. 1. Although the slack adjusters, cam and followers are not directly known as components of the foundation brakes, they will be covered herein.

The following paragraphs cover the step-by-step procedures in servicing these components.

The need to be properly equipped in order to perform "quality" brake service is greater now than it ever was because of the fine tolerances of brake systems.

The key to precision brake service is in the machine or truing every brake drum and fitting new brake lining and shoe to the new drum diameter.

Various tools are available which assist in servicing brake systems. These tools are Brake Recliner (SE-1272), which is designed to remove, drill, rivet and circle grindlining, Shoe Gauge (SE1572) to measure arc diameter, determine from old shoe the diameter of drum the shoe has been working in and thickness of lining to use in order to insure same arc diameter of drum. Brake Drum Checker (SE-1605) to measure brake drum. Brake shoe Grinder (SE-1690) used to circle grind or grind lining on shoes in a true radius.

DISASSEMBLY

Variations in the disassembly procedure may be required as different types of brakes have been used on IH vehicles. Some typical brakes used are single and double anchor as well as wedge type actuated brakes.

To disassemble the wheel brakes, proceed as follows, referring to the exploded view of that particular brake group. Fig. 2 illustrates ' a typical front brake group while Figs. 3 and 4 illustrate typical rear brake groups.

NOTE: More detailed information covering various components can be found elsewhere in this section.

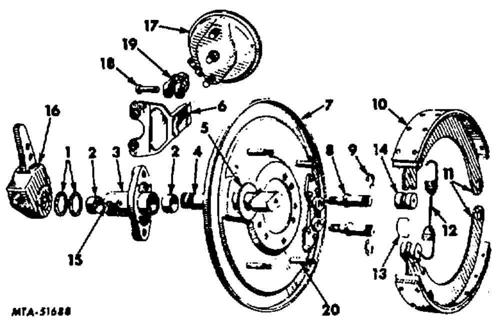


Fig. 2 Exploded View of Front Brake Group

Legend for Fig. 2

1	WASHER, adjuster spacing
2	BUSHING, camshaft bracket
3	BRACKET, w/BUSHING, camshaft
4	CAMSHAFT
5	WASHER, camshaft spacing
6	BRACKET, brake chamber
7	PLATE, w/BRACKET, backing
8	PIN, shoe anchor (4)
9	RETAINER, anchor pin
10	LINING, brake
11	SHOE, w/LINING
12	SPRING, shoe return
13	RETAINER, brake shoe roller
14	ROLLER, brake shoe
15	LUBRICATOR, 1/8 straight
16	ADJUSTER, slack, assy
17	CHAMBER, brake, assy
18	PIN, brake chamber yoke
	PIN, cotter
19	YOKE, brake chamber
20	PIN, brake shoe guide
	WASHER, guide pin outer
	WASHER, bowed
	WASHER, guide pin inner
	WASHER, "C"

1. Position the truck on floor stands and remove wheel and drum.
2. Remove dust shields from rear axle brake groups.
3. Remove the shoe return spring or springs.
4. Remove "C" washers from shoe guide pins (if so equipped).
5. Remove anchor pin retainers, washers, felt retainers and felts from anchors.
6. Remove brake shoes. To remove brake shoes from rear brake groups, the anchors must be removed. To do so, remove anchor pin retainers, felt retainers, felts, lock wire and lock screws or pins (Figs. 3 and 4).
7. The brake shoe anchors can now be re moved from the front axle brake group by removing nut and lockwasher from anchor then forcing the anchor from the backing plate.
8. Remove cam roller assemblies from brake shoes.
9. Remove clevis pin, connecting brake chamber push rod to slack adjuster. Remove lock ring, cotter key or capscrew holding the slack adjuster to end of the camshaft. Remove slack adjuster.
10. Push or tap the camshaft out of the spider or backing plate bracket. Be sure to keep spacer washers in proper order for correct reassembly.
11. Inspect camshaft bushings and replace if necessary.

CLEANING AND INSPECTION

Clean all brake parts in cleaning fluid and wipe them dry. It is particularly important that brake shoes with lining removed be cleaned thoroughly. Use steam, solvent or wire brush to remove all traces of rust and corrosion. If any rust or corrosion is allowed to remain on the lining surface or shoe table of the shoes, it is possible that the lining may crack while being attached to the shoe.

Brake drums should be thoroughly cleaned. See "Brake Drums".

REASSEMBLY

After the various components of the brake assemblies have been serviced, the brakes may be reassembled by reversing the disassembly procedure.

It is recommended that newly installed brake lining be circle ground before installing the brake drums. Circle grinding the lining to fit drum assures full contact between lining and drum.

The brake lining may either be circle ground either when lining is installed on shoes (See "Brake Lining and Shoes") or after shoes are installed on vehicle.

The brake shoe grinder which mounts on the spindle is used after installing shoes with new lining (Fig. 5). The grinder rotates about on its axis, the grinding head equalizes the distance between the two brake shoe lining surfaces and the drum surface. Grind the new lining approximately .070" less than the inside diameter of brake drum. Make certain that the brake is fully released before grinding.

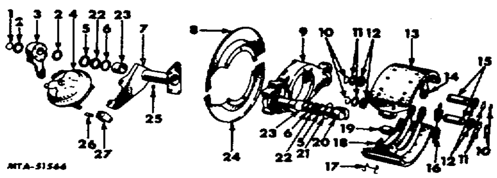


Fig. 3 Exploded View of Rear Brake Group (Double Anchors)

Legend for Fig. 3

1 RING, camshaft lock
2 WASHER, adjuster spacing
3 ADJUSTER, slack, assy
4 CHAMBER, brake, assy
5 RETAINER, camshaft felt seal
6 WASHER, felt seal
7 BRACKET, camshaft
GASKET, bracket oil seal
8 SHIELD, dust (upper)
9 SPIDER, w/BUSHING AND SEAL
10 RETAINER, anchor pin
11 RETAINER, anchor pin felt seal
12 SEAL, anchor pin felt
13 LINING, brake
14 SHOE, w/LINING
15 PIN, shoe anchor
16 SPRING, shoe return
PIN, shoe return spring
17 RETAINER, roller
18 SHOE, w/LINING
19 ROLLER, brake shoe
20 CAMSHAFT, brake
21 WASHER, camshaft spacing
22 SEAL, felt
23 BUSHING, spider and bracket
24 SHIELD, dust (lower)
25 LUBRICATOR, camshaft
26 PIN, brake chamber yoke
PIN, cotter
27 YOKE, brake chamber

Lubricate brake shoe anchor pins and cams as outlined in "Lubrication".

BRAKE ADJUSTMENT

Every month or every 2000 miles the brake should be adjusted. Push rod travel should be kept at a minimum without brakes dragging.

If brake lining is satisfactory, adjust the brakes as follows, making the brake adjustment at one wheel at a time and with all brake drums in place and all slack adjusters connected to the chambers temporarily.

1. With wheels raised and parking brake released so the wheels will rotate freely, check each brake chamber push rod to make

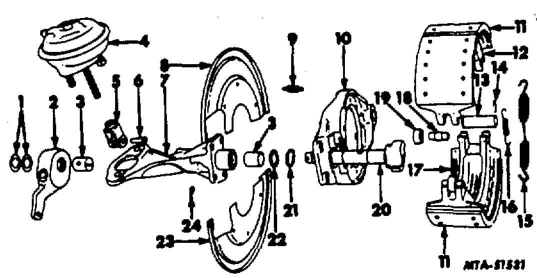


Fig. 4 Exploded View of Rear Brake Group (Single Anchor)

Legend for Fig. 4

1 WASHER, adjuster spacer
2 ADJUSTER, slack, assy
3 BUSHING, camshaft bracket
4 CHAMBER, brake, assy
5 YOKE, brake chamber
6 PIN, yoke
7 BRACKET, w/BUSHINGS
8 SHIELD, brake dust (upper)
9 NOT USED
10 SPIDER, brake
11 LINING
RIVETS, brake lining (40)
12 SHOE w/LINING, brake
13 PIN, shoe anchor
14 RETAINER, anchor pin
15 SPRING, shoe return
16 SPRING, shoe anchor end
17 SHOE, w/LINING, brake
18 PIN, brake shoe roller
19 ROLLER, brake shoe
20 CAMSHAFT, brake
PIN, cotter
21 RETAINER, camshaft cork seal
22 SEAL, cork
23 SHIELD, brake dust (lower)
24 LUBRICATOR, camshaft

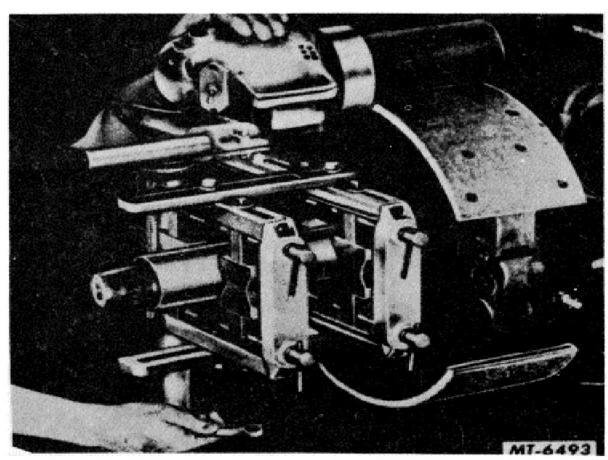


Fig. 5 Brake Shoe Grinder Installed on Axle

certain that it is in fully released position. To do this, disconnect the push rod at the slack adjuster. If push rod moves toward (release) the brake chamber, turn the worm shaft and rotate the slack adjuster toward the push rod until the clevis pin can be reinstalled.

2. Disengage locking sleeve on worm shaft or adjusting screw by depressing the spring loaded sleeve with open or box end wrench (Fig. 6).

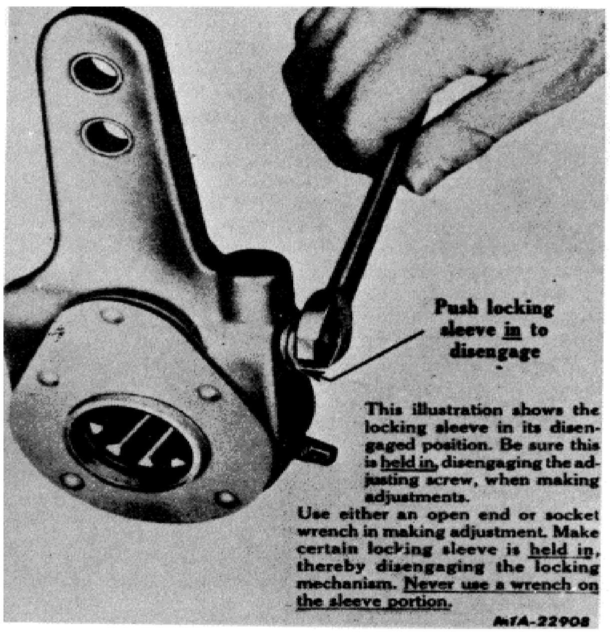


Fig. 6 Stack Adjuster Locking Sleeve on Adjusting Nut

3. Turn the vehicle wheel and at the same time the rotate adjusting screw until the brake shoes are tight against the drum.

4. Back off the adjusting .screw just enough to eliminate drag.

5. Make and hold full brake application to fully seat brake shoes against drum and note the angle between the slack adjuster and the push rod. This angle must be greater than 900 as stated in "BRAKE CHAMBER" (Adjustment).

   If the foregoing adjustment or relining of the brake shoes does not establish a greater angle than 900 between the push rod and slack adjuster with brakes applied, then maximum

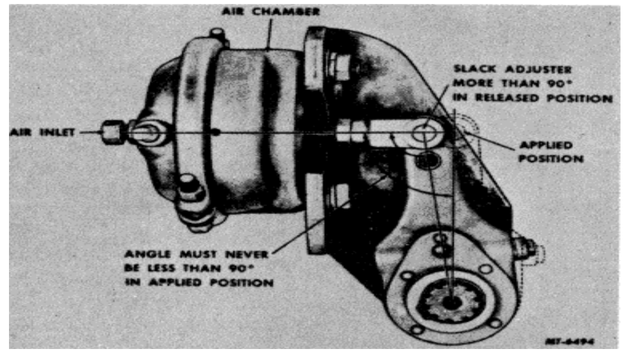


Fig. 7 Brake Chamber and Slack Adjuster

force against the slack adjuster cannot be obtained. Readjust push rod as follows:

1. Disconnect the slack adjuster and push rod. Do this carefully because the slack adjuster may be turned toward the brake chamber with considerable pressure.

2. Loosen the lock nut on the clevis and thread the clevis onto the push rod toward the brake chamber, for several turns.

3. Reconnect the slack adjuster and push rod with clevis pin.

4. Make a full brake application and check the angle between the slack adjuster and push rod. If it is not greater than 90° with the brakes applied, repeat the adjustment until the angle is satisfactory. The desirable situation is to bring the brake shoes against the drum as the slack adjuster attains the 90° position, Fig. 7.

5. Once adjustment is correct, install the cotter pin and tighten the clevis lock nut securely. Perform the above adjustment at each wheel in turn.

DRUMS

Friction surface of brake drum must be smooth, true and concentric. Make sure that the drum is not bulged, bell-mouthed, scored, or eccentric. A bulged drum results from overheating (Fig. 8). Braking surface is reduced and uneven lining wear will result if this condition is not corrected.

Extreme pressures which, over a period of time will create a bell-mouthed drum as shown in Fig. 9. Brake lining on a bellmouthed brake drum will make contact only on the inner surface of the drum. In addition to cutting the braking surface to a minimum, it will also cause uneven and rapid wear.

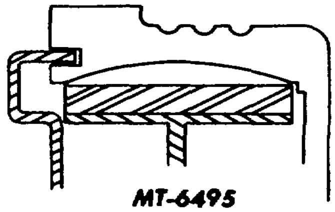


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Fig. 8 Bulged Brake Drum

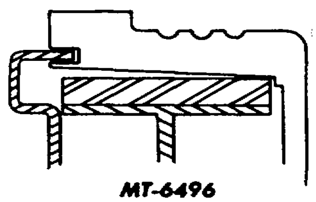

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Fig. 9 Bell-Mouthed Brake Drum

Scored drums are the result of worn lining to the point where drum to shoe contact is made or an accumulation of small steel particles imbed themselves in the brake lining (Fig. 10). The steel particles form a tough scale which is sometimes harder than the drum. As a result, in either case deep grooves are formed in the friction surface of the drum.

Brake drum scoring never improves but continually gets worse until both the lining and the brake drum are useless. Attempting to reline brakes without turning scored brake drums is impractical because the rough drum surface will quickly destroy new lining and make effective braking impossible.

Brake lining in an eccentric or out-round drum cannot make full contact with the drum, thus resulting in rapid or uneven lining wear and could even cause brakes to seize or chatter. Maximum allowable out-of-round or eccentricity should be . 004".

If inspection shows that any of the foregoing conditions exist, the brake drum should be either turned or replaced. To assure a balanced braking system, always install turned or new brake drums in pairs on each axle.

Remember that each time brake drums are turned, less metal remains to absorb the heat developed by braking action. Brake drums containing less metal will operate at higher

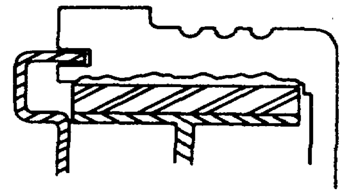

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Fig. 10 Scored Brake Drum

temperature. As a result, brake fade, slow recovery and erratic action will be more noticeable. Also, the extremely high temperatures will not only shorten lining life, but also can cause heat checks and cracks to form on the inner surfaces of the drums. These conditions will become progressively worse until finally the drums will fail.

To recondition a brake drum in a lathe, the drum must be mounted so that it is centered. Use the proper size cone to provide accurate centering. Turn drum, taking only light cuts and remove just enough material to clean up drum. Then grind the finish surface if grinder is available or use emery cloth on a straight piece of wood and polish the drum friction surface.

NOTE: Brake drums that are otherwise in good condition can be turned in a lathe.

However, it must be remembered that the recommended rebore limit for brake drums 14 inches diameter and under must not exceed .060" diameter (total cut) and brake drums with a diameter over 14" may not be increased more than .080" diameter (total cut).

Brake drums should be cleaned thoroughly with a steam cleaner or hot water. Do not use a solvent which leaves an oily residue. If inspection shows the drums may be used without remachining, rub the friction surface with fine emery cloth or sandpaper to remove any foreign deposits. If the drum has been reconditioned, clean the friction surface with fine emery cloth or sandpaper and wash. Next, examine very carefully to see that no metal chips remain in the drum.

BRAKE SHOES AND LINING

The brake shoe is that part of the brake mechanism to which the brake lining is attached. The brake shoe with the lining retards the rotation of the wheel when forced against the drum during brake applications.

Brake shoes must be true and of correct radius.

Wherever brake linings or blocks are worn to within 1/16" of rivets, the brake shoes must be removed and relined. It is recommended that all the brakes be relined at the same time since this will maintain balanced braking on the vehicle. If complete replacement is not desirable or necessary, be sure that all lining on one axle (both sides) is replaced at the same time.

When removing worn lining from shoes, drill out old rivets if possible to prevent distorting shoe table. After the old linings are removed from the shoes, the shoes should be cleaned and buffed to remove all dirt and grease. Grease is one of the greatest deteriorating agents of lining.

Examine shoes carefully and discard those which have any defects as shown in Fig 11.

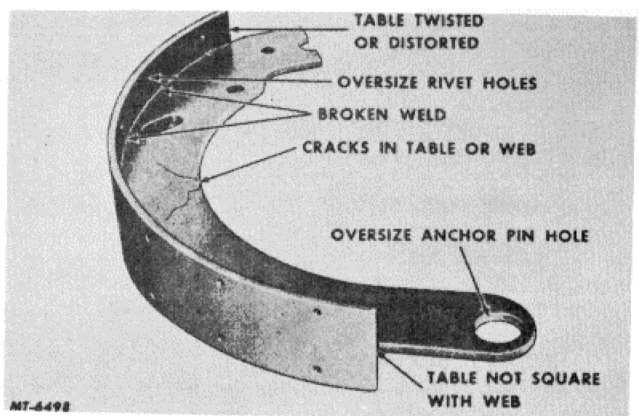

Fig. 11 Defects to be Looked for on Brake Shoe

Discard used lock washers after removing lining bolts. Use new washers when installing new lining. Replace bolts and nuts if signs of distortion or wear are present.

Care should be used in selecting the correct thickness of lining for each brake shoe and drum. Usually the standard thickness will be used. If the drum has been turned or become worn, increasing the diameter, oversize lining may be required.

If it is not known how much material has been removed from the drum during the turning operation, the following simple test may be used to help select the proper lining.

Hold standard size lining snugly to the shoe, position it against the inner surface of the drum, forcing it into contact with the drum surface. The lining is now in the same position as during a brake application. If space is noted at the ends of the shoe (shoe can be rocked), oversize lining is required (Fig. 12. If lining selected is too thick, only the ends of the lining will contact the drum. see Fig. 13.

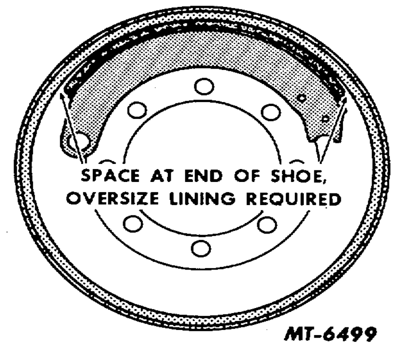

Fig. 12 Lining Selected too Thin

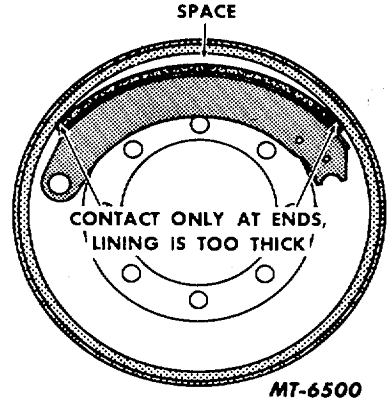

Fig. 13 Lining Selected Too Thick

The lining must be installed on the shoe so that it fits smoothly and evenly, contacting the shoe throughout the entire radius. If gaps occur between the rivets, difficulty will be met in adjusting the brakes in that "spongy" or rubbery pedal may occur which makes satisfactory brake application impossible.

To insure complete contact and avoid gaps between lining and shoe, secure lining to shoe with "C" clamp so that rivet or bolt holes are in alignment. Position "C" clamp as close to the holes as possible, clamping the lining firmly in place.

When securing brake lining to shoes, start with the center rivet or bolt and work toward the ends as shown in Fig. 14. When securing brake block lining to shoe, use the sequence as shown in Fig. 15. Always use new lock washers when installing bolt on lining and tighten nuts to 20-25 ft. lbs. torque.

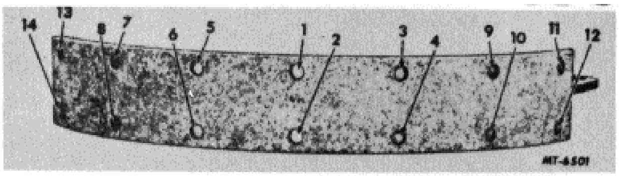

Fig. 14 Sequence in Securing Brake Lining to Shoe

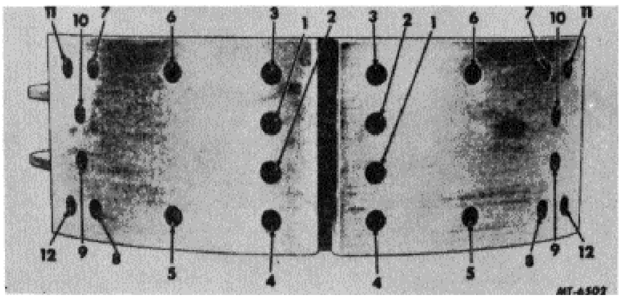

Fig. 15 Sequence in Securing Brake Block Lining to Shoe

When riveting linings, use a roll set to up-set the rivets. A star set may split the tubular end of rivet and prevent a tight fit. After the lining is installed, check tightness of lining to shoe, with a 002" feeler gauge. Gauge should not penetrate past rivets or bolts, Fig. 16.

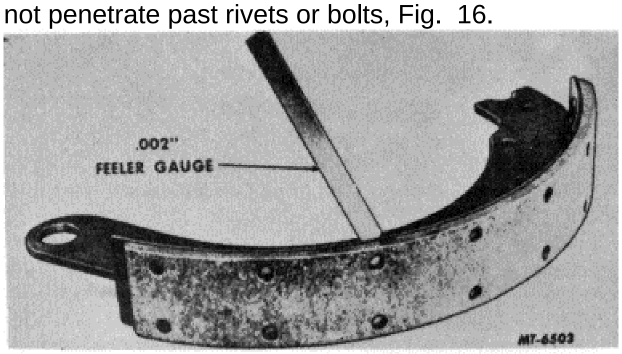

Fig. 16 Checking Tightness of Lining

After installing the new lining on the shoes, the lining should be ground in a true radius to fit the drum diameter. A brake shoe grinder is provided on brake reline (SE-1272) which is designed to dress the lining in a true radius and fit the drum diameter. This grinder swings the shoe in an arc across the surface of an abrasive wheel.

ANCHOR PINS

The anchor pins provide a point where the shoes can be secured to the backing plate or spider and also permit positioning the shoe in respect to the drum.

The anchor pins are designed to withstand 190 all the braking force of slowing or stopping the vehicle.
The anchors should be inspected for signs of wear. In most cases rust will be the factor in servicing brake anchors. Clean all dirt and rust from anchors and coat them with a very light coat of "Lubriplate 110' or equivalent.

CAMSHAFT, BUSHINGS AND FOLLOWERS

The camshaft is actuated by the movement of the slack adjuster. The rotating movement of the cam forces the shoe followers away from the cam, thus forcing the shoes into contact with the drum.

Removal procedure for camshaft assembly is covered in the Brake Disassembly procedure. When removing the camshaft from the backing plate or spider, note the position of spacing washers to assure correct reinstallation, Do not remove camshaft bushings from spider and/or mounting bracket unless replacement is necessary.

NOTE: Do not interchange right and lefthand camshafts.

If camshaft bushings or needle bearings must be replaced, a suitable tool (remover) can be made locally as shown in Fig. 17.

Apply Lubriplate 110 or equivalent to outside diameter of bushings to assist in pushing them into position

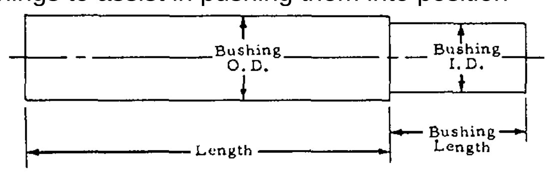

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Fig. 17 Recommended Type of Camshaft Bushing Removing Tool

BRAKE CHAMBERS

Brake chambers (Fig. 18) transform the energy of compressed air into mechanical force and motion to apply the brakes. One chamber is used at each wheel to operate the brakes.

Air pressure entering the brake chamber, Fig. 18, behind the diaphragm forces the diaphragm and push rod outward, rotating the slack adjuster, brake camshaft and cam applying the brakes. The higher the air pressure admitted to the chamber, the greater the force pushing the brake shoes against the drum.

When the air pressure is released from brake chamber, the brake shoe return spring and brake chamber release spring return the shoes, cam, slack adjuster and brake chamber back to the released position.

The brake chamber consists of two dished metal sections, namely, the pressure plate assembly and the non-pressure plate, separated by a rubber diaphragm, all of which are held together by a metal two-segment clamp. In front of the diaphragm are the push rod, push rod spring and retainer, Fig. 18.

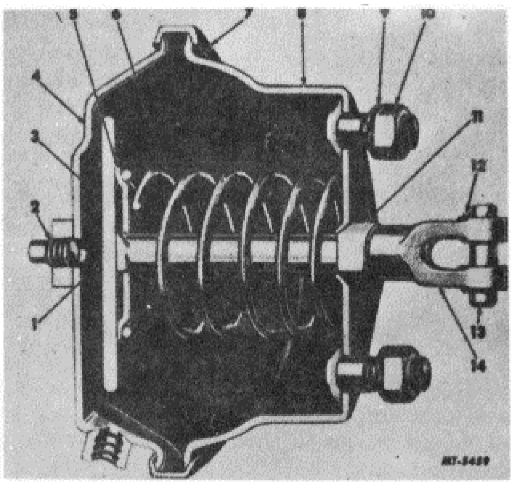

Fig. 18 Brake Chamber (cross-sectional View

Legend for Fig. 18

Key	Description	Key	Description
1	Rod, push	8	Plate, non-press
2	Plug	9	Washer, lock
3	Diaphragm	10	Nut
4	Plate, pressure	11	Nut, lock
5	Retainer, spring	12	Pin, cotter
6	Spring	13	Pin, clevis
7	Clamp	14	Yoke, clevis

Several types of auxiliary "spring brakes" are used in conjunction with or are attached to the brake chambers while others replace the entire brake chamber, Fig. 19.

The purpose of auxiliary spring brakes is to provide an emergency brake which will stop the vehicle in the event air pressure drops.

These spring brake systems are covered in the "Parking Brake" section.

<u>Remove</u>

Disconnect air line and push rod yoke. Remove nuts from mounting studs and remove chamber.

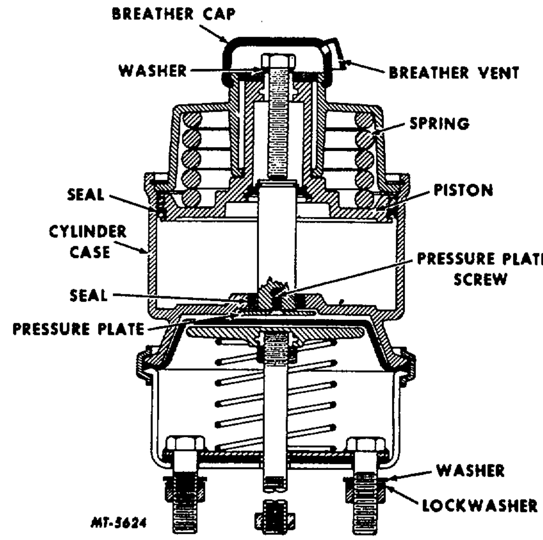

Fig. 19 Typical "Spring Brake" Air Chamber

<u>Install</u>

Position brake chamber on mounting bracket and install nuts on mounting studs. Install lock nut and yoke on push rod. Connect air line. Adjust yoke to slack adjuster (see "Adjustment"). Be sure end of push rod does not bind with the slack adjuster when brakes are applied.

<u>Disassemble</u>

To disassemble the brake chamber:

1. Mark the non-pressure plate (8), pressure plate (4) and clamp (17). This will make it easier to reassemble air chamber in its original position and avoid installation interference.
2. Remove the yoke (14) and lock nut (10) from the push rod (1).
3. Remove the nuts and bolts from the clamp ring. CAUTION: Separate the plates carefully. The return spring inside the brake chamber is under tension.
4. With the two sections of the brake chamber separated, remove the push rod, spring retainer (5) and spring (6) from the non-pressure plate.

Cleaning and Inspection

After the brake chamber has been disassembled, proceed as follows:

1. Using a suitable cleaning solvent, clean all metal parts thoroughly

2. Examine the diaphragm. If any signs of damage or deterioration are evident, replace the diaphragm. When one diaphragm requires replacement, it is good practice to replace all of the brake chamber diaphragms in the system while the vehicle is out of service. Brake chamber diaphragms must be replaced every 50, 000 miles or at least once a year, regardless of condition.

3. Inspect push rod, spring and spring retainer. If parts. are damaged, they should be replaced. Check return springs. If a load scale is available, compare their tension with new spring. Matching an old spring with a new spring will indicate the condition of the old part.

4. Check the condition of the non-pressure plate. If the clamping flanges on the plates are dented or damaged, replace the plates.

Reassemble

1. Install nuts (10) on mounting studs and clamp non-pressure plate (8) in vise with inside of plate facing up.

2. Install spring (6) in spring retainer (5).

3. Install push rod assembly in body, press the assembly down (brake applied position) to compress the spring and use vise grip pliers on the outside of the push rod to hold the spring compressed.

4. Install diaphragm (3) in pressure plate (4).

5. Position brake chamber plates matching up etch marks made prior to disassembly.

6. Install clamp (7) with bolts and nuts and tighten nuts to 150 in. lbs. torque. Remove vice grip pliers.

7. Install lock nut (11), yoke (14), pin (13) and cotter pins (12).

8. Assemble yoke and lock nut to push rod.

Test

To check for leaks, coat brake chamber around clamp with soapsuds and apply air pressure to port in pressure plate (4). No leakage allowed.

Preventive Maintenance

Every month or every 2, 000 miles the brake chamber push rod travel should be checked. Push rod travel should be kept at a minimum without brakes dragging. Excessive travel of the brake chamber push rod shortens the life of the diaphragm. Over travel also slows braking response.

Every year or every 50, 000 miles the brake chambers should be disassembled and cleaned. New diaphragms must be installed. Be sure to use the correct diaphragm return springs when reassembling the chamber or uneven braking may result.

Adjustment

After the brake chamber is installed, the brakes must be adjusted and checks made to be sure the linkage does not bind. Adjustment of the push rod length may be accomplished by altering the location of the yoke.

With brakes released, the angle formed by the push rod and slack adjuster must be greater than 900, and all slack adjusters should be set at the same angle. With the brakes applied, after being. adjusted, this angle should still be greater than 90°. In other words, the slack adjuster should not go "over center" when the brakes are applied (Fig. 7).

SLACK ADJUSTERS

Slack adjusters provide method of adjusting brakes to compensate for brake lining wear, and also serve as a lever during braking operation, (Fig. 20).

Slack adjusters were designed to conform to the development of heavy-duty two-shoe foundation brakes.

During brake operation, the entire slack adjuster rotates bodily with the camshaft. When adjusting the brakes, the worm moves the gear so as to change the position of the lever arms in relation to the brake camshaft.

Remove

1. Remove cotter key and clevis pin from slack adjuster and push rod clevis.

2. Remove snap ring from camshaft.

3. Slide slack adjuster from end of brake camshaft.

Install

Slack adjuster installation is the reverse procedure for removal.

Disassemble Refer to Fig. 21 for numbers in parenthesis

1. Clean all grease and dirt from the outside

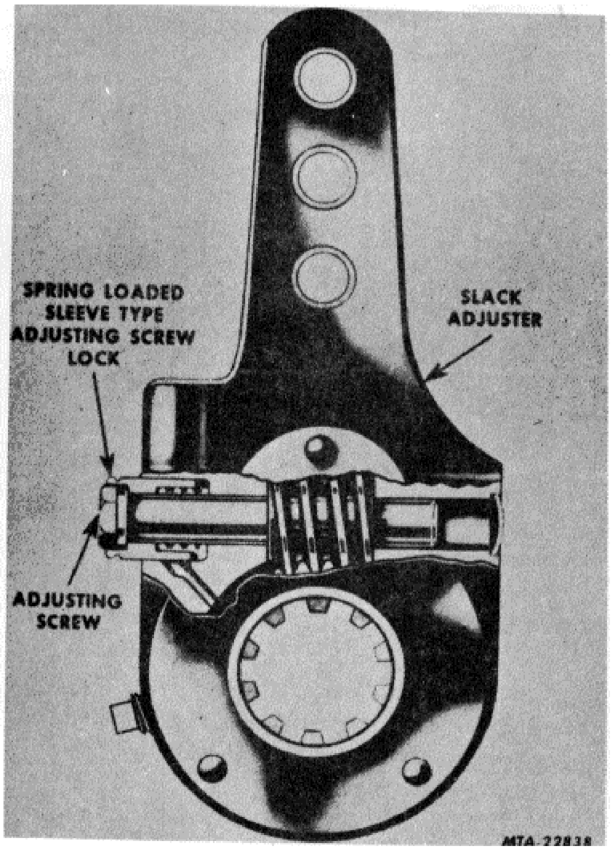

Fig. 20 Sectional View of Slack Adjuster

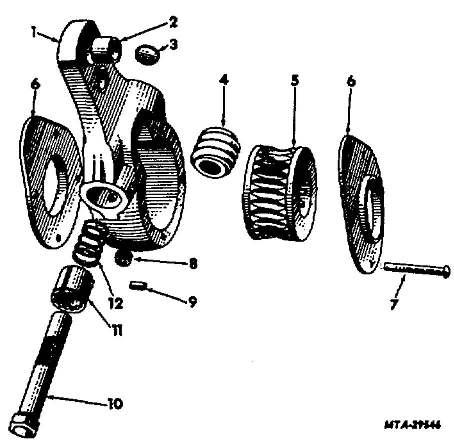

Fig. 21 Exploded View of Slack Adjuster

Legend for Fig. 21

Key	Description	Key	Description
1	Body slack adjuster	7	Rivets
		8	Plug or fitting
2	Bushing	9	Pin, guide
3	Plug, Welch	10	Shaft, worm
4	Worm	11	Sleeve, lock
5	Gear	12	Spring
6	Plate, cover		

of the slack adjuster with suitable cleaning solvent.

2. Cut off heads of rivets (7)-which attach cover plates (6) to the body. Drive rivets out and remove the cover plates.

3. Remove the Welch plug (3) from the end of the worm shaft bore.

4. Position an adapter into the worm shaft bore and using a hydraulic press, force the shaft out of the body and worm, freeing the lock sleeve (11) and spring (12).

5. The worm (4) and gear (5) can now be removed from the body (1).
6. Remove the lubricating fitting or plug if equipped.
7. Remove guide pin (9) from body if necessary.

Cleaning and Inspection

Wash all of the parts in cleaning solvent and dry thoroughly. Inspect parts carefully. Replace components when their condition is not satisfactory.

Inspect the bushing in the lever arm. If it is worn, out-of-round, it must be replaced. To replace the bushing, press out the old bushing and press the new one into place. Ream the bushing so that the clevis pin fits the opening.

Reassemble

1. Reinstall new guide pin in body if removed from body.

2. Place the worm (4) and gear (5) in position in the body.

3. Place the lock sleeve over the worm shaft with the socket end of the sleeve at the hex end of the shaft.

4. Place the lock spring in the recess formed by the sleeve and shaft, Fig. 20.

5. Insert the small end of the worm shaft through the hole in the body and the worm.

6. Press the worm shaft into the worm and body, making certain the groove in the lock sleeve is aligned properly with the guide pin in the body. Press the shaft in until the distance from the small end of the shaft (Welch plug end) to the outside edge of body is approximately 5/8" on front brakes and 9/16" on rear brakes.

7. Install Welch plug in worm shaft bore.

8. Lubricate worm with viscous chassis lubricant.

9. Position the cover plates (6) on the body and rivet together. The covers must be flat and in good contact with the body after riveting.

10. If slack adjuster body will accept a lubrication fitting, install a fitting in the body and force grease into the slack adjuster with a grease gun.

LUBRICATION

Brake camshafts and slack adjuster should be lubricated every 1, 000 to 2, 000 miles with Lithium-12 Hydroxy Stearate EP grease. Do not over lubricate. Slack adjusters without fittings require no lubrication. The provision for lubrication may differ on slack adjusters. Some have zerk fittings while others utilize pipe plugs or snap-in type plugs or covers.

Every 15,000 to 25,000 miles or when brake linings are replaced, apply a thin coating of Lithium-12 Hydroxy Stearate EP grease to brake shoe anchor pins and camshafts. Do not over lubricate.

WEDGE ACTUATED TYPE

STOPMASTER

INDEX

STOPMASTER II

Various improvements have been made to the STOPMASTER Brakes since original production. With these improvements, the wheel brake units have been designated as STOPMASTER II. The improvements to the brake groups can be found in this manual section on Pages 217 through 225.

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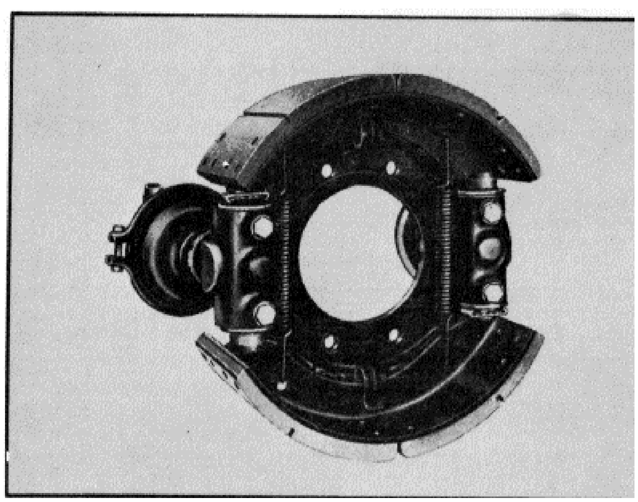
ROCKWELL-STANDARD
STOPMASTER BRAKES

The Stopmaster Brake is a wedge actuated brake.

The brake power unit forces a wedge between two rollers and two plungers. This causes the plungers to spread apart and push the brake shoes against the brake drum.

There are several variations of Stopmaster Brakes in use. Some have two power units per brake and others only one. Where two power units are used, there may be a Fail-Safe unit on one or both. The brake support may be either a cast spider or a stamped backing plate. On the cast spiders, the plunger housings may be either integral or bolted on. Brake shoe adjustment may be either automatic or manual. Other minor variations are also in use.

The various basic Stopmaster Brakes are identified as model RDA, with letters denoting the following: R-Stopmaster Brake, Wedge Actuated; D-Double Actuated; A-Air operated;

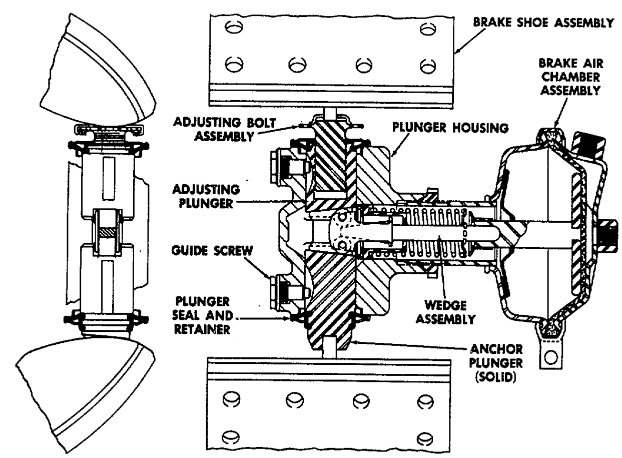


RDA
Bolted on Spider Mounted
Integral Plunger Housings

STOPMASTER ACTUATING SYSTEM

This picture (as illustrated) shows one of the actuating systems of an air-operated double-actuated Stopmaster Brake (RDA). All parts are shown in the off position.

This system has an air chamber power unit threaded into the wedge bore of the plunger housing. The socket in the end of the diaphragm push rod connects the air chamber to the wedge rod. The wedge retracting spring acts as the return spring for both the wedge and the diaphragm. A pair of rollers are held in place on the wedge head by a retaining cage. The rollers are also engaged in corresponding slots in the inner ends of the plungers. The unslotted portions of the inner ends of the plungers are resting on abutments in the plunger housing. The outer ends of the plungers are engaged with and supporting the brake shoes.

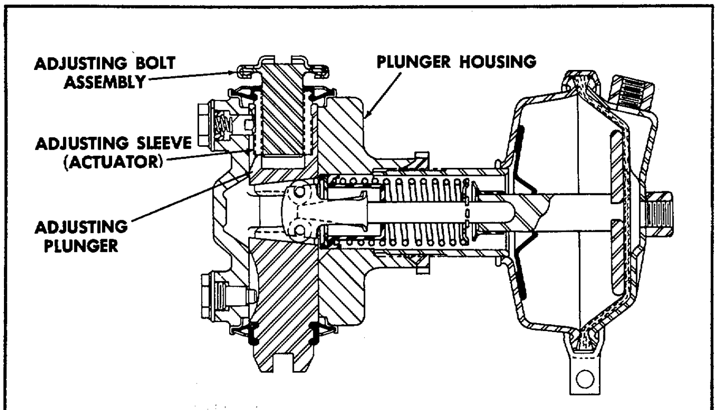


MANUAL ADJUSTING SHOWN
1¾" STROKE WEDGE ASSEMBLY

On a double-actuated brake, each of the two actuating systems has one anchor (solid) plunger and one adjustable plunger (as illustrated). On a single actuated brake the one actuating system would have two adjustable plungers. All of the plungers are retained in the housings and the roller slots are kept in proper alignment by means of guide screws which engage slots in the side of the plungers.

When the brake is actuated, the air chamber pushes the wedge head deeper in between the rollers. This spreads the rollers and plungers apart and pushes the brake shoes outward. Initially all the plungers are lifted off of the plunger abutments and momentarily suspended. As the shoes (linings) contact the drums, the drum drags the shoes and the suspended plungers around with it. This causes the plunger at the trailing end of each shoe to reseat on its abutment and thus absorb and transfer the brake torque to the brake support. When the brake is released, the wedge spring returns the wedge and diaphragm to the off position. At the same time, the shoe return springs push the raised plungers back to their abutments.

BRAKE ADJUSTMENT

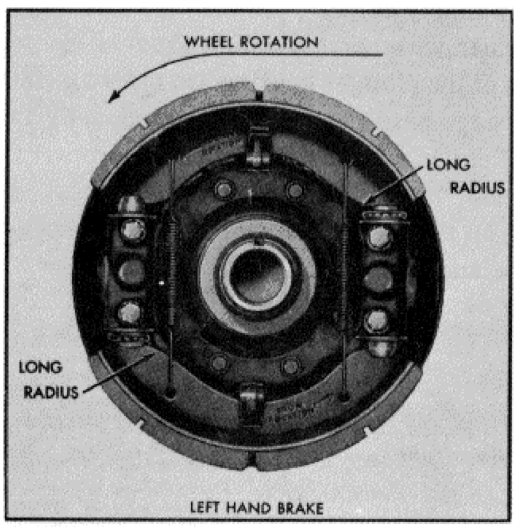


AUTOMATIC ADJUSTING SHOWN
1¾" STROKE WEDGE ASSEMBLY

On the automatically adjusted plunger, the adjusting bolt is threaded into an adjusting sleeve which in turn is free-fitted inside the plunger proper. The plunger guide screw is replaced by a hollow cap screw, a spring, and an adjusting pawl which also serves as the plunger guide. The end of the adjusting pawl has saw-tooth type teeth which engage corresponding helical teeth on the outside of the adjusting sleeve.

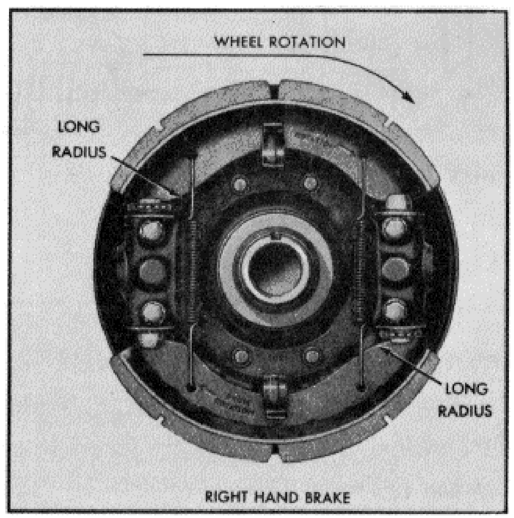
As the brake is actuated; the plunger, sleeve, and bolt move outward and the sloping face of the teeth on the adjusting sleeve lifts the adjusting pawl (against the spring). When the brake is released, all the parts return to their starting points. As the lining wears, the plunger stroke and resulting pawl lift gradually increases until the pawl climbs over and drops into the next tooth space. This time, when the brake is released and the plunger is pushed back in its bore, the upright face of the pawl teeth causes the adjusting sleeve to rotate and advance the adjusting bolt. This reduces the lining clearance and the cycle starts over again. The automatic adjuster operates only in forward vehicle direction.

PLUNGER AND SHOE POSITION



STOPMASTER BRAKES

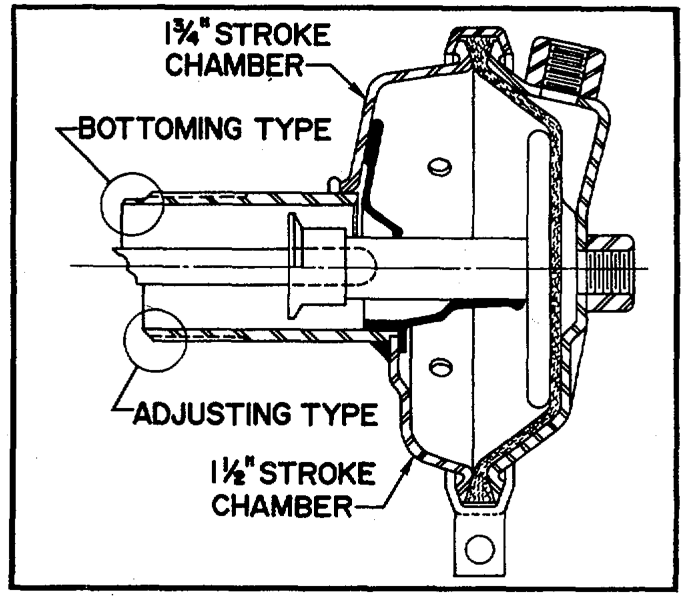
(Bolted on Spider Mounted Integral Plunger Housing)



On double-actuated brakes, the anchor (solid) plungers should be positioned at the trailing end of each shoe (where they will absorb the brake torque during forward wheel rotation). This will position the adjustable plungers at the leading end of the shoes. Also note that the shoe web is unsymetrical. The long-radius end should be engaged with the adjustable plungers.

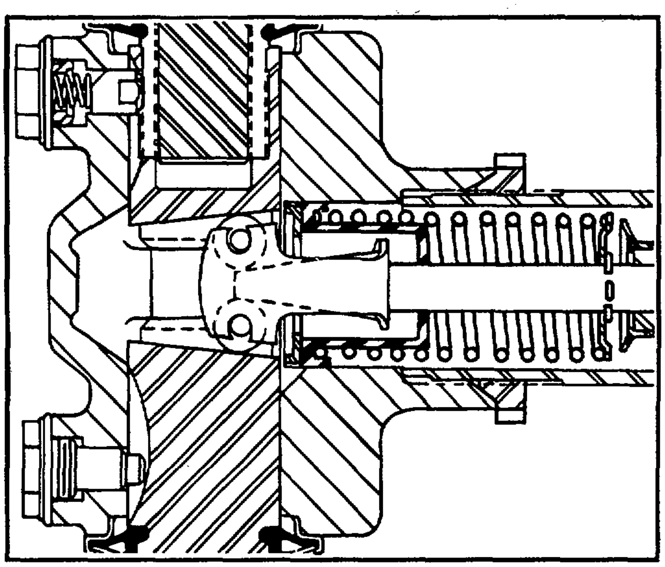
POWER UNIT ADJUSTMENT

The air chamber should be screwed into the wedge bore of the plunger housing to a depth such that the wedge is ready to lift the plungers off of the abutment seats at the first movement of the diaphragm (or piston). This provides the least lost motion and maximum useful chamber (or piston) stroke. Current power units are designed to "bottom out" in the wedge bore and provide this optimum adjustment automatically. (The bottoming type units have a short unthreaded portion on the leading end.) manually



The newer bottoming type units can be used as replacements for the earlier units to obtain the bottoming feature.

WEDGE ALIGNMENT



Whenever the power unit is removed from the brake, the wedge assembly may also become dislodged. Before reinstalling the power unit, reposition the wedge assembly so that the rollers and roller cage are engaged in the plunger slots. On newer brake assemblies this is accomplished automatically by simply aligning the two ears on wedge spring retainer with corresponding grooves in the wedge bore of the plunger housing. On older assemblies, the wedge head must be aligned manually so that the rollers engage the plunger slots properly. In either case, proper alignment can be checked by pushing on the wedge rod while visually checking for shoe and plunger lift.

SERVICE RECOMMENDATIONS

Recommended Preventive Maintenance

A. Periodic inspections-25,000 to 30,000 mile intervals or every two months:
   1 Check lining wear to determine proper reline time.
   2 When automatic adjusters are used, check lining to drum clearance-if clearance is .060" or less, adjusters are working properly.
   3 Check service by cycling respective application valves.

B At 100,000 miles or once yearly:
   1 remove all wheels and drums.
      a Inspect plunger seals.
      b If seals are cut, torn, or leaking-disassemble and overhaul brake actuating components.
      c If seals are in good condition, remove upper adjusting plunger and its seal and check internal condition.
      d If grease is contaminated or hardened, or if parts are dry-disassemble and overhaul brake actuating components.
      e If internal condition is satisfactory, reassemble adjusting plunger and replace seal and run until next inspection.

C At each brake reline:
   1 If reline period is 100,000 miles or greater - disassemble and overhaul all brake actuating components. *NOTE: Do not use combination linings*.
   2 If reline period is appreciably less than 100,000 miles:
      a Remove adjusting plungers and related parts.
      b Clean and regrease adjusting bolt and sleeve (or plunger).
      c Check internal condition-if satisfactory reassemble-if unsatisfactory overhaul entire actuating system.

Recommended Grease

A high temperature water-proof grease, IH 251 HE.P. grease or equivalent to NLGI #2 multipurpose grease is recommended for lubricating the brake actuating system.

The following greases meet all of these recommendations:

Texaco Thermotex EP f1
Shell Darina f1
Marathon 528 H.D.
Sunaplex t1 EP
Amdex f1 EP
Philube B t1

NOTE: Vehicles operating in extremely cold weather (below -400F) may require a grease conforming to MIL-G-25013C.

Replacing Air Chamber Diaphragm: The air chamber diaphragm and push rod boot may be serviced in either of two ways-removing the complete chamber from the brake, or removing the clamp ring and pressure half only and leaving the non-pressure half attached to the brake. The latter method is recommended but, since the wedge assembly is left inside the tube, certain precautions must be taken to prevent the wedge assembly from being pulled out of position and becoming misaligned with the plungers. The proper procedure is given under Servicing Air Chamber Diaphragm

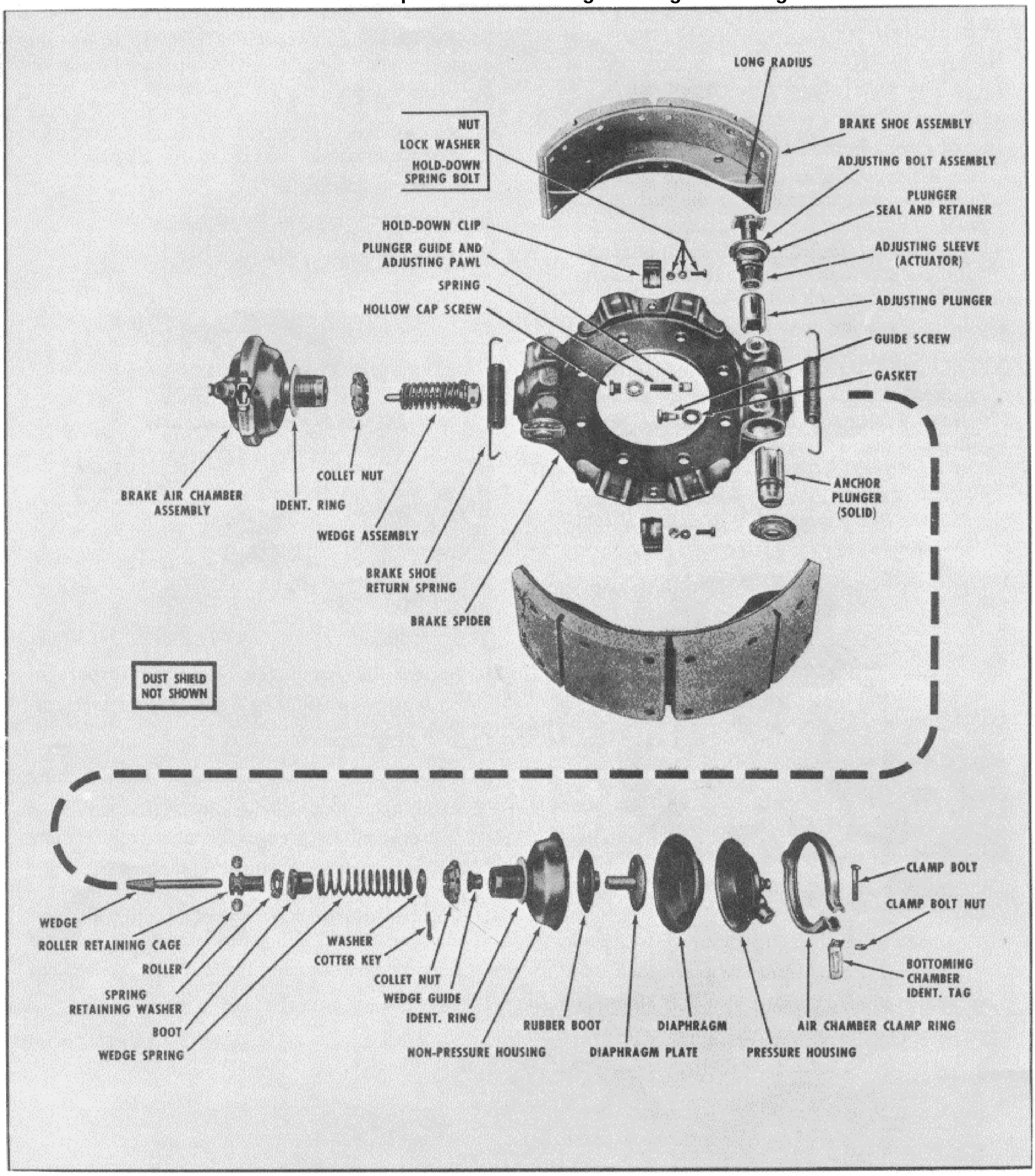
TROUBLE SHOOTING GUIDE

If brakes are poor or do not apply- check system pressure at source and at brakes possible restriction or leak in brake lines, valves, etc. brakes out of adjustment leaking diaphragm or wheel cylinder cup.

Uneven braking or lining wear-ruptured diaphragm wedge rod out of push rod socket rollers and cage out of plunger socket corroded or frozen plungers brakes out of adjustment grease on lining glazed lining shoes installed backward combination linings.

Automatic Adjusters not working-adjusting pawl installed backward pawl spring collapsed or missing bolt frozen in adjusting sleeve detent damaged and allowing bolt to rotate with sleeve adjusting plunger in wrong position (should be at leading end of shoe) double lip seals not installed correctly.

RDA Bolted on Spider Mounted Integral Plunger Housings



The RDA Brake shown, with integral plunger housings, employs a cast spider mounting which bolts to a flange on the axle housing. Adjusters may be manual or automatic (automatic shown). Dust shields are the one or two piece type.

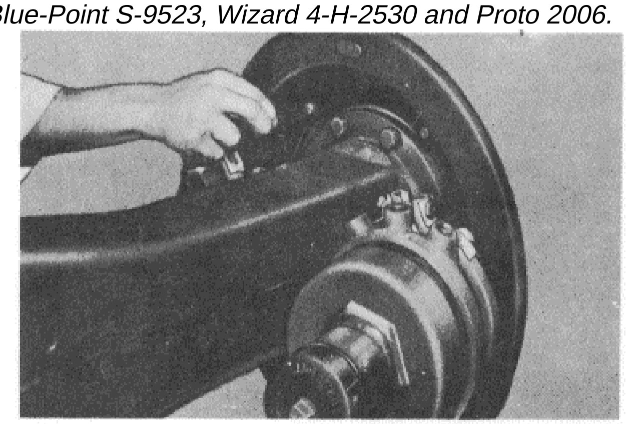
GENERAL MAINTENANCE

BRAKE ADJUSTMENT

A. Manual Adjusters.

1. Jack or hoist wheels free of ground.
2. Remove dust cover from adjusting slot two places on each brake.
   On RD type brakes the adjusting slots are below the forward and above the rear power unit.
   If star-wheel adjusting bolts are not found at these positions, the brake had been assembled on the wrong side of the vehicle.
3. Adjusting bolts have right hand threads. With an adjusting spoon, turn the star-wheel until a heavy drum drag is developed. Then back off the bolt to a very light drag on the drum. Repeat for other shoe on the brake. Replace dust covers in adjusting slots. Repeat for other brakes.

NOTE: Recommended adjusting spoons, are Snap-On-Blue-Point S-9523, Wizard 4-H-2530 and Proto 2006.



B. Automatic Adjusters

1 Check drum to lining clearance with feeler gage. If the clearance is more than .060", adjust brake manually (same as above) and schedule the vehicle for brake service.

SERVICING POWER UNITS

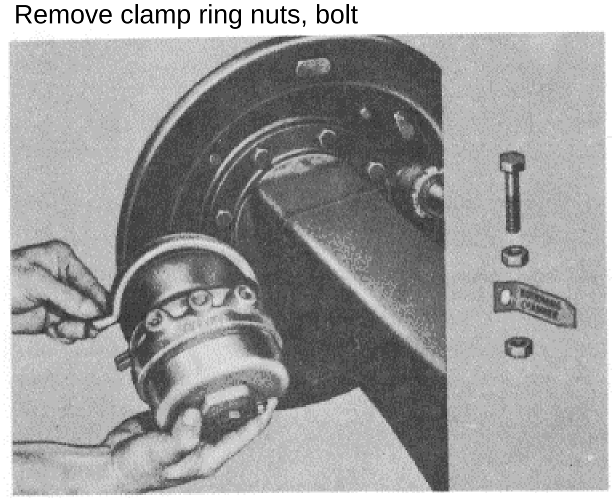
AIR CHAMBER DIAPHRAGM

The following procedures are used to replace the diaphragm and boot with the non-pressure housing on / the brake assembly.

A. Refer to PARKING BRAKE SECTION for removal of spring brake air chambers.

B. Remove air lines and tag emergency line.

C. Remove clamp ring nuts, bolt

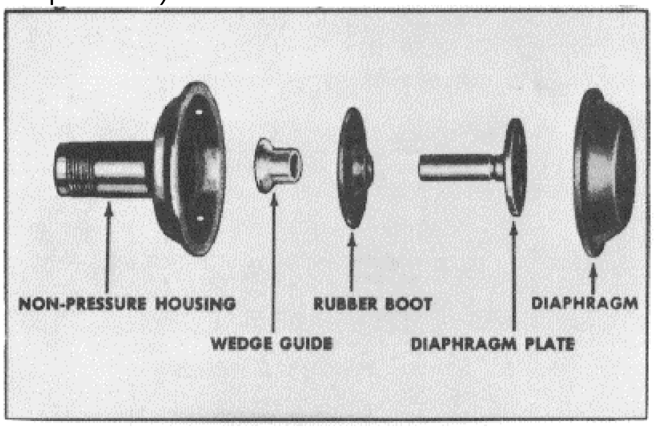


D. Spread the clamp ring. Hold the diaphragm on the non-pressure half and remove the pressure half

E. Carefully remove the diaphragm while holding diaphragm plate against the wedge rod. This will prevent the wedge assembly from coming out of engagement with the plungers.

NOTE: If wedge assembly backs out of plunger anytime during this entire procedure, remove non-pressure housing from brake to replace diaphragm.

F. Continue to hold plate and inspect boot. If boot is torn or not attached to housing, strip old boot free from housing and carefully re- move plate assembly off wedge rod and out of non-pressure housing tube. (Boot and wedge guide will remain on plate push rod.)



G. Remove wedge guide and old boot from push rod. Inspect guide for wear and replace if necessary.

H. Install new boot on diaphragm plate push rod and press wedge guide all the way onto end of push rod.

J. Clean non-pressure housing with cement thinner or similar material in area where boot is to be cemented.

K Apply cement to housing around tube end. Position the plate-push rod assembly into tube. Carefully engage wedge rod so as to not pull it out of plungers.

L. While holding plate against wedge, press boot into position for cementing.

M. Install new diaphragm over plate and onto nonpressure housing while pushing plate against wedge. Assemble pressure half and clamp ring in reverse manner of disassembly.

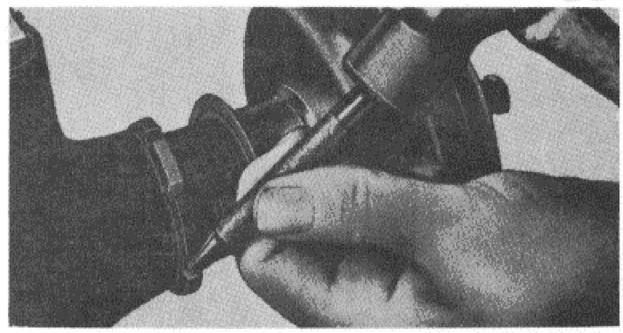
N. Connect air lines to proper chamber ports. Make a full-pressure brake application and check for air leaks. Road test for brake performance.

REMOVING POWER UNIT FROM BRAKE ASSEMBLY.

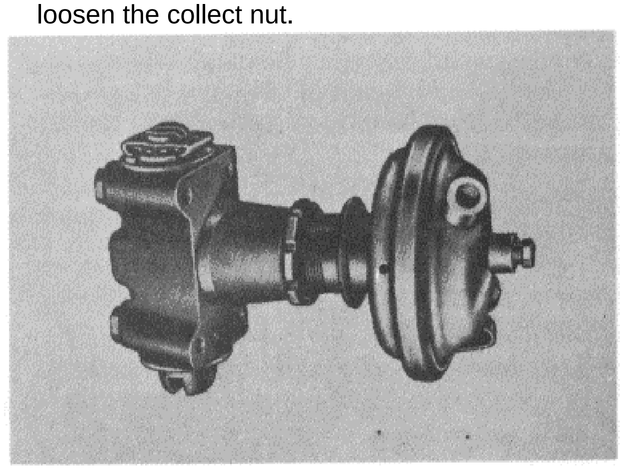
A. Remove brake lines and tag emergency line.

B Determine the type of power unit used, bottoming or adjusting type. (Bottoming air chambers have an identification tag fastened to the clamp ring bolt

C. If adjusting type unit is used, carefully mark the position of the assembly on the first exposed thread on the housing tube with a scribe or punch and hammer to aid reassembly.



D. Using a drift or other blunt tool and hammer, loosen the collect nut.

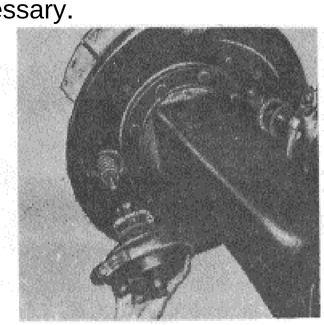


NOTE

On welded on spider mounted brakes with open ends the entire actuation system can be taken off at this time if desired as one assembly by removing four spider to plunger housing capscrews. However, the *hub and drum and dust shield will have to* be *taken off* before *removing the actuation system.*

E. Unscrew the power unit out of the plunger housing. At this time remove and inspect the wedge assembly. Service if necessary.

SERVICE



CURRENT

AIR CHAMBERS

DISASSEMBLE

A. To disassemble air chamber follow procedures A thru F of Servicing Air Chamber Diaphragm, Page204, disregarding wedge assembly precautions.

ASSEMBLE

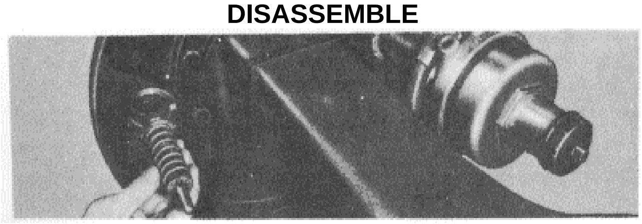
NOTE: Adjusting type non-pressure housing is interchangeable with bottoming type housing and may be converted at this time.

A. To install boot and guide and reassemble chamber, follow procedures H thru L of Servicing Air Chamber Diaphragm, page 204 disregarding wedge assembly precautions.

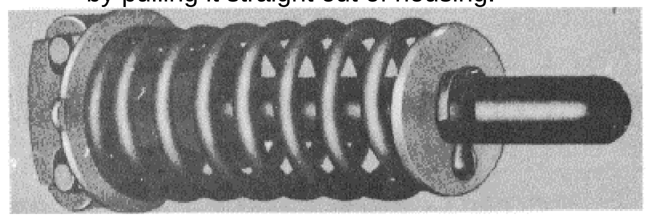
B. Test for leaks.

WEDGE ASSEMBLY

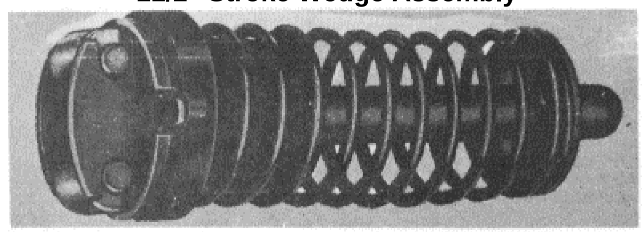
DISASSEMBLE



A. Remove wedge assembly from plunger housing by pulling it straight out of housing.



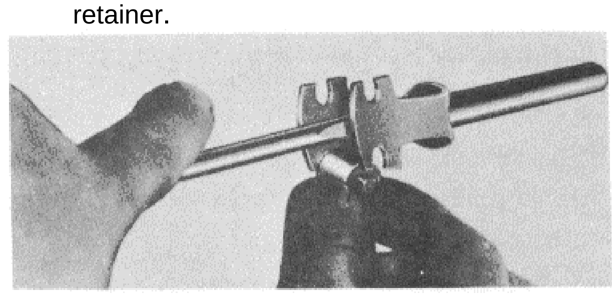
11/2" Stroke Wedge Assembly



13/4" Stroke Wedge Assembly

B. Remove cotter or "E" washer (earlier design not shown) from wedge shaft while holding spring compressed by hand.

C. Remove wedge spring washer, wedge spring, rubber boot (13/4" assembly) and wedge spring retainer.



D. Insert a thin bladed screwdriver between one flat of the wedge head and roller retainer cage. Spread the cage open just far enough to remove the rollers.

IMPORTANT: DO NOT ATTEMPT TO DRIVE THE WEDGE THROUGH THE ROLLERS AND CAGE OR FORCE THE ROLLERS THROUGH THE SLIGHTLY CLOSED SLOTS OF THE CAGE. THIS WILL PERMANENTLY DAMAGE THE CAGE.

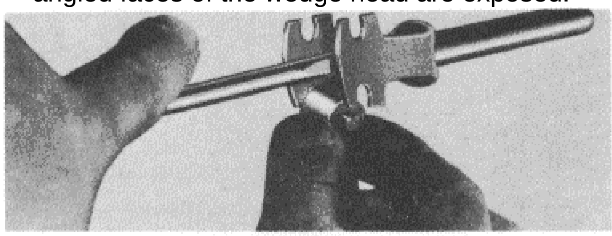
E. Remove the roller retainer cage by sliding it off the wedge shaft.

*Do not mix components from **1½2** and 1¾/4 stroke wedge assemblies.*

ASSEMBLE

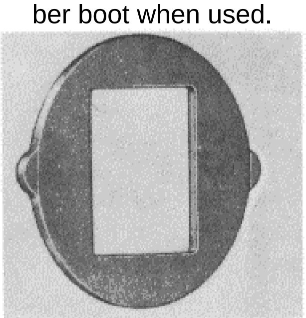
A. Clean all parts thoroughly and inspect. Check angled faces of wedge to see that they are free from pits or marks. If "E" washer type lock is used, inspect wedge shaft lock groove to see that it is sharp and clean. Inspect roller retainer cage to make sure it will contain rollers properly and inspect the spring for marks that would cause breakage. Replace parts if necessary.

B. Insert wedge shaft into roller retainer cage so angled faces of the wedge head are exposed.

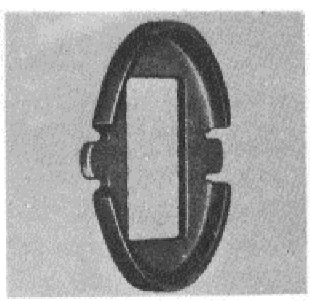


C. Insert a thin bladed screwdriver between flat of the wedge head and roller retainer cage. Spread cage open just far enough to insert roller (journal hub into cage slot). Tip roller into cage and position other journal hub into slot of retainer. Install other roller in same manner and remove screwdriver. DO NOT force rollers thru ends of the cage slots.

D. Install spring retainer over wedge shaft and position centrally over cage and roller assembly. Install rubber boot when used.

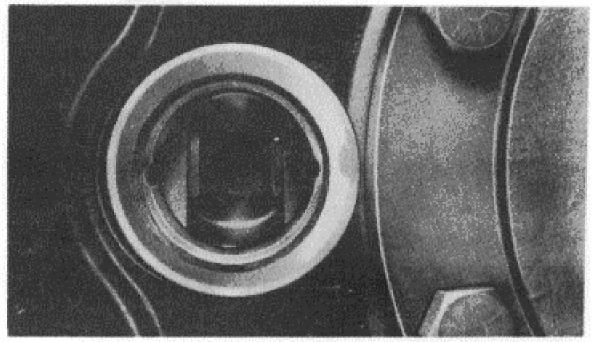


1 1/2" ASSEMBLY



1 3/4" ASSEMBLY

NOTE: Current production and service replacement use a spring retainer that has two tabs or protrusions on the O.D.



These tabs serve to align the wedge assembly as it is installed into the plunger housing by engaging grooves in the wedge bore. If the plunger housing is not equipped with such grooves, remove the tabs at the breakoff marks and file the O.D. of the retainer smooth.

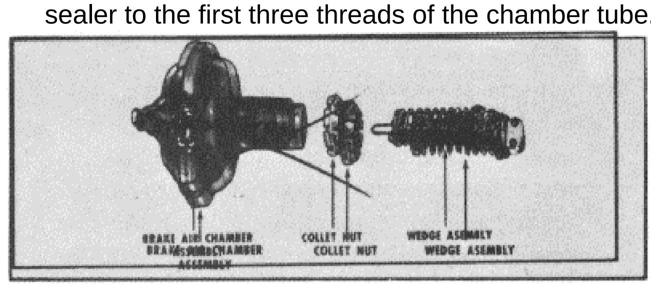
E Install wedge spring over wedge shaft, large coil diameter first. Add spring washer and compress spring by hand far enough to expose cotter key hole or "E" lock groove and install lock (cotter key or "E" washer).

F. Install the wedge assembly into the plunger housing. Check for correct roller-plunger engagement by (1) pushing on wedge rod by hand while checking for plunger and shoe lift, and (2) measuring the standout of the wedge rod from the end of the threaded housing bore. When properly assembled, the wedge standout is 2 1/4

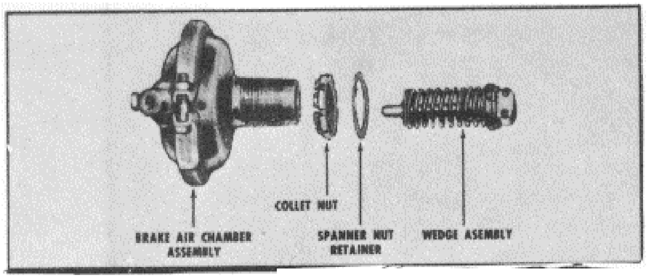
INSTALLING POWER UNIT ONTO

BRAKE ASSEMBLY

A. Check position of the wedge in plunger housing to make certain wedge assembly is properly seated. Be sure to replace automatic adjusting identification ring (if used) on power unit tube. Thread spanner nut or collet nut onto power unit tube and install spanner nut retainer if used. Apply a non-hardening sealer to the first three threads of the chamber tube.



This is the correct position of the collet nut when used with current brake spider having a conical counterbore.



This is the correct "reversed" position of collet nut and retainer when brake spider *does not* have conical counterbore.

B. **INSTALLING BOTTOMING TYPE POWER UNIT.**

1. Screw the power unit into the plunger housing until it bottoms (collet nut loose).

2. Align connection ports with brake lines, if necessary, unscrew power unit not more than one full turn.

3. Connect brake lines.

4. Make and hold a full pressure brake application. (At this time position spanner nut retainer if used so it will engage plunger housing slot.) Hand tighten collet nut.

5. On current assemblies, drive collet nut with a drift and hammer **11/2** teeth (or 3/16 turn). Release brake pressure.
6. On older assemblies using retainer and "reverse" collet nut, drive collet with drift and hammer until it is tight against retainer.

   Using a drift or other blunt tool, peen section of the retainer into one slot of the collet nut. Release brake pressure.

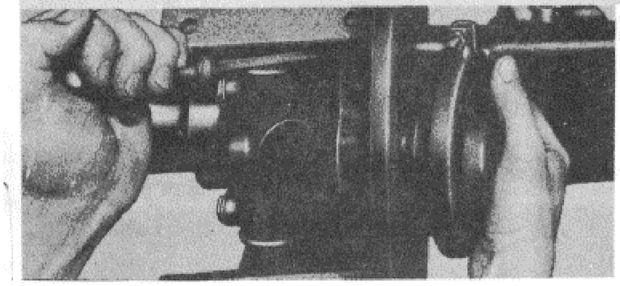
7. Check for leaks at all connections.

C. INSTALLING ADJUSTING TYPE POWER UNIT WITH DEPTH MARK.

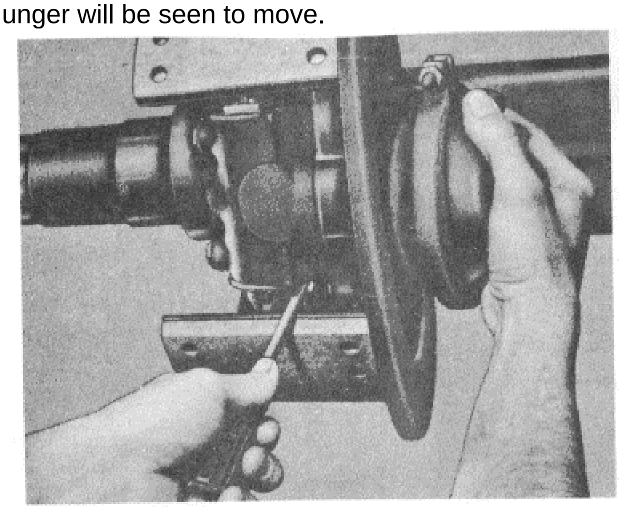
1. Follow procedures in paragraph "A"Page 207
2. Screw power unit into the plunger housing several turns. Turn spanner nut toward plunger housing so depth mark on threads is just ex- posed. Continue turning power unit into plunger housing until it bottoms on spanner nut and retainer. (Collet nut can be substituted for spanner nut when needed.)
3. Follow procedures 3 thru 7 of *Installing Bottoming Type Power Units.*

D. **INSTALLING ADJUSTING TYPE POWER UNIT WITHOUT DEPTH MARK.**

1. Follow procedures in paragraph "A", page 207



2 Screw the power unit mto the plunger housing until it bottoms. This will push wedge assembly between plungers and lift them off their seats inside the housing. By pushing. on one shoe or plunger, the second shoe or plunger will be seen to move.



3. Unscrew the power unit one turn. Push on one shoe or plunger and then the other alternately, observing movement of the opposite plunger. If there is movement of the opposite plunger, unscrew the power unit another turn and continue this procedure until no plunger movement can be detected. This point is usually two or three turns from the bottomed position.

4. Follow procedures 3 thru 7 of *Installing Bottoming Type Power Units.*

SERVICING DUST SHIELDS

A. Welded on spider brakes have dust shields of the four-piece type attached to the spider with capscrews and lockwashers. Either one or all of the sections can be removed directly from the brake by removing the capscrews and lockwashers.

B. Most bolted on spider brakes with two-piece dust shields can be serviced as described in paragraph "A" after removing wheels, drums and brake shoes.

C. Bolted on spider brakes with one-piece dust shields will have to be taken off the vehicle for servicing. To remove dust shield from brake first remove power units then remove shield to spider capscrews and lockwashers. The shields can be replaced with a one or two piece dust shield D. On backing plate mounted brakes the backing plate serves. as a support for the plunger housing and anchor block as well as a dust shield. For servicing the complete backing plate will have to be taken off the vehicle by removing the plate to spindle flange bolts, nuts and lockwashers.

SERVICING BRAKE SHOES

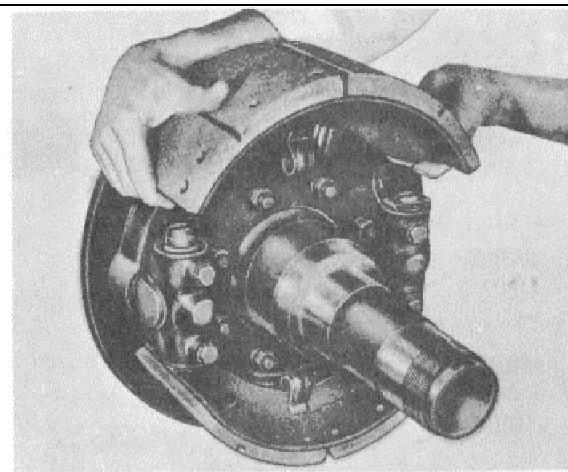
REMOVE SHOES

NOTE: If necessary back off shoes away from drum manually by turning adjusting bolt assemblies.

B. Remove wheel, hub and drum assemblies.
C. Remove brake shoe return springs, using one of the following two methods:

"COIL" RETURN SPRING

1. Use brake spring pliers. (DO NOT use screwdriver.) On backing plate mounted brakes, remove the anti-rattle rod assembly by pushing on rod head on back side, while depressing spring and cap. Turn cap Y4 turn and remove caps, spring and rod.



Remove brake shoe assemblies. DO NOT remove brake shoe hold down clip, support bracket, lockwashers and capscrews, or wear buttons unless in need of service.

2. Remove dust shield, cotter key and nut from brake shoe guide pin. Remove guide pin, spring and washers. Lift brake shoe out of plunger slots, and tilt brake shoe to unhook the return springs.

ASSEMBLE SHOES ONTO BRAKE:

A. If necessary, reline brake shoes. Apply film of grease to the shoe rest pads and the plunger and bolt slots. Caution: Do not use combination linings.

B. Rotate adjusting bolts to align slots in bolt retainer with brake shoe webs, being certain that bolts are not bottomed in adjusting plungers.

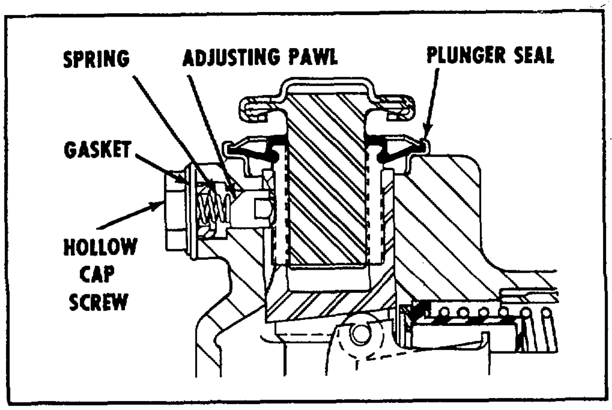
C. Assemble brake shoes in reverse manner in which they were disassembled. Be sure that the long radius of the shoe web fits into slot in adjusting bolt retainer, and that the arrow stamped on the brake shoe web points to the anchor plunger in forward wheel rotation. See page 199 for correct position of brake shoes and plungers.

D. Install brake drums and adjust brakes.

SERVICING PLUNGER HOUSING

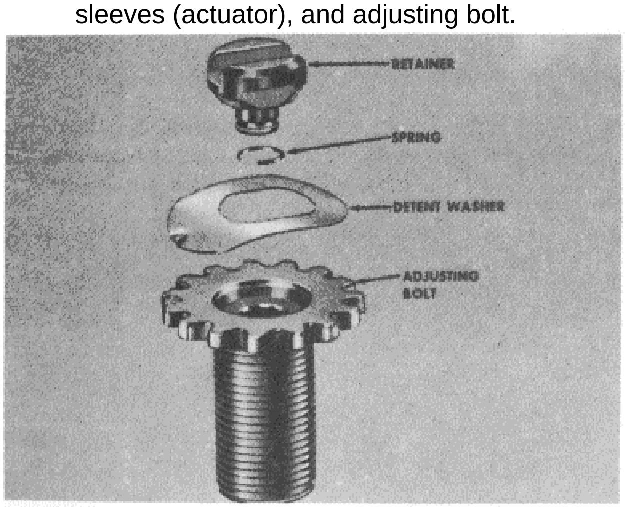
DISASSEMBLE

A. With brake shoes removed, remove guide screws and gaskets from the plunger housing.



If brake is automatic adjusting remove hollow capscrew, gasket, spring, and adjusting pawl. Use a small magnet to remove pawl.

B. Pry plunger seals loose and remove anchor (solid) plungers, adjusting plungers, adjusting sleeves (actuator), and adjusting bolt.



If a four-piece adjusting bolt assembly is employed it should also be disassembled.

ASSEMBLE

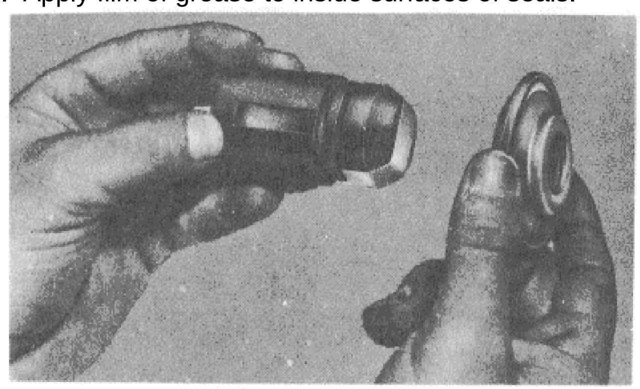
A. Thoroughly inspect and clean all parts including the housing plunger and seal bores and shoe rest pads. DO NOT solvent clean any rubber parts (plunger seals. or gaskets). Wire brush plunger parts and adjusting bolt threads to remove caked on dirt and corrosion.

Carefully inspect plunger seals and gaskets for tears, cuts or deterioration, and replace if necessary. Also check the angled plunger roller faces for pits, grooves or nicks and replace if necessary.

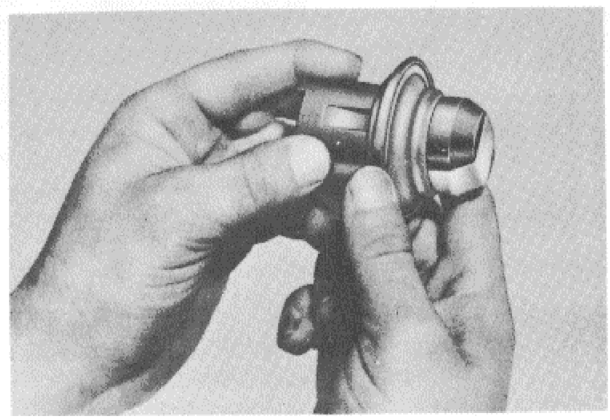
NOTE
: RD spider mounted brakes have one adjusting plunger and one anchor (solid) plunger per plunger housing. The anchor plungers are marked on the shoe slot end, "R" for right hand brakes and "L" for left hand brakes. DO NOT mix at reassembly.

B. **ASSEMBLE SEALS ONTO PLUNGERS**
IMPORTANT: DO NOT ASSEMBLE SEALS INTO PLUNGER HOUSING FIRST. THIS WILL RESULT IN COMPLETE LACK OF SEALING OF INTERNAL PLUNGER HOUSING COMPONENTS.

1. Apply film of grease to inside surfaces of seals.

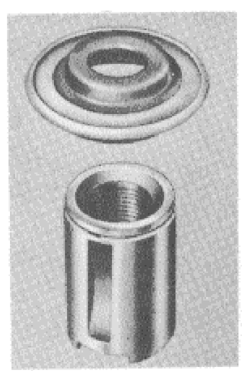


2. On anchor (solid) plungers-inspect nose for burrs. Mask brake shoe web slot in the plunger nose with masking tape to protect seal.



Carefully push the double lip seal onto the plunger, stretching the outer seal lip over the plunger nose end, until the inner seal lip is completely in the second plunger groove and the outer seal lip is in the first plunger groove. Remove masking tape. (Brakes employing single grooved plungers and single lip seals should be assembled in the same manner except masking tape is not used.)

3. On manual adjusting plungers-push the inner seal lip over the threaded hole end of the plunger .until the lip completely., enters the plunger seal groove. See paragraph 4 on page 2 1 for automatic, adjusting plungers.'



C. INSTALL PLUNGERS INTO PLUNGER HOUSING.

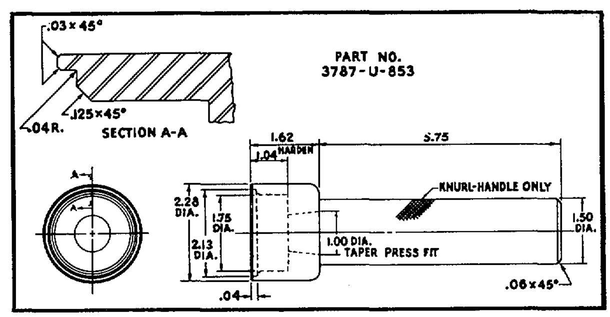
1. Coat all plunger bores with grease.

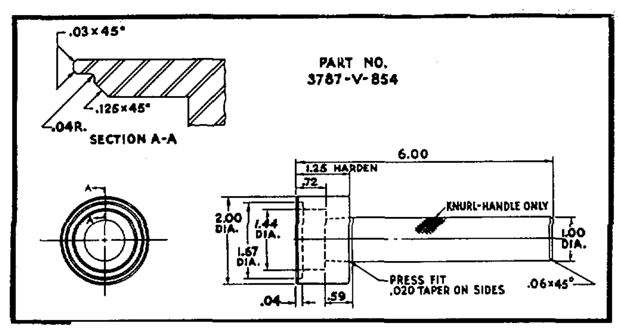
2. Anchor (solid) plungers-make sure anchor plungers marked "L" are installed in left hand brake and anchor plungers marked "R" are installed in the right hand brake. See pagel99for correct location of anchor plungers in the plunger housings.

a. Coat entire anchor plunger with grease, packing cavity behind seal, and insert plunger and seal into housing with plunger key-way slot aligned with guide screw hole. Make certain the plunger goes all the way into the plunger bore and seats on bosses at the bottom.

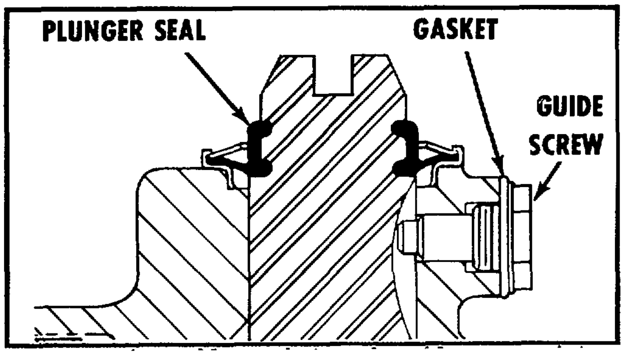
b. Seat plunger seal in plunger housing with correct seal driver tool.

Driver must be centered over seal retainer to prevent damage to seal assembly.





Driver for backing plate mounted brakes. If seal driver is not available a 13/4" wrench 211 socket can be used for spider mounted brakes and 13/8" wrench socket can be used for backing plate mounted brakes.

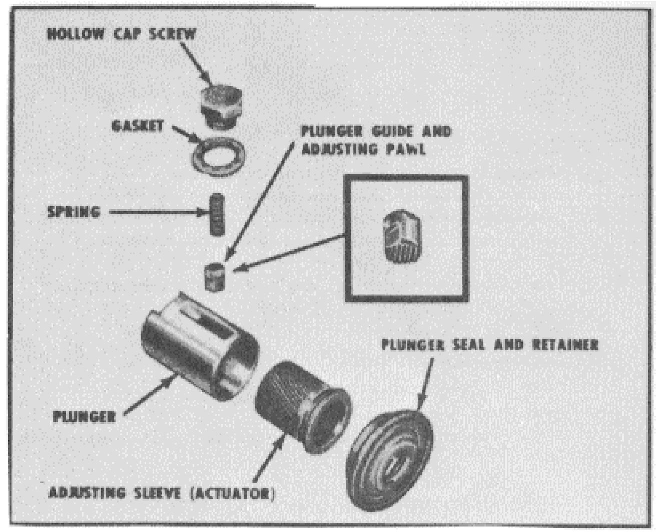


c. Assemble gasket and guide screw into plunger housing.

4. AUTOMATIC ADJUSTING PLUNGERS

a. Grease coat the inside and outside surfaces of both the adjusting plunger and the adjusting sleeve. Place the plunger into the plunger housing aligning plunger key-way slot with the guide hole and assemble adjusting pawl* Push pawl back flush with inside of plunger and hold in this position with a small screwdriver while installing grease coated adjusting sleeve.

NOTE The adjusting pawl has teeth and flats on one end and a chamfered edge on the other end. Coat pawl with grease and insert it into the guide hole, teeth first, and IMPORTANT with chamfer toward the brake shoe. This aligns the pawl and sleeve teeth and the flats with the key-way slot.



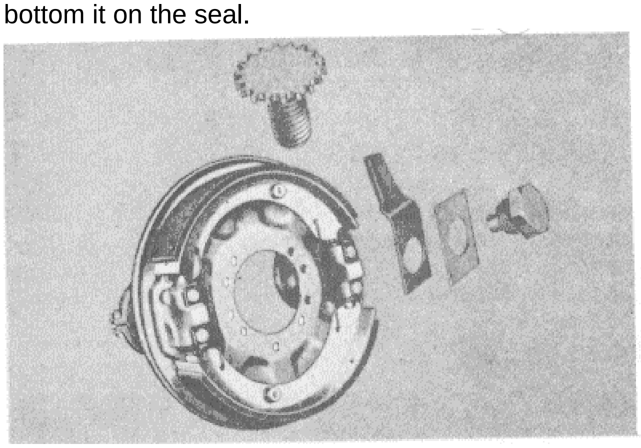
b.-Insert the sleeve into the plunger until it bottoms. Install gasket, spring and hollow capscrew into the plunger housing. Tighten capscrew finger tight.

c. Proper meshing of the pawl and sleeve teeth can be checked at this point. Grease coat adjusting bolt threads and thread it into the adjusting sleeve until it bottoms. A clicking sound and a ratcheting feel will indicate meshing of the teeth. Turn the bolt out three turns, if there is no clicking sound or ratcheting feel, this indicates proper meshing. Remove adjusting bolt after check. Tighten hollow capscrew to 15-20 ft. lbs. torque.

d. Pack a small amount of grease into underside of seal and seal lips. Assemble the plunger seal over the adjusting sleeve in the plunger housing by pushing the seal over end of adjusting sleeve so the inner lip enters seal groove. Check by lightly pulling up on seal.

e. Using the proper tool seat the seal into the plunger housing as in paragraph "2b"

f. Coat adjusting bolt threads with grease and thread it into the sleeve after working it through the seal flap hole, being careful not to pinch the seal on the threads. Turn bolt in to just short of the seal. **DO NOT** bottom it on the seal.

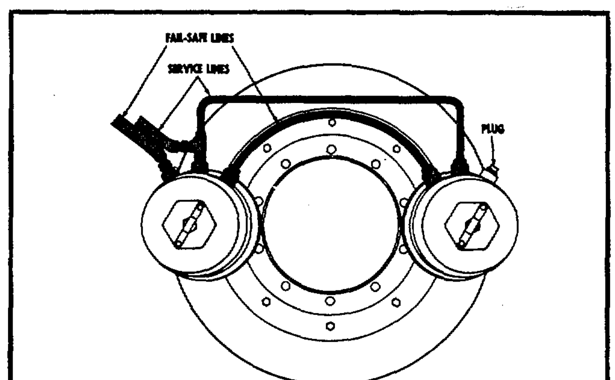


NOTE: On earlier models of front brakes (backing plate mounted) a finger spring type of adjusting bolt lock was used.

To assemble, first install plunger parts, press in seal, turn bolt into plunger or adjusting sleeve and then install finger spring and guide bolt. Lock guide bolt by peening lock plate to bolt boss and head.

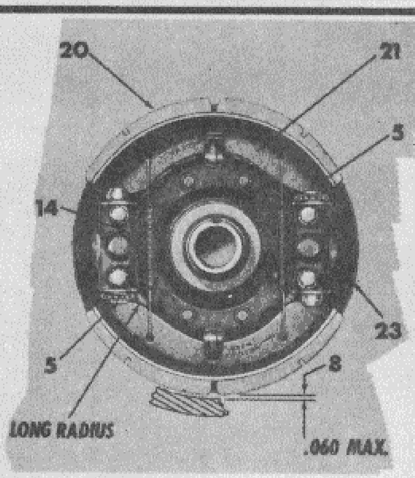
The installation of plungers with single lip seals is the same as for double lip seals except with automatic adjusters. The single lip seal is installed on the adjusting sleeve first. Grease the sleeve, seal and adjusting plunger and install in the plunger housing. Then assemble the adjusting pawl, spring and hollow capscrew with gasket. Drive the seal into the housing. Screw the adjusting bolt into the sleeve until it bottoms and perform the check for adjusting pawl tooth mesh. Then back the bolt out about 1/2 turn.

MANIFOLDING



MANIFOLDING OF THE FAIL-SAFE CHAMBERS

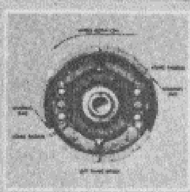
STOPMASTER® BRAKES
PROBLEM ANALYSIS GUIDE



RDA — 15" Bolted-on Spider with Integral Plunger Housings. Cast spider bolts to flange on the axle housing. Adjusters may be manual or automatic. Dust shields one or two piece type.

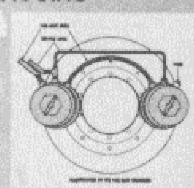
THE NUMBERS APPEARING IN FRONT OF VARIOUS STATEMENTS ARE "KEYED" TO CORRESPONDING NUMBERS IN THE SEVERAL ILLUSTRATIONS

AUTOMATIC ADJUSTERS NOT WORKING



3. Adjusting bolt threads tight in adjusting sleeve (actuator).
4. Adjusting bolt detent spring broken or damaged.
2. Adjusting pawl spring collapsed or missing.
1. Adjusting pawl in backward or upside down. (Should be — teeth first and chamfer toward the brake shoe).
5. Adjusting plunger not at leading end of shoe. (Refer to illustration).
6. Double lip seals not installed correctly or installed on single lip adjusting sleeve.
8. NOTE:
If drum to lining clearance is .060" or less the automatic adjusters are working properly.

BRAKES DRAGGING

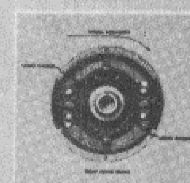


10. Improper connection of service lines. (Refer to illustration).
10-11. Leaking air lines .
12-19. Plungers tight or sticking.
22. Wedge shaft out of push rod socket. Wedge guide missing or broken.
14. Brake shoe return springs not fully returning.
16. Return springs incorrectly installed on 12¼" diameter brake — long hook must overlap short hook on both springs.
LOOSE WHEEL BEARINGS

BRAKES GRABBING

17. Adjusting-type power chambers threaded too far into plunger housing.
20. Grease or dirt on brake lining.

UNEVEN LINING WEAR

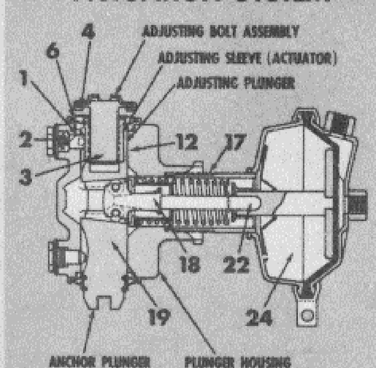


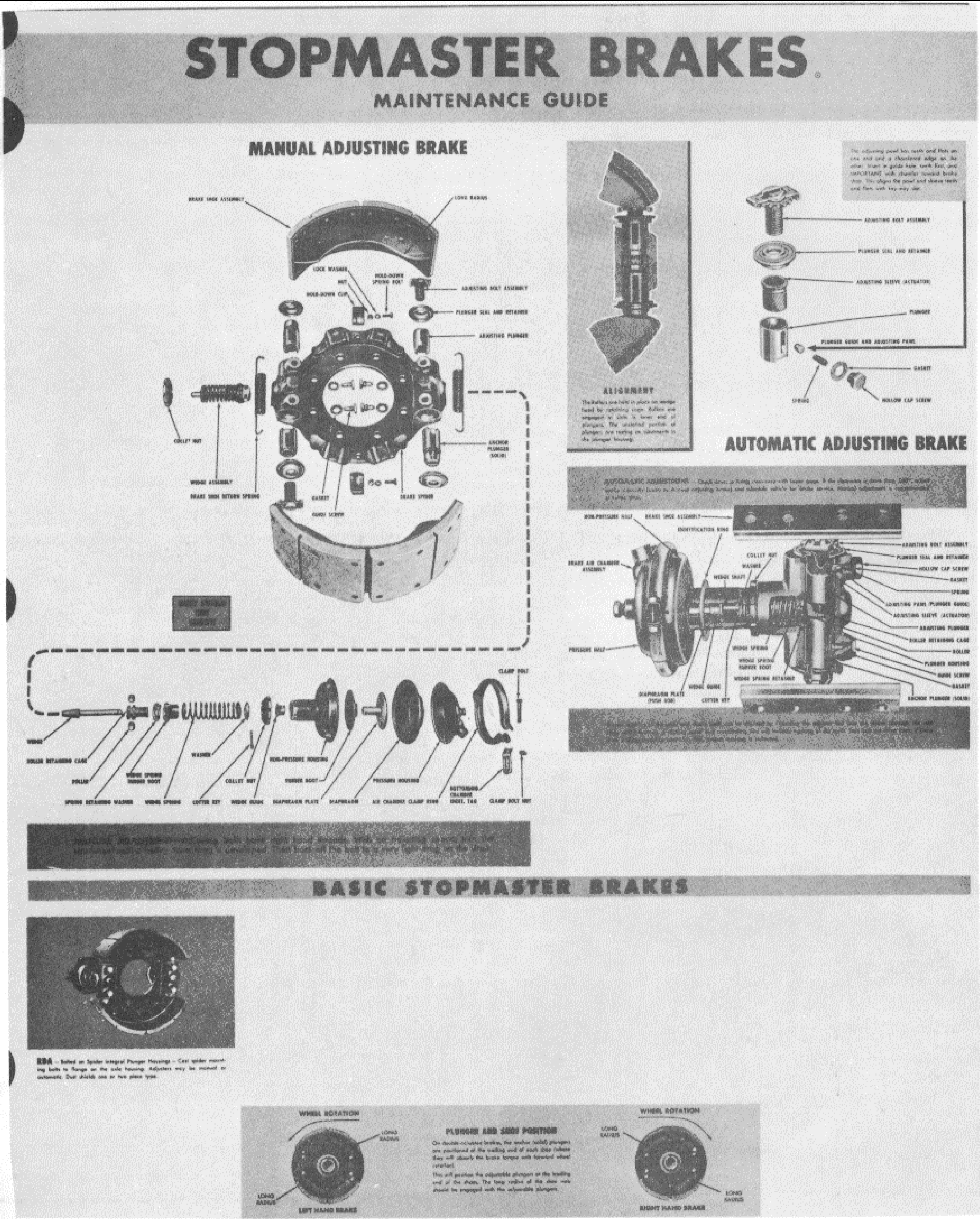
21. Brake shoes installed backwards (should be with "arrow" in direction of normal drum rotation). Refer to illustration.
14. Brake shoes not releasing fully (shoe return spring broken or elongated).
20. Brake linings are not same mix. Do not use combination linings.
20. Grease or dirt on lining.
22. Wedge shaft out of push rod socket. Wedge guide missing or broken.
18-19. Wedge and roller assembly not engaged with plunger slots. (Wedge assembly cocked—Early wedge assemblies do not have ears on spring retainers or guide grooves in plunger housings. Wedge assembly does not seat far enough into plunger housing—incorrect push rod length or power chamber not assembled deep enough into plunger housing).
23. Dust shields not installed.
17. Adjusting type power chambers threaded too far into plunger housing.

BRAKES FROZEN OR LOCKED

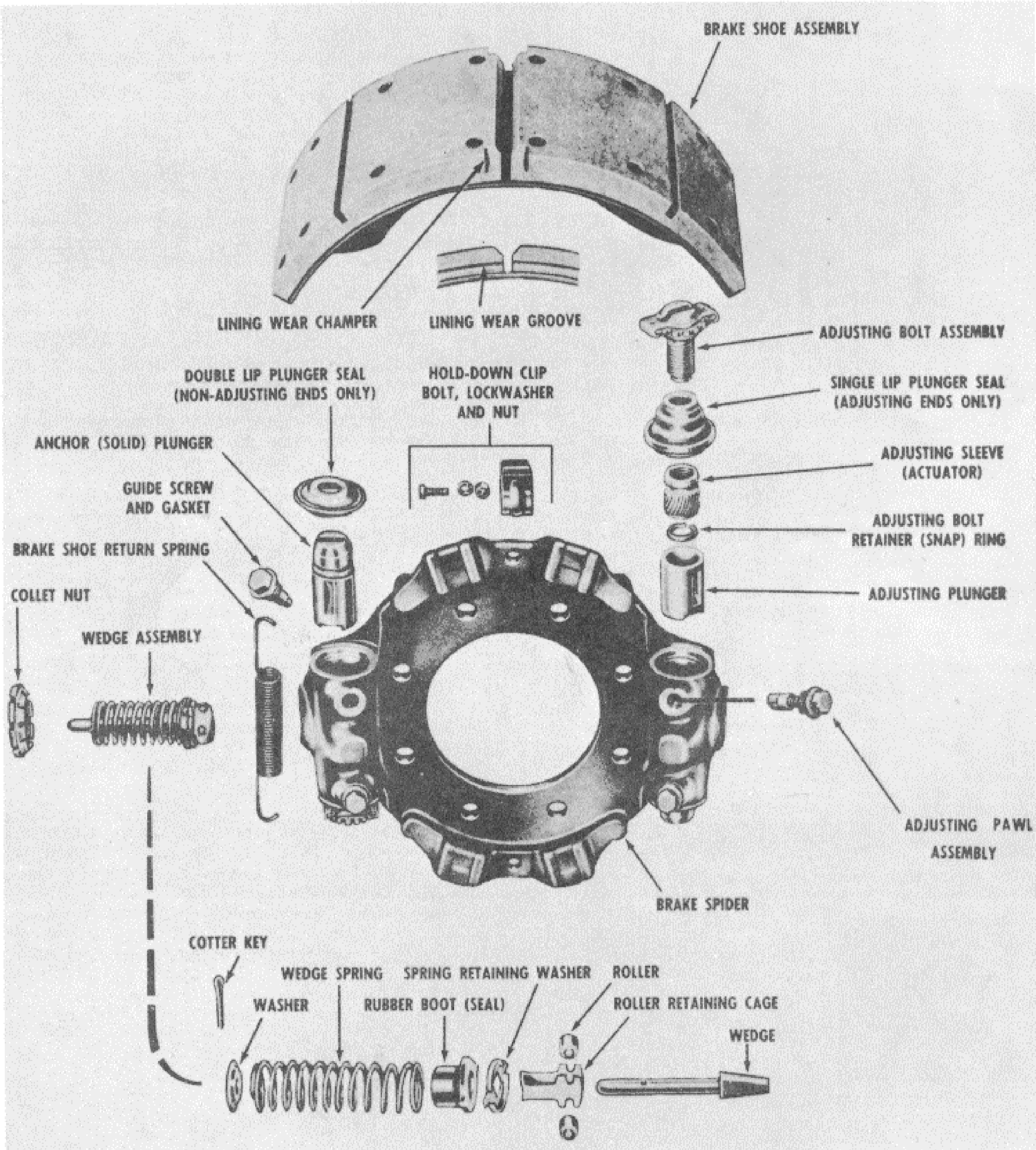
20. Lining frozen to brake drum.
24. Air not released from brake chamber.
9. Fail-Safe units not releasing.

ACTUATION SYSTEM



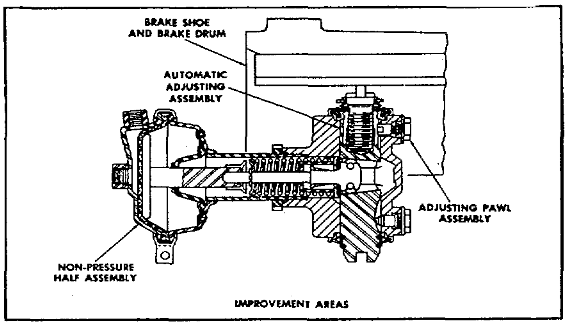

STOPMASTER BRAKES
MAINTENANCE GUIDE
MANUAL ADJUSTING BRAKE
AUTOMATIC ADJUSTING BRAKE
BASIC STOPMASTER BRAKES

RDA STOPMASTER



STOPMASTER II WEDGE BRAKE DESIGN IMPROVEMENTS

The Stopmaster II Wedge brake now incorporates a series of design changes based on the original Stopmaster brake.



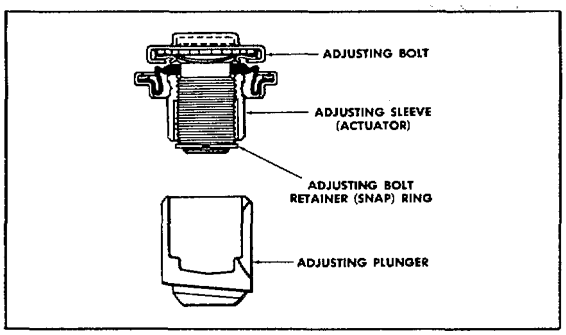
IMPROVEMENT AREAS

Major design improvements have been made in four general areas of the brake: (1) The automatic adjusting assembly; (2) The adjusting pawl assembly; (3) The non-pressure half of the air chamber; and (4) The brake shoe and drum.

AUTOMATIC ADJUSTING BOLT ASSEMBLY

Limited Travel Adjusting Bolt

The automatic adjusting assembly for the Stopmaster II employs a limited travel adjusting bolt which cannot over adjust or cock when the brake lining has been extremely worn.



This is accomplished with the addition of a snap ring at the foot of the bolt and a redesigned adjusting sleeve (actuator) and plunger.

The adjusting sleeve has been counterbored on the I.D. to accept the redesigned adjusting bolt.

Thus, when the lining Is worn, the counterbored shoulder of the adjusting sleeve stops the bolt from advancing further. Consequently, the bolt is prevented from over adjusting.

To accommodate these changes, the I.D. of the adjusting plunger has also been counterbored to make room for the snap ring.

WARNING

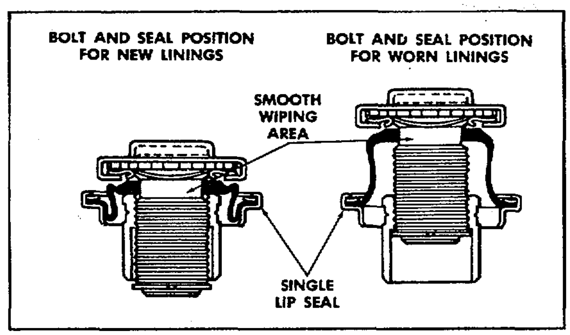
Once a condition exists of worn linings and the adjusting bolt is totally extended, continued braking will result in a gradual deterioration of that wheels braking ability. Periodic inspection in accordance with the recommended preventive maintenance is necessary to retain maximum braking performance.

If the original adjusting sleeve (actuator) which does not have the new counterbore (has internal threads the full length) is to be used, do not employ the adjusting bolt retainer (snap) ring. Use of the retainer (snap) ring with the old style adjusting sleeve (actuator) and new style adjusting bolt would prevent the adjusting bolt from moving outward and making the necessary lining wear adjustment.

In addition, the adjusting bolt now has a machined smooth wiping surface under the head to accept a new single lip plunger seal.

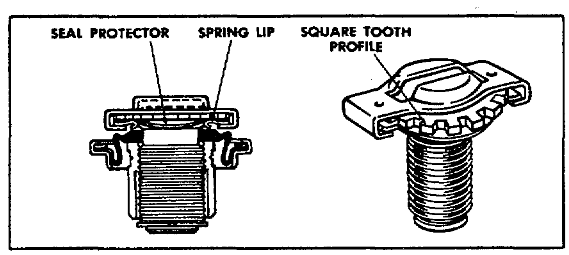
Single Lip Plunger Seal

The adjusting assembly also employs a new single lip plunger seal to provide more protection for the bolt threads and improved sealing for the actuation housing components. The lip of this seal wipes against the smooth machined surface beneath the head of the bolt.



This seal is designed to allow more flexibility and will provide additional protection for the adjusting assembly when the bolt is extended outward in brake application. Thus, this will reduce the possibility of the adjusting bolt freezing, due to any corrosion or dirt inside the actuation housing.

Adjusting Bolt

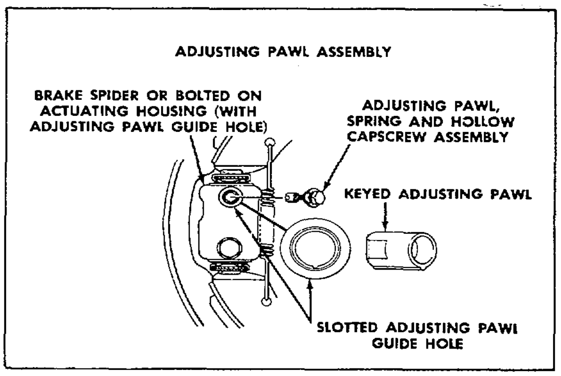


To protect the plunger seal, the head of the adjusting bolt incorporates a redesigned stamped seal protector and rolled spring lips. The seal protector is angled downward to act as a shield over the plunger seal. This prevents contact between the seal and the adjusting spoon when the brake is being adjusted manually. The spring lip serves to protect the plunger seal when the bolt is in the bottomed position.

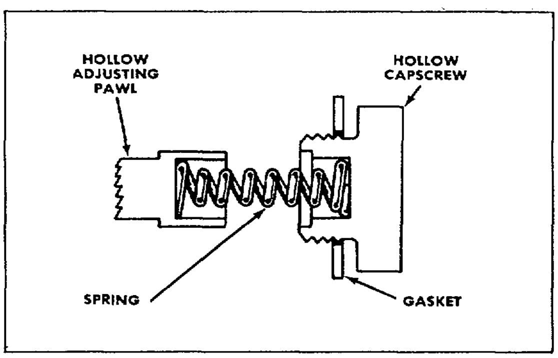
To further facilitate the initial manual adjustment, the star wheel portion of the adjusting bolt head employs square teeth.

ADJUSTING PAWL ASSEMBLY

The adjusting pawl for the Stopmaster II Wedge brake employs an integral key which mates with a slot in the adjusting pawl guide hole of the redesigned brake spider or actuation housing.

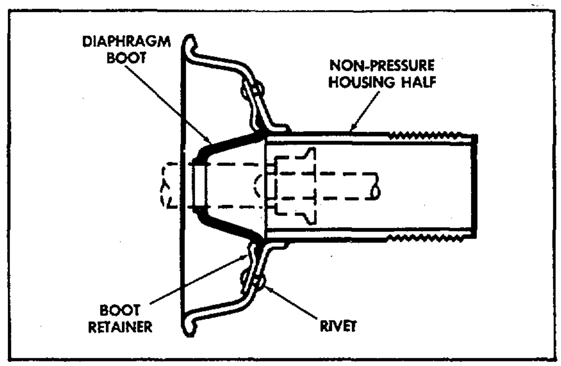


The keyed pawl and slotted guide hole assures correct positioning of the pawl inside the plunger to allow the brake to adjust automatically. This design makes it necessary for the keyed pawl assembly to be used only with brake spiders and bolted on actuation housings which employ slotted pawl guide holes.



The keyed adjusting pawl, spring and hollow capscrew are pre-snapped together as one assembly to facilitate reassembly of these parts into the spider and bolted on actuation housings. To achieve this, both the capscrew and pawl have hollow ends, and the spring has one large diameter coil at each end which force fits (presnaps) into the open ends of the pawl and capscrew. The keyed adjusting pawl assembly is not interchangeable with the original adjusting pawl assembly because of the keyed pawl. However, the individual spring, gasket and hollow capscrew are interchangeable with original parts.

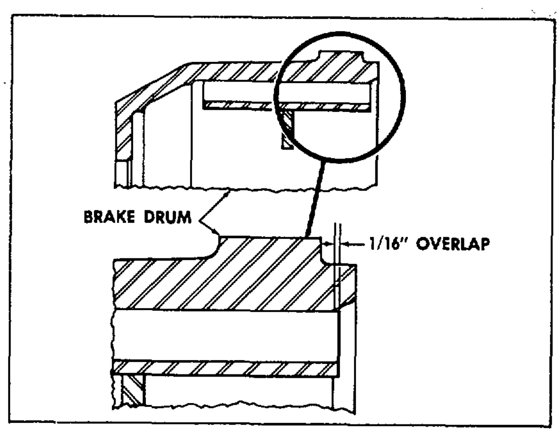
NON-PRESSURE HALF ASSEMBLY



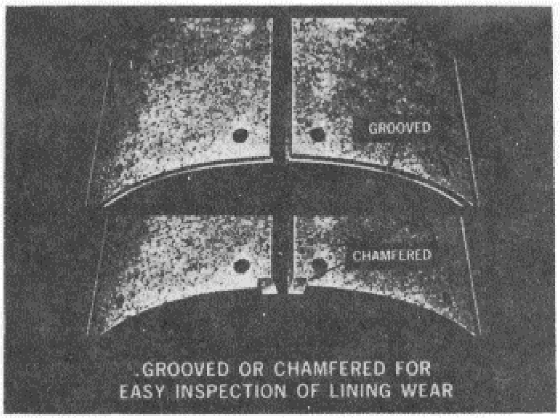
The power unit of the Stopmaster II employs a larger, and more flexible diaphragm boot seal It also employs a boot retainer clamp which is riveted to the wall of the non-pressure half of the housing. The lip of the diaphragm boot is positioned beneath the boot retainer clamp, and Is thus held tightly against the wall of the nonpressure housing. This provides improved sealing for the air chamber tube by preventing road contaminates from entering the wedge area and contaminating the lubricant. Further, the mechanical attachment of the boot retainer clamp prevents possible separation of the diaphragm boot from the housing.

CHAMFERED BRAKE DRUM

Other design improvements for the Stopmaster II include a chamfer on the brake drum on the inside outer edge to facilitate removal when brake service is necessary. The chamfer allows the brake lining to overlap the drum edge by approximately 1/16". This, in turn, prevents the development of scored wear rings on I.D. of the drum, which could interfere with disassembly.



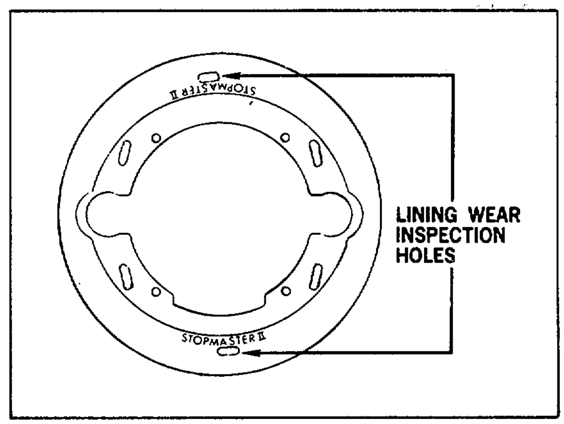
GROOVED BRAKE LINING



For visual inspection of brake lining wear, the linings of the Stopmaster II can be grooved on the side, as shown, as customer option. Also, as an option, the lining could be chamfered on the 4 inner corners, as shown.

This makes it easier to determine how much the lining has been worn, and when the vehicle should be scheduled for relining. When the lining has worn down to the groove, or when the chamfered corners have been worn away, replacement is necessary. A visual check may be made through the inspection holes in the dust shields.

DUST SHIELDS



To further facilitate visual inspection of brake linings, dust shields of the Stopmaster II employ two inspection holes as shown. This allows the linings to be inspected without removing the dust shields from the brake. These dust shields have been stamped, above the inspection holes with the letters and numerals, "Stopmaster II" for identification of service parts.

Recommended Grease

A high temperature water-proof grease IH 251 HE.P. grease or equivalent to NLGI # 2 multi-purpose lithium grease is recommended for lubricating the brake actuating system.

The following greases meet all of these recommendations:

Texaco Thermotex EP #1
Shell Darina #1
Marathon 528 H.D.
Sunaplex #1 EP
Amdex # 1 EP
Philube B #1

NOTE: Vehicles operating in extremely cold weather (below -400F) may require a grease conforming to MIL-G-25013C.

TROUBLE SHOOTING GUIDE

If brakes are poor or do not apply - check system pressure at source and at brakes possible restriction or leak in brake lines, valves, etc. brakes out of adjustment leaking diaphragm or wheel cylinder cup.

Uneven braking or lining wear - ruptured diaphragm wedge rod out of push rod socket rollers and cage out of plunger socket corroded or frozen plungers brakes out of adjustment grease on lining glazed lining shoes installed backward combination linings.

Automatic Adjusters not working - adjusting pawl installed backward pawl spring collapsed or missing bolt frozen in adjusting sleeve detent damaged and allowing bolt to rotate with sleeve adjusting plunger in wrong position in the spider (should be at leading end of shoe) double lip seals not installed correctly.

GENERAL MAINTENANCE

This section of maintenance instructions is outlined specifically for the major design improvements of the Stopmaster II,

BRAKE ADJUSTMENT

The following procedures can be used for the initial manual adjustment of Stopmaster II wedge brakes.

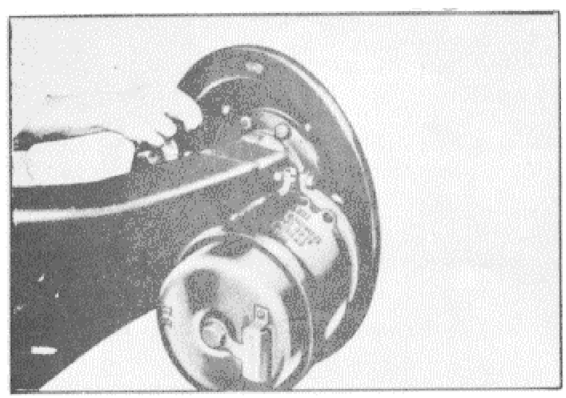
NOTE: Since the Stopmaster II is an automatic adjusting brake, periodic manual adjustment is not necessary.

A Jack or hoist wheels free of ground.

B. Remove dust cover from adjusting slot two places on each brake.

NOTE:

(double actuated) type brakes the adjusting slots are below the forward and above the rear power unit.



C. Adjusting bolts have right hand threads. With an adjusting spoon,' turn the star-wheel until a heavy drum drag is developed. Then back off the bolt to a very light drag on the drum. Repeat for other shoe on the brake. Replace dust covers in adjusting slots. Repeat for other brakes.

SERVICING POWER UNITS

AIR CHAMBER DIAPHRAGM

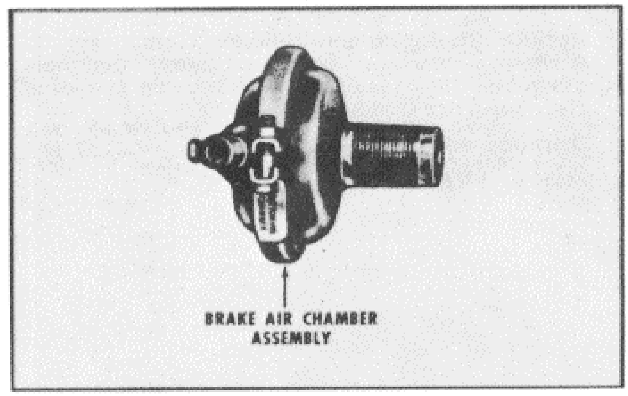
The following procedures can be used to replace the diaphragm boot and retainer clamp assembly, diaphragm plate and wedge guide of the brake air chamber.

REMOVE POWER UNIT FROM BRAKE ASSEMBLY

A. Remove brake lines

B. Using a drift or other blunt tool and hammer, loosen the collet nut.

NOTE: With welded on spider mounted brakes employing open ends, the entire actuation system can be taken off at this time, if desired, as one assembly by removing four spider to plunger housing capscrews. However, the hub, drum and dust shield will have to be taken off before removing the actuation system.



C. Unthread the power unit out of plunger housing.

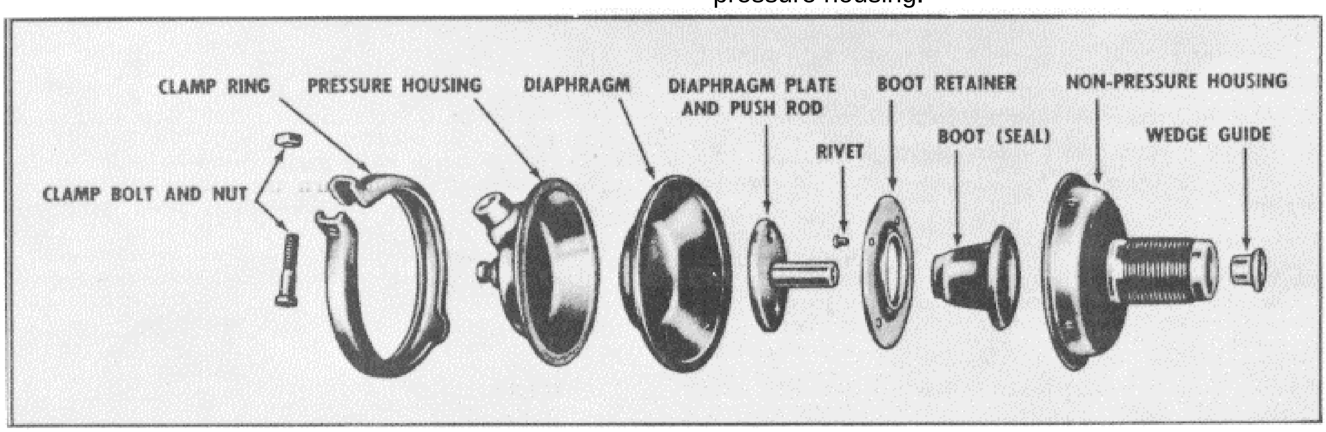
NOTE: The wedge assembly can be removed and serviced at this time if desired.

DISASSEMBLE AIR CHAMBER

A.. With power unit removed from brake assembly,

B. Spread clamp ring and remove pressure half

C. Remove diaphragm, diaphragm plate and remove clamp ring nuts, bolt, wedge guide from non-pressure housing.



D. Remove rivets and separate boot and retainer clamp from non-pressure housing using the following:

1. Carefully center punch rivets in center of head.

2. Use drill 1/32" smaller than body of rivet (9/64" dia. drill) to drill through head.

3. Press out rivets.

4. Remove old diaphragm boot and retainer clamp from housing.

REASSEMBLE AIR CHAMBER

A. Position the lip of new retainer clamp over lip of new diaphragm boot and place complete assembly into non-pressure housing so that rivet holes are in alignment.

B. Install appropriate size bolts and nuts in two rivet holes 180^0 apart and fasten retainer clamp and boot assembly to non-pressure. housing.

C. Make certain clamp and boot assembly is firmly fastened to non-pressure housing and tap rivets from outside non-pressure housing squarely into remaining 2 rivet holes with a flat head drift.

D. Form the rivet head with correct rivet set.

E. Remove bolts and nuts and repeat riveting procedure for two remaining holes.

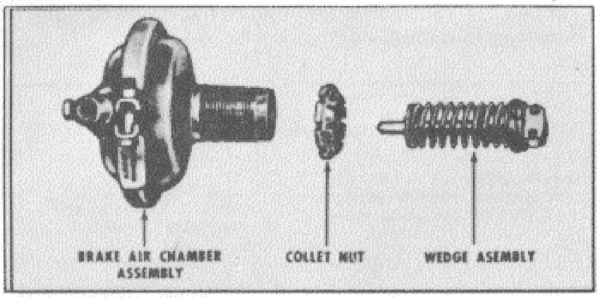
F. Install diaphragm plate push rod through new boot and press wedge guide all the way onto end of push rod.

NOTE: Replace wedge guide if necessary.

G. Install diaphragm over plate and onto nonpressure housing. Assemble pressure half and clamp ring in reverse manner of disassembly.

INSTALLING POWER UNIT ONTO BRAKE ASSEMBLY

A. Check position of the wedge in plunger housing to make certain wedge assembly is properly seated. Then, thread collet nut onto power unit tube.



This is the correct position of the collet nut when used with current broke spider having a conical counterbore.

B. Apply a non-hardening sealer to the first three threads of the chamber tube.

C. Thread the power unit into the plunger housing until it bottoms (collet nut loose).

D. Align connection ports with brake lines. If necessary, unthread power unit not more than one full turn.

E. Connect brake lines.

F. Make and hold a full brake application. Then, hand tighten collet nut.

G. Tighten collet nut with a drift and hammer 1% teeth (or 3/16 turn) and release brake pressure.

H. Check for leaks at all connections.

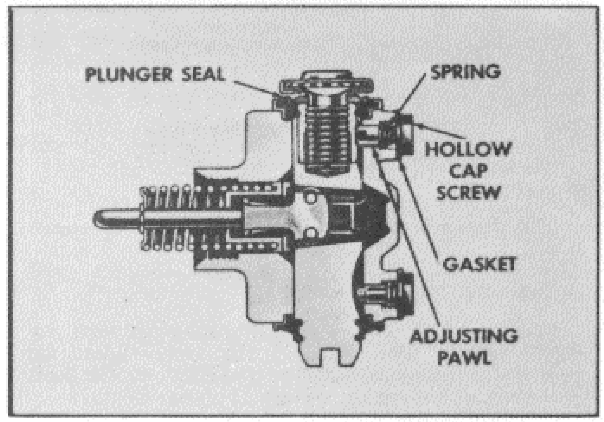
SERVICING PLUNGER HOUSING

The following maintenance instructions can be used to service the automatic adjusting assembly of the Stopmaster II wedge brake.

REMOVE AND DISASSEMBLE AUTOMATIC ADJUSTING ASSEMBLY

A. Remove brake shoes from brake spider.

B. Remove adjusting pawl assembly (hollow capscrew, gasket, spring and adjusting pawl) from plunger housing. It may be necessary to use a magnet to remove the adjusting pawl.



C. Using a suitable screwdriver, pry the plunger seal loose from the plunger housing. Then, remove the adjusting plunger (with adjusting sleeve, adjusting bolt, and plunger seal) from the plunger housing.

D. Remove the adjusting bolt, with sleeve (actuator) and plunger seal from adjusting plunger.

E. Thread adjusting sleeve all the way onto the adjusting bolt until it bottoms against plunger seal. Then, use a suitable pair of snap ring pliers and remove snap ring from end of adjusting bolt.

F. Unthread adjusting sleeve from adjusting bolt.

G. Remove plunger seal from adjusting bolt by gradually working the bolt through the seal hole.

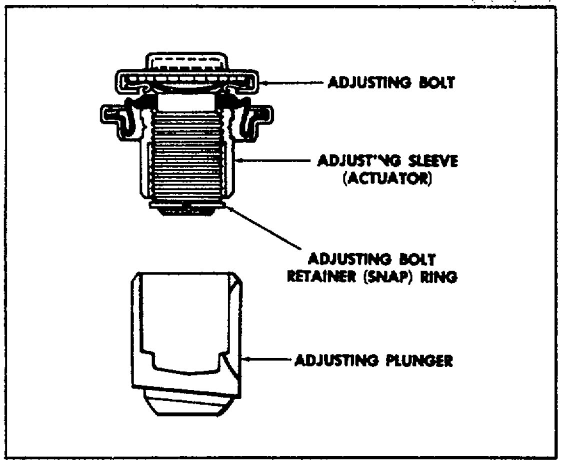
PREPARE FOR REASSEMBLY

A. Thoroughly clean and inspect all parts, including the housing plunger, seal bores, and shoe rest pads. Wire brush plunger parts and adjusting bolt threads to remove caked-on dirt and corrosion.

IMPORTANT: DO NOT use solvent to clean any rubber parts (plunger seals or gaskets).

B. Carefully inspect plunger seals and gaskets for tears, cuts or deterioration and replace if necessary. Also, check the angled plunger roller faces for pits, grooves or nicks. Replace if necessary.

REASSEMBLE ADJUSTING ASSEMBLY



A. Grease coat the adjusting bolt threads with recommended grease.

B. Install plunger seal onto the adjusting bolt by working the bolt through the seal hole. Be careful not to damage the seal lip on the bolt threads. Also, make certain the seal lip is seated against the smooth machined surface beneath the head of the bolt.

C. Grease coat the inside and outside surfaces of both the adjusting plunger and the adjusting sleeve.

D. Thread the adjusting sleeve all the way onto the adjusting bolt until it bottoms against the plunger seal.

E. Use a suitable pair of snap ring pliers and install snap ring in place on end of adjusting bolt.

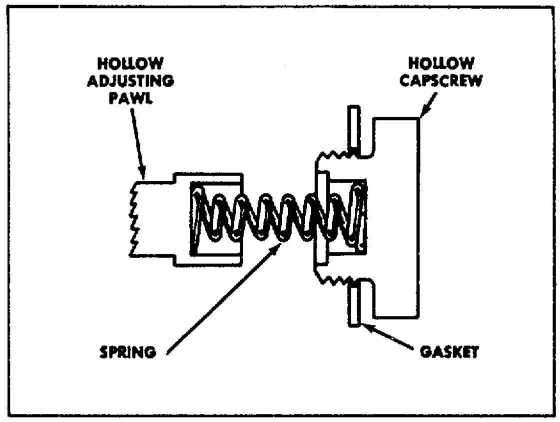
F. Install the adjusting plunger into the plunger housing, aligning plunger key-way slot with capscrew hole of housing.

G. Insert adjusting bolt (with adjusting sleeve and plunger seal) into the adjusting plunger. Make certain adjusting sleeve bottoms against inside shoulder of plunger.

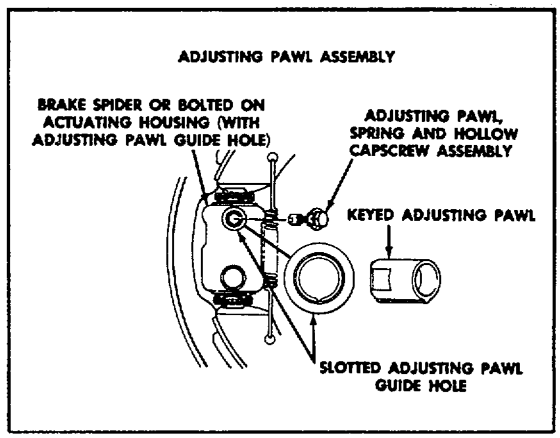
H. Use an appropriate seal driver and seat plunger seal retainer into plunger housing.

NOTE Make certain seal driver is centered over seal retainer to prevent damage to seal assembly.

J. Grease coat the teeth of the hollow adjusting pawl with recommended grease. Then assemble adjusting pawl spring and pawl by forcing one end of spring into the hollow end of pawl.



K. Install hollow capscrew gasket over capscrew. Then, assemble open end of adjusting pawl Spring into hollow end of capscrew.



L. Align the key of the adjusting pawl with the corresponding guide hole seat of the plunger housing. Then, assemble the complete adjusting pawl assembly (pawl, spring, gasket, hollow capscrew) into the plunger housing. Tighten the hollow capscrew finger tight.

M Proper meshing of the pawl and sleeve teeth can be checked at this point. Turn the adjusting bolt out about three turns. If there is clicking sound or ratcheting feel, the teeth are meshing properly. If teeth are not meshing properly, continue to turn the bolt in and out until proper meshing is achieved.

N. Tighten hollow capscrew 15-20 lbs. ft. torque, and reassemble brake shoe assembly in reverse of disassembly.

ROCKWELL-STANDARD

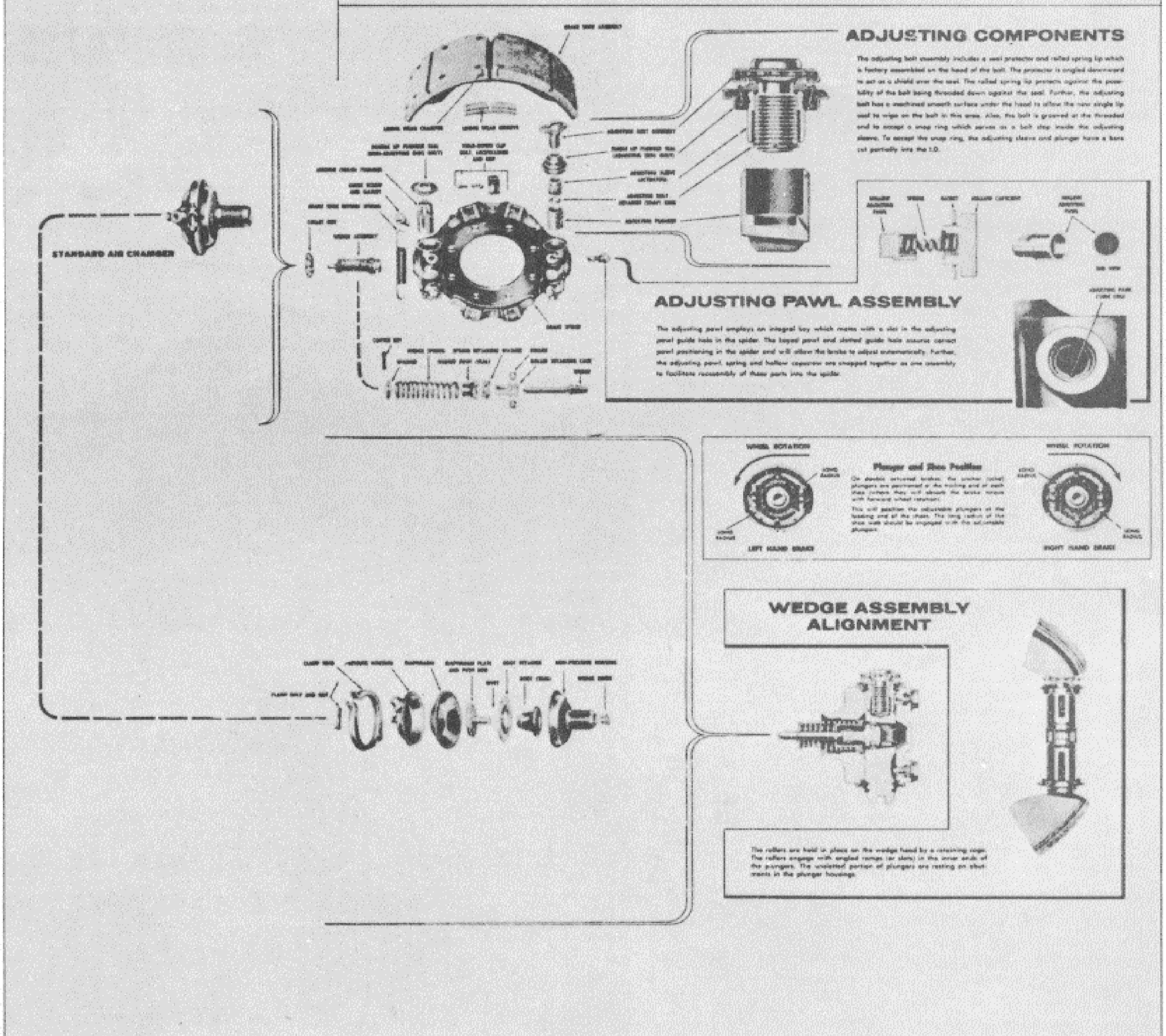
STOPMASTER II BRAKES

MAINTENANCE GUIDE

DESCRIPTION – This wall chart is a quick reference for lubrication, adjustment, parts alignment and parts identification for the (4) basic on-highway Stopmaster II Wedge Brakes. Most of the information on this chart is common to all Stopmaster models.

Shown to the right are the four basic types of Stopmaster II wedge brakes used on either front, rear or trailer axles. The 15" diameter bolted on spider brake is most commonly employed on rear axles with ratings of 18,000 lbs. or more. It is also used on front axles with ratings of 12,000 lbs. or more. Front axles with ratings less than 12,000 lbs. usually employ backing plate mounted brakes of the type shown. The two welded on spider mounted brakes (15" diameter and 12¼" diameter) are employed on trailer axles.

Recommended Lubricant: A high temperature water resistant grease in a No. 2 NLGI grade is recommended for normal parking and storage temperatures. If this type of lubricant is not available a suitable grease can be obtained from Rockwell-Standard (use IH 251 HE.P. Grease).



PARKING BRAKES

SPRING ACTUATED-TANDEM TYPE

30 INCH CHAMBERS

INDEX

DESCRIPTION

The spring actuated tandem-type parking brake consists of a tandem-type cylinder connected through the air brake slack adjuster and brake camshaft to the wheel brake shoes, Fig. 1.

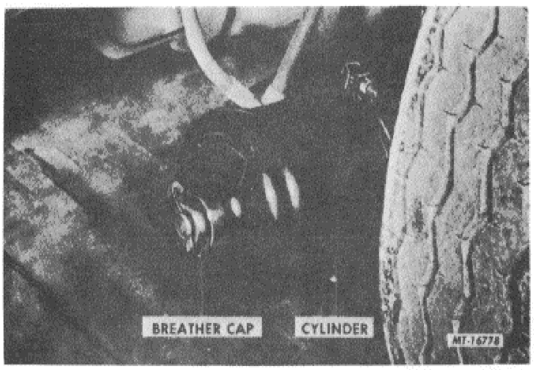


Fig. 1 Typical Installation of Spring Actuated Parking Brake.

The cylinder assembly is divided into two sections. One section is a conventional air brake chamber. The second section is the spring brake section. This section contains a powerful spring which is compressed by air pressure, Figs. 2 and 3.

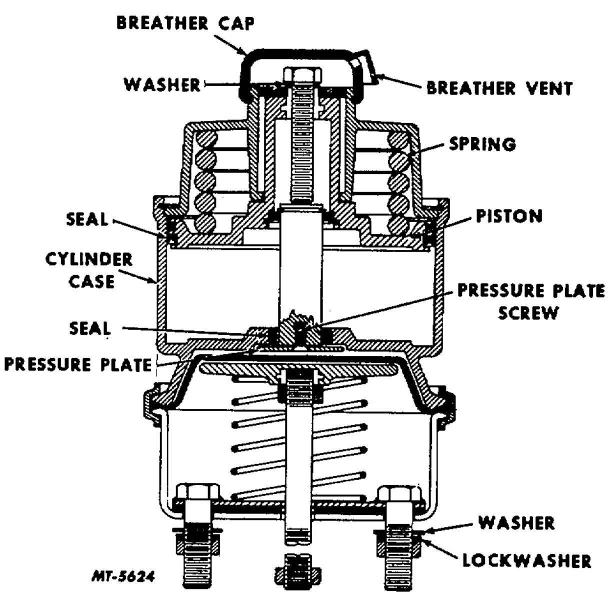


Fig. 2 Type 20 and 24 Chambers.

OPERATION

To apply the spring parking brake, the driver operates a control valve which exhausts the air pressure from the spring

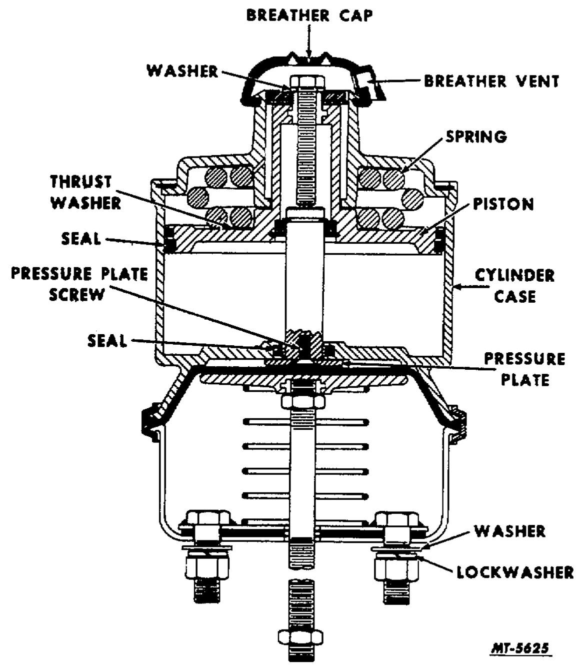


Fig. 3 Type 30 Chamber.

loaded cylinders. Upon reduction of air pressure in the cylinders, the springs apply the rear brakes through linkages connected to the rear slack adjusters.

To release the parking brake, the driver operates the control valve to apply air pressure to the parking brake spring loaded cylinders, thereby, compressing the springs and releasing the rear wheel brakes.

Upon loss of air pressure or reduction of air pressure in the vehicles air system, the parking brakes will automatically apply, thereby, providing an emergency brake.

In the event of a failure in the service brake system, the spring parking brakes can be applied.

The parking brake cylinders differ from the service brake cylinders in, that the parking brake cylinders apply the brakes by spring pressure and release them by air pressure. The service brake cylinders apply the brake with air pressure and release them by spring pressure.

The parking brake unit requires approximately 60 to 65 psi air pressure to be released. At approximately 70 to 80 psi, the springs are fully compressed.

To release the spring brakes (manual

release) in the event of air failure on the road, for towing, or relining brakes, the spring brake can be released by removing the breather cap and backing off (counterclockwise) the release bolt, approximately 13/4", until brake shoes are free from brake drum. NOTE

Before releasing spring brakes, be sure vehicle is properly blocked so it cannot move when the brakes are released. For towing, make sure vehicle is connected or secured to tow vehicle before releasing spring brakes.

The following four sectional views of the parking brake show the various stages of operation:

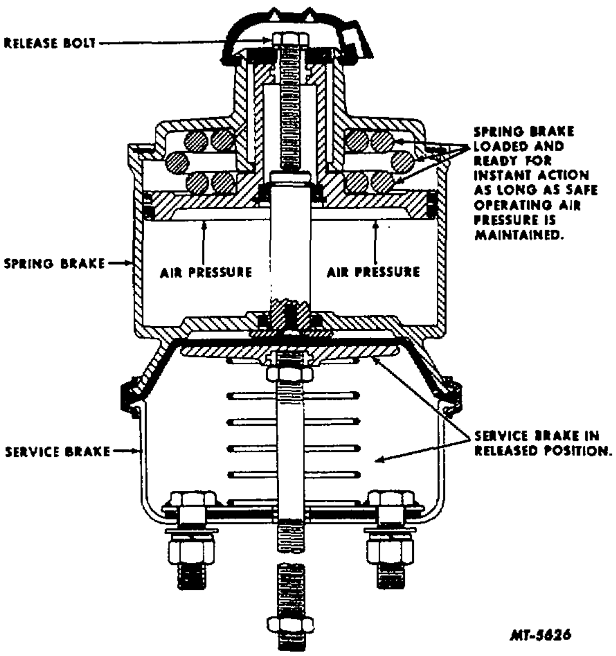


Fig. 4 Parking Brake and Service Brake in Released Position (Air Pressure Applied to Parking Brake Spring).

Fig. 4 illustrates the spring brake with the spring in a loaded position. The force of air pressure against the piston keeps the powerful spring compressed. Notice position of release bolt (in a down position). The service brake is shown in a released position.

CAUTION: DO NOT attempt to perform any disassembly whatsoever of the parking brake (either on the vehicle or with the brake assembly removed) with the air pressure applied as shown in Fig.4. The parking brake spring while in the compressed position, Fig. 4, is exerting a force against the head of the chamber of approximately 1800 lb. on a 20" or 24" chamber or 2300 lb. on a 30" chamber.

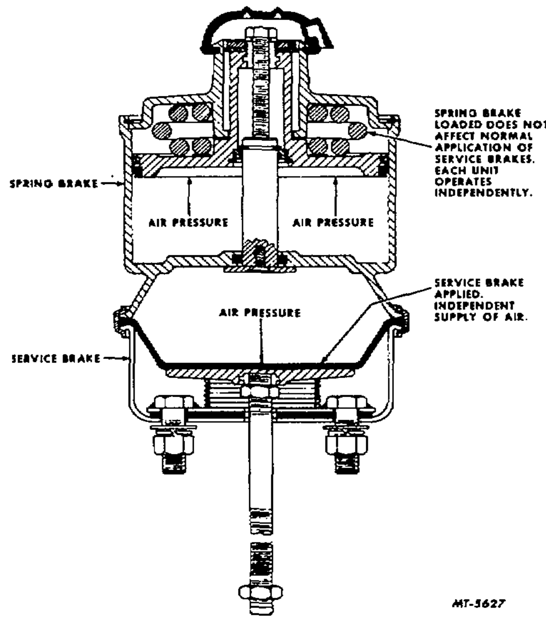


Fig. 5 Parking Brake in Released Position and Service Brake in Applied Position (Air Pressure Applied to Both).

Fig. 5 illustrates normal operation of both spring brake and service brake. The spring brake does not affect normal application of the service brakes; each unit operates independently.

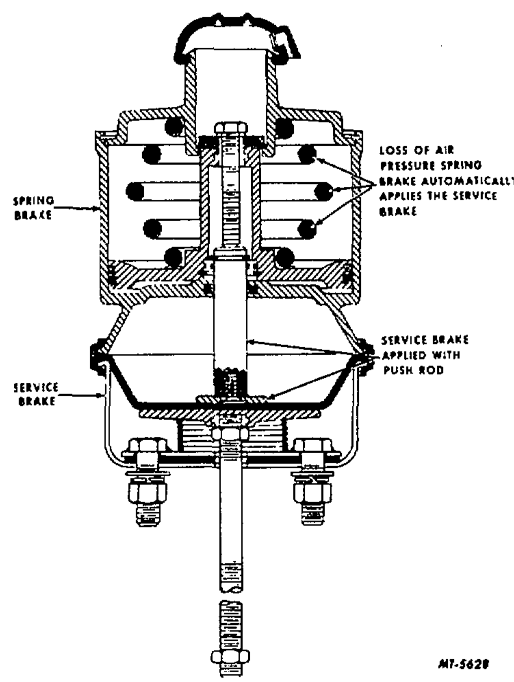


Fig. 6 Parking Brake in the Applied Position with Service Brake Applied through Parking Brake Push Rod (Loss of Air Pressure).

Fig. 6 illustrates the loss of air pressure. The loss of air pressure below safe operating pressure limits, will result in the spring brakes automatically applying the service brakes.

CAUTION: DO NOT attempt to perform any disassembly whatsoever of the parking brake with the unit on the vehicle, even though the air pressure is exhausted and the parking brake spring is some what decompressed as shown in Fig. 6. The parking brake spring is by no means completely decompressed. It is still exerting a force of approximately 1200 lb. against the head of the chamber.

Disassembly of the parking brake should be performed with the unit on an arbor press or hydraulic press where adequate safety measures can be taken (see "DISASSEMBLY").

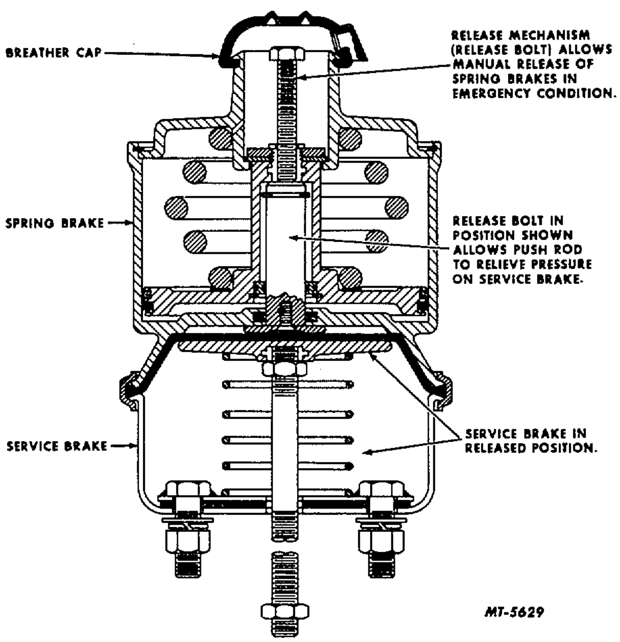


Fig. 7 Parking Brake Applied through Loss of Air Pressure and Service Brake Released with Release Bolt.

Fig. 7 illustrates release mechanism of the spring brake. Note position of release bolt and push rod.

REMOVAL From the information outlined under "OPERATION", it can be readily seen that to avoid possible serious bodily injury and damage to the brake assembly, no attempt should be made to disassemble the parking brake with unit installed on the vehicle. The parking brake should be removed from the vehicle as a complete assembly and moved to a suitable press where adequate safety measures can be taken during disassembly.

The following information will assist in the removal of the parking brake and service brake assembly:

1. Adequately block vehicle wheels to prevent vehicle from rolling.
2. Release air pressure to parking brake and service brake.
3. Remove air hoses from parking brake and service brake chambers. Tag hoses for proper reassembly.
4. Disconnect service brake piston rod from slack adjuster.
5. Remove parking and service brake assembly from mounting bracket.

DISASSEMBLY

The following disassembly procedure is based on the parking and service brake assembly being removed from the chassis:

1. Remove the breather cap from end of parking brake cylinder. This will expose the release bolt.

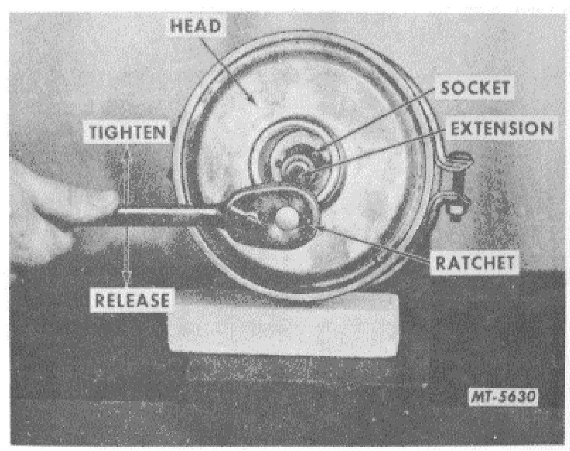


Fig. 8 Backing Off Release Bolt.

2. Back off parking brake release bolt located in end of parking brake chamber, Fig. 8. This action will compress the parking brake spring and at the same time allow the coil spring within the service brake to decompress to a brake released position.
3. Remove clamp ring securing parking brake chamber to service brake chamber, Fig. 9. Separate parking brake chamber from service brake chamber.
4. Reset or tighten release bolt. This should

extend the push rod.

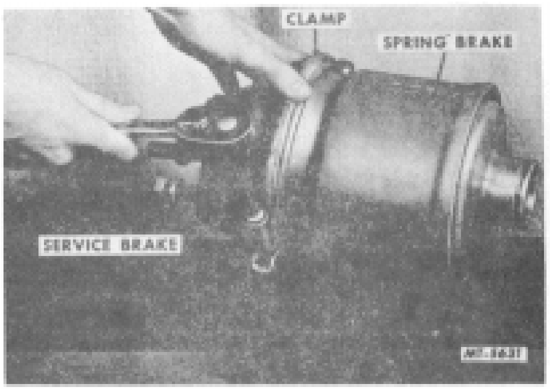


Fig. 9 Removing Clamp Ring.

5. Remove pressure plate from push rod, Fig. 10.

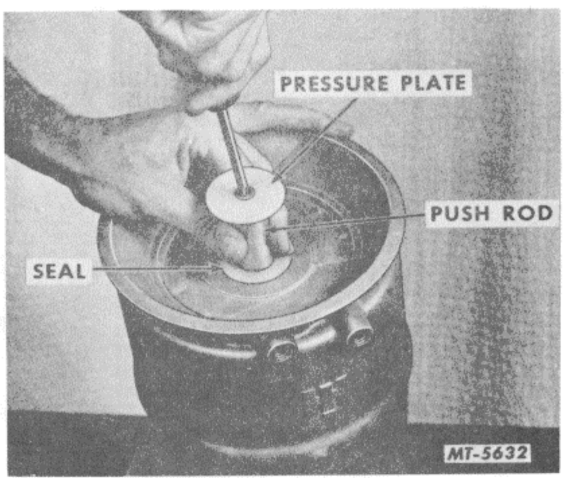


Fig. 10 Removing Pressure Plate.

6. At this point the spring brake section must be checked to determine the condition of the internal parts before continuing with disassembly. With parking brake unit on work bench, apply 60 psi of air to the spring brake chamber air inlet.

CAUTION : When applying air pressure to spring brake chamber, always keep brake chamber head (release bolt end) pointed away from you. Never point the head end towards you when charged with air pressure.

With the spring brake chamber charged, check and observe the following:

Push rod should travel into parking spring brake chamber. If push rod does not travel into chamber, this can indicate a damaged head, spring or piston. CAUTION: With a damaged piston, the heavy spring in the parking brake unit is no longer restricted and could be forcefully expelled when snap ring retaining head to cylinder case is removed. When the above condition exists or when in doubt as to the spring being restricted, use a tool similar to SE17151 (crankshaft gear puller) under press during disassembly of the cylinder, Fig. 11.

Release air pressure from parking spring brake chamber.

7. Prior to disassembly, back off and remove release bolt and special small air seal washer.

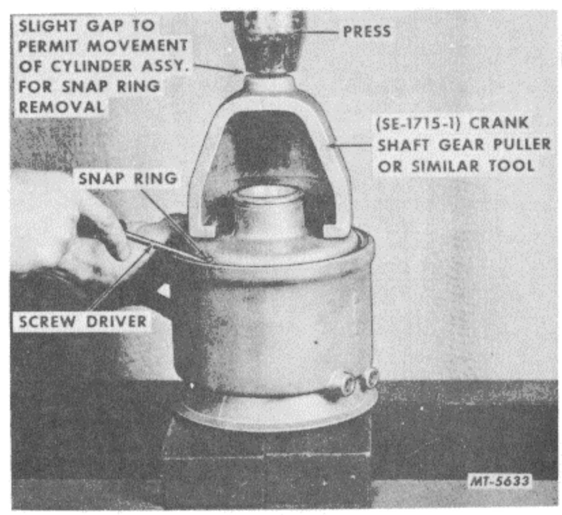


Fig. 11 Removing Snap Ring.

8. With assembly under tool (SE17151 or similar tool) and press, remove snap ring, Fig. 11. NOTE: Snap ring removal may be somewhat difficult due to a sealer applied over the snap ring and snap ring groove.
9. With snap ring removed, relieve press slowly. As the press is relieved and while the press will still act as a restric

tion, use a soft hammer to bump the head carefully to loosen since head may be stuck in place by foreign material, sealer, or corrosion. If difficulty in removing head is still experienced, use the three mill notches equispaced around the cylinder head for prying head from cylinder case (Fig. 12). Use a screwdriver or similar tool carefully at each notch in turn so that cylinder head does not become cocked.

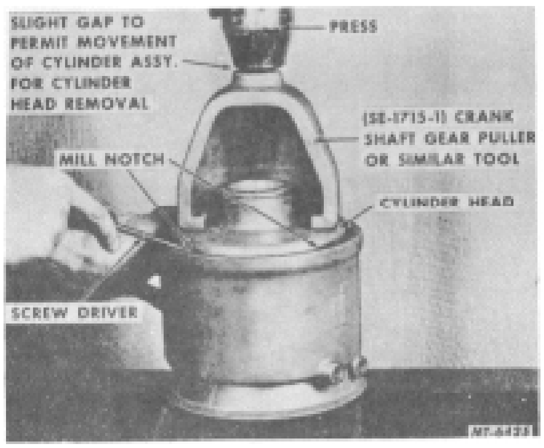


Fig. 12 Using Screwdriver to Loosen Cylinder Head

CAUTION: If spring brake unit has a damaged piston, the spring is no longer restricted when snap ring is removed. This could allow cylinder head to be forcefully expelled. When this condition exists or when there is doubt as to the spring being restricted, always use a tool similar to a crank shaft gear puller (SE17151).

On early production spring brake cylinder heads (where no notches were provided) the cylinder head can be reworked to include these notches. When making this modification, be careful to avoid cutting through the cylinder head wall. While there is no air pressure under the spring brake cylinder head, any notch inadvertently cut through the head would allow dirt or moisture to enter and cause damage to internal parts.

It should be further emphasized that the addition of notches to the cylinder head does not lessen the need for the safety precautions previously pointed out. Always mount spring brake assembly in press when disassembling.

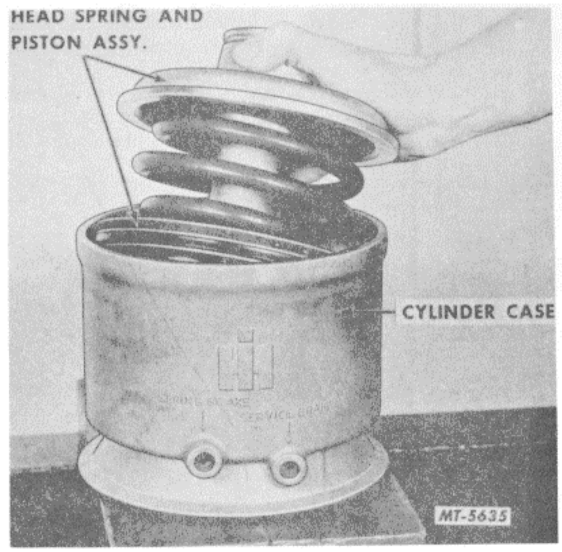


Fig. 13 Removing Head, Spring and Piston Assembly

When cylinder head is free, slowly release press gradually and remove cylinder head, spring and piston assembly from cylinder case (Fig. 13).

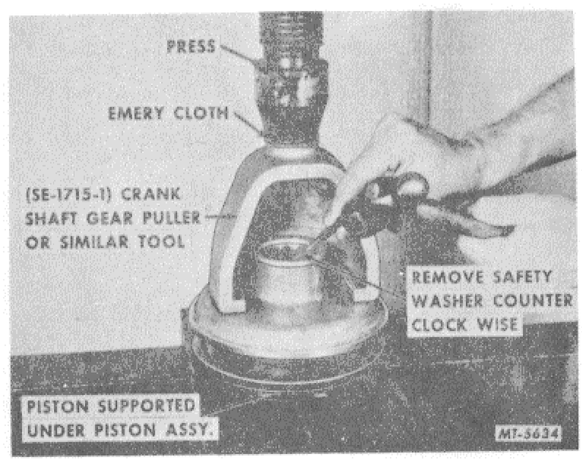


Fig. 14 Loosening Safety Washer.

10. In order to dissemble the head, spring and piston assembly, this unit must be set under a press. Use a tool similar to SE17151. Fold a small square of

emery cloth (abrasive side against press and tool) to serve as a nonslip pad between the press ram and tool, Fig. 14. Depress assembly as shown in Fig. 14.

Use punch, loosen safety washer (counterclockwise for removing). Remove safety washer and guide washer, Fig. 15. The safety washer retains the head, spring and piston assembly. Relax press gradually, Fig. 16. This is the correct way the head, spring or piston can be disassembled.

Fig. 15 Removing Safety Washer and Guide Washer.

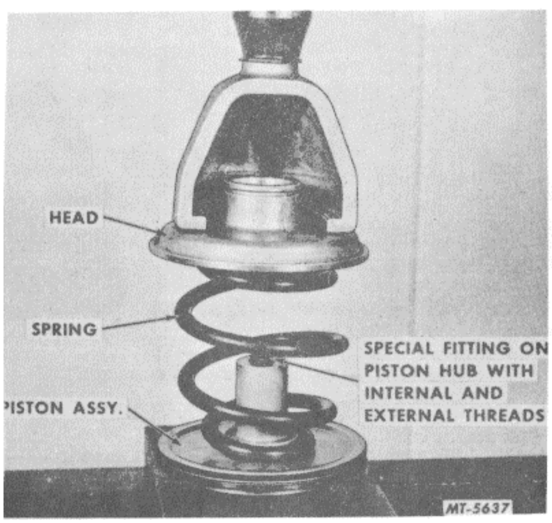


Fig. 16 Head, Spring and Piston Assembly with Press Relaxed.

CLEANING, INSPECTION AND REPAIR

Examine and clean piston felt wiper and seal. Replace either or both if damaged or worn, Fig. 17.

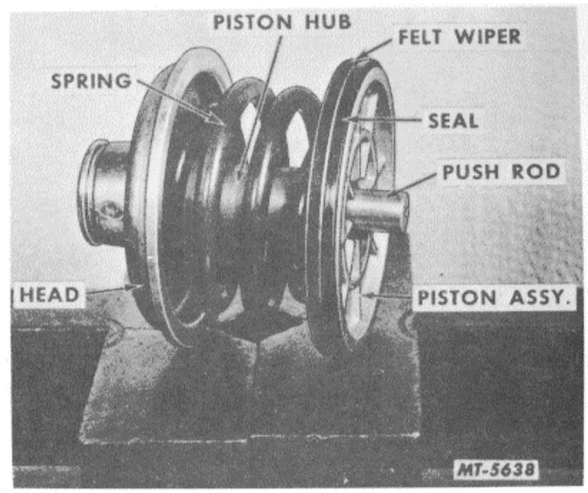


Fig. 17 Piston, Spring and Head Assembly.

Examine push rod for stratches and replace if damaged.

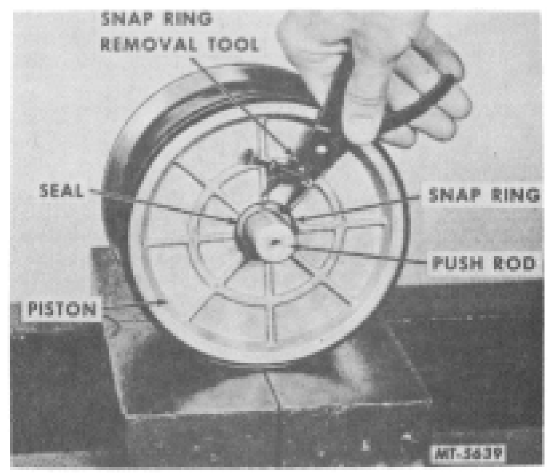


Fig. 18 Push Rod Seal Removal.

Remove snap ring from piston and replace push rod seal if damaged, Fig. 18. Reinstall snap ring, Inspect push rod seal in bottom of brake chamber housing. If damaged or worn, replace with new seal assembly. A groove is machined directly into the housing for retaining the seal.

Clean inside of chamber and all components with a clean solvent before reassembly.

Examine service brake diaphragm. Replace if worn, damaged or over one year old.

REASSEMBLY

1. Position piston assembly, spring and head in a press as shown in Fig. 16. Thread release bolt into piston so that bolt may be used to align piston with bore in head, Fig. 19. Fold a small square of emery cloth (abrasive side against press and tool) to serve as a nonslip pad between the press ram and tool, Fig. 14. CAUTION: Be certain that components are aligned with press ram so that when pressure is applied from press, spring does not "kickout". Slowly compress assembly. Remove release bolt after pistbn is aligned with bore in head.

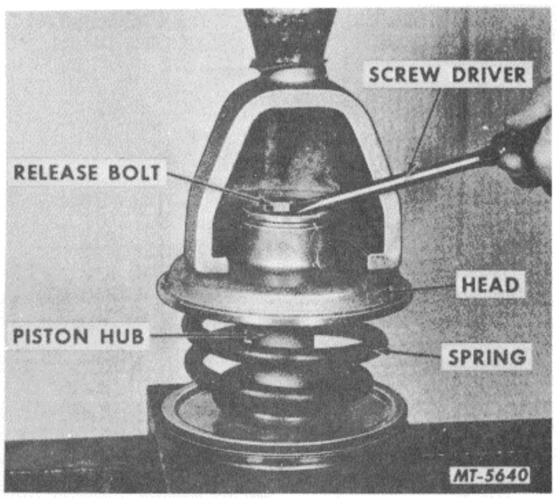


Fig. 19 Aligning Piston with Head Bore.

2. With assembly compressed, install guide washer and safety washer. Tighten safety washer (clockwise) and gradually relax press. CAUTION : Be certain safety washer is not cross threaded. Washer must be properly installed and securely tightened to retain the 1200 lbs. of spring pressure when press is relaxed.
3. Lubricate push rod seal grooves with light oil.
4. Saturate piston felt wiper with oil and replace into piston groove.
5. Push the push rod back into the piston.
6. With cylinder on work bench, carefully replace head spring piston assembly into brake chamber. Start at a 40 degree angle and work into a vertical position as the piston and seal enter the chamber. NOTE: Do not use force, damage to the "feather edge" of the seal may result. If directions are followed, the assembly will return to the case easily. After piston is inserted, turn the complete assembly over and carefully guide the push rod through the push rod seal in the bottom of the chamber.
7. Replace snap ring holding parking brake together.
8. To insure against water entering the chamber, a waterproof sealant (3M clear cement or equivalent such as windshield sealer) should be applied over the snap ring and snap ring groove. This is only required after the chamber has been opened, because all new chambers are sealed. Clean oil from all surfaces before applying sealer.
9. Replace pressure plate on end of push rod, Fig. 10. It is recommended that after tightening the screw, a lead BB or a piece of nonacid lead solder be hammered into the screwdriver hole. This will forestall service brake diaphragm damage. Remove any slag so screw face is perfectly smooth.
10. Inspect small air seal washer under release bolt. If damaged, replace.
11. With washer on release bolt, screw release bolt into piston about 3/4".
12. With parking brake unit on work bench, apply approximately 60 psi of air to the spring brake air inlet. Check for air leakage around the push rod extending through the base. CAUTION: When applying air pressure to brake chamber, <u>always keep brake chamber head (release bolt end) pointed away from you. Never point the head end towards you when chamber is charged with air pressure.</u>
13. Release air pressure and pour approximately one ounce of light oil into opening in the end of the chamber. Allow oil to drain down into chamber.
14. Replace diaphragm and set parking brake assembly back on service brake chamber. Make sure the parking brake is not offcenter with the service brake chamber, then replace the clamp ring.

15. After tightening clamp ring bolts, tap the ring with a hammer to insure proper seating. Then recheck the nuts for tightness.
16. Replace air lines in their respective inlets.

Apply air pressure and check for air leaks around fittings.

17. To reactivate the parking brake, apply air pressure to the parking brake section and tighten release bolt to approximately 50 pounds torque, Fig. 8.
18. Replace breather cap. If breather cap is equipped with a screen the hole must face downward.
19. Adjust service brakes after resetting parking brakes.

INSTALLATION

1. Assemble parking and service brake assembly to vehicle mounting bracket.
2. Connect service brake piston rod to slack adjuster.
3. Connect air supply hoses to their respective inlets on parking brake and service brake chamber.

NOTE: Be certain to install correct hose in correct chamber inlet.

4. Apply air pressure to parking and service brake chamber.
5. Remove vehicle blocking.

SERVICE REPLACEMENT

Whenever a spring brake chamber replacement is made there are three important service precautions which should be observed:

1. Do not use parking spring brake chambers on chassis not already equipped with them unless the service brake chambers are also changed to the type having reinforcing plate inside the service brake chamber (Fig. 20). Standard air chambers do not provide sufficient strength in mounting stud area to withstand added weight and load imposed by the spring brake unit.
2. When replacing spring brake chamber assemblies on early parking spring brake assemblies, always remove service brake chamber from mounting bracket. Also, remove mounting plate and rubber insulator pad (Fig. 20) from bottom exterior of service brake chamber. This will enable you to check service brake chambers for damage or cracks-particularly in mounting bolt areas. Replace with new reinforced brake chambers if damaged.
3. When reinstalling service brake chambers to mounting brackets, do not use rubber insulator pad and mounting plate between brake chamber and bracket. Proper mounting bolt nut torque cannot be maintained with exterior pad and mounting plate in this location. Tighten service brake mounting bolt nuts to 150 ft. lbs. torque.

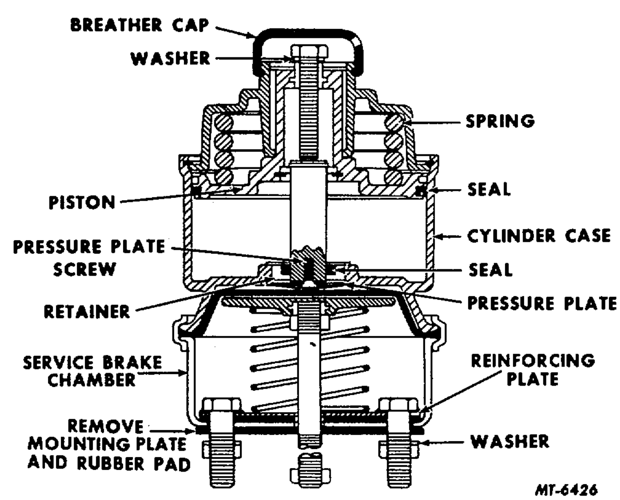


Fig. 20 Early Model Parking Spring Brake Unit Having Mounting Plate and Rubber Pad

LUBRICATION

Every three months or 20, 000 miles add two ounces of light engine oil (SAE10) into spring brake air inlet port. Remove air inlet hose at spring brake chamber inlet port and add oil into port. It will gradually work its way into the cylinder and lubricate the seal. Under extremely cold weather conditions, it may be necessary to pour an ounce or two of antifreeze (Methanol) into the spring brake air inlet port.

ANTIFREEZE - PERMANENT TYPE

The permanent type automotive antifreeze commonly used today has been developed to a high point of reliability. This type antifreeze often referred to as "ethylene glycol base antifreeze, " is now used in practically all cooling systems and in most cases is recommended for year round service-especially since the widespread use of the pressurized cooling system as well as air conditioning equipment.

Ethylene glycol base antifreeze coolant is a product which contains a number of characteristics particularly suited to protect against freezing, at the same time, maintain compatibility with various kinds of metals as well as nonmetals such as gaskets, seals and other nonmetallic materials. Other features include a high boiling point, corrosion resistance, foam resistant, non-harmful to paint finishes and storage stability. These antifreezes are usually colored with a dye for identification purposes, which in no way adversely affects their use.

Maintenance

For best results, maintain at least a 33% (by volume) standard strength ethylene glycol antifreeze in the cooling system at all times.

The 33% mixture, with clean water, would be sufficient to protect the system down to 0* F.

It is generally agreed that this is the minimum required to protect an engine (year around) against corrosion. The maintenance of a 33% solution also aids in the efficient operation of the pressure type cooling system due to the higher boiling point of the antifreeze.

Avoid an over-concentration of ethylene glycol permanent antifreeze mixture. A mixture of over 60% (by volume) adversely affects freeze protection and heat transfer rates. In general, a 60% mixture will protect to temperatures as low as 60 F. Good practice would be to follow the instructions printed on containers, since the various products may vary somewhat in this respect.

Where considerable cooling system service is performed, good procedure would be to keep a supply of premixed antifreeze on hand for makeup purposes. In systems using permanent antifreeze, most coolant loss is due to over-flow-not boil away; therefore, antifreeze and water are lost in the same proportions as originally installed.

In checking the protective strength of permanent antifreeze, the refractometer type tester is recommended in preference over the hydrometer. Refractometer testers are usually accurate within about 1 F. Hydrometers are known to have a wide variation even when new and sometimes become inaccurate in the course of time. In any event, use a tester known to be reasonably accurate.

Do not add rust inhibitors to permanent type anitfreeze, since the antifreeze already contains specific material for this purpose.

The addition of such additives may react undesirably with additives already in the antifreeze. Never use additives containing soluble / oil with ethylene glycol antifreeze. Should conditions develop which would tend to cause foaming, the presence of soluble oil would aggravate the foaming.

The use of additives that are intended to improve heat transfer for the purpose of preventing engine overheating is not recommended. Tests have indicated that there is as yet no additive that will increase heat transfer. Furthermore, there is the possibility that the addition of such material might generate cooling system problems because of incompatibility with the carefully formulated permanent antifreeze. Regular periodic cooling system maintenance has proven to be the best way to insure efficient cooling.

To assure continued corrosion protection as well as efficient general cooling system efficiency, the permanent type antifreeze should be renewed (drain and refill) once each year. This service should be performed before cold weather. In any event, check the antifreeze protection level before cold weather to safeguard against freeze damage.

COOLING SYSTEM

PREFACE

Because the effects or damage that result from an improperly maintained cooling system usually occur gradually, this system is often times neglected. However, the cooling system must be treated with the same attention to maintenance as is given such other systems as fuel, ignition and lubrication. A review of the cooling system's function will show this more clearly.

In general the circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and force s it through the water jackets and cylinder head. There it accumulates heat. Then the water flows to the upper radiator tank and down through the radiator core, being cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its most efficient operating temperature.

The following paragraphs point out several facts about cooling system components, The affects of cooling system neglects and procedures to be followed for cooling system maintenance. Trouble Shooting helps have also been prepared.

COOLING SYSTEM COMPONENTS

Radiator

This component which is one of the most important in the cooling system is made up of the following parts:

1. Top and bottom tank look for leaks, particularly where tank is soldered to core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler neck the sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow loose fitting cap. Make sure overflow tube is not plugged.
3. Radiator cap is the pressure sealing type. Its purpose is to hold the cooling system under a slight pre s sure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap (Fig. 1) has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure drops below the predetermined point.

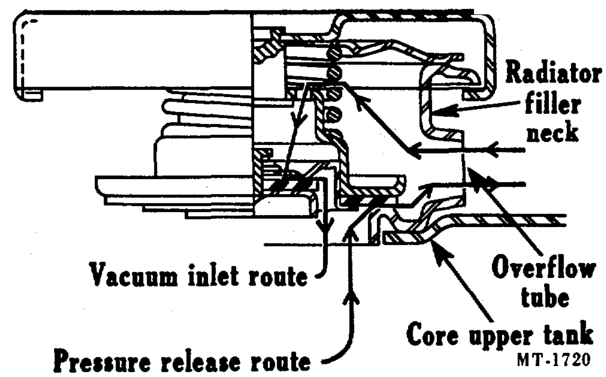


Fig. 1 Radiator Cap (Pressure Type)

When removing the pressure type cap from the radiator, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap it should be possible to depress the cap approximately 1/8". The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

CAUTION: When removing the cap, loosen it slowly and then pause a moment. This will avoid possible burning by hot water or steam. Continue to turn the cap to the left until you can remove it.

4. Tubes because the se are very small they can become easily clogged, or partially so, by rust and scale. The general condition of cooling system and operating temperature are indications as to whether or not tube s are clean. Another good test is to feel core for cold spots.
5. Fins these thin metal sheets radiate or pass off heat picked up by tubes. They should be kept free of bugs, leaves, straw, etcetera so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged if cooling system does not receive the proper maintenance. Figure 2 illustrates how rust and scale deposits will accumulate inside the water jacket on an engine that has been neglected.

Fig. 2 Cross Section of Engine Shoving Cooling System Neglect.

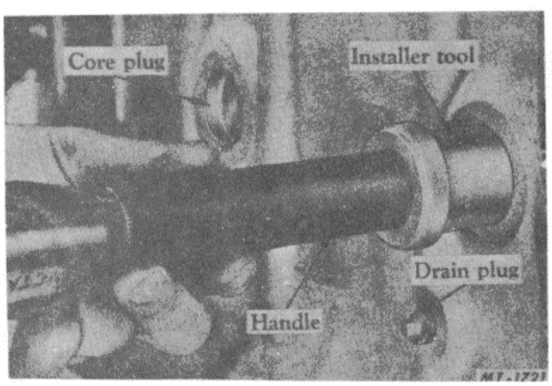


Fig. 3 Installing Core Plug Using SE1725 Installer Tool with SE1581B Handle.

1. Core plugs these are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion but are only pre sent because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through Use installing tool for core plug replacement (Fig. 3).
2. Drain plugs the water jacket of each engine has one or more drain plugs. These should receive seasonal care and kept free of rust and scale.
3. Gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around head gasket.

Water Pump

The water pump which circulates coolant through the cooling system is likewise a most essential part. The pump should be checked carefully for leaks and proper lubrication, and if leaking, cracked or in bad condition, it should be rebuilt or replaced promptly. For rebuild of water pump, see Engine Section.

Fan and Belts

The fan should be checked for loose or bent blades. A loose blade might work free during operation and cause damage. A bent blade will reduce the fan's efficiency.

Fan belts must be adjusted for proper tension. A belt adjustment that is just tight enough to prevent slipping on pulleys maybe considered a proper adjustment. A tight belt adjustment is to be avoided since this will damage generator bearings.

Thermostat

Thermostats used in H trucks are of the non-adjustable-type and are incorporated in the cooling system for the purpose of retarding or restricting the circulation of coolant during engine warm-up.

Engine overheating and loss of coolant is some times due to an inoperative thermostat. To check for this condition, remove thermostat and test by submerging in hot water and noting temperature at which thermostat opens or closes. Use an accurate high temperature thermometer for making this test.

Hose and Clamps

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hose can oftentimes appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

Transmission Oil Cooler or Heat Exchanger

On some trucks equipped with automatic or semiautomatic transmissions, the transmission oil is circulated through an oil cooler or heat exchanger . The function of this unit is to control transmission temperature and thereby keep oil in the proper temperature range for its most efficient lubrication. This is done either by using engine heat to bring transmission temperature up, or by using the cooling system to dissipate any excessive heat generated within the transmission.

Leakage due to corrosion or an improper seal will cause contamination between cooling system and transmission. The effects of this condition are obvious.

EFFECTS OF COOLING SYSTEM NEGLECT

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the engine part directly responsible is not even a part of the cooling system. Most of these ills will be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Vapor lock.
4. Poor lubrication increased engine wear.
5. Sticking valve and valve lifters.
6. Short spark plug life.
7. Engine hot spots.
8. Need for higher octane fuel.

Overcooling

The following engine troubles result when an engine is overcooled.

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids formed in crankcase.

COOLING SYSTEM MAINTENANCE

Rust Prevention

To keep engines operating to new truck efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of water, iron, and oxygen and can only be prevented by maintaining full strength corrosion protection at all times. For rust protection during the winter months, an antifreeze having a corrosion preventive should be installed in the fall. When spring arrives, drain the old antifreeze solution from the cooling system as all corrosion inhibitors are weakened and may be entirely exhausted, depending on how the truck has be en taken care of and how far and fast it has been driven. To rust proof the cooling system for summer driving,add a good rust inhibitor with the first fill of clean water in the spring. This solution should then be drained in the fall and a fresh filling of chemically treated antifreeze installed. A good quick test to determine if cooling system needs cleaning or flushing due to rust, scale or grease is shown in Fig. 5.

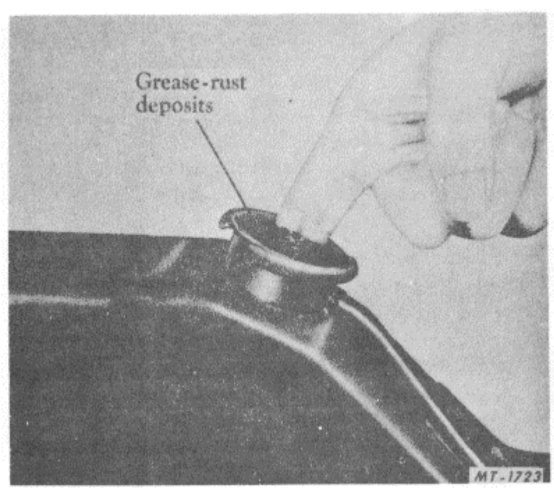


Fig. 5 Quick Visual Check of Cooling System

Seasonal Care

The cooling system of any truck should be drained and flushed out at least twice a year. Unless the cooling water or antifreeze has a corrosion preventive, rust and scale will eventually clog up the cooling system. If no recommended cleaning solution is available when cleaning the system, dissolve four pounds of washing soda in water and fill the complete cooling system. Leave the radiator cap off and run the engine until it is hot. Then disconnect the radiator outlet hose so all sediment will pass through the drain cock and flush thoroughly with clean water. NOTE : Remove radiator cap when draining system to as sure proper draining.

Cleaning

1. Coolant shutoff cocks to heaters and other accessories should be open to allow complete circulation during cleaning, flushing and draining. Run the engine with radiator covered if necessary until temperature is up to operating range (160°180°F). Stop engine, remove radiator cap and drain system by opening drain cocks on radiator and crankcase.
2. Allow engine to cool, close drain cocks and pour cleaning compound into radiator according to directions. Fill system with water.
3. Place a clean drain pan to catch overflow, and use to maintain level in radiator. Do not spill solution on vehicle paint.
4. Replace radiator cap and run engine at moderate speed, covering radiator if necessary, so that radiator core reaches a temperature of 180°F. or above, but does not reach the boiling point. Allow the engine to run at least two hours at 180°F. so that cleaning solution may take effect. Do not drive vehicle or allow liquid level in radiator to drop low enough to interfere with circulation.
5. Stop engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe temperature gauge reading. Where there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of core is relieved but not fully corrected, allow the engine to cool, pressure flush the system (See Pressure Flushing) and repeat cleaning operation.
8. If clogging of core, indicated by low temperature spots on core, is not relieved, radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of upper and lower tanks and rodding out the accumulated rust and scale from the water passage of the core.

Pressure Flushing

1. Disconnect the upper radiator hose which connects radiator core to engine water outlet and remove thermostat from engine water outlet.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. With radiator cap on tight, fill core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill engine block with water, partly covering water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. For badly clogged engine water jackets that do not respond to regular pressure flushing, remove engine cylinder head and core hole plugs and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through openings.

9. When the vehicle is equipped with a heater connected to the cooling system, flush the heater, following same procedure as for radiator core.
10. After completing the flushing operation, clean out radiator overflow pipe, inspect the water pump, clean the thermostat and the radiator cap control valves. Check thermostat for proper operation before installation. (See "Thermostat".)
11. Blow insects and dirt from radiator core air passages, using water, if necessary, to soften obstructions.

Test Equipment

To aid the service man in maintaining the cooling system at top efficiency, various items of test equipment are available. Among these are the Cooling System Pressure Tester and the Hydrometer.

1. Cooling System Pressure Tester (Fig. 6)- This equipment may be used in detecting the hard to find leaks in the cooling system. Any leak from cracked cylinder heads, warped cylinder heads or blown gaskets whether internal or external can be located easily and in a short time with the pressure tester. Adapters are available with the tester which permit the testing of radiators on trucks having the cab forward or cab over engine design (Fig. 6). Pressure caps can also be tested with the pressure tester.

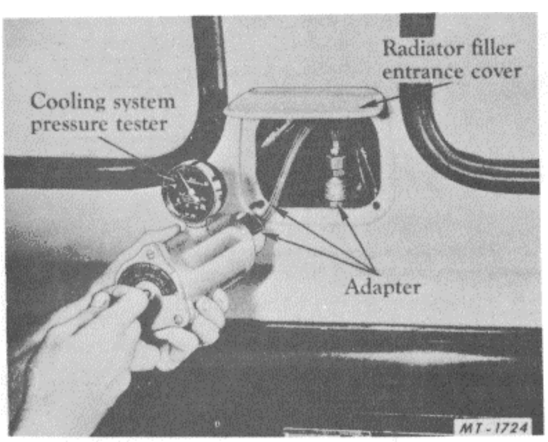


Fig. 6 Using Cooling System Pressure Tester (SE-1870 Adapter)

2. Hydrometers (Fig. 7) which are used to test the freezing protection of an antifreeze solution, work on the principle of specific gravity or weight of the antifreeze solution. They are simple to use provided they are used in the proper manner. When using the hydrometer, the solution must be warm (at least 110), the temperature and level must be noted correctly, and the float must be able to move freely. Read only the hydrometer scale corresponding to the type antifreeze solution in the radiator. Keep hydrometer clean inside and out and treat it with the same care as given any other precision instrument.

NOTE: Hydrometers do not correctly register the freezing protection of a mixture of methanol and glycol base antifreeze.

Therefore, always flush the cooling system with thermostat removed before adding antifreeze for the winter.

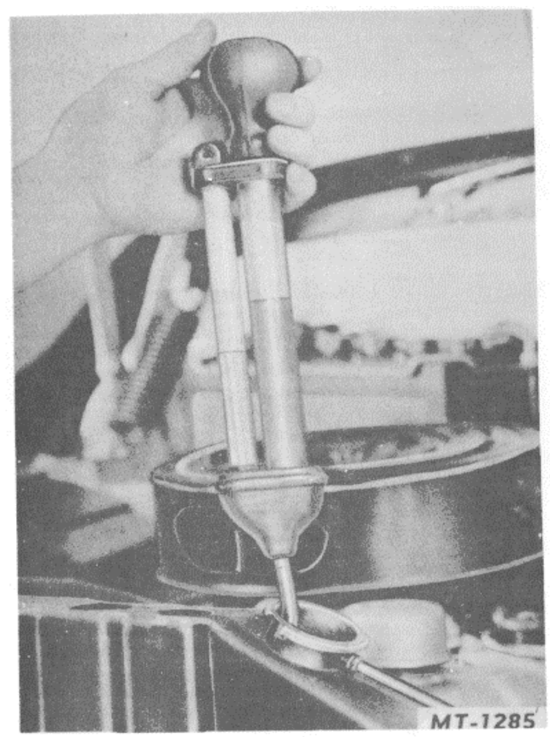


Fig. 7 Using Hydrometer to Test Antifreeze Solution.

TROUBLE SHOOTING

Causes of Coolant Loss:

1. Leaks and seepage - may be either external or internal.

External leaks easy to locate, may occur at radiator, heater, water pump, core plug hole, hose connections, radiator cap, drain cocks, and gaskets.

Internal leaks are more difficult to locate since these leaks occur at cracks and faulty head gaskets.

Internal leaks are indicated by a decrease in coolant level and the presence of coolant in crankcase. Correct this condition immediately or serious damage to engine will result.

2. Boiling - may be caused by any of the following:
   a. Radiator or other parts of cooling system clogged with rust or scale.
   b. Grille or bug screen clogged.
   c. Radiator core fins damaged.
   d. Thermostat defective stuck closed.
   e. Water pump leaking air into system.
   f. Radiator hose collapsed or rotting inwar dly.
   g. Radiator pressure cap defective.
   h. Cylinder head loose causing exhaust gas leakage into cooling system.
   i. Water pump impeller corroded or loose on shaft.
   j. Antifreeze protection inadequate causing partial freeze-up.
3. After-Boil - Boiling which may occur in a cooling system after the engine is shut off even though it did not occur during operation is known as afterboil. This condition which usually happens to cooling systems that need attention, occurs because the coolant is still picking up heat from the engine and the heat is not being dispersed by circulation through the radiator. Other causes of afterboil are overprotection or use of high temperature thermostat with alcohol type antifreeze, improper installation of the thermostat, or a thermostat that is operating improperly.
4. Foaming - Foaming of coolant may also cause coolant loss. This occurs only with a very dirty cooling system and under severe operating conditions. Usually an air or exhaust leak in the system contributes to foaming and this is caused by a faulty gasket, leaky radiator hose or water pump seal. Foam is an excellent insulator and can seriously interfere with proper circulation.
5. Evaporation - Evaporation reduces the amount of coolant in the system. This is a common occurance where alcohol base types of antifreeze are used. A faulty pressure cap may also be the cause of evaporation.

Cause of Overheating:

1. Cooling System
   a. Low coolant supply
   b. Leaks at any of the following: gaskets, hose connections, water pump, radiator, heater, core plugs, drain cock or plugs, cracked head or block.
   c. Broken or loose fan belt.
   d. Radiator clogged.
   e. Collapsed or clogged hose.
   f. Defective pressure cap.
   g. Worn or corroded impeller on water pump.
   h. Foaming.
   i. Radiator air flow obstructed.
   j. Bent fan blade.
   k. Improper or defective thermostat.
2. Ignition System
   a. Ignition timing late.
   b. Defective spark advance.
3. Fuel System
   a. Carburetor set too lean.
   b. Valves timed late or leaking.
   c. Intake manifold leaking.
   d. Leak in vacuum operated accessories.
4. Miscellaneous
   a. Clogged muffler or tail pipe.
   b. Stiff rebuilt engine.
   c. Dragging brakes.
   d. Low engine oil level.
   e. Engine overloaded.

Cause of Overcooling:

1. Missing thermostat.
2. Defective thermostat stuck open.
3. Short runs and intermittent driving.

COOLING SYSTEM

AUTOMATIC RADIATOR SHUTTER
(With Modulated Control)

INDEX

DESCRIPTION

An internal combustion engine operated at a constant predetermined temperature has less wear and greater efficiency. To provide this constant temperature, shutters are mounted in front of the radiator. The shutter blades are opened and closed automatically by a thermostatic modulated control, Fig. 1.

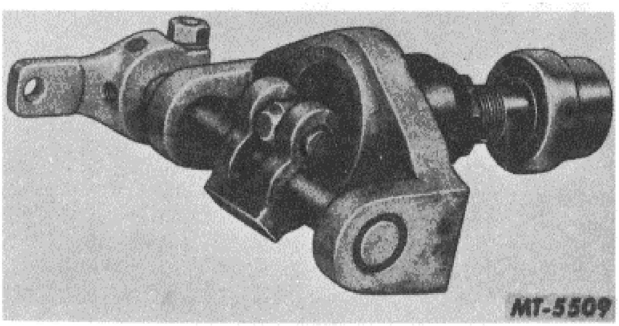


Fig. 1 Radiator Shutter Control.

The operating temperature of the engine is dependent upon the shutter control thermostat setting, therefore, it is important that a shutter control of the correct degree rating be installed (see "NOTE ", page 6).

OPERATION

The modulated shutter control is mounted in the radiator bottom tank with the thermostat unit extending into the coolant. When the engine is cold, the engine thermostat and radiator shutter blades are closed. The shutter blades are held closed by a spring in the shutter assembly. When the temperature of the coolant reaches the opening temperature of the engine thermostat, the thermostat opens allowing the coolant to circulate through the radiator. The shutter control thermostat element senses the increase in coolant temperature and expands, moving the control lever which is connected to the shutters by means of a rod. This action gradually opens the shutter blades until the coolant temperature rise is halted at the required setting.

If atmospheric temperatures should cause the coolant temperature to receed, the shutter control thermostat element contracts allowing the return spring on the shutter assembly to gradually close the shutter blades until the coolant is again raised to the required temperature.

Because of the modulated control, the shutter blades do not necessarily move from a fully closed to a fully open position or vise-versa. They open only that amount necessary to maintain a constant operating temperature. The slight temperature rise possible when an engine is shutdown will not affect the position of the shutter blades. The blades should be in the closed position when the engine temperature is cold.

Failure of the shutter control thermostat will not result in engine damage because the expansive properties of the thermostat element will always keep the blades in an open position.

NOTE: Do not discard thermostat because plunger is extended.

A small spring is provided to return piston of thermostat if shutter should be held open while engine cools. However, should piston be in extended position when cold, it is necessary that thermostat be heated to operating temperature before attempting to return. Cover radiator completely and bring temperature to normal, then apply spring tension and piston will return when engine cools. If thermostat is removed, heat in circulating water and apply spring tension until it cools. NEVER FORCE piston back when cold, as serious damage will result. Should the piston not return to proper height, the neoprene diaphragm may be ruptured and thermostat will have to be replaced.

REMOVAL

Shutter Control Assembly

To remove modulated shutter control, drain coolant from radiator. Disconnect control rod from control lever. Remove the two (2) bolts securing shutter control to bottom tank of radiator and take out control assembly.

Shutter Assembly

To remove shutter assembly, take out bolts securing frame assembly and lift out shutter assembly.

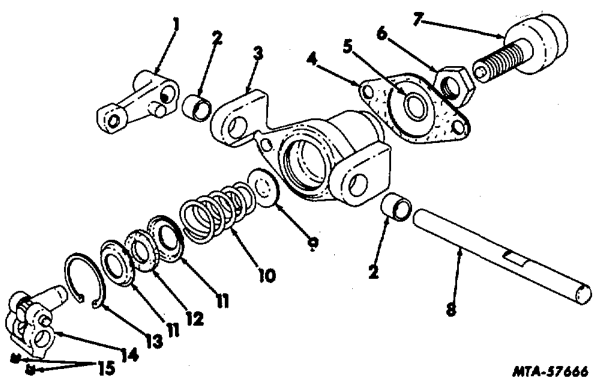


Fig. 2 Radiator Control Assembly (Exploded View).

Legend for Fig. 2

Key	Description
1.	LEVER, control
2.	BUSHING, shaft
3.	BODY
4.	GASKET, control mounting
5.	SEAL, "O" ring
6.	NUT, hex jam
7.	THERMOSTAT
8.	SHAFT, control
9.	SEAT *
10.	SPRING *
11.	SEAT *
12.	WASHER felt
13.	RING, snap
14.	PLUNGER, w/Yoke
15.	SCREW
*	Not Serviced Separately

DISASSEMBLY

Shutter Control

All key numbers refer to Fig. 2.

Loosen clamp bolt nut and sockethead setscrew in control lever (1) and remove lever. Loosen the two (2) sockethead setscrews (15) and pull control shaft (8) out of body (3); sliding plunger with yoke assembly (14) off of shaft as shaft is withdrawn.

Mount control body (3) in a vise (thermostat up) and loosen jam nut (6). Turn thermostat (7) out of body (3). Invert body in a vise and using suitable pliers remove snap ring (13). Remove body from vise and take out seat (11), felt washer (12), spring (10) and seat (9).

Adequately support control body (3) and using an adapter of correct diameter, drive bushing (2) out of body flange. An alternate method is the use of a cape chisel to collapse the bushing.

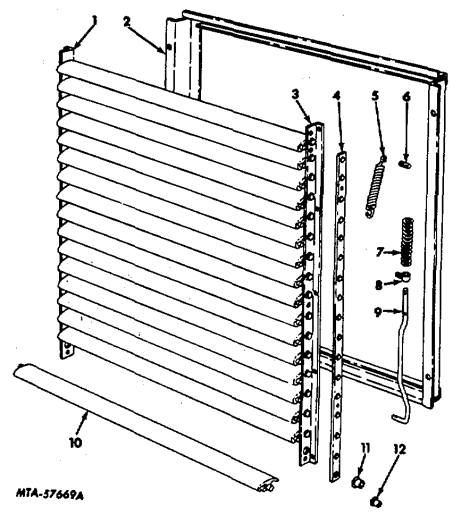


Fig. 3 Shutter Assembly (Exploded View).

Legend for Fig. 3

Key	Description
1.	ANGLE, left
2.	FRAME *
3.	ANGLE, right
4.	BAR, control
5.	SPRING, blade
6.	STUD, control bar
7.	SPRING, control rod
8.	BLOCK, control rod
9.	ROD, control
10.	BLADE, shutter
11.	BUSHING, blade pin
12.	BUSHING, blade crank
*	Not Serviced Separately

Shutter Assembly

All key numbers refer to Fig. 3.

Remove bolts attaching left angle (1) and right angle (3) to frame (2). Disconnect block (8) from control bar (4). Remove cotter pins and withdraw control rod (9) while removing block (8) and spring (7). Remove blade spring (5) and lift shutter blade assembly out of frame (2).

Pull control bar (4) off of blade crank pins.

Remove left angle (1) and right angle (3) from shutter blades (10).

CLEANING, INSPECTION AND REPAIR

Clean all parts thoroughly and examine for damage or wear. Be sure all old gasket material is removed from body. Check to see that small disc (antifriction washer), located in bore of thermostat unit, is not stuck to lower end of piston. If disc is stuck it is very important that it boe replaced. Be certain that piston is free of dirt or abrasive material. Also, see that piston is a free sliding fit in bore of thermostat unit.

Check linkage and shutter blade crank bushings for excessive wear. Replace parts where necessary.

REASSEMBLY

<u>Shutter Control</u>

All key numbers refer to Fig. 2.

Using proper adapter, drive or press new bushings in body flanges.

Install small disc (antirattle washer) into bore of thermostat unit. Lubricate piston with # 200 fluid or silicone grease and place piston into bore of thermostat unit (bulletnose end out). Assemble jam nut (6) followed by new "O" ring seal (5) on thermostat unit (7). Install thermostat into body (3). See "ADJUSTMENTS" for correct positioning of thermostat in body.

Position seat (9) in body (3), flanged side opposite thermostat side of body. Install spring (10), seat (11), felt washer (12) and secure in body (3) with snap ring (13).

Place plunger (14) into body. Slide control shaft (8) through one side of body flange.

Mount yoke with plunger assembly (14) on shaft. Push shaft through remaining flange.

Align plunger with opening in seats (11) and position yoke on shaft so that there is no interference when plunger moves in and out of body. Install and tighten socket head setscrews in yoke. Position control lever (1) on shaft with lever pointing in opposite direction from thermostat unit. Do not tighten clamp bolt or setscrews in lever at this time. See "ADJUSTMENTS" for final positioning of lever.

<u>Shutter Assembly</u>

All key numbers refer to Fig. 3.

Install bushings (11) on shutter blades (10). Assemble left angle (1) and right angle (3) on ends of blades (10). Place bushings (12) on blade crank pins and install control bar (4).

Place shutter blade assembly in frame (2). Connect blade spring (5) from control bar (4) to control bar stud (6).

Insert control rod (9) and install block (8) and spring (7) on rod. Install cotter pins in control rod. Connect block (8) to control bar (4). Install bolts securing right angle (3) and left angle (1) to frame (2).

INSTALLATION

<u>Shutter Assembly</u>

Position shutter assembly in vehicle and install retaining bolts.

<u>Shutter Control</u>

Adjust thermostat location in control body (see "ADJUSTMENTS"). Place new gasket on control body and assembly body to radiator, thermostat unit extending into bottom tank. Install the two (2) bolts securing shutter control to radiator tank.

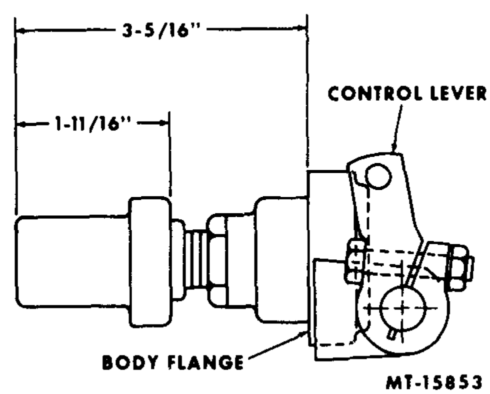


Fig. 4 Shutter Control Thermostat Unit Adjustment.

ADJUSTMENTS

Thermostats with different body lengths are being used, see Figures 4 and 5. Therefore, the dimensions between the face of the body flange and end of the thermostat unit will also be different as shown in the illustrations.

When installing shutter control, control lever must be correctly positioned on shaft to properly open and close shutter blades.

With engine cold (150° or below) and control rod disconnected at control lever, manually close shutter blades. This can be done by pushing back on each side at the bottom of the top blade. With the blades completely closed and shutter control plunger pushed in against piston, rotate control lever on shaft until control rod will index with hole in lever. Hold lever in this position and tighten sockethead setscrews and clamp bolt nut. Install cotter key in control rod.

Recheck linkage between shutter and control to see that all slack was removed.

Check to see that shutters close tightly by attempting to insert a calling card between the blades. If not closed tightly, repeat adjustment procedure previously outlined.

Be certain shutter blades have sufficient end clearance (not exceed 1/16"). End clearance can be adjusted by loosening bolts on side of frame that retain the bushing angles. Move angle to obtain adequate clear ance and while holding in this position tighten retaining bolts.

Full open position of shutter blades is at an angle of approximately 70° (not 90°).

Maximum air flow is attained when blades are open from 60° to 70° (angular degrees).

LUBRICATION

Periodic inspection is advisable at which time nylon blade bushings should be cleaned with light or penetrating oil and blown out with air pressure. DO NOT oil at frequent intervals, only after cleaning or reassembly, as normal lubricating oils tend to gather dirt and dust. Light oil on linkage periodically is desirable.

Periodically remove thermostat piston.

Clean piston thoroughly and lubricate with # 200 fluid or silicone grease.

TROUBLE SHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine Running Too Hot	1. Coolant Level Too Low.	1. Fill radiator and check for leaks.
	2. Faulty Temperature Gauge.	2. Replace gauge.
	3. Slack in Linkage.	3. Adjust linkage.
	4. Faulty Engine Thermostat.	4. Replace engine thermostat.
	5 Broken or Loose Fan Belt.	5 Replace or tighten fan belt.
	6 Faulty Water Pump.	6 Replace or repair water pump.
	7 Radiator Clogged.	7 Clean radiator.
	8 Thermostat Dimensional Setting Incorrect.	8 Remove shutter control and adjust.
	9 Incorrect Shutter Control Thermostat Temperature Range.	9 Install correct thermostat.
	10 Shutters or Linkage Binding.	10 Free shutters and linkage.
Engine Running Too Cold.	1 Faulty nperature Gauge	1 Replace gauge.

TROUBLE SHOOTING (Continued)

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine Running Too Cold (Continued)	2. Linkage Adjusted to Tight.	2. Adjust linkage.
	3. Thermostat Dimensional Setting Incorrect.	3. Remove shutter control and adjust.
	4. Incorrect Shutter Control Thermostat Temperature Range.	4. Install correct thermostat.
	5. Faulty Shutter Control Thermostat.	5. Replace thermostat.
	6. Shutter Linkage Binding.	6. Free linkage.

NOTE

The degree rating of the engine thermostat and shutter control thermostat should be identical.

For example, if a 180° engine thermostat is used, a 180° shutter control thermostat unit should also be used. The engine thermostat will open at approximately 180° and allow the coolant to flow to the radiator top tank. As the coolant flows down through the radiator core, a drop in coolant temperature of approximately 10° will take place. The shutter blades will remain closed until the coolant temperature in the bottom tank is raised to the arbitrary figure of 180°. This will cause the coolant temperature in the engine to actually be slightly above 180° which will keep the engine thermostat open, allowing the shutter control thermostat to control the operating temperature.

Shutter control thermostat units are available in temperature control ratings of 160°, 170°, 175° and 180°.

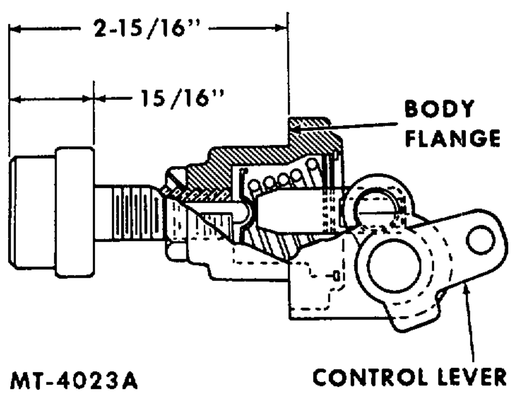


Fig. 5 Shutter Control Thermostat Unit Adjustment.

ELECTRICAL

ALTERNATOR MODEL 27SI TYPE 200

80 AMP

INDEX

DESCRIPTION

The alternator with integral charging system, illustrated in Fig. 1, features a solid state regulator that is mounted inside the slip ring end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the slip ring end frame. Only one wire is needed to connect the integral charging system to the energizer or battery along with an adequate ground return. An "R" terminal is provided to operate auxiliary equipment in some circuits.

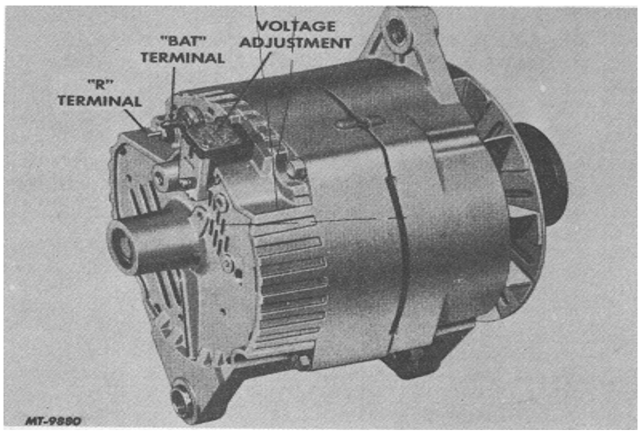


Fig. 1

The bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. Two brushes carry current through the two slip rings to the field coil mounted on the rotor and under normal conditions will provide long periods of attention free service.

The stator windings are assembled on the inside of a laminated core that forms part of the frame. A rectifier bridge connected to the stator windings contains six diodes and electrically changes the stator A. C. voltages to a D. C. voltage, which appears at the output terminal. Field current is supplied through a diode trio, which also is connected to the stator windings. A capacitor, or condenser, mounted in the end frame protects the rectifier bridge and diode trio from high voltages and suppresses radio noise.

OPERATION

A typical wiring diagram is illustrated in Fig. 2. With the integral charging system operating, A. C. voltages initially are generated in the stator windings by residual magnetism in the rotor. Current then flows through the diode trio, resistor R1 and resistor R4 to turn transistor TRI on. The stator then supplies D. C. field current through the diode trio, the field, TR1, and then through the grounded diodes in the rectifier bridges back to the stator. Also, the diodes in the rectifier bridges change the stator A. C. voltages to a D. C. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the energizer or battery and operating electrical accessories.

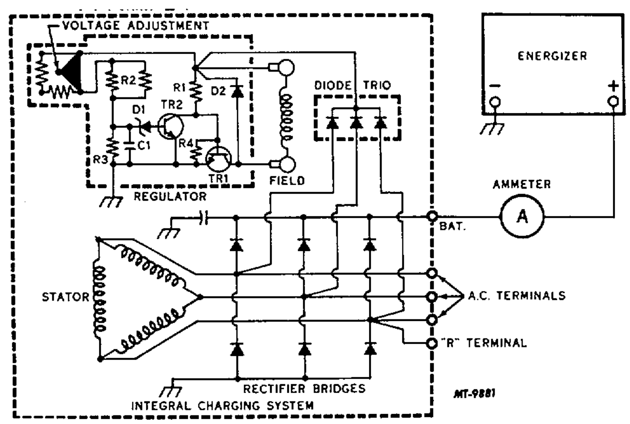


Fig. 2

As the speed and voltage increase, the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TRZ then turns on and TR1 turns off. With TR1 off the field current and system voltage decrease, and D1 then blocks current flow causing TR1 to turn back on. The field current and system voltage increase, and this cycle then repeats many times per second to limit the voltage to the adjusted value.

Capacitor C1 smooths out the voltage across R3; resistor R4 prevents excessive current through TR1 at high temperatures; and diode D2 prevents high induced voltages in the field windings when TR1 turns off.

TROUBLESHOOTING PROCEDURES

Close adherence to the following procedures in the order presented will lead to the location and correction of charging system defects in the shortest possible time. Only a portion of these procedures need be performed. It will never be necessary to perform all the procedures in order to locate the trouble.

A basic wiring diagram showing lead connections is shown in Fig. 3. To avoid damage to the electrical equipment, always observe the following precautions:

1. Do not polarize the integral charging system.

2. Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.

3. Make sure the integral charging system and battery have the same ground polarity.

4. When connecting a charger or a booster battery to the vehicle battery, connect negative

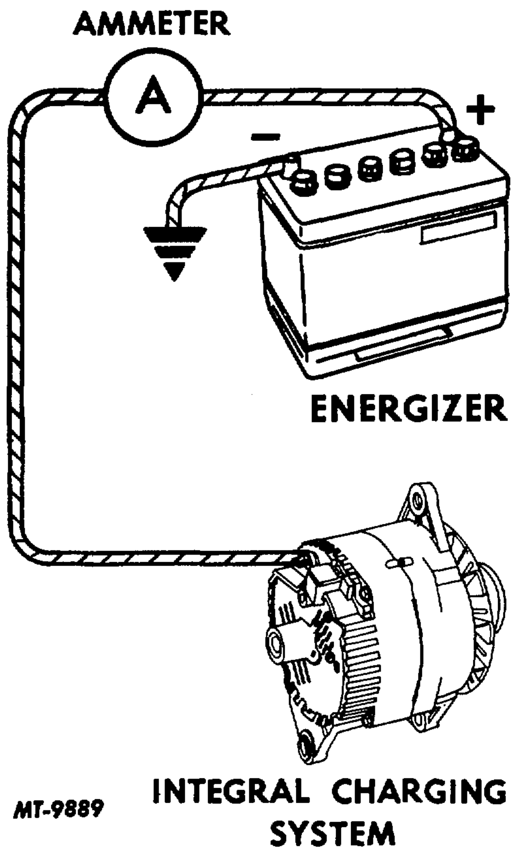


Fig. 3

Trouble in the charging system will show up as one or more of the following conditions:

A. An undercharged battery or energizer, as evidenced by slow cranking and low specific gravity readings.

B. An overcharged battery or energizer, as evidenced by excessive water usage.

A. Undercharged Battery

This condition, as evidenced by slow cranking and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.

2. Check the drive belt for proper tension.

3. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.

4. With ignition switch on and all wiring harness leads connected, connect a volt-meter from:
   a. generator "BAT" terminal to ground.
   b. generator No. 1 terminal to ground.
   c. generator No. 2 terminal to ground.

   A zero reading indicates an open between voltmeter connection and battery or energizer. NOTE :An open No. 2 lead circuit on early production generators caused uncontrolled voltage, battery overcharge and possible damage to battery and accessories. Generators supplied for later applications have a built-in feature which avoids overcharge and accessory damage by preventing the generator from turning on if there is an open in the wiring harness connected to the No. 2 generator terminal. Opens in the wiring harness connected between the No. 2 generator terminal and battery may be between the terminals, at the crimp between the harness wire and terminal, or in the wire.

5. If previous steps 1 through 4 check satisfactorily, check integral charging system as follows:

   a. Disconnect battery ground cable.

   b. Connect an ammeter in the circuit at the "BAT"' terminal of the alternator.

   c. Reconnect battery ground cable.

   d. Turn on accessories. Connect a carbon pile across the battery.

   e. Operate engine at moderate speed as required, usually 4000 generator RPM or more, and adjust carbon pile as required to obtain maximum current output.

f. If ampere output is within 10 percent of rated output as stamped on generator frame, integral charging system is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90° and then reinserting the cap in the connector body. As illustrated in Fig. 4, the cap is set for medium high voltage. With position 2 aligned with the arrow, the setting is medium low; position "LO" is low, and position "HI" is the highest regulator setting. After adjusting the setting, check for an improved energizer condition after a service period of reasonable length, such as one week.

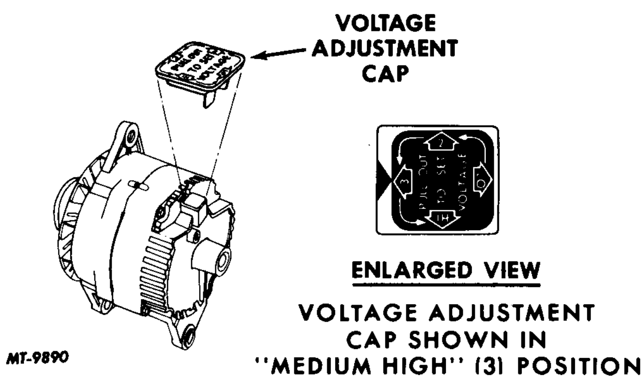


Fig. 4

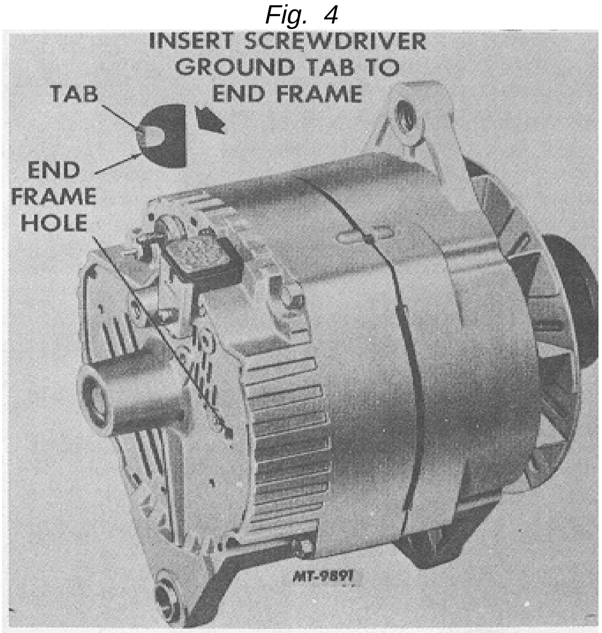


Fig. 5

IMPORTANT: The voltage adjustment in Fig. 4 is for purposes of illustration only. The actual adjustment as shipped from the factory may be in some other position depending on the application requirement.

g. If ampere output is not within 10 percent of rated output as stamped on integral charging system frame, ground the field winding by inserting a screwdriver into the test hole, Fig. 5. NOTE : Tab is within 3/4 inch of casting surface. Do not force screwdriver deeper than one inch into end frame.

h. Operate engine at moderate peed as required and adjust carbon pile as required to obtain maximum current output.

i. If output is within 10 percent of rated output, replace regulator and check field winding.

j. If output is not within 10 percent of rated output, check the field winding, diode trio, rectifier bridge and stator.

k. Remove ammeter from generator and turn accessories off.

B. <u>Overcharged Battery</u>

1. Check the battery.
2. If battery is not defective or overheated, connect a voltmeter between No. 2 terminal to ground. If reading is zero, No. 2 lead circuit is open.
3. If battery and No. 2 lead circuit check good, but an obvious overcharge condition exists as evidenced by excessive battery water usage, proceed as follows:
    a. Separate end frames as covered in "DISASSEMBLY." Check field winding for shorts. If shorted, replace rotor and regulator.
    b. Connect ohmmeter using lowest range scale from brush lead clip to end frame as shown in Step 1, Fig. 6; then reverse lead connections.
    c. If both readings are zero, either the brush lead clip is grounded or regulator is defective.

d. A grounded brush lead clip can result from omission of insulating washer, Fig. 6, omission of insulating sleeve over screw, or damaged insulating sleeve. Remove screw to inspect sleeve. If satisfactory, replace regulator as covered under "Brush Holder and Regulator Replacement. "

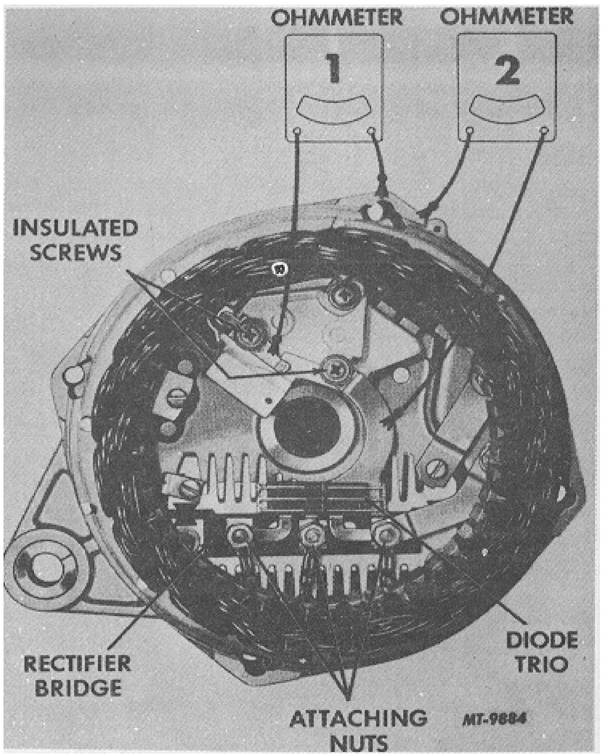


Fig. 6

DISASSEMBLY

1. Remove four thru-bolts from drive end frame.

2. Separate slip ring end frame and stator assembly from drive end frame and rotor assembly.

3. Separate stator from end frame by removing three stator lead attaching nuts.

4. Place tape over bearing and shaft to protect from dirt. Use pressure-sensitive tape and not friction tape, which would leave a gummy deposit.

5. Inspect all leads for burned connections or opens, and brushes for excessive wear. Inspect springs for distortion or discoloration. Replace as required. Clean brushes with a soft, dry cloth if they are to be reused. During servicing and reassembly hold brushes and springs in holder with a pin or toothpick inserted through end frame hole.

Rotor Field Winding Checks

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light or if the ohmmeter reading is high (infinite), the winding is open, Fig. 7.

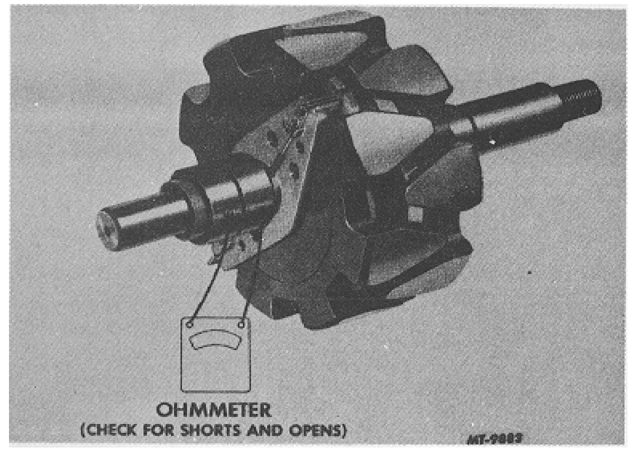


Fig. 7

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance. If the winding is shorted, replace the rotor and the regulator as covered in "Brush Holder and Regulator Replacement."

An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings, Fig. 7. If the resistance reading is below the specified value, the winding is shorted; if above the specified value, the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current. Remember that the winding resistance and ammeter reading will vary slightly with winding temperature changes.

<u>Diode Trio Check</u>

The diode trio is identified in Fig. 6. To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. Connect an ohmmeter having a 11/2 volt cell and using the lowest range scale to the single connector and to one of the three connectors, Fig. 8. Observe the reading. Then reverse the ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors. NOTE: Diode trios differing in appearance may be specified for use in the same integral charging system, and the two are completely interchangeable.

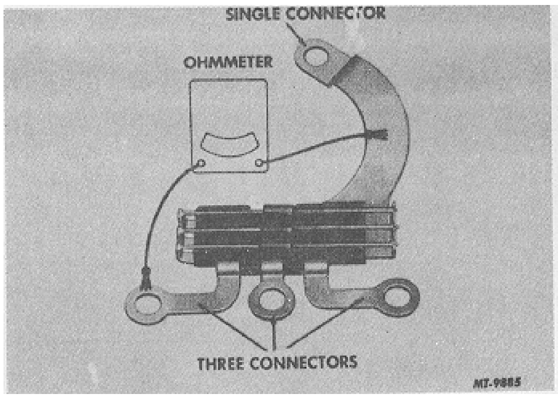


Fig. 8

Rectifier Bridge Check
(Omit for overcharged battery)

Note that the rectifier bridge has a grounded heat sink and an insulated heat sink, Fig. 9

To check the rectifier bridge, connect the ohmmeter to a heat sink and one of the flat metal clips and not to threaded stud. Press down firmly onto flat metal clip. Then reverse lead connections. If both readings are the same, replace the rectifier bridge.

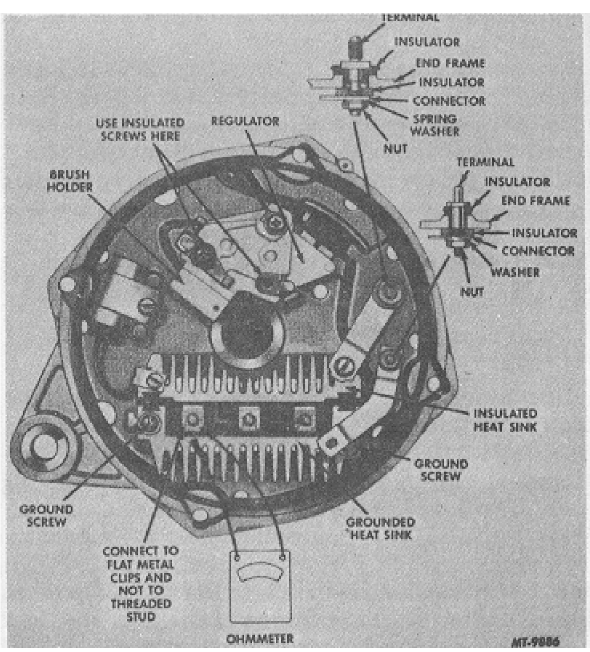


Fig. 9

Repeat this same test between the same heat sink and other two metal clips and between the other heat sink and the three metal clips.

CAUTION: Do not use high voltage, such as 110-volt test lamp, to check the rectifier bridge.

Stator Checks
(Omit for overcharged battery)

The stator windings may be checked for grounds with a 110volt test lamp or an ohmmeter. If the lamp lights or if the meter reading is low when connected from any stator lead to a clean metal part of the frame, the windings are grounded, Fig. 10. The delta windings cannot be checked for opens or for short circuits without laboratory test equipment. However, if all other electrical checks are normal and the generator fails to supply rated output but will supply at least 10 amperes output, shorted stator windings are indicated.

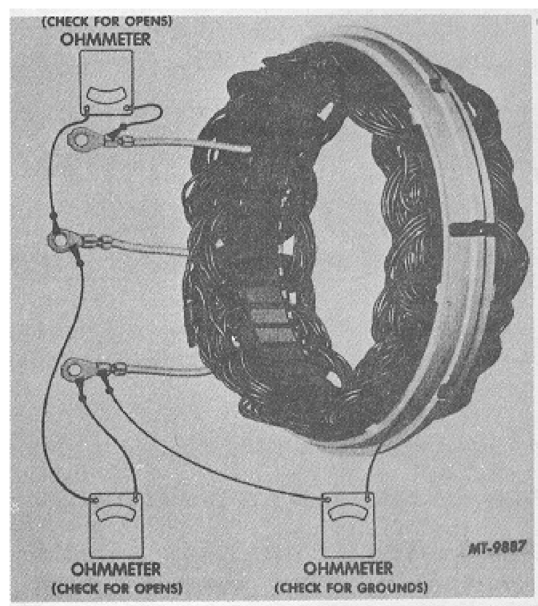


Fig. 10

Brush Holder and Regulator Replacement

After removing the stator and diode trio, the brush holder and regulator may be replaced by removing the two remaining screws. Note the two insulated screws in Fig. 6. These screws have special insulating sleeves over the screw body above the threads. The third screw may or may not have an insulating sleeve. Do not interchange screws if one does not have an insulating sleeve. A ground could result causing no output or uncontrolled output of alternator.

Slip Ring Servicing

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor and hold the polishing cloth against the slip rings until they are clean. NOTE: The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

Bearing Replacement and Lubrication

1. Remove retainer plate screws, retainer plate assembly, gasket and collar.
2. Press bearing from end frame.
3. Remove retainer plate and felt washer.
4. Install retainer plate and new felt washer.
5. Press bearing in with sealed side away from grease reservoir.
6. Fill grease cavity one-quarter full with Delco-Remy lubricant part number 1948791.
7. Attach gasket and retainer plate assembly to end frame using new retainer plate assembly.

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

To install a new bearing, place a flat plate over the bearing and press in from the outside towards the inside of the frame until the bearing is flush with the outside of the end frame. Support the inside of the frame with a hollow cylinder to prevent breakage of the end frame. Use extreme care to avoid misalignment or otherwise placing undue stress on the bearing

If the seal is separate from the bearing, it is recommended that a new seal be installed whenever the bearing is replaced. Press the seal in with the lip of the seal toward the rotor when assembled; that is, away from the bearing. Lightly coat the seal lip with oil so that the shaft will slip into the bearing more easily.

REASSEMBLY

Reassembly is the reverse of disassembly.

To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru bolts, remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

When installing the drive pulley on the alternator, the pulley nut must be torqued to 4060 foot pounds. If not properly tightened, it is possible that the nut and pulley could loosen and slip on the shaft or even come off during operation.

To assist in tightening the pulley nut, a 5/16 inch hex hole is provided in the end of the shaft for holding with an Allen wrench. Also a special 15/16 inch socket wrench, Fig. 11, which is applicable to the nut, is available from the Snap-On Tool Company. This special 1/2 inch drive socket wrench is designed with a cutout to receive the Allen wrench and may be used in conjunction with a torque indicating wrench. Where desired, a length of 3/8 inch pipe may be applied to the Allen wrench to provide additional leverage for the holding effort.

The special 15/16 inch socket wrench, Fig. 11, is available from your local Snap- On representative under their number S-8183.

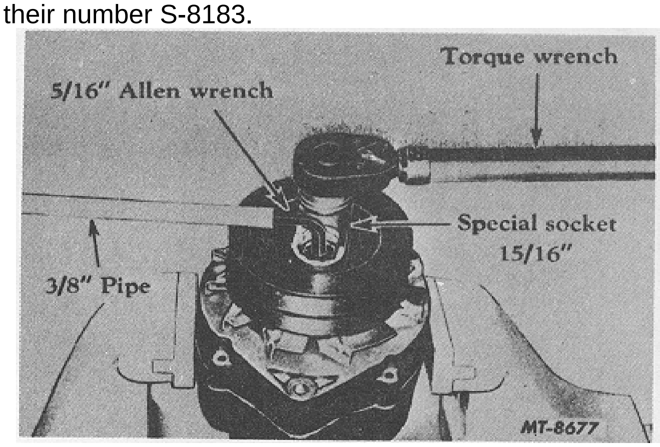


Fig. 11

Alternator Bench Check

To bench check the alternator, position the alternator in a holding fixture.

1. Make connections as shown in Fig. 12, except leave the carbon pile disconnected. IMPORTANT: Ground polarity of energizer or battery and generator must be the same. Use a fully charged battery and a 10 ohm resistor rated at six watts or more between the generator No. 1 terminal and the battery.

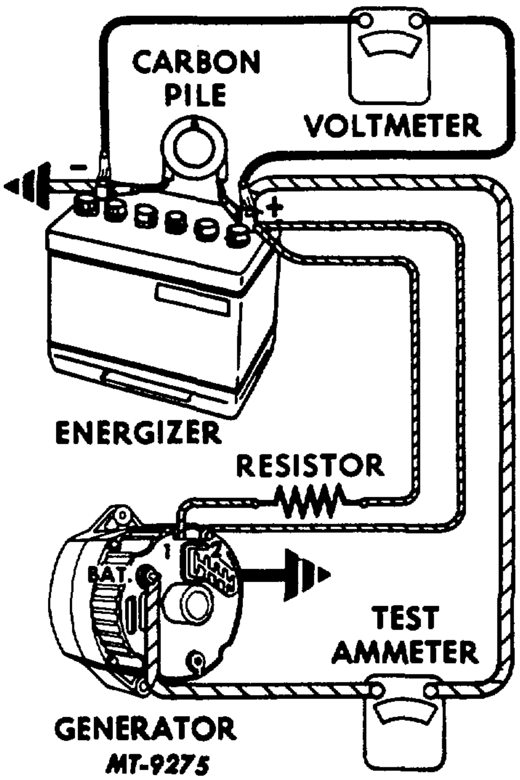


Fig. 12 Connections for Bench Check of Alternator

2. Slowly increase the generator speed and observe the voltage.

3. If the voltage is uncontrolled with speed and increases above 15.5 volts on a 12volt system, check for a grounded brush lead clip as covered under "Overcharged Battery, " Step 3. If not grounded, replace the regulator and check field winding.

4. If voltage is below 15.5 volts on a 12-volt system, connect the carbon pile as shown.

5. Operate the generator at moderate speed as required and adjust the carbon pile as required to obtain maximum current output.

6. If output is within 10 percent of rated output as stamped on generator frame, generator is good.

7. If output is not within 10 percent of rated output, keep battery loaded with carbon pile and ground generator field, Fig. 5.

8. Operate generator at moderate speed and adjust carbon pile as required to obtain maximum output.

9. If output is within 10 percent of rated output, replace regulator as covered under "Brush Holder and Regulator Replacement" and check field winding.

10. If output is not within 10 percent of rated output, check the field winding, diode trio, rectifier bridge and stator as previously cove red.

Model	Series	Ground	Field Current (80° F)		Specified Volts	Cold Output				Rated Hot Output† (Amps)
			Amps	Volts		Amps	Approx. RPM	Amps	Approx. RPM	
1100073	27-SI/200	Neg.	4.4-4.9	12	14	54	2000	73	5000	80

† At maximum operating speed

ELECTRICAL

BATTERY

INDEX

BATTERY

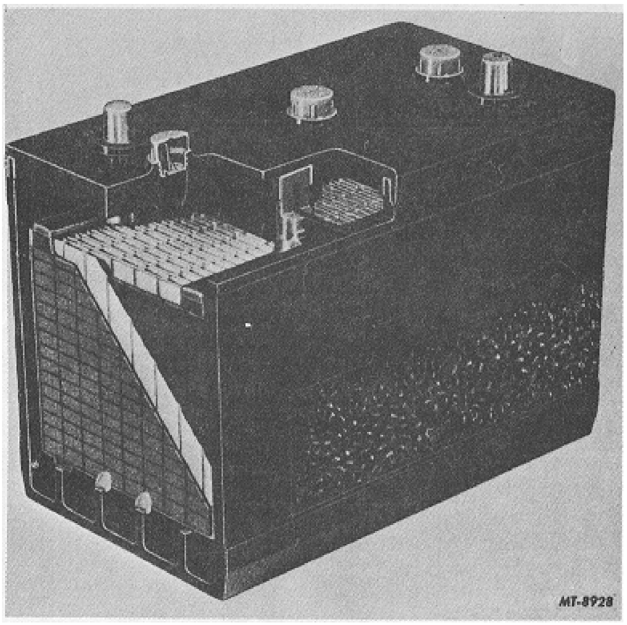


Fig. 1 Six-Volt Storage Battery (Cutaway)

DESCRIPTION AND CONSTRUCTION

The storage battery, Figs. 1 is a lead acid electrochemical device mounted in a molded hard rubber (or other nonconductor type material) case. The case is divided into a number of cells, which is determined by whether the battery is a six-volt three cell type or a twelve-volt six cell type.

Late model batteries use the one piece cover construction with the cover over the post straps and epoxy sealed to the case. Older model batteries use individual cell covers which fit into the case and cover the top of the cells. These are secured with a hot asphalt sealant.

While the battery is the heart of the automotive electrical system, it does not generate electricity but stores it in chemical form until needed. When connections are made to the battery terminals, chemical action between the plates is converted to electrical energy. By putting electrical energy back into the battery the action is reversed.

Battery location on the vehicle also has much influence on the life of the battery. For this reason the battery is usually located close to the cranking motor but away from engine heat. It must also be accessible and mounted so as to be level and protected from road splash and dirt.

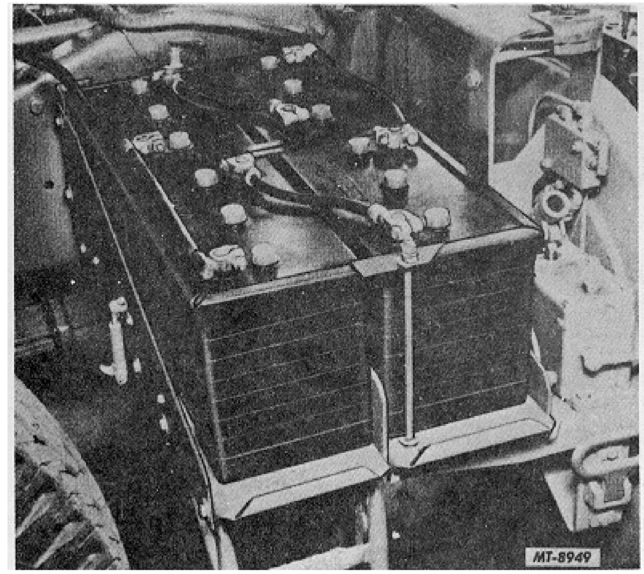


Fig. 6 Typical Multiple Battery Installation

MAINTENANCE IN THE VEHICLE

Battery Service and Care

Batteries perform at their best when serviced regularly. During vehicle operation (charging) water is lost from the electrolyte by evaporation and moisture leaves the battery with the gas which is produced. The battery is also subjected to vibration, road shock, moisture and dust, depending on where and how the vehicle is used. Several periodic service items which require only minor attention mean much in obtaining top performance from the battery. For this reason your battery should be serviced every two weeks, noting especially for the following (Fig. 7):

1. Appearance: Make sure battery has no physical damage such as breaks or cracks in cover or leaks from the case.

2. Electrolyte Level: Keep battery water at indicator level to prevent internal damage to plates.

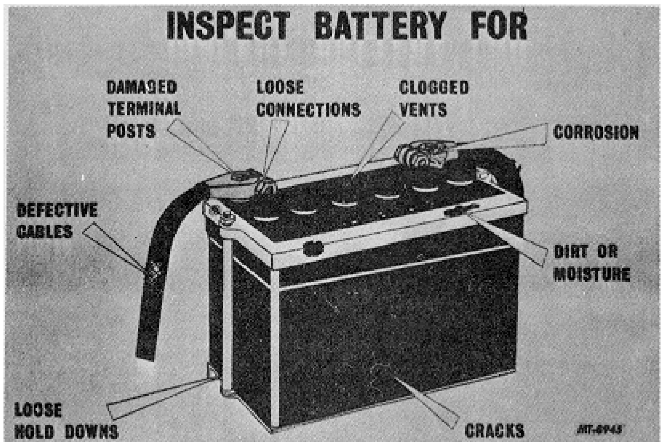


Fig. 7 Battery Maintenance Checks

3. Cleanliness: Remove all corrosion and dirt from terminals and battery post and coat them with lube to prevent future corroding. Keep top of battery clean to prevent self-discharge.

4. Terminal Connections: Keep terminals tight to prevent hard starting.

5. Mounting: Keep mounting snug but not over tight to prevent damage to battery case.

These items are covered in greater detail in later paragraphs of this section.

Keeping the Battery Charged

A battery gives the best service and lasts longer when maintained at or near a full state of charge. When checking electrolyte level the specific gravity of electrolyte should be checked with an accurate hydrometer. If battery is partially or fully discharged, it should be charged from an outside source, Fig. 8. If it takes a charge, the vehicle electrical system should be checked to determine the reason for the discharged battery. Batteries refusing to take a charge should be immediately replaced by a battery of same size and capacity as that which was removed.

Overcharging - Evaporation of Electrolyte

When much water is added at each service period this is an indication that voltage regulator settings are too high and battery overcharge results. Reduce regulator voltage settings to avoid overcharge. Also, the need for too frequent recharging is an indication of undercharging and normally due to regulator voltage setting being too low. Correct this •y increasing regulator voltage setting.

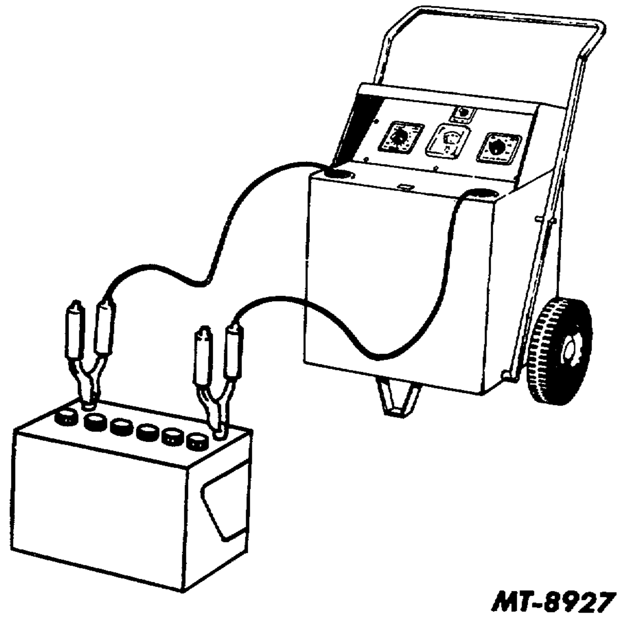


Fig. 8 Charging Battery from Outside Source

Filling

Electrolyte should always cover the plates of the battery. Batteries with level indicators should be filled to the bottom of the indicator. Where there is no indicator fill battery 1/4" to 1/2" above the visible separators. Never overfill. This can cause damage to battery itself, cables, connectors and other parts of the vehicle. Overfilling causes electrolyte to be pushed out of the cell during charging or from vibration. When this happens, anything that can be attacked by 2id can be damaged.

Even with electrolyte at proper level some acid leaves the battery with the gas which is produced during the charging process. When this happens, cables and terminals may become corroded and this can eventually lead to high resistance connections, which reduce the efficiency of the electrical system. Whenever corrosion is noted it should be cleaned off with a stiff brush and a mild solution of baking soda and water. After cleaning affected parts apply a light coat of chassis lube or petroleum jelly to retard further corrosion.

Terminals, Cables and Connections

Always make sure battery connections are clean and tight and that battery cables are not rubbing against other parts which tend to weak them away or break through their insulation. If a part of the battery cable is worn away, it leaves a smaller area through which the current can pass and reduces the efficiency of the system. If the insulation of the starter cable is broken or worn away, there is also danger of a violent short which might ruin the battery or other parts or cause a damaging fire.

Hard Starting - Battery Not at Fault

Temperature plays an important part of battery capacity, and the lower the temperature, the lower will be its ability for doing work. With this in mind it will be seen that a fully charged battery is only partially capable at subzero temperatures. This fact, coupled with the conditions in which many engines are found, brings about complaints regarding the size, quality and construction of the standard equipment battery.

There are times when it is necessary to increase the size of the battery, but such action should not be considered a "cure-all" for hard starting complaints during winter months. Even when special equipment is installed, it is still essential to:

1. Use lube oil with correct SAE rating for winter service.
2. Maintain distributor points in good condition and properly adjusted.
3. Have clean and properly gapped spark plug electrodes.
4. Have good compression in the engine.
5. Maintain all joints and connections between carburetor, manifolds and engine in a gas tight condition.
6. Ascertain that automatic choke and choke plate are operating properly.
7. Determine that engine and cab are well grounded and that ground straps are securely fastened to clean contacts.

Using Jumper Cables and Booster Battery for Starting

When starting vehicles with a booster battery and jumper cables always use a booster battery having the same voltage as that in the vehicle to be started. To use a twelve-volt battery to start a vehicle equipped with a 6volt system will impose a heavy electrical load on the 6volt starting motor, which may result in starting motor damage. Fig. 9 illustrates correct method for connecting jumper cables from one battery to another.

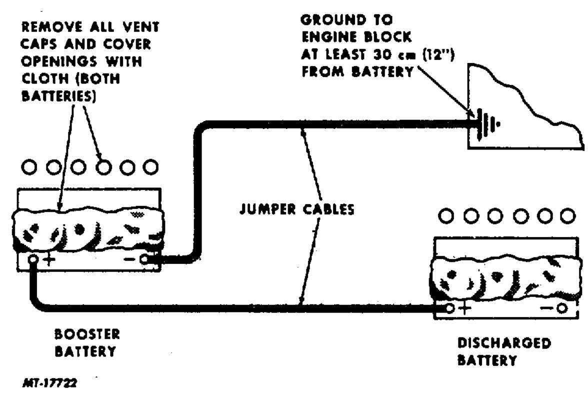


Fig. 9 Proper Jumper Cable Connection

TESTING

Specific Gravity Test or Hydrometer Reading

Check the specific gravity of battery electrolyte to determine the strength of the solution. Since acid is heavier than water, the more acid in a solution the heavier it will be. If the battery is discharged, the acid combines with the plates and leaves the solution lighter, showing a lower hydrometer reading. Inversely, the acid leaves the plates and reenters the solution as the battery is charged, causing the solution to become heavier and resulting in a higher hydrometer reading.

The following chart (A) illustrates a typical range of specific gravity for a cell in various stages of charge with respect to its ability to crank the engine at 80°F.

Hydrometer Reading	Useful Capacity
1.260 Sp. Gr.	100%to Charge
1.230 Sp. Gr.	75%o Charge
1.200 Sp. Gr.	50% Charge
1.170 Sp. Gr.	25% Charge
1.140 Sp. Gr.	Very Little
1.110 Sp. Gr.	None

CHART A

In reading a hydrometer, Fig. 10, barrel must be held vertically with just the right amount of acid drawn into the barrel, with bulb fully expanded, to lift the float. Float must not touch side, top or bottom stoppers of barrel.

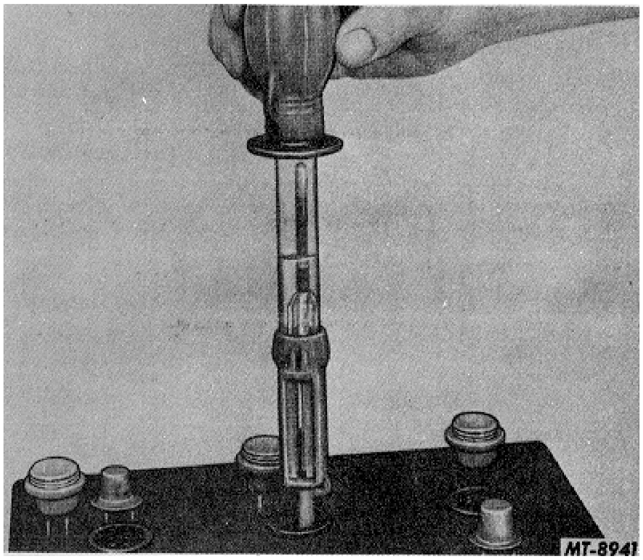


Fig. 10 Checking Battery Specific Gravity

Hydrometer barrel and float must be kept clean with soap and water so float will not stick to sides. Inspect float occasionally for cracks which would allow acid to enter the airtight float and make reading unreliable. If paper scale inside float is wet, it is an indication that float leaks and should not be used.

Temperature Correction for Hydrometer

No hydrometer reading is strictly correct until a temperature correction has been applied. Floats are calibrated to indicate correctly only at one fixed temperature. The reason for this is that acid volume expands when heated and shrinks when it cools. When expanded it will not be as dense and it will not raise float as high, thereby causing reading to be low. Temperature correction is, therefore, most important when making a specific gravity test. Add .004 for every 10°F above 80°F and subtract .004 for every 10°F below 80°F.

Cranking Test

A cranking test should be made with high rate discharge equipment, Fig. 11. Follow the test equipment manufacturer's instructions for the instrument used. If such equipment is not available, similar results may be accomplished by cranking the engine with center high tension wire of distributor removed. With a voltmeter connected across the battery terminals, crank the engine for not more than 15 seconds. During this period a 6volt battery should read not less than 4.8 volts; a 12volt battery not less than 9.6 volts. This test is valid only if battery's specific gravity is 1.225 or above at 80°F.

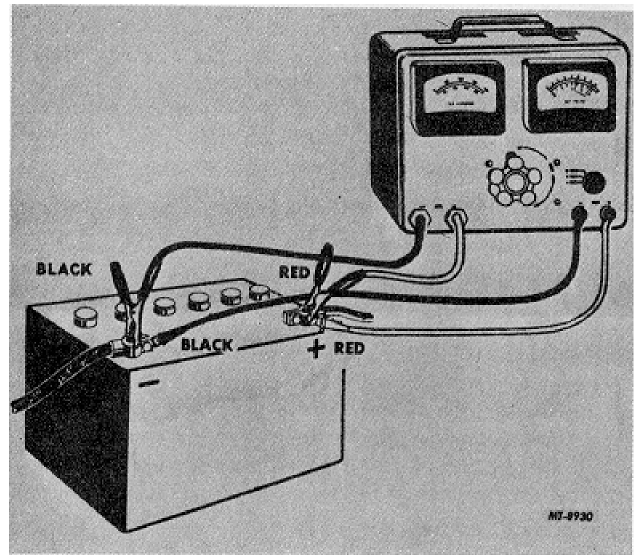


Fig. 11 High Rate Discharge Tester

RECHARGING

Fast Charge

A convenient method for recharging a battery is by the Fast Charge Method, Fig. 8. This can be accomplished in the vehicle and the battery does not have to be removed. Fast charging, however, is only a booster charge and does not fully charge a battery, since this takes time. Also, the electrolyte temperature must be watched closely (never allowed to exceed 125°F) or damage can result. A sulphated battery should never be fast charged. When using the battery charger always follow equipment manufacturer's instructions. Most modern charging equipment can be set for either a fast or slow charge.

Slow Charge

In general the Slow Charge Method for battery charging is as follows:

1. With vent plugs in place wash top of battery using a solution of water and baking soda. Rinse with clear water.
2. Remove all vent plugs.
3. Fill cells with distilled water to indicator level in battery cover. Never fill with acid. If distilled water is not available, ordinary tap water which is colorless, tasteless and odorless may be used.

4. Connect battery to charger unit in series, connecting positive terminal outlet from the supply line to the positive terminal of the first battery. Connect the negative terminal of the first battery to the positive terminal of the second battery and so on through the number of batteries being charged. (Do not exceed the capacity of the charging equipment in the number of batteries being charged at one time.) The last battery must have its negative terminal connected to the negative outlet of the charging unit.

5. Adjust charging rate in amperes to the lowest normal charge rate of the smallest size battery according to the accompanying chart (B). Batteries should remain on charge for a period of time sufficient to obtain normal voltage and specific gravity readings of each cell. Required length of time will vary from 12 to 48 hours, depending on state of discharge at time battery was placed on charge and the rate of charge.

   Temperature readings should be taken frequently to prevent the electrolyte temperature from exceeding 125°F at any time. If temperature does rise above 125°F, the charge rate should be reduced to allow electrolyte temperature to drop below 125°F.

6. Battery voltage is determined by normal electrolyte temperature of 80°F. Voltage readings are to be taken while the battery is on charge at the normal rate as specified in Chart B.

Battery	Volts	Number of Plates	Normal Charge Rate (Amps)
1424X	6	99	15

CHART B

The battery voltage of a fully charged battery on charge at the normal rate should read as shown in Chart C.

Temperature	6-Volt-Battery
80°F	7.5 -7.8 volts
100°F	7.2 -7.8 volts
110°F	7.05- 7.65 volts
120°F	6.9 -7.5 volts

CHART C

A battery is fully charged when battery voltage values are as shown in Chart C and there is no further rise in voltage over two successive readings taken at one-half hour intervals.

7. Add water as necessary; disconnect the batteries from charging line; replace vent plugs; wash and dry tops of batteries and return to service or the storage rack.

<u>Putting Dry Charged Batteries into Service</u>

Dry charged batteries can be used immediately after activating. Prepare dry charge battery for service as follows:

1. Remove or destroy any sealing device used to close or restrict the vent openings.

2. Fill the cells 1/4 to 1/2 inch above the separators or to the indicator level with sulphuric acid.

3. The battery is now ready for use. If the vehicle is to be driven considerable mileage after battery activation, no boosting charge is required. However, if it is not driven as noted above, a boosting charge

should be applied as follows for a 10-minute period:

6-Volt Batteries - 50 to 70 amperes
12-Volt Batteries - 30 to 40 amperes

If a high- rate charger is not available, charge at 15 amperes for 30 minutes.

REMOVA L AND INSTALLATION

Selecting the Size

Batteries sold for replacement should be of an electrical size at least equal to battery placed in vehicle by the manufacturer. Frequently additional current-consuming devices have been added to the vehicle by the owner, which may make a larger capacity battery desirable.

Also the drain on battery may be very high when engine is not running. High capacity alternators or generators carry the electrical load when the engine is running, but too small a battery may be discharged so much by lights and miscellaneous current draws while parked that cold weather starting is seriously impaired before the driving time allows the generator to restore the charge to the battery. A larger battery will also have longer life and, therefore, be a worthwhile investment. Make sure larger battery will fit the application.

Removing Old Battery

When removing old battery note the location of positive terminal so that new battery is installed in the same manner. Remove "ground" terminal first.

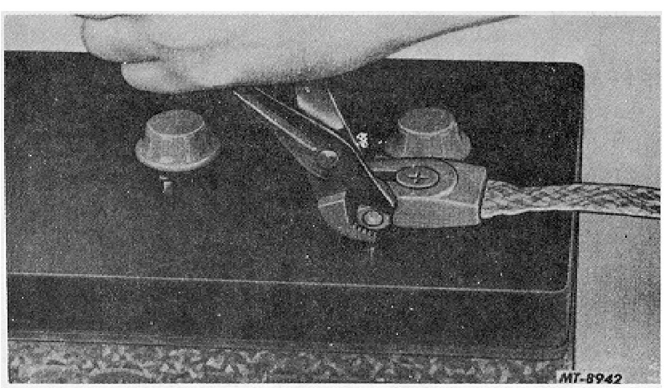


Fig. 13 Loosening Battery Terminals

In removing hex nut on the bolt of clamp terminal, use only a properly fitted end wrench or special battery clamp pliers, Fig. 13.

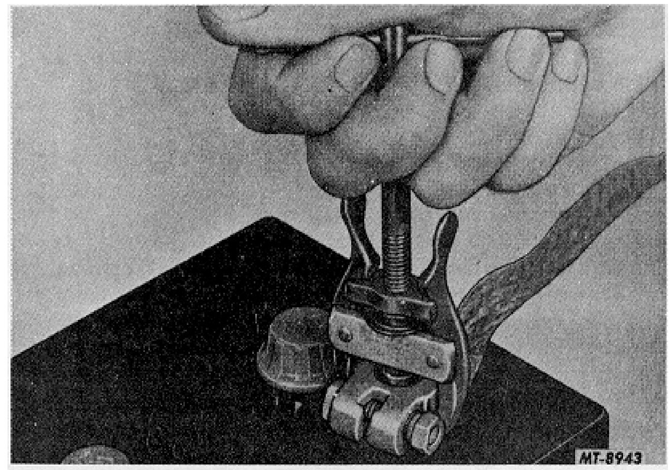


Fig. 14 Using Terminal Puller

In order to avoid damage to battery, pry terminal jaws apart or apply a terminal puller, Fig. 14, to remove cable. Don't hammer or pry up on clamps, as this can damage post seals and break cover.

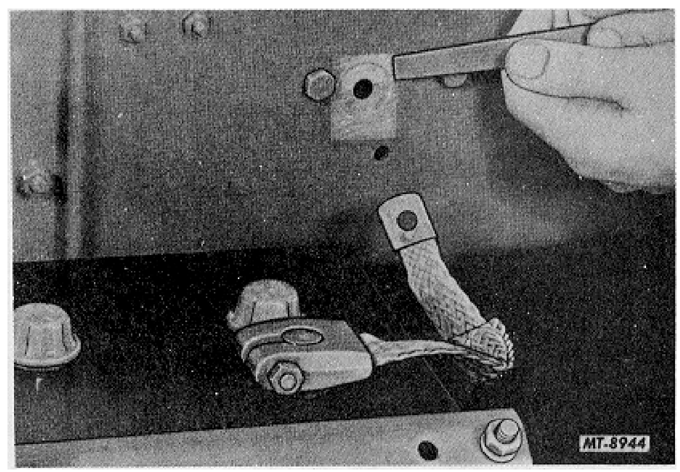


Fig. 15 Cleaning Ground Connection Using an Old File Ground to a Sharp, Blunt Edge

Inspect the cradle for damage caused by corrosion from loss of acid from old battery. Be sure hold-downs are mechanically strong and free of corrosion. Corroded parts and cables may be cleaned with a mixture of water and household ammonia or baking soda by scrubbing with a stiff brush.

Also check cables to see that insulation is intact and the clamp terminal or its bolt are not damaged by corrosion. Clean the ground terminal, Fig. 15, at the frame and tighten; also the switch and starter connections.

Installation of Battery

Only a fully charged battery can deliver the published and guaranteed performance which is the basis of the sale. The best assurance against trouble and costly service is to make certain that batteries sold to customers are fully charged when installed.

Each battery must be coded indicating the month and year it was installed.

The battery should rest level in the cradle and be fastened securely in place by suitable hold-downs, using care to tighten evenly from each end a little at a time so as not to distort or break the container. Do not draw the hold-downs too tight.

Installation of Cables

Cables must be of sufficient length to reach terminal posts without causing undue strain on cover or terminals. Note that tapered positive terminal of the battery is 1/16 inch larger at the top than the negative terminal and the opening of the positive cable clamp is correspondingly larger to fit it. Always clean the battery terminal parts and the inside of the clamps bright with sandpaper or special terminal cleaner, Fig. 16. Cleaning the clamp terminals and tapered posts each time they are reconnected is very important in voltage-regulated systems.

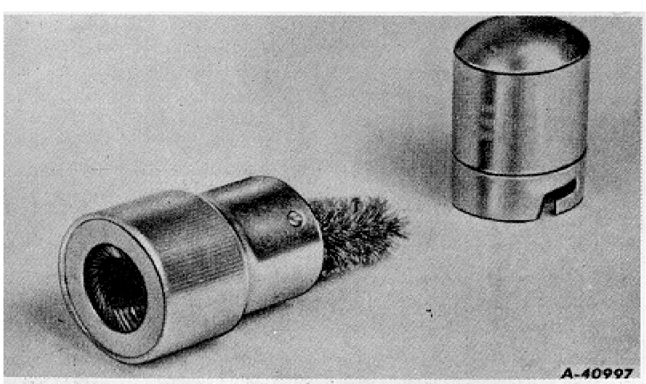


Fig. 16 Combination of Brushes for Cleaning Terminals and Cable Clamps

Care should be taken when installing a cable terminal. It should never be hammered into place. To do so may crack battery cover seal. Also some metal may be sheared from post, making it too small for good contact when the next replacement is necessary. The best practice is to pry jaws of terminal apart or use a clamp spreader, Fig. 17, before slipping it over the post.

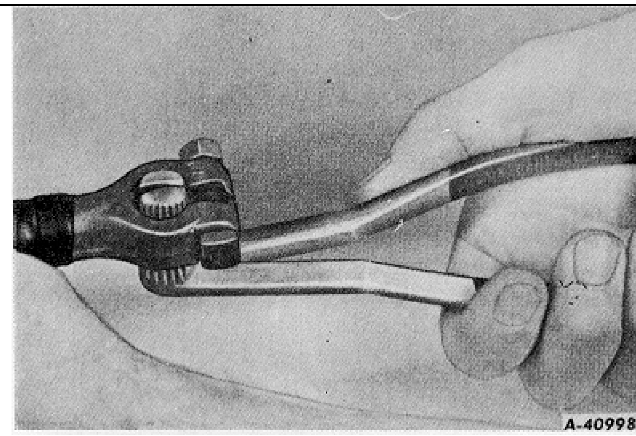


Fig. 17 Spreading Cable Clamp with Terminal Spreader

Apply a thin film of chassis lube to inside of clamp terminals and over bolt stud before reconnecting terminal. Connect ground terminal last. Tighten the terminal bolts, being careful to position the clamp terminals and cables so as not to interfere with the filler caps or rub on the hold-down parts.

Before cranking the engine, turn on the lights and make certain the ammeter indicator shows discharge. This will indicate correct battery installation. Considerable damage to the electrical system can result if a battery is installed incorrectly.

When making replacement of original battery cables, starting motor cables or other wires utilizing protective loom or grommets, it is essential that the service cable be equipped with the same type loom or grommet protection as was removed on the replaced cable or wire. Cables that are replaced without proper loom protection create a fire hazard. The wiring circuits on new vehicles are closely checked and approved by Underwriter Companies; therefore, the original circuits should be maintained both as to location and protective devices.

The loom or grommet is placed on cables for safeguarding against chafing or cutting through the insulation at points where cables contact chassis.

When replacing cables on customers' trucks or when making sales of cables, make certain that a protective loom or proper grommets are provided where required.

The storage battery can deliver only what the battery cables are able to carry to the electrical system. The battery cannot operate efficiently if it has to overcome the resistance f a worn-out, corroded or undersize cable. Faulty battery performance may indicate cable trouble.

PROPERTIES OF ELECTROLYTE

pecific Gravity Affects Freeze Point

Specific gravity of the electrolyte determines the temperature at which a battery will be harmed or damaged by freezing.

Chart D which follows gives the freezing point of battery electrolyte at given specific gravities.

Electrolyte Specific Gravity	Freezing Point (F)
1.280	90° below 0°
1.265	75° below 0°
1.220	30° below 0°
1.210	20° below 0°
1.180	10° below 0°
1.160	0°
1.140	10° above 0°
1.100	20 above 0°
1.000	32° above 0°

CHART D

Temperature Affects Battery Capacity

The battery container is a good heat insulator, and the electrolyte temperature will lag several hours behind atmospheric temperature.

The specific gravity of the electrolyte (distilled water and acid solution) must be maintained at 1.225 minimum, and the level of the solution should be at the indicator level in the battery cover. A fully charged battery has a specific gravity of 1.255- 1.270 at 80° F.

To eliminate the possibility of harmful sulfation of plates, a battery with a specific gravity of 1.225 or less should be recharged.

The following chart (E) shows the effect of temperature on the capacity of a battery.

State of Charge	Electrolyte Temperature (F)	Percentage Capacity
Full	80° above 0°	100
Full	60° above 0°	88
Full	40° above 0°	75
Full	20° above 0°	62
Full	0°	45
Full	20° below 0°	20

CHART E

Precautions When Working Around Batteries

It cannot be stressed too strongly that there are certain dangers involved in working with or around lead-acid batteries. Care should be taken to avoid these dangers.

1. Electrolyte is a combination of water and sulfuric acid and as such is dangerous to clothing, vehicle parts and human skin-and especially dangerous to the eyes. Take care to avoid slopping or spilling acid when reading hydrometers or filling batteries. Acid on the skin should be washed off with cold water and soap as soon as possible. Eyes should be immediately washed with cold water and a physician notified.

   NOTE: Use only distilled water or odorless, colorless and tasteless drinking water in a storage battery. Patent electrolytes or battery dopes are injurious and void the battery guarantee.

2. Never smoke or bring a flame close to batteries. The gas given off during charging is hydrogen, which is extremely explosive in the presence of a spark or flame, Fig. 18. Never check the condition of a battery by shorting between terminals, and for safety's sake never lay tools or other metal objects on top of a battery where they might short between terminals or short between ground and the ungrounded terminal. Always remember that one side of the battery is grounded to the frame of the vehicle and when working on other electrical components, it is best to remove the ground side of the battery first.

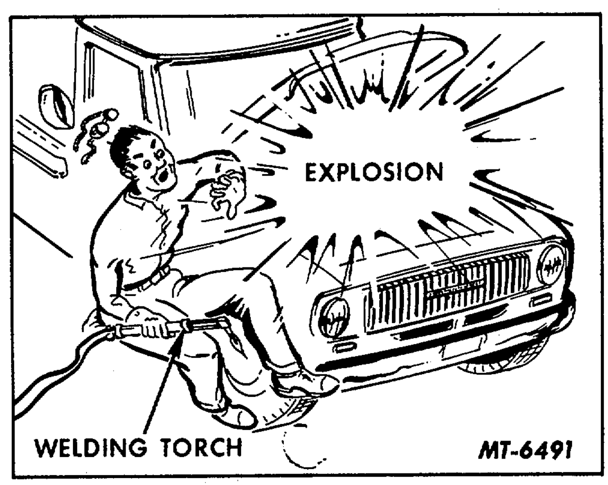


Fig. 18 Explosion Caused by Open Flame Near Battery

BATTERY STOCK MAINTENANCE

Preparation of Stock

Bring batteries to the fully charged state before placing them in stock. In the absence of level indicators, the proper electrolyte level is about 1/4" to 1/2"Itabove the tops of separators at 80° F. Electrolyte level in very cold batteries will be lower than normal, so let batteries warm to normal temperature before judging levels. Remember to correct hydrometer readings for temperature if accurate values are desired and make due allowances for the time and temperature involved in transit.

Rotation of Stock

Place new batteries in stock, preferably in cartons, so that oldest batteries can be sole first. Batteries discharge during storage and should be located so they can be reached for recharging without moving newer batteries away from them. Segregate batteries by types. Mark date battery is received on carton or battery with red chalk. This date is helpful in selecting the oldest battery of any type in stock for earliest sale.

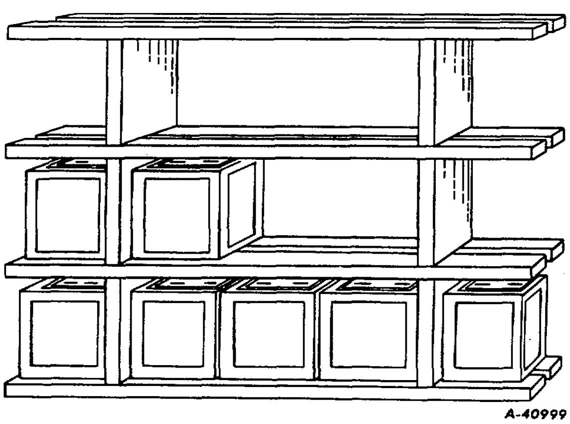


Fig. 19 Battery Storage Racks

Racks for Storage

Never pile batteries on top of one another. Simple racks for temporary battery storage, Fig. 19, can be made from loose, flat boards supported by the batteries themselves. Lay parallel on a smooth flat floor two shelf boards spaced so that bottom ends of batteries are supported. Place five batteries side by side in a row and insert one upright between Nos. 1 and 2 and between Nos. 4 and 5, pushing the batteries up snugly together so as to support the 10" high uprights. The next shelf may then be added When not in use the rack boards may be compactly stored. A heavier permanent rack with shelves 24" apart will provide working space over the batteries for testing and charging.

Charge All Batteries Fully Before Installation

All wet batteries will slowly discharge whil4 standing and will discharge much faster when warm than when cold. They will discharge faster when fully charged than when only partially charged.' At normal temperatures of about 70-80°F loss of capacity by self-discharge, starting with a fully charged battery, may amount to an average of about . 001 sp. gr. per day over a 30 day period. At the start it may amount to .002 sp. gr. loss per day and gradually taper off to less than . 001 sp. gr. loss per day by the end of 30 days. The effect of temperature on self-discharge for the average fully charged battery in good condition may be about as follows:

Temperature	Amount of Self- Discharge
At 100°F	.003 sp. gr. per day
At 80°F	.002 sp. gr. per day
At 50°F	.0005 sp. gr. per day

CHART F

The above values are approximate for about the first ten days of standing after being fully charged. Some makes of batteries have a higher or lower state of self-discharge than the above, depending on method of manufacture and purity of materials used. To minimize self-discharge, store batteries in as cool a place as possible, away from hot air ducts or radiators in winter and shielded from direct sunlight in summer.

To make up for loss of charge while standing in stock, a boosting charge without excessive overcharge must be given batteries whenever they fall to 1.240 sp. gr., corrected to 80°F. This is necessary whether batteries remain in stock or are made ready for sale. Check every 30 days at warm temperatures and less often during cold weather. See "RECHARGING" for proper procedure.

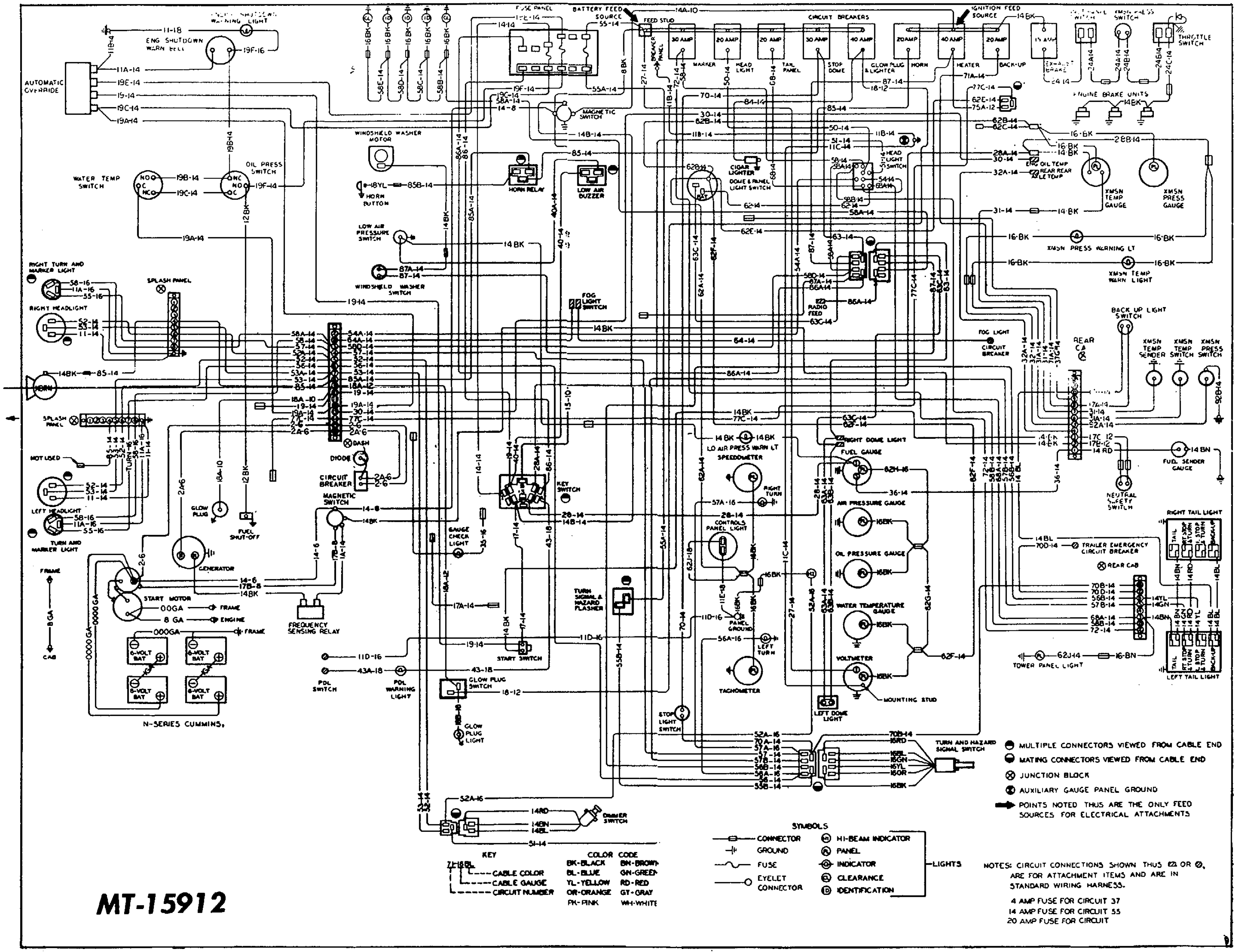
Display Batteries Must Be Charged

Do not forget wet batteries. used for display purposes or standing in vehicles in storage. They must be considered as batteries "in stock" and boosted whenever the gravity falls to 1.240. Use "dummy" batteries with no elements in them for display purposes. These can be obtained from the battery manufacturer.

CIRCUIT DIAGRAM AND CIRCUIT COMPONENTS

1. Generator (Field)
2. Generator (Charge)
3.
4.
5.
6. Regulator, Volt (Field Relay)
7. Regulator, Volt (Charge)
8.
9.
10. Battery Cables
11. Ground
12.
13.
14. Main Feed
15. Key Switch
16. Ignition
17. Starting Control
18. Glow Plug, Pre Heater
19. Fuel Shut-Off
20. Propane
21.
22.
23. Magnetic Fan
24. Exhaust Brake
25.
26. Generator Indicator
27. Voltage Indicator
28. Instrument
29. Eng Water Temp
30. Eng Oil Temp
31. Trans Oil Temp
32. Axle Oil Temp
33. Eng Oil Level
34. Water Level
35. Eng Oil Pressure
36. Fuel Level
37. Fuel Pump
38.
39.
40. Air Pressure Warning
41. Vacuum Warning
42. Frt Axle Warning
43. P.D. Lock Warning
44. Brake System Warning
45. Anti-Theft Warning
46.
47. Speedometer
48. Tachometer
49.
50. Light Switch
51. Dimmer Switch
52. Head Light - Hi Beam
53. Head Light - Lo Beam
54. Parking Lights
55. Dir. Signal Switch
56. Dir. Signal Lights - Left
57. Dir. Signal Lights - Right
58. Clear., Ident., & Marker Lts
59.
60. Hazard Switch
61.
62. Panel Lights
63. Dome &/or Courtesy Lt
64. Auxiliary Lights
65.
66.
67.
68. Tail Light
69. License Plate Light
70. Stop Light
71. Back-Up Light
72. Trailer
73.
74.
75. Heater
76. Defroster
77. Air Conditioner
78. Heated Mirror
79. Sander Traction
80.
81.
82. Wshld Wiper
83. Window Lift
84. Cigar Lighter
85. Horn
86. Radio
87. Wshld Washer
88. Clock
89.
90.
91. Electric Brake
92. Transmission
93. Axle Shift
94. Anti-Skid
95. Exhaust Emission
96. Snow Plow
97. Auto-Cruise
98.
99.

MT-16916


MT-15912
N-SERIES CUMMINS
MULTIPLE CONNECTORS VIEWED FROM CABLE END
MATING CONNECTORS VIEWED FROM CABLE END
JUNCTION BLOCK
AUXILIARY GAUGE PANEL GROUND
POINTS NOTED THUS ARE THE ONLY FEED SOURCES FOR ELECTRICAL ATTACHMENTS
SYMBOLS
CONNECTOR
GROUND
FUSE
EYELET CONNECTOR
HI-BEAM INDICATOR
PANEL
INDICATOR
CLEARANCE
IDENTIFICATION
LIGHTS
KEY
CABLE COLOR
CABLE GAUGE
CIRCUIT NUMBER
COLOR CODE
BK-BLACK
BL-BLUE
YL-YELLOW
OR-ORANGE
PK-PINK
BN-BROWN
GN-GREEN
RD-RED
GY-GRAY
WH-WHITE
NOTES: CIRCUIT CONNECTIONS SHOWN THUS OR ARE FOR ATTACHMENT ITEMS AND ARE IN STANDARD WIRING HARNESS.
4 AMP FUSE FOR CIRCUIT 37
14 AMP FUSE FOR CIRCUIT 55
20 AMP FUSE FOR CIRCUIT

FUSE AND CIRCUIT BREAKER PANELS

DESCRIPTION

All chassis incorporate safety device to protect electrical wiring and equipment from short circuits or electrical overloads. These protective devices may be fuses, circuit brakers or fusible links.

Fuses

Fuses are designed to pass a given amount of current. The current flow limit is indicated by the rating of "Size" of the fuse (10 ampere, 14 ampere, etc.). Exceeding this limit will cause the fuse to "blow" opening the circuit.

After the cause of the overload is determined and corrected, a new fuse must be installed in the circuit. Do not replace a "blown" fuse with a fuse of higher capacity. To do so may result in damage to electrical components or wiring. Where fuse failure is encountered, correct the cause of the overload and install a new fuse of the originally specified rating.

Fuses for most vehicle wiring circuits are grouped together in a fuse panel (Fig. 1). Some fuse panels have removable fuse terminals which can be replaced if damaged.

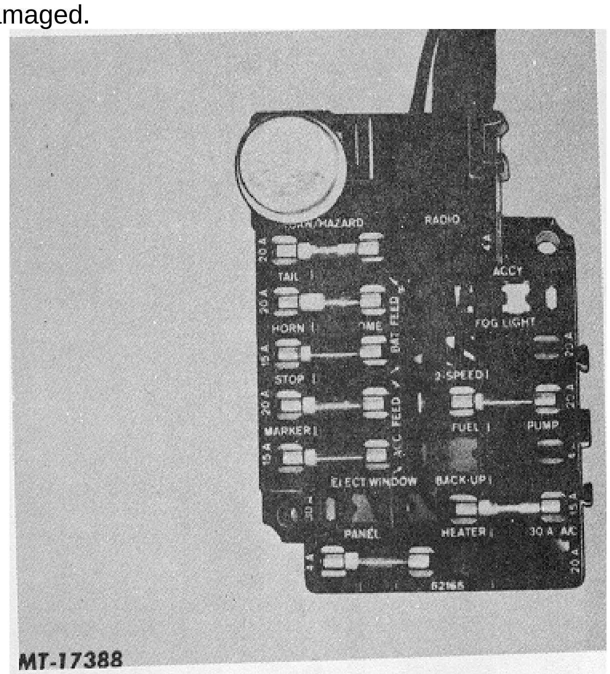


Fig. 1 Fuze Panel (Typical)

Most fuse panels provide space to install additional fuse terminals if needed for installation of accessory circuits.

Locations of fuse panels on various vehicle models are shown in this section.

Circuit Brakers

Circuit brakers are designed to open the circuit any time current demand exceeds the capacity of the braker. In the event of short or overload, the circuit breaker will open due to excessive heat developed by the higher amperage passing through it. When the heat dissipates, the breaker will close allowing current flow again.

If the cause of the short or overload has not been removed, the circuit breaker will open again to protect the circuit. The current flow limit is indicated by the rating (capacity) of the circuit breaker15 amperes, 20 amperes, etc. Do not replace a circuit breaker with one of a higher capacity.

Circuit breakers for vehicle wiring circuits are generally grouped together in a circuit breaker panel. Most circuit breaker panels provide space for installing additional circuit breakers if needed for installation of accessory circuits.

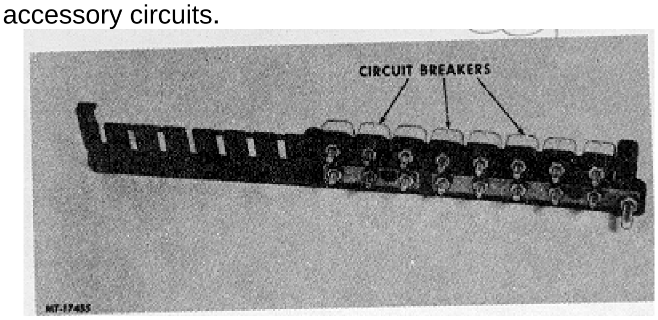


Fig. 2 illustrates the type of circuit breakers used in heavy duty vehicles equipped with circuit breaker panels.

FUSE PANEL AND CIRCUIT BREAKER PANEL LOCATIONS

Illustrated below are locations of fuse panels or circuit breaker panels on various vehicle models. Some heavy duty vehicles are equipped with both a fuse panel and a circuit breaker panel.

Vehicles may have additional secondary or accessory circuits not routed through the fuse or circuit breaker panel. Such circuits are protected by "in line" fuses or remote mounted circuit breakers in the current feed wiring. Refer to vehicle circuit diagrarms for fuse or circuit breaker locations.

5000 Paystar Series

On these vehicles, the fuse panel and the circuit breaker panel are located beneath a hinged access cover at the right side of the instrument panel (Fig. 3).

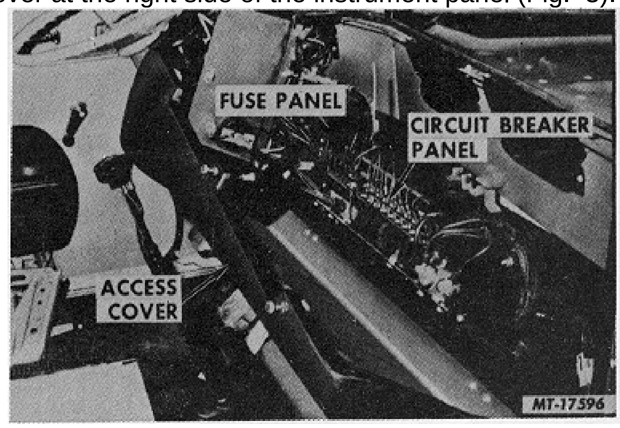


Fig. 3 Fuse Panel and Circuit Breaker Panel Locations 5000 Paystar Vehicles

ELECTRICAL

HEADLIGHTS SINGLE

CONTENTS

TYPE-1

Description

Sealed beam headlights provide two separate and distinct beams; namely, an upper beam for open highway use and a lower beam to be used in city traffic or when approaching vehicles on the highway. These headlights were designed for easier night driving by the use of an opaque shield over the light filament. This shield reduces radiation of stray beams and improves lighting in inclement weather. The Type sealed beam unit retainer is held in position by a spring.

Removal

1. Remove the headlight bezel (rim).

2. Unhook the headlight retaining spring from the headlight retainer, Fig. 1.

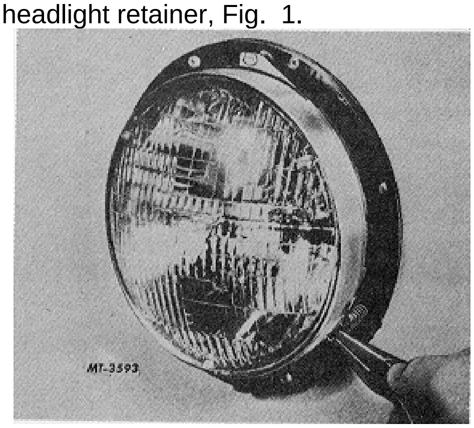


Fig. 1

Do not loosen headlight adjusting screws shown in Fig. 2.

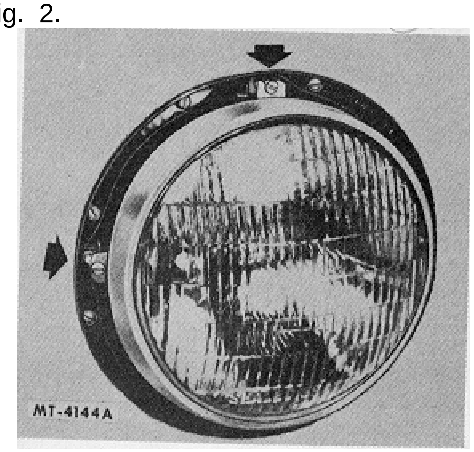


Fig. 2

4. Remove the seal beam unit from the headlight, Fig. 3.

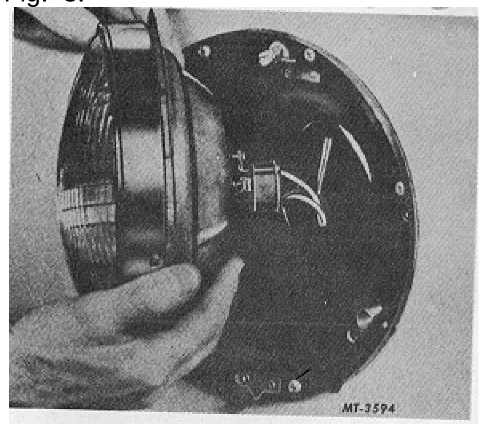


Fig. 3

5. Disconnect the three way connector, Fig. 4, at the rear. Hold the connector firmly to avoid damage to the wiring. Remove the headlight retainer from the sealed beam unit.

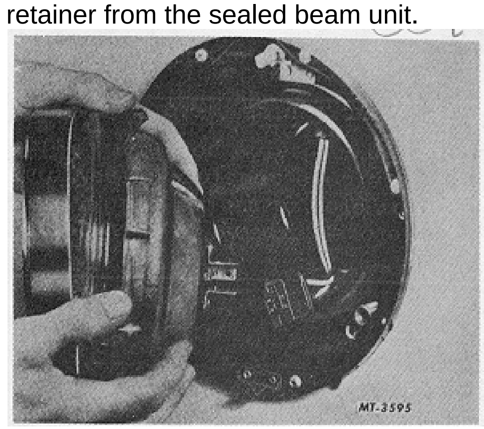


Fig. 4

TYPE-2

Description

The description of the Type2 headlight is the same as Type1 except the retainer is attached by three screws.

Removal

1. Remove the headlight bezel (rim) retaining screw and remove headlight bezel.

2. Remove the retaining ring attaching screws Fig. 5. NOTE The screw mounting hole: may have enlarged openings which permit the retaining ring to pass over the screw heads after loosening the screws 4 or 5 turns. Complete removal of screws is not required.

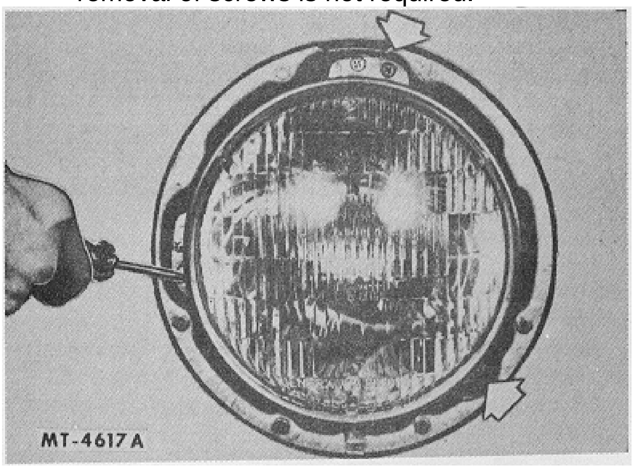


Fig. 5 3

3. Remove the retaining ring and sealed beam unit from the headlight, Fig. 6. In the event the retaining ring is equipped with the enlarged screw mounting holes rotate the ring clockwise enough to permit the ring to pass over the screw heads.

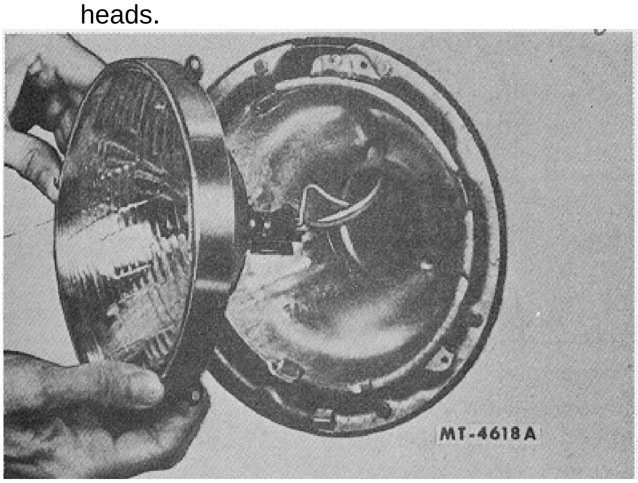


Fig. 6

4. Disconnect the connector plug from the sealed beam unit and remove unit. Do not damage wiring, Fig. 7.

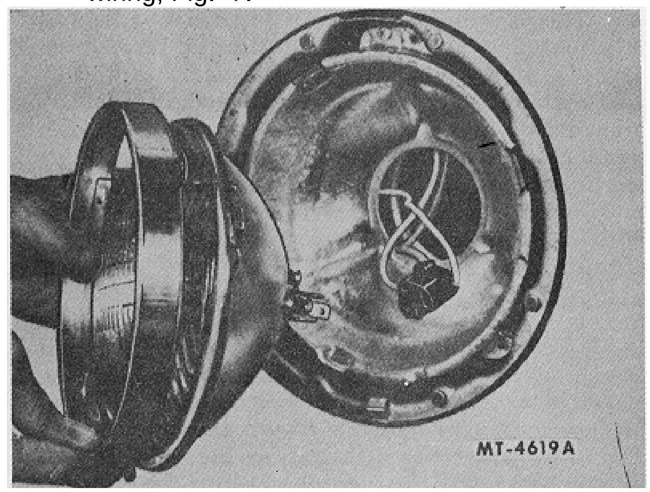


Fig. 7

ADJUSTMENT

NOTE: Always adjust the headlights with the truck empty and on a level floor.

The lateral or side adjustment is accomplished by turning the adjusting screw at side of headlight as shown in Fig. 8.

The vertical or up and down adjustment is accomplished by turning the adjusting screw at top of headlight also shown in Fig. 8.

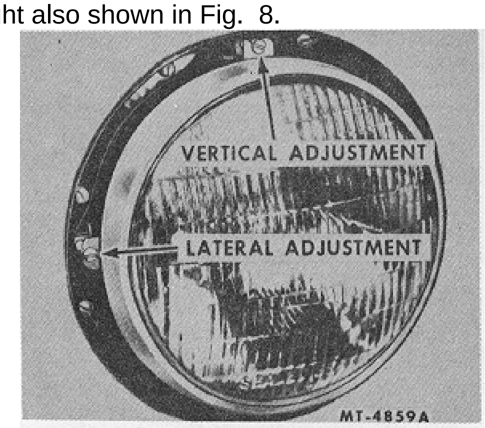


Fig. 8

HEADLIGHT AIMING

The aiming of the sealed-beam headlights is effected by projecting the upper beam of each light upon a screen or a chart at a distance of about 25 feet from the headlights as shown in Fig. 9. The truck should be squarely lined up with the screen. The vertical lines on the chart mark the distance between the center lines of ,the headlights and are equally spaced from the center line of the chart.

A horizontal line should be placed on the chart at a level of two inches below the height of the headlight centers above the floor. Each headlight must be adjusted so that the hot spot of the beam will be centered over the point of intersection of the vertical and horizontal lines as shown in Fig. 9.

IMPORTANT: In some states, the above instructions conflict with the existing laws and regulations. Whenever such is the case, the legal requirements must control and the instructions should be modified accordingly.

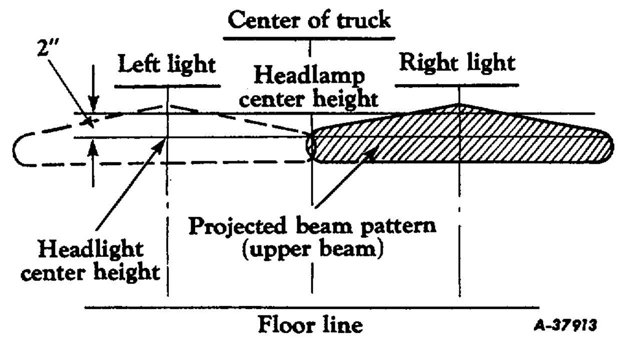


Fig. 9

ELECTRICAL

STARTING MOTOR ENCLOSED SHIFT LEVER TYPE

HEAVY DUTY

INDEX

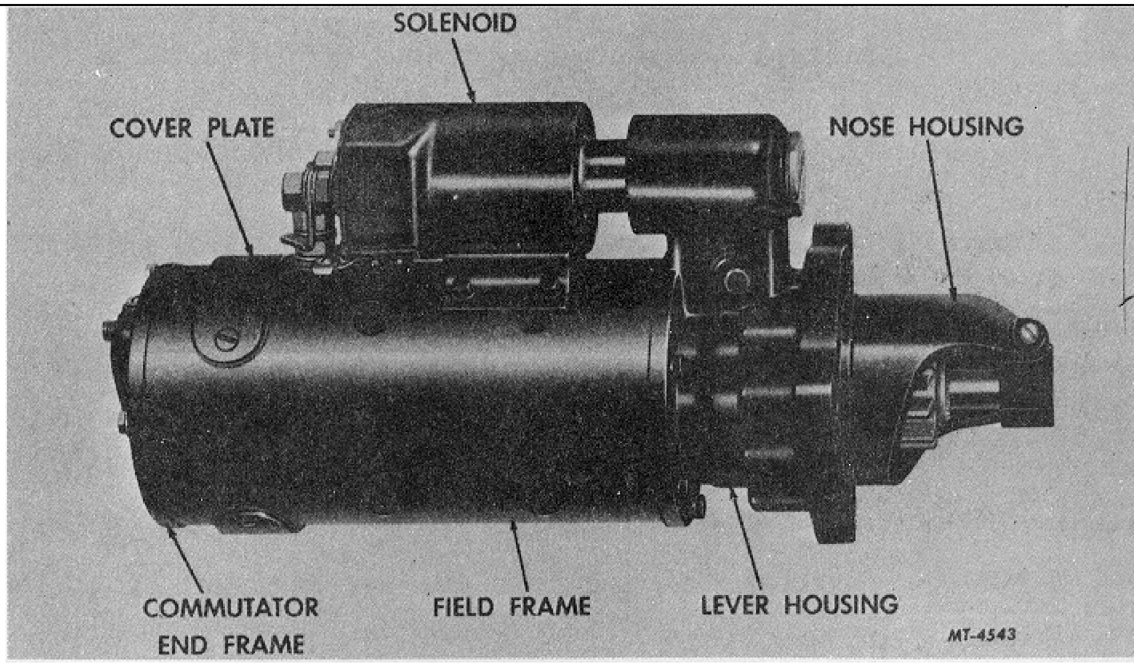


Fig. 1 Heavy Duty Starting Motor with Enclosed Shift Lever.

DESCRIPTION

Heavy duty, enclosed shift lever type starting motors are designed to protect the shift lever and solenoid plunger from dirt, road splash and icing conditions.

The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange, which permits a variety of mounting applications.

NOTE: Be sure to mark the location of the nose housing in some manner to assure proper location of nose housing to lever housing upon reassembly of starting motor.

Either the intermediate duty or the heavy duty overrunning type sprag clutches may be used on the heavy duty starting motors with the enclosed shift lever. Both types of clutches are shifted into mesh with the flywheel ring gear by action of the solenoid. When the drive

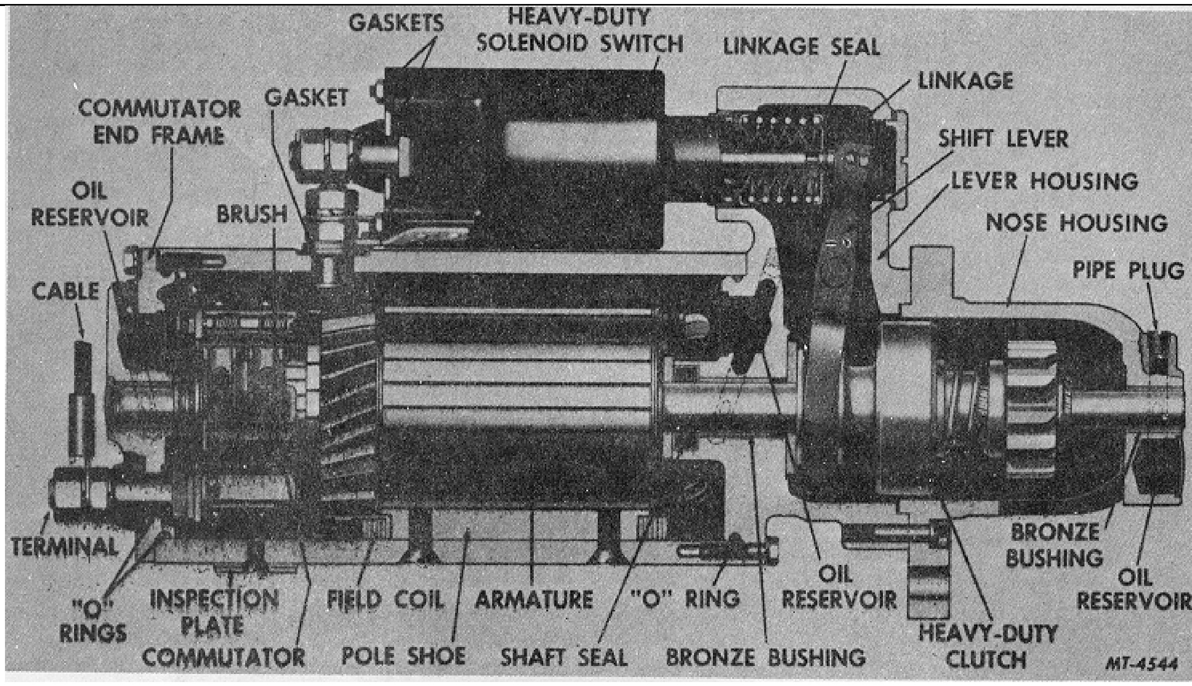


Fig. 3 Sectional View of Staring Motor with Heavy Duty Sprag Clutch

pinion is engaged with the flywheel, the pinion will not be permitted to disengage until the engine has started and the solenoid circuit is interrupted.

Some of the heavy duty starting motors feature a seal between the shaft and lever housing, and all of the heavy duty starting motors with the enclosed shift lever have a rubber boot or linkage seal over the solenoid plunger. These seals prevent the entry of dirt and oil into the motor main frame.

LUBRICATION

Lubrication is provided for the bronze bushings located in the commentator end frame, lever housing and the nose housing, by an oil saturated wick that projects through each bushing and contacts the armature shaft. Oil can be added to the wicks by removing the pipe plugs.

The starting motor should be lubricated whenever it is disassembled with SAE10 oil.
All the wicks should be saturated, reservoirs filled and the splines underneath the clutch should be lubricated with a light coat of oil.

Some of the starting motors are equipped with a large oil reservoir for each wick, also "0" rings are used at various locations to resist entry of dirt and moisture. The starting motors which utilize the large oil reservoirs and the "0" ring are called "long life motors".
MAINTENANCE

On chassis operating under normal conditions no maintenance to these starting motors will be required. When the engine is overhauled the starting motor should be disassembled, inspected, cleaned, tested and any repairs made.

TROUBLE SHOOTING THE STARTING CIRCUIT

When trouble develops in the starting motor system, and the starter motor cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble is in the battery, starting motor, wiring circuit between them, or elsewhere. Many conditions besides defects in the motor can result in poor cranking performance.

To obtain full performance from a starting motor or to determine the cause of abnormal operation, the motor should be subjected to one or more of the following tests. These tests are performed with the starter motor removed from the engine. Failure of the motor to perform according to the specifications will require disassembly and further checks or adjustments made.

NOTE: All starting motor tests should be made with engine and battery at room temperature (not cold).

Regardless of the construction, never operate the starting motor more than 30 seconds at a time without pausing to allow it to cool for at least Z minutes. Overheating caused by excessive cranking will seriously damage the motor.

For the most part a volt-ampere tester (SE2283) will be used in performing the starter tests and the instruction manual supplied with the tester will provide the detailed instructions using the volt-ampere tester.

NOTE: All illustrations of starting motor and circuit tests show leads connected for NEGATIVE grounded system. Reverse the positions of the leads when testing a POSITIVE grounded system. Make sure the volt selector switch on the volt-ampere tester is positioned properly for the voltage system being inspected.

Test No. 1 Cranking Voltage Test

This test tells us the overall condition of battery, starter, cables or switches to determine if sufficient voltage is available to operate ignition system when starter is in operation.

Connect voltmeter leads at the starter observing the polarity, Fig. 5. Disconnect secondary coil lead to prevent engine from starting. Crank engine noting voltmeter reading (should be 9.6 volts or better with 12volt electrical system).

If a reading of less than 9.6 volts is found, proceed to the next test.

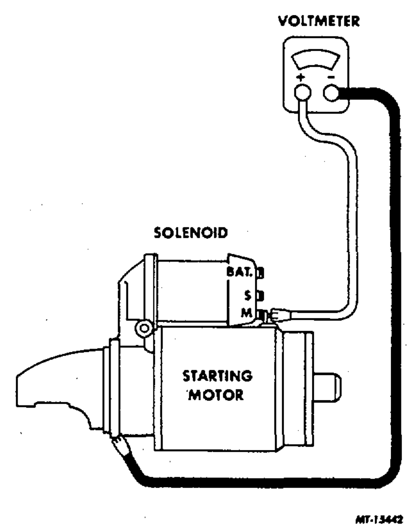


Fig. 5 Cranking Voltage Test

Test No. 2 Battery Capacity Test

The battery capacity test is performed to determine if the battery is in satisfactory condition. See "Battery" Section B. If the battery passes this test, continue the next test.

Test No. 3 Voltage Drop Test

Generally, the starting or cranking circuit is a series circuit from the battery insulated post to the starting motor solenoid, to the motor, to ground (chassis) and return to the battery ground post, Fig. 6.

In the cranking circuit we also have a cranking control circuit, Fig. 6. In this circuit the solenoid is controlled or operated by closing an ignition switch or push button starting switch at the instrument panel. In this cranking control circuit there are frequently some safety switches such as transmission "neutral safety switch" and/or vacuum operated cutout switch.

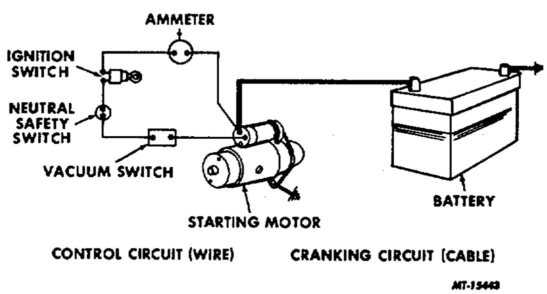


Fig. 6 Starting Motor Circuit

Excessive resistance in the starting or cranking system circuit will cause slow cranking speeds and hard starting. The starting system will function properly only when the "cranking circuit" and "control circuit" with the components are in satisfactory condition.

Corrosion, loose terminal, damaged or undersized cables (wires) will cause cranking problems. In addition, the switches involved must make good electrical connections when closed.

The voltage drop test will be performed in three steps: cranking circuit, control circuit and grounded side.

Cranking Circuit: Voltage drops are measured by connecting a voltmeter in parallel across the circuit or section of a circuit being inspected, then reading the voltmeter while circuit is in operation. To test voltage drop in the cranking circuit from battery to starter, connect the voltmeter (observing the polarity and voltage rating of meter) to battery post CTS2259K (not clamp) to starter motor terminal as shown in Fig. 7. Prevent engine from starting during test. Crank engine and observe voltmeter reading.

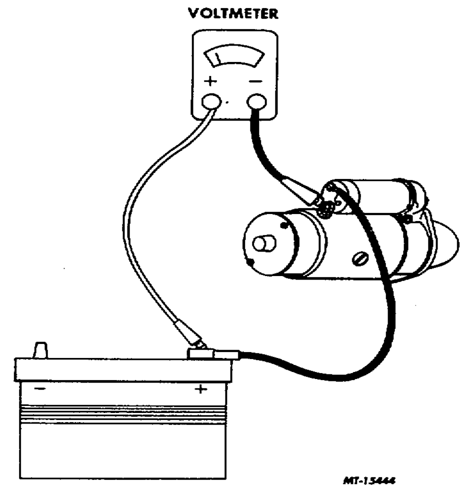


Fig. 7 Cranking Circuit Test

Values of maximum voltage drops for a standard 12volt cranking circuit are as follows:

Cable Under Three (3) Feet	.1
Cable Over Three (3)to Six (6) Feet	.2
Mechanical Switch	.1
Solenoid Switch	.2
Magnetic Switch	.3
Each Connection	.0

Add these values together. For example, you have a total of .5 volt and you have less than . 5 volt drop, continue to grounded side test.

However, if you have more than .5 volt drop, you have an excessive voltage drop. This must be located by moving test lead from starting motor and working toward the battery. Crank engine and each move. When a noticeable decrease in the voltage reading is obtained the trouble will be located between that point and the preceding point checked.

Items which could be at fault can either be a damaged cable or poor connection, an undersized wire or possibly a bad solenoid (contact within the solenoid). Repair the fault.

Grounded Side: High resistance in ground circuit of starting motor system will result in hard starting and may affect the charging circuit as well.

Connect voltmeter leads to ground on starting motor and to ground post of battery. The allowable voltage drop of .2 volt is permissible. If more than .2 volt is obtained, a poor ground is present, such as a loose starting motor mounting bolt, bad battery ground connector or ground connection to engine or frame, depending upon the battery installation. The excessive voltage drop is located in much the same manner as in the preceding test working toward the battery.

Control Circuit: High resistance in the control circuit will reduce the current flow through the solenoid windings, which can cause improper function of solenoid or not at all. Improper functioning of the solenoid could result in burning of contacts in the solenoid causing high resistance in the starting motor circuit.

To complete control circuit test, check the vehicle circuit diagram to assist in locating the wires and particular switches involved in the chassis. Observe polarity of voltmeter and connect leads to battery post and solenoid switch terminal as shown in Fig. 8. Crank engine using the vehicle ignition switch or push button if equipped observing the voltmeter reading. If the voltmeter shows less than .5 volt, the circuit is in good condition. If more than .5 volt, this is an indication of excessive resistance. However, with experience, slightly higher voltage loss will be found and will be normal.

Isolate the point of high resistance by placing the voltmeter leads across each component in the circuit in turn. A reading of more than . 1 volt across any one wire or switch is usually an indication of the trouble.

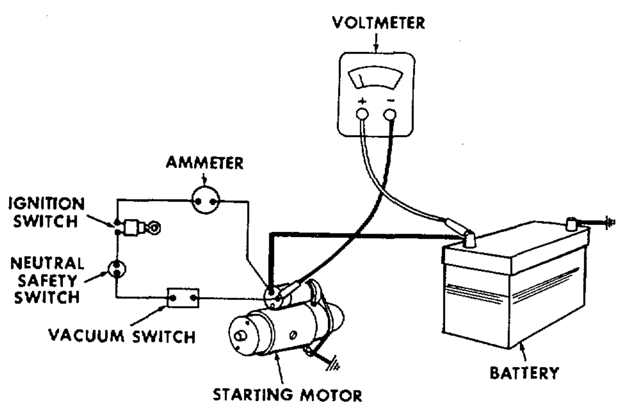


Fig. 8 Control Circuit Test

Test No. 4No Load Test

After completing the cranking voltage test, battery capacity test and the voltage drop tests, and the starting motor still fails to function, remove the motor and make the no load test as follows.

Note that the preceding tests were made in the particular order to make certain the starting motor circuit is in good condition before needless starter motor removal.

Before performing the "No Load Test" look the motor over. The pinion should be checked to be sure it is free by turning it on the screw shaft. The armature should be checked so that it is free to rotate by prying the pinion with a screw driver. Tight bearing, bent armature shaft or loose pole shoe screws could cause the armature not to turn freely. The motor should be disassembled if the armature does not turn freely. However, if the armature will rotate freely, the next step is to give the motor a no load test before disassembly.

Connect the starting motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated in Fig. 9 from the motor terminal to the motor frame. An R. P. M. indicator is necessary to measure armature speed. Obtain the specified voltage by varying the resistance unit, then read the current draw and the armature speed and compare these readings with the values listed in the specifications.

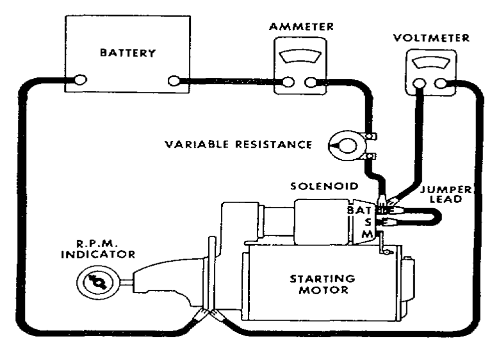


Fig. 9 No Load Test Hookup

DISASSE MB LY

If the starting motor does not perform according to the specifications it will be necessary to disassemble it for further tests of the components.

NOTE: Before starting to disassemble the starting motor etch mark the field frame, lever housing and the nose housing so they may be reassembled in the same position.

Heavy Duty Drive Clutch Motor

1. Disconnect field coil connector from solenoid motor terminal and lead from solenoid ground terminal.

2. Motors which have brush inspection plates, remove the plates, then remove the brush lead screws which disconnect the field leads from the brush holders.

3. Separate the commentator end frame from the field frame.

4. Separate the nose housing and field frame from the lever housing.

5. Remove the armature and clutch assembly from lever housing.

6. Separate solenoid from lever housing by pulling apart.

INSPECTION AND REPAIR

1. Brushes and Brush Holders-- Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Clean brush holders and be sure that the brushes will not bind in the holders. The full length of the brush surface should ride on the commentator with spring tension to provide a good contact. Inspect the brush leads and screws to be sure they are tight and clean.
2. Armature-- Inspect the armature to be sure there are no short circuits, open or grounds.

   a. Short circuits are located by turning the armature in a growler while holding a steel strip on the armature. The steel strip will vibrate on the area of the short circuit, see Fig. 11.

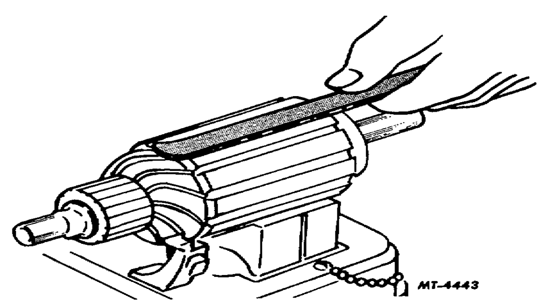


Fig. 11 Testing Armature for Short Circuits

b. Opens are usually found where the conductors are joined to the commutator. Loose or poor connections will cause arcing and burning of the commutator. If the bars are not burned too bad, resolder the leads in the riser bars and turn the commutator down in a lathe. Then under cut the insulation between the commutator bars 1/32".

c. Grounds in the armature can be found using a test lamp and prods, see Fig. 12 If the lamp lights when one prod is positioned on the commutator and the other prod on the armature core or shaft the armature is grounded.
If the commutator is worn, dirty or out-of-round or the insulation is high, the commutator should be turned down and under cut.

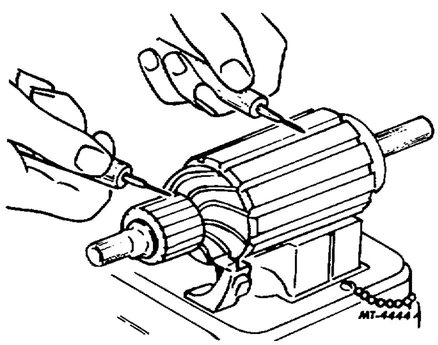


Fig. 12 Testing Armature for Grounds

3. Field Coils-- Check field coils for grounds and opens with a test lamp.

   a. Grounds With the field coil ground disconnected, position one test prod on the field frame and the other to the field connector. If the lamp lights the field coils are grounded and must either be replaced or repaired.
   b. Opens If the test lamp does not light when the prods are connected to the ends of coil leads, the field coils are open.

A pole shoe spreader and pole shoe screw driver should be used if the field coils are to be removed. Extra caution should be taken in replacing the field coils to prevent grounding or shorting when they are tightened in place. If the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

CLUTCH ASSEMBLIES

Four kinds of clutches or motor drives (a heavy duty sprag, a Positork drive, an intermediate duty type and a splined drive) may be used on the enclosed shift lever heavy duty motors.

The intermediate clutch may be either the sprag type or the four roll type. All four types are moved into mesh with the flywheel ring gear by action of the solenoid. The pinion will remain engaged until starting is assured and the solenoid is interrupted.

4. Reassembly is the reverse of the disassembly.

Heavy Duty Sprag Clutch and DR250 Drive

1. Remove the cupped pinion stop and split washer. When removing the cupped pinion stop it will probably be damaged. A new one will be required at time of reassembly.

2. Remove remaining parts such as pinion washer or retainer cups and baffle if equipped. The splined drive will have a spring cup (spring inside cup).

3. DO NOT lubricate the sprags on heavy duty clutches as they are lubricated for life with a special lubricant.
4. Reassembly is the reverse of the disassembly.

REASSEMB LY

The reassembly procedure for the most part is the reverse of the disassembly.

3. When reinstalling the field frame lever housing and nose housing align the etch marks scribed when the motor was disassembled.

4. Starting motors with the end frame which utilize eight brushes a. Pull the armature out of the field frame just enough to permit the brushes to be positioned over the commutator.

    b. Push the commutator end frame and armature back against the field frame.

5. On intermediate duty clutch motors, be sure to assemble all brushes to the brush arms so the long side of the brush is toward the commutator end frame (the brush holes are offset). Otherwise, the brushes may contact the riser bars.
6. Be sure all wicks and oil reservoirs are saturated with SAE10 oil and the splines were coated with a light coat of SAE10 oil also. Lever housings having a bearing and seal should have the grease cavity between the bearing and seal filled with Delco Remy Lubricant No. 1960954 or equivalent (Fig. 3

PINION CLEARANCE

There are no provisions for adjusting the pinion clearance on motors using the intermediate duty clutch, Fig. 2. However, the pinion clearance should be checked on all motors after reassembly to insure proper clearance. Check the pinion clearance as follow s:

1. Disconnect the motor field coil connector from the solenoid motor terminal. CAREFULLY INSULATE IT.
2. Connect a battery, of the same voltage as the solenoid, one lead to solenoid switch terminal and the other to the starter or solenoid frame, Fig. 15W
3. Connect a jumper wire to the starting motor terminal on the solenoid, then touch the second end to the motor frame. This will shift the pinion into cranking position and will remain until the battery is disconnected.
   CAUTION: Do not keep the jumper wire connected too long as overheating of the solenoid may result.
4. Push the pinion back towards the commutator end to eliminate any over travel. Measure the distance between the pinion stop and

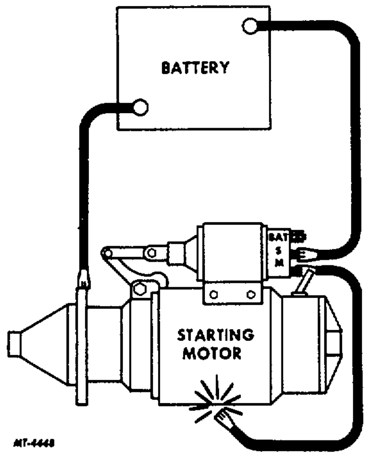


Fig. 15 Pinion Drive Clearance Check Hookup

pinion. The clearance should be:

Heavy Duty Clutch 23/64 inch, Fig. 17.

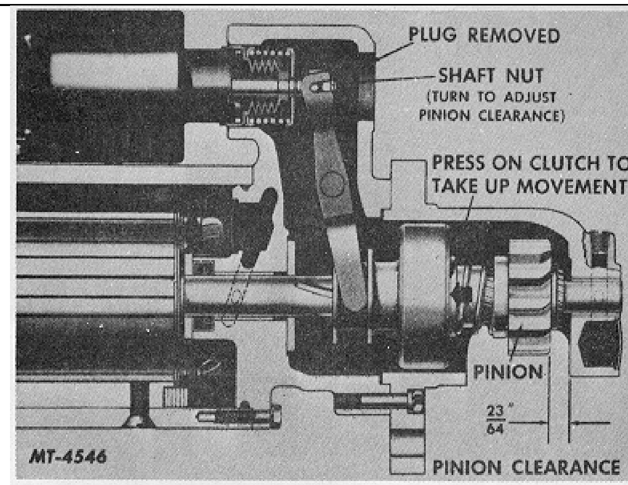


Fig. 17 Checking Pinion Clearance on Motors with the Heavy Duty Sprag Clutch

5. Clearance is adjusted by removing plug and gasket on rear housing and turning the adjustment nut, Fig. 17

SPECIFICATIONS

			NO LOAD TEST			
Model Number	Type System (Voltage)	Volts	Min. Amps.*	Max. Amps.*	Min. RPM	Max RPM
1114088	12	9	140	190	4000	7000

* Includes Solenoid

ENGINE, CUMMINS - MAINTENANCE

MODEL NTC 290 CUBIC INCH DISPLACEMENT 855

290 HP @ 2100 RPM (500 Ft/850 F.)

TURBOCHARGED 6CYLINDER

51/2" BORE AND 6" STROKE

CONTENTS

MAINTENANCE SCHEDULE

Preventive maintenance performed on schedule is the easiest, as well as the least expensive type of maintenance. It permits the Maintenance Department to do work on schedule, rather than at inconvenient hours.

Accessories must have a place in the maintenance schedule the same as the basic engine, for an accessory failure may put the engine out of operation. Consult accessory manufacturer for maintenance recommendations.

Actual operating environment of the engine must govern the establishment of the maintenance schedule. Some engines operate under rather clean conditions, some under moderately dusty conditions and others under severely dusty or dirty conditions; each type of operation must be analyzed as the maintenance schedule is established.

Hours of operation, miles [kilometers], or calendar period as shown on Page291are convenient units of measurement, and should be used to set up the maintenance schedule interval basis. These periods, as stated, are based on average operating conditions.

The maintenance schedule check sheet is designed as a guide until adequate experience is obtained to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, calendar of time or miles [kilometers] driven.

A maintenance schedule should be established using the check sheet as a guide; the result will be a maintenance program to fit a specific operation.

The check sheet shown can be reproduced by any printer so the forms may be available for use. The person making each check can then indicate directly on the sheet that the operation has been completed. When a complete column (under A, B, C, etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Storage For Engines Out Of Service

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Contact the nearest Cummins Distributor for information concerning engine storage procedures.

IMPORTANT

Cummins Diesel Engines are built by Cummins to comply with the requirements of the Federal (U.S.) Clean Air Act. Proper Maintenance of the Engine, which is the owner operators responsibility, is essential to keep emission levels low. This Section sets forth the maintenance schedule which should be followed.

To prove that you have properly maintained the Engine you should retain records, such as work orders and receipts, showing that scheduled maintenance has been performed.

The maintenance record form on page 292 is for your convenience.

"A" MAINTENANCE CHECKS

<u>Check Leaks And Correct</u>

Check for evidence of external air, coolant or oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. Fig. 2-1. See that they are tightened securely.

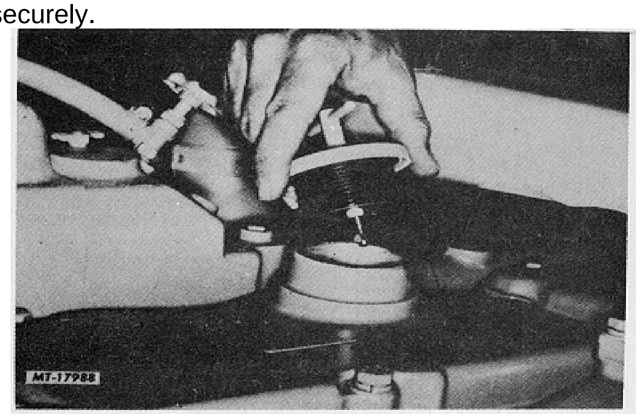


Fig. 2-1 Checking lubricating oil filler tube cap

If there are indications of air leaks on suction side of fuel pump, check for air leaks by placing ST998 Sight Gauge (1, Fig. 22) in the line between fuel filter(s) or fuel tank and pump. Bubbles or "milky" appearance indicates an air leak. Find and correct.

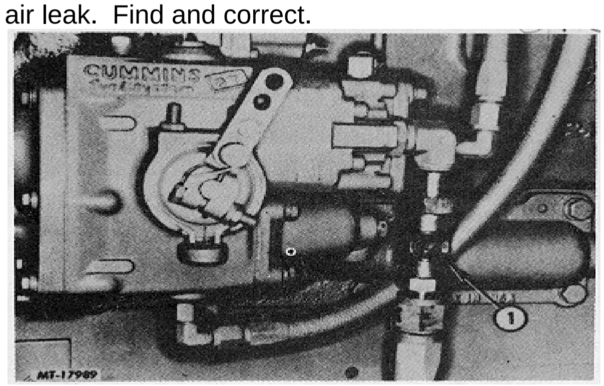


Fig. 2-2 Check ins air leaks with ST998 Sight Gauge

Maintenance Schedule

Cummins Automotive Engines

EQUIPMENT NO. ____________ ENGINE SERIAL NO. ____________
MECHANIC ____________ MILEAGE, HOURS ____________
TIME SPENT ____________ CHECK PERFORMED ____________
PARTS ORDER NO. ____________ DATE ____________

Check each operation as performed.

A–Daily	B–Check	C–Check	D–Check	E–Check	Seasonal
☐ Check Operator Report	☐ Repeat "A"	☐ Repeat "A" and "B"	☐ Repeat "A, B and C"	☐ Repeat "A, B, C and D"	☐ Spring and Fall
☐ Check Leaks and Correct ☐ Check Engine Oil Level ☐ Check Oil Bath Cleaner Oil Level ☐ Check Completely for Damage	☐ Change Engine Oil ☐ Change Full-Flow Filter Elements ☐ Change By-Pass Filter Element ☐ Record Oil Pressure ☐ Change Fuel Filter(s) ☐ Check Air Piping and Mountings ☐ Check Air Cleaner Restriction – Service Element(s)/Oil Level as Required ☐ Clean Crankcase Breather ☐ Check Throttle Linkage ☐ Change Water Filter [2] ☐ Check Engine Coolant ☐ Check and Adjust Belt Tension ☐ Adjust Injectors, Crossheads and Valves[3]	☐ Clean Engine ☐ Check Alternator and Cranking Motor Brushes and Commutators ☐ Adjust Injectors, Crossheads and Valves ☐ Check Exhaust Back Pressure ☐ Check Vibration Damper ☐ Check Fuel Manifold Pressure ☐ Change Aneroid Oil and Replace Aneroid Breather ☐ Check Aneroid Adjustment ☐ Inspect Water Pump, Idler Pulley and Fan Hub	☐ Clean and Calibrate Injectors ☐ Replace Fuel Pump Screen and Magnet ☐ Check Fuel Pump Calibration ☐ Clean Turbocharger/Check Clearance ☐ Inspect/Install Rebuilt Units as Necessary ☐ Replace Bellows and Calibrate Aneroid ☐ Clean Oil Bath Air Cleaner ☐ Rebuild or Replace Water Pump	☐ "In Chassis Inspection" ☐ Check Engine Blow-By	☐ Clean Cooling System ☐ Check Hose ☐ Clean Electrical Connections ☐ Check Cold Starting Aid ☐ Check Thermal Controls ☐ Check Mountings ☐ Check Fan Mountings ☐ Check Crankshaft End Clearance
Interval Basis[1]	B	C	D	E	
Miles Hours Calendar	10,000 250 3 Mos.	50,000 1,250 1 Year	150,000 3,750 2 Years	300,000 7,500 4 Years	Line haul

Notes:
1. Perform checks on operating basis of interval that occurs first. Normally calendar period is used only when mileage is less than 1/3 that suggested during the three (3) month period.
2. At any time cooling system is completely drained and/or flushed, use DCA pre-charge element until next "B" Check.
3. At first oil change or initial inspection, adjust injectors and valves, thereafter at "C" Check.

Engine Serial No. ____________ Engine Model ____________

Owner Name ____________ Equipment Name/Number ____________

Interval Basis						Actual	Distributor/Dealer	Authorized
Mileage	Check	Mileage	Check	Other	Date	Mileage	Location/Shop	Signature
6,000	A, B	10,000	A, B					
12,000	A, B	20,000	A, B					
18,000	A, B	30,000	A, B					
24,000	A, B	40,000	A, B					
30,000	A, B, C							
36,000	A, B	50,000	A, B, C					
42,000	A, B	60,000	A, B					
48,000	A, B	70,000	A, B					
54,000	A, B	80,000	A, B					
60,000	A, B, C	90,000	A, B					
66,000	A, B							
72,000	A, B	100,000	A, B, C					
78,000	A, B	110,000	A, B					
84,000	A, B	120,000	A, B					
90,000	A, B, C, D	130,000	A, B					
96,000	A, B	140,000	A, B					
102,000	A, B	150,000	A, B, C, D					

Engine Oil Level

1. Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked until oil has settled into pan after engine shutdown. Keep dipstick with the engine and oil pan with which it was originally furnished. Keep oil level as near "H" (high) mark as possible.

Caution: Never operate the engine with oil level below "L" (low) mark or above the "H" (high) mark.

2. Add oil as necessary of the same quality and brand as already in the engine. See Section 3.

Check Oil Bath Cleaner Oil Level

Daily check oil level in oil bath air cleaner to be sure oil level in oil cup is at indicated mark. To remove oil cup, loosen wing nuts. During wet weather and in winter months, excessive moisture in air cleaner oil sometimes causes cleaner to become flooded and results in oil pullover or plugging of the bottom air cleaner screen. Add or change oil as necessary.

Check Completely For Damage

Visually check fuel system, aneroid, if used, etc. for misadjustment or tampering, check all systems and connections for leaks or damage.

"B" MAINTENANCE CHECKS

At each "B" Maintenance Check, perform all "A" Checks in addition to the following.

Change Engine Oil

General Limits For Oil Change

1. Minimum Viscosity (Dilution limit): Minus one SAE grade from oil being tested or point equal to a minimum containing five percent by fuel oil volume.
2. Maximum Viscosity: Plus one SAE grade from oil being tested, or ten percent increase at 210 deg. F [99 deg. C] or 25 percent increase at 100 deg. F [38 deg. C].
3. Sediment Content: Normal penetane insoluble 1.0 to 1.5 percent. Benzine insoluble 0.75 to 1.0 percent.
4. Acid Number: Total number 3.5 maximum.
5. Water Content: 0.2 percent maximum.
6. Additive Reduction: 25 percent maximum.

Caution: If the above tests indicate presence of any bearing metal particles, or if found in filters, the source should be determined before a failure results.

The efficiency of any maintenance program can only be judged on the basis of the failures prevented or intercepted before the engine or unit is damaged.

Change Engine Full-Flow Filter Element (Can Type With Center Bolts)

1. Remove drain plug from filter can and allow oil to drain. Replace drain plug.

2. Loosen center bolt and remove filter can and filter element. See Fig's. 2-4

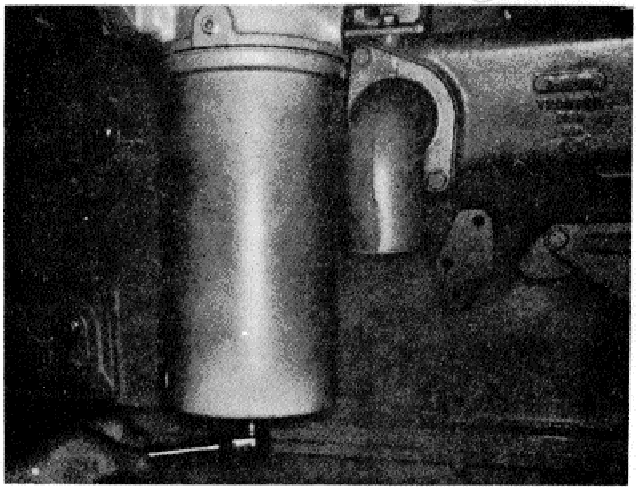


Fig. 2-4, (N10098) Lubricating oil filter (center bolt)

3. Inspect filter element then discard.

   a. Inspect for metal particles.

   b. Inspect outside wrapper of element for wrinkles and pleats for waviness or bunching. Presence of these conditions indicates that oil contains moisture.

   c. If element is relatively clean, it may be possible to lengthen change periods.

   d. If element is clogged, the change period should be shortened, Oil pressure drop reading across filter is the best way to determine change periods.

   e. Discard element after inspection.

4. Remove seal ring from filter head and discard.

Caution: Two or more seal rings attached to filter head will cause leakage, permitting unfiltered oil to enter by-pass element.

5. Clean filter can thoroughly. Handle can and/or store in manner to prevent out-of-round.

Note: Every second oil change, change the small seal ring to prevent oil leakage due to hardening of rubber seal. Inspect seal each oil change. Inspect copper washer each oil change and replace at engine overhaul or if damaged or leaking.

6. Check to make sure element and seals are in place and install new element over spring support assembly.

7. Position new seal ring on filter head; install new element in filter case. Position to filter head and tighten center capscrew to 25 to 35 ft-lbs [34 to 47 N. m]. Tighten clamp-type filter capscrew securely.

Caution: Make sure to fit new seal ring to filter can as design requires or seal may become distorted or damaged.

Change Lubricating Oil By-Pass Filter Element.

To change Cummins Fleetguard by-pass filter elements:

Note: By-pass filters may be mounted either vertically, horizontally or inverted; all are serviced in like manner.

1. Remove drain plug from bottom of housing and drain oil,
2. Remove clamping ring capscrew and lift off cover. lift out element (4) and hold-down assembly. Discard element.
4. Clean housing and hold-down assembly in solvent.
5. Inspect hold-down assembly spring and seal. Replace if damaged.
6. Inspect drain plug and connections. Replace if damaged.
7. On the Cummins Fleetguard by-pass filter, check orifice plug inside oil outlet connection or standpipe; blow out with air jet to make sure orifice is open and clean.
8. Check filter cover "O" ring . Replace if damaged or deteriorated.
9. Install new element in housing.
10. Replace upper support hold-down assembly in filter and tighten down to stop.
11. Position "O" ring seal on housing flange.
12. Install cover and clamping ring; tighten capscrews until clamping lugs are indexed.
13. Fill engine to "H" (high level) mark on dipstick with lubricating oil.
14. Add enough extra oil to crankcase to fill case and element. Run engine check for leaks.
15. Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick. Always allow oil to drain back to oil pan before checking level.

Caution: Never use a 'by-pass filter in place of a full-flow filter.

Record Oil Pressure

Start the engine and operate at 800 to 1000 rpm until the oil temperature gauge reads 140 deg. F [60 deg. C]. Reduce engine speed to idle and record the oil pressure. A comparison of pressure at idling speed with previous readings will give an indication of progressive wear of lubricating oil pump, bearings, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

Change Fuel Filter Element
Replaceable Element

1. Remove drain plug from bottom of filter case and drain contents.

2. Loosen bolt at top of fuel filter. Take out dirty element, clean filter case and install a new element.

3. Fill filter case with clean fuel to aid in faster pick-up of fuel. Install a new gasket in filter head and assemble case and element. Tighten center bolt to 20 to 25 ft-lbs [27 to 34 No m] with a torque wrench.

Check Air Piping Turbocharger
Connections And Manifolds

Check air intake piping from air cleaner to turbocharger or intake manifold. Check for loose clamps, connections, cracks, punctures or tears in hose or tubing. Tighten clamps, manifold capscrews and turbocharger mounting nuts. Replace parts as necessary to insure an air-tight intake system.

Check Inlet Air Restriction Gauge

The best method for determining dry-type air cleaner maintenance periods is through air restriction checks.

A mechanical restriction gauge is available/to indicate excessive air restriction. This gauge can be mounted in air cleaner outlet or on vehicle instrument panel. The restriction indicator signals when to change cartridges. The red flag in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. Change cartridge when flag locks at top. After changing cartridge, reset indicator by pushing reset button Push button all the way in firmly; then release. If button sticks, repeat pushing slowly.

Note: Never remove felt washer from gauge, it is necessary to absorb moisture.

Clean Air Cleaner Elements

Refer to Fuel System for instructions pertaining to servicing the Air Cleaner.

Screen Element Breather Cleaning
And Inspection

1. Remove vent tube if not previously removed.

2. Remove capscrews, washers, cover screens and baffle from the breather body.

3. Clean vent tube, screens and baffle in an approved cleaning solvent. Dry with compressed air. Wipe out breather housing.

4. Assemble baffle, screens and new gasket in body.

5. Replace cover with cover boss resting securely on point of screen; secure with washers and capscrews.

6. Replace vent tube.

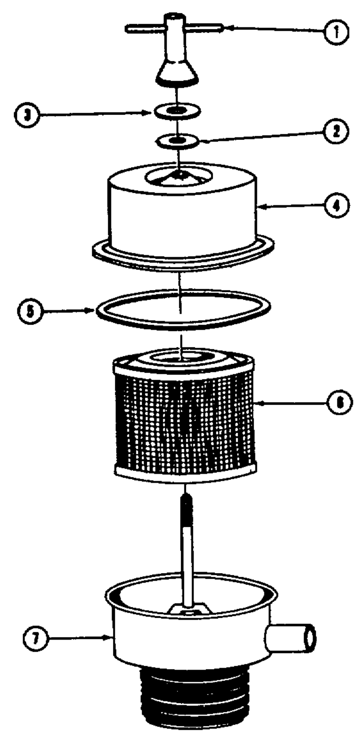


Fig. 2-22, (N20311) Crankcase breather combination type

Check Throttle Linkage

Check throttle linkage and make sure it is in good operating condition. Check throttle travel to make sure linkage operates throttle from stop to full throttle.

Change DCA Water Filter

Change filter or element at each "B" Check; selection of element to be used should be based upon size of system. See "Coolant .

Spin-On Element

1. Close shut-off valves on inlet and drain lines.
2. Unscrew element and discard.
3. Install new element, tighten until seal touches filter head.

Tighten an additional one-half to three-fourths turn. Fig. 2-24. Open shut-off valves.

Caution: Mechanical tightening will distort or crack filter

Fig. 2-24, (N12015). Installing DCA spin-on water filter

Check Engine Coolant

Periodic tests of engine coolant should be made to insure that the frequency of water filter servicing or concentration of DCA inhibitor is adequate to control corrosion for any specific condition of operation. In cases where "make-up' water must be added frequently, we suggest that a supply of water be treated and added as necessary.

The concentration of effective inhibitors dissolved in coolant can be measured by Fleetguard DCA Coolant Checking Kit Part No. 3300846S or Cummins 3375208 which is available from Cummins Distributors.

The test kit indicates DCA concentration by measuring the total nitrite of a coolant sample, which provides cylinder liner cavitation protection.

When antifreeze is present, it may contribute to the total nitrite, but most of the nitrite protection is obtained from the DCA inhibitor. In general, a good nitrite reading indicates that the combined inhibitor packages contained in the antifreeze (if used) and in DCA are sufficient to insure complete cooling system protection.

Check And Adjust Belt Tension

All driven assemblies must be secured in operating position before reading or judging belt tension.

1. Always shorten distance between pulley centers so belt can be Installed without force. Never roll belt over the pulley and never pry it on with a tool such as a screwdriver. Either will damage belts and cause early failure
2. Replace belts in complete sets. Belt riding depth should not vary over 1/16 inch [1. mm] on matched belt sets.
3. Pulley misalignment must not exceed 1/16 inch [1.6mm] for each foot [0. m] of distance between pulley centers.
4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 inch 12. mm] above top edge of groove.
5. Do not allow belts to rub any adjacent parts.

Fig. 2-27, (Ni1977) Checking belt tension

Belt Tension

1. Using appropriate gauge, Fig . 2-27, check and/or adjust belts to tension as indicated in Table 2-2.

Table 2-2: Belt Tension (Pounds)

Belt Width (Inches)	New Belt Installation Tension	Running Tension	Reset Tension After Run-In	Belt Tension Gauge
3/8	110	70 to 90	70	ST-1274
3/8	110	80 to 95	80	ST-968
1/2	110	80to100	80	ST-1274or ST-968
11/16	110	80to100	80	ST-1138
3/4	110	70 to 100	80	ST-1138
7/8	120	90to 110	90	ST-1138
1	130	100to 120 100	ST-1138	
15/32 (FFC Idler Pulley)	120 to 140	70 to 90	70	ST-1274 or ST-968

Inline Engine Water Pump Belts (With Idler)

1. Loosen capscrews and lockwashers or locknut securing idler pulley to bracket or water pump (3, Fig. 2-29).

2. Using a pry bar (NTA) or adjusting screw (FFC Series)adjust idler pulley until proper belt tension is indicated on gauge See Table 2-2.

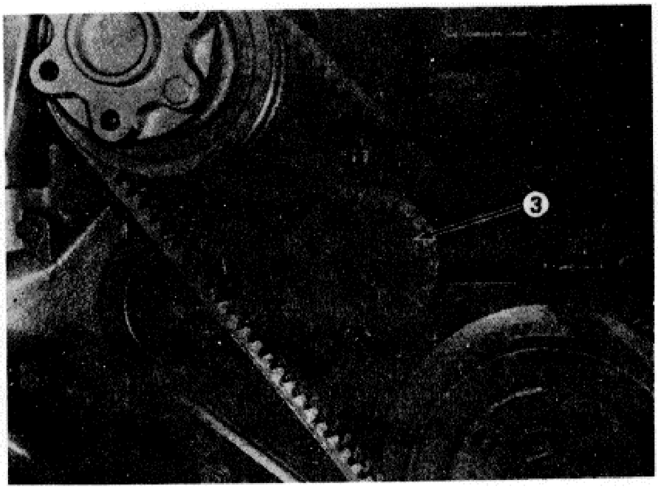


Fig. 2-29, (N11974) Water pump -with idler

3. Secure idler pulley or bracket in position by tightening locknut or capscrews and lockwashers to 45 to 55 ft-lb 161 to 75 No m] torque.

Fan Drive Belts

1. Loosen large locking nut on fan hub shaft or capscrews securing fan hub shaft to mounting bracket. The fan hub will fall out of line when this is done.
2. Turn the adjusting screw to increase belt tension.
3. Tighten the locknut or capscrews until the fan hub is straight. Snug the nut to maintain hub in proper alignment with the fan hub bracket.

Caution: Do not adjust to full tension with the adjusting screw, this would result in overtightening.

4. Belt tension should read as indicated in Table 2-2 on applicable gauge. If a gauge is not available, the belt should be checked with finger pressure at the center of the longest span. Deflection should be one thickness per foot [0.3 ml of pulley center distance.
5. Tighten 855 Series Engines locknut to 400 to 450 ft-lb [542 to 610 N • J, then back off 1/2 turn.
6. Recheck belt tension.
7. Back out adjusting screw one-half turn to prevent breakage.

Generator/Alternator Belts

Belt tension should be as indicated in Table 2-2

Readjusting New Belts

All new belts will loosen after running a short period of time and must be readjusted to installation tension. After initial installation and retensioning, belts should then be set at running tension. Ref. Table 2-2.

"C" MAINTENANCE CHECKS

At each "C" Maintenance Check, first perform ail "A" and "B" Checks in addition to those following.

Steam Clean Engine

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use an approved solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the cleaner spray nozzle.

Check Alternator And Cranking Motor Brushes And Commutators Failure of an alternator or cranking motor may cause unit downtime and nearly always result in expensive replacement.

1. Inspect terminals for corrosion and loose connections and wiring for frayed insulation. Check mounting bolts for tightness and check belt for alignment, proper tension and wear.
2. Slip rings and brushes can be inspected through alternator end frame assembly. If slip rings are dirty, they should be cleaned with 400-grain or finer polishing cloth.

Note: Never use emery cloth to clean clip rings. Hold polishing cloth against slip rings while rotating alternator, blow away all dust after cleaning operation.

3. Check alternator bearings for wear. Shaft will be excessively loose if bearings are worn.
4. If brushes are worn close to the holder, the alternator must be removed and sent to manufacturer's rebuild station.

Adjust Injectors And Valves

It is essential injectors and valves be in correct adjustment at all times for engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Final operating adjustments must be made using correct values as stated.

Temperature Settings

The following temperature conditions provide the necessary stabilization of engine components to assure accurate settings.

Definition of "Cold Set"

Engine must have reached a stabilized temperature (oil temperature to be within 10 deg. F of ambient air temperature).

Definition of "Hot Set"

1. Set injectors and valves immediately after the engine has reached normal stabilized operating oil temperature.

2. If oil temperature gauge is unavailable, set injectors and valves immediately after engine has operated at rated speed and load or at high idle for a period of 20 minutes.

Injector And Valve Adjustment Using ST-1270 Dial Indicator Method NH-NT Series

This method involves adjusting injector plunger travel with an accurate dial indicator rather than tightening the adjusting screw to a specified torque. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-11.

When engine has been set in proper position for injector to be adjusted, tighten adjusting screw until all lash is removed from injector train. Then tighten adjusting screw one additional turn to properly seat links and to squeeze oil from socket surfaces. Back adjusting screw off until spring washer contacts stop. Now adjust zero clearance, use 3375232 Torque Wrench and tighten screw to 5 to 6 inch-lbs [0.56 to 0.68 N. m] torque. Zero clearance being defined as the condition where the link is slightly loaded.

Note: If torque wrench is not available, zero clearance can be set at point approximately where link is slightly loaded, but just free enough to be rotated by thumb and forefinger.

Hold adjusting screw with screwdriver and tighten locknut to proper torque.

Note: If injectors were removed for cleaning or replacement tighten injector, hold-down capscrews In alternate steps' to 10 to 12 ft-lb [14 to 16 N•m J torque.

Table 2-11: Injector and Valve Set Position

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A or 1-6VS	3	5
Adv To	B or 2-5 VS	6	3
Adv To	C or 3-4 VS	2	6
Adv To	A or 1-6 VS	4	2
Adv To	B or 2-5 VS	1	4
Adv To	C or 3-4 VS	5	1

Injector And Valve Adjustment

Note: Injectors and valves may be adjusted without removal of the Jacobs Brake by using 3375096 Jacobs Brake Kit. This kit includes a special rocker lever actuator, dial indicator extension, feeler gauge and special offset wrenches.

See Table 2-12 for adjustment with cast iron or aluminum rocker housings.

1. Bar engine until A or "1-6 VS" is aligned with pointer. Fig. 2-50. Both valve rocker levers for No. 5 cylinder should be free (valves closed). Injector plunger for No. 3 cylinder must be at top of travel. If not, check No. 2 cylinder for valves being free and No. 4 injector plunger should be at top of travel. See Table 2-11 for Valve Injector Set Position.

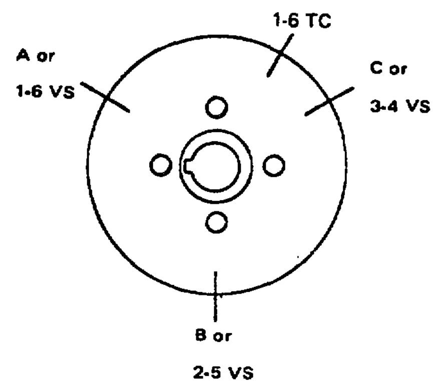


Fig. 2-50, (NI14230) Accessory drive pulley markings

2. Install ST-1270 to rocker housing with indicator extension on top of injector plunger for cylinder as determined in Step 1 above. See Fig. 2-51.

3. Screw injector lever adjusting screw down until plunger is bottomed in cup, back off approximately 1/2 turn then bottom again, set dial indicator at zero (0).

Note: Care must be taken to assure injector plunger is correctly bottomed in cup, without overtightening adjusting screw, before setting dial indicator.

4. Back adjusting screw out until a reading of 0.170 inch [4.32 mm] or 0.175 inch [4.45 mm] , reference Table 2-12, is obtained on dial indicator. Snug tighten locknut.

5. Using ST-1193 Rocker Lever Actuator, bottom injector plunger, check zero (0) setting. Fig. 2-51. Allow plunger to rise slowly, indicator must show plunger travel to be within range specified in Table 2-12.

6. Using ST-669 Torque Wrench Adapter to hold adjusting screw in position, torque locknut 30 to 35 ft-lb [41 to 47 No mi. If torque wrench adapter is not used, hold adjusting screw with a screwdriver, torque locknuts 40 to 45 ft-lb [54 to 61 No mi.

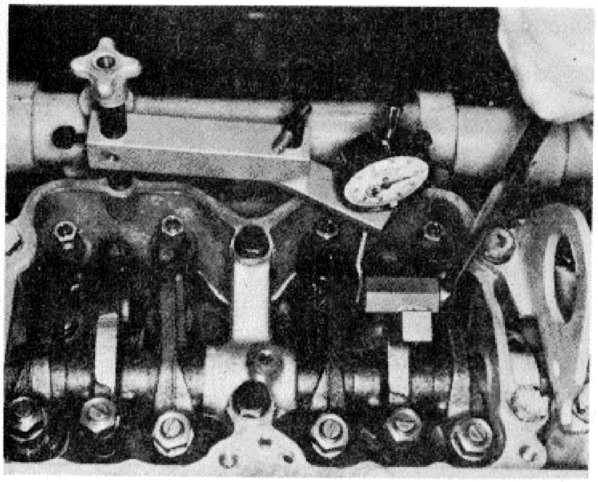


Fig. 2-51, (N114237) Bottoming injector plunger in cup

7. Actuate injector plunger several times as a check of adjustment. Remove dial indicator assembly.
8. Adjust valves on appropriate cylinder as determined in Step 1 and Tables 2-11 and 2-12. Tighten locknuts same as injector locknut.
9 Continue to adjust remaining cylinders. See Table 2-11.

Table 2-12: Adjustment Limits Using Dial Indicator Method Inch [mm]

Oil Temp	Injector Plunger Travel	Valve Clearance Intake	Exhaust
Aluminum Rocker Housing			
Cold	0.170 + 0.001	0.011	0.023
	(4.32 + 0.03]	[0.28]	[0.58]
Hot	0.170 + 0.001	0.008	0.023
	[4.32 + 0.03]	[0.20]	[0.58]
Cast Iron Rocker Housing			
Cold	0.175 + 0.001	0.011	0.023
	[4.45 + 0.031	[0.28]	[0.58]
Hot	0.175+ 0.001	0.008	0.023
	[4.45 + 0.03]	[0.20]	[0.58]

Adjust Injectors And Valves NH, NT (Torque Method)

Timing Mark Alignment

1. Loosen the injector rocker lever adjusting nut on all cylinders. This will aid In distinguishing between cylinders adjusted and not adjusted.
2. Bar engine in direction of rotation until a valve set mark (1, Fig. 2-52) aligns with the boss (2) on the gear case cover. Example: A or "1-6 VS". This location is marked with a notch in the drive pulley. Note: Fig. 2-52 illustrates 3-4 "VS" valve set mark,

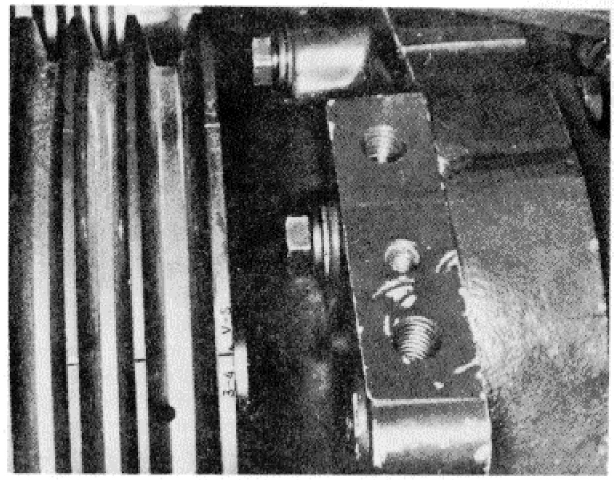


Fig. 2-52, (N114220) Valve set timing marks

3. Check the valve rocker levers on the two cylinders aligned as indicated on pulley (example: 1 and 6 cylinders for A or "1-6 VS"). On one cylinder of the pair, both rocker levers will be free and valves closed, this is cylinder to be adjusted.
4. Adjust injector plunger first, then crossheads and valves to clearances indicated in the following paragraphs.
5. Engine Firing Order is 1-5-3-6-2-4.
6. Continue to bar engine to next "VS" marks and adjust each cylinder in firing order.

Note: Only one cylinder is aligned at each mark. Two complete revolutions of the crankshaft are required to adjust all cylinders.

Injector Plunger Adjustment

The injector plungers must be adjusted with an Inch-pound torque wrench to a definite torque setting. A torque wrench with a screwdriver adapter can be used for this adjustment. See Fig. 2-53.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.
2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter, tighten’ the adjusting screw to values shown in Table 2-14 and tighten the locknut to 40 to 45 ft-lb [54 to 61 N•m] torque. If ST-669 Torque Wrench Adapter is used, torque to 30 to 35 ft-lb [41 to 47 N•m.

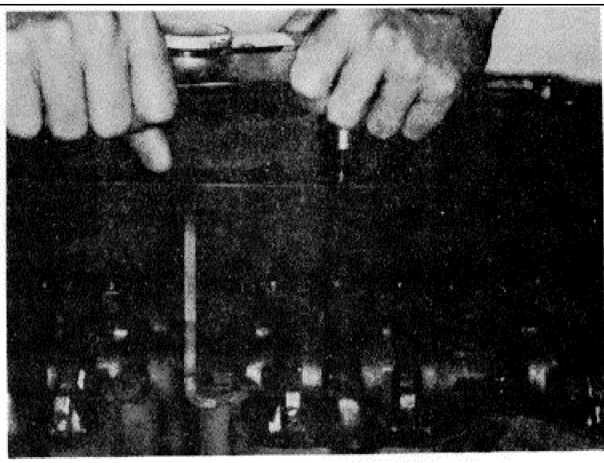


Fig. 2-53 (N-11466)

Table 2-14: Injector Adjustment (Oil Temperature)

Cold Set	Hot Set
Cast Iron Rocker Housing	
48 inch-lb	72 inch-lb
[5.4 N m]	[8.1 N•m]
Aluminum Rocker Housing	
72 Inch-lb	72 inch-lb
18.1 No m]	[8.1 N•m]

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves.

The crosshead adjustment changes as a result of valve seat wear during engine operation. Make sure crossheads are adjusted before adjusting valve rocker levers.

1. Loosen valve crosshead adjusting screw locknut and back off screw (4, Fig. 2-54) one turn.

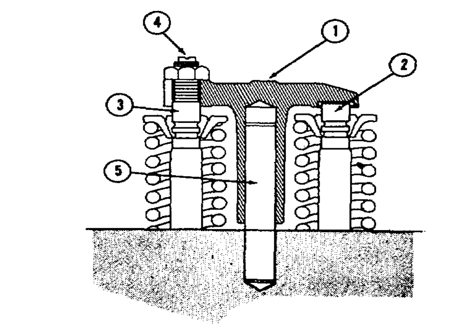


Fig. 2-54,(N21461) Valve crosshead.

2. Use light finger pressure at rocker lever contact surface (1) to hold crosshead in contact with valve stem (2) (without adjusting screw).
3. Turn down crosshead adjusting screw until it touches valve stem (3).
4. With new crossheads and guides,-advance setscrew an additional one-third of one hex (20 deg.) to straighten stem on its guide (5) and compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance screw as much as 30 deg. to straighten stem on Its guide.
5. Using ST-669 Torque Wrench Adapter, tighten locknuts to 22 to 26 ft-lbs [30 to 35 N•ml. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lbs [34 to 41 N•m]
6. Check clearance (6) between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in running position.

Table 2-15: Valve Clearance - Inch [mm]

Intake Valves		Exhaust, Valves	
Cold Set	Hot Set	Cold Set	Hot Set
Aluminum Rocker Housing			
0.014	0.014	0.027	0.027
[0.36]	[0.36]	[0.69]	[0.69]
Cast Iron Rocker Housing			
0.016	0.014	0.029	0.027
(0.411	[0.361	(0.74]	[0.691

2. Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Fig. 2-55. Tighten locknut to 40 to 45 ft-lbs [54 to 61 No m] torque. When using ST-669 torque to 30 to 35 ft-lbs [41 to 47 N•M].
3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-15 for appropriate valve clearances.

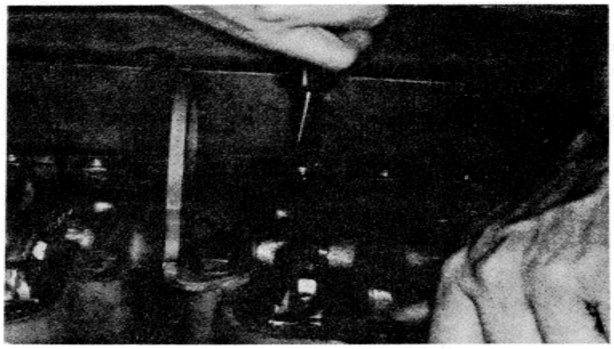


Fig. 2-55, (N114215) Adjusting valves

Check Exhaust Back Pressure

1. When engine pistons must act against a back pressure in exhaust system to expel exhaust gas; usable output of engine is lowered; since air-fuel ratio will be reduced because of incomplete scavenging of cylinder, fuel economy is reduced and exhaust temperatures will increase. Although turbocharged engines are affected to a lesser degree than naturally aspirated engines due to positive pressure in intake manifold, it is essential exhaust system for all engines be designed to offer least possible restriction to exhaust flow.
2. High pressure indicates restriction caused by foreign objects, excessive bends or small size of piping. The lowest pressure obtainable is desired.
3. If exhaust back pressure exceeds value listed below, early engine failure and poor performance may be expected.
4. Check exhaust restrictions (back-pressure) as follows:

a. Using a mercury or water manometer, take readings when engine is developing maximum horsepower at maximum engine speed.

b. Maximum permissible back-pressure is 3.0 inch [76.2 mm] Hg or 40.8 inches [103.6 cm] of water.

Cummins Distributors are equipped with special tools to check exhaust back pressure. If back pressure is too high check entire exhaust system for restrictions.

Inspect Water Pump, Idler Pulley And Fan Hub

Inspect water pump, idler pulley and fan hub for wobble and evidence of grease leakage. Replace with rebuilt prelubricated units as necessary.

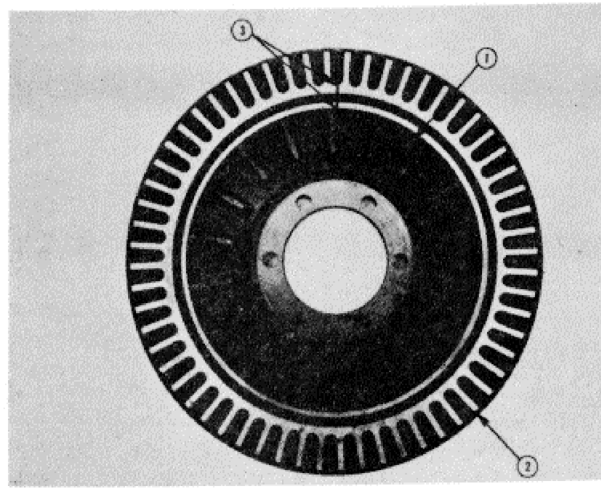


Fig. 2-63, (N10146) Vibration damper alignment marks

There should be no indication of relative rotation between hub and inertia member. Check for extrusion of rubber particles between hub and inertia member.

Check Fuel Manifold Pressure

Note: Air pressure on AFC Fuel Pumps can only be checked by Cummins Distributor.

Assurance of correct governed speed is necessary before any other fuel pump checks are attempted. Use an accurate tachometer or revolution counter. Use of a dynamometer makes determining rated speed easy. If no dynamometer is used, take a reading of the no-load maximum speed. Allow 10% above the rated speed as a maximum governed speed. Example: 2100 rpm rated, 2310 rpm maximum.

There may be some variation In maximum governed speed from various causes.

1. Fan load.
2. Engine temperature.
3. Air compressor pumping.
4. Alternator carrying high charging rate.
5. Any auxiliary load such as power-steering pump, air-conditioning compressor, etc.

6. Variations in governor characteristics make small difference in maximum governed speed between different engines. Such variations are of small importance In most applications.

Note: Injectors must be adjusted to proper specifications before fuel manifold pressure readings.

7. Check maximum fuel manifold pressure with ST-435. Fig. 2-64. Remove 1/8 inch pipe plug from side of fuel shut-off valve on top of fuel pump. Connect the gauge line in pipe plug hole.

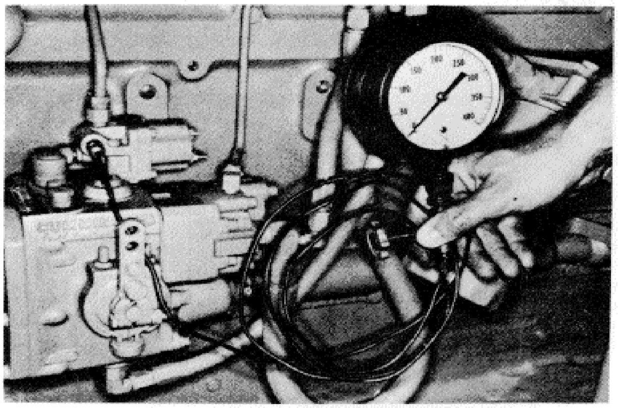


Fig. 2-64, (N11966) Checking fuel manifold pressure with ST-435

8. Remove linkage from the throttle lever. This will allow throttle to be operated by hand.

Caution: On turbocharged engines with aneroids, temporarily disconnect aneroid, inlet line and plug hole, to reach maximum fuel pressure during the short acceleration period.

9. Start the engine. Run long enough to purge air from the pump. Loosen the gauge end of pressure line and bleed air from line.

10. Watch gauge closely and snap throttle fully open. The gauge hand will hit a maximum value, then immediately drop back as the governor takes control.

11. Compare the maximum value with previous readings taken to determine if fuel readings are satisfactory. Normally this check is only taken if there is a suspected loss of power.

12. Remove plug and reconnect aneroid to fuel pump, remove air line from intake manifold to aneroid and check "no air" pressure.

Note: "No air" pressures are given in Fuel Pump Calibration Manual. Check with a Cummins Distributor.

13. Always make the above checks on a hot engine.

__Check Aneroid Adjustment__

Normally, no adjustment of the aneroid is required, however, if smoke is evident and all other engine adjustments have been checked, back out adjusting screw (4, Fig. 2-65). If screw must be backed out until acceleration is slow, have unit checked by a Cummins Distributor.

Note: If smoke is excessive after 15 seconds of full throttle operation, aneroid is not at fault, have fuel system and turbocharger checked.

If, during Fuel Manifold Pressure Check, it is determined that aneroid bellows should be replaced,

__Check Turbocharger Bearing Clearance__

Check bearing clearances every "C" Check; refer to "D" Check.

__Change Aneroid Oil And Replace Breather__

At each "C" Check, remove fill plug and drain plug , allow aneroid to drain. Replace drain plug , fill aneroid with clean engine lubricating oil. Replace fill plug. Remove and replace aneroid breather Tighten breather to 10 to 13 ft-lbs [15 to 18 No m] torque.

’D" MAINTENANCE CHECKS

At each "D" Maintenance Check, perform all "A", "B" and "C" Checks in addition to those following.

__Clean And Calibrate Injectors__

Clean and calibrate injectors regularly to prevent restriction of fuel delivery to combustion chambers. **To clean and calibrate injectors refer to FUEL SYSTEM, Injectors, Calibration Instructions.**

Replace Fuel Pump Screen And Magnet

PT (type G) Fuel Pump

1. Loosen and remove cap, remove "O" ring and spring.
2. Lift out filter screen assembly. Discard screen assembly.
3. Install new filter screen assembly in fuel pump with hole down, position spring on top of filter screen assembly.
4. Replace cap and "O" ring; tighten to 8 to 12 ft-lbs [11 to 16 N•m] torque.

Check Fuel Pump Calibration

Check fuel pump calibration on engine if required. To calibrate fuel pump refer to FUEL SYSTEM Fuel Pump Calibration Instructions.

Clean Turbocharger Compressor Wheel And Diffuser

Keep the compressor wheel and diffuser clean for best turbocharger performance. Any buildup of dirt on the compressor wheel will choke off air flow and cause rotor imbalance.

At every "D" Check, clean the compressor wheel and diffuser. Refer to FUEL SYSTEM, Intake Air System (Turbochargers).

Check Turbocharger Bearing Clearance

Check bearing clearances. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate end-play of the rotor shaft and a feeler gauge to indicate radial clearance.

Checking Procedure

1. Remove exhaust and intake piping from the turbocharger to expose ends of rotor assembly.
2. Remove one capscrew from the front plate (compressor wheel end) and replace with a long capscrew. Attach an indicator to the long capscrew and register indicator point on end of rotor shaft. Push shaft from end-to-end making note of total indicator reading. end clearance should be 0. to 0.020 inch [0.08 to 0.51 mm].
3. Check radial clearance on compressor wheel only.
a. Push wheel toward side of bore.
b. Using feeler gauge, check distance between tip of wheel vanes and bore. clearance should be 0.003 to 0.033 inch [0.08 to 0.84 mm].
4. If end clearance exceeds limits, remove turbocharger from engine and replace with a new or rebuilt unit.
5. Install exhaust and intake piping to turbocharger.

Inspect/Install Rebuilt Unit As Necessary

At this time the following assemblies should be inspected and rebuilt as necessary in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and disassembly and assembly procedures:

Fan Hub
Lubricating Oil Pump
Air Compressor
Injectors
Fuel Pump

Inspect each rebuilt unit before installing it on the engine. Be sure all units are clean and that all capscrews, nuts and bolts are tight. Install units on engine in convenient sequence;

Replace Bellows And Calibrate Aneroid

At each "D" Check replace aneroid bellows. This can be accomplished without changing aneroid settings if precautions are taken to assure that same spring and shims are reinstalled.

1. Remove flexible hose or tube from aneroid cover to intake manifold.
2. Remove lead seal or file away end of rivet type seal, if used.
3. Remove screws and aneroid cover.
4. Remove capscrew or self-locking nut and retaining washer securing bellows to shaft and piston.
5. Clean bellows sealing area on body and cover.
6. Install new bellows, align holes in bellows with corresponding holes in aneroid body. Position retaining washer over bellows and secure with capscrew or self-locking nut.
7. Position cover to body; secure with flatwashers, lockwashers and fillister head screws.
8. Install new seal. Refer to FUEL SYSTEM, Fuel Pump calibration instructions for sealing instructions and calibrating.
9. Reinstall flexible hose or tube from aneroid cover to intake manifold.

Clean Complete Oil Bath Air Cleaner (As Required)

Steam

Steam clean the oil bath air cleaner main body screens. Direct the steam jet from the air outlet side of the cleaner to wash dirt out in the opposite direction of air flow.

Solvent-Air Cleaning

Solvent-bath cleaning requires a 55-gallon drum and a source of air pressure. Any good commercial solvent may be used.

1. Steam clean exterior of cleaner.
2. Remove air cleaner oil cup.
3. Clamp hose with air line adapter to air cleaner outlet.
4. Submerge air cleaner in solvent.
5. Introduce air into unit at 3 to 5 psi [21 to 34 kPa] and leave in washer 10 to 20 minutes.

6. Remove cleaner from solvent and steam clean thoroughly to remove all traces of solvent.
7. Dry thoroughly with compressed air.

Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from cleaner.

8. If air cleaner is to be stored, dip in lubricating oil to prevent rusting of screens.

Note: If screens cannot be thoroughly cleaned by either method, or if body is pierced or otherwise damaged, replace with new air cleaner.

Water Pump

At each "D" check remove and replace water pump with new or rebuilt prelubricated water pump. Refer to Engine Shop Manual for rebuild and lubricating procedure.

Idler Pulley

At each "D" Check, rebuild and repack idler pulley with correct grease. Refer to Engine Shop Manual for rebuild and lubricating procedure for idler pulley.

"E" MAINTENANCE CHECKS

At each "E" Maintenance Check, perform all "A", "B", "C" and "D" Checks in addition to those following.

In Chassis Inspection

The "E" Maintenance Check is made while engine remains in the unit but some assemblies are rebuilt and a major inspection is performed to determine whether engine may be operated for another service period, or whether it should be completely overhauled. Oil consumption, no oil pressure at idling, oil dilution and other signs of wear such as "blow-by" should be analyzed as part of the inspection.

Since major inspection requires partial disassembly of the engine, it should be done only in a well-equipped shop by mechanics thoroughly familiar with worn replacement limits and disassembly and assembly procedures. This information is available in all Cummins Shop Manuals which can be purchased from any Cummins Distributor.

At this period, perform all previous checks and:

- Inspect Bearings
- Rebuild Cylinder Head
- Inspect Cylinder Liners
- Replace Cylinder Liner Seals
- Inspect Pistons
- Inspect Connecting Rods
- Replace Piston Rings
- Inspect Crankshaft Journals
- Inspect Camshaft
- Inspect Cam Followers
- Replace Front And Rear Crankshaft Seals
- Replace Vibration Damper
- Clean Oil Cooler
- Rebuild Water Pump and Idler Pulley
- Rebuild Fan Hub

Parts which are worn beyond replacement limits at this inspection should be replaced with new or rebuilt parts or units.

If, during major inspection, it is determined that crankshaft journals or any other engine parts are worn beyond worn replacement limits, engine should be removed and completely rebuilt.

Check Engine Blow-By

Engine blow-by or escape of combustion gases between pistons and liners, is usually caused by worn or stuck piston rings, worn cylinder liners or worn pistons.

Blow-by can be detected by running the engine and observing the gas escape from the lubricating oil filler hole with cap or breather open or removed. There is always some vapor or gas escape at this point due to heated oil and piston movement, but distinct puffs indicate blow-by.

Experience and comparison with other units operating at the same speed are-needed to make a conclusion as to the extent of blow-by. Normally, excessive blow-by is accompanied by oil consumption.

SEASONAL CHECKS

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Clean Cooling System (As Required)

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection from radiator. Use clean water that will not clog any of the hundreds of small passages in radiator or water passages in block. Clean radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing. Chemical Cleaning A Fleetguard Water Filter is the best way to insure an efficient cooling system by preventing formation of rust and scale. If rust and scale have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by a neutralizer and flushing.

Pressure Flushing

Flush radiator and block when antifreeze is added or removed, or before installing a water filter on a used engine.

When pressure flushing radiator, open upper and lower hose connections and screw radiator cap on tight. Use hose connection on both upper and lower connections to make the operation easier. Attach flushing gun nozzle to lower hose connection and let water run until radiator is full.

When full, apply air pressure gradually to avoid damage to core. Shut off air and allow radiator to refill; then apply air pressure. Repeat until water coming from radiator is clean.

Sediment and dirt settle into pockets in block as well as radiator core. Remove thermostats from housing and flush block with water. Partially restrict lower opening until block fills. Apply air pressure and force water from lower opening. Repeat process until stream of water coming from block is clean.

Check Hose (Spring And Fall)

Inspect oil filter and cooling system hose and hose connections for leaks and/or deterioration. Particles of deteriorated hose can be carried through cooling system or lubricating system and restrict or clog small passages, especially radiator core, and lubricating oil cooler, and slow or partially stop circulation. Replace as necessary.

Clean Electric Connections (Spring And Fall)

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork alternator and regulator and shorten their lives.

1. Add water (distilled) to battery cells as required. Check solution level every 15 days during hot weather, every 30 days during cold weather, keep solution filled to 3/8 inch [9.5 mm] above separator plates.
2. Remove corrosion from around terminals; then coat with petroleum jelly or a non-corrosive inhibitor.
3. Keep connections clean and tight. Prevent wires and lugs from touching each other or any metal except screw terminals to which they are attached.
4. Replace broken or worn wires and their terminals.
5. Have battery tested periodically. Follow battery manufacturer's instructions for maintenance.

Check Cold-Starting Aid (Fall)

Remove 1/8 inch pipe plug from manifold, near glow plug, and check operation of preheater as described in Operators Manual.

Check Shutterstats And Thermatic Fans (Fall)

Shutterstats and thermatic fans must be set to operate in same range as thermostat with which they are used. Table 2-18 gives settings for shutterstats and thermatic fans as normally used. The 180 to 195 deg. F [82 to 91 deg. C] thermostats are used only with shutterstats that are set to close at 187 deg. F [86 deg. C] and open at 195 deg. F [91 deg. C].

Check Thermostats And Seals (Fall)

Remove thermostats from thermostat housings and check for proper opening and closing temperature.

Most Cummins Engines are equipped with either medium 170 to 185 deg. F [77 to 85 deg. C] or low 160 to 175 deg. F [71 to 79 deg. C] and in a few cases high-range 180 to 195 deg. F [82 to 91 deg. C] thermostats, depending on engine application.

Checking Mountings

Tighten Mounting Bolts And Nuts (As Required)

Engine mounting bolts will occasionally work loose and cause the engine supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Tighten Turbocharger Mounting Nuts (As Required)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten mounting bolts and supports so that vibration will be at a minimum. Fig. 2-70.

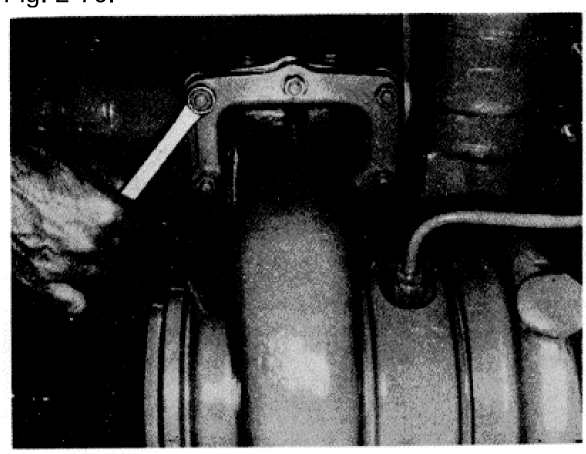


Fig. 2-70, (N11953) Tightening turbocharger mounting nuts

Check Fan And Drive Pulley Mounting (Spring And Fall)

Check fan to be sure it is securely mounted; tighten capscrews as necessary. Check fan for wobble or bent blades.

Check fan hub and crankshaft drive pulley to be sure they are securely mounted. Check fan hub pulley for looseness or wobble; if necessary, remove fan pilot hub and tighten the shaft nut. Tighten the fan bracket capscrews.

Table 2-18: Thermal Control Settings

Control Used	Setting With 160 deg. to 175 deg. F [71 deg. to 79 deg. C] Thermostat		Setting With 170 deg. to 185 deg. F [77 deg. to 85 deg. C] Thermostat		Setting With 180 deg. to 195 deg. F [82 deg. to 91 deg. C Thermostat	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185 deg. F [85 deg. C]	170 deg. F [77 deg. C]	190 deg. F [88 deg. C]	182 deg. F [83 deg. C]	Not Used	
Shutterstat	180 deg. F [82 deg. C]	172 deg. F [78 deg. C]	185 deg. F [85 deg. C]	177 deg. F [81 deg. C]	195 deg. F [91 deg. C]	187 deg. F [86 deg. C]
Modulating Shutters Open	175 deg. F [79 deg. C]		185 deg. F [85 deg. C]		195 deg. F [91 deg C]	

Check Crankshaft End Clearance (At Clutch <u>Adjustment)</u>

The crankshaft of a new or newly rebuilt engine must have end clearance as listed In Table 2-19. A worn engine must not be operated with more than the worn limit and clearance shown in the same table. If engine is disassembled for repair, install new thrust rings.

The check can be made by attaching an indicator to rest against the damper or pulley, Fig. 2-71, while prying against the front cover and inner part of pulley or damper. End clearance must be present with engine mounted in the unit and assembled to transmission or converter.

Caution: Do not pry against outer damper ring.

Table 2-19: Crankshaft End Clearance - Inch [mm]

Engine Series	New Minimum	New Maximum	Worn Limit
NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]

Lubricant

Lubricating Oil

Lubricating oil is used in Cummins engines to lubricate moving parts, provide internal cooring and keep the engine clean by suspending contaminants until removed by the oil filters. Lubricating oil also acts as a combustion seal and protects internal parts from rust and corrosion.

The use of quality lubricating oil, combined with appropriate lubricating oil, drain and filter change intervals, is an important factor in extending engine life. Cummins Engine Company, Inc. does not recommend any specific brand of lubricating oil, The responsibility for meeting the specifications, quality and performance of lubricating oils must necessarily rest with the oil supplier.

Break In Oils

Special "Break-In" lubricating oils are not recommended for new or rebuilt Cummins Engines. Use the same lubricating oil as will be used for the normal engine operation.

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 3-1. Multigraded oils are generally produced by adding viscosity index improver additives to a low viscosity base stock to retard thinning effects at operating temperatures. Poor quality multigraded oils use a viscosity index improver additive which has a tendency to lose its effectiveness after a short period of use in a high speed engine. These oils should be avoided.

2. Oils which meet the low temperature SAE viscosity standard (0 deg F [- 18 deg C] carry a suffix "W". Oils that meet the high temperature viscosity SAE standard 210 deg F [99 deg C)) as well as the low temperature carry both viscosity ratings - example 20-20W. See Table 3-2.

Table 3-2: Operating Temperatures Vs Viscosity

Ambient Temperatures	Viscosity
-10 deg. F [-23 deg. C] and below	See Table 3-3.
-10 to 30 deg. F [-23 to -1 deg. C]	10W
20 to 60 deg. F [-7 to 16 deg. C]	20 - 20W
40 deg. F [4 deg. C] and above	30

Arctic Operations

For operation in areas where the ambient temperature is consistently below -10 deg F [-I23 deg C] and there is no provision for keeping engines warm ’during shutdowns, the lubricating oil should meet the requirements in Table 33.

Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is now void, and SAE 5W mineral oils should not be used.

Table 3-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC or API class CC/CD
Viscosity	10,000 Centistrokes Max. @ -30 deg. F 5.75 Centistrokes Min. @ 210 deg. F
Pour Point (ASTM D-97)	At least 10 deg. F [6 deg. C] below lowest expected ambient temperature
Ash, sulfated (ASTM D874)	1.85% by wt. Maximum

Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact lubricant supplier for grease meeting these specifications.

TEST	TEST PROCEDURE
High-Temperature Performance	
Dropping point, deg. F	ASTM D 2265 350 min.
Bearing life, hours at 300 deg. F. 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0 deg. F.	15,000 max.
Run at 0 deg. F.	5,000 max.
Rust Protection and Water Resistance	
Rust test	ASTM D 1743 Pass
Water resistance, %	ASTM D 1264 20 max.

GREASE - Cont.

Stability	
Oil separation, % 30 Hours @ 212 deg. F.	*FTM 321 5 max.
Penetration	
Worked	ASTM D 217 250-300
Bomb Test, PSI Drop	ASTM D 942
100 Hours	10 max.
500 Hours	25 max.
Copper, Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc	*FTM 3005
25 Micron +	5,000 max.
75 Micron +	1,000 max.
125 Micron +	None
Rubber Swell	*FTM 3603
10 max.	

*Federal Test Method Standard No. 791a.

Caution: Do not mix brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow lubricant to be thrown out, due to rotative speed.

Fuel

Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	Centistokes 1.4 to 5.8 @ 100 deg. F. (30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.

FUEL - Cont.

Flash Point (ASTM 0-93)	At least 125 deg. for legal temperature if higher than 125 deg. F.
Gravity (ASTM D-287)	30 to 42 deg. A.P.I. at 60 deg. F. (0.815 to 0.875 sp. gr.)
Cloud Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122 deg. F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D86)	The distillation curve should be smooth and continuous, At least 90% of the fuel should evaporate at less than 675 deg. F. All of the fuel should evaporate at less than 725 deg. F.

Coolant

Water should be clear and free of any corrosive chemicals such as chloride, sulfates and acids. It should be kept slightly alkaline with pH value in range of 8.0 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleetguard DCA Water Filter on the engine. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

1. In summer, with no antifreeze, fill system with water.
2. In winter, select an antifreeze and use with water as required by temperature.

Note: Some antifreeze also contain anti-leak additives such as inert inorganic fibers, polymer particles or ginger root, these antifreeze should not be used in conjunction with the water filter. The filter element will filter out the additives and/or become clogged and ineffective.

3. Install or replace DCA Water Filter as follows and as recommended (page 294).

New Engines Going Into Service Equipped With DCA Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a DCA precharge element. This element is compatible with plain water or all permanent-type antifreeze except Dowtherm 209. See Table 3-4 for Dowtherm 209 precharge instructions.
2. At the first "B" Check (oil change period) the DCA precharge element should be changed to DCA Service Element. See Table 3-4.
3. Replace the DCA Service Element at each succeeding "B" Check.

a. If make-up coolant must be added between element changes, use coolant from a pre-treated supply.

b. Each time system is drained, precharge per coolant specifications, Table 3-4.

4. Service element may be changed at "C" Check if 3300858 (DCA-4L) direct chemical additive is added to the cooling system at each "B" Check between service element changes. One bottle of direct additive should be used for every 10 gallon of cooling system capacity. Add one bottle for every 15 gallon capacity if methoxy propanol antifreeze (Dowtherm 209) is used in the cooling system.
5. To insure adequate corrosion protection have the coolant checked at each third element change or more often. See "Check Engine Coolant", (page 295).

Table 3-4: Spin-On Type DCA Water Filter

Cooling System	**Ethylene Glycol Base Antifreeze**		**Methoxy Propanol Base Antifreeze (Dowtherm 209)**	
Capacity (U.S. Gallons)	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**	**DCA-4L Precharge (P/N 3300858)**	**Service Element(s)**
0-8	1	WF-2010 (P/N 299080)	1	WF-2011 (P/N 3300721)
9-15	2	WF-2010	2	WF-2011
16-30	5	WF-2010	4	WF-2011
31-60	10	(2) WF-2010	8	(2) WF-2011
35-90 (V-1710)	12	(2) WF-2016 (P/N 299086)	8	(2) WF-2017 (P/N 3300724)
70-90 (KT-2300)	16	(4) WF-2010	16	(4) WF-2011

COOLANT - Cont.

Engines Now In Service With Spin-On Type Chromate Corrosion Resistor Element

1. Remove chromate element.
2. Clean and flush cooling system.
3. Install service DCA element and precharge according to Table 3-4. Operate engine to next "B" Check; then treat as "New Engine Going Into Service" above. See Table 3-4.

Trouble Shooting

Trouble shooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins Diesel Engine.

TROUBLE SHOOTING

CUMMINS ENGINES

ENGINE

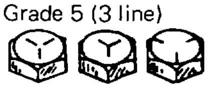
CAUSES		Hard Starting or Failure to Start	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumption	Crankcase Sludge	Dilution	Low Lubrication Oil Pressure	Fuel Leakage AFC Vent Capscrew	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration
AIR SYSTEM	Restricted Air Intake	●			●	●		●	●																			
	High Exhaust Back Pressure				●	●			●											●								
	Thin Air In Hot Weather or High Alt.				●	●		●																				
	Air Leaks Between Cleaner and Engine							●														●	●	●				
	Dirty Turbocharger Compressor				●	●		●	●																			
	Improper Use of Starter Aid/Air Temp.	●																							●			
FUEL SYSTEM	Out of Fuel or Fuel Shut-Off Closed	●										●																
	Poor Quality Fuel	●	●		●	●			●			●													●			
	Air Leaks in Suction Lines	●	●			●				●	●	●	●												●			
	Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●	●	●		●	●																		
	External or Internal Fuel Leaks					●			●			●				●	●											
	Plugged Injector Spray Holes	●	●	●	●	●			●																			
	Broken Fuel Pump Drive Shaft	●										●																
	Scored Gear Pump or Worn Gears	●				●																						
	Loose Injector Inlet or Drain Connection	●														●												
	Wrong Injector Cups			●	●	●			●							●												
	Cracked Injector Body or Cup	●	●	●	●	●			●							●												
	Mutilated Injector Cup "O" Ring								●							●												
	Throttle Linkage or Adjustment					●	●			●	●	●	●															
	Incorrectly Assembled Idle Springs									●	●	●																
	Governor Weights Assembled Incorrectly										●	●																
	High-Speed Governor Set Too Low					●	●																					
	Water in Fuel	●	●				●					●																
	Aneroid Set Improperly				●	●																						
	Aneroid Check Valve Stuck Open	●																										
	AFC Set Improperly			●		●																						
	Damaged or Worn AFC Plunger Seal																	●										
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●												
	Dirty Oil Filter														●		●						●	●				
	Faulty Cylinder Oil Control			●	●									●		●						●						
	Clogged Oil Drillings																					●	●	●				
	Oil Suction Line Restriction																●					●	●	●				
	Faulty Oil Pressure Regulator																●											
	Crankcase Low or Out of Oil																●			●	●	●	●	●				
	Wrong Grade Oil for Weather Conditions													●			●											
	Oil Level Too High					●			●					●							●							
COOLING SYSTEM	Insufficient Coolant					●											●			●	●							
	Worn Water Pump					●											●			●	●							
	Faulty Thermostats					●									●		●		●	●	●							
	Damaged Water Hose																●			●	●							
	Loose Fan Belts																●			●	●							
	Radiator Shutters Stuck Open														●				●									
	Clogged Water Passages																●			●	●							
	Internal Water Leaks															●												
	Clogged Oil Cooler																●				●							
	Radiator Core Openings Dirty																●			●	●							
	Air in Cooling System																●			●	●							
	Exterior Water Leaks																●			●	●							
	Insufficient Coolant Capacity					●											●			●	●							
	Coolant Temperature Low														●	●									●			
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●							●	●	●				
	Long Idle Periods	●	●	●	●	●									●	●												
	Engine Overloaded				●				●								●			●	●	●	●	●	●	●		
	Oil Needs Changing														●							●	●	●				
	Engine Exterior Caked with Dirt																●			●	●							
MECHANICAL ADJUSTMENTS OR REPAIR	Gasket Blow-by or Leakage			●	●	●										●												
	Faulty Vibration Damper																									●		●
	Unbalanced or Loose Flywheel																									●		●
	Valve Leakage	●	●			●																		●				
	Broken or Worn Piston Rings	●	●	●	●	●								●								●				●		
	Incorrect Bearing Clearances					●			●								●						●			●	●	
	Excessive Crankshaft End Clearance																						●			●	●	
	Main Bearing Bore Out of Alignment																						●			●		●
	Engine Due for Overhaul	●		●	●	●			●					●			●					●	●	●		●	●	●
	Damaged Main or Rod Bearings																●						●			●		
	Broken Tooth in Gear Train																									●	●	
	Excessive Gear Back Lash																									●	●	
	Misalignment Engine to Driven Unit								●														●				●	●
	Loose Mounting Bolts																									●		●
	Incorrect Valve and Injection Timing	●		●	●	●																		●	●			
	Worn or Scored Liners or Pistons			●	●	●								●								●				●		
	Injectors Need Adjustment		●	●	●	●			●																●			

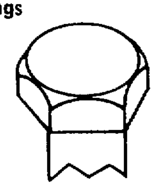
Current Useage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI MPa	To 1/2–69,000 [476] To 3/4–64,000 [421] To 1–55,000 [379]	To 3/4–120,000 [827] To 1–115,000 [793]	To 5/8–140,000 [965] To 3/4–133,000 [917]	150,000 [1 034]
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6 or 7	8

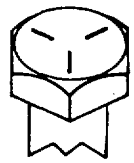
Capscrew Head Markings

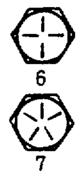
Manufacturer's marks may vary

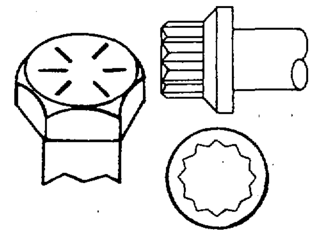
These are all SAE Grade 5 (3 line)











Capscrew Body Size (Inches) – (Thread)	Torque Ft-Lb [N•m]	Torque Ft-Lb [N•m]	Torque Ft-Lb [N•m]	Torque Ft-Lb [N•m]
1/4 – 20	5 [7]	8 [11]	10 [14]	12 [16]
– 28	6 [8]	10 [14]		14 [19]
5/16 – 18	11 [15]	17 [23]	19 [26]	24 [33]
– 24	13 [18]	19 [26]		27 [37]
3/8 – 16	18 [24]	31 [42]	34 [46]	44 [60]
– 24	20 [27]	35 [47]		49 [66]
7/16 – 14	28 [38]	49 [66]	55 [75]	70 [95]
– 20	30 [41]	55 [75]		78 [106]
1/2 – 13	39 [53]	75 [102]	85 [115]	105 [142]
– 20	41 [56]	85 [115]		120 [163]
9/16 – 12	51 [69]	110 [149]	120 [163]	155 [210]
– 18	55 [75]	120 [163]		170 [231]
5/8 – 11	83 [113]	150 [203]	167 [226]	210 [285]
– 18	95 [129]	170 [231]		240 [325]
3/4 – 10	105 [142]	270 [366]	280 [380]	375 [508]
– 16	115 [156]	295 [400]		420 [569]
7/8 – 9	160 [217]	395 [536]	440 [597]	605 [820]
– 14	175 [237]	435 [590]		675 [915]
1 – 8	235 [319]	590 [800]	660 [895]	910 [1234]
– 14	250 [339]	660 [895]		990 [1342]

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more of Grade 5 capscrews torque and must attain two capscrew diameters of thread engagement.

Operating Principles

Engine

Cummins Diesel Cycle

Cummins Diesel Engines have a high compression ratio; the charge taken into combustion chamber during the intake stroke consists of air only with no fuel mixture. Cummins injectors receive low-pressure fuel from the fuel pump and deliver it into individual combustion chambers at the proper time, in equal quantity and atomized condition for burning. Ignition of fuel is caused by heat of compressed air in the combustion chamber.

It is easier to understand the function of engine parts if it is known what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and order in which they occur are: Intake Stroke, Compressor Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly, valves and injectors must act in direct relation to each of the four strokes of the piston. The intake valves, exhaust valves and injectors are camshaft actuated, linked by tappets or cam followers, push rods, rocker levers and valve crossheads. The camshaft is gear driven by the crankshaft gear, thus rotation of the crankshaft directs the action of the camshaft which in turn controls the opening and closing sequence of the valves and the injection timing (fuel delivery).

Intake Stroke

During intake stroke, the piston travels downward; intake valves are open, and exhaust valves are closed. The downward travel' of the piston allows air from the atmosphere to enter the cylinder. On turbocharged engines the intake manifold is pressurized as the turbocharger forces more air into the cylinder through the intake manifold. The intake charge consists of air only with no fuel mixture.

Compression Stroke

At the end of the intake stroke, intake valves close and piston starts upward on compression stroke. The exhaust valves remain closed. At end of compression stroke, air in combustion chamber has been forced by piston to occupy a smaller space (depending upon engine model about one-fourteenth to one-sixteenth as great in volume) than it occupied at beginning of stroke. Thus, compression ratio is the direct proportion in the amount of space the air occupies in the combustion chamber before and after being compressed.

Compressing air into a small space causes temperature of that air to rise to a point high enough for ignition of fuel.

During last part of compression stroke and early part of power stroke, a small metered charge of fuel is injected into combustion chamber.

Almost immediately after fuel charge is injected into combustion chamber, fuel is ignited by the existing hot compressed air.

Power Stroke

During the beginning of the power stroke, the piston is pushed downward by the burning and expanding gases; both intake and exhaust valves are closed. As more fuel is added and burns, gases get hotter and expand more to further force piston downward and thus adds driving force to crankshaft rotation.

Exhaust Stroke

During exhaust stroke, intake valves are closed, exhaust valves are open, and piston is on upstroke.

Upward travel of piston forces burned gases out of combustion chamber through open exhaust valve ports and into the exhaust manifold.

Proper engine operation depends upon two things first, compression for ignition; and second, that fuel be measured and injected into cylinders in proper quantity at proper time.

Fuel System

The PT fuel system is used exclusively on Cummins Diesels.

The identifying letters, "PT," are an abbreviation for "pressure-time." The operation of the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the passage size through which the liquid flows. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

1. A fuel pump.
2. A means of controlling pressure of the fuel being delivered by the fuel pump to the injectors so individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Fuel passages of the proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantities and proper condition to burn.

The PT fuel system consists of the fuel pump, supply lines, drain lines, fuel passages and injectors. Fig. 5-1 There are four types of PT fuel pumps. The first type called PT (type G) is shown in Fig. 5-3.

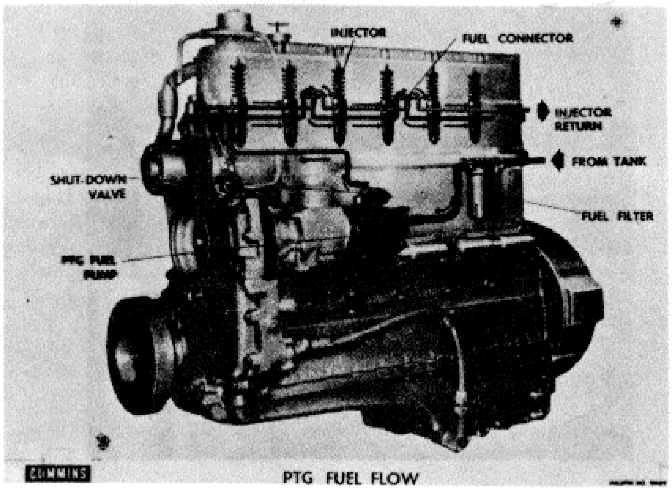


Fig 5-1, (FWC-13) Fuel flow diagram - PT (type G) pump- inline engine

Fuel Pump

The fuel pump is coupled to the compressor, vacuum pump or fuel pump drive which is driven from the engine gear train. Fuel pump main shaft in turn drives the gear pump, governor and tachometer shaft assemblies.

PT (type G) Fuel Pump

The PT (type G) fuel pump assembly, Fig. 5-3, is made up of three main units, the gear pump, standard governor and, throttle.

Gear Pump And Pulsation Damper

The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. Inlet is at the rear of the gear pump. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smoothes fuel flow through the fuel system. Automotive engines also may have fuel filter mounted to damper. From gear pump, fuel flows through the filter screen and to the. governor assemblies as shown in Fig's. 5-3,

Throttle

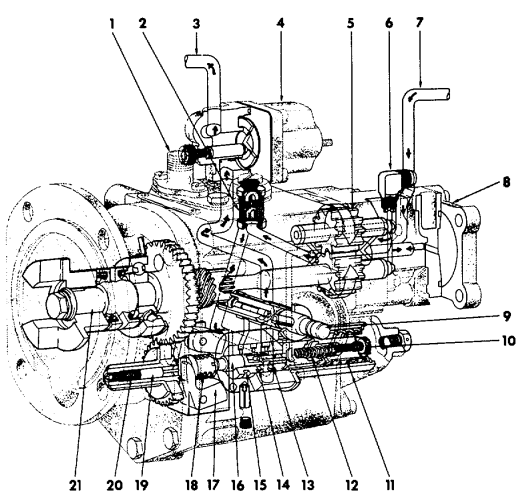
The-throttle provides a means for the operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In the fuel pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the shaft.

Governors

The "standard" governor is actuated by a system of springs and weights, and has two functions:

1. The governor maintains sufficient fuel for idling with the throttle control in idle position.



1 TACHOMETER SHAFT
2 FILTER SCREEN
3 FUEL TO INJECTORS
4 SHUT-DOWN VALVE
5 GEAR PUMP
6 CHECK VALVE ELBOW
7 FUEL FROM TANK
8 PULSATION DAMPER
9 THROTTLE SHAFT
10 IDLE ADJUSTING SCREW
11 HIGH SPEED SPRING
12 IDLE SPRING
13 GEAR PUMP PRESSURE
14 FUEL MANIFOLD PRESSURE
15 IDLE PRESSURE
16 GOVERNOR PLUNGER
17 GOVERNOR WEIGHTS
18 TOROUE SPRING
19 GOVERNOR ASSIST PLUNGER
20 GOVERNOR ASSIST SPRING
21 MAIN SHAFT

Fig. 5-3. (FWC-31) PT (type G) fuel pump and fuel flow

2. It cuts off fuel to the injectors above maximum rated rpm.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors. This fuel is controlled by the throttle and limited by the size of the idle spring plunger counterbore. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner, engine speed is controlled and limited by the governor regardless of throttle position.

Aneroid

The aneroid control, Fig. 5-7, provides a fuel by-pass system that responds to air intake manifold pressure and is used for close control of exhaust smoke.

During acceleration or rapid engine load changes, turbocharger speed (intake manifold pressure) change inherently lags behind the power or fuel demand exercised by opening of the throttle. This lag does not exist in the fuel system; therefore, an overrich or high fuel to air ratio, usually accompanied by smoke, occurs until the turbocharger "catches up".

The function of the aneroid is to create a lag in fuel system so response is equivalent to the turbocharger, thus controlling engine smoke level.

Caution: Aneroids must not be removed, disconnected or otherwise rendered ineffective, nor should settings be altered to exceed specifications as set at the factory, see "Maintenance Schedule".

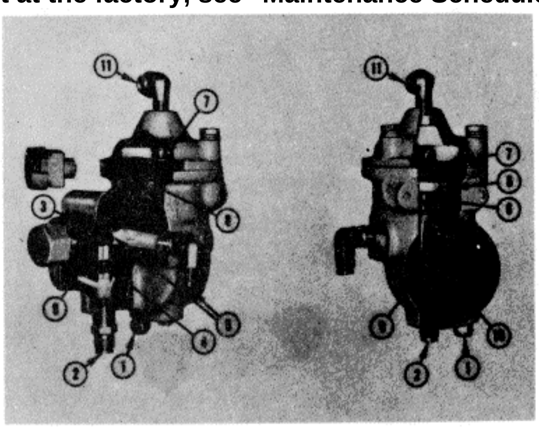


Fig. 5-7, (F5244). Aneroid cutaway

Fuel Flow (Aneroid)

1. Fuel from the fuel pump enters aneroid and is directed to starting check valve area (5, Fig. 5-7).
2. The starting check valve (3) prevents aneroid from by-passing fuel at engine cranking speeds. For speeds above cranking, fuel pressure forces the check valve open, allowing fuel to flow to valve port (4) or shaft (9).
3. Shaft (9) and its bore form, a fuel by-pass valve. This shaft and bore allows or, restricts fuel flow.
4. The shaft and sleeve are by-passing fuel when arm (10) of lever is resting against adjusting screw (1). The amount of fuel by-passed is adjusted by this screw, which protrudes from bottom of aneroid.
5. The lever arm connected to piston (8) by actuating shaft (6), rotates shaft; closing valve port. The lever is rotated by action of air intake manifold pressure against piston and diaphragm (7), moving actuating shaft downward against resisting spring force.
6. Anytime engine intake manifold air pressure is above preset "air actuation pressure", the aneroid is ineffective.
7. The aneroid begins dumping when intake manifold pressure drops below preset value as happens after deceleration in traffic, deceleration during gear shifts, down grade motoring with closed throttle or down grade operation on light load portion of governor droop curve.
8. The aneroid does not by-pass fuel under full throttle lug down conditions until speed is low enough to reduce intake manifold air pressure to aneroid operating range (usually below engine stall-out speed).
9. Fuel allowed to pass through by-pass valve is returned to suction side (inlet fitting) of PT gear pump. The by-passed fuel reduces fuel pump out-put to engine and reduces fuel manifold pressure in proportion to the by-pass rate.

PT (type D) Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are the same for inline and V-engines but injector size and internal design differs slightly. Fig. 5-11 illustrates injectors used on the NTC-290 Engine.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads Fig's. 5-1. A radial groove around each injector mates with the drilled passages in the cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in the injector body. A fine mesh screen at each inlet groove provides final fuel filtration.

The fuel grooves around the injectors are separated by "O" rings which seal against the cylinder head injector bore. This forms a leak-proof passage between the injectors and the cylinder head injector bore surface.

Fuel flows from a connection atop the fuel pump shut-down valve through a supply line into the lower drilled passage in the cylinder head. A second drilling in the head is aligned with the upper injector radial groove to drain away excess fuel. A fuel drain allows return of the unused fuel to the fuel tank.

The injector contains a ball check valve. As the injector plunger moves downward to cover the feed opening, an impulse pressure wave seats the ball and at the same time traps a positive amount of fuel in the injector cup for injection. As the continuing downward plunger movement injects fuel into the combustion chamber, it also uncovers the drain opening and the ball rises from its seat. This allows free flow through the injector and out the drain for cooling purposes and purging gases from the cup.

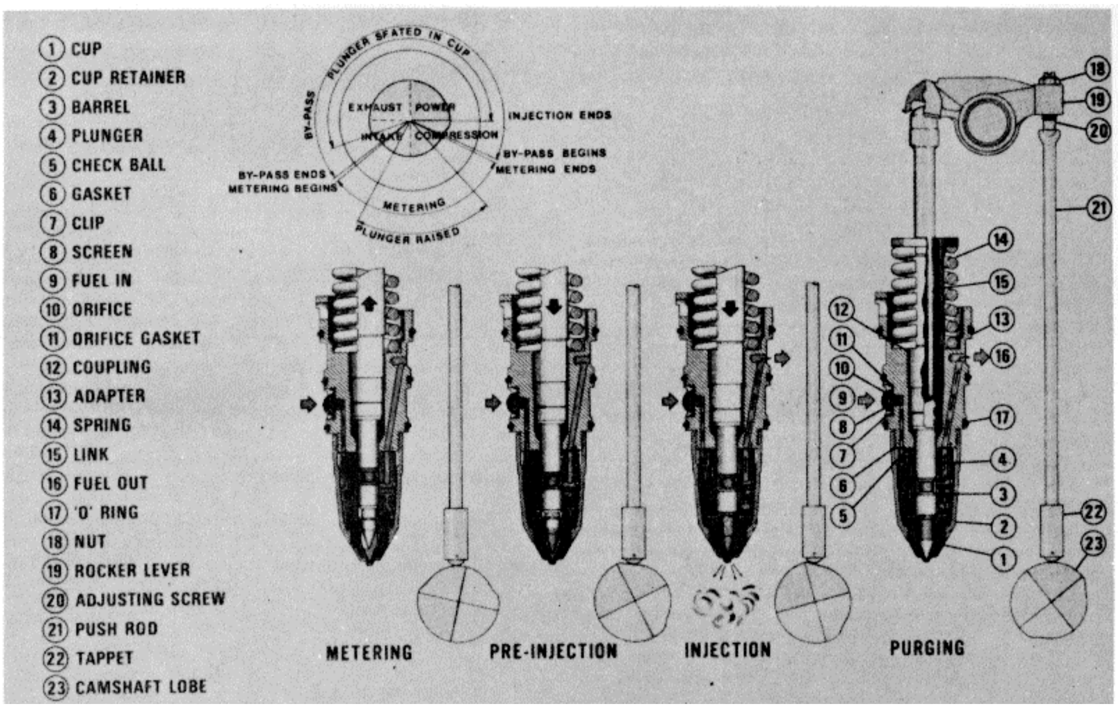


Fig. 5-11, (FWC 29),. Fuel injection cycle PT (type D) injector 5/16 inch diameter plunger.

Lubricating System

Cummins engines are pressure lubricated by a gear-type lubricating oil pump located in the oil pan or on side of the engine.

A pressure regulator is mounted in the lubricating oil pump to control lubricating oil pressure.

Filters and screens are provided in lubricating oil system to remove foreign material from circulation and prevent damage to bearings or mating surfaces. A by-pass valve is provided in full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

Maximum cleansing and filtration is achieved through use of both by-pass and full-flow lubricating oil filters. Full-flow filters are standard on all engines; by-pass filters are used on all turbocharged models and optionally on all other engines.

Engines may be equipped with special oil pans and filters for some applications, and others with auxiliary oil coolers to maintain closer oil temperature regulation.

Air compressors and turbochargers are lubricated from engine oil system. Turbocharger is cooled by same lubricating oil used for lubrication.

Fuel pumps and injectors are lubricated by fuel oil.

Inline Engines

NTC Series (Full Flow Oil Cooling)

The NTC (FFC) engine is pressure lubricated by a gear-type lubricating oil pump located on the intake manifold side of the engine. Oil pressure to the main rifle is controlled by a regulator located in the cooler support on the exhaust side of the engine.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig. 5-13, then transferred from the suction cavity by the pump gears into the pressure cavity.

Lubricating oil passes from the pump into the block, then across the front of the block by means of an internal oil passage and enters the cooler support. Oil is routed out of the cooler support and into the cooler housing, passing through the cooler housing. (The oil cooler is a counterflow tube-and-shell type heat exchanger, with oil passing from front to rear through the shell and coolant water passing from rear to front through the tubes.) Oil exits the cooler housing and passes into the cooler cover, then enters the "rifle drilling" at the bottom rear of the cooler housing and flows forward into the filter head.

Lubricating oil flowing into the filter shell from the filter head enters outside the filter element and passes through the element from outside to inside. Filtered lubricating oil then re-enters the filter head and flows through rifle drilling in the bottom of the cooler housing, then flows forward out of the cooler housing and into the cooler support where the flow divides.

Filtered and cooled lubricating oil re-enters the block from the cooler support and is transferred internally back across the front of the block through a drilled oil transfer passage to the head of the main rifle drilling. Accessory drive lubrication is supplied from the transfer passage out the front of the block and into the gear cover on the exhaust side of the engine, then across the front of the engine through a tube in the gear cover. The flow path then splits, part being routed to the accessory drive bushing in the gear cover and the rest being routed to the air compressor.

Piston-cooling is supplied from the transfer passage leading to the head of the main rifle drilling. An intersecting drilling allows flow to the piston-cooling rifle which extends from the front to the rear of the block on the exhaust side of the engine. Six piston-cooling nozzles inserted from the outside of the block direct a spray of lubricating oil from the piston-cooling rifle to the bottom of each piston.

Lubricating oil entering the main rifle is routed by means of drilled passages and pipes to the main bearings, rod bearings, piston pin bushings, camshaft bushings, cam follower shafts and levers, rocker box shafts and rocker arms, etc. then returns to the oil pan.

Cooling System

Water is circulated by a centrifugal water pump mounted either in or on the front of the engine belt driven from the accessory drive or crankshaft.

Water circulates around wet-type cylinder liners, through the cylinder heads and around injector sleeves. Injector sleeves, in which injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat to control engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.

The Fleetguard D C A Water Filter is standard on Cummins Engines. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

Air System

The diesel engine requires hundreds of gallons of air for every gallon of fuel that burns. For the engine to operate efficiently, it must breathe freely, intake and exhaust systems must not be restricted.

The intake air should always be routed through an air cleaner. The cleaner may be mounted on engine or equipment and may. be either oil bath, paper element of composite type depending upon engine application. Air is routed from air cleaner directly to intake air manifold or turbocharger.

Turbocharger

The turbocharger forces additional air into combustion chambers so engine can burn more fuel and develop more horsepower than if it were naturally aspirated.

In some cases the turbocharger is used for the engine to retain efficiency (balanced fuel to air ratio) at altitude above sea level.

The turbocharger consists of a turbine wheel and. a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft.

The power to drive turbine wheel - which in turn drives the compressor - is obtained from energy of engine exhaust gases. Rotating speed of the turbine changes as the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements.

The turbocharger is lubricated and cooled by engine lubricating oil.

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TRUCK SERVICE MANUAL ENGINE

ENGINE SHOP MANUAL
CUMMINS
ODEL NTC-290

855 CUBIC INCH DISPLACEMENT

CONTENTS

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CONTENTS (Continued)

Introduction

THE MANUAL AND ITS ARRANGEMENT

This manual covers the basic 855 Cubic Inch Displacement Engine Series built by Cummins Engine Company, Inc., Columbus, Indiana and its subsidiaries. These engines are used in many applications and have gained world-wide recognition for their dependability and simplicity of design.

Parts Dimensions, Wear Limits And Torque Specifications

An exploded view of components and pertinent specifications are listed in a table at the beginning of each Group. Worn limits are listed where applicable. Torque specifications are within the text or tabulated the same as parts dimensions.

Near the end of the manual is Section 18, a complete tabulation of parts dimensions, worn limits and torque specifications.

Worn Limits

Worn limits, as stated in this manual, indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. Of course, the reuse of any part is partially the responsibility of the person making the inspection, as it could well be damaged in an area not listed as a worn limit, thus making it unfit for further use.

Universal Units

Units such as fuel pumps, injectors, air compressors and turbochargers are also used on other models of Cummins Engines. These group sections are in separate manuals and written so they may be used with other engine shop manuals, These units are covered in full detail to make the information as useful and universally applicable as possible.

Auxiliary Equipment

Units such as hydraulic governors, exhaust brakes, thermatic fans, etc. are sometimes used on Cummins Engines. These special units are listed in the group in which they operate (hydraulic governors with Fuel Pump Group, etc.), information not contained in this or separate Cummins manuals must be obtained from the manufacturer.

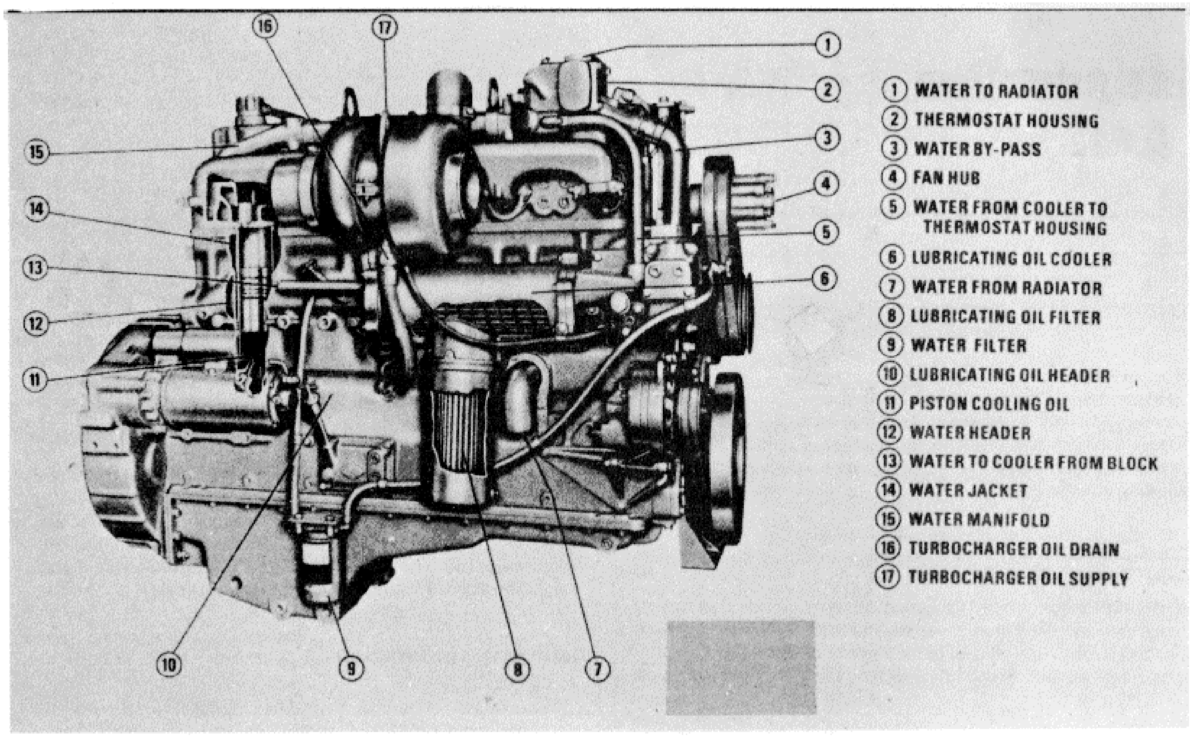
Service Tools

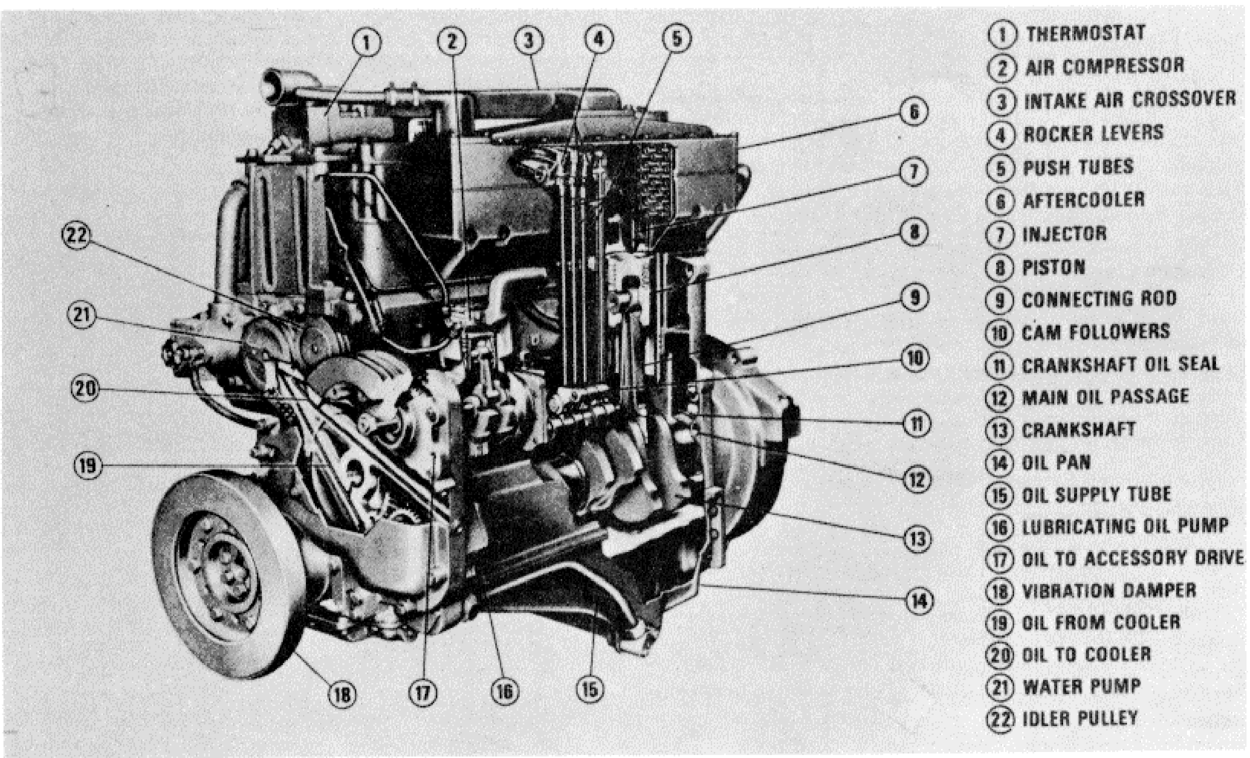
The average repair shop does not have all the factory facilities to do machining; however, it must be equipped with sufficient tooling to duplicate factory standards if the rebuilt unit is to do a good job.

Cummins Service Tools identified by "ST" numbers are listed at the beginning of each group and described as those required and those which are desirable. Procedures for use of those Service Tools that are most difficult to use are described at the end of each group. Cummins Service Tools may be ordered through Cummins Distributors.

Additional Information

Cummins Engine Company, Inc. is constantly improving its products and Cummins Distributors and Dealers are kept fully abreast of these improvements, and where possible the instructions to apply the improvements to engines already in service at the lowest possible cost to the engine owner. Information on improvements and changes are released and arranged using the group number system so the Distributor or Dealer has a ready cross reference between manuals, new information and parts. Complete new products as released will be applied to the engine group within which it is used or, if necessary, a new group will be established.


1 WATER TO RADIATOR
2 THERMOSTAT HOUSING
3 WATER BY-PASS
4 FAN HUB
5 WATER FROM COOLER TO THERMOSTAT HOUSING
6 LUBRICATING OIL COOLER
7 WATER FROM RADIATOR
8 LUBRICATING OIL FILTER
9 WATER FILTER
10 LUBRICATING OIL HEADER
11 PISTON COOLING OIL
12 WATER HEADER
13 WATER TO COOLER FROM BLOCK
14 WATER JACKET
15 WATER MANIFOLD
16 TURBOCHARGER OIL DRAIN
17 TURBOCHARGER OIL SUPPLY


1 THERMOSTAT
2 AIR COMPRESSOR
3 INTAKE AIR CROSSOVER
4 ROCKER LEVERS
5 PUSH TUBES
6 AFTERCOOLER
7 INJECTOR
8 PISTON
9 CONNECTING ROD
10 CAM FOLLOWERS
11 CRANKSHAFT OIL SEAL
12 MAIN OIL PASSAGE
13 CRANKSHAFT
14 OIL PAN
15 OIL SUPPLY TUBE
16 LUBRICATING OIL PUMP
17 OIL TO ACCESSORY DRIVE
18 VIBRATION DAMPER
19 OIL FROM COOLER
20 OIL TO COOLER
21 WATER PUMP
22 IDLER PULLEY

Engine Disassembly Group 0

Unit removal is a simple operation, time and labor will be saved if the necessary steps are followed. A few precautions are included that will help prevent accidents and/or damage to the parts.

The following service tools or tools of equal quality are considered necessary to disassemble the 855 C.I.D. (Cubic Inch Displacement) Series Cummins Diesel Engines.

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-125	Lifting Fixture
ST548	Engine Rebuild Stand
ST-805	Engine Stand Adapter

Desirable (Or Equivalent) Service Tools

ST-163	Engine Support
ST-647	Puller (Pulley)
ST-845	Fan Hub Wrench
ST-887	Crankshaft Flange Puller
ST-893	Fan Hub Wrench
ST-1147	Injector Removal Tool
ST-1178	Main Bearing Cap Puller
ST-1201	Liner Puller Bridge
ST-1202	Liner Puller Assembly

Standard Tools - Obtain Locally

	Hoist (Power or Chain)
	Steam Cleaner
	Cleaning Tank
	Rinsing Tank
	Impact Wrench
	Glass Bead Cleaner

UNIT REMOVAL AND CLEANING

Before disassembly of an engine or any unit used on the engine, inspection of the over-all condition should be made. This will furnish a great deal of information concerning necessary repair.

Inspection of each unit and tagging of electrical wires and components, bearing shell positions and other parts identification will help insure correct assembly.

Remove units and parts from cylinder block in a convenient order by removing mounting hardware, such as clamps, brackets, capscrews, washers, drive belts, etc. Mark or identify mounting components, as removed, for mounting location. Place parts and units (except electrical parts) on a rack or cart for cleaning. Discard gaskets and lockplates.

Engine Serial Number Plate

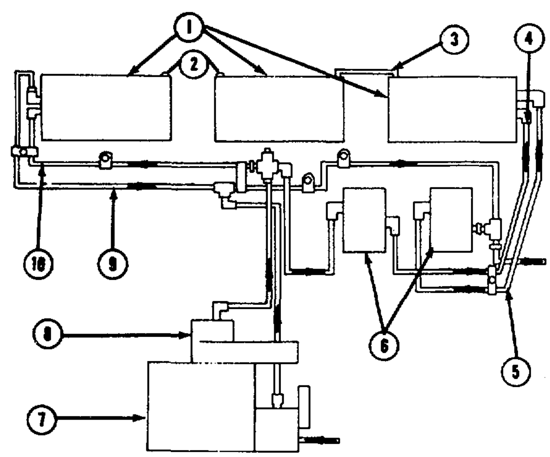
Engine serial number plate is located on the gear case mounting flange. Always refer to serial number and model designation when ordering parts or assemblies.

Note:
Non-certified engine serial dataplate, applies to current non-certified engines. Certified engine serial dataplate applies to engines conforming to the Federal (U.S.A) Clean Air Act. Engine serial dataplate may not be changed without consent and approval of Cummins Engine Company, Inc.

DRAIN WATER AND OIL

Drain complete system of lubricating oil, fuel and water. Bleed compressed air system, if used.

Note: Engines used as Duel Diesels will be equipped with two sets of fuel lines and additional fuel control valves so four cylinders can be used for compressor pumping. Fig. 0-2



1. Cylinder Head
2. Plugs
3. Fuel Crossover Tube
4. Fuel Supply Tube
5. Fuel Drain Tube
6. Fuel Valves
7. Fuel Pump
8. MVS Governor
9. Fuel Drain Tube
10. Fuel Supply Tube

Fig. 0-2, (N11830). Typical fuel line and valve plumbing - dual diesel.

STEAM CLEAN ENGINE EXTERIOR
Prior to steam cleaning remove all electrical components such as cranking motor, generator or alternator and electrical controls, as used.

NOTE: Cover all openings with water proof tape.

In addition to actual time-saving affected by engine cleaning, inspections can be made more quickly and accurately during disassembly if surfaces are clean.

A heavy-duty steam cleaner is preferred; however, any model for general use is satisfactory.

ENGINE DISASSEMBLY
Prior to mounting engine on engine stand remove the following:

Rock Shield
Oil Gauge and Bracket
Water Filter
Mechanical Controls, Water, Air, Fuel Connections, Filters
and Lines
Turbocharger and Connections
Crankcase Vent
Oil Spray Nozzles
Water Transfer Tube (FFC Series)
Oil Cooler and Connections

Auxiliary Oil Cooler (if used)

Water Pump, Idler and Fan Hub (FFC Series), See Fig's. 0-3 and 0-4

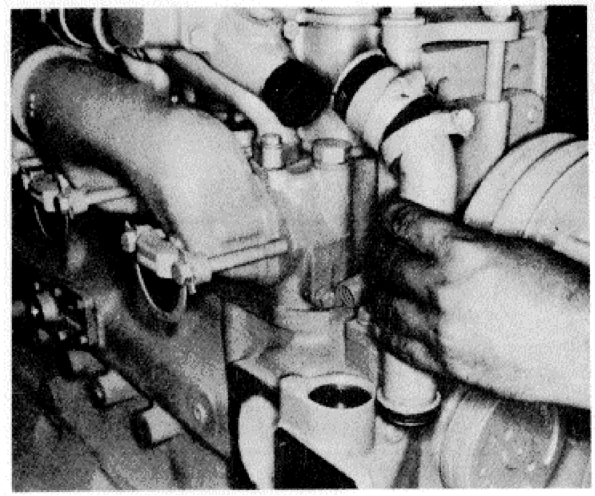


Fig. 0-3, (N100119). Removing water transfer tube (FFC Series)

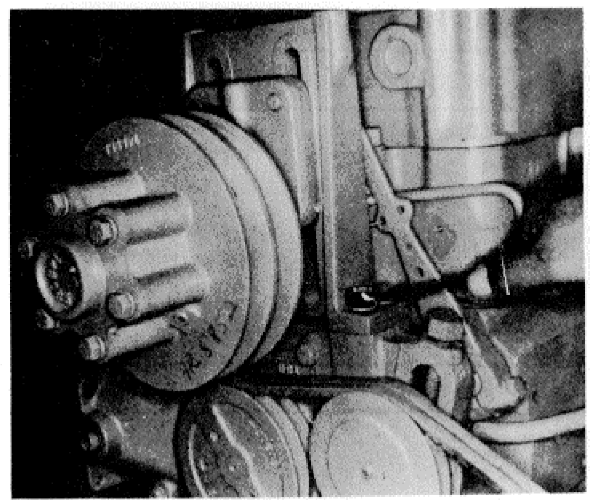


Fig. 0-4, (N100120). Removing fan hub assembly (FFC Series)

MOUNT ENGINE ON ENGINE STAND
Replace water header cover plates with mounting adapter plates. Secure ST-805 Engine Stand Adapter to ST-548 Engine Rebuild Stand. Position engine to stand, secure with capscrews and lockwashers.

With engine mounted securely to roll-over stand, remove the following:

Fan Hub, Belts And Brackets
Using ST-893 or ST-845 Fan Hub Wrench, remove fan hub shaft locknut, adjusting screw, and belts, lift shaft and hub from bracket. Remove fan hub bracket and water pump or cavity cover.

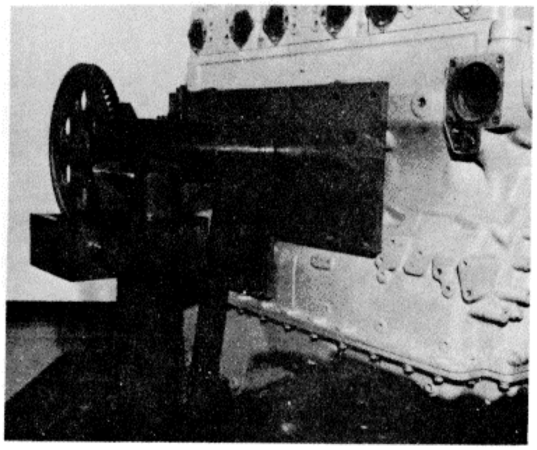


Fig .08, (N10056) . Engine mounted on stand

Compression Release Lever
Remove spring, link, bracket and lever from compression release shaft.

Vibration Damper and Pulley Vibration damper and pulley combination may be removed as an assembly by removing capscrews securing pulley to crankshaft. Fig. 0-9.

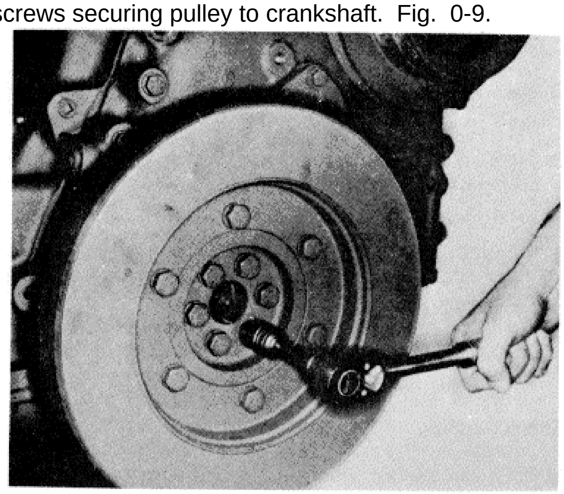


Fig . 09, (N 10093) .Removing vibration damper - Viscous type

CAUTION

Pounding or prying must not be resorted to in removing the Viscous type damper. Denting the outer shell may render the damper ineffective.

Front Engine Support
Two types of front engine supports are used on 855 C.I.D. engines. Trunnion supports are normally left in the engine chassis.

Accessory Drive Pulley
After removing locking nut and washer, use ST-647 Puller to remove pulley. Remove shaft key and oil slinger.

Aneroid Control
Disconnect air and fuel lines. Aneroid and mounting bracket may be removed as an assembly, if so desired.

Fuel Pump

1. Remove fuel supply and drain lines from fuel pump and cylinder head.
2. Remove fuel pump from hydraulic governor drive or air compressor. Lift out drive buffer or splined coupling as used.
3. Cover fuel pump connections to prevent entrance of dirt.

Air Compressor or Hydraulic Governor
Remove air compressor and/or hydraulic governor, lift out splined drive.

Fuel Pump/Compressor Drive
After removing capscrews it may be necessary to tap assembly lightly with a soft hammer or wooden block to loosen; remove drive.

Lubricating Oil Filter
Lubricating Oil Pump
Rocker Housing Covers And Rocker Housings

CAUTION

Do not damage or mutilate injector adjustment procedure decal while removing rocker housing cover.

Push Tubes
It is recommended posh tube be marked for position as removed, so they can be replaced in same mating cam follower if reused.

Valve Crossheads
Fuel Connectors
Injectors

Remove injector hold-down plate, use ST-1147 Injector Removal Tool to remove injectors from cylinder head.

Note: To avoid dropping plunger, do not turn injector upside-down. Place injectors in a rack for protection. Number by cylinder from which removed.

Cylinder Heads

Compression Release Shaft

Remove shaft lockscrew and copper washer at rear of cylinder block. Pull shaft through block from lever end.

Note: Do not remove stop pin from cylinder block unless damaged.

Cam Follower Housings

Note: Do not discard metal spacer used on some engines. Gasket(s) total thickness varies to space cam follower housings for establishment of injection timing..

Flywheel

1. Install two (2) 5/8-18 studs in crankshaft flange to provide support for flywheel during removal.

2. Install two (2) 1/2-13 capscrews, threaded their entire length, to act as jackscrew to pull flywheel from crankshaft.

Flywheel Housing

Oil Pan

Note: Two bolts through oil pan and cylinder block flange at flywheel end of engine may be dowel fit. Remove nuts and drive out dowel bolts with soft hammer.

Rear Cover And Seal

Gear Case Cover

If gear case cover is equipped with outboard bearing at camshaft, remove from cover. Place two (2) guide studs into capscrew holes to Support cover during removal.

Camshaft And Gear

Note: Rotate camshaft while pulling camshaft from engine. Do not remove gear.

Connecting Rod And Piston Assemblies

1. Turn engine right-side-up and clean all carbon from upper inside wall of each cylinder liner and polish with fine emery cloth. Do not damage liner finish. Clean area thoroughly.

2. Use care not to damage cylinder liners as connecting rods are withdrawn. Check each' rod and cap as removed to be sure it is stamped or labeled. Reassemble each connecting rod cap to mating rod, tape mating bearing shells together and label by cylinder.

3. Remove and discard piston rings, remove snap rings.

4. To facilitate removal of piston pins, first heat piston in boiling water; then push pin from piston, using finger pressure or other suitable method. **Do not drive or otherwise force pin from piston. Remove and discard piston rings.**

Cylinder Liners

Use ST-1201 Liner Puller Bridge and ST-1202 Liner Puller Assembly with an impact wrench or rachet to remove cylinder liners. Discard "O" rings and crevice seals.

Crankshaft And Main Bearings

1. Using ST-1178 Main Bearing Cap Puller, loosen main bearing caps from dowels. Lift caps and rear thrust rings from block. Make sure all bearing caps are marked so they can be installed in their original locations.

2. Remove lower main bearing shells from main bearing caps or crankshaft.

3. Remove crankshaft using hooks protected by rubber hose. Handle crankshaft with care to avoid possible damage to finished surface.

4. Remove upper main bearing shells and ring dowels from cylinder block. Tape mating halfs of bearing shells together and identify from position removed.

CLEANING

Steam Cleaning

Steam clean all disassembled units and parts (except those that might be damaged by steam or-moisture) with a steam jet and dry with compressed air. All units such as oil coolers, oil pan, heat exchanger, etc. should be cleaned as quickly as possible to prevent hardening and drying of accumulated foreign substances.

Glass Bead Cleaning Glass bead cleaning has been proven most effective for pistons, valves, cylinder heads, etc. The nature and degree of treatment is controlled by the size of glass beads used, operating pressure and exposure time.

1. Bead Size for pistons and other similar parts, use U.S. sieve size No. 70. For general purpose cleaning use No. 60.

2. Operating Pressure 90 psi [5.4 kg/sq cm] for pistons etc. for general cleaning, pressures from 90 to 125 psi [5.4 to 8.8 kg/sq cm] may be used.

3. Do not expose the part being cleaned to the bead blast any longer than absolutely necessary. This is particularly true when cleaning soft material such as aluminum.

4. The only additional cleaning required is to wash with solvent and dry with compressed air. Be sure all foreign material has been removed from parts before reassembling.

Solvent/Acid Cleaning

Several solvent and acid type cleaners are effective cleaning solutions, always follow manufacturers recommendations as to concentration and use.

CAUTION

Solvent cleaners may damage bearing shells and aluminum parts, check with manufacturer before cleaning these parts in solvent.

Remove all gasket material and deposits of sludge, carbon, etc., with a wire brush or scraper, from units such as cylinder heads, oil pan, rocker lever housing and cover etc before submerging them in wash tank.

CAUTION

Do not damage gasket surfaces

1. Solvent solution should be heated to approximately 180 to 200 deg. F (82 to 93 deg. C) and kept in constant agitation. With sufficient heat, the agitation can be accomplished by built-in baffle plates.

2. After unit disassembly, put all small parts in wire mesh baskets, steam clean, then immerse in cleaning tank for as long as necessary. Larger parts can be lowered directly by chain hoist into tank.

3. Cylinder block must have all pipe plugs removed from oil and water passages, etc. Run rods with brushes or swabs through all oil passages, clean air vent hole (No. 1 cylinder) that opens into water pump cavity. Scrape liner counterbore lightly to remove scale, sand lower liner bore or use emery cloth to remove any nicks or burrs that might damage packing rings as liner is installed.

4. To remove heavy deposits of lime, use circulated acid type cleaner.

WARNING

The use of acid may be extremely dangerous to workmen and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

5. Rinse all parts in hot water and dry with compressed air, blow cleaning fluid or water from capscrew holes to prevent damage when capscrews are tightened.

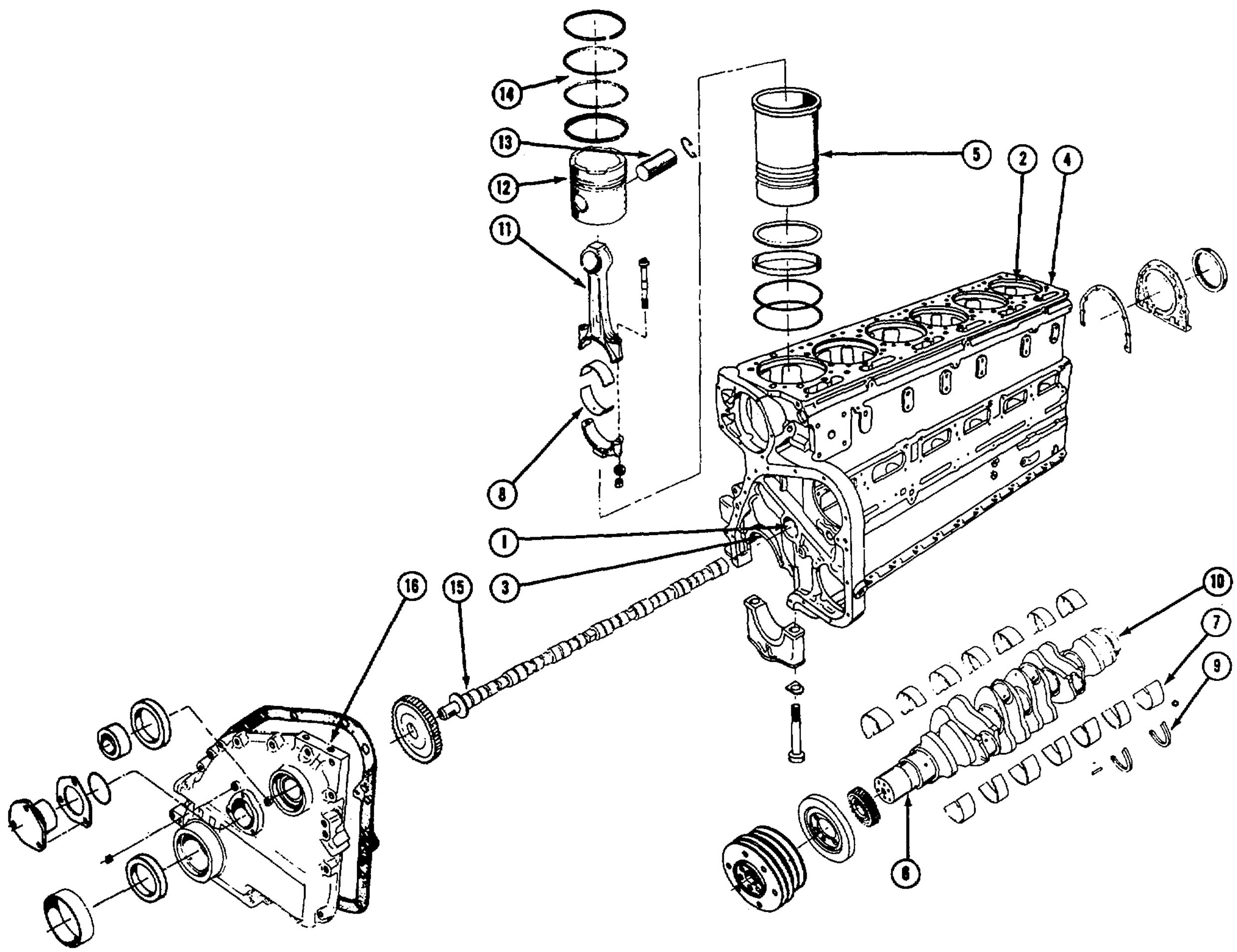
6. Replace pipe plugs removed for cleaning, torque to specifications. Note: If rebuild machining is required, replace pipe plugs and reclean affected area after machining is completed.

7. If parts are not to be reused immediately after cleaning, dip them in a suitable rust proofing compound.

Note: Rust proofing compound must be removed before installing parts in engine.

Cylinder Block
Group 1

The cylinder block group consists of cylinder block, cylinder liners, crankshaft, bearing shells, vibration damper, connecting rods, pistons, rear cover, camshaft and gear cover.

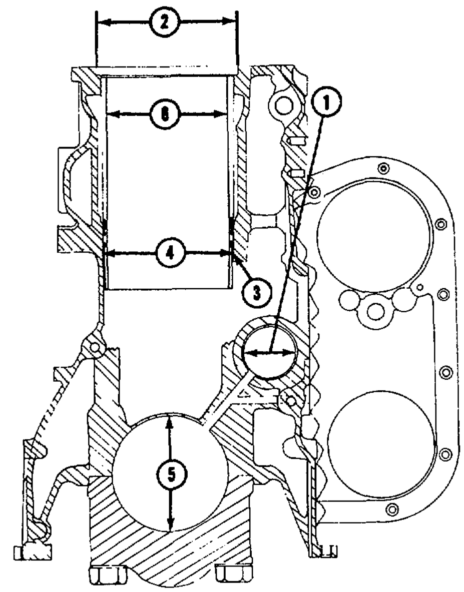


1. Camshaft Bushing Bore
2. Cylinder Liner Counterbore
3. Main Bearing Bore
4. Cylinder Block
5. Cylinder Liner
6. Crankshaft
7. Main Bearings
8. Rod Bearings
9. Crankshaft Thrust Ring
10. Crankshaft End Clearance
11. Connecting Rod
12. Piston
13. Piston Pin
14. Piston Ring
15. Camshaft
16. Gear Case Cover

Fig. 10. Cylinder block, exploded view

Table 1-1: Cylinder Block Specifications - Inch [mm] (Reference Fig. 1-0)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1	**Camshaft Bushing**			
	Inside Diameter **(1)**	**2.0015 [50.838]**	1.999 [50.775]	2.0005 [50.813]
	Camshaft Bushing Bore Inside Diameter	**2.1306 [64.115]**		
2	**Cylinder Liner Counterbore**			
	Inside Diameter **(2)**		6.5615 [166.662]	6.5635 [166.713]
	Depth	**0.412 [10.46]**	0.350 [8.89]	0.352 [8.94]
	Liner to Block Clearance			
	Lower Bore **(3)**		0.002 [0.05]	0.006 [0.15]
	Note: Current liners (1972) provide 0.002 to 0.006 inch [0.05 to 0.15 mm] clearance.			
	Lower Liner Bore			
	Inside Diameter **(4)**		6.124 [155.55]	6.126 [155.60]
3	**Main Bearing Bore**			
	Inside Diameter **(5)**	**47505 [120.663]**	4.7485 [120.612]	4.750 [120.650]
4	**Block Ref Fig 1-2**			
	Height from Main Bearing Centerline	**18.994 [482.448]**	19.004 [482.702]	19.006 [482.752]
	Height from Installed Alignment Bar	**16.619 [422.123]**	16.629 [422.38]	16.631 [422.43]
5	**Cylinder Liner**			
	Inside Diameter **(6)** [139.83]	**5.505 [139.687]**	5.4995 [139.73]	5.501
	Note: New cylinder liners dimensions at 60 to 70 °F [16 to 21 °C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.			
	Protrusion (Installed)		0.003 [0.08]	0.006 [0.15]
6	**Crankshaft**			
	Connecting Rod Journal Outside Diameter **(7)**	**3.122 [80.30]**	3.1235 [79.337]	3.125 [79.38]
	Main Bearing Journal Outside Diameter **(8)**	**44975 [114.237]**	4.4985 [114.262]	4.500 [114.30]
	Thrust Bearing Surface to Rear Counterweight	**3.006 [76.35]**	3.001 [76.23]	3.003 [76.28]
	Main and Rod Journals Out-of-round T.I.R.**	**0.002 [0.05]**		
	Main and Rod Journal Taper (Length of Journal)	**0.0005 [0.013]**		
	****T.I.R** - Total Indicated Runout			
7	**Main Bearings**			
	Shell Thickness	**0.1215 [3.086]**	0.123 [3.12]	0.1238 [3.145]
	Journal Clearance	**0.007 [0.18]**	0.0015 [0.038]	0.005 [0.13]



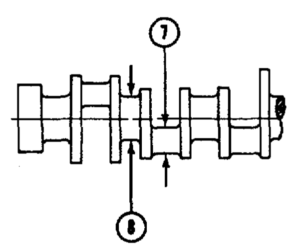


Table 1-1: Cylinder Block Specifications - Inch [mm] (Reference Fig. 1-0) (Cont.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
8	**Rod Bearings**			
	Shell Thickness	**0.071**	0.0724	0.0729
	(855 C.I.D.)	**[1.80]**	[1.839]	[1.852]
	Journal Clearance	**0.007**	0.0015	0.0045
		[0.18]	[0.038]	[0.114]
9	**Crankshaft Thrust Ring**			
	157280 Std.			
	Thickness	*	0.245	0.247
			[6.221	[6.27]
	157281 0.010 O.S.			
	Thickness [0.25]	*	0.255	0.257
			[6.48]	[6.53]
	157282 0.020 O.S.			
	Thickness [0.51]	*	0.265	0.267
			[6.73]	[6.78]
*Use Crankshaft End Clearance				
10	**Crankshaft End Clearance**			
	End Clearance	**0.022**	0.007	0.017
	(Installed)	**[0.56]**	[0.18]	[0.43]
11	**Connecting Rod**			
	Crankpin Bore Inside		3.2722	3.2732
	Diameter (855 C.I.D.) **(1)**		[83.114]	[83.139]
	Center to Center Length **(2)**		11.998	12;000
			[304.75]	[304.80]
	Piston Pin Bushing			
	Inside Diameter **(3)**	**2.0025**	2.001	2.0015
		[50.864]	[50.83]	[50.838]
	Connecting Rod			
	Alignment	**0.008**		
	Without Bushing	**[0.20]**		
	Alignment	**0.004**		
	With Bushing	**[0.10]**		
	Twist	**0.020**	0.010	0.020
	Without Bushing	**[0.51]**	[0.25]	[0.51]
	Twist	**0.010**	0.004	0.010
	With Bushing	**[0.25]**	[0.10]	[0.25]
	Connecting Rod Bolt			
	(855 C.I.D.)			
	Minimum Outside Diameter	**0.540**		
		[13.72]		
	Pilot Outside Diameter		0.6245	0.6250
			[15.852]	[15.875]
	Bolt Hole Pilot			
	(855 C.I.D.)			
	Rod	**0.6249**	0.6243	0.6248
		[15.872]	[15.857]	[15.870]

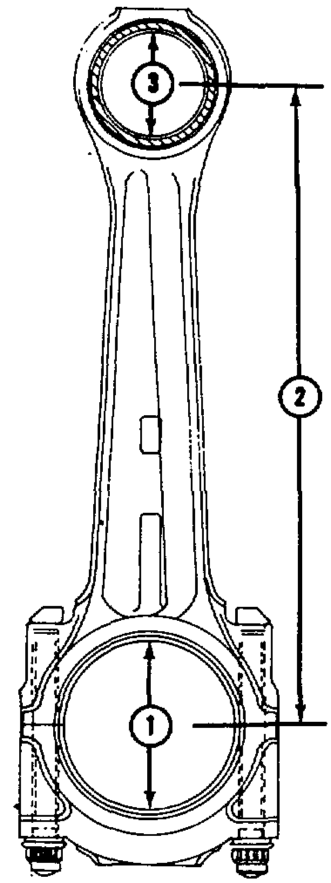
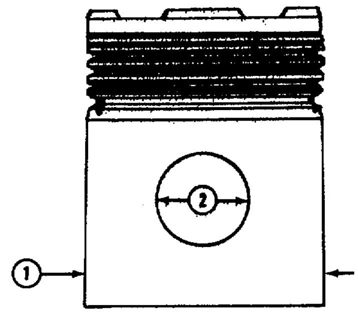
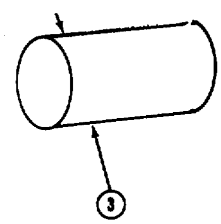


Table 1-1: Cylinder Block Specifications - Inch [mm] (Reference Fig. 1-0) (Cont.)

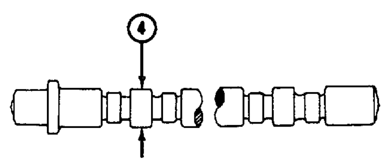
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Cap	**0.6262 [15.880]**	0.6246 [15.865]	0.6251 [15.878]
12	**Piston**			
	Skirt Diameter at 70 °F [21 °C] **(1)**	**5.483 [139.27]**	5.487 [139.37]	5.488 [139.40]
	Piston Pin Bore Inside Diameter at 70 °F [21 °C] **(2)**	**1.999 [50.776]**	1.9985 [50.762]	1.9990 [50.775]
13	**Piston Pin**			
	Outside Diameter **(3)**	**1.9978 [50.754]**	1.99875 [50.768]	1.9990 [50.775]
14	**Piston Ring Part No.**			
	147670			
	Gap In Ring Travel Area of Liner	*	0.023 [0.58]	0.033 [0.85]
	132880			
	Gap In Ring Travel Area of Liner	*	0.019 [0.48]	0.029 [0.74]
	168680			
	Gap In Ring Travel Area of Liner	*	0.028 [0.71]	0.038 [0.97]
	194610			
	Gap In Ring Travel Area of Liner	*	0.010 [0.25]	0.020 [0.51]





* Add 0.003 inch [0.08 mm] ring gap to new maximum limit for 0.001 inch [0.03 mm] wear in cylinder liner wall.

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
15	**Camshaft**			
	Journal			
	Outside Diameter **(4)**	**1.996 [50.70]**	1.997 [50.72]	1.998 [50.75]
	Thrust Bearing			
	Thickness	**0.083 [2.11]**	0.093 [2.36]	0.098 [2.49]
	Support Bushing			
	Inside Diameter	**1.370 [34.80]**	1.3725 [34.862]	1.3755 [34.938]
	Outboard Bearing Support			
	Inside Diameter **(5)**	**1.757 [44.63]**	1.751 [44.48]	1.754 [44.55]



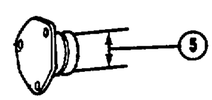
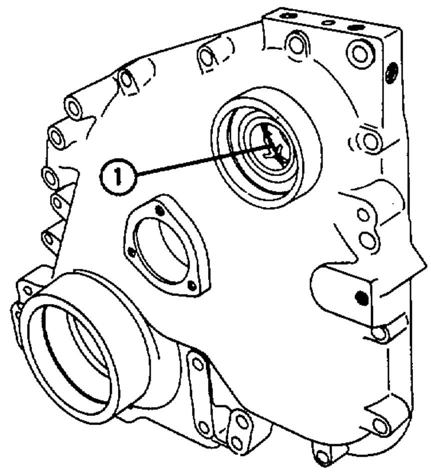


Table 1-1: Cylinder Block Specifications - Inch [mm] (Reference Fig. 1-0) (Cont.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
16	**Gear Case Cover Accessory Drive Bushing Part No.**			
	132770 Std.			
	Inside Diameter **(1)**	**1.571 [39.90]**	1.565 [39.75]	1.569 [39.85]
	132771 0.010 U.S	**[0.25]**		
	Inside Diameter	**1.561 [39.65]**	1.555 [39.50]	1.559 [39.60]
	132772 0.020 U.S	**[0.51]**		
	Inside Diameter	**1.551 [39.40]**	1.545 [39.24]	1.549 [39.34]
	200822 Std (NTA Series)			
	Inside Diameter	**1.7585 (44.67]**	1.7525 [44.51]	1.7565 [44.62]



Torque Specifications ft-lb [kg m]

17	**Pipe Plug Size**	**Minimum**	**Maximum**
	1/8	15 [2.1]	20 [2.8]
	1/4	30 [4.1]	35 [4.8]
	3/8	35 [4.8]	45 [6.2]
	1/2	45 [6.2]	55 [7.6]
	3/4	60 [8.3]	70 [9.7]
	1-1/4	75 [10.4]	85 [11.8]
	1-1/2	90 [12.4]	100 [13.8]
18	**Main Bearing Capscrews**		
	Step 1. Tighten to	140 [19.4]	150 [20.7]
	Step 2. Advance to	300 [41.5]	310 [42.9]
	Step 3. Loosen	All	All
	Step 4. Tighten to	140 [19.4]	150.[20.7]
	Step 5. Advance	300 [41.5]	310 [42.9]

19	**Connecting Rod Nuts**		
		855 C.I.D. Engines	
		Minimum	**Maximum**
	Step 1. Tighten to	70 [9.7]	75 [10.4]
	Step 2. Advance to	140 [19.4]	150 [20.7]
	Step 3. Loosen	All	All
	Step 4. Tighten to	25 [3.5]	30 [4.1]
	Step 5. Tighten to	70 [9.7]	75 [10.4]
	Step 6. Advance to	140 [19.4]	150 [20.7]

The following service tools or tools of equal quality are considered necessary to repair and or rebuild the cylinder block as outlined in this section.

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-526	Boring Machine
ST-1010	Counterboring Tool (Water Hole)
ST-1059	Counterboring Tool (Cylinder Liner)
ST-1064	Adapter Plate
ST-1065	Tool Holder
ST-1081	Boring Tool
ST-1084	Bore Adapter
ST-1096	Lower Bore Chamfer Kit
ST-1168	Counterbore Salvage Tool
ST-1177	Boring Tool (Main Bearing Bore)
ST-1228	Camshaft Bushing Drive Kit
ST-1250	Cylinder Liner Bore Salvage Tool
ST-1252	Concentricity Gauge
ST-1272	Head Capscrew Thread Salvage Tool

Desirable (Or Equivalent) Service Tools

ST-205	Plug Gauge (Connecting Rod)
ST-547	Gauge Block
ST-560	Ring Groove Gauge
ST-561	Checking Fixture (Connecting Rod)
ST-563	Locating Mandrel (Connecting Rod)
ST-598	Bushing Mandrel (Gear Cover)
ST-861	Chamfering Tool (Connecting Rod)
ST-896	Ring Gauge (Connecting Rod)
ST-897	Ring-Gauge (Connecting Rod)
ST-903	Ring Gauge (Main Bearing Bore) ST-
1171	Bushing Mandrel (Accessory Drive) ST-
1178	Puller (Main Bearing Cap)
ST-1184	Cylinder Liner Hold Down Tool
ST-1242	Mandrel Set

Standard Tools-Obtain Locally

Dial Bore Indicators
1/2 inch Electric Drill
Micrometers

CYLINDER BLOCK

INSPECTION

Before any parts are discarded or used again a careful inspection must be performed. The inspection should include wearing surfaces and general over-all conditions.

Note: Inspection of cylinder block must be performed on a flat surface to prevent distortion, do not leave on engine stand.

Using Dye Penetrants To Locate Flaws

Use dye penetrate method for locating cracks, porosity, leaks, etc. Clean suspected defective area with kerosene or other grease-removing cleaner.

Apply dye penetrate allowing time for it to dissolve or enter into the defect (usually about fifteen minutes); do not "force" dry. Remove all excess penetrant and apply developer so defect will stand out; cracks usually show up as a solid or dotted line; however, caution must be observed as this can be a non-damaging forging lap. Porosity usually shows up as dots in local areas. The wider the area spreads, the larger the defect.

Corrosion

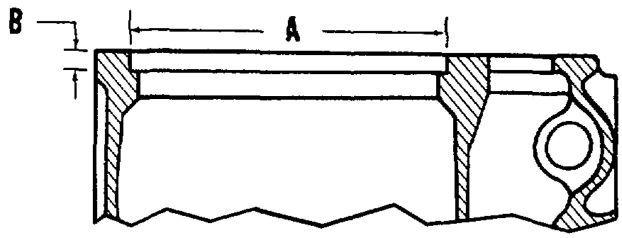
Corrosion most frequently occurs on portions of block nearest cylinder liners and is evidenced by pitting. Discard block if area cannot be cleaned, or if area is distorted and cannot be repaired by sleeving as outlined under "Parts Replacement and Repair" following.

Camshaft Bushings

Use inside micrometers or dial bore gauge to measure camshaft bushing inside diameter. Mark bushings for replacement if worn larger than "Worn Limit" (Table 1-1) (1) or are chipped, scored or scratched. If bushings have turned in block bore, check block bore size; see Table 1-1 (1). Make certain oil passages between bushings and block oil holes are properly aligned. If bushing replacement is necessary, see "Parts Replacement and Repair."

Cylinder Liner Counterbore

1. Check upper liner counterbore and remove burrs, dirt, etc., so liner will enter without distortion (A, Fig. 1-1). If counterbore exceeds limits listed in Table 1-1 (2) for the top 0.250 inch [6.35 mm] depth, mark blocks for counterbore repair. The counterbore ledge must be smooth and perpendicular to the liner bore to within 0.005 inch [0.13mm] total indicator reading. Use a straight edge to check flatness of top of block. Refer to "Top Surface Refinishing."



A. Upper Liner Counterbore
B. Counterbore Depth

Fig. 1-1 (N 10103). Cylinder liner counterbore dimension location.

2. Check counterbore depth so installed liner will be assembled to correct protrusion and to determine if refinish of counterbore surface is necessary. Depth of counterbore on a new block is listed in Table 1-1 (2). If worn to or beyond limit, the cylinder block must be salvaged using ST-1250 Cylinder Liner Bore Salvage Tool or replaced. If worn less than worn limit, the surface can be refinished and shims installed under the cylinder liner to restore proper protrusion.

3. Installed cylinder liners must protrude 0.003 to 0.006 inch [0.08 to 0.15 mm] above block. To check for proper protrusion without installing a liner: a. Measure liner flange outside bead with micrometer. Do not include bead on top of liner flange in taking measurement.

b. Measure block counterbore depth with dial indicator depth gauge or ST-547 Gauge Block. Always measure counterbore depth on ledge at the edge of liner bore.

c. Check depth at four equidistant locations. Ledge must not be "cupped" more than 0.0014 inch [0.036 mm]. Depth must not vary more than 0. inch [0.03 mm] throughout counterbore circumference.

d. Counterbore must always be resurfaced if it slants downward toward the center or if dimensions do not meet standards. See "Parts Replacement and Repair."

e. Subtract counterbore depth from liner flange thickness to determine amount of shims and depth of counterbore cut that must be used to provide 0.003 to 0.006 inch [0.08 to 0.15 mm]. liner protrusion; 0.007 inch [0.18 mm] shims are thinnest available. If material to be removed will result in a counterbore depth exceeding worn limit, block cannot be reused, unless a sleeve can be installed.

4. The most accurate method of checking protrusion is as follows:

a. Install liner in block with proper number of liner shims beneath the flange. Shims are available from 0.007 to 0.068 inch [0.18 to 1.73 mm]. Use ST-1005 or ST-1184 cylinder liner hold-down tool. Tool should be spaced so even load will be applied.

b. Use ST-547 Gauge Block and check liner protrusion above the cylinder block at four equidistant points outside the bead. Add or remove shims from beneath the liner flange as needed to reach 0.003 to 0.006 inch [0.08 to 0.15 mm] protrusion.

c. With liner installed, check for out-of-round as described under "Install Liner in Block," Group 14.

Cylinder Liner Lower Bore

1. Install a new cylinder liner in the block without packing rings or crevice seal.,

2. Desirable clearance between liner and block should be as listed, but liner contact with block is permissible as long as it does not cause liner out-of-round.

3. If clearances do not fall within limits, recheck after counterboring, limits do not apply with cylinder head installed and tightened to operating torque. If clearance is not correct, check lower block packing ring bore inside diameter.

4. Lower liner bore concentricity should be checked with ST-1252. If a piston seizure has occurred or after counterboring the cylinder block, check the counterbore to lower cylinder liner bore concentricity. Follow Service Tool Instructions, Page 344. Liner bore should be concentric within 0.005 inch [0.13 mm] total indicator reading.

Main Bearing Caps

Caps must fit in block with no perceptible clearance or "shake." Milled faces of cap must always rest on mating portion of block to prevent distortion during tightening. Replacement caps are available as service parts.

Main Bearing Bore

1. Assemble main bearing caps to block in operating position. Tighten capscrews to operating tension.

2. Gauge main bearing bores horizontally, vertically and diagonally with dial bore gauge or inside micrometers properly adjusted to ST-903 Ring Gauge. See Table 1-1 (3) for dimensions.

ST-1177 Boring Tool may also be used to check main bearing bore alignment, see Service Tool Instructions, Page 347 If it is definitely determined that a main bearing cap has been distorted, mark block for reaming.

Water Passages

1. Check all water passages to make sure they are open and for eroded water holes which may prevent proper seating of head gasket or grommet retainers,

2. Water holes not eroded more than 1/16 inch [1.59 mm] from edge of hole can be sleeved.

3. Check for erosion within 1/32 to 3/32 inch [0.79 to 2.38 mm] from liner counterbore; if not too deep, block may be resurfaced. Block must clean up before removing a maximum of 0.010 inch [0.25 mm] material.

PARTS REPLACEMENT AND REPAIR

After a thorough inspection of cylinder block, bushings and main bearing caps, the decision must be made whether to install a new or reconditioned block assembly, replace bushings or caps and how much can be done to rebuild or recondition the reusable parts.

Camshaft Bushing Replacement

Bushings may be removed and installed with ST-782 Bushing Driver and ST-784 Mandrel or ST-1228 Camshaft Bushing Driver Kit. The bushing at No. 7 journal must be installed so it is away from rear face of block so oil can drain from hole at end of camshaft to prevent hydraulic lock.

Main Bearing Cap Replacement

1. Replacement main bearing caps have 0.015 inch [0.38 mm] material in bore. Other dimensions are the same as finished main bearing caps. No. 7 replacement cap does not have cap-to-block dowel holes and must be machined to block width.

2. Main bearing caps provide 0.0015 to 0.0045 inch [0.04 to 0.11 mm] interference fit in block.

3. If the cap is a rear cap (No. 7):

a. Remove locating dowels from block. Locate cap so thrust faces of cap and block are flush. Use Prussian Blue on block surface to locate dowel holes in cap.

b. Remove cap, drill dowel holes. Reinstall cap and ream dowel holes to the smallest permissible oversize. Install dowels in block.

4. Install all caps on block and machine bore as described in Service Tool Instructions, Page 347

Sleeve Eroded Water Holes

The cylinder block surfaces around the water holes must be free of any erosion scratches or blemishes which are more than 0.003 inch [0.08 mm] deep in the area 1/16 to 3/32 inch [1.59 to 2.38 mm] from edge of water holes. Use ST-1010 Water Hole Counterboring tool to enlarge hole for sleeve. See Service Tool Instructions, Page 343

1. To install water passage sleeve Part No. 191079:

a. Slide sleeve onto stop end of ST-1010-9 Bushing Driver.

b. A sealant may be used to coat sleeve before installation, if desired.

c. Align sleeve in top of water passage hole and drive sleeve in with a hammer until it bottoms. Sleeve will protrude above surface of block.

2. If block is to be resurfaced, see "Top Surface Refinishing." If not to be resurfaced, file bushing flush with top of block, using a wide, flat mill file.

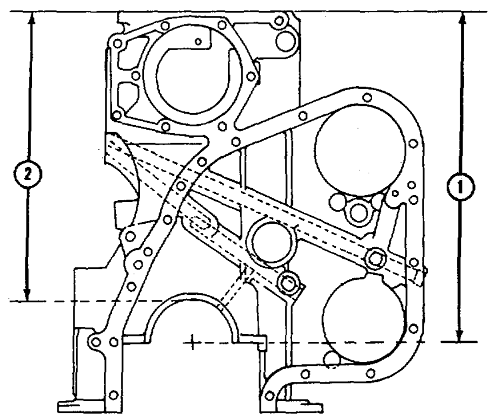
Top Surface Refinishing

If necessary, a cylinder block may be salvaged by removing a maximum of 0.010 inch [0.25 mm] of material from the top surface.

1. Use either a milling machine or large surface grinder; locate block on main bearing pads.

2. Remove dowels from head mounting surface and make light cuts of 0.001 to 0.003 inch [0.03 to 0.08 mm] deep, removing only enough material to make block usable.

3. Check distance from centerline of main bearing bore (1, Fig. 1-2) to top of block. See Table 1-1 (4).



1. Block Height From Centerline of Main Bearing Bore
2. Block Height From Top of Main Bearing Bore

Fig. 1-2 (N10181) Cylinder block height check location.

a. Find this dimension by placing block, top down, on a flat surface plate and measuring from main bearing bore centerline to plate.

b. An alternate method is to check distance from installed main bearing bore alignment bar to top surface of block (2, Fig. 1-2).

c. Distance from head surface to main bearing bore centerline must not vary more than 0.002 inch [0.05 mm] throughout length of block. Head surface flatness must not vary over 0.002 inch [0.05 mm].

4. Finish surfaces to .125 R.M.S.

5. Resurface counterbore to obtain proper liner protrusion. Check liner to block contact in crevice seal area.

Lower Liner Packing Ring Bore Repair - Installation Of Cast Iron Sleeve

Use ST-1081 Boring Tool as indicated in Service Tool Instructions, Page 343, when installing 195778 cast iron sleeves in lower bore of block.

Machining Lower Bore Entry Chamber

If the lower bore or the lower bore entry chamfer is beyond the tolerances, pitted, or eroded, one of the following operations may be performed to salvage the cylinder block.

If the erosion has occurred only on the entry chamfer and not in the packing ring sealing area, the chamfer may be "built-up" by the use of a plastic steel compound such as Devcon Plastic Steel, Type "A." The manufacturer's directions should be followed for this salvage procedure.

Check the chamfer depth after this operation and resurface the chamfer if beyond acceptable tolerances. Follow Service Tool Instructions, Page 343,

Cylinder Liner Counterbore

Resurface cylinder liner counterbore if block has been resurfaced, ledge is uneven or where liner protrusion is incorrect. ST-676 or ST-1059 Counterbore Tool with appropriate adapter plate can be used for this operation. See Service Tool Instructions, Page 343.

Rebuilding Cylinder Liner Counterbores

ST-1168 Cylinder Liner Counterbore Salvage Tool will enable salvaging a block which has a damaged or cracked counterbore ledge. ST-1166 Magnetic Crack Detecting Tool may be used to determine the extent of cracks. The bores can be enlarged and a new sleeve installed. See Service Tool Instructions, Page 343,

The new counterbore salvage sleeve Part No. 202226 is a precision sleeve. No inside diameter cutting is required except cutting the counterbore ledge to depth. When installed 0.005 inch [0.13 mm] to 0.010 inch [0.25 mm] must be cut from the counterbore ledge to meet specification, Table 1-1 (2).

Cylinder Head Capscrew Threads

If threads are damaged, block may be repaired by using ST-476 Heli-Coil Kit.

1. If capscrew hole is 2-11/32 inch [59.53 mm] deep,* drill hole to depth of 1-7/8 inch [47.63 mm] with 23/32 inch drill; tap to 1-3/4 inch [44.45 mm] depth.

2. If capscrew hole is 2-9/16 inch [65.09 mm] deep,* drill hole to 2-1/16 inch [52.39 mm] depth with a 23/32 inch drill; tap to 1-15/16 inch [49.21 mm] depth. Clean all chips and shavings from repair hole.

3. Install insert, Part No. 102674, to a depth of 1/2 inch [12.70 mm] for Step 1, and 11/16 inch [17.46 mm] for Step 2 below top surface of block. Break off insert tang, using a punch and hammer, not an inserting tool; remove tang from bottom of hole with a magnet.

* The specified dimensions are obtained by using a depth gauge with a 1/4 inch wide blade seated in center taper of' hole.

Main Bearing Capscrew Threads

If threads are damaged, block may be repaired by installing Heli-coil insert using ST-1230 Hell-Coil Kit as follows:

1. Drill out old threads with a 1-1/32 inch drill to a depth of 2.675 to 2.705 inches [68.16 to 68.74 mm] from the main bearing cap pad.

2. Tap drilled hole with Tap No. 9193-16H4 to a depth of 2.425 to 2.455 inches [61.60 to 62.36 mm].

3. Install insert, Part No. 3591-16CN-1.500 with inserting tool No. 535-16 until insert is to a depth of 0.860 to 0.890 inch [21.84 to 22.61 mm] below cap mounting pad.

4. Break off tang using tang break-off tool No. 1196-16. (Do not use inserting tool.)

CYLINDER LINERS

Cummins cylinder liners form combustion chamber walls and are in direct contact with coolant for efficient cooling. Coolant is sealed in block by accurately machined surfaces at liner flange and by packing rings and crevice seal at lower end of liner.

1. Check for cracks in cylinder liners just under top flange, at bottom of liner, or above top seal ring groove as follows:

a. Magnetic Method.

b. Dye Penetrants.

2. Discard any liner with excessive corrosion or erosion and pits 1/16 inch [1.59 mm] deep or more or if dents, pitting or fretting on underside of liner flange cannot be removed by lapping.

3. Check worn liners with dial bore gauge. Replace if worn more than Worn Limit as shown in Table 1-1 (5).

4. Deglaze cylinder liner walls.

CLEANING

1. After liners are deglazed, they must be cleaned thoroughly with solvent, steam cleaner or hot soap and water. It is recommended that cleaning operation be ended by scrubbing bore with a bristle brush to remove as much debris as possible. Blow liners dry with compressed air. Coat bore of liners generously with clean lubricating oil. If possible, let liners stand 5 or 10 minutes. Use white paper towels to wipe lubricating oil from liner bores. Note gray and even black residue that appears with oil on white towels. Repeat application of lubricating oil and wipe off with white paper towels.

2. All new cylinder liners should be "prebrushed" and cleaned before assembly to assure no abrasives are present in the Lubrite coating.

CRANKSHAFT

Crankshafts are steel forgings with accurately machined and hardened main and connecting rod journals. Each shaft is balanced for proper weight distribution to insure even forces during rotation.

DISASSEMBLY AND INSPECTION

1. If crankshaft gear is chipped, cracked, broken or worn; remove lockplate and nut (if used).

Note: If crankshaft gear condition is satisfactory, do not remove gear.

2. Attach a circular-type puller behind the crankshaft gear.

3. Apply 75 to 100 ft-lbs [10.4 to 13.8 kg ml on puller screw.

4. Heat gear with heating torch not a cutting torch to 300 deg. to 400 °F [150° to 205 °C] .,The gear will expand, making it easier to pull. Remove gear key.

5. Inspect crankshaft visually for scratches, nicks, cracks and obvious wear pattern and measure crankshaft journals with micrometers. See Table 1-1 (6).

6. Check crankshaft for out-of-round condition. Crankshafts should be reground if main bearing or crankpin journals are worn out-of-round more than 0.002 inch [0.05 mm] .

CLEAN DRILLINGS IN CRANKSHAFT

1. Remove all pipe plugs, clean all drilled oil passages in crankshaft with a rod and rag as if cleaning a rifle barrel.

2. Lubricate threads with clean SAE 20W or 30W lubricating oil, install and tighten plugs to 60 to 96 inch-lb [0.7 to 1.1 kg ml torque.

INSPECT CRANKSHAFT JOURNALS AND THRUST FLANGE

1. Carefully examine crankshaft journals and thrust flange at No. 7 main bearing. If surfaces are scored or scratched, crankshaft should be reground and undersize rod and main bearings or oversize thrust rings installed.

2. Reground crankshafts or those used with undersize rod · ,and main bearings and/or oversized thrust rings should be marked so correct bearing shells and thrust rings can be installed in proper position. Fig's. 1-3 and 1-4.

3. The marking for undersize rod and main bearings should be on front counterweight, oversize thrust ring size on rear counterweight. Both thrust ring size and ring location must be included in stamping as shown in Fig. 1-4.

For example: Front 0. inch [0.25 mm] and rear 0.020 inch [0.51 mm].

ASSEMBLY

Install crankshaft gear, if removed.

Note: Check parts catalog for correct gear part number.

a. Install key or dowel pin in shaft.

b. Heat gear in a pre-heated oven at 450 deg. F [214 deg. C] for a minimum of one hour.

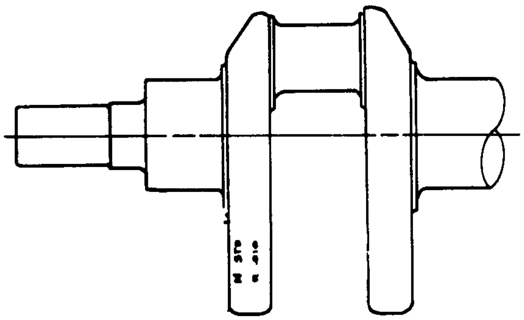


Fig . 143 (V50138) Identification of rod and main journal size

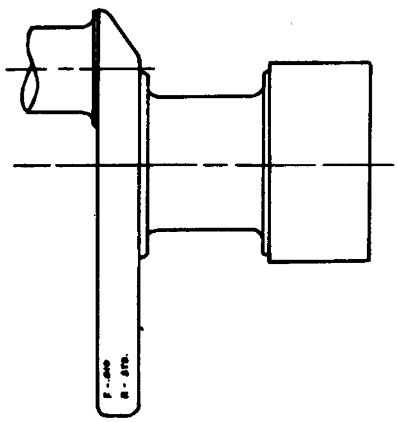


Fig . 1-4 . (N101140) Oversize thrust bearing mark on crankshaft

c . Lubricate flange with high pressure grease and drive gear onto shaft with piece of tubing.

d. Install lockplate and nut (if used).

BEARINGS

Main and connecting rod bearings (or shells) are two-piece units with one unit containing an oil hole for lubrication. Thrust rings are used at the rear main bearing.

INSPECT BEARING SHELLS

1. Gauge shell with ball point micrometer, dial indicator thickness gauge, or comparator. Discard shells that are worn more than 0.001 inch [0.03 mm] or if chipped, flaked, or scored. See Table 1-1 (7-8) for thickness of standard shells.

2. Total worn maximum oil clearance should not vary more than 0.002 inch [0.05 mm] between adjacent main bearings. See Table 1-1 (7-8).

Note: Under no circumstances should an attempt be made to scrape bearing shells, nor should they be lapped or filed to increase oil clearances. A properly fitted bearing will appear dull gray after a reasonable period of service, indicating it is running on an oil film. Bright spots indicate metal-to-metal contact and black spots indicate excessive clearance.

CRANKSHAFT THRUST RINGS

1. The best measurement of wear on crankshaft thrust rings is the crankshaft end clearance check. See "Engine Assembly" Group 14 and Table 1-1 (9-10).

2. Oversize thrust rings are available; be sure to use same size (thickness) half-ring on both upper and lower portions. Stamp crankshaft rear counterweight indicating size used.

Note: Allowable amount of wear on thrust ring depends upon wear of crankshaft surfaces. Installed in a cylinder block, crankshaft end clearance should not exceed 0.022 inch [0,56 mm] at rebuild; however, at the maintenance check, when engine is operating satisfactorily, end clearance is allowable to maximum of 0.035 inch [0.89 mm on 855 series engines.

VIBRATION DAMPER

The vibration damper is a unit which counteracts twisting or torsional vibrations of crankshaft. The damper is engineered to match engine model on which it is used. To prevent failures make sure it is operative at all times. Two types of vibration dampers are used on Cummins engines rubber element and viscous.

CLEANING

Viscous dampers should be cleaned of rust, dirt or grease with a suitable solvent cleaner.

Dampers are not subject to Field repair; therefore, if inspection shows them to be defective, install new dampers.

Rubber Element Damper

Most engines use rubber element dampers, which are tuned to the engine’s natural system frequency. These are made of metal units separated by rubber compound material. The dampers are designed to provide adequate protection for

Viscous Dampers

Viscous dampers operate on a different principle and are not as critical in their operation. Due to design, operation over a greater variation in load and mass is possible

1. Spray damper with Spotcheck Developer, Type SKD-NF, or equivalent. Place damper in oven heated to 200 deg. F [93 deg. C]. Allow damper to reach oven temperature.

2. Remove damper from oven and inspect for oil smudges or fluid leakage. If oil smudges appear, discard vibration damper.

3. Check damper for eccentricity and wobble after installation. Refer to Group 14. An alternate but less effective method for inspecting viscous dampers is by shaking damper. Movement of loose pieces may be felt or heard if fluid has been lost. Tap front face at outside and inside seal. If seal is broken, a hollow sound will be heard at break. The viscous damper cannot be balanced in the Field; if out of balance is suspected, install a new damper.

Vibration Damper Mounting Flange

1. Check damper mounting capscrew hole threads.

2. Maximum eccentricity of mounting flange, measured on outside diameter of pilot, should not exceed 0.004 inch [0.10 mm] total indicator reading. Wobble of flange, measured at 2-3/4 inch [69.85 mm] radius, should not exceed 0.003 inch [0.08 mm]. The above readings are to be taken after assembly to engine. Crankshaft must be kept to front or rear thrust limit while wobble is checked.

CONNECTING RODS

INSPECTION

1. Magnaflux all connecting rods, caps and bolts; discard if cracks are detected.

Note: Be sure rod and cap are kept mated at all times.

a. Check rods for cracks with 1800 ampere current AC equipment or 1500 ampere current DC or rectified AC equipment longitudinally between plates.

b. Check rods for cracks with 3000 to 3400 ampere-turns with AC equipment or 2600 to 2800 ampere-turns with DC or rectified AC equipment in a coil. Pay particular attention to shaded critical areas shown in Fig. 1-6.

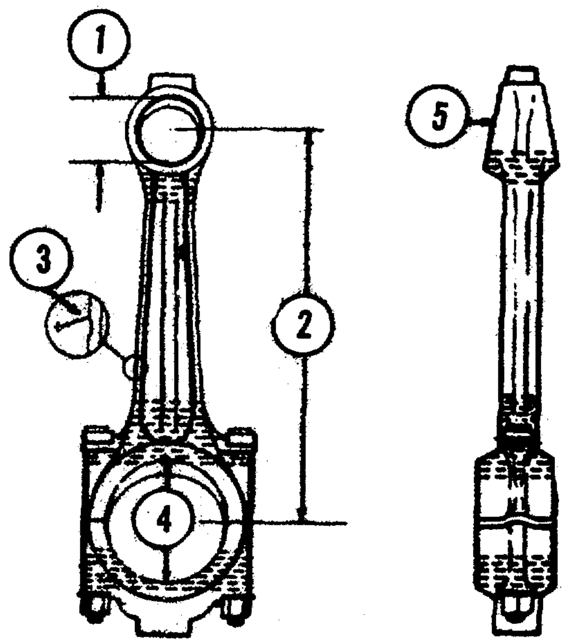
Note: Ampere-turns is defined as the amperage flowing through the coil, multiplied by the number of turns in the coil. Most coils contain four turns and therefore only 700 amperes need to be applied with DC equipment, or 850 amperes with AC equipment.

c. Apply one and one-half percent wet solution while current is on. Make visual inspection after each application of current.

2. Assemble cap to rod and alternately tighten nuts to operating tension as described in Table 1-1 (19).

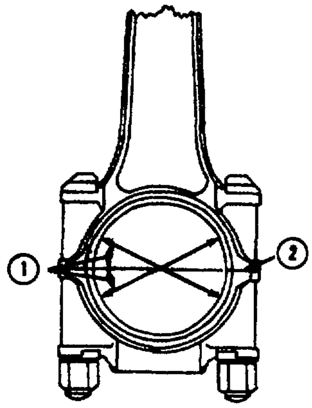
3. Check crankpin bore with a dial bore gauge or inside micrometer.

a. On 2 bolt connecting rods the bore diameter must be within 3.2722 to 3.2736 inch [83.114 to 83.149 mm] up to 30 deg. on either side of parting line. Fig. 1-8.



1. Pin Bushing Bore
2. Rod Length
3. Defect In Rod
4. Crankpin Bore
5. Rod Taper

Fig. 1-6 (V40114). Connecting rod specifications.



2. Parting Line
Fig. 1-8 (N10194) . Connecting rod wear limits

b. On 2 bolt connecting rods, bore diameter must be within 3.2722 to 3.2732 inch [83.114 to 83.139 mm] beyond 30 deg. on either side of parting line.

c. If either specification is not met, the rod must be resized.

4. Gauge piston pin bushing diameter with ST-205 Plug Gauge or with inside micrometer. See Table 1-1 (11).

5. Use ST-561 Checking Fixture and ST-563 Locating Mandrel to check rod alignment.

Calibrate ST-561 Checking Fixture For Rod Size

1. Select a new rod that has been checked for correct absolute center to center length, 12 inch [304.80 mm] between centers. Production rods may vary from 11.998 to 12.000 inch [304.75 to 304.80 mm] .

2. Assemble cap to rod as described in Step 2 under Inspection.

3. Insert piston pin, furnished in ST-563 Mandrel Set, in piston pin bore. Insert and tighten ("snug" only) expanding arbor in crankpin bore.

CAUTION

The expanding arbor must be installed with locking pin down and on center line of rod.

4. Set rod in fixture and move dial holder so dials indicate on piston pin. Zero dial indicators.

5. Lift rod, arbor and pin assembly from fixture; turn horizontally 180 deg; set back in fixture. Readjust dial indicators to divide difference between first and second readings; fixture is now calibrated.

Check Rod Alignment

1. Measurements read directly from dial indicator indicate comparative length and misalignment of bores. Measurements apply with or without bushing installed.

2. Assemble ST-563 Mandrel Set in rod to be checked. Set rod in fixture; be sure pin in mandrel is down and locked in position in center line of rod.

3. Take readings for length (compared to length set up in calibration of fixture) and misalignment of bores (difference in reading from one indicator to other).

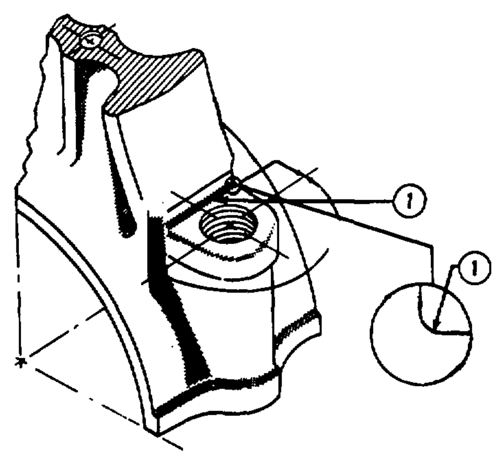
4. Turn rod 180 deg. Total reading must not exceed 0.008 inch [0.20 mm] when connecting rod does not contain bushing or 0.004 inch [0.10 mm] with bushing installed and bored to size. This is combined plus and minus readings of indicator. Length must read 0.001 inch [0.03 mm] on gauges.

5. Measure rod twist with a feeler gauge between piston pin and dial holding plate. When measuring connecting rod twist in ST-561 and rod does not contain piston pin bushing, twist must not exceed 0.020 inch [0.51 mm]. Twist must not exceed 0. inch [0.25 mm] with bushing in place and bored to size.

Check Bolts, Bolt Holes And Bolt Pads (2 Bolt Rod)

1. The bolt head must rest squarely on milled surfaces of rod.

2. If connecting rod bolts have been tightened excessively



1. Bolt Head Fillet Radius
Fig. 1-9 (N40114A) Connecting rod radius specifications.

they may be permanently stretched, in which case they must be discarded. Discard bolts if smallest diameter is less than listed in specifications.

3. Discard all bolts and nuts that have distorted threads.

4. Check rod bolt hole pilot inside diameter in rod and cap. If diameter exceeds wear limits, discard rod and cap.

5. Check bolt pad radius. See (1-Fig. 1-9).

REPAIR

Restore Fillet

1. A dimension of 0.045 to 0.055 inch [1.14 to 1.40 mm] (2 bolt rod 1, Fig. 1-9)(0.240 to 0.260 inch [6.10 to 6.60 mm] 4 bolt rod) fillet radius must be present at all corners where rod is milled for bolt head. Maximum 1/16 inch [1.59 mm] metal may be milled off to restore radius.

2. Remove nicks and dents which are less than 1/16 inch [1.59 mm] deep by grinding or filing with a half-round file. Radius must be 1/2 inch [12. mm] or more, Blend radii at ends of cut. Scrap rod if dents are deeper than 1/16 inch [1.59 mm] (3, Fig. 1-6).

Resize Crankpin Bore

Resize only if crankpin bore is outside limits given in Table 1-1 (11).

1. Remove old piston pin bushing with ST-870 Mandrel and Block. Install cap and tighten nuts to operating tension.

2. Recheck rod length on ST-561 Checking Fixture, If rod length is 11.991 Inch [304.57 mm] or less, rod cannot be resized and must be discarded.

Note: Rod must measure 12. inch [304.80 mm] in length to remove 0.009 inch [0.23 mm] from mating surfaces of cap and rod face.

a. Parts must be clamped securely during operation to insure proper contact of entire mating surfaces and proper alignment of bores for rod bolts when assembled. Bolt holes must remain perpendicular to machined mating faces.

b. Use surface plate and lapping compound to lap rod and cap mating surfaces. After grinding and lapping, "blue" surfaces; seating or flatness pattern must show a minimum 75% contact. Still-blued area must not be in area outside bolt centerline (area farthest from bore centerline); this area should indicate 100% seating.

c. Place mating rod and cap surfaces together and check closely for evidence of out of flat.

3. The rod cap must be reassembled to rod and tightened to operating tension. On 2 bolt rod line bore or grind crankpin bore to 3.2720 to 3.2725 inch [83.119 to 83.134 mm] inside diameter.

Note: The above measurement is boring dimension before rod and cap separation.

4. Check alignment on ST-561. See "Check Rod Alignment".

Note: ST-294 Boring Machine is not suitable for this job.

Use ST-526, a milling machine or cylinder grinder with a precision fixture. Finished surface must be to 75 micro-inch or better to insure proper contact with connecting rod bearing shells.

5. Install and bore new heavy-wall piston pin bushing as described under "Replace Piston Pin Bushing". Heavy-wall special bushing, Part No. 1'52770, must be used, Bore piston pin bushing off-center to restore rod to original 11.998 to 12.000 inch [304.75 to 304.80 mm] length.

Replace Piston Pin Bushing

1. Remove worn tapered bushings with ST-1242 Mandrel and Detail (5, Fig. 1-10), remove tool.

2. To install standard size tapered bushing (7) in rod, assemble bushing (7) on Mandrel (1), position Sleeve (4) then Cup (2) on Mandrel (1). Secure with Locking Pin (6).

3. Place connecting rod on Block (3) and support in horizontal position.

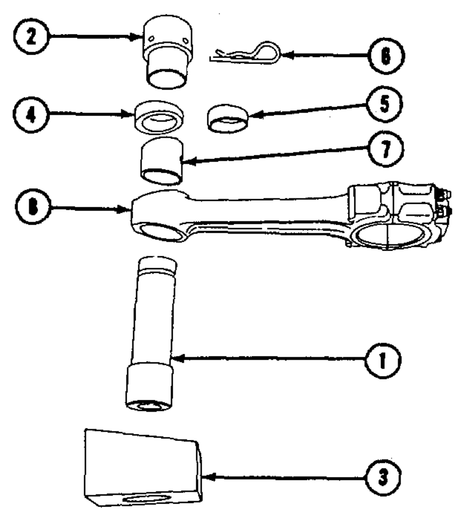


Fig. 1-10. (N10158) Installing piston pin bushing in rod.

4. Insert mandrel with all components listed in Step "2" into connecting rod bushing bore.

5. Align Detail (4) with middle of boss on rod.

Note: Be sure to line up oil holes.

6. Using an arbor press,. press bushing into bore until Detail (4) contacts side of rod pin boss.

7. To install thick-walled bushings in rods which have been resized at crankpin end, install in same manner as outlined in Steps 2 through 6 above.

Bore Rod Piston Pin Bushing

1.Fill lubricating holes with soap to keep out shavings.

2. Mount connecting rod in ST-526 Tobin-Arp Boring Machine or equivalent.

Note: Lower mandrel should have only the two horizontal blades in place to properly locate the side position of the piston pin end of rod.

3. See instruction booklet furnished with ST-526 for operating procedure.

4. Bore bushing to 2.001 to 2.0015 inch [50.83 to 50.84 mm] inside diameter. Remove rod from ST-526 and check size with ST-205 Plug Gauge.

5. Remove sharp edges with a scraper.

6. Remove shavings and soap, wash in mineral spirits and dry with compressed air.

7. Check all dimensions on rebushed and rebored rods on ST-561 Checking Fixture as previously described.

Note: All connecting rods used in an engine should have the same part number and letter code. Never attempt to interchange caps.

Chamber Piston Pin Bore

1. ST-861 Chamfering Tool is used to chamfer tapered piston pin bushing bore, if not chamfered.

2. Install proper bushing tool detail by use of flat-head screw.

3. Set the guide screw holder. in position; there are three notches, so guide screw wi ll follow on face of bore.

4. Adjust tool bit until point just clears guide screw and tighten in position with two set screws.

5. Install unit into bore.

6. Adjust the guide screw (up or down) until tool bit just engages bore.

Note: A slight pressure is required against guide screw. To obtain this pressure, tighten set screw in end of holder against guide screw.

7. Insert drive ratchet and turn tool one complete turn to clean up edge of bore.

8. Loosen guide screw and again turn tool one or more complete turns to give a clean cut.

Note: Repeat until a uniform chamfer of 0. to 0.060 inch [1.02 to 1.52 mm] depth is reached.

9. Remove tool from bore, turn rod over and chamfer other side of bore.

10. With both sides chamfered, remove tool.

11. Use emery cloth to remove any sharp edges which may have been left on chamfer.

12. Wash rod before bushing installation.

PISTONS AND PISTON RINGS

Piston Rings

New rings should be checked in cylinder liner in which they are to be used to make sure the gaps are correct.

1. Insert each ring in mating cylinder liner; position with head of piston so it is seated squarely in ring travel area of liner.

2. Measure ring gap with a feeler gauge. Gap should fall within limits given in Table 1-1 (14).

3. Never file or stone chrome-plated rings and never use chrome-plated rings in chrome-plated cylinder liners.

4. Check current parts catalogs to assure use of proper ring/piston combination. When used, chrome-plated compression ring is always installed in top piston ring groove.

Pistons

INSPECTION

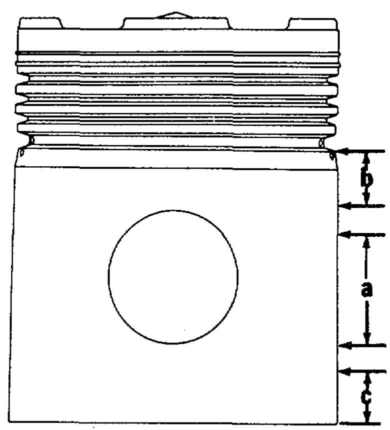
1. Check top and second ring grooves with ST-560 Ring Groove Gauge. Shoulders of gauge must not touch ring groove lands if piston is to be reused. If shoulders touch, discard piston.

2. If ST-560 is not available, check wear with a segment of a new ring and a feeler gauge.

a. Hold ring in groove, flush with land and insert 0.006 inch [0.15 mm] feeler gauge.

b. If gauge enters groove without forcing or disengaging ring, wear is excessive and piston should not be used.

3. Measure piston skirt diameter with micrometer at right angle to piston pin bore (A, Fig. 1-11 for barrelground pistons); measure straight or tapered ground pistons at Point B, 1 inch [25.4 mm] below ring groove and C, 1 inch [25.4 mm] above bottom of piston. Pistons should not be reused if worn more than 5.483 inch [139.27 mm].



a. Pin Bore Area
b. Area Below Ring Groove
c. Piston Skirt

Fig. 1-11 (N20171) Piston check points.

4. Pistons should be checked at temperature of 70 to 90 deg. F [21 to 32 deg. C]. After measuring piston and comparing with liner inside diameter, piston-to-liner clearance may be computed if desired.

5. Piston pin bore checked at 70 deg. F [21.1 deg. C] should fall within limits shown in Table 1-1; add 0.0005 inch [0.013 mm] per 10 deg. F [-12 deg. C] up to 90 deg. F [32 deg. C] .

6. Check piston pin outside diameter with micrometer. Pins should not be reused if out-of-round more than 0.001 inch [0.03 mm] or worn smaller than indicated in Table 1-1 (13). Reboring of piston pin bores and use of oversize pins is not practical because the misalignment that results from such practice will cause seizure of piston or failure of connecting rod bearings.

Piston-To-Connecting Rod Assembly

1. Pistons are machined to a very close weight tolerance; therefore, as long as the same part number piston is used throughout the engine, weight does not affect engine operation.

2. Be sure rod and cap are stamped with cylinder number from which removed before disassembly to prevent mixing parts.

3. Install one piston pin snap ring in groove of piston pin bore.

4. Heat aluminum pistons in boiling water or in an oven at or below 210 deg. F [98.9 deg. C] and install pin through piston and connecting rod pin bores before piston cools; at 70 deg. F [21 deg. C] the pin fit is 0.0001 to -0.0003 inch [0.003 to -0.008 mm] which prevents pin assembly unless piston is heated, Secure pin with second snap ring in groove at opposite end of pin bore.

CAUTION

Never drive piston pin in pistons. Driving may cause distortion of piston, causing piston seizure in cylinder liner.

REAR COVER

The rear cover is a unit subject to replacement of seals only. Damaged housings require replacement by a new assembly or installation of a "Heli-Coil" for stripped threads; these are only items of repair.

Alignment during engine assembly is the biggest factor for proper performance of the rear cover unit. See Group 14.

CAMSHAFT

INSPECTION

Check camshaft bushing journals with micrometers.
Replace camshaft if journals are worn beyond limits given in Table 1-1 (15).

Replace camshafts that have scuffed, scored, or cracked injector or valve lobes. Check by magnetic inspection for possible cracks.

Cummins Engine Company, Inc. does not recommend regrinding of camshaft lobes.

Camshaft Support

If cast iron support is used, inspect bushing in support; remove if damaged or worn smaller than 1. inch [34.80 mm]; press in new bushing flush with inner bore. New dimensions are 1.3725 to 1.3755 inch [34.86 to 34.93 mm]. Replace aluminum support.

Thrust Bearing

Inspect thrust bearing for flaking, burrs, distortion and wear; discard if damaged or worn smaller than 0. inch [2.11 mm]. New dimensions are 0.093 to 0.098 inch [2.36 to 2.49 mm].

Gear

1. Remove gear if chipped, cracked or visibly worn. Gear is press-fit on camshaft.

2. Place camshaft in a press between V-blocks. Heat gear with heating torch to 300 deg. to 400 deg. F [148 to 204 deg. C].

CAUTION

Never support gear on outer gear surface. Always support hub area with V-blocks or equivalent spacers.

3. Press camshaft from gear; remove key.

4. Remove pipe plug from drive end of camshaft; clean oil passages as required.

Note: On engines not equipped with outboard bearing, camshaft contains an orifice plug 68193. Do not mix with other 1/8 inch orifice plugs.

5. Install pipe plug in drive end of camshaft, if removed. Torque pipe plug to 5 to 10 ft-lbs [0.7 to 1.4 kg m].

6. Heat camshaft gear evenly to 400 deg. F [204 deg. C] with heating torch. Maximum clearance between camshaft flange and gear face is 0.0015 inch [0.038 mm]; check with feeler gauge.

7. Place camshaft in press; insert new key in camshaft. Press on camshaft gear while hot.

Note: Always check timing when a new camshaft or gear is installed in an engine.

GEAR COVER

INSPECTION

1. Remove and discard all oil seals.

2. Check trunnion and/or bushing for wear; replaceable bushing is available to "rebuild" outside diameter of trunnion which was not originally equipped with bushing.

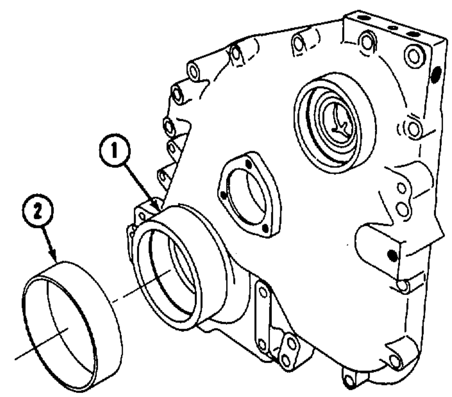
3. Check thrust plates for deep scores or wear beyond point where removal of gaskets will now allow establishment of correct camshaft end play. See Camshaft Installation, Group 14.

PARTS REPLACEMENT AND REPAIR

Gear Cover Trunnion

If gear trunnion on cover is to be "bushed," install as follows:

a. On 855 C.I.D. engines machine gear case trunnion (1 Fig. 1-12) to 4.747 to 4.750 inch [120.57 to 120.65 mm] outer diameter.



1. Gear Case Trunion
2. Bushing

Fig. 1-12. (N10145). Gear case cover and trunion bushing.

b. Press bushing (2) (Part No. 68226-1) over machined trunnion with chamfered side of bushing toward gear case.

Camshaft Support

1. Front camshaft supports are used in gear cover of some turbocharged engines and are one piece aluminum.

2. Check inside diameter, per wear limits in Table 1-1 (15), discard unserviceable parts.

Accessory Drive Bore Bushing (855 C. .D.)

1. Check bore of accessory (fuel pump and compressor) drive; if worn larger than 1.571 inch [39.90 mm], replace.

2. If accessory drive shaft is worn enough to allow use of oversize bore bushing (maintain minimum clearance of 0.003 inch [0.08 mm] between shaft and bushing), use as listed in Table 1-1 (16).

3. Press in new bushing using ST-598 Mandrel.

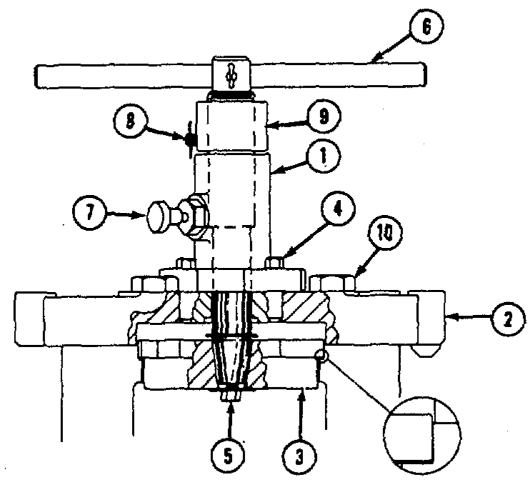
INSTRUCTIONS FOR USE OF SERVICE TOOLS

ST-1010 Water Hole Counterboring Tool
See Service Tool Instructions, Cylinder Heads, Group 2.

ST-1059 Cylinder Liner Counterboring Tool
ST-1064 and ST-1065 Service Tools are used in this operation. Assemble tools as follows:

1. Install ST-1059 driver (1), Fig. 1-13, onto ST-1064 adapter (2) with capscrews (4).

2. Install ST-1065 Tool Holder (3) onto driver unit (1). Fasten holder onto drive unit with capscrew (5).



1. Drive of ST-1059
2. Adapter of ST-1064
3. Tool Holder of ST-1065
4. Capscrew of ST-1064
5. Capscrew
6. Handle
7. Plunger
8. Locking Screw
9. Adjusting Nut
10. Capscrew and Washer

Fig. 1-13, (V40156). ST-1059 Counterbore Tool

PRESETTING TOOL BIT

1. Loosen thumb screw and push adjusting pin back into housing. Tighten thumb screw.

2. Place tool bit setting gauge onto tool holder with dowel pins, engaging smaller diameter of tool holder and holding locating surfaces of housing against flat surface of tool holder.

3. While holding tool bit setting gauge in the above position, loosen thumb screw allowing adjusting pin to engage larger diameter of tool holder. Tighten thumb screw.

4. Install tool bit into tool holder. Set point of tool bit below larger diameter of tool holder and tighten one setscrew.

5. Place tool bit setting gauge with dowel pins engaging smaller diameter of tool holder, holding locating surfaces of housing against flat surface of tool holder.

6. Position adjusting pin over point of tool bit. Loosen setscrews allowing tool bit point to rest against locating point of adjusting pin. Tighten setscrews.

INSTALLATION AND OPERATION

1. Pull out on handle (6) until plunger (7) will hold tool holder (3) in the up position. Place unit on cylinder block with hold-down holes matching in cylinder block.

2. Hold onto handle (6) and pull out on plunger (7). Slowly lower tool holder into counterbore. Engaging larger diameter of holder allow tool bit to rest on counterbore ledge.

3. Loosen locking screw (8) and rotate adjusting nut (9) in clockwise direction until tool bit clears counterbore ledge. Tighten locking screw.

4. Assemble hold-down capscrews and washers (10) through adapter plate into cylinder block finger tight, then torque to 50 to 75 ft-lbs (6.9 to 10.4 kg m].

Note: Tool holder must rotate freely.

5. To measure depth of counterbore:

a. Install depth gauge into gauging hole of adapter plate. Loosen capscrew and push down on dial indicator to end of travel.

b. Pull dial indicator 0.010 to 0.020 inch [0.25 to 0.51 mm] off bottom. (End of travel.) Tighten capscrew.

c. Set dial indicator to zero.

d. Rotate tool holder until red indicator line matches red line on adapter plate.

e. Place depth gauge on four counterbore measuring holes. The average of the four readings will be the present depth of counterbore. See Table 1-1 (2) for counterbore depth.

6. To operate counterboring tool:

a. Loosen locking screw. Rotate adjusting nut in counterclockwise direction until tool bit is resting on lowest part of counterbore ledge and there is clearance between housing and adjusting-nut.

Note: The distance between housing and adjusting nut equals amount of material that will be removed from counterbore ledge.

b. To set the depth of cut, place a feeler gauge of required thickness between adjusting nut and top of housing. For example: if 0.005 inch [0.13 mm] of material is to be removed from counterbore ledge, use 0.005 inch [0.13 mm] feeler gauge. Make sure there is no grease or dirt between adjusting nut and top of housing.

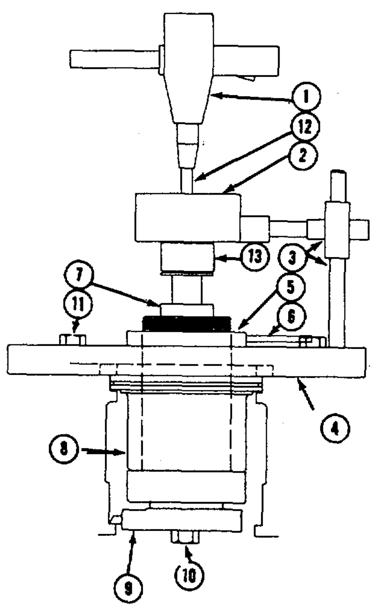
c. Rotate adjusting nut until feeler gauge is just held between adjusting nut and top of housing. Tighten locking screw. Remove feeler gauge.

d. Hold down on handle applying more pressure on tool bit side and rotate handle in a clockwise direction until unit turns freely and is bottomed out between adjusting nut and top of housing.

e. Measure depth of counterbore as described in Step 5.

ST-1081 Boring Tool (Lower Cylinder Liner Bore)

ST-1064, ST-1081, ST-1081-52 and ST-1084 Service Tools are also used in this operation. Assemble boring tool as follows:



1. Drill Motor
2. Drive Gear
3. Torque Reaction Bar
4. Adapter Plate
5. Retaining Nut
6. Retaining Nut Handle
7. Boring Tool
8. Bore Adapter
9. Tool Holder
10. Capscrew
11. Capscrew
12. Drive Adapter
13. Upper Bearing

Fig. 1-14, (V40153), ST-1081 Tool Bit installed in blockST-1081 Tool Bit installed in block

1. Install ST-1084 Bore Adapter (8, Fig. 1-14) onto ST-1081 Boring Tool.

2. Install ST-1064 Adapter Plate (4) onto boring tool with 3/4 inch recess toward bore adapter.

3. Engage retaining nut (5) onto boring tool and tighten retaining nut until boring tool, bore adapter and adapter plate are secure.

4. Install ST-1081-52 Tool Holder (9) into boring tool (7) and tighten in position with capscrews (10).

PRESETTING TOOL BIT

1. Loosen two setscrews. Install ST-1081-55 Tool Bit into tool holder, being sure that spring is in place.

2. Push in on tool bit until it bottoms on spring. Lock one setscrew.

3. Place tool holder into setting gauge and fasten in place with capscrew finger tight and position point of tool bit so it will engage setting nib.

Note: Proper nib will be indicated by stamped letters or numerals for particular engine.

4. Loosen setscrews allowing point of tool bit to engage setting nib, then tighten against bit.

5. Remove tool holder and bit from setting gauge. Install in boring tool.

INSTALLATION AND OPERATION

1. Install assembled boring tool into cylinder block, allowing bore adapter (8) to engage counterbore and holes in adapter plate to match holes in cylinder block.

2. Fasten adapter plate in place, tighten capscrews to 50 to 75 ft-lbs [6.9 to 10.4 kg m] torque. Install torque reaction bar (3) into plate.

3. Install gear drive (2) onto boring tool with 1/2 inch square drive engaging boring tool and gear drive anchor arm engaged over the torque reaction bar.

4. Install drive adapter (12) into drill motor (1)and fasten in place. Engage adapter and motor onto gear drive.

5. Being sure boring tool shaft is in maximum up position, turn on drill motor. Initial contact of tool bit with bore will be intermittent and care should be exercised at start of cut. While unit is rotating, apply a slight downward pressure until maximum depth bf bore is complete.

6. Pull-up on drive shaft of boring tool (turning clockwise) until drive shaft is in up position, then repeat procedure to be sure of a true hole.

7. Remove unit from cylinder block and sandpaper rough edges from top and bottom of cut and clean with compressed air.

Note: If tool bit is changed, be sure and reset new tool bit.

Installing Repair Sleeve Into Cylinder Block 1. Push sleeve, Part No. 195778, through upper bore and install sleeve driver when sleeve is positioned in lower bore.

2. Place sleeve and driver as a unit in position to go into lower bore, insert driver handle.

Note: Inside diameter chamfer of sleeve to be toward deck.

3. Install locator over driver handle and into counterbore.

4. Tap gently on driver handle until sleeve is located on starting radius, then drive sleeve into place. When sleeve is in correct position, the sleeve drive handle will become free for removal.

Note: This tool is also used when machining the lower bore entry chamfer. If erosion has occurred, the chamfer area may be built up by the use of a plastic steel compound (follow manufacturers instructions) and resurfaced. Follow above instructions using ST-1096-2 Spacer and ST-1096-4 Tool Bit when remachining chamfer.

ST-1252 Concentricity Gauge

Check the cylinder liner counterbore to lower bore concentricity as follows:

1.Place gauge flat on top deck of cylinder block with bumper pins against counterbore inside diameter.

2. Raise or lower bar to position indicator in area of lower bore to be checked.

3. Holding gauge bumper pins firmly against counterbore inside diameter, zero indicator.

4. Release pressure, reposition gauge to check indicator reading. Rezero indicator if necessary.

5. Place gauge 180 deg. from original setting position, hold bumper pins firmly against counterbore inside diameter, record indicator reading.

6. Move gauge 90 deg. and repeat procedure.

Note: Indicator readings recorded are two (2) times actual shift of bore. (Example: Indicator reading 0.002 inch [0.05 mm]. Actual shift from center of bore 0.001 inch [0.03 mm].

ST-1168 Cylinder Liner Counterbore Salvage Tool

This tool is used to enlarge damaged counterbores for the installation of salvage sleeve or bores that have been reworked to maximum depth.

ASSEMBLY OF TOOL

1.Assemble and secure adapter plate (ST-1168-28), (Fig. 1-15) to main body.

2. Assemble tool holder (ST-116839) on shaft of main body (1168) and secure with nut (ST-1168-33) and washer (ST-1 168-34).

MACHINING THE BLOCK

1.Remove cutting tool from (ST-1 16839) holding plate.

2. Place boring machine on cylinder block above bore to be cut and hand start mounting capscrews. Capscrew spacers (ST-1168-29 or 40) must be on capscrews.

3. Lower tool holder into bore by pulling up on orifice retractor knob (ST-1168-14) while pushing down on set collar (ST-1 168-12).

4. Tool holder lower diameter is used to center machine in counterbore inside diameter. Push tool holder lower locating diameter into counterbore and tighten four mounting capscrews alternately to 25 to 35 ft-lbs [3.5 to 4.1 kg m] torque.

5. Retract tool holder by pulling up on orifice retractor knob (ST-1 168-14).

6. Loosen setscrew (ST-1168-23) in back end of tool bit and push adjustable set pin (ST-1168-21) all the way in. Lock setscrew.

7. Adjust micrometer (ST-1168-25) to 6.750 inch [171.45 mm] .

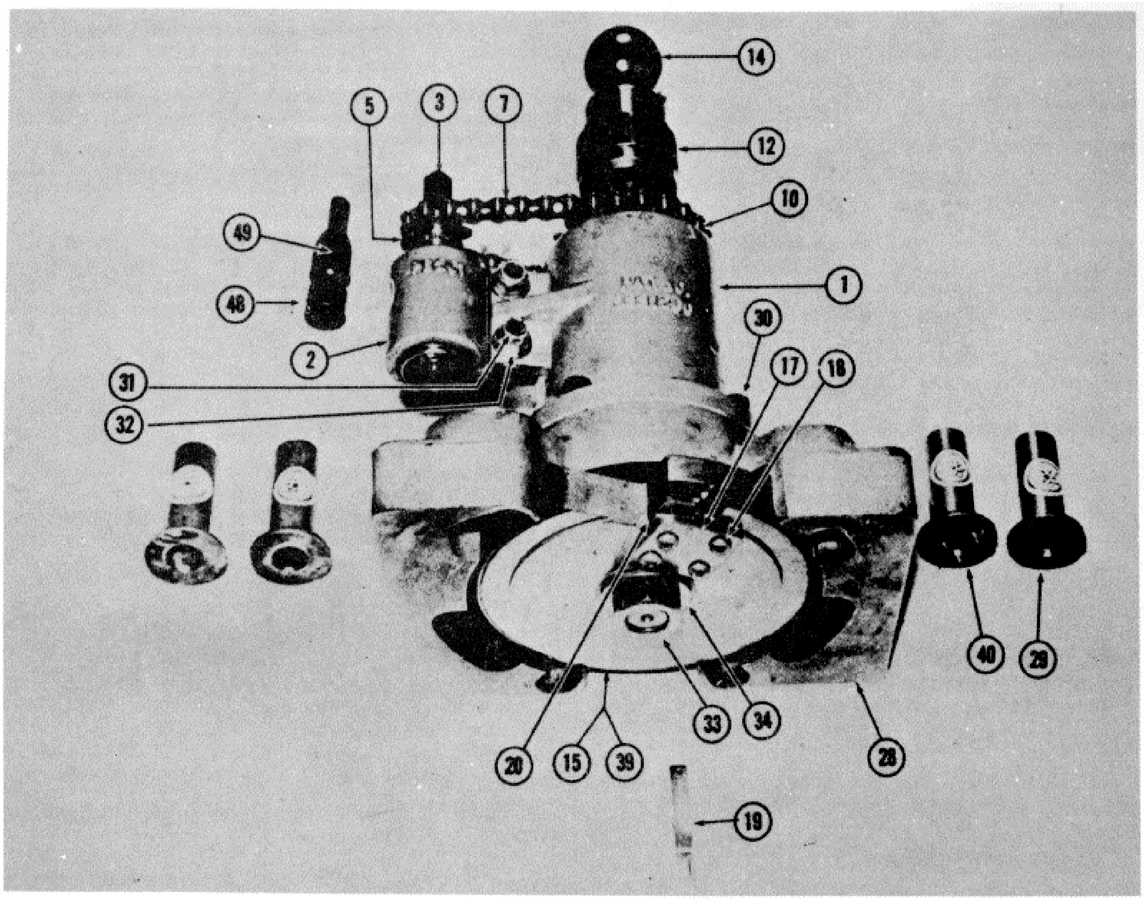
8. Place tool bit (ST-1168-19) in tool bit gauge and hold firmly against stop and hardened pad (ST-1168-27). Loosen setscrew and allow adjustable set pin to come out against micrometer spindle. Lock setscrew.

9. As a further check, back off thimble on micrometer and recheck tool bit length again.

10. Insert tool bit into tool holder and tighten lockscrew (ST-1168-20). Tool bit must be held all the way in against tool holder.

11. Turn tool holder until tool bit recess is at large opening in (ST-1168-28) adapter plate.

12. Place a 0.004 inch [0.10 mm]feeler gauge between block and tool bit and lower tool bit onto feeler gauge by



1. Body	12. Depth Collar	20. Adjusting Pin	33. Jam Nut
2. Drive Bracket	14. Knob	28. Base Plate	34. Washer
3. Drive Shaft	15. Guide Plate	29. Spacer	39. Guide Plate
5. Drive Sprocket	17. Tool Locating Plate	30. Capscrew	40. Adapter
7. Drive Chain	18. Capscrews	31. Bolt	48. Universal Joint
10. Driven Sprocket	19. Tool Bit	32. Nut	49. Roll Pin

Fig. 1-15, (V40172). ST-1168 Boring Tool.

pulling up on retractor knob while pushing down on set collar.

13. Loosen set collar setscrew and back off collar counterclockwise until salvage sleeve can be placed between collar and boring machine main body as a depth indicator. Tighten setscrew in set collar. Remove feeler gauge.

Note: This spaces the set collar to cut a depth 0. inch [0.10 mm] less than total height of salvage sleeve to be used.

14. Place 1/2 inch drive flex adapter (ST-1168-48) in a 1/2 or 3/4 inch heavy duty (10 amperes or more) hand drill.

CAUTION

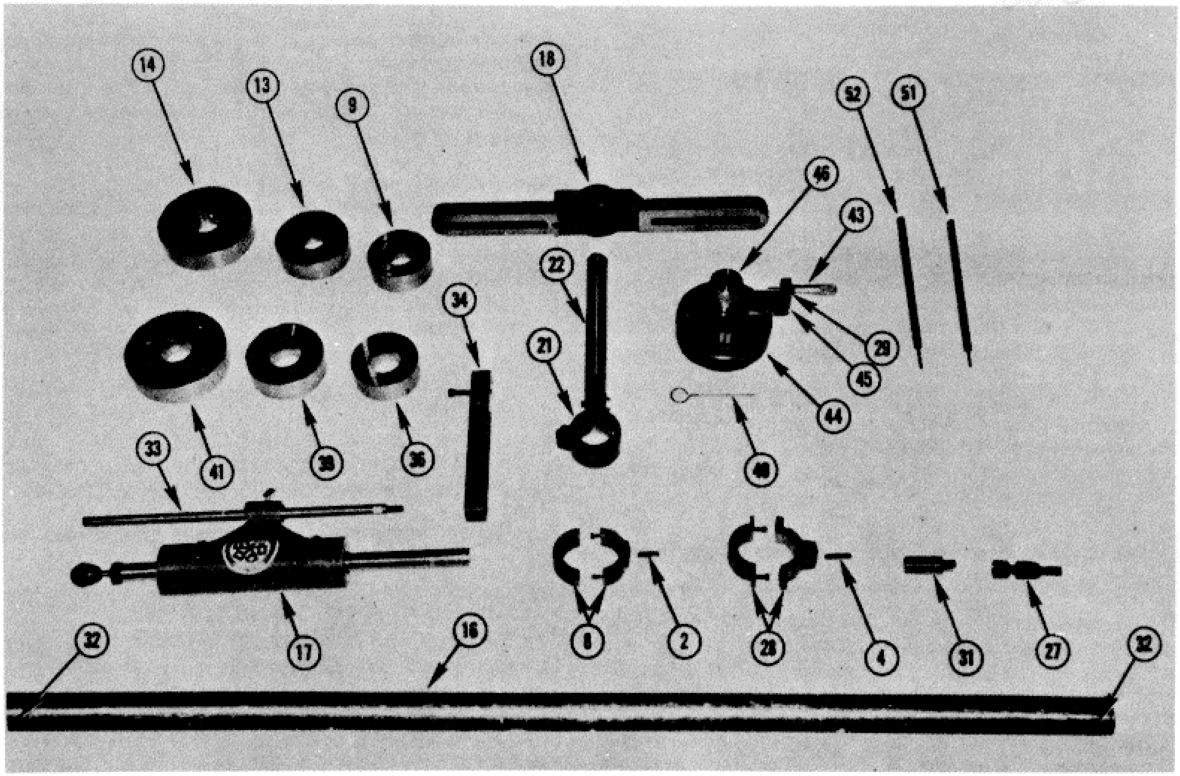
Do not use drill rated less than 10 amperes or over 450 rpm.

15. With drill on half inch drive of boring tool (ST-1168-3), bore hole until drill freewheels. About half way down during cut, tool bit begins cutting out old counterbore ledge, operator should have a firm grip on drill to be prepared for increased load on drill from added metal being cut. Stop immediately when drill freewheels.

16. Retract tool holder by pulling up on retractor knob. Remove tool bit from tool holder. Clean away all shavings and deburr bore with emery cloth.

INSTALLING SALVAGE SLEEVE

1. Clean bore thoroughly with a nonpetroleum base solvent or cleaner.



2.	Cutting Tool	17.	Bore Feed Assembly	31.	Drive Adapter	43.	Micrometer i
4.	Cutting Tool	18.	Bore Bar Bridge	32.	Capscrew	44.	Micrometer Base
8.	Cutter Holder	21.	Bearing Bridge	33.	Torsion Bar	45.	Micrometer Bracket
9.	Checking Ring	22.	Bearing Bar	34.	Bracket	46.	Micrometer Shaft
13.	Checking Ring	27.	Swivel Joint	36.	Centering Ring	49.	Cutter Pin
14.	Checking Ring	28.	Cutter Holder	39.	Centering Ring	51.	Allen Wrench
16.	Bore Bar	29.	Capscrew	41.	Centering Ring	52.	Allen Wrench

Fig. 1-16, (ST-1177). Exploded view of ST-1177 Boring Tool

2. Coat outside of sleeve lightly with a suitable sealant and drive sleeve into bore with driver until it bottoms (see ST-1168-36 through 46). A solid sound can be heard when sleeve bottoms.

3. The sleeve will protrude above the top of block by 0.004 inch [0.10 mm] and must be filed even with the top of block. Remove all burrs with emery cloth.

4. The salvage sleeve is designed to be 0.005 to 0.010 inch [0.13 to 0.25 mm] above required counterbore depth.

Check depth and cut to specifications listed in Table 1-1 (2).

ST-1177 Main Bearing Boring Tool

This tool is designed to perform both the boring and checking functions. Before boring operation, allow tool and block to stabilize to room temperature.

ASSEMBLY TO BLOCK

1. Remove two undamaged main bearing caps. Preferably one from each end of block or as far apart as possible.

2. Insert proper centering rings, with oiler up, in two bores and tap top of centering ring with plastic hammer to seat.

3. Reinstall main bearing caps and torque to required specifications, following steps in Table 1-1 (18).

Note: If centering ring must be installed in journals which have had caps replaced by semi-finished caps, limit torque to 10 ft-lbs [1. kg m].

4. Oil centering ring bores and boring bar, install boring bar

(ST-1177-16), Fig. 1-16, through centering rings rotating slowly. Bar should spin free. Slide bar out one end until appropriate checking ring can be installed in bar. Oil outside diameter of checking ring.

5. Using light finger pressure against checking ring (ST-1177-13) on both sides of bar, push checking ring through each bore. Bar must be turned during this check.

a. Check bore for burrs if checking ring will not pass through bore.

b. A 0.003 inch [0.08 mm] feeler gauge (not over 1/2 inch [12.70 mm] wide) can be used in detecting irregularities in the bore.

c. Attempt to insert feeler gauge between bore and bar or slip ring as used on ST-1177 Boring Tool. Run gauge completely around bar or slip ring on each side of bore. Evaluate as follows:

(1) Gauge does not enter at any point, bar rotates freely std. bore.

(2) Gauge enters on one side and not on opposite slight misalignment. No problem if bar rotates freely.

(3) Gauge loose oversize bore.

(4) Gauge enters on front and not on rear of bore tapered bore.

6. Mark bores to be salvaged.

ASSEMBLING MICROMETER TOOL BIT SETTING GAUGE AND TOOL BIT

1. Place micrometer base shaft (ST-1177-46) through bore of micrometer bracket (ST-1177-45) and thread into micrometer base (ST-1177-44). Tighten securely.

2. Tighten the socket head screw (ST-1177-29) in the micrometer .bracket until the bracket is tight on the micrometer base shaft; micrometer hole in micrometer bracket must be in alignment with cutting tool hole in micrometer base shaft.

3. Install centering ring (ST-1177-39) over micrometer base shaft and micrometer (ST-1177-43) in micrometer bracket: a. Adjust micrometer thimble to value stamped on centering ring.

b. Hold micrometer spindle against centering ring and tighten socket head screw in micrometer bracket. Check to see that micrometer spindle turns free.

4. Remove centering ring and install appropriate cutter holder over micrometer shaft.

5. Align tool bit hole in cutter holder with hole through micrometer base shaft and tighten cutter holder socket head screws. Scribed lines are used on the base shaft and cutter holder for this purpose. Keep even gaps between two halves of cutter holder.

6. Insert appropriate cutting bit in tool holder. Tool must be short enough so it does not extend into the bore of the tool holder. When adjusting micrometer or tool cutter, be careful to "just contact" tool to prevent damage.

7. With cutter key (ST-1177-49) adjust tool bit against micrometer spindle and tighten tool bit retaining screw in cutter holder, back off micrometer and check tool bit setting.

Note: Do not tighten micrometer spindle against tool bit point or carbide may be chipped. Do not sweep micrometer spindle across carbide cutter for it will chip cutting edge.

8. Back off micrometer and remove cutter holder from micrometer base shaft.

CUTTING BORES

1. Install bore feed assembly (ST-1177-17) in one end of boring bar and tighten socket head screw (ST-1177-32).

2. Install torsion bar (ST-1177-33), threaded end first, through bore feed assembly, (ST-1177-17) start threads into end hole of torsion bracket (ST-1 177-34). The flats on bar can be used to secure it to bracket.

3. Locate tapped hole in end of block and secure torsion bracket to block with a suitable capscrew and washer.

4. Pull out on plastic knob of feed assembly until pin is free of slot and turn one-fourth (1/4) turn, then pull complete feed assembly back all the way to the knob and tighten wing setscrew in feed assembly to secure on torsion bar.

5. Install square head set bolt in second threaded hole of torsion bracket end and tighten snug against cylinder block to stabilize torsion assembly.

6. Turn plastic knob on drive assembly one-fourth (1/4) turn until pin seats in groove.

7. Install adapter (ST-1177-31) in other end of boring bar with the 1/2 inch square drive out. Lock with socket head setscrew.

8. Lock swivel joint (ST-1177-27) in a 1/2 inch drill chuck. These instructions assume use of a right hand rotation drill.

9. Install tool bit holder on boring bar, next to journal to be cut. When operating, boring bar will feed toward feed assembly. Make sure tool bit cutting edge is turned in direction of drill rotation.

10. With swivel joint on boring bar adapter, bore the journal. Keep boring bar well lubricated during all boring operations.

CAUTION

Do not use drill rated less than 10 amperes or over 450 rpm.

11. To cut next journal:

a. Remove cutter holder from boring bar.

b. Pull out on plastic knob on feed assembly and turn one-fourth (1/4) turn.

c. Push in on feed shaft (the knob) until it stops against feed assembly.

d. Turn plastic knob one-fourth (1/4) turn, until pin seats in slot.

e. Repeat Steps 9 and 10.

12. Clean block and check size of bore with a dial bore gauge and alignment with checking ring.

USE OF THE BRIDGES

The bridges and bearings are intended for additional support of boring bar and are designed to compensate for any distortion of block oil pan surface. It is not necessary to use bridges if centering rings are located equally apart.

For example: If No. 1, 3, 4, 5 or 7 journals are to be bored and centering rings are in 2 and 6 journals, bridges are not necessary.

1. Assemble bearing bar (ST-1177-22) on bearing bridge (ST-1177-21) with hexagon head capscrew (ST-1177-23) finger tight.

2. Slide bearing over boring bar at point where support is needed. Allow room for cutter holder, if next to journal being cut.

3. Lower line bore bridge (ST-1177-18) over bearing bar and secure to oil pan rails.

4. Tighten socket head screw (ST-1177-25) in bearing until bearing is snug on boring bar; do not restrict bar from turning.

5. Tighten hexagon head capscrew (ST-1177-25) in bearing bar and socket head capscrew (ST-1177-19) in bridge.

6. Turn boring bar to see that it is free.

Cylinder Head

Group 2

Cylinder head group covers inspection, repair and assembly of cylinder head, valves and guides, crossheads and guides, valve seats, Injector sleeves and valve springs.

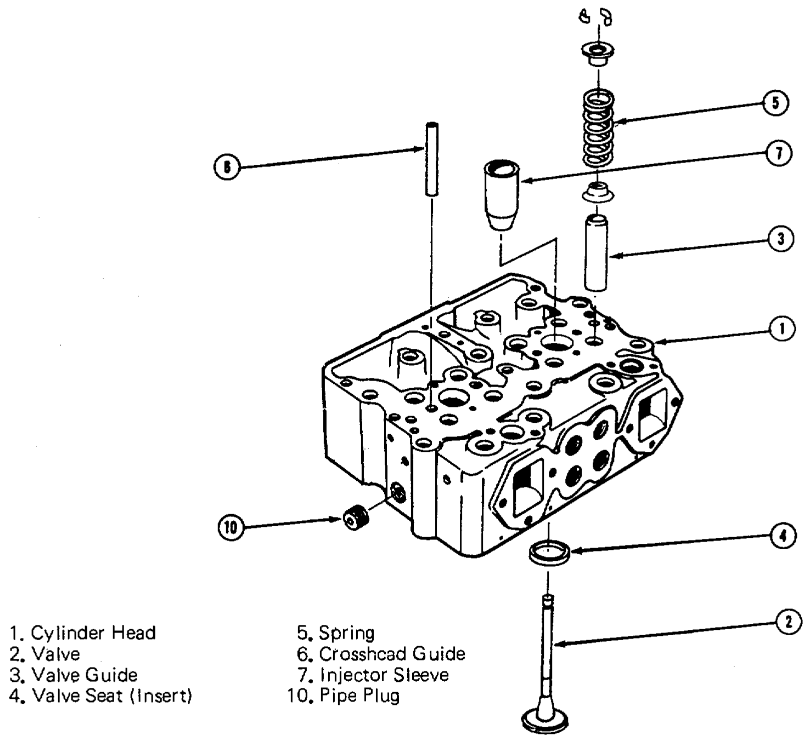


Fig . 2-1 (N10295) . Cylinder head - exploded view

Table 2-1: Specifications - Inch [mm] (Reference Fig . 2-1)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
1.	**Cylinder Head**			
	Height **(1)**	**4.340 [110.24]**	4.370 [111.00]	4.380 [111.25]

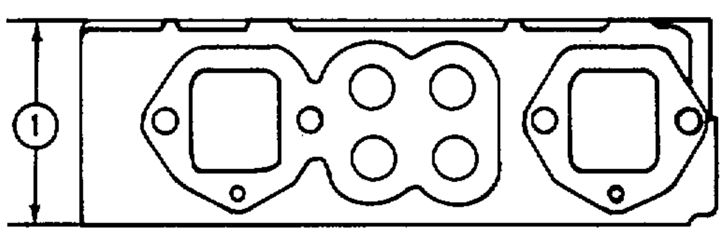
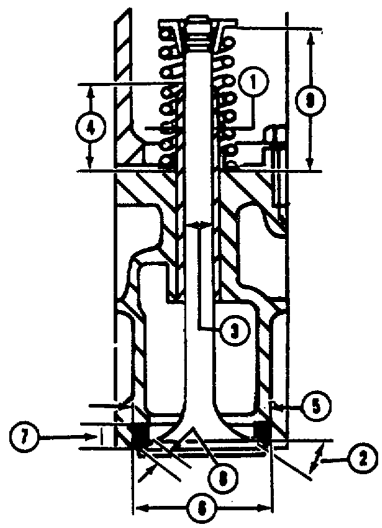


Table 2-1: Specifications - Inch [mm] (Reference Fig . 2-1) (Cont)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
2	**Valve, Stem**			
	Outside Diameter **(1)**	**0.449 [11.41]**	0.450 [11.43]	0.451 [11.46]
	Face Angle **(2)**		30 deg.	30 deg.
3	**Valve Guide**			
	Inside Diameter **(3)**	**0.455 [11.56]**	0.4525 [11.494]	0.4532 [11.511]
	Assembled Height **(4)**		1.315 [33.40]	1.325 [33.66]
4	**Valve Seat Insert***			
	Outside Diameter **(5)**		2.0025 [50.864]	2.0035 [50.889]
	Cylinder Head			
	Inside Diameter **(6)**		1.9995 [50.787]	2.0005 (50.813]
	Insert Height **(7)**		0.278 [7.06]	0.282 [7.16]
	Run Out In 360 Deg.	**0.002 [0.05]**		
	Refaced Seat Width **(8)**		0.063 [1.59]	0.125 [3.18]
5	**Valve Spring ** **			
	Assembled Height **(9)**			2.250 [57.15]



* See Ref No. 8 for oversize valve seat inserts.
** See Ref No. 9 for valve spring data.

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
6	**Crosshead Guide**			
	Outside Diameter **(10)**	**0.432 [11.18]**	0.433 [11.00]	0.4335 [11.011]
	Assembled Height **(11)**		1.860 [47.24]	1.880 [47.75]

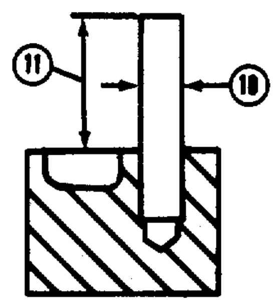
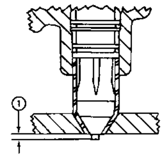


Table 2-1: Specifications - Inch [mm] (Reference Fig. 2-1) (Cont.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
7.	**Injector Sleeve** Tip Protrusion **(1)**		0.060 [1.52]	0.070 [1.78]



8. Valve Seat Insert Part No	Oversize Diameter	Oversize Depth	Insert O.D	Cylinder Head I.D	Insert Thickness
127935	0.005	Std	2.0075/2.0085 [50.991/51.016]	2.0045/2.0055 [50.914/50.940]	0.278/0.282 [7.06/7.16]
127931	0.010	Std	2.0125/2.0135 [51.118/51.143]	2.0095/2.0105 [51.041/51.067]	0.278/0.282 [7.06/7.16]
127932	0.020 [0.50]	0.005 [0.137]	2.0225/2.0235 [51.372/51.397]	2.0195/2.0205 [51.295/51.321]	0.283/0.287 [7.19/7.29]
127933	0.030 [0.76]	0.010 [0.25]	2.0325/2.0335 [51.626/51.651]	2.0295/2.0305 [51.549/51.575]	0.288/0.292 [7.32/7.42]
127934	0.040 [1.02]	0.015 [0.38]	2.0425/2.0435 [51.880/51.905]	2.0395/2.0405 [51.803/51.829]	0.293/0.297 [7.44/7.54]

Be sure to measure insert before machining head or installing insert in head.

9 <u>**Valve Spring Data**</u>

					Required Load For Length		
Valve Spring Part No	**Approximate Free Length Inch [mm]**	**No Coils**	**Wire Diameter Inch [mm]**	**Length Inch [mm]**	**Lb [kg] Worn Limit**	**Lb [kg] New Minimum**	**Lb [kg] New Maximum**
143907	2.890 [73.41]	10.5	0.162 [4.11]	1.765 [44.83]	**105** **[47.63]**	108 [48.97]	130 [58.97]
211999	2.685 [68.199]	9	0.177 [4.496]	1.724 [43.789]	**143** **[64.865]**	147.25 [66.793]	162.75 [73.823]

10. <u>**Cylinder Head Pipe Plug Torque - ft. lb. [kg m]**</u>

Plug Size	Minimum	Maximum
1/8 inch	5 [0.7]	10 [1.4]
Fuse Plug	5 [0.7]	10 [1.4]
3/8 Inch	35 [4.8]	45 [6.2]
1/2 Inch	60 [8.3]	70 [9.7]
3/4 Inch	65 [9.0]	75 110.4)
1 Inch	135 [18.7]	145 [20.1]

Service Tools (or Equivalent) Required	
Service Tool Number	**Tool Name**
ST-257	Valve Seat Insert Tool
ST-417 or	Valve Vacuum Tester
ST-417-A	Valve Vacuum Tester
ST-646	Valve Guide Reamer
ST-662	Valve Seat Insert Cutter Set
ST-663	Valve Guide Arbor Set
ST-684	Valve Facing Machine
ST-685	Valve Seat Grinding Machine
ST-788	Bead Cutting Tool
ST-880	Injector Sleeve Expander
ST-884	Injector Sleeve Cutter
ST-913	Cylinder Head Grooving Tool
ST-1010	Water Hole Counterboring Tool
ST-1012	Hydrostatic Tester
ST-1013	Hydrostatic Tester Base Plate
ST-1034	Dowel Pin Extractor
ST-1142	Spark Plug Sleeve Seat Facing Tool (Natural Gas Engines)
ST-1179	Injector Sleeve Holding Tool
ST-1217	Valve Guide Mandrel
ST-1227	Injector Sleeve Installation
ST-1257	Vacuum Tester
Desirable (Or Equivalent) Service Tools	
ST-448	Valve Spring Compressor
ST-547	Gauge Block
ST-583	Head Holding Fixture
ST-633	Crosshead Guide Mandrel
ST-876	Cleaning Brush
ST-890	Spark Plug Adapter Wrench.
ST-981	Injector Tip Protrusion Checking Tool
ST-1022	Valve Spring Compressor Stand (Used with multiple compressor plate).
ST-1026	Valve Spring Compressor Plate (Compress 8 springs in one operation).
ST-1122	Staking Tool Driver
ST-1124	Valve Seat Insert Staking Tool
ST-1133	Valve Seat Extractor
ST-1166	Magnetic Crack Detector
ST-1187	Valve Guide Reamer 0.015 inch [0.38 mm] Oversize
ST-1188	Valve Guide Reamer 0.010 inch [0.25 mm] Oversize
ST-1244	Injector Sleeve Puller
ST-1247	Injector Sleeve Puller Impact Wrench Socket
Standard Tools-Obtain Locally	
	0-1 Micrometers
	Small Bore Gauge
	Vernier Depth Gauge

CYLINDER HEAD

DISASSEMBLY AND TESTING

1. Use ST-448 or other suitable valve spring compressor, compress valve springs, remove half collets, retainers, springs, valve spring guides and valves. If used, remove intake valve oil seals and discard.

2. Place valves on a numbered valve board for inspection.

Pressure Testing

Install ST-1179 or equivalent Injector Sleeve Holding Tool (Fig. 2-2) or a scrap injector assembly in each injector sleeve. Tighten tool or injector hold-down capscrews to 10 to 12 ft-lbs [1.4 to 1.7 kg ml torque to seal lower end of injector sleeve and place cylinder head in ST-1012 Hydrostatic Tester (Fig. 2-3) or equivalent.

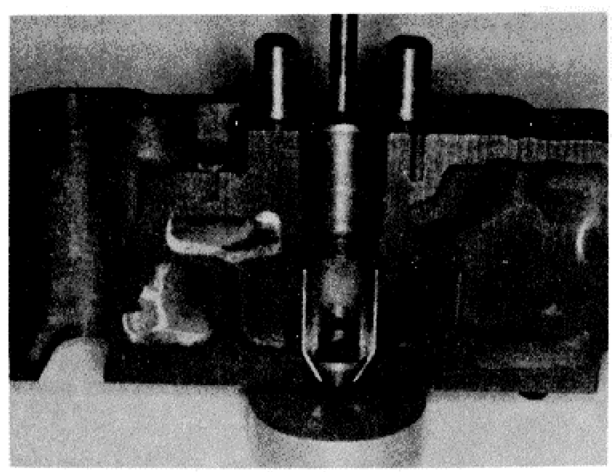


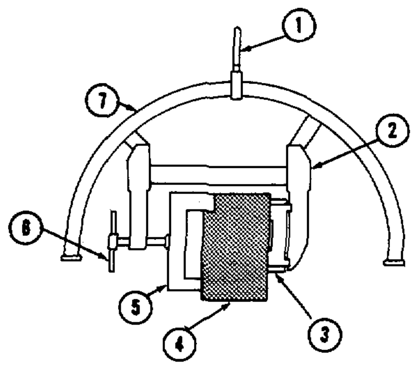
Fig. 2-2 (N10278) ST-1179 Injector sleeve holding tool

Air Test

Use hoist or suitable lifting device to position head and tester over water tank, connect air line with quick coupler, apply 20 to 30 psi [1.4 to 2.1 kg/sq cm] air pressure. Submerge head in water deep enough to cover entire head. Check carefully around valve seats and injector sleeve for cracks. Discard head if cracked; replace leaking sleeves.

Water Test

1. Test cylinder head for leaks at 35 to 85 psi [2.46 to 5.98 kg/sq cm] water pressure with water at 180 to 200 deg. F [82 to 93 deg. C] if possible. Check carefully around valve seats and injector sleeve for cracks even though such cracks



1. Lifting Eye.
2. Clamping Device
3. Lower Plate
4. Cylinder Head
5. Upper Plate
6. Hold Down Screw
7. Quadrant

Fig. 2-3 (V10244) Cylinder head installed In ST-1012 Hydrostatic Tester

may not show water leakage. Discard head if cracked; replace leaking sleeves.

2, Open water outlet of test fixture; check for free water circulation through cylinder head. If restriction is evident, remove all pipe plugs and fuse plug; clean water jackets of salt, lime or sludge.

a. If alkaline cleaners are used in recommended concentration, immersion times are followed and temperatures regulated according to instructions supplied with each product, no damage will result to injector sleeve "0" rings.

b. Solvent type cleaners may damage the "O" ring and should not be used unless the injector sleeves and "0" rings are all to be replaced.

c. To remove heavy deposits of lime, use circulated acid-type cleaner.

WARNING
The use of acid is extremely dangerous to workmen and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

3. Clean fuel passage with ST-876 Brush or equivalent. Flush passages with solvent to remove deposits.

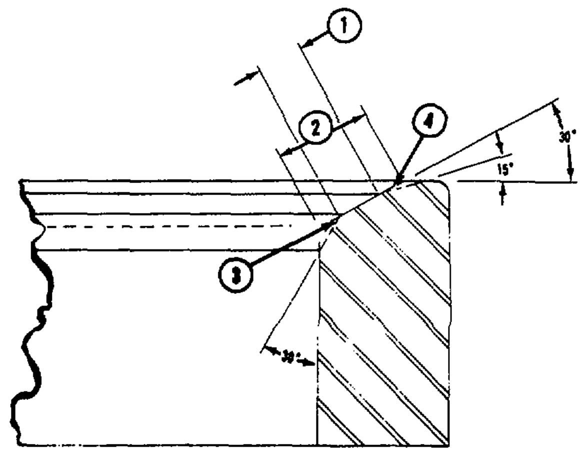
Magnetic Crack Detection
As a precautionary measure, check cylinder head for cracks using ST-1166 Magnetic Crack Detector in valve and injector port areas. Discard head if cracked.

INSPECTION

Valve Seats

1. Check for loose *valve seat. inserts* by lightly tapping cylinder head near insert, if valve seat is loose enough to bounce, mark for replacement. A slight looseness found only by tapping when head is cold and covered with a film of oil is not objectionable.

2. If seat area width (2, Fig. 2-4) exceeds 0.125 inch [3.18 mm] at any point and cannot be narrowed sufficiently (1) during regrind, mark for replacement.



1. Minimum Seat Width 0.063 inch [1.59 mm]
2. Maximum Seat Width 0.125 inch [3.18 mm]

Fig. 2-4 (N10228) Valve seat insert-cross section

Injector Sleeves

Note results of pressure test. Leaks indicate need for replacement of injector sleeves. Visually check sleeves, which pass pressure test, for scratches on cup seat area. If seat area is scratched, mark for replacement.

Injector Tip Protrusion

Injector sleeves that have passed the above tests must further be checked for injector tip protrusion (seat depth) and seating pattern.

1. Lightly coat injector cup with Prussian Blue, install injector assembly into sleeve torque to 10 to 12 ft-lbs [1.4 to 1.7 kg m]. Remove and check seat pattern. Bluing band must be 0.060 inch [1.52 mm] minimum in width and located approximately 15/32 inch [11.91 mm] from

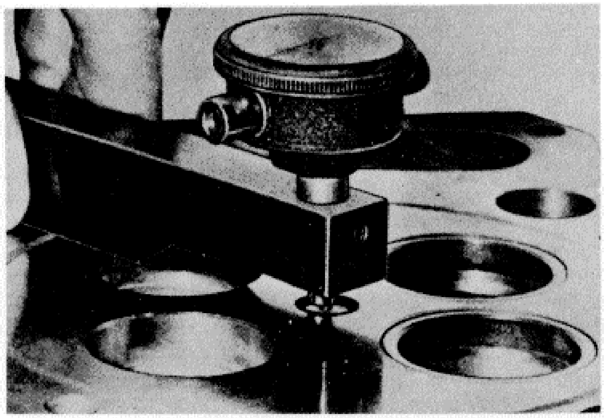


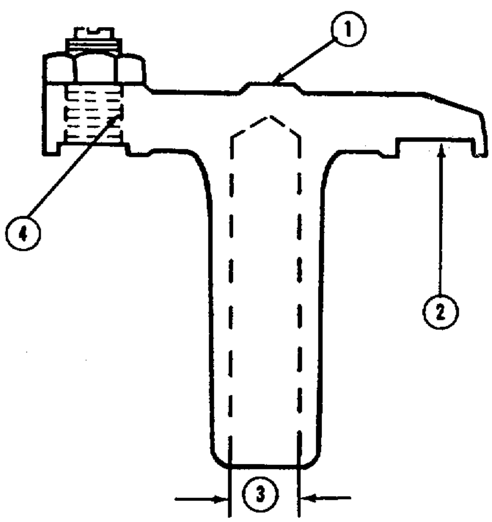
Fig. 2-5 (N 10206) Measure injector tip protrusion

bottom of head surface. If indicated seat width does not meet these specifications, mark sleeve for replacement.

2. Install injector assembly, torque to 10 to 12 ft-lbs [1.4 to 1.7 kg m]. Measure tip protrusion with ST-547 Dial Indicator, ST-981 Injector Tip Protrusion Checking Tool or equivalent. Fig. 2-5. Tip protrusion must be 0.060 to 0.070 inch [1.52 to 1.78 mm] . See Service Tool Instructions.

Valve Crosshead Guides And Crossheads

1. Check guide outside diameter with micrometers. See Table 2-1 (6) for worn replacement limits.



1. Rocker Lever Contact Area
2. Valve Stem Contact Area
3. Crosshead Bore
4. Adjusting Screw Threads

Fig.2-6. (V40236) Crosshead wearpoints

2. Check guide for straightness. It should be at right angles with milled surface of head. Mark guides for replacement if not straight or worn beyond replacement limit.

3. Check crossheads for cracks with Magnaglo process.

4. Check stem inside diameter (3, Fig. 2-6) using a small bore gauge set at 0.4402 inch [11.181 mm]. Use as a "No Go" gauge to check for wear beyond worn replacement limit,

5. Check for out-of-round holes, gauge at several points 90 deg. apart. Do not use plug gauge for this operation.

6. Visually check for excessive wear on rocker lever (1) and valve stem contact surface (2). Check adjusting screw and crosshead threads (4) for wear or distortion. Mark for replacement If excessive wear is found.

Valve Guides

1. Check guide inside diameter; using a small bore gauge set at 0.4552 inch [11.562 mm]. Use bore gauge as a "No Go" gauge, Table 2-1 (3).

2. Check for out-of-round holes; gauge at several points crosswise and endwise of head. Do not use a plug gauge for this operation. Visually check valve guides for chips, cracks or burrs. Mark for replacement any guides showing excessive wear or damage.

Valves

Visual

Clean valves with a buffer and polish with crocus cloth. Inspect. then discard if:

Heads are cupped, cracked, pitted or worn too thin to regrind within limits. Check valve head rim thickness (A, Fig. 2-7), it should be a minimum of 0.105 inch [2.67 mm]. Stems are worn beyond worn replacement limit as listed in Table 2-1 (2). Collet recesses are worn so new collets will not fit securely in recesses.

Magnetic Method

1. Surface to be inspected must be cleaned to remove all foreign material which could give false indications or react in any way with penetrant or developer. Vapor degreasing is recommended.

2. Welded valves which have two types of metal, may be Magnaglo inspected. However, due to change of metal at weld, there will be magnetic leakage at this point. This will be indicated by a broad fuzzy pattern of magnetic particles. For this reason, such valves should be magnetized in coil at

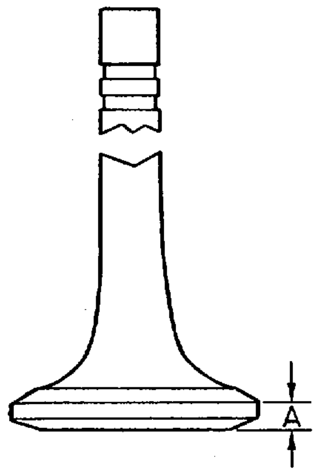


Fig. 2-7 (N10231) Minimum valve head rim thickness

low amperage, at 100 to 200 amps, and then inspected residually with Magnaglo. A crack at, or near, the weld would show as a sharp bright fluorescent line.

3. Valves with only one type of metal can be inspected in normal way. Magnetize and inspect in two directions. Coil magnetization, use 100 to 300 amps. Inspect with residual Magnaglo. Defects found after this magnetization will be in a transverse direction. Follow by headshot magnetization, at 500 to 700 amps, use residual Magnaglo. Defects by this magnetizing method will be radial.

4. Magnetic indications should be as follows: Reference Fig. 2-8.

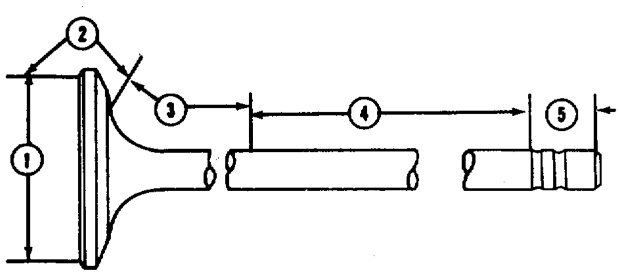


Fig. 2-8 (N10269) Magnetic indication areas of maegnaglo

a. No magnetic indication over 1/2 inch [12.70 mm] in length or more than 5 indications spaced closer than 1/8 inch [3.18 mm] can be accepted in area (1).

b. No visible or magnetic indication acceptable in area (2).

c. No visible or circumferential magnetic indications are acceptable in areas (3) and (4).

d. No visible or magnetic indication is acceptable in area (5).

Note: "Visible" means indication can be seen by use of a 3 power magnifying glass after removing magnetic particle suspension.

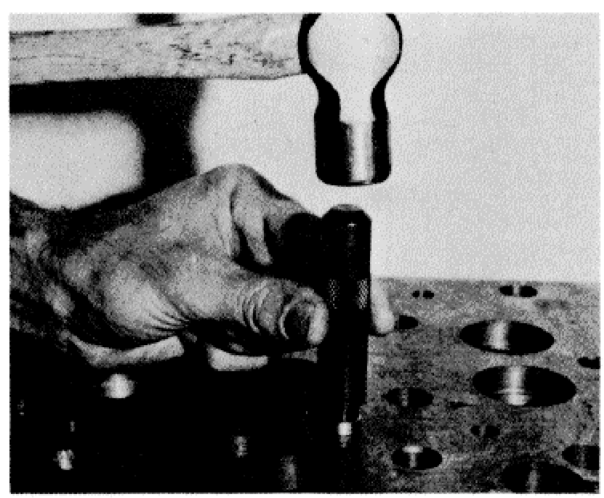
5. Demagnetize all acceptable parts.

REBUILDING

Sleeve Eroded Water Holes

Cylinder head surface around water holes must be free of any erosion, pits, scratches or blemishes which are more than 0.003 inch [0.08 mm] deep in the area 1/16 to 5/32 inch [1.59 to 3.97 mm] from edge of water hole. Use ST-1010 Water Hole Counterboring Tool to enlarge hole for sleeve. See Service Tool Instructions.

1. Coat sleeve, Part No. 191078, (1, Fig. 2-9) with sealant, align sleeve in top of water passage hole, drive into position using bushing driver (2) and hammer.



1. Sleeve
2 Bushing Driver
Fig. 2-9 (N10264) Drive bushing into hole

2. Use a flat mill file to file sleeve flush with top of cylinder head. Do not damage head surface. Remove burrs from inside diameter of sleeve, clean all cuttings and filings from water passages.

3. If proper sleeve is not available, heavy wall copper tubing may be used. Tubing must provide 0.002 to 0.005 inch [0.05 to 0.13 mm] press fit. Overall length should be approximately 1/2 inch [12.70 mm]; inside diameter must be 7/16 inch [11.11 mm] to allow proper water flow.

Resurface Cylinder Head

If cylinder head has been scratched, etched or is uneven at point of contact in gasket sealing area, head may be milled or surface ground.

1. Use ST-1 133 Valve Seat Extractor, remove all valve seat inserts.

2. After resurfacing check head height, use micrometer or vernier depth gauge. Do not remove more than indicated as worn limit. See Table 2-1 (1).

3. Rework valve seat insert counterbore, remove amount of stock equal to that removed during cylinder head resurfacing.

Replace Valve Guides

1. Drive out guides marked for replacement from underside of cylinder head. Install new valve guide with ST-1217 Mandrel or if valve guide bore in cylinder head has been damaged, install oversize guides as follows:

a. Using ST-1188 Reamer, ream defective valve guide bore in head to 0.760 to 0.761 inch [19.30 to 19.33 mm]. Ream through, remove all burrs. Corner break should not exceed 0.015 inch [0.38 mm].

b. Using ST-1217 Mandrel, press oversize valve guide, Part No. 208362, into cylinder head.

Note: If damaged valve guide bore does not clean up, use ST-1187 Reamer, Ream 0.765 to 0.766 inch [19.43 to 19.46 mm] and use oversize valve guide, Part No. 208363. Repeat Steps a and b above. It may be necessary to ream valve spring guide hole to 0.768 to 0.773 inch [19.74 to 19.75 mm] to accommodate oversize valve guides.

2. If proper valve guide mandrel is not available, press guide into head. See Table 2-1 (3).

3. Normally valve guide inside diameter does not require reaming. Insert valve stem into guide and check for freedom of movement.

4. If reaming is necessary: Ream valve guide from bottom side of cylinder head using ST-646 Reamer. Use lubricating oil or soluble oil and water solution for proper finish. Do not ream valve guide beyond worn limit as listed in Table 2-1 (3).

Replace Crosshead Guides

1. Remove crosshead guides marked for replacement using ST-667 or ST-1134 Dowel Puller.

2. Using ST-633 Crosshead Guide Mandrel, press new guides into cylinder head. If mandrel is not available, press new guides into head to obtain protrusion as listed in Table 2-1 (6).

3. Oversize crosshead guides may be installed as follows:

a. Drill guide bore in head to original depth with a 29/64 inch [11.51 mm] drill.

b Lubricate and ream bore with 15/32 inch [11. mm] reamer.

c. Install oversize guide, Part No. 161527, as per Step 2 above.

Replace Valve Seat Insert

1. If cylinder head has not been resurfaced, use ST-1133 Valve Seat Extractor to remove valve seat inserts that are marked for replacement.

2. Enlarge counterbore to next oversize. Inserts are available in standard oversizes as listed in Table 2-1 (8).

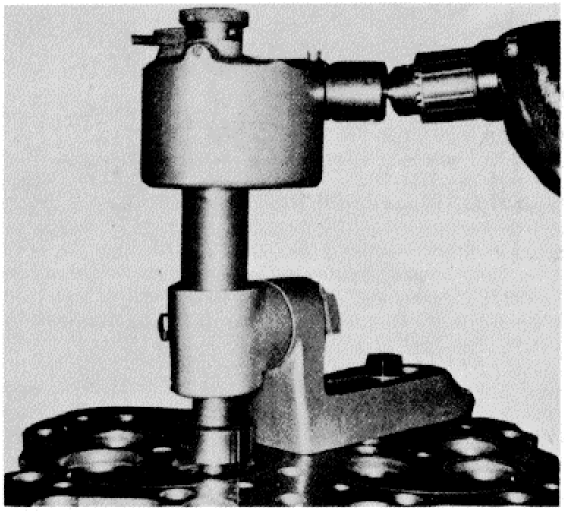


Fig. 2-10 (N 10288) Counterboring for valve seat with ST-257

3. Use ST-663 Valve Guide Arbor and ST-257 Valve Seat Insert Tool Driver, Fig. 2-10, to hold and drive ST-662 Valve Seat Insert Cutter when cutting valve seat insert counterbore.

4. Cut counterbore 0.006 to 0.010 inch [0.15 to 0.25 mm] deeper than insert thickness to permit staking or peening of head to hold insert. Allow cutter to dwell upon reaching proper depth to insure a flat seating surface.

5. Install valve seat insert and stake insert in head using ST-1122 Tool Driver over shaft of ST-1124 Insert Staking Tool. A 1/4 inch [6.35 mm] diameter round end punch may be used if staking tool is not available.

CAUTION

Over-swaging around insert may crack cylinder head.

Grind Valve Seats

1. Use ST-685 Valve Seat Grinder and correct arbor from ST-663 Valve Guide Arbor Set.

2. Check valve seat width, it should be 0.063 to 0.125 inch [1.59 to 3.18 mm], see (1 or 2, Fig. 2-4).

3. If seating area (1) is wider than 0.125 inch [3.18 mm] maximum, stock can be removed from points (3) and (4) with specially dressed stones. Narrowing should not extend beyond chamfer on valve seat insert. Chamfer provides metal for staking or peening.

4. Check valve seat concentricity with valve seat indicator.

Total run-out should not exceed value listed in Table 2-1 (4).

Replace Injector Sleeves

Remove injector sleeves marked for replacement with ST-1244 Injector Sleeve Puller and ST-1247 Impact Socket Wrench or equivalent. See Service Tool Instructions.

Bead Or Cut Sleeve Seat In Head

Cylinder heads machined for 0.060 to 0.070 inch [1.52 to 1.78 mm] injector tip protrusion (after Engine Serial No.

781887) are machined 0.015 inch [0.38 mm] deeper than previous heads. Due to this change it may be necessary to cut 60 deg. beaded seat deeper to obtain 0.060 to 0.070 inch [1.52 to 1.78 mm] injector tip protrusion. Cut the 60 deg. beaded seat with ST-788 Cutter. It is recommended that several light cuts be taken and the depth rechecked until the correct depth is obtained. Clean sleeve bore thoroughly with compressed air.

Sleeve Installation

1. Coat new "0" rings with clean engine lubricating oil. Install "O" ring into groove of head injector sleeve bore.

2. Using ST-1227 or equivalent Injector Sleeve Installation Mandrel, push new injector sleeve into bore of cylinder head until it bottoms. Do not strike mandrel with hammer during this step. Remove mandrel.

3. Install ST-1179 Injector Sleeve Holding Tool. Tighten nut to 35 to 40 ft-lbs [4.8 to 5.5 kg m] torque.

4. Insert mandrel into sleeve bore, strike mandrel two moderate blows with hammer to insure that Injector sleeve is properly seated. Retighten injector sleeve holding tool to 35 to 40 ft-lbs [4.8 to 5.5 kg m] torque.

5. Roll top 1/2 Inch [12.70 mm] area of sleeve with ST-880 Expanding Roller. Fig. 2-11. Use inch-lb [kg m] torque wrench to turn ST-880; turn mandrel until a 75 inch-lb [0.9 kg m] maximum torque reading is obtained on torque wrench.

CAUTION

Over-rolling of injector sleeve will cause deformation of sleeve into "O" ring groove.

6. Cut injector seat to provide proper seat and injector tip protrusion. To determine amount of cut, insert injector and torque to specifications, then measure tip protrusion. Depth of cut must provide 0.060 to 0.070 inch [1, 52 to 1.78 mm] protrusion of injector cup tip beyond milled face of cylinder head when injector is installed at proper torque.

7. Sleeve must "blue in" with Prussian Blue 360 deg. around injector seat when injector is Installed in cylinder head. Bluing band must be 0.060 inch [1.52 mm] minimum width.

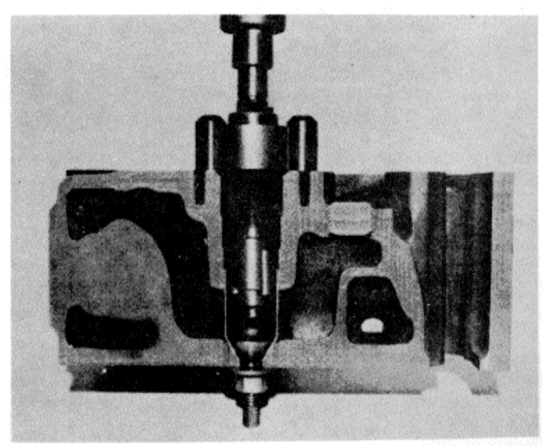


Fig. 2-11 N10222T-880 in upper injector sleeve bore

8. Use ST-884 Injector Sleeve Cutter in a drill press with pilot, using a solid stream of good cutting oil to allow cutter to cut freely without grabbing, etc.

9. Water test cylinder head. See Page 2-4.

Grind Valves

1. Check valve grinder setting by using a new valve and an indicator gauge:

a. Check valve in valve grinder on guide area of stem. Relieved portions on both ends of guide area are not necessarily concentric to guide area of stem.

b. Indicate on ground face of valve.

c. Turn valve and mark high spot on head of valve.

d. Rechuck valve 180 deg. from first position.

e. Repeat (b) and (c). If high spots are same for both (a) and (d) position, valve is warped. If high spots occur in different positions, chuck is out of alignment. Runout should not exceed 0.001 inch [0.03 mm].

2. Wet-grind valves to an exact 30 dep. angle from horizontal. Check rim thickness as shown in Fig. 2-7. If rim is less than 0.105 inch [2.67 mm], valve is not suitable for reuse.

3. Pencil mark valve face as shown in Fig. 2-12, position in valve guide against a newly ground valve seat, rotate valve 10 deg. A good seat will be indicated if all pencil marks are broken. If pencil marks are not broken, tools need dressing or machine has not been properly adjusted; final check should be made with a vacuum tester.

4. Valve seats properly ground with precision equipment

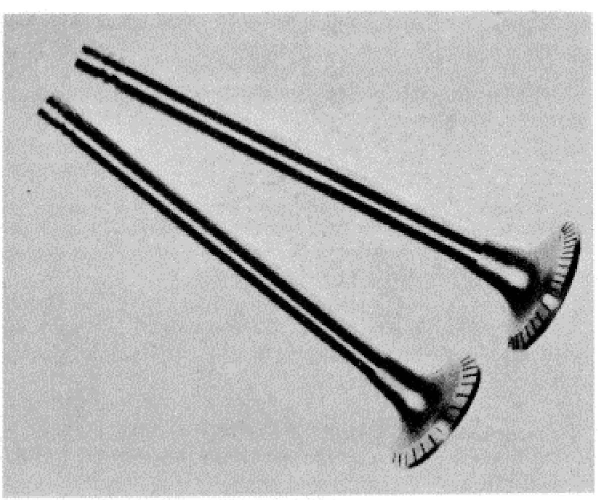


Fig.4 21 (N201Pencil marks on valves

should not require lapping to effect an air-tight seal; however, a small amount of lapping is permissible if necessary in order to pass Valve Seating (vacuum) Test.

Valve Springs

Weak valve springs may cause valve flutter resulting in excessive wear on both valve and seat. Valve flutter interferes with valve timing and may cause valve to strike top of piston.

1. Test valve spring on spring tester that is capable of accurate measurement of valve springs length, apply required load for length as listed in Table 2-1 (9). If valve springs compress to dimensions shown, at less than load indicated under "worn-limit", discard valve spring.

2. Spacers should be used under valve spring when insert and valve have been refaced more than a total of 0.030 inch [0.76 mm]. A maximum of two (2) Part No. 68803-A spacers may be used under valve springs.

ASSEMBLY

1. Install pipe plugs and fuse plug using sealant or sealing tape. Torque plugs to values listed in Table 2-1 (10).

Note: Cylinder heads contain breather or vent holes that must be "plugged" on turbocharged engines and "open" on naturally aspirated engines. Vent holes are located above air, intake port on cylinder head.

2. Dip valve stems into clean engine lubricating oil, insert into valve guides. Place cylinder head face down on wooden bench or protective surface to prevent marring finish surface.

3. Place lower valve spring guides over valve guides.

CAUTION

See current Parts Catalog for correct spring and guide combination, certain valve springs and spring guides must not be mixed under a given crosshead.

4. Install intake valve guide seals (if used). Valve guide seals are not currently being used on factory built engines. It is recommended seals be removed from engines using them unless it is desired to continue use of valve guide seals. Valve guides need not be changed if seals are removed.

5. Assemble springs, spring seats, and spring spacers as required. Place upper valve spring retainer over springs, compress with ST-448 Valve Spring Compressor, install new half-collets.

Valve Seating Test

Vacuum testers are available to check valves and seats for leakage. ST-417 Tester for 6 volt system, ST-417-A Tester for 12 volt system and ST-1257 for 110 volt AC system. The systems consist of vacuum pump, vacuum gauge and vacuum cups.

CAUTION

Never vacuum test cylinder head with injectors installed. Installation of injectors while head is removed from block could cause misalignment of valves in valve seat area and result in leakage during testing which would not necessarily occur during actual engine operation.

1. Operate vacuum pump until hand on vacuum gauge (1, Fig. 2-13) reaches 18 to 25 inches vacuum. Close shut-off valve (2), release push-button to stop pump.

2. Time fall of gauge hand as follows: a. Begin timing as soon as hand reaches "18" on dial.

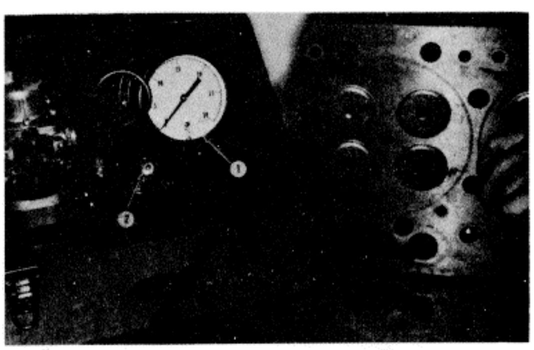
b. Stop timing when hand reaches "8." c. If elapsed time is less than ten seconds, valve seat is unsatisfactory.

3. Tap stem end of valve with a soft-faced mallet and retest. If valve seat is unsatisfactory:

a. Check for leaking connections in tester; operate vacuum pump against a clean window glass or any smooth flat surface; fall of indicator hand indicates a loose connection.

b. Check valve and seat face area to be sure they are free of dirt particles.

4. Regrind seat and reface valve if necessary; however, it is possible to mistake leakage around valve seat insert for valve seat leakage. If this type leakage is suspected, apply



1. Vacuum Gauge
2. Shut-off Valve

Fig. 2-13 (N10283) Vacuum test valves for leaks

grease around outside edge of insert to make a grease seal.

5. Perform vacuum test and inspect grease seal for a break indicating air leakage between wall of counterbore and valve seat insert. If leak around valve seat insert is found:

a. Stake or peen insert, vacuum test.

b. Remove insert, counterbore for next smallest oversize. See "Replace Valve Seat Insert."

INSTRUCTIONS FOR USE OF SERVICE TOOLS

ST-981 Injector Tip Protrusion Checking Tool

To check injector tip protrusion with injector sleeves installed:

Note: The cylinder head must be on a flat metal surface, valves removed for this measurement. If tip protrusion exceeds specifications injector sleeves must be replaced.

1. Loosen indicator clamping screw and raise indicator. Push plunger end down, against a flat metal surface, until plunger is fully compressed.

2. Lower dial indicator until maximum reading is obtained, plunger bottoms and hand movement stops, then back off 0.010 inch as indicated by hand movement; tighten indicator clamping screw.

3. Push plunger against a flat metal surface until plunger is fully depressed, set indicator at 0.076 inch reading on dial.

4. Position tool into injector sleeve bore, with tool firmly seated, indicator should read "O" +0.0025 inch to provide 0.060 to 0.070 inch injector tip protrusion. The indicator plunger drops 0.176 inch (dial makes one (1) complete revolution) below tip of gauge.

To check injector tip protrusion with injector sleeves removed:

1. Follow Steps 1, 2 and 3 preceding.

2. Place tool on beaded seat of injector sleeve bore. The indicator should read "O" + 0.005 inch for the correct depth of seat bore. The indicator plunger on this measurement drops approximately 0.076 inch below tip of gauge.

ST-1244 Injector Sleeve Puller/ST-1247 Impact Socket Wrench

Remove injector sleeves marked for replacement as follows:

1. Position ST-1244 Injector Sleeve Puller into injector bore; allow forming collar teeth to rest on injector sleeve. Back nuts off to extent of their threads.

2. Place driving buffer over tool, drive complete unit down until forming collar bottoms. Remove driving buffer and tighten top nut until snug.

3. Place ST-1247 Impact Socket Wrench over lower nut. Using impact wrench or ratchet run nut down until injector sleeve is free.

4. Firmly hold puller, back off lower nut. Remove socket. Back top nut off to extent of threads.

5. Tap lower end of injector sleeve, to loosen, turn 60 deg. to remove. Discard injector sleeve.

ST-1010 Water Hole Counterboring Tool

Counterbore cylinder head water hole for sleeving as follows:

1. Position bushing plate to cylinder head with end stamped 5/8 inch bushing over water hole to be sleeved. Align adapter handle and locking screw with injector sleeve hole in cylinder head.

2. Insert ST-1010-13 locating pin through guide hole in bushing plate and into water hole to be repaired, tighten adapter knob as tight as possible by hand, remove locating pin. Adjust depth of cut as follows: a. Loosen setscrew in stop collar with socket head wrench.

b. Place cylinder head gauge block on top of bushing in bushing plate, with arc on gauge block aligned with hole in bushing.

c. Lower counterbore cutter into bushing, in bushing plate, until it bottoms on cylinder head.

d. Slide stop collar down until it rests against top of gauge block, tighten setscrew.

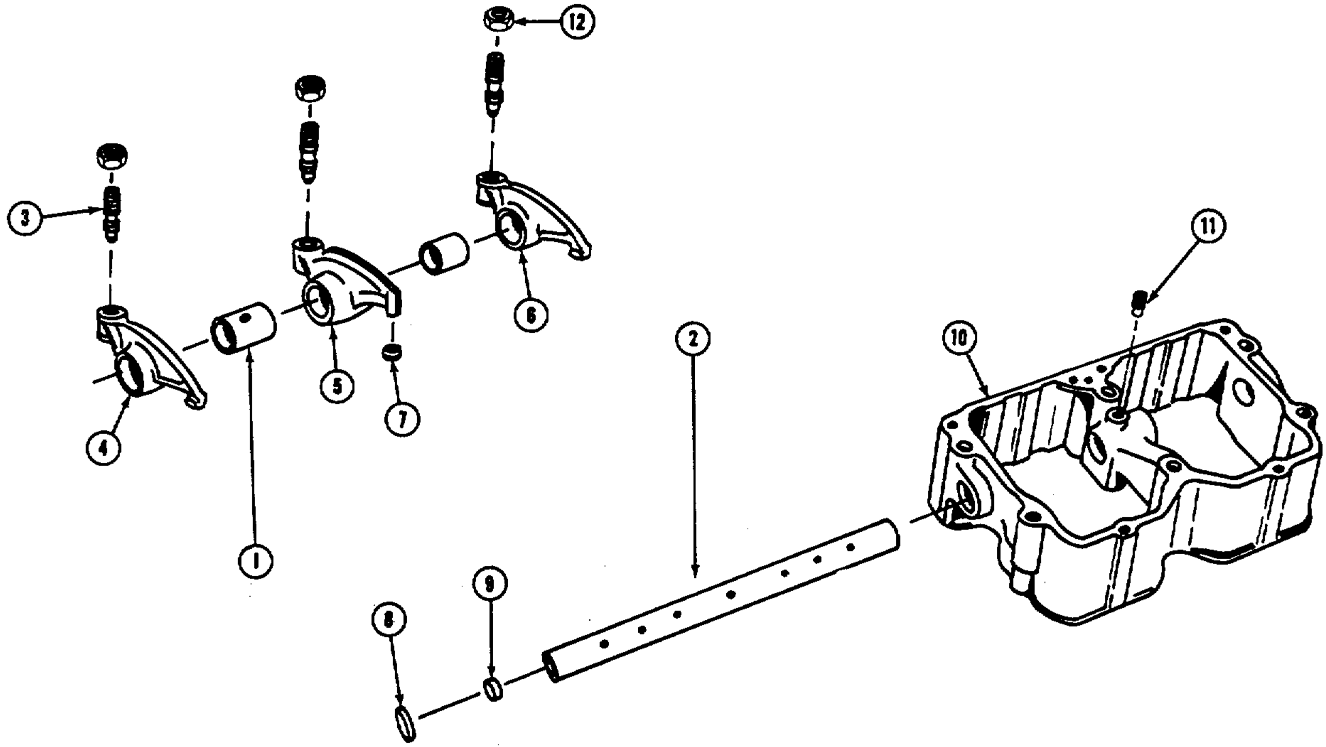
3. Lock drive adapter in drill chuck. Remove gauge block from below stop collar.

4. Lower drive adapter into top of tool adapter, making sure slot in drive adapter straddles roll pin in top of tool adapter. Lubricate bushing inside diameter and bottom of stop collar.

5. With light pressure on drill, cut hole to depth, cutter will free wheel when stop collar reaches drive bushing. Remove tool assembly, clean hole thoroughly and install sleeve.

Group 3 Rocker

Rocker lever group consists of rocker levers, rocker lever shafts, rocker lever covers, crankcase breathers and rocker lever housings

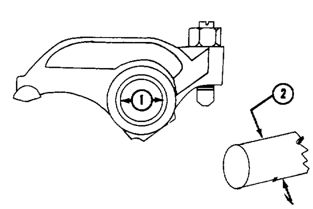


1. Bushing
2. Shaft
3. Adjusting Screw
4. Intake Lever
5. Injector Lever
6. Exhaust Lever
7. Injector Lever Socket
8. Housing Plug
9. Shaft Plug
10. Rocker Lever Housing
11. Shaft Setscrew
12. Adjusting Screw Locknut

Fig. 3-1. (N1039). Rocker levers, shaft and housing

Table 3-1: Specifications - Inch [mm]

Ref. No.	Measurement		Worn Limit	New Minimum	New Maximum
1.	Bushing				
	Inside Diameter	**(1)**	**1.1286** [28.664]	1.1245 [28.562]	1.1275 [28.639]
2.	Shaft				
	Outside Diameter	**(2)**	1.122 [28.50]	1.123 [28.52]	1.124 [28.55]



Service Tools (Or Equivalent) Required	
Service Tool Number	**Tool Name**
ST-691	Mandrel and Block
ST-863	Mandrel
ST- 1053	Driver
ST-1182	Alignment Tool (80 deg. Tilt engine)

Standard Tools - Obtain Locally	
	Small Bore Gauge
	Micrometers (1 to 2 inch)
	Radius Gauge (1/4 inch [6.35 mm])

ROCKER LEVER HOUSING

DISASSEMBLY AND INSPECTION

1. Tag rocker levers for position, as removed and remove adjusting screws and nuts from all levers.

2. Remove setscrew or spray nozzle and jam nut (80 deg. tilt engines) positioning rocker lever shaft in housing.

3. Drive a sharp pointed punch through plug at end of rocker shaft. Pry out concave type plug or press through housing if cup type. Use a flat or drift punch to drive or press shaft through housing.

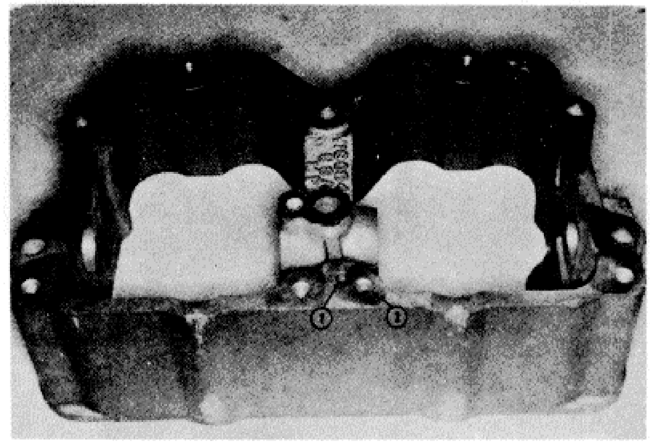
4. Locate shaft in V-block, not a vise and remove plugs.

5. Visually inspect all capscrew holes for damaged threads and inspect all levers, housings and covers for cracks, chips or breaks

6. Inspect entrance of shaft bore for sharp edges, nicks or burrs when cup plugs are used, entrance of bore should have a slight radius. Sharp edges can be removed by using 240 grit aluminum oxide paper over a split rod, rotating in an electric drill.

7. Check breather vent hole (1, Fig. 3-2) and rocker lever oil drilling (2) to make sure they are free of dirt or other deposits.

8. Check rocker lever shaft bore of housing inside diameter. Dimensions should be 1.1238 to 1.1246 inch [28.545 to 28.565 mm] . If shaft bore does not meet these dimensions. discard housing and replace. See Parts Catalog for correct part number.



1. Vent Hole
2. Oil Drilling

Fig. 3-2, (N 10318). Breather hole location

ROCKER LEVERS

INSPECTION AND REPAIR

1. Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500 with residual Magnaglo. See Fig. 3-3 for most likely areas. Demagnetize after checking.

2. The ball end of rocker lever adjusting screw must be a true sphere. Check with 1/4 inch [6.35 mm] radius gauge. Replace if flat at bottom or there is evidence of scratching or galling. Check thread condition on all screws and in levers. Check closely for threaded distortion at assembly position of locknut. Screws must run freely through levers.

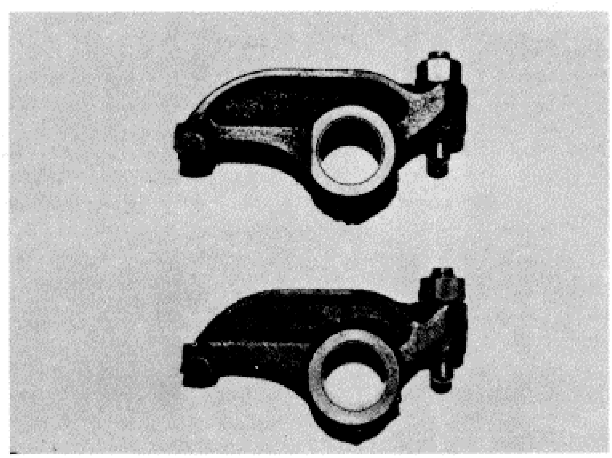


Fig. 3-3, (V40305). Magnetic inspection crack indication

3. Examine injector rocker lever sockets for a true fit on injection links. Check sockets with a radius gauge or by observation of a small protrusion at bottom of socket. Remove and discard damaged or badly worn injector rocker lever sockets by drilling a small hole in lever above socket and knock out with a small punch and hammer; after socket is removed, weld hole closed, install and stake plug in hole.

4. Check rocker lever bushings for scratches, pitting or scoring. Check rocker lever bushing inside diameter with inside micrometers or small bore gauge. If bushing exceeds 1.1286 inch [28.664 mm], press out bushing with ST-691 Mandrel and Block. Clean lever thoroughly and dry with compressed air. See Parts Catalog for current replacement bushing part numbers.

5. Install new bushing with ST-691 and arbor press.

a. On injector and exhaust valve levers, install bushings so oil holes to crosshead nose or injector link and adjusting screw are open for oil flow.

b. On intake valve levers, with oil drilling to crosshead nose end, install bushing so "nose" hole is closed and so "slot hole" is in line with adjusting screw oil hole. Do not bore steel bushings.

6. Check intake and exhaust rocker lever-to-crosshead contact surfaces. If worn or damaged, grind to original contour or replace with new rocker lever.

7. Check rocker lever shaft for wear or scoring. If shaft has shoulders or ridges due to rocker lever action on shaft, replace with new rocker lever shaft. See Table 3-1 (2) for shaft dimensions. Flush out shaft bore and dry thoroughly.

8. Current shafts are 12.880 inch [327.15 mm] long, older shafts are 13, 060 inch [331.72 mm]. Older shafts can be reduced to new shaft length if oil leakage has been encountered at the shaft cup seal plug. Machine equal amount from each end of shaft.

ASSEMBLY

1. Install adjusting screws and locknuts in rocker levers.

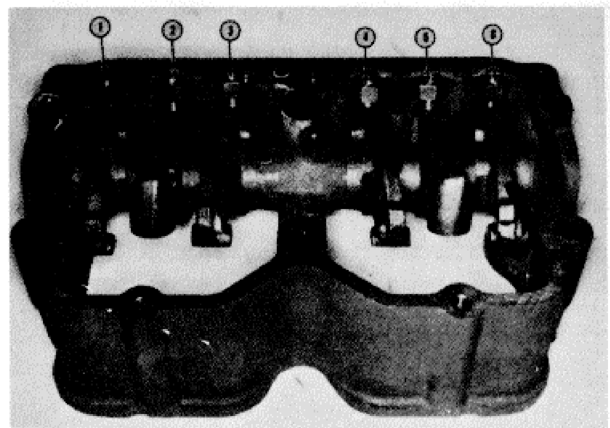
2. Install cup type plug in rocker lever shaft with ST-863 Cup Plug Driver. Coat rocker lever shaft with clean lubricating oil.

3. Start shaft into housing, install levers on shaft as shaft is pushed through housing. See Fig. 3-4 for correct position of levers.

a. Install exhaust (1), injector (2) and intake levers (3).

b. Install intake (4), injector (5) and exhaust levers (6).

4. Index locking hole in shaft with locking hole in housing



1. Exhaust Lever	4. Intake Lever
2 Injector Lever	5. Injector Lever
3. Intake Lever	6. Exhaust Lever

Fig. 3-4, (N10326). Rocker lever assembly

and secure shaft position with setscrew or oil spray nozzle. Check all levers for freedom of movement on shaft to prevent galling.

Note: Oil spray nozzles are used on 80 deg. tilt engines. Use ST-1182 Alignment Tool to obtain proper alignment of oil spray holes in nozzle to permit oil flow from rocker lever shaft to valve mechanism. Secure spray nozzle in desired position with jam nut.

5. Coat expansion (cup) plug contact surface with sealant. Install new expansion plug in rocker lever housing using ST-1053 Driver.

CRANKCASE BREATHER

Four different types of crankcase breathers are used on 855C.I.D. Series Engines. Mesh element with vapor barrier, mesh element, paper element and screen element.

1. Remove cover, screens and baffle or element from breather body; discard paper element.

2. Clean vent tube, screens and baffle or mesh element in an approved cleaning solvent. Wipe out breather housing.

3. Assemble baffle, screens or element and new gasket in body. Replace cover.

Note: Current engines using aluminum rocker lever cover with baffle plate, Part No. 210051, installed, do not have baffle or screens in crankcase breather body.

ROCKER HOUSING COVER

There are two types of rocker lever housing covers; plain and breather type. One plain cover has "Injector Adjustment Procedure" decal attached.

INSPECTION

1. Remove all gasket material from sealing edge of cover. Inspect for cracks, dents and distorted sealing area; discard unserviceable parts. Inspect for cracks around all capscrew holes and breather port area.

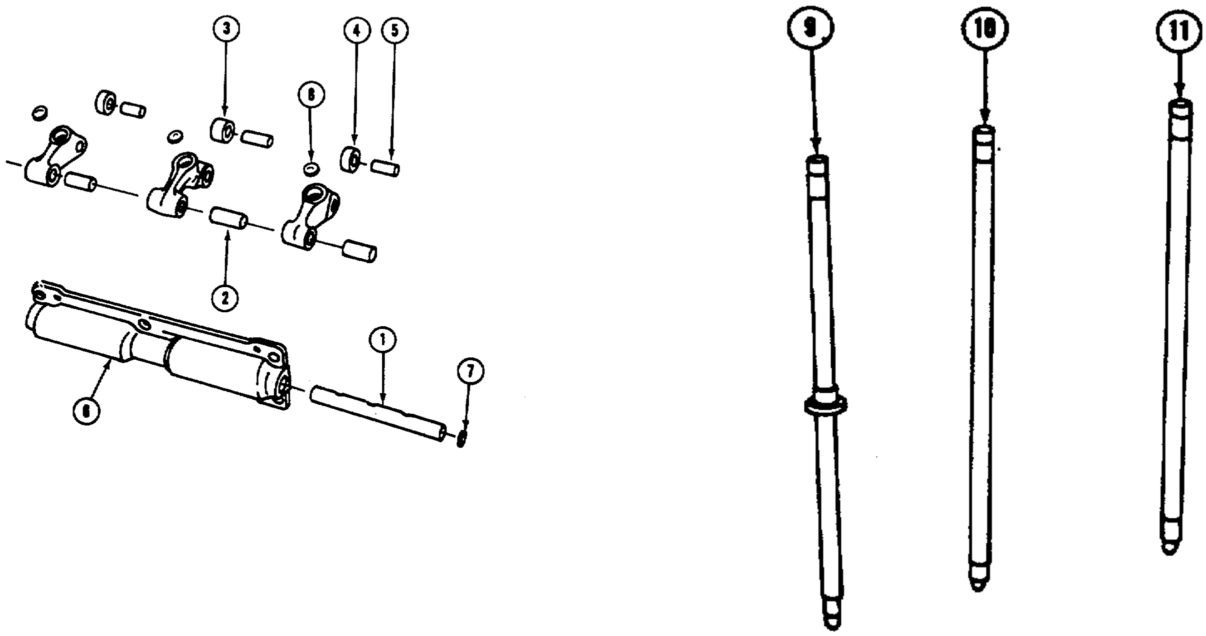
2. If Injector Adjustment Procedure decal is not intact and legible after cleaning cover, replace with new Part No. 213214 decal. See Injector and Valve Adjustment using ST-1170 Dial Indicator Method, Group 14.

ASSEMBLY

It a new breather-type cover is used, press in new breather neck, install new or reconditioned breather body (breather must be pressed in straight). After installation of breather body, or breather neck, check closely for cracks around press-fit area.

CamFollower
Group 4

Cam followers are used in the 855 C.I.D. Engines to transmit movement from the camshaft lobes through push tubes and rocker levers to actuate injectors and valves.

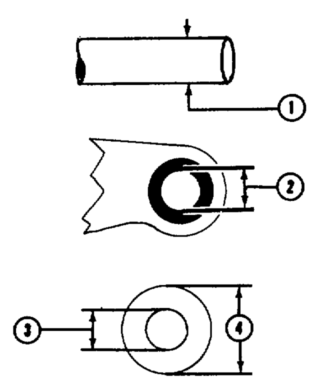


1. Shaft
2. Bushing
3. Injector Cam Roller
4. Valve Cam Roller
5. Cam Roller Pins
6. Housing
7. Shaft Plug
8. Insert
9. Exhaust Push Tube
10. Injector Push Tube
11. Intake Push Tube

Fig. 4-1, (N10419). Cam followers and push tubes

Table 4-1: Specifications - Inch [mm]

Ref. No.	Measurement		Worn Limit	New Minimum	New Maximum
1.	Shaft				
	Outside Diameter	(1)	**0.748**	0.7485	0.749
			[19.00]	[19.012]	[19.02]
2.	Bushing				
	Inside Diameter	(2)	**0.7515**	0.7495	0.7505
			[19.088]	[19.037]	[19.063]
3.	Injector Cam Roller				
	Inside Diameter	(3)	**0.505**	0.503	0.504
			[12.831	[12.78]	[12.80]
	Outside Diameter	(4)	**1.247**	1.249	1.251
			[31.67]	[31.72]	[31.78]
4.	Valve Cam Rollers				
	Inside Diameter		**0.503**	0.5005	0.5015
			[12.78]	[12.713]	[12.738]
	Outside Diameter		**1.247**	1.249	1.250
			[31.67]	[31.72]	[31.75]
5.	Cam Roller Pins				
	Outside Diameter		**0.497**	0.4995	0.500
			[12.621	[12.687]	[12.70]



Service Tools (Or Equivalent) Required	
ST-195	Plug Gauge
ST-249	Mandrel and Block
3T-970	Plug Driving Mandrel
ST-1053	Plug Driving Mandrel

Standard Tools Obtain Locally	
	Small Bore Gauge
	Micrometer (o to 1 inch)
	Micrometer (1 to 2 inch)
	Feeler Gauge (0.006 inch [0.15 mm])

CAM FOLLOWERS

DISASSEMBLY AND INSPECTION

1. Remove lockscrews holding shafts in housing and cup plug by using a sharp pointed chisel. Using proper mandrel press both shafts out opposite end forcing remaining cup plug out of hole. Mark or tag cam follower levers for position before removal.

2. Remove cam follower levers from housing. Clean other parts in solvent.

3. Measure outside diameter of shafts with micrometers. If worn smaller than 0.748 inch [19.0 mm] mark for replacement.

4. Check cam follower shafts around lockscrew end to make sure grooves are clean, inspect cam follower housing for cracks or mating surface imperfections. Discard unserviceable parts.

5. Check cam follower bushings for scratches, pitting or scoring. Check bushing inside diameter with micrometers. If worn larger than 0.7515 inch [19.088 mm] mark for replacement.

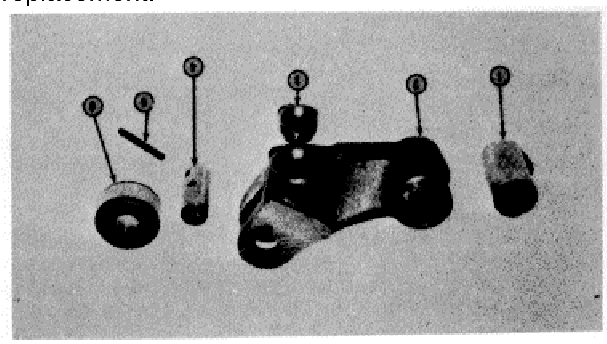
6. Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500 with residual Magnaglo.

7. Inspect edges of cup plug holes in cam follower housing for sharp edges or nicks. If damaged, chamfer entrance of hole to form a slight radius and break sharp edges to aid installation of cup plug.

8. Cam follower levers have a removable insert (3, Fig. 4-2). These must be replaced if scored or extremely worn. Check with a new push tube ball or 0.625 inch [15.88 mm] checking ball and Prussian Blue. This area must "blue in" 80% blue or insert must be replaced.

9. Remove cam roll pins (5), roller pins (4) and rollers (6) from cam follower levers (2).

10. Inspect cam rollers. Set small bore gauge 0.0002 inch [0.005 mm] above worn replacement limit listed in Table 4-1. Use as a "No-Go" gauge in bore to check wear beyond replacement limits Check for out-of-round holes. New dimensions on injector cam rollers are 0.503 to 0.504 inch [12.78 to 12.80 mm]. Worn replacement limit is 0.505 inch [12.83 mm]. On valve cam rollers new dimensions are 0.5005 to 0.5015 inch [12.713 to 12.738 mm]. Worn replacement is 0.503 inch [12.78 mm]. If rollers do not meet these specifications, mark for replacement.



1. Bushing
2. Lever
3. Insert
4. Roller Pin
5. Roll Pin
6. Roller

Fig. 4-2 (N10412) Cam follower exploded view

11. Use micrometers to check outside diameter of rollers. Injector cam roller new dimensions are 1.249 to 1.251 inch [31.72 to 31.78 mm]. Valve cam roller new dimensions are 1.249 to 1.250 inch [31.72 to 31.75 mm]. Worn replacement limit for all rollers is 1.247 inch [31.67 mm].

12. On all rollers the inside diameter must be concentric with the outside diameter within 0.002 inch [0.05 mm]. Sides must be square to bore and parallel to each other within 0.004 inch [0.10 mm]. Check cam roller pins. New dimensions are 0.4995 to 0.500 inch [12.69 to 12.70 mm]. If worn smaller than 0.497 inch [12.62 mm] mark for replacement. If rollers were scored or galled, make careful inspection of camshaft lobes for damage.

BUSHING INSTALLATION

1. If cam follower bushing is worn beyond limits, remove bushing with ST-249 Mandrel and Block. Blow out oil passages with compressed air.

2. Install new cam follower bushings using ST-249 Mandrel. Either one-piece or two-piece bushings may be used. When installing one-piece bushings, care must be taken to align oil holes in bushing with holes in cam follower.

Note: Do not use a two-piece bushing with levers that are not welded closed at rear or loss of oil pressure will occur.

Hole may be welded if necessary.

3. Fill lubricating oil holes in bushing with semi-soft soap to prevent chips from entering oil passages during boring operation. Chamfer each end of bushing with 60 deg. angle cutter in a slow speed drill press.

4. Bore bushings to 0.7495 to 0.7505 inch [19.037 to 19.063 mm]. Blow soap from oil holes and clean lever. Check bored bushings with ST-195 Plug Gauge.

ASSEMBLY

1. If removed, press in new lever insert. Make sure insert is securely seated. If new injector insert is installed, a new injector push tube must be used.

2. Install rollers with 0.006 inch [0.15 mm] feeler stock beneath roller and next to lever as a support. Press pins through rollers and levers, then remove feeler stock. Secure with roll pins.

3. Assemble levers and shafts in housing. Make sure injector lever is in center position of each assembly. Cam rocker levers must be installed in housing with push tube sockets and housing dowel pin holes topside.

4. Install "dummy" screw in shaft. A "dummy" screw is used at this point to prevent lockscrew breakage. Screws have tendency to break due to close shaft-housing fit, causing plug to act as hydraulic ram when driven in place. Use ST-1053 Plug Driving Mandrel with end marked 175831, press plug in until flush to 0.010 inch [0.25 mm] below edge of hole. Remove "dummy" screw and install shaft lockscrews.

PUSH TUBES

Each cylinder has exhaust, injector and intake push tubes. Injector push tube is largest and fits in middle socket. On engines equipped with compression release, the exhaust push tube is equipped with collar to match with milled recess in compression release shaft; the remaining push tubes are plain. On engines without compression release, intake and exhaust push tubes are both plain.

INSPECTION

1. Check injector and valve push tube ball end for wear with radius gauge. Ball end diameter is 0.623 to 0.625 inch [15.82 to 15.88 mm]. Check for loose ends.

2. Check socket of push tube with ball end of a new rocker lever adjusting screw or with 1/2 inch [12.7 mm] check ball, which should "blue in" 80% of seat area. Push tubes with worn ball ends should never be installed in new cam follower sockets.

3. Check push tubes to see if they are bent. Tubes should not be out-of-round more than 0.025 inch [0.64 mm] when located in centers of socket and ball. Push tubes that are bent have usually had the adjusting screws over-torqued,

Fuel System
Group 5

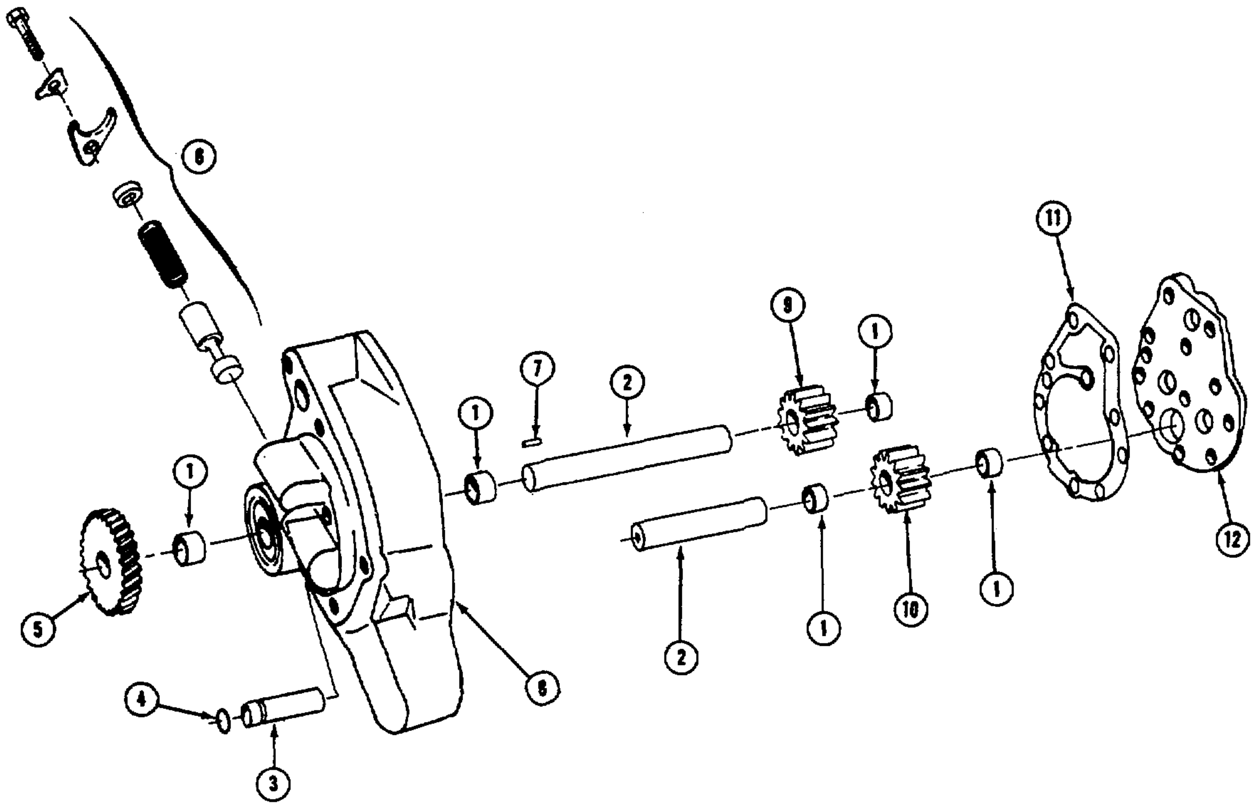
Refer to FUEL PUMP SECTION

Injector
Group 6

Refer to INJECTOR SECTION

Lubricating System
Group 7

Lubricating system group consists of oil pan, lines, dipstick, filters, coolers, oil pumps and pressure regulators.



1. Bushin
2. Shaft
3. Tube
4. "O" Ring
5. Main Drive Gear
6. Pressure Regulator
7. Dowel
8. Body
9. Drive Gear
10. Idler Gear
11. Gasket
12. Cover

Fig. 7-0 Lubricating oil pump, exploded view

Table 7-2: Hose Size

Location		Minimum Hose Size
Turbo. Oil Supply	No. 6	
Full Flow Filter		No. 16
Turbo. Oil Drain	No. 16	
By-pass Filter		See Page 7-8.

Table 7-4: Hose Bends - Inch [mm](Teflon-Lined)

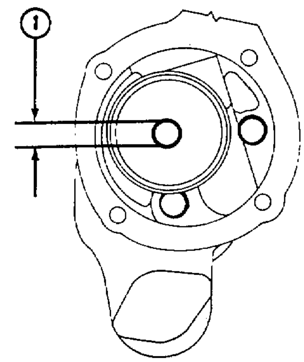
Hose Size	Inside Dia.		Outside Dia.	Minimum Bend Radius
6	5/16	[7.94]	39/64[15.48]	4[101.601
16	7/8	[22 23]	1-13/64 [30.56]	7-3/8 [187.33]

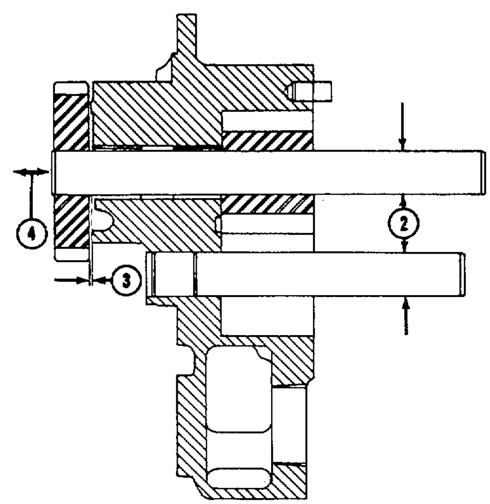
Table 7-3: Hose Bends - Inch [mm](Rubber-Lined)

Hose Size	Inside Dia.		Outside Dia.		Minimum Bend Radius	
4	3/16	[4.76]	31/64	[12.30]	2[50.80]	
5	1/4	[6.35]	35/64	[13.89]	2-1/4 [57.15]	
6	5/16	[7.94]	39/64	[15.48]	2-3/4 [69.85]	
8	13/32	[10.32]	47/64	[18.65]	4-5/8 [117.48)	
10	1/2	[12.70]	53/64	[21.03]	5-1/2 [139.70]	
12	5/8	[15.87]	61/64	[24.21]	6-1/2 [165.10]	
16	7/8	[22.231	1-13164	[(3.56]	7-3/8 [187.341	
20	1-1/8	[28.58]	1-31/64	[37.70]	9	
	[228.60]					
24	1-3/8	[34.93]	1-23/32	[43.66]	11	[279.40]

Table 7-5: Lubricating Oil Pump Specifications - Inch [mm] (Reference Fig. 7-0)

Ref. No.	Measurement		Worn Limit	New Minimum	New Maximum
1	Single Lubricating Oil Pump Bushings Inside Diameter	(1)	**0.6185 [15.710]**	0.6165 [15.659]	0.6175 [15.684]
2.	Idler and Drive Shaft Outside Diameter	(2)	**0.6145 [15.608]**	0.615 [15.62]	0.6155 [15.634]
	Drive Gear to Body Clearancem0.012	(3)	**0.012 [0.30]**		
	Drive Shaft End Play	(4)		0.002 [0.05]	0.005 [0.13]
	Idler Shaft Shaft Protrusion Inside Body			0.720 [18.29]	0.740 [18.80]
	Driven Gear/Drive Shaft Shaft Protrusion			0.855 [21.72]	0.875 [22.22]
Single Double Capacity Lubricating Oil Pump					
1.	Bushings Inside Diameter	(1)	**0.879 [22.33]**	0.8767 [22.268]	0.8777 [22.293]
2.	Idler and Drive Shaft Outside Diameter)		**0.873 [22.17]**	0.8745 [22.212]	0.875 [22.22]
	Drive Gear to Body Clearance	(3)	**0.012 [0.30]**		
	Drive Shaft End Play	(4)		0.002 [0.05]	0.008 [0.20]
	Idler Shaft Shaft Protrusion Above Body to Cover Face				0.955 [24.26]
	Driven Gear/Drive Shaft Shaft Protrusion			1.035 [26.29]	1.055 [26.80]
3.	Piston Cooling Oil Tube Protrusion Above Body Mounting Face	(5)		2.970 [75.44]	3.000 [76.20]
	Double Lubricating Oil Pump				
1.	Bushings Inside Diameter	(1)	**0.6185 [15.710]**	0.6165 [15.659]	0.6175 [15.684]
2.	Idler and Drive Shaft Outside Diameter		**(0.6145 [15.608]**	0.615 [15.62]	0.6155 [15.634]
	Drive Gear to Body Clearance Suffix Letter L	(3)	**0.012 [0.30]**		
	Drive Shaft End Play	(4)		(0.004 [0.10]	0.007 [0.18]
	Idler Shaft Shaft Protrusion Above Back Surface of Body			2.600 [66.04]	2.620 [66.55]





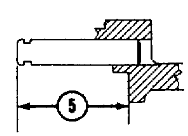
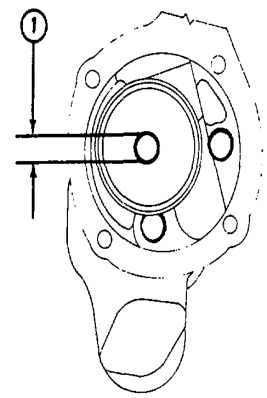
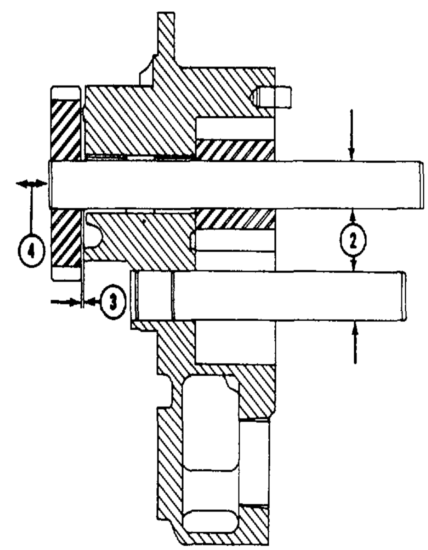


Table 7-5: Lubricating Oil Pump Specifications - Inch [mm] (Reference Fig. 7-0) (Cont)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Idler Shaft Suffix Letter L		2.680 [68.07]	2.690 [68.33]
	Drive Gear/Drive Shaft Shaft Protrusion		0.040 [1.02]	0.060 [1.52]
	Single Scavenger Pump			
1.	Bushings Inside Diameter (1)	**0.6185** **[15.710]**	0.6165 [15.659]	0.6175 [16.684]
2.	Idler and Drive Shaft Outside Diameter)	**0.6146** **[15.608]**	0.615 [15.62]	0.6155 [15.634]
	Idler Shaft Protrusion	Flush with front surface of pump		
	Driven Gear/Drive Shaft Protrusion		0.580 [14.73]	0.610 [15.49]
	Coupling Dowels Protrusion Above Coupling Face		0.990 [25.15]	1.010 [25.65]
	Coupling/Drive Shaft Shaft Protrusion		0.050 [1.27]	0.070 [1.78]
	Drive Shaft End Play		0.004 [0.10]	0.010 [0.25]
	Double Scavenger Pump			
1.	Bushings Inside Diameter	**0.841** **[21.361]**	0.840 [21.34]	0.8405 [21.349]
2.	Idler and Drive Shaft Outside Diameter)	**0.837** **[21.261]**	0.8375 [21.272]	0.838 [21.29]
	Idler Shaft Protrusion	Flush with front surface of pump		
	Driven Gear/Drive Shaft Protrusion		0.580 [14.73]	0.610 [15.49]
	Coupling Dowels Protrusion Above Coupling Face		0.990 [25.15]	1.010 [25.65]
	Coupling/Drive Shaft Shaft Protrusion		0.050 [1.27]	0.070 [1.78]
	Drive Shaft End Play		(0.004 [0.10]	0.010 [0.25]





Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-994	Bushing Mandrel
ST-1 157	Spacer Mandrel
ST-1158	Bushing Mandrel

Desirable (Or Equivalent) Service Tools

ST-1134	Dowel Pin Extractor
ST-1160	Hose Assembly Tool Kit
ST-1218	Mandrel ("0" ring)
ST-1223	Mandrel ("0" ring)

LUBRICATING OIL PAN

The -extreme angular operation at which a vehicle is to be operated must be known and a lubrication system provided that is suitable for the maximum angle of operation. Engines for automotive vehicles should be protected to at least 10 deg. vehicle angularity of operation and engines for construction equipment must be equipped with the necessary components to permit at least 30 deg. vehicle angularity of operation. See Table 7-1 for oil pan capacities and sump location.

INSPECTION

1. Visually check oil pan for cracks or, if a leak is suspected, check using dye penetrant.
a. Spray suspected area with dye penetrant. Allow penetrant to dry for fifteen minutes. Do not "force dry," b. Spray area with dye developer and check for crack indications.
2. Check heli-coil inserts on aluminum oil pans. If damaged, replace. Check all threaded holes for damaged threads.

REPAIR

1. Repair damaged heli-coil inserts.
a. Determine hole size; then use proper heli-coil extraction tool to remove damaged heli-coils. Condition hole and insert new heli-coil. Refer to Cummins Service Tool
b. Use starting and finishing tap for heli-coil inserts for new or oversize holes in aluminum. When tapping aluminum, use fuel oil for lubricant to prevent tearing.
c. After inserting heli-coil, bend starting end toward center
then back toward side of hole to break off installation tip.

2. Repair small cracks in pan by welding. Do not weld finished surfaces.

3. Repair oil plug drain hole in aluminum oil pans when drain hole threads are damaged. Two oversize plugs are. available to permit re-thread of oil pan drain holes at least twice.
a. Part No. 62117 Oil Pan Drain Plug; Size 1-1/4 inch x 12 thread.
(1) Enlarge damaged hole by drilling to 1-11/64 inch [29.77 mm].
(2) Tap hole with a 1-1/4 inch x 12 tap. When tapping aluminum, use fuel oil for lubricant to prevent tearing of metal.
(3) Install new drain plug with a new copper gasket. Tighten to 60 to 70 ft-lbs [8.3 to 9.7 kg m] torque.
b. Part No. 120349 Oil Pan Drain Plug; Size 1-3/8 inch x 12 thread.
(1) Enlarge damaged hole by drilling 1-19/64 inch [32.94 mm]. Tap hole with a 1-3/8 inch x 12 tap.
(2) Install new drain plug with a new copper gasket. Tighten to 60 to 70 ft-lbs [8.3 to 9.7 kg m] torque.
4. Install pipe plugs in oil pan securely. Do not overtighten.

LUBRICATING OIL DIPSTICK

The dipstick has been calibrated for a certain oil level when used with a specific oil gauge tube and with engine in a certain position. Too high an oil level will cause foaming, excessive oil temperature and power loss. Too low an oil level will result in oil pressure fluctuation and possible loss of oil pressure. In the event a dipstick should be lost or damaged a new dipstick is required. If part number is unknown and it is necessary to mark a blank dipstick for use, see part numbers listed below for lengths available.

Blank (Unmarked) Dipstick Length

Part Number	Inch	[mm]
131461	11-7/16	[290.51]
131462	23-1/4	[590.55]
131463	47-11/16	[1211.261
161482	20-1/16	[508.061
161483	40-1/16	[1016.06]
16t484	60-1/16	[1524.06]
197737	80-1/16	[2032.06]

Engine must be mounted in chassis and in operating position.

1. Determine oil pan part number; check high and low capacity.

2. Drain all oil from oil pan, make sure all oil has drained from engine.
3. Fill oil pan with amount of oil indicated as low level in Table 7-1; allow sufficient time for oil to drain down into the pan.
4. Insert dipstick into dipstick tube until dipstick contacts bottom of pan. Measure distance dipstick protrudes above tube, remove dipstick and cut off end the same amount as measured protrusion (to bottom of cap).
5. Insert dipstick all the way into tube. Remove dipstick and mark low oil level indicated. Mark should be 0.010 inch [0.3 mm] deep. Stamp (electric etch on spring steel) letter "L" immediately above mark (Fig. 7-1). Do not use a chisel for marking, or stamp too deep. This may cause dipstick to break. Cut excess length off dipstick leaving minimum of 1/2 inch [12.70 mm] below low level mark.

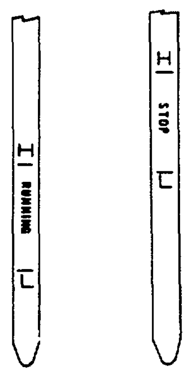


Fig. 7-1. (V40726) Dipstick markings

6. Add amount of oil to pan to bring to high level as indicated in Table 7-1. Allow time for all oil to drain into pan. Insert dipstick and withdraw; now mark oil level indicated. Stamp letter "H" immediately above mark.
7. Mark opposite side of dipstick (if desired) for running levels (Fig. 7-1). Running levels provide equivalent readings to static levels with engine running at low idle (550 25 RPM). Add running level marks with oil supply, low and high, as stated previously.

Note: Running level readings require oil gauge tube with increased internal length and an internal drilled hole to provide for tube venting (if not originally equipped with running level markings).

LUBRICATING OIL FILTERS
Full-Flow Paper Element Filter
DISASSEMBLY

1. Remove filter case and element from filter head, remove seal ring and discard.

2. Lift element from case; inspect element pleats if metal is found in elements, an inspection of connecting rod and main bearings should be made at once; discard element.

3. The filter by-pass valve normally requires no servicing; however, check to make sure the valve works freely. The valve is spring loaded and opens on a spring differential.

INSPECTION

1. Remove all pipe plugs and fittings from filter head. Remove filter by-pass valve retainer (1, Fig. 7-2) with a standard puller, valve seat (2) and spring (3) from filter head (1), if necessary after Step 3 above. Housing may remain in filter head. Clean housing and case in approved cleaning solvent and dry with compressed air.

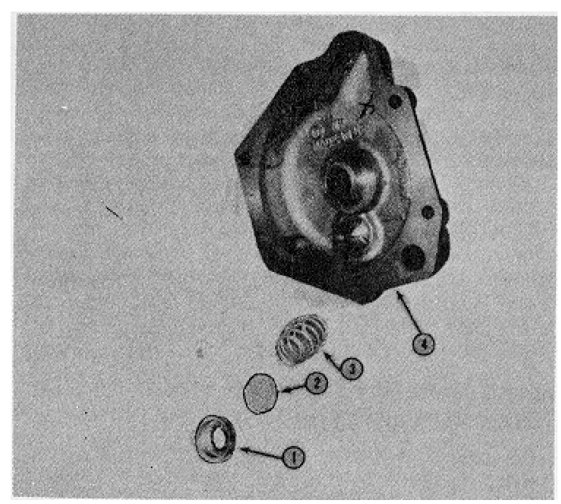


Fig. 7-2 (N10730) By-pass valve full-flow filter

2. Remove snap ring from capscrew securing support, seal washer and spring on capscrew in case. Slide bolt from case; remove and discard copper washer and seal.
3. Inspect all parts for wear or distortion; discard and replace all damaged parts.

ASSEMBLY

1. Position new copper washer on capscrew.
2. Insert capscrew in filter case; slide seal spring, washer, seal and support over capscrew; secure in position with snap ring or circlip in case. Snap ring or circlip must be in proper position in groove in center bolt.
3. Coat all plugs and fittings with sealing tape or lead sealer; install in filter head.
4. If removed, insert filter by-pass valve spring (3, Fig. 7-2) (large end first) in filter head (4), position relief valve (2) in bore coated side out over spring (3) and secure with retainer (1), press retainer in bore flush with head.

Note: By-pass valve discs, hard composition type, have been replaced by steel disc valves (rubber coated one side) Part No. 200819. Hard composition discs removed, should be replaced with rubber coated steel discs.

5. Position new seal ring or gasket on filter head; slide new element with seals in place over capscrew and into filter case.
6. Position assembly to filter head and secure with capscrew; tighten to 25 to 35 ft-lbs [4.8 to 5.5 kg m] .

By-Pass Filter

A by-pass filter is often used in conjunction with a full-flow filter, never use a by-pass filter instead of a full-flow filter.

DISASSEMBLY

1. Remove clamping ring capscrew and lift off cover.

2. Unscrew upper support element hold-down assembly and lift out hold-down assembly and element.

3. Clean housing and hold-down assembly in solvent.

INSPECTION

1. Inspect hold-down assembly spring/seal, drain plug, connections and filter cover "0" ring. Replace if damaged.
2. Clean orifice in tee-handle or orifice hole in standpipe; these are very important and control amount of flow through the by-pass filter.

ASSEMBLY 1. Install new element.

2. Replace upper support element hold-down assembly in filter and tighten down to stop.
3. Position "O" ring gasket on housing flange.

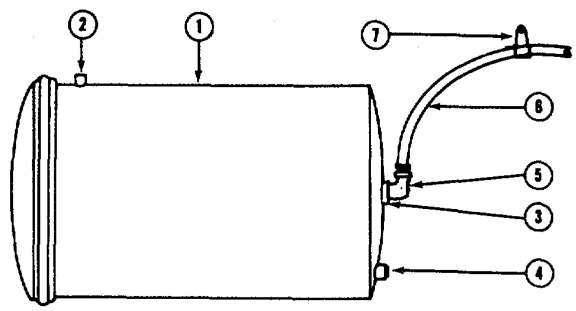
4. Install cover and clamping ring; tighten capscrew until clamping lugs come together.

Mountings (Fig. 7-3) Vertical Mounting

Vertical or up-right filters can be mounted with up to 45 deg. inclination. The inlet should be positioned at the highest location to minimize drain back of oil when engine is shut-down. None of the vertical mounted filters contain anti-drain back valves on either the inlet or outlet.

Horizontal Mounting

Horizontal mounted filters can also be mounted up-right when it is desirable to have both inlet and outlet hose attached to bottom end of filter.



1. By-Pass Filter
2. Lubricating Oil Inlet
3. Lubricating Oil Outlet
4. Drain Fitting
5. 90 Deg. Elbow
6. No. 10 Hose (Minimum)
7. Hose Hump To Be Higher Than Filter Can

Fig. 7-3 (V50709) By-pass filter installation

Flow Characteristics And Specifications

With a 180 deg. F [82 deg. C] oil temperature and with engine at high idle, oil flow through the by-pass filter should be a minimum of 1-1/2 to 3 gal. [5.7 to 11.4 lit] per minute maximum (total flow through both filters) to insure maximum filtration and maintain adequate oil pressures.

Hose Size
1. The supply and drain lines should be No. 6 (5/16 inch [7.9 mm] inside diameter) flexible hose up to 10 ft. [3 m] in length. For lines over 10 ft. [3 ri], use No. 8 (13/32 inch [10.3 mm] inside diameter). All fittings in by-pass circuit should be no less than 1/4 inch [6.4 mm] pipe size.
2. The return line should discharge below oil level in the oil pan to prevent foaming.
3. Supply line should be connected to oil circuit between oil pump and full-flow filter.

LUBRICATING OIL COOLERS Direct Mounted DISASSEMBLY
1. Remove cooler cover, "O" ring, and brass retainer, being careful not to scratch or mar sealing surface on element.
2. Use mineral spirits or equivalent to clean out lubricating oil and contaminants trapped in housing by forcing cleaner through the oil ports.
3. To remove element from housing, insert two 7/32 inch [5.56 mm] rods 8 inches [503.2 mm] long into the outside row of tubes opposite each other, rods should not drag bottom of housing.
4. Place a bar on top of housing and bundle face, between rods, and rotate element in housing to unseat lower "O" ring. Lift up gradually on rods to free "0" rings.

INSPECTION
1. To prevent hardening and drying of foreign substances, clean immediately, after removing end cover plates, with approved cleaning solvent that will not harm non-ferrous metal, blow through core with compressed air.
2. Inspect core for corrosion or cracks where tubes are welded to end plates. Inspect connections and liner for cracks or damage.
3. Inspect cooler assemblies for leakage between oil and water passages.
a. Clamp cooler assembly in fixture and assemble air connection.
b. Place unit in water tank and apply 1 to 4 psi [0.07 to 0.28 kg/sq cm] air pressure to water side. Inspect for air leaks, porosity in casting, etc.
c. Apply line air pressure 35 to 40 psi [2.5 to 2.8 kg/sq cm] to oil side. Inspect for air leaks.

REPAIR

Repair damaged tubes by inserting a small O.D. tube inside damaged tube. Cut and flare ends; then solder securely. Do not damage adjacent tubes with heat while soldering. If more than 5% of tubes are defective, discard cooler.

ASSEMBLY
1. Lubricate rubber "O" ring and place in groove at bottom of housing. Make sure ring is not twisted and is free of cuts or nicks.
2. Push element (3, Fig. 7-8) into housing (1), aligning index marks (2) on housing and element.
3. Using proper "O" Ring Mandrel, install "O" ring around top of element. Place retainer ring over rubber "O" ring.
4. Install pipe plugs (if removed), on coolers using 3/4 inch pipe plugs with raised bosses torque to 25 to 35 ft-lbs [3.5 to 4.8 kg ml. Torque others to values in Table 1-1, Cylinder Block Group.

Support, Pump Mounted Or Auxiliary Oil Cooler DISASSEMBLY

1. Remove cooler, cover, support and gaskets from cooler

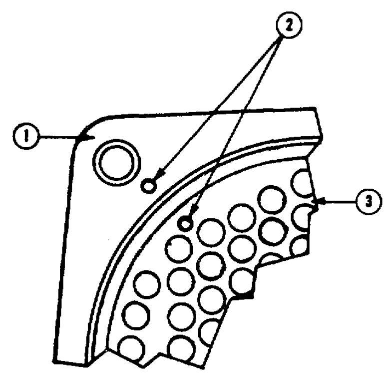


Fig. 7-8 (N10705) Aligning oil cooler index marks

housing (2, Fig. 7-9) if not previously removed.
2. Remove retainer rings (4) from housing (2).
3. Remove exposed "O" ring (3) under retainer, being careful not to scratch or mar sealing surface on element.

4. Use mineral spirits or equivalent to clean out lubricating oil and contaminates trapped in housing by forcing cleaner through oil ports in reverse direction of normal flow.
5. To remove element (1) from housing (2): a. Insert two long rods into outside row of tubes opposite each other.
b. Place a flat bar on top of housing and bundle face between rods, and rotate element in housing to unseal lower "O" ring.
c. Remove tube bundle from cooler housing. Two small threaded holes are provided in end of tube bundle; if necessary make a suitable puller utilizing the two threaded holes in end of tube bundle.
6. Discard "O" rings (3) and retainers,(4).

Note: To prevent hardening and drying of foreign substances, clean core or cores as soon as possible after removal.

CLEANING (OI L SIDE)

1. Immerse core in approved cleaning solvent, let stand several minutes. Force cleaner around tubes until clean.

WARNING

This operation should be done in open air or in a well ventilated room to avoid toxic effect of chemicals being used.

2. If oil passages are badly clogged, circulate an oakite or alkaline solution through the tubes. After cleaning, flush thoroughly with hot water.

CLEANING (WATER SIDE)

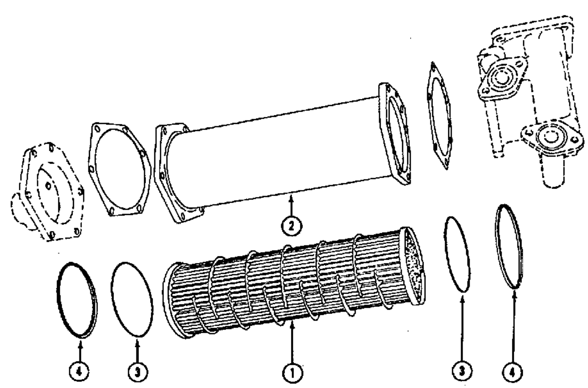
1. Plug oil inlet and outlet.
2. Immerse oil cooler in solution of one part muriatic acid and nine parts water after adding 1 lb. [0.45 kg] of oxalic acid and 0.01 gal. [0.04 lit., 0.008 UK gal.) of pyridene to each 5 gal. [18.9 lit., 4.16 UK gal.] of acid.
3. Remove core when foaming and bubbling stops. Immerse unit in a 5% solution of sodium carbonate. Remove when bubbling ceases and pressure flush with clean warm water.

Note: Flush inside of tubes with clean, light oil after both oil and water sides of cooler have been cleaned.

INSPECTION

1. Seal both ends of tube bundle. Immerse tube bundle in water and apply approximately 40 psi [2.8 kg/sq cm] air pressure. If air bubbles are observed, mark bundle for repair or replacement.

2. Inspect support for broken or cracked welds; repair or replace as necessary.



1. Element 3. “O” Ring
2. Housing 4. Retainer

Fig. 7-9 (N10741) Lubricating oil cooler exploded view

REPAIR (HEADER LEAKS)
Header leaks may occur where tubes protrude through plate or where header is soldered into case. Repair damaged tubes by inserting a smaller outside diameter tube inside damaged tube. Cut and flare ends; then solder securely. Do not damage tubes or header material with heat while soldering. If more than 5% of tubes are defective, discard element.

ASSEMBLY
1. Lubricate new rubber "O" ring (3, Fig. 7-9), using appropriate mandrel, place in groove at bottom of housing (2). Make sure ring is fully seated, not twisted and is free of cuts or nicks.
2. Push element (1) carefully into housing, aligning index marks on housing and element,
3. Press second "O" ring around top of element with equal pressure around ring circumference.
4. Place retainer ring (4) over rubber "O" rings.
5. Assemble new gaskets, cooler, cover and support; secure snugly with capscrews and lockwashers. Tighten capscrews to 30 to 35 ft-lbs [4.1 to 4.8 kg m] torque.

LUBRICATING OIL PUMP
Lubricating oil pumps used on 855 C.I.D. Cummins Engines are disassembled, assembled and inspected in a like manner. Care must be taken during disassembly to mark or identify parts, such as pressure regulator plunger, idler shaft, drive shaft, capscrews as to length, size, location, etc., as removed to aid in reassembly. Clean disassembled pump in an approved cleaning solvent as described in Engine Disassembly, Group 0.

DISASSEMBLY AND INSPECTION
1. Remove pump cover or filter head from pump body. Tap lightly with a soft hammer to loosen from dowel.
2. Remove idler gear, press drive shaft through driven gear, remove shaft and gear or coupling (Scavenger Pump).
Note: Double lubricating oil pumps have a scavenger pump body that must be removed after drive shaft is pressed through driven gear. After removing scavenger body repeat Step 2.
3. If piston cooling tube, on pumps so equipped, is mutilated, drive or press out from inside body.
4. Press idler shaft from body if worn beyond worn replacement limits as listed in Table 7-5 (2).
5. Remove pressure regulator cap, spring and plunger, check plunger for freedom of movement in pump body.
6. Remove by-pass valve from filter mounting head, if so equipped, inspect disc, spring and seat for wear or distortion.
7. Remove damaged dowel pins with ST-1 134 Dowel Puller.
8. If drive shaft is worn beyond worn replacement limits or gear is chipped or worn, press shaft from gear.
9. Inspect all gears for worn or broken teeth, all parts for pitting or cracks and body(s) for distorted threads.
10. Check gasket mating surfaces for flatness, nicks or burrs. Replace all unserviceable parts.
11. Inspect bushings in body(s), cover and idler gear(s), if bushings are damaged or worn larger than worn replacement limits replace as follows:
a. Remove bushings with ST-1 158 Bushing Mandrel.
b. Press new bushings into gear(s), body or cover, as required, with ST-1158 Mandrel. Bushings must be flush to 0.020 inch [0.51 mm] below surface of gear(s), body or cover.
c. Bore new bushings to specifications as listed in Table 7-5
(1) with appropriate boring machine.

ASSEMBLY
1. If removed, press large end of idler shaft in gear pocket side of pump body using deep end of ST-1157 Spacer Mandrel where applicable. If mandrel is not used, press idler shaft in to protrude as listed in Table 7-5 (2).
2. Press driven gear onto drive shaft with shallow end of ST-1157 Mandrel. If mandrel is not used, press gear onto shaft so protrusion meets specifications, Table 7-5 (2).
3. Lubricate drive shaft, position drive shaft and gear into pump body. Support drive shaft on a suitable arbor press and press drive gear or coupling (Scavenger Pump) on drive shaft.
Note: Coupling protrusion or drive gear to body press fit clearance should meet specifications in Table 7-5 (2).
4. Lubricate idler shaft and place gear on shaft.
Note: On double lubricating oil pumps, install scavenger pump body, using new gasket, and press scavenger driven gear onto drive shaft, leave 0.002 to 0.004 inch [0.05 to 0.10 mm] clearance between gear surface and bottom of gear pocket. Repeat Step 4.
5. If removed, (piston cooled engine pumps), press new piston cooling oil tube into pump body with beveled edge up. Protrusion should be as listed in Table 7-5 (3).
6. Install new dowels in pump body, if removed.

7. Lubricate gears, bushing, shafts, etc. with clean lubricating oil.

8. Install by-pass spring, disc and seat or plate in filter mounting head, if so equipped.

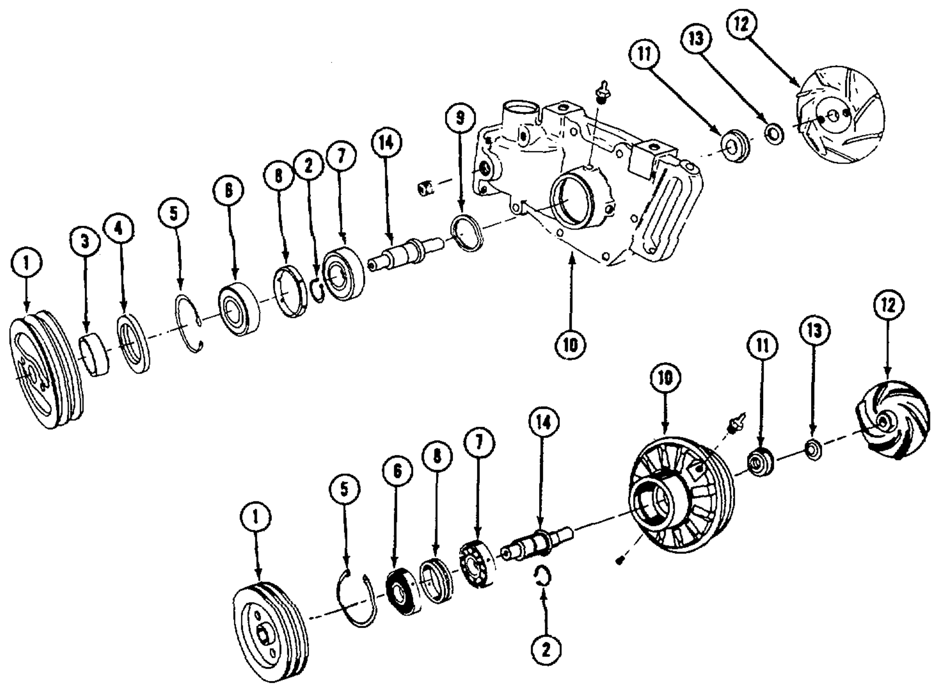
9. Using new gasket, install cover or filter head to pump body; replace pipe plugs if removed.

10. Position spring in pressure regulator plunger open end. Install assembly in pump body, solid end of plunger down; secure with retainer assembly. Rotate drive shaft, check end play. Ref. Table 7-5 (2).

Note: Double lubricating oil pumps with the letter "L" stamped following the part number (example 164163L) have increased gear pocket depth to allow drive shaft end clearance to meet specifications. See Table 7-5 (2).

Cooling System
Group 8

The cooling system consists of engine water pump, fan hub, thermostats, heat exchanger, sea or raw water pump and coolers.



1. Pulley
2. Snap Ring
3. Sleeve
4. Front Oil Seal
5. Snap Ring
6. Bearing
7. Bearing
8. Bearing Spacer
9. Rear Oil Seal
10. Body
11. Carbon Face Seal
12. Impeller
13. Ceramic Seat and Seal
14. Shaft

Fig. 8-1, (N10843). Water pump exploded view (855 C.I.D Series)

Service Tools (Or Equivalent) Required

ServiceTool Tool Number	**Name**
ST-647	Puller
ST-1114	Bearing Disassembly Tool
ST-1159	Seal-Wear Sleeve Driven
ST-1191	Seal Mandrel
ST-1225	Seal Mandrel (Thermostat)

Desirable (Or Equivalent) Service Tools

ST-658	Mandrel
ST-659	Mandrel-Seal Driven
ST-709	Puller
ST-1154	Seal Driving Mandrel
ST-1161	Seal Mandrel

WATER PUMP

Two basic water pumps are used on 855 C.I.D. engines, they are the eccentric or idler pulley belt adjustment pumps as shown in Fig. 8-1 or N.T.A. Series with idler belt adjustment as shown in Fig. 8-2. Remove idler pulley assembly and drain lubricant where applicable before pump disassembly. Water pumps are to be lubricated with grease meeting specifications in Group 18 when reassembled.

WATER PUMP/I D LER (FFC SERIES-ECCENTRIC)

DISASSEMBLY AND INSPECTION

1. Remove pulley (1, Fig. 8-1) and impeller (12) using ST-647 puller or equivalent.
2. Remove ceramic seat and rubber seal (13), large oil seal (4) and snap ring (5), discard seals.
3. Support pulley end of pump body (10) and press bearing and shaft assembly from body.
4. Using both halves of ST-1114 Bearing Puller installed around bearing spacer in the grease channel, press shaft through outer bearing (6) and bearing spacer (8).
5. Remove snap ring (2) securing inner bearing (7), supporting bearing race, press shaft from bearing.
6. Remove carbon face seal (11) and small oil seal (9) from water pump body (10); discard seals.
7. 1 nspect bearings and spacer for roughness and wear.
8. Inspect water pump impeller; replace if cracked or corroded to extent that it will retard coolant circulation.
9. Measure impeller/pulley bore and shaft diameter. There should be a minimum of 0.001 inch [0,03 mm] press-fit between shaft and bore. Inspect shaft for straightness and galling on press fit diameter surfaces.
10. Inspect pulley grooves for wear, water pump body for cracks, possible damage from bearing spinning, and that "weep" hole is open. Repair or replace parts as necessary.
11. Inspect wear sleeve (3) on pulley (if used). If grooves are visible, remove sleeve as follows:

a. Grind a 15 deg. angle on end of a 3/16 inch straight shank round punch.
b. Secure pulley in vise. Do not tighten too tight, excessive pressure could crack pulley.
c. Using punch, drive sleeve from pulley hub by placing punch through puller holes in pulley; discard sleeve.
d. Install new sleeve with a suitable mandrel.

ASSEMBLY

1. Lubricate shaft (14, Fig. 8-1) and using ST-658 Mandrel seated on inner race, press inner bearing (7) over shaft (14) until it bottoms on shaft shoulder. Install snap ring (2) and bearing spacer (8).
2. Using ST-658 Mandrel seated on inner race of outer bearing (6), press bearing on shaft (14) until it seats against bearing spacer (8). Check both bearings for free rotation.
3. Install small oil seal (9), if used (idler pulley type body), into body, using ST-1191-2 Seal Mandrel, with lip of seal opposite impeller end.
4. Using ST-659 Mandrel, install new carbon face seal (11), into body (10) until seal bottoms in bore. Keep seal face free of grease or other foreign material.
5. Press shaft and bearing assembly into water pump body (10) using ST-658 Mandrel. Do not support body on thin sections of impeller cavity. Install retaining ring (5).
6. Install large oil seal (4), if used (idler pulley type body), into body using ST-1 191-3 Seal Mandrel.
7. Install new ceramic seat (with dimples on face away from carbon face seal) on shaft; install rubber seal on shaft against ceramic seat (with flat side toward impeller end of shaft). Lubricate bore with a solution of clean soap water or liquid soap to ease installation onto shaft.
8. Support water pump on pulley end of shaft and press impeller on shaft, maintaining 0.020 to 0.040 inch [0.51 fo 1.02 mm] clearance between impeller and cavity.
9. Support water pump assembly on impeller end of shaft (not on impeller) and press pulley on shaft until pulley hub is flush with shoulder on shaft. Install locknut and washer (if used), tighten to 90 to 100 ft-lbs [12.5 to 13.8 kg m] torque.
10. Install new grease and relief fittings if required. Fill 1/2 to 2/3 full with grease. See Group 18 for type grease.
11. Check assembly for freedom of rotation.

Idler Pulley Assembly
DISASSEMBLY AND INSPECTION

1. Remove spacer from shaft. Remove "O" ring, oil seal and snap ring.
2. Remove shaft and bearing assembly from pulley. It may be necessary to remove pipe plug and use a small punch to knock shaft and bearing assembly from pulley.
3. Inspect idler bearing for roughness and wear, if required, press shaft from bearing, inspect shaft for straightness or galling on bearing surface and mutilated threads.
4. Inspect spacer for excessive wear or grooves in oil seal area. If grooves are visible replace spacer.
5. Inspect pulley grooves for wear. Replace parts as necessary.

ASSEMBLY

1. Lubricate shaft and using a suitable mandrel seated on

inner race, press bearing onto shaft until Inner race bottoms on flange of shaft.
2. Supporting bearing on outer race, press pulley onto bearing until pulley bottoms; install snap ring in groove.
3. Using ST-658 Mandrel, install new oil seal. Lubricate *"O"* ring and lip of seal, position "O" ring in groove of shaft.
4. Install idler shaft spacer over shaft and "O" ring, press into position through seal until spacer bottoms against bearing inner race.
5. Install new grease fitting, if required, fill 1/2 to 2/3 full with grease. See Group 18 for type grease.
6. Position idler assembly to water pump housing. Secure finger tight with flatwasher and nut. Install adjusting screw. Do not tighten.

FAN AND FAN HUB
Check fan blades for bends, dents or cracks; clean disassembled part as outlined in Group 0, Engine Disassembly.

Tapered Roller Bearing Type With Bearing Spacer DISASSEMBLY AND INSPECTION
1. Remove pipe plugs (6, Fig. 8-4), drain oil from hub.
2. Remove spacer (12), "0" ring retainer (10), locknut (9) and washer (if used).
3. Remove pulley (5) from shaft, remove front bearing (3) and spacer (7) from pulley.
4. Remove seal (2) and rear bearing (3), discard seal.
5. Inspect bearings, races, and fan hub shaft for roughness, pitting and wear.
6. If shaft is damaged in seal mating area it can be cleaned up by'using 240 grit or fine emery paper.
7. Bearing races (4) may be removed with a flat punch by striking, from the back side, alternately from side to side until the race drops out.
8. If bearing races are removed, inspect snap rings (8). Do not remove snap rings unless damaged.
9. Inspect parts for chips, cracks, wear or distorted threads. Replace all unserviceable parts.

ASSEMBLY
1. If removed, install new snap rings (8) (position into grooves with hammer handle). Press in bearing races (4), beveled side out, until races "bottom" against snap rings.

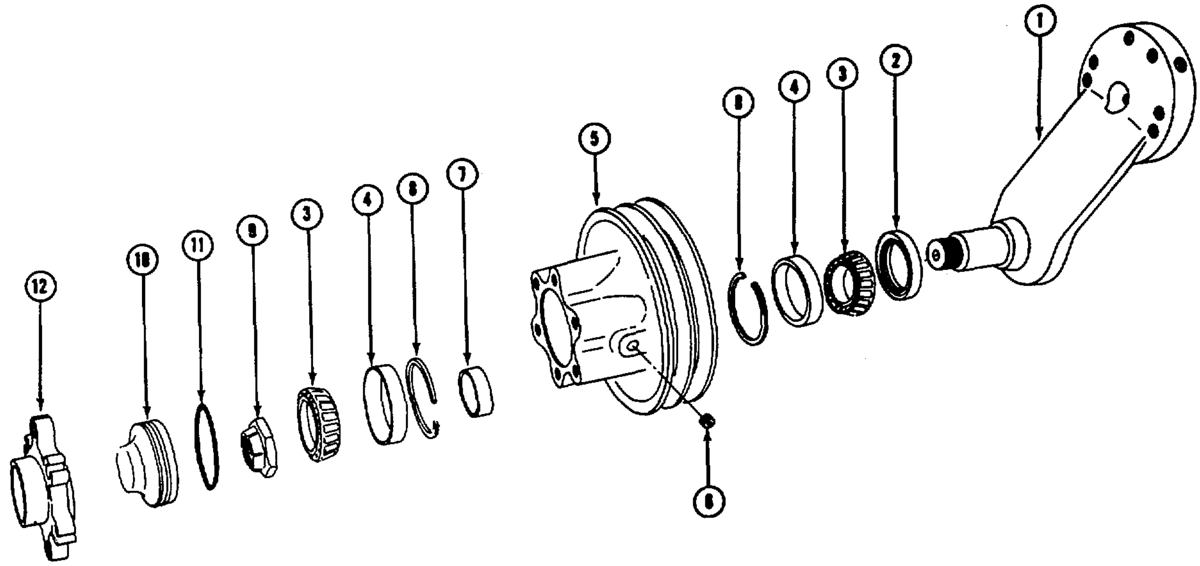
2. Position rear bearing (3) in race (4) and press seal (2) into pulley bore until flush. (Lip of seal toward bearing.)

Note: Lubricate bearings with SAE 30 lubricating oil before installation.
3. Coat lip of seal (2) with lubricating oil, slide shaft (1) through seal and bearing. Do not damage seal.
4. Place bearing spacer (7) over shaft and install front bearing (3).
5. Install washer (if used) and locknut (9). Tighten nut to 150 ft-lbs [20.7 kg m] torque.
6. Rotate fan hub and check end clearance. Fan hub must rotate freely, end clearance must be 0.003 to 0.010 inch [0.08 to 0.25 mm].
7. Place lubricated "O" ring (11) on retainer (10) and press or drive into pulley bore.
8. Install fan spacer (12) with cupped side next to retainer.
9. Position fan hub so that drain hole is horizontal, filler hole must either be at top of hub or opposite drain hole. Fill with grease lubricating oil to level of drain hole.
10. Install pipe plugs, tighten to 5 to 7 ft-lbs [0.7 to 0.10 kg m] torque.

THERMOSTAT AND HOUSING
Thermostats are not subject to repair, but should be checked to make sure they are opening and closing at the proper temperatures.

DISASSEMBLY AND INSPECTION
1. Remove water outlet connection(s), thermostat housing, and thermostat(s). Remove thermostat seal from housing.

2. Check thermostat to see if it opens and closes at the correct temperature.
a. Immerse thermostat and thermometer in water.
b. Heat water to operating temperature, allow time for thermostat metal to stabilize with water temperature, then compare thermostat operation with thermometer.
c. Low-range thermostats start opening at 160 deg. F [71 deg. C] and are fully open at 175 deg. F [79 deg. C] .
d. Intermediate thermostats start opening at 175 deg. F [79 deg. C] and are fully open at 185 deg. F [85 deg. C] .



1. Shaft and Bracket	4. Race	7. Spacer	10. "0" Ring Retainer
2, Oil Seal	5. Hub	8. Snap Ring	11. "O" Ring
3. Bearing	6. Pipe Plug	9. Nut	12. Spacer

Fig. 8-4, (N 10839). Fan hub assembly with tapered roller bearing and spacer

e. High-range thermostats start opening at 180 deg. F [82 deg. C] and are fully open at 195 deg. F [91 deg. C] .

3. Discard thermostat if it does not operate in correct range.

ASSEMBLY

1. Using ST-1225 Seal Mandrel, install new seal(s) into thermostat housing. Seals must be installed with part number, or metal flange of seal up, toward mandrel during installation, to insure proper operation.

2. Install new or tested thermostat into housing with vent hole at top. Install thermostat cover and water outlet connection.

TESTING RELIEF VALVE

Pressurize exchanger to 7 psi [0.5 kg/sq cm]; relief valve should be open. If relief valve opens below 7 psi [0.5 kg/sq cm] or fails to open at 7 psi [0.5 kg/sq cm], mark for replacement.

CONVERTER COOLER

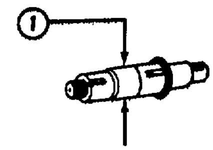
See Support, Pump Mounted or Auxiliary Oil Cooler (Group 7).

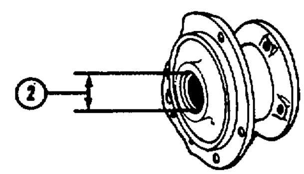
Drive Unit
Group 9

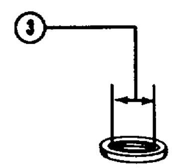
The drive unit is used to transmit power from engine crankshaft, through camshaft gear, to drive a compressor, fuel pump, water pump and other assemblies. Usually, repair consists of replacement of oil seals, bearings or bushings only.

Table 9-1: Drive Unit Specifications - Inch [mm]

Ref. No.	Measurement		Worn Limit	New Minimum	New Maximum
7 (Fig. 9-1)	Shaft				
	Outside Diameter	1	1.310 **[33.27]**	1.3115 [33.312]	1.312 [33.32]
4 (Fig. 9-1)	**Bushing**				
	Inside Diameter	2	1,321 ***[33.55]***	1,312 [33,32]	1.315 [33.40]
4 (Fig. 9-1)	**Bushing**				
	Out of Round		**0.002 [0.05]**		
5 (Fig. 9-2)	Shaft				
	Outside Diameter	1	0.499 [12.67]	0.4995 [12.687]	0.5005 [12.712]
6-11 (Fig. 9-2)	**Bushing**				
	Inside Diameter	2	0.6035 **[12.789]**	0.501 [12.73]	0.502 [12.78]
12 (Fig. 9-3)	**Shaft**				
	Outside Diameter	1	**0.870 [22.10]**	0.8715 [22.136]	0.872 [22.15]
13 (Fig. 9-3)	Collar				
	Inside Diameter	3	**0.876 [22.25]**	0.873 [22.17]	0.875 [22.23]
33	Accessory Drive End Clearance			0.005 [0.13]	0.010 [0.25]
34	Hydraulic Governor Drive End Clearance			0.003 [0.08]	0.006 [0.151







Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-850	Puller
ST-1249	Puller

FUEL PUMP DRIVE
Bearings

1. Bearings should be installed or removed from housing with an arbor press, using the right size and type of mandrel or plate. Pressing should be done on the race that is press fit. When bearing is being pressed into a housing, force should always be applied to outer ring.

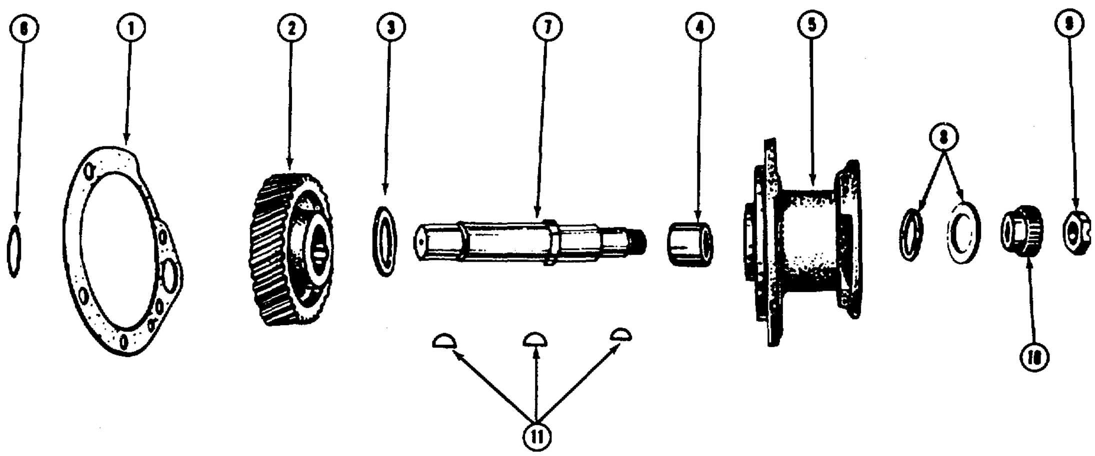


Fig. 9-1, (N10903). Fuel pump or compressor drive

2. Do not spin bearings before cleaning. Do not spin by force of air. Hold both races while drying with clean, compressed air. The following defects cause bearings to be rejected for further use:

a. Broken or cracked race.
b. Dented shields or seals.
c. Cracked or broken separators.
d. Flaked areas on balls, rollers or raceways.
e. Broken or cracked balls or rollers.
f. Bearings that have been overheated. These bearings are generally darkened to a brownish-blue or blue-black color.
g. Bearings whose raceways are indented or "brinelled" by impressing balls or rollers into the races.

Oil Seals

Effectiveness of the seal depends on surface where seal seats. Always check hub sleeve surface for wear and replace sleeve if necessary before installing new seal. Immediately before installing seals, always lubricate with clean lubricating oil.

Bores In Housing

Bearings or bushings must not turn in housing retaining bore. If old bearing has turned and ruined housing, the housing must be scrapped. Bore of housing must be clean before pressing bearing in place.

Thrust Washers

In installation of thrust washers on accessory drives, thrust side of washers is installed away from housing. Thrust side is identified by grooves. Steel backing against the cast iron housing will reduce the possibility of thrust washers' turning. Improper installation of these washers will result in excessive wear and increased end play, which causes early failure of accessory drive assembly.

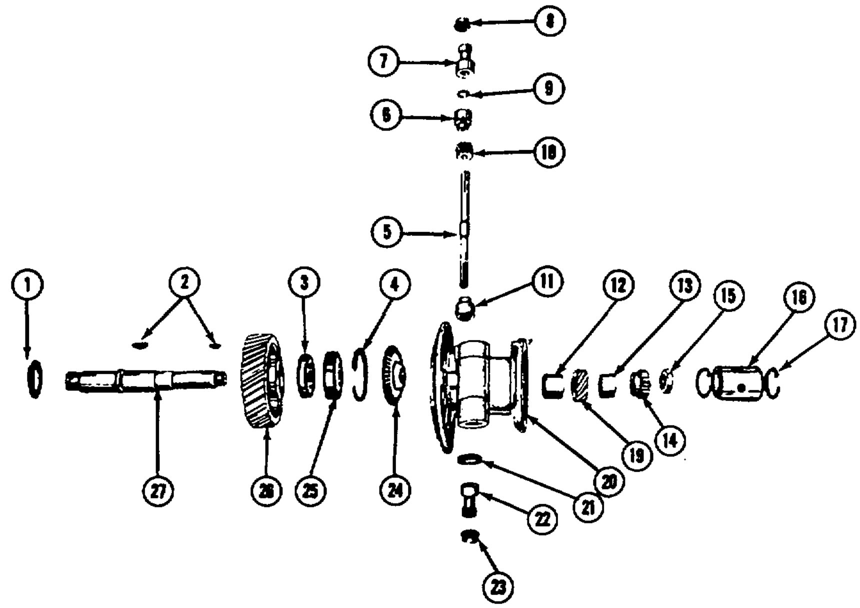
Fuel Pump Or Compressor Drive
DISASSEMBLY AND INSPECTION

1. Remove drive shaft locknut (9, Fig. 9-1), using ST-850 or ST-1249 Coupling puller, pull coupling (10) from shaft (7).

Press shaft and gear assembly from housing (5), press shaft (7) from gear (2), and remove keys (11) from shaft (7).

Note: A splined coupling is used on air compressor drive. A buffer type coupling is used on fuel pump and magneto drive.

2. Inspect bushing in drive housing. Replace if worn beyond specifications as shown in Table 9-1(4). Replace thrust washers if worn or damaged.



1. linger
2. Keys
3. Oil Seal
4. Snap Ring
5. Drive Shaft
6. Bushing
7. Adapter

8.Dust Lap
9. Oil Seal
10. Driven Gear
11. Bushing
12. Spacer
13. Spacer
14. Drive Coupling

I5. Nut
16. Coupling
17. Snap Ring
19. Drive Gear
20. Support
21. Oil Seal
22. Adapter

23.Dust cap
24. Governor Drive Gear
25. Bearing
26. Drive Gear
27. Drive Shaft

Fig. 9-2, (N10906). Fuel pump, hydraulic governor and hourmeter drive

ASSEMBLY

1. Install shaft (7) through housing (5) and bushing (4). Slip on larger thrust washer (3) with face up.
2. Install key (11) and press on drive gear (2).
3. Turn assembly over; slip on small thrust washer (8) (face up) and clamp washer. Install coupling key (11).
4. Press on coupling (10), hub end down. Secure with locknut (9) or washer and capscrew.
5. Install slinger (6) over gear end of shaft.
6. Check end clearance. It should be as listed in Table 9-1(33) with unit assembled.

Fuel Pump And Hourmeter Drive

The hydraulic governor and hourmeter drive is used to drive a hydraulic governor and hourmeter as well as the fuel pump.

DISASSEMBLY AND INSPECTION

1. Remove nut (15, Fig. 9-2) (if used). With suitable puller, remove drive coupling (14). Remove spacer (13).
2. Pull governor drive gear (24) from shaft. Inspect for chipped, cracked or worn teeth. Remove key (2).
3. Press drive shaft (27) assembly from support (20). Check for wear or damaged threads.
4. Press drive gear (26), spacer (12) and hourmeter drive gear (19) from shaft. Remove key (2). If used, press bearing (1) from shaft (27).
5. Unscrew dust caps (8 and 23).
6. Using a suitable puller, remove adapters (7 and 22) from hourmeter drive. Press drive shaft (5) from support. Remove and discard seals (9) and (21).

Note: One of the drive gear bushings (6 or 11) and the drive shaft (5) may be damaged during removal of the shaft. Be sure to check shaft for straightness.

7. Withdraw drive gear bushings (6 and 11) and driven gear (10) from support. Remove snap ring (4), bearing (25) and seal (3) from support.
8. Check all parts for cracks, breaks, wear or rough mating surface. Replace bushing if worn beyond limits as shown in Table 9-1(6-11).

ASSEMBLY

1. Press driven gear (10) onto drive shaft (5) to distance of 3.435 to 3.440 inch [87.25 to 87.38 mm].
2. Press drive gear bushing (11) into bottom of support.
3. Press long end of drive with gear into top of support. Clearance between gear face and bushing must be 0.015 to 0.040 inch [0.38 to 1.02 mm]).
4. Press second drive gear bushing (6) into top of support over drive gear. Clearance between gear face and bushing must be 0.015 to 0.040 inch [0.38 to 1.02 mm].
5. Install oil seals (9 and 21) into top and bottom of support and seat against bushings. Install adapters (7 and 22) in support. Install dust caps.
6. Press seal (3) and bearing (25) into support; secure with snap ring (4). Install key (2) in shaft (27) and press gear (26) onto shaft against shaft shoulder.
7. Install spacer (12) and press hourmeter drive gear (19) onto shaft (27). Press drive gear assembly into support.
8. Install key (2) and press governor drive gear (24) onto shaft. Install spacer (13) and press on drive coupling (14). Install locknut (if used).

9. Install slinger (1) or press on bearing as used.

DRIVE PULLEYS INSPECTION AND REPAIR

1. Check for cracks and chips in hub, web and groove areas and for wear in grooves and oil seal sleeve. If wear on sleeve is visible:

a. Remove worn oil sleeve by splitting with chisel. Do not damage pulley hub.

b. Press new sleeve onto pulley hub with mandrel, until it is flush to 0.015 inch [0.38 mm] below face of hub. Consult latest Parts Catalog for correct pulley/sleeve combination.

Intake Air System

Group 10

The intake air system group consists of intake manifolds, connections, air cleaners, piping, cold-starting aids, and turbochargers. The turbochargers are covered in separate manuals.

INTAKE MANIFOLDS AND CONNECTIONS CLEANING AND INSPECTION

1. Clean intake manifold or air connection with steam.
2. Inspect for chips, cracks, distortions and damaged threads. Discard unusable parts.
3. Damaged threads may be repaired by installing Heli-Coils.

COLD-STARTING AIDS

Preheater

Due to the lower compression ratio of turbocharged engines, they may not start unaided below 50 deg. F [10 deg. C]. For this reason, the glow plug cold-starting aid is supplied as standard on these engines.

This aid uses engine fuel which is pressurized by a hand pump and atomized in a nozzle in the intake system. The atomized spray is ignited by the glowing coil of the glow plug and provides sufficient heat for combustion of fuel in the cylinders.

Fuel supply should be obtained from fuel tank. If this is impractical, supply may be taken from pipe plug in center bottom of fuel pump housing or by a connection in engine fuel supply line. These methods are not desirable due to possible deterioration of hand pump seals which may allow air to be pulled into engine fuel system.

Preheater Servicing

1. Remove preheater adapter (6, Fig. 10-1) and glow plug (1) from intake manifold.

2. Remove nozzle (2) and clamping washer (5) from adapter (6).

3. Clean adapter and nozzle with Bendix carburetor cleaner, or equivalent. Be sure nozzle screen (3, Fig. 10-1) and spray holes are open and clean. Check "O" ring (4) for damage.
4. Check glow plug on 6-volt or 12-volt source, as applicable.

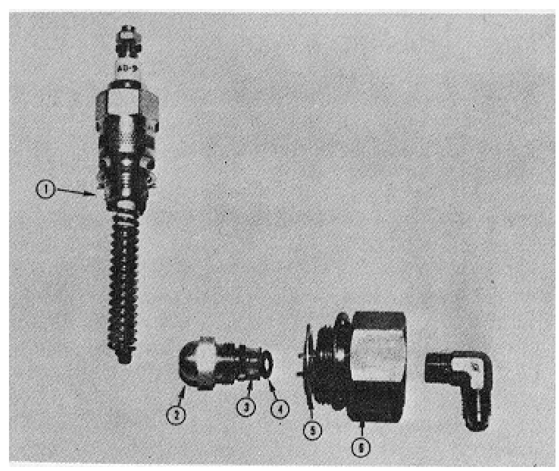
CAUTION
6 and 12-volt plugs are not interchangeable.

5. Assemble clamp washer (5, Fig. 10-1) and nozzle (2) to adapter (6).
6. Tighten nozzle to 15 to 20 ft-lbs [2.1 to 2.8 kg m] and bend washer over one of hexagonal sides of nozzle.
7. Install assembled adapter in intake manifold.

Ether-Starting Aids

A pressurized spray can or a rag wet with ether will usually provide quick starting as low as -10 deg. F [-23 deg. C] . Below this temperature, some means of injecting a carbureted ether vapor directly into intake manifold is necessary.

CAUTION
Do not attempt to use ether compound type starting aids near heat, open flame or on engines equipped with glow plug system.



1. Glow Plug	4. "0" Ring
2. Nozzle	5. Washer
3. Screen	6. Adapter

Fig. 10-1, (N21019). Glow plug preheater adapter spray nozzle

AIR CLEANERS AND PIPING

Dry Type Servicing

1. Disassemble cleaner. Clean element with compressed air.
2. Wipe out housing with clean cloth.
3. Inspect gasket, replace if not reusable.
4. Install new or cleaned element.
5. Assemble cleaner.

Heavy Duty Single And Dual Type Servicing

1. Wipe dirt from cover and upper portion of cleaner.
2. Disassemble cleaner and remove element.
3. Blow out element from clean air side using compressed air of not more than 100 psi [7 kg/sq cm].
4. Wash element with non-sudsing detergent and warm water. Dry with compressed air not exceeding 40 psi [2.8 kg/sq cm].
5. Inspect element for holes.
6. Install new or cleaned element.
7. Check air restriction indicator, if air restriction is excessive, disassemble air cleaner, remove wing nut and replace safety element.
8. Reassemble air cleaner.

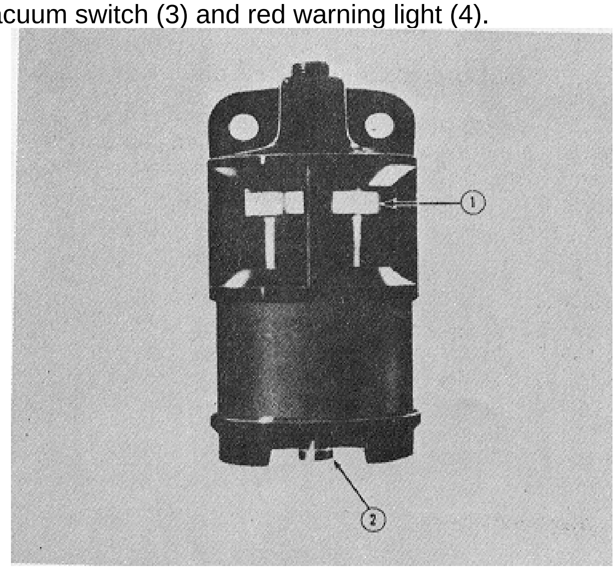
Cartridge Type Air Cleaner Servicing

1. Disassemble cleaner. Remove dirty Pamic cartridge by inserting fingers in cartridge opening. Loosen all four corners, one at a time by pulling straight out.
2. Clean pre-cleaner or moisture eliminator (where applicable). Wipe out housing with clean cloth.
3. Inspect housing and all other parts. Replace if defective.
4. It is not recommended to clean and reuse cartridge.
5. Install a new cartridge; hold cartridge in same manner as when removing from housing. Insert clean cartridge into housing; avoid hitting cartridge tubes against sealing flange on edges of air cleaner housing.
6. The cleaner requires 'no separate gaskets for seals; therefore, care must be taken when inserting cartridge to insure a proper seat within air cleaner housing. Firmly press all edges and corners of cartridge with fingers to effect a positive air seal against sealing flange of housing. Under no circumstances should cartridge be pounded or pressed in center to effect a seal.

7. Assemble cleaner.

CLEANER RESTRICTION INDICATOR

1. The restriction indicator signals when to change cartridges. The red flag (1, Fig. 10-2) in window gradually rises as cartridge loads with dirt. Do not change cartridge until flag reaches top and locks in position. When locked, flag will remain up after engine is shut down. After changing cartridge, reset indicator by pushing re-set button (2). Push button all the way in firmly; then release. If button sticks, repeat pushing slowly.
2. A second method is utilization of a vacuum gauge and warning light that performs the same function as described in Step 1. Components for vacuum gauge include electrical source (1, Fig. 10-3) air piping (2), vacuum switch (3) and red warning light (4).



1. Red Flag
2. Re-set Button

Fig. 10-2, (CGS-20). Air cleaner restriction indicator

TURBOCHARGERS

Refer to TURBOCHARGER SECTION.

Exhaust System
Group 11

The exhaust system group consists of engine exhaust manifolds, piping and mufflers or silencers.

EXHAUST MANIFOLDS

Exhaust Manifold (Dry Type)

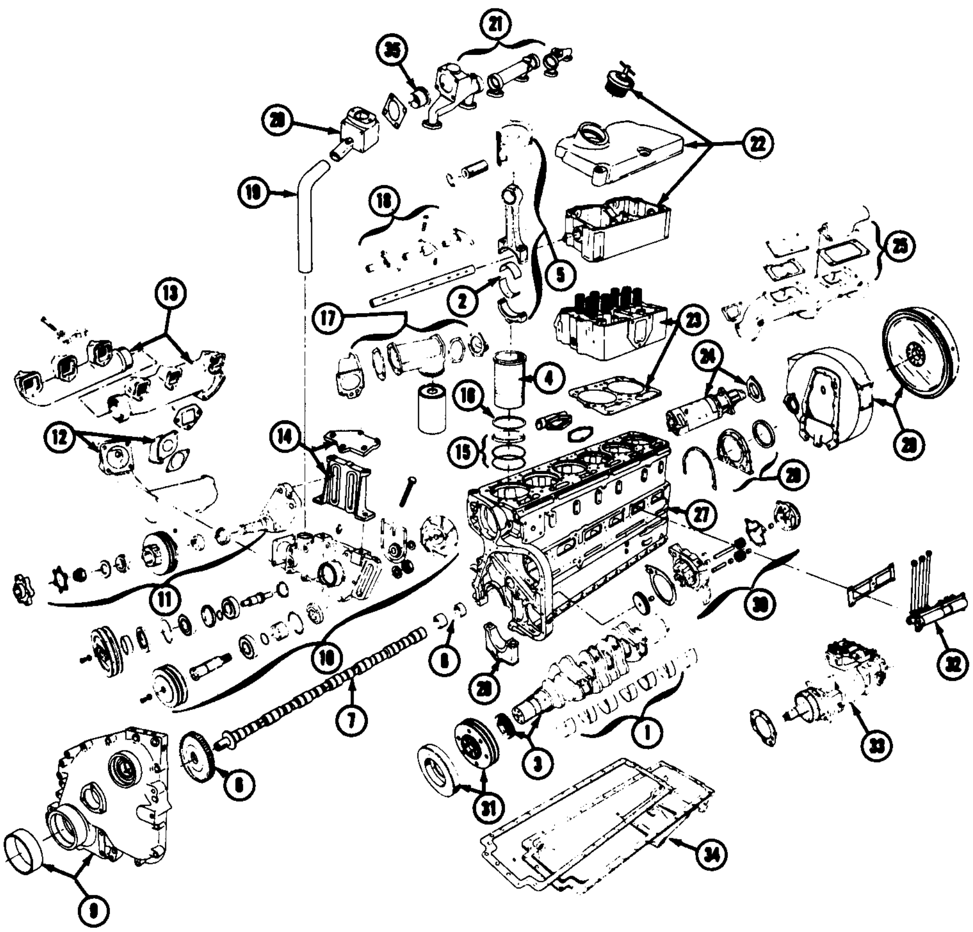
INSPECTION

Inspect exhaust manifold for cracks and distortions; discard defective parts.

When ordering replacement parts, order same part as presently used.

Engine Assembly and Testing Group 14

The engine assembly section covers assembly of all units and subassemblies to the cylinder block as well as adjustments and engine testing.

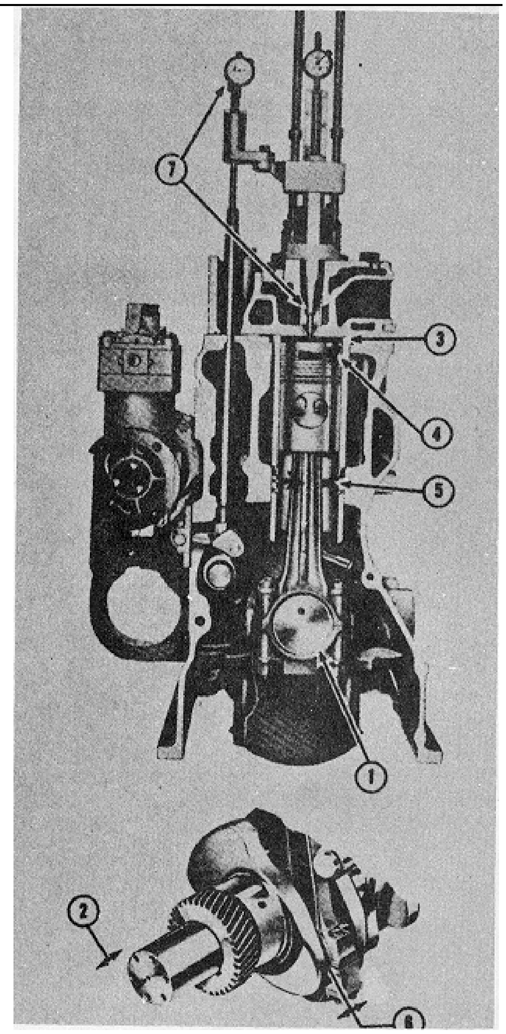


1. Main Bearings
2. Connecting Rod Bearings
3. Crankshaft and Gear
4. Cylinder Liner
5. Conn Rod/Piston Assy
6. Camshaft Gear
7. Camshaft
8. Camshaft Bushings
9. Gear Cvr/Trunion Bushing
10. Water Pump/Idler Assy.
11. Fan Hub Assembly
12. Water Inlet Connections
13. Exhaust Manifolds
14. Fan Hub Mtg Brkt/Supp.
15. Cyl Liner Pack Rings
16. Cylinder Liner Shim
17. Lub Oil Cooler/Filter
18. Rocker Levers/Shaft
19. Water By-Puss Tube
20. Thermostat Housing
21. Water Manifold Assy
22. Rkr Lvr Hsg, Cover/Cap
23. Cyl Head and Gasket
24. Cranking Motor/Spacer
25. Intake Manifold Assy
26. Main Bearing Cap
27. Cylinder Block
28. Rear Cover Assembly
29. Flywheel and Housing
30. Lubricating Oil Pump
31. Vib. Damper/Pulley
32. Cam Follower/Push Tubes
33. Acc Drive/Air Comp/Fuel Pump
34. Oil Pan and Gasket
35. Thermostat

Fig. 14-1, (N 1142356). Engine exploded view

Table 14-1: Assembly Specifications - Inch [mm] (Reference Fig. 141)

Ref No	Measurement		Worn Limit	New Minimum	New Maximum
1	Main Bearing				
	Journal Clearance	0.007 [0.18]	0.0015 [0.038]	0.005 [0.13]	,
2	Connecting Rod Bearing				
	Journal Clearance 'U	1	0.007 [0.18]	0.0015 [0.038]	0.0045 [0.114]
3	Crankshaft				
	End Clearance	2	0.022 [0.56]	0.007 [0.18]	0.017 [0.43]
4	Cylinder Liner				
	Protrusion	3		0.003 [0.08]	0.006 [0.15]
	, Out of Round Top One(1) Inch	4			0.003 [0.081]
	Out of Round Packing Ring (Lower) area		5		0.002 [0.05]
5	Connecting Rod				
	Side Clearance	6	0.0045 [0.114]	0.013 [0.33]	
6	**Gear Train (Gear to Gear) Crankshaft, Camshaft, Accessory Drive and Lubricating Oil Pump**				
	Backlash		0.020 [0.511	0.0045 [0.114]	0.0105 [0.267]
7	Camshaft (With Thrust Plate)				
	End Clearance			0.001 [0.031	0.005 [0.13]
	(With Outboard Bearing Support) End Clearance			0.008 [0.20]	0.013 [0.33]
8	Injection Timing Refer to Table 14-3	7			
9	Injector, Crosshead and Valve Adjustments Refer to Injector and Valve Adjustment				
10	Dynamometer Testing Refer to Test Procedure				
11	Lubricating Oil Pressure Refer to Table 14-15				
12	Blow-By Refer to Test Procedure				
13	Back Pressure Refer to In-Chassis Run-In				



Crankshaft Flange Capscrew Torque Specifications - ft-lb. [kg m]

	Engine Model	Part No	Minimum	Maximum
14	NT-Series 196654 Retainer	196653 Capscrew [34.9]	250 [38.8]	270

Service Tools (Or Equivalent) Required	
Service Tool Number	**Tool Name**
ST-112	Dial Gauge Attachment
ST-435	Pressure Gauge
ST-487	Blow-By Checking Tool
ST-547	Gauge Block
ST-593	Timing Fixture
ST-835	"O" Ring Loader
ST-997	Seal And Sleeve Driver
ST-1172	Seal Mandrel
ST-1173	Seal Mandrel
ST-1 176	Piston Ring Compressor Sleeve
ST-1170	Injector Indicator
ST-1182	Valve Spring Spray Nozzle Locator (80 deg. Tilt Engine)
ST-1193	Rocker Lever Actuator
ST-1229	Liner Driver
ST-1259	Seal Mandrel (Teflon Seal)
ST-1260	Seal Pilot (Teflon Seal)
Desirable (Or Equivalent) Service Tools	
ST-163	Engine Support Stand
ST-386	Pulley Assembly Tool
ST-406	Drill Reamer Fixture
ST-548	Engine Rebuild Stand
ST-669	Torque Wrench Adapter
ST-763	Piston Ring Expander
ST-756	Engine Lifting Fixture
ST-805	Block Mounting Plate
ST-968	Belt Gauge
ST-1138	Belt Gauge
ST-1184	Cylinder Liner Hold-Down Tool
ST-1190	Fuel Consumption Measuring Device
	None Smoke Meter (order from Cummins Distributors)
Standard Tools - Obtain Locally	
	0-150 Inch-pound Torque Wrench
	0-250 Foot-pound Torque Wrench
	0-600 Foot-pound Torque Wrench
	Dial Indicator (Starret No. 196A)
	Dial Indicator Sleeve (Starret No. 196-L)
	Manometer (Mercury or Water)
	0-1 Micrometer
	Impact Wrench
	Engine and/or Chassis Dynamometer
	Hoist (Power or Chain)
	Straight Edge
	Feeler Gauge

ENGINE ASSEMBLY

Mount Cylinder Block To Engine Stand

1. Secure ST-805 Block Mounting Plate to ST-548 Engine Rebuild Stand. Secure water header cover plate adapter and adapter plate to cylinder block.

2. Lift cylinder block and secure to block mounting plate with lockwashers and capscrews.

Crankshaft And Main Bearings

1. Turn cylinder block upside-down.

2. Using a clean rag, wipe main bearing bores and main bearing shells clean. Lay upper main bearing shells in block. All upper main bearing shells are grooved and drilled for lubrication. No's. 1, 3 and 5 are alike and No's. 2, 4 and 6 are alike; No. 7 shell has oil groove off-center. The wide portion of the shell is installed toward flywheel end of block. Groove on each shell for dowel ring must match with counterbore at capscrew hole on exhaust manifold side of block.

3. Install main bearing ring dowels. Coat upper main bearing shells thoroughly with clean lubricating oil.

4. Lift crankshaft into position, using hooks protected with rubber hose or a rope sling at two crank throws. Check rear counterweight of crankshaft to see if oversize thrust rings are to be used and where installed, front or rear. Roll upper thrust rings into position, babbitt or grooved sides next to crankshaft flanges. Upper thrust rings are not doweled to block; lower halves are doweled to cap.

5, Coat lower main bearing shells and crankshaft surface, with clean lubricating oil. Snap into place over crankshaft. 6. Install lower thrust rings, rings must be located over dowels in No. 7 main bearing cap.

7. Install main bearing caps with numbers corresponding to those stamped on block on camshaft side of engine.

8. Lubricate main bearing capscrew threads with clean engine lubricating oil, coat under head of capscrew and lockplates with SAE 140W gear lubricant and install lockplates, start each capscrew; tighten alternately and slowly, to set caps into position.

9. Tighten main bearing capscrews by template method.

a. Tighten main bearing capscrews to 140 to 150 ft-lbs [19.4 to 20.7 kg ml .

b. Continue to tighten capscrews to 300 to 310 ft-lbs [41.5 to 42.9 kg ml to "set" shells, caps and lockplates.

c. Loosen completely; retighten to 140 to 150 ft-lbs [19.3 to 20.7 kg ml .

d. Tighten both capscrews on each cap alternately and evenly to 300 to 310 ft-lbs [41.5 to 42.9 kg ml torque.

Note: There are two torque methods which are acceptable:
Template and Torque method. Refer to Groups 1 and 8.

10. Attach dial indicator gauge securely to rear of cylinder block with contact point of gauge resting on crankshaft flange end face. With a pry bar, pry crankshaft toward front of engine. Remove pry bar and set gauge at "O."

11. Pry crankshaft toward rear of engine. Total gauge reading should be 0.007 to 0.017 inch [0.18 to 0.43 mm], with a new crankshaft and thrust rings.

12. If reading is less than 0.007 inch [0.18 mm]:
a. Loosen bearing cap capscrews slightly.
b. Shift crankshaft first toward front and then toward rear of engine.
c. Retighten capscrews by template method, Step 9.
d. Recheck clearance.
13. If reading is more than 0.022 inch [0.56 mm], crankshaft must be reworked or oversize thrust rings used.

Cylinder Liners

1. Before installing cylinder liners, check protrusion. If 'necessary, install shims around liner to maintain 0.003 to 0.006 inch [0.08 to 0.15 mm] protrusion.
2. Just prior to installation lubricate packing rings with a light coat of clean lubricating oil, roll into position and install crevice seal. Using mold mark on ring as guide, straighten as required.

Caution: To prevent swelling of "0(' rings, lubricate lightly with clean engine lubricating oil, just prior to installation. Make sure proper part numbers are used.

3. Lubricate machined portions of block on which rings seat with a light coat of clean engine lubricating oil.
4. Place liner in block by hand, being careful to avoid dislodging "O" rings and crevice seal. Press liner into position. Use ST-1229 Liner Driver to drive liner securely into the block so it fits squarely into block bore.
5. Install ST-1184 Cylinder Liner Hold-Down Tool so foot of tool rests upon cylinder liner "fire ring." Secure tool, space capscrews so even load will be applied. Tighten capscrews to 50 ft-lbs [6.9 kg m] torque.
8. Use' ST-547 Gauge Block to determine if protrusion meets specifications.
7. Check liner bore with precision dial bore gauge, for roundness at several points within range of piston travel. If liner is more than 0.002 inch [0.05 mm] out-of-round in packing ring area, remove liner and check for cause of distortion. It is permissible to have 0.003 inch [0.08 mm] out-of-round at the top 1 inch [25.4 mm] of liner bore.

Connecting Rods And Pistons

1. Install rings on piston with word "TOP" toward top, using ST-763.Piston Ring Expander.
2. Over-expanding a piston ring during installation on the piston can cause distortion resulting in damage leading to failure. The ring should only be expanded enough to allow it to pass over the piston.
3. A simple formula can be applied to insure that a ring is not over-expanded. The measured gap should not be expanded more than eight (8) times the nominal radial wall thickness of the ring. Stagger ring gaps so they are not in line with each other or piston pin. Lubricate piston and rings with clean engine lubricating oil.
4. Slide connecting rod cap from bolts. Make certain bolt heads are seated squarely on rod shoulder. Keep rod cap with mating connecting rod.
5. Turn engine to vertical position on engine stand and rotate crankshaft so any two crank throws are at bottom-center position.
6. Compress rings with ST-1176, insert piston and rod assembly into cylinder. Position numbered side of rod toward camshaft side of block. Push piston and rod assembly through ring compressor until rings are in liner. Use care to prevent scratching of liners.
7. Pull piston and rod assembly down by rod bolts, leave assembly short of seating to allow insertion of bearing shell.
8. Coat crank side of rod bearing shells with clean lubricating oil, roll rod bearing shell into rod. Shell locking tang must fit in milled recess. Seat rod on crank journal.
9. Seat lower shell in rod cap and install rod cap over bolts so numbered side of cap is matched with numbered side of rod.

Note: Lubricate hardened washers with SAE 140W gear lubricant before installation.

10. Lubricate bolt and nut threads on 855 C.II.D. Engines
with clean lubricating oil. Install new hardened flatwashers and nuts to bolts. Tighten nuts by Template Method, see Table 14-2.

Table 14-2: Tightening Connecting Rod Nuts

Tightening Sequence With Hardened Washer	Tightening Values Ft-Lb [kg ml
Step 1 Tighten to	70 to 75 [9.7 to 10.3]
Step 2 Tighten to	140 to 150 [19.4 to 20.7)
Step 3 Loosen all	Completely
Step 4 Tighten to	25 to 30 [3.5 to 4.1]'
Step 5 Advance to	70 to 75 [9.7 to 10.3]
Step 6 Advance to	140 to 150 [19.4 to 20.7]

Camshaft And Gear

1. Coat- both sides of thrust ring with high pressure lubricant and install over end of camshaft with oil grooves toward camshaft gear.
2. Lubricate cam lobes with high pressure lubricant. Install camshaft, rotating slowly, being careful not to damage lobes and bushings.
3. Index timing mark on camshaft gear with mark on crankshaft gear. Fig. 14-3.

4. Attach dial indicator gauge to block, Fig. 14-4, check the camshaft to crankshaft gear backlash. Rotate gear as far as it will move, zero the gauge. Rotate gear in opposite direction and read dial.
5. Normal backlash is 0.0045 to 0.0105 inch [0.114 to 0.267 mm] on a new gear, with a minimum of 0.002 inch [0.05 mm].
6. Gears will rattle if backlash exceeds 0.010 inch [0.25 mm]. If noise is not objectionable, do not replace gears unless backlash exceeds 0.020 inch [0.51 mm] .

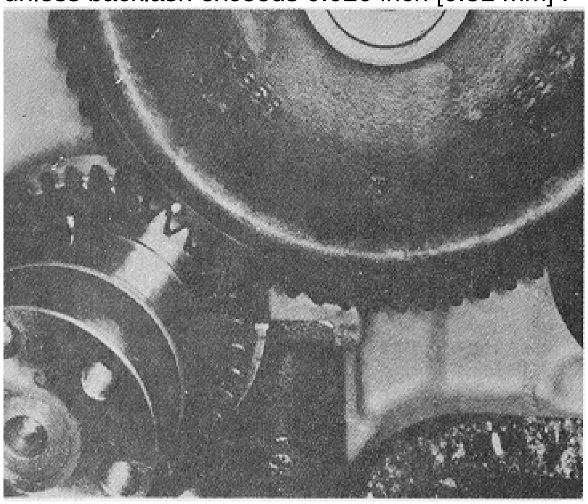


Fig. 14-3, (N114167). Timing marks on camshaft and crankshaft gear

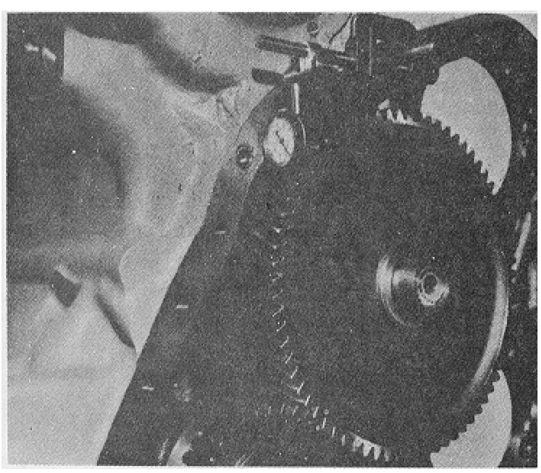


Fig. 14-4, (N11424). Checking gear backlash

Lubricating Oil Pipes

Coat new "O" ring with clean lubricating oil, position "O" ring in groove in oil pipe, install oil pipes in block.

Cylinder Heads

1. Plug breather hole on turbocharged engine heads with 1/8 inch [3.18 mm] pipe plug. Breather hole is located at top of head above intake air port.
2. Install gasket over dowels so word "TOP" on gasket is visible. Use gasket with standard (white) grommets (0.097 to 0.103 inch [3.8 to 4.1 mm] thick) if water holes are free of erosion. Use service (black) grommets (0.107 to 0.113 inch [4.2 to 4.4 mm] thick) if there is evidence of erosion. No grommet retainers are required.
3. Insert two guide studs in block and lower head into place on block.

Note: All turbocharged engines must use cylinder head capscrews that have letters NT forged on head. Do not intermix.

4. Lubricate entire cylinder head capscrew with rust preservative lubricant. Allow excess lubricant to drip from capscrew before installation.

Note: Rust preservative lubricants with 2 percent or higher sulfated ash content must be used.

5. Install washers and capscrews. Torque capscrews to 25 ft-lbs [3.5 kg ml in sequence shown in Fig. 145. Continue torquing in increments of 80 to 100 ft-lbs [11.1 to 13.8 kg m] to final torque of 280 to 300 ft-lbs [38.7 to 41.5 kgm] .

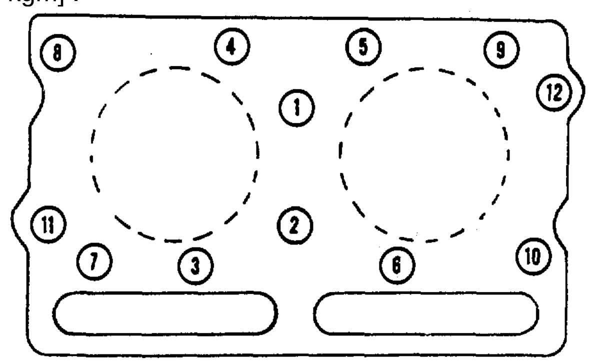


Fig. 14-5,(N11427). Cylinder head torquing sequence

Fuel Cross-Over

Install "0" rings in end of each cylinder head and cross-over, secure cross-over with springtite screws. Tighten with torque wrench and screwdriver adapter to 34 to 38 inch-lbs [0.4 to 0.5 kg m .

Compression Release Shaft

Install new "0" ring over shaft. Insert shaft into cylinder block and secure at rear end of block with copper washer and lockscrew. Coat expansion plug with sealant, install plug in counterbore at rear of block, until it seats.

Cam Followers And Push Tubes

1. Install cam follower gaskets. It may be necessary to add or remove gaskets to obtain correct injection timing.
2. Position cam follower assembly to block. Torque capscrews in sequence as shown in Fig. 14-6 in increment of 15 to 20 ft-lbs [2.1 to 2.8 kg m] to 30 to 35 ft-lbs [4.1 to 4.8 kg ml .

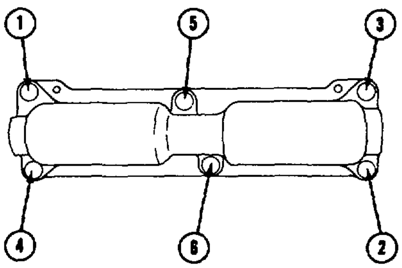


Fig. 146, (N114236). Cam follower torquing **sequence**

3. install push tubes. Injector push tube is largest and fits in middle socket. On engines equipped with compression release, exhaust push tube is equipped with collar to match with milled lift of compression release. On engines without compression release, intake and exhaust tubes are identical.

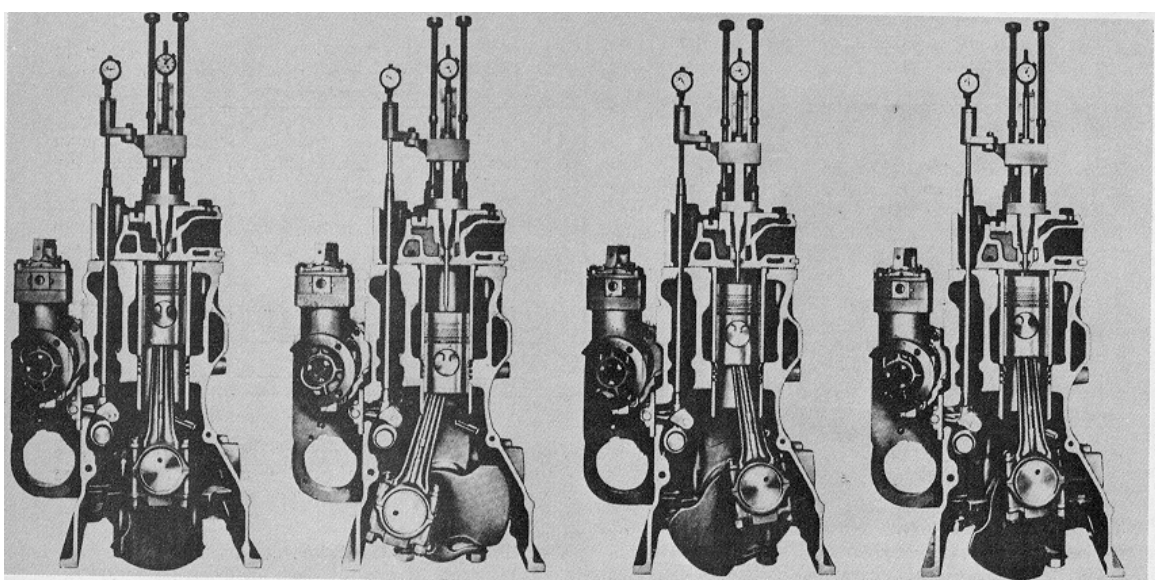
Timing The Engine

Use ST-593 to obtain precise timing of push tube travel with piston travel. The travel readings for engine model must be as listed in Table 14-3. Adjustments to timing are made by altering thickness of cam follower housing gaskets.

1. Position ST-593 Timing Tool in injector sleeve. Engage rod of push rod indicator in injector push tube socket. Secure tool in place by tightening knurled hold-downs evenly by hand. Be sure tool is straight in the cylinder. Fig.14-7.

Note: Each of the two dial indicators used in timing engine must have total travel of at least 0.250 inch [6.35 mml .

2. Loosen both indicator supports to prevent damage. Bar engine crankshaft to bring piston to top center. Position piston indicator to compress indicator stem to within 0.010 inch of inner travel stop. Carefully bar crankshaft to bring piston to exactly top center (1, Fig. 14-8). Zero the indicator dial at this point.



TOP CENTER — “O” Indicator Over Piston.

90 DEG. AFTER TOP CENTER — “O” Indicator Over Rod.

45 DEG. BEFORE TOP CENTER — Both Indicators Move In some Direction. If Not Bar Engine One Revolution For Proper Position.

19 DEG. BEFORE TOP CENTER — Both indicators retate Twice. Step 0.032 (0.2032 Before”O” On Indicator Over Piston. Read Push Rod Indicator.

Fig. 14-7, (FWC-34). Injection timing

Table 14-3: Injection Timing

Engine Model	Piston Travel (Inches)	Push Tube Travel (Inches) Nominal	Fast	Slow
NT-855-310 (All) NT-855 Series	-0.2032	-0.0360	-0.0340	-0.0380

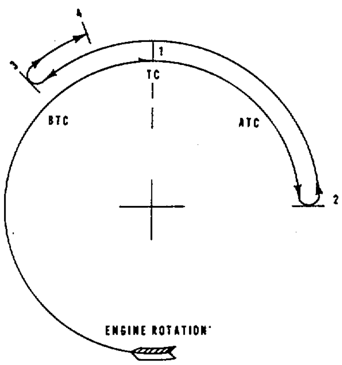


Fig. 148, (Ni1432). injection timing procedure

3. Bar crankshaft in rotating direction (2) until piston follower rod top is opposite 90 deg. ATC mark on timing tool. At this point, position push tube indicator on push rod follower to about 0.020 inch from its inner travel stop. Zero indicator dial at this point.
4. Bar crankshaft opposite rotating direction (3) to position piston follower rod at 45 deg. BTC.
Note: Both indicators move in same direction when cylinder is on proper stroke. If push tube indicator does not move same direction as piston indicator, bar crankshaft one complete revolution to place cylinder on compression stroke.
5. Bar crankshaft in direction of rotation until piston follower rod is almost in contact with indicator stem. Gently move crankshaft to position piston indicator to 0.0032 inch before 0. This position is actually 0.2032 inch before 0, since the indicator will have receded (hand will have gone around twice) over 0.200 inch as the crankshaft was moved to 45 deg. BTC. Since exact reading in ten-thousandths must be estimated, exercise care in bringing piston travel indicator to reading.
6. Read push tube travel indicator. It should read the number of thousandths before zero that is called for in Table 14-3. Notice that a range of about 0.004 inch is within specification.
Note: Never make a change in cam follower gaskets for timing purposes before making following checks:
a. Be sure cam follower housing capscrews are tightened to 30 to 35 ft-lbs [4.1 to 4.8 kg ml torque.
b. Recheck indicator positioning. Be sure indicators are not bottoming or binding.
c. Carefully recheck top center position. Be sure each step is carried out as described.
7. If push tube travel is greater than limits indicated in Table 14-3, engine timing is slow; if push tube travel is less, timing is fast. Injection timing may be advanced or retarded by adding or removing cam follower gaskets. Remove gasket on right hand engine to retard timing. Add gaskets on left hand engines to retard timing.
Note: If required, an extra-thick gasket should be used when needed instead of several thin gaskets.

Injectors

1. Lubricate the injector body "O" rings with light coat of clean lubricating oil.

2. Start the injector assembly into bore, from intake side of engine, injectors are to be placed with filter screen at twelve o’clock, guide by hand until injector is aligned.

3. Place ST-448 Valve Spring Compressor on top of injector plunger coupling and "seat" injector by giving a quick, hard push.

4. Place hold-down plate over injector body with counterbore up. Start hold-down capscrews. Do not tighten.

5. Carefully insert injector plunger link. Torque hold-down capscrews to 11 to 12 ft-lbs [1.5 to 1.7 kg ml in 4 ft-lb [0.6 kg m] increments.

Fuel Fittings And Lines Coat fuel fittings with sealer. Inlet and drain fittings may be installed either in front of No. 1 head or rear of No. 3 head as used. Connect tubing to appropriate fitting.

VALVE CROSSHEAD ADJUSTMENT

1. Position crossheads over guides with adjusting screw toward water manifold. Loosen adjusting screw locknut, back adjusting screw off one turn.

Note: Engines using Jacobs Brake use special crossheads on exhaust side of head. See Group 20.

2. Use light finger pressure at the rocker lever contact surface to hold crosshead in contact with.valve stem nearest the push tube. Turn adjusting screw down until it contacts its mating valve stem.

Note: With new crossheads and guides, advance adjusting screw one-third of one hex to straighten stem in its guide and to compensate for slack in threads. With worn crossheads and guides, it may be necessary to advance the screw as much as 1/2 of hex in order to straighten the stem in its guide.

3. Hold adjusting screw in position and torque locknut to 25 to 30 ft-lbs [3.5 to 4.1 kg m]; or, if ST-669 Torque Wrench Adapter is used, tighten to 22 to 26 ft-lbs [3.0 to 3.6 kg m].

4. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance.

Rocker Lever Housing

1. Position new rocker lever housing gasket on cylinder head.

2. Loosen locknuts and back off rocker lever adjusting screws two or three turns. Holding rocker levers in place, position housing on heads with ball ends of rocker levers fitting into their respective push tube sockets. Install lifting brackets and fan hub bracket support bell crank, if used.

3. Secure housing, brackets and support with capscrews. Torque in sequence, Fig. 14-9, to 55 to 65 ft-lbs [7.6 to 8.9 kg mi.

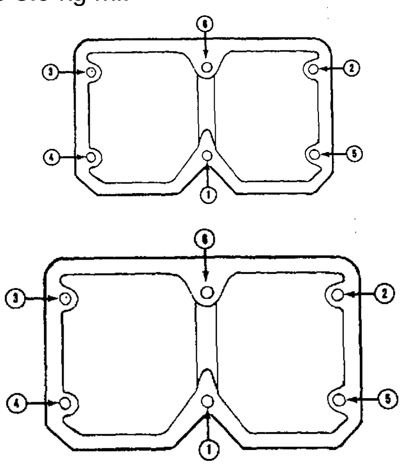


Fig. 14-9, (N11463). Rocker lever housing torquing sequence

Note: On 80 deg. tilt engines use ST-1182 Valve Spring Spray Nozzle Locator to check that oil spray nozzles are properly located.

Compression Release Lever

1. Install dowel in cylinder block if removed.

2. Position upper lever and bracket assembly to front rocker arm housing and secure.

3. Using screwdriver in slot in end of compression release shaft, turn shaft clockwise until lifting notch contacts a valve push tube collar, move compression release shaft lever to middle of travel; secure with clamping screw.

4. Secure spring on cylinder head with capscrew; hook spring in lever on compression release shaft. Attach link to lower and upper lever; secure with' cotter pins.

Fuel Pump/Compressor Drive/Accessory Drive

Bar 'engine to No. 1 cylinder, TDC position (firing stroke), continue rotating to 90 deg. ATC. In this position, the two center-punched marks on drive gear will mesh or index with two dash marks on camshaft gear. This timing. is required so external timing marks on accessory drive pulley will be properly aligned with timing mark on gear case to show valve and injector adjustment positions, keyway of drive shaft will be at top. Secure drive to cylinder block. Using a scrap gear case cover, fabricated as illustrated in Fig. 14-10, check accessory drive gear backlash.

1. Attach a dial indicator gauge to the block with plunger on accessory drive gear tooth. Fig. 14-10. Rotate gear as far as it will move to take up backlash, zero indicator.

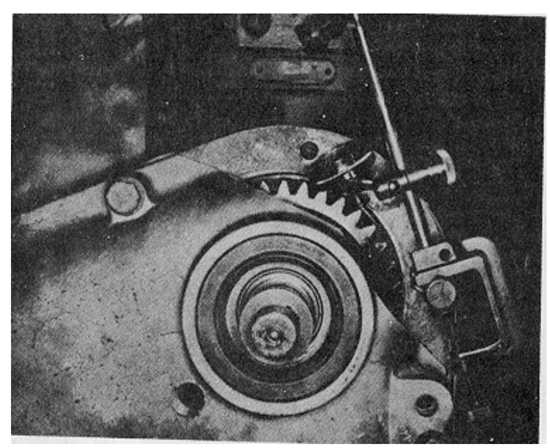


Fig. 14-10, (N114132). Checking accessory drive gear backlash

2. Rotate gear in opposite direction and read backlash on dial gauge. Backlash should be 0.0045 to 0.0105 inch [0.114 to 0.267 mm].

Air Compressor
For balance of engine and air compressor reciprocating force, the coupling driven air compressor must be timed to engine firing order.

1. Bar engine to "B" or "2-5" valve set mark.

2. Rotate air compressor crankshaft so male splined coupling half key-way will be pointing directly away from engine (3 o'clock position when looking at coupling end of compressor).

3. Assemble splined coupling to air compressor drive shaft.

4. With a new gasket in place, position air compressor coupling to accessory drive shaft; secure air compressor to accessory drive housing. Connect air and water lines to compressor.

Note: Bendix Westinghouse Tu-Flo 500 Compressor air intake may be plumbed to engine intake manifold,

5. Position and secure air compressor support bracket to block and air compressor.

Fuel Pump
1. Position and secure fuel pump to fuel pump drive or air compressor with new gasket and buffer or spline in place, use same part number as removed.

2. Install line from fuel pump shut-down valve to cylinder head fuel drilling connection previously installed.

Lubricating Oil Pump
1. Place lubricating oil pump gasket to gear case. Make certain oil passages are open.

2. Mesh drive gear teeth with camshaft gear as pump is installed. Secure pump.
3. Use same procedure to check pump gear backlash, Fig. 4-1 1, as used for checking accessory drive gear backlash.

Note: If power steering pump is driven by lubricating oil pump, position coupling to shaft, install power steering pump.

4. When used, secure oil filter can with new element and sealing "O" ring to lubricating oil pump by torquing center bolt to 25 to 35 ft-lb. [3.5 to 4.8 kg m] .

Intake Manifold Or Aftercooler
1. Install new gasket, flatwasher, lockwasher and capscrew at bottom of each intake manifold port. Lift manifold into place with slots over capscrews.
Note: Extra long capscrews are used to install aftercooler.

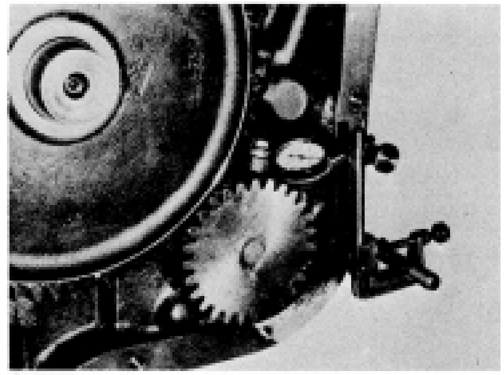


Fig. 14-11, (N114129). Checking lubricating oil pump gear backlash

2. Install remaining flatwashers, lockwashers and capscrews;
torque all capscrews to 20 to 25 ft. lbs. [2.8 to 3.5 kg mi.

3. Position and secure air inlet connection with new gasket on air intake manifold.

4. Using new hose and "O" ring, position water transfer tube assembly to aftercooler connection and block adapter, secure transfer tube connection using new "0" ring into block adapter with snap ring. Install new hose to aftercooler connection and transfer tube connection. Tighten hose clamps.

Aneroid Control
1. Secure aneroid control and bracket to fuel pump side of engine.
2. Install fuel pressure line from bottom of fuel pump (out-board fitting) to "IN" connection on aneroid control and fuel return line from "OUT" connection on aneroid control to fuel inlet connection.
3. Install air line and fittings, if removed, from top of aneroid to air intake manifold.

Fuel Filter Replaceable Element Type

1. Position and secure mounting bracket in desired location.
2. Check fittings in filter head for leaks, torque to 30 to 40 ft-lb. [4.1 to 5.5 kg mi.
3. Install filter head to mounting bracket; using a new gasket, assemble case and element. Torque center bolt to 20 to 25 ft-lb. [2.8 to 3.5 kg m] .
4. Connect fuel supply line between fuel filter and fuel pump.

Gear Case Cover

1. Shellac new gasket to gear case cover. Check current Parts Catalog for correct gear case cover and gear case cover
gasket part numbers.
2. Install gear cover in place over dowels. Torque capscrews to 45 to 50 ft-lb. [6.2 to 6.9 kg ml, trim off excess gasket material at pan flange mounting area.
3. Make sure that bottom surface of cover is within +0.004 inch [0.10 mm] of flush with oil pan surface of block. Fig.14-12.

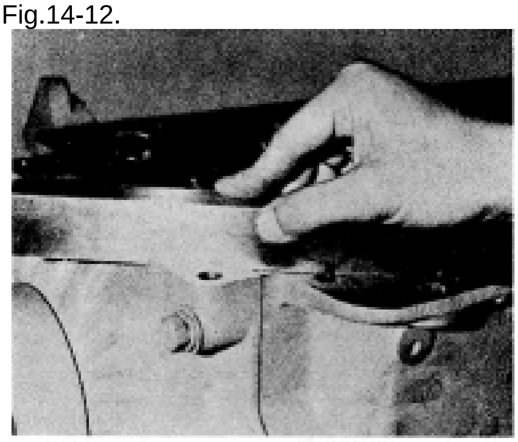


Fig. 14-12, (N114134). Checking gear case cover to block alignment

4. Install crankshaft oil seal and fuel pump compressor drive shaft oil seal.
a. Check concentricity of oil seal bore in relation to crankshaft. If total indicator reading exceeds 0.010 inch [0.25 mm] remove, clean and relocate gear cover.

b. Coat oil seal outside diameters and seal bore with lubricating oil. Install Teflon crankshaft seal with ST-1259 Seal Mandrel using ST-1260 Seal Pilot. ST-1172 Mandrel is used on tapered crankshaft. Install accessory drive seal in gear case cover with ST-1173 Mandrel and ST-386 Pulley Assembly Tool, ST-1173 Mandrel will insert seal to required depth.

c. Check clearance between seal and shoulder on gear case cover bore, if so equipped. Minimum clearance is 0.030 inch [0.76 mm]. Seal must not bottom on shoulder of bore.

d, Front face of oil seal must be square with crankshaft axis within 0.010 inch [0.25 mm] total indicator reading.

5. Install camshaft thrust plate or support bearing.

a. Remove "O" ring seal and spacers. Push plate or support against camshaft so camshaft rests against thrust washers. Measure dimension between thrust plate and gear case cover with feeler gauge.
b. Using micrometer, select enough spacers to provide 0.001 to 0.005 inch [0.03 to 0.13 mm] camshaft end clearance for engines with camshaft thrust plate, 0.008 to 0.013 inch [0.20 to 0.33 mm] for engines with camshaft outboard bearing support.

c. Install spacers and "0" ring seal; secure thrust plate to gear case cover.

Rear Cover Plate And Oil Seal

1. Clean crankshaft sleeve or seal area with crocus cloth and coat area with clean lubricating oil.

Note: If wear sleeve is required, refer to Parts Catalog for correct seal and sleeve combination.

2. Insert wear sleeve, if used, in ST-997 Seal and Sleeve Driver with beveled end of sleeve facing sleeve driver; drive sleeve on crankshaft until sleeve driver bottoms on end of crankshaft.
3. Install rear cover and gasket to cylinder block. Tighten capscrews finger tight so rear cover plate will move for alignment and position sleeve driver over end of crankshaft, rear cover plate should pilot over tool.
4. Tighten so cover can be shifted. Remove sleeve driver and mount indicator on crankshaft with point on cover trunnion. Rear cover must be aligned within 0.005 inch [0.13 mm] total indicator runout. Fig. 14-13. Tighten cover capscrews to 24 to 29 ft-lb. [3.3 to 4.0 kg m] and trim off excess gasket material.
5. Install and tighten two ST-997-6 Buttons into the two threaded holes inside of ST-997 Seal Driver. Position correct seal in rear cover plate bore and drive in until buttons bottom.
6. Use ST-1263 Seal Pilot when using Teflon oil seal.

Note: Clearance on inside diameter of some 101092 or 123982 Rear Cover Plates and 151621 Oil Seal Retainer may not be sufficient to allow plates to slide over wear sleeve, if not, grind 0.015 to 0.030 inch [0.38 to 0.76 mm] from inside diameter of rear cover plate seal stop lip.

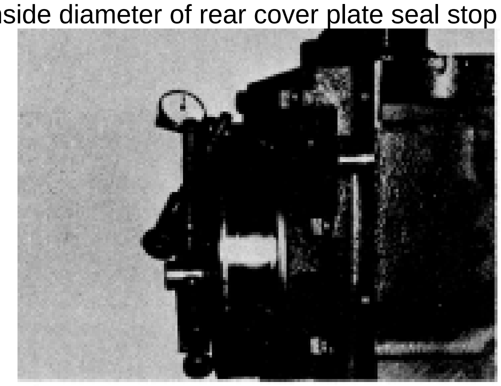


Table 14-4: Flywheel Housing Specifications Inch [mm]

SAE No.	Bore Diameter (For Reference Only)	True Location Tolerance		Face Run Out Tolerance	
00	31.000 to 31.010 [787.40 to 787.65 mm]	.012 [0.30 mm]	TIR	.012 [0.30 mm]	TIR
0	25.500 to 25.510 [647.70 to 647.95 mm]	.010 [0.25 mm]	TIR	.010 [0.25 mm]	TIR
1/2	23.000 to 23.008 [584.00 to 584.20 mm]	.010 [0.25 mm]	TIR	.010 [0.25 mm]	TIR
1	20.125 to 20.130 [534.27 to 534.40 mm]	.008 [0.20 mm]	TIR	.008 [0.20 mm]	TIR
2	17.625 to 17.630 [447.68 to 447.80 mm]	.008 [0.20 mm]	TIR	.008 [0.20 mm]	TIR
3	16.125 to 16,130 [409.58 to 409.70 mm]	.008 [0.20 mm]	TIR	.008 [0.20 mm]	TIR
4	14,250 to 14.255 [361.95 to 362.08 mm]	.006 [0.05 mm]	TIR.	.006 [0.05mm]	TIR
5	12.375 to 12.380 [314.33to 314.45 mm]	.006 [6.05 mm]	TIR	.006.[0.05 mm]	TIR
6	10.500 to 10.505 [266.70 to 266.83 mm]	.006 [0.05 mm]	TIR	.006 [0.05 mm]	TIR

Flywheel Housing

1. Clean mating surface of flywheel housing to block and install new cork camshaft bore gaskets in flywheel housing with gasket cement. Allow sufficient time for drying.
Gasket slippage will allow oil to leak from rear of camshaft bore.

2. If new flywheel housing is being installed, or if dowels are worn, sheared or loose, remove dowels from block.
Snug housing to block with lockwashers and capscrews.

INDICATE FLYWHEEL HOUSING BORE

1. Draw chalk marks at 12, 6, 9 and 3 o'clock. Attach ST-112 and a dial gauge to crankshaft flange. Fig. 14-14.

2. Check readings at 9 and 3 o'clock. If run-out exceeds specifications in Table 14-4, move housing one-half of distance to center horizontally.

3. Check readings at 12 and 6 o'clock. If run-out exceeds specifications, move housing to center vertically.

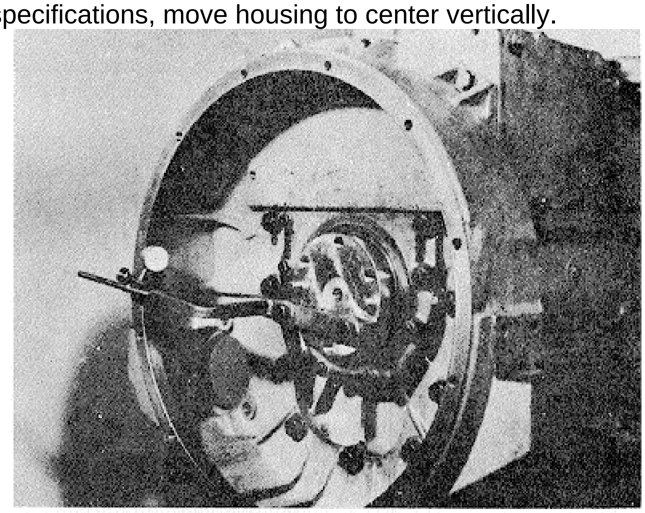


Fig. 14-14, (N 11447). Indicating flywheel housing bore

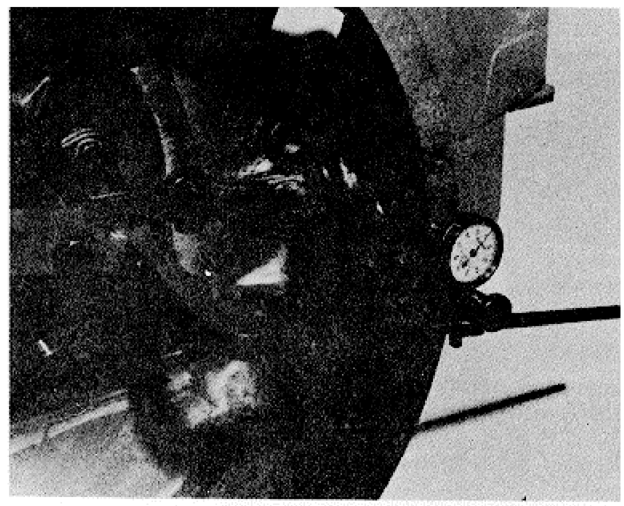


Fig. 14-15, (N11448). Indicating flywheel housing face

INDICATE FLYWHEEL HOUSING FACE

1. Attach ST-112 and a dial gauge as shown in Fig. 14-15.

2. Push crankshaft forward to take up end clearance and turn crankshaft to obtain readings on housing face. Take up crankshaft end clearance in same direction each time.

3. Total flywheel housing tape run out must exceed specifications in Table.14.4.

4. If both bore and face run-out *readings* are *within limits* and dowels were removed, ream dowel holes to smallest permissible oversize with ST-406 Drill Ream Fixture.

5. If necessary to correct for housing face run-out after the bore has been aligned, remove housing and recheck mating surfaces. Then reinstall, realign and dowel. After readings are within limits, tighten capscrews alternately and evenly to 150 ft-lb. [20.7 kg m] .

Oil Pan

With Body-Fit Bolts

1. Two oil pan capscrew holes at flywheel end of block are reamed for body-fit bolts. If not previously installed, install bolts in block.

2. Shellac new oil pan gasket to cylinder block.

a. When using new "tab-lock" gasket; paint oil pan flange with a non-hardening gasket compound. Allow gasket compound to dry. Start at either end of oil pan, lay gasket sections on oil pan flange. Proper assembly is assured by matching letters located on end of each gasket section.

b. Insert several capscrews through gasket and oil pan flange capscrew holes to line up. When gasket sealing compound dries, remove guide capscrews.

3. Check oil pan screen to make certain that it is properly assembled and that all screws are tight.

4. Assemble pan to block with nuts, lockwashers and capscrews. On aluminum oil pans, install flat steel washers between pan and lockwashers.

5. If new pan is being installed prior to installing flywheel housing:

a. Position so buttress-end of pan is flush with end of block. Check with straight-edge. Fig. 14-16.

b. Ream holes to next oversize and install oversize body-fit bolts.

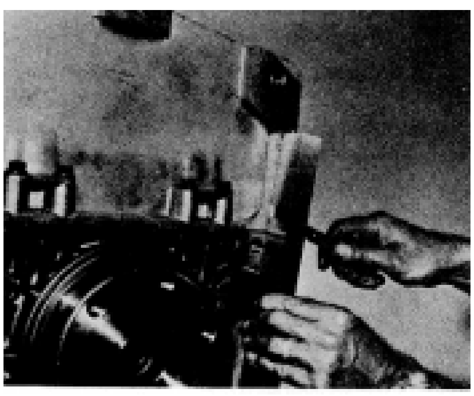


Fig. 14-16, (N114136). Checking oil pan to block alignment

Less Body-Fit Bolts

Oil pan currently used on 80 deg. tilt engines have bosses drilled to accommodate oil gauge and filler bracket, alternator mounting bracket and' lifting eyes. Brackets, lifting eyes and spacers, as used, should be installed during oil pan installation.

Note: Flywheel housing must be on engine.

1. Install guide studs in oil pan flange of block.
2. Shellac new oil pan gasket to oil pan flange of block.
3. Position oil pan over guide studs and start oil pan flange capscrews, flatwashers and lockwashers by hand.
4. Install and tighten middle buttress to flywheel housing capscrews with washers on both sides of oil pan. This pulls pan tight and square with flywheel housing.
5. Lock pan in position by tightening two (2) center capscrews on each side of block.
6. Loosen and remove buttress capscrews assembled and tightened in Step 4. (Capscrews must be removed to provide socket clearance to buttress corner capscrews.)
7.. Tighten two (2) rear corner pan flange to block capscrews. This pulls the block and pan flanges together and ensures that pan is pulled firmly into corner by housing and block. Remove guide studs.
8. Insert and tighten all capscrews from 28 to 40 ft-lb. [3.8 to 5.5 kg m] torque.
9. Insert pan to rear cover plate flatwashers, lockwashers and capscrews; tighten to 15 to 20 ft-lb. [2.1 to 2.8 kg m] torque.

Oil Suction Tube

1. Assemble tube nuts and rubber sleeves lubricated with clean engine lubricating oil, to suction tube. Start nuts on oil pump adapter and oil pan flange, do not tighten.
2. Position oil pan flange with new gasket to oil pan. Do not tighten capscrews.
3. Push tube and sleeve into oil pump adapter until it bottoms and tighten nut 1 to 1-1/4 turn from finger tight.
4. Tighten tube nut on oil pan suction flange finger tight.

Torque suction flange to oil pan capscrews to 30 to 35 ft-lb. (4.1 to 4.8 kg m]. Tighten tube nut against stop on suction flange.

Crankshaft Flange And Vibration Damper

Lapping

Each time the crankshaft flange or pulley is removed or replaced, it must be lapped to the crankshaft to provide maximum contact area between mating parts.

1. Insure that all mating surfaces are free of burrs, nicks and fretting. Do not attempt lapping until all Imperfections have been removed.
2. Inspect flange with a magnetic particle process for cracks or inclusions.

3. Coat inside diameter of flange with Grade A (280 grit) lapping compound and lap by turning flange one-fourth (1/4) to one-half (1/2) turn each way, until both crank nose and flange inside diameter are mated.

4. Clean all compound from flange and crankshaft nose; allow no compound to reach seal or enter engine.

Contact Check

1. Apply a light even coat of Prussian Blue on nose of crankshaft. Hold flange or pulley perpendicular to centerline of crankshaft and position on nose, turn flange one-eighth (1/8) turn and pull straight off.
2. Contact area should be 100% for a distance of 1/2 inch [12.70 mm] at large diameter of crank nose, remainder of taper must have 70% to 100% of bluing contact.
3. Clean all Prussian Blue from the crank nose and flange.

INSTALLATION

CAUTION

Lubricate crankshaft nose in flange area with SAE 30 rust preservative lubricant with 2 percent or higher sulfated ash content DO NOT use lubricant when cast iron flanges 115562, 115563, 175183 or 175185 are used.

1. Install crankshaft flange over end of crankshaft. Center line of key-way in flange and key-way in crankshaft should be aligned within plus or minus 1/8 inch [3.18 mm] .

2. Install retainer and capscrew, check current Parts Catalog for correct capscrew and retainer, torque to specifications listed in Table 14-1
3. With dial gauge mounted to gear case cover, check crankshaft flange eccentricity and wobble. Eccentricity must not exceed 0.004 inch [0.10 mm] total indicator reading; wobble must not exceed 0.003 inch [0.08 mm] measured at 2-3/4 inch [69.85 mm] radius. Fig. 14-20.

4. Install vibration damper to crankshaft flange with lockplates and capscrews. Torque to 60 ft-lb. [8.3 kg m] and lock in place.

5. Position a dial gauge to gear case cover and rest arm on outer machined surface at point (A, Fig. 14-21) to check eccentricity and at point (B) on inner machined surface of outer member to check wobble. Run-out must not exceed 0.0025 inch [0.064 mm] per one (1) inch radius of damper (as measured from center of damper). Crankshaft must be kept at front or rear limit of thrust clearance while wobble is being checked. See Vibration Damper.

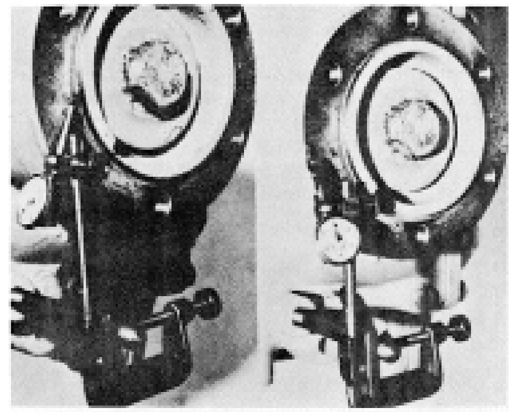
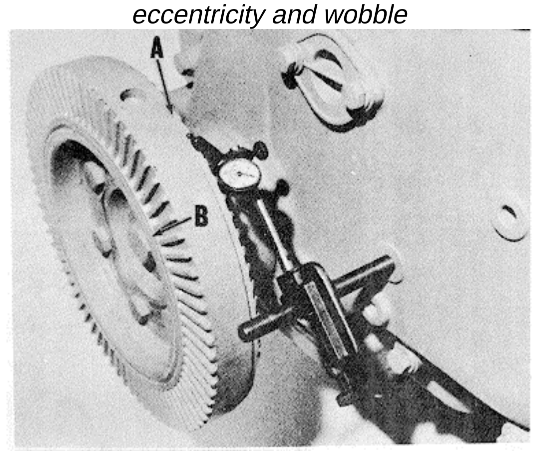


Fig. 1420, (N114156). Checking crankshaft flange eccentricity and wobble



A. Outer Machined Surface
B. Inner Machined Surface
Fig. 14-21, (N114140). Checking vibration damper run-out

Vibration Damper And Pulley

1. Position front engine support to block, if used, maintain a minimum of 1/32 inch [0.79 mm] clearance between support and gear case cover. Tighten capscrews to 55 ft-lb. [7.6 kg m] torque.

CAUTION

Do not use any lubricant on pulley or crankshaft mating surfaces. Wipe with clean dry cloth.

2. Align capscrew holes and install pulley and vibration damper assembly to crankshaft, tap into position with soft hammer. Coat capscrews with clean lubricating oil, secure pulley and damper assembly to crankshaft torque to 85 ft-lb. [11.8 kg m].

Note: Check capscrew marking, if ’1/2 inch Grade 8 capscrews are used tighten capscrews to 115 to 125 ft-lb. [15.9 to 17.3 kg m] torque. If 5/8 inch Grade capscrews are used tighten to 210 to 240 ft-lb. [29.0 to 34.0 kg m] torque. See Capscrew Markings and Torque Values,

3. If vibration damper was removed from pulley, wipe mating surface of damper and pulley clean, position damper to pulley, install and torque capscrews to 85 ft-lb. [11.8 kg mi.

4. Check damper for eccentricity and wobble as described in Step 5 preceding.

Accessory Drive Pulley

Note: Remove pipe plug in gear cover, check to make sure timing marks are lined up, Fig. 14-22. Replace pipe plug.

1. Install oil slinger over accessory drive shaft, with key and keyway seal, if used, on accessory drive shaft. Lubricate shaft with clean lubricating oil, start accessory drive pulley over shaft and key; use ST-386 to position pulley on shaft.

2. Remove ST-386; install flatwasher and pulley nut. Torque nut to 90 to 110 ft-lb. [12.4 to 15.2 kg ml]

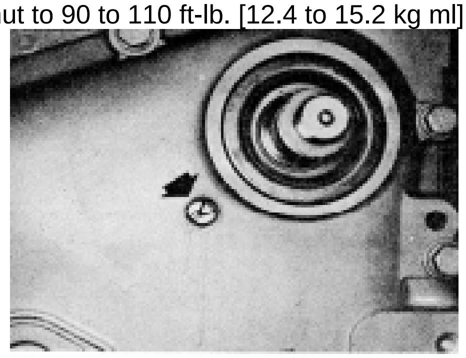


Fig. 14-22, (N114143). Camshaft and accessory drive gear timing marks

Water Pump And Idler

1. Using new gasket, position water pump and idler assembly to block. Torque as follows.

a. Torque in rotation to 10 ft-lb. [1.4 kg m .

b. Repeat rotation torque to 20 ft-lb. [2.8 kg m .

c. Final torque in rotation to 30 ft-lb. [4.1 kg m] .

2. Position belts over water pump, idler and accessory drive pulleys. Tighten idler adjusting screw to obtain, 120 to 140 lb. belt tension using ST-968 or ST-1274 Belt Tension Gauge.
3. Secure idler shaft to bracket with flatwasher and locking nut. Tighten to 50 ft-lb. [6.9 kg ml torque. Back off adjusting screw 1/2 turn.
4. If not previously installed, position fan hub assembly to mounting bracket. Tighten capscrews finger tight.
5. Position and secure fan hub assembly and bracket to water pump housing.
6. Secure fan bracket support to fan bracket and install adjusting screw and hardened washer (if used).
7. Position belts over fan hub pulley and accessory drive pulley, tighten fan hub adjusting screw to obtain 90 to 110 lb. belt tension using ST-968 or ST-1138 Belt Tension Gauge.
8. Secure fan hub assembly to fan mounting bracket, torque capscrews to 50 ft-lb. [6.9 kg m] .

Fan Hub And Pulley

1. Assemble fan pulley to fan bracket, if not previously installed. Position flatwasher and locking nut on shaft. Start nut on thread, do not tighten.

2. Avoid stretching belts, loosen adjusting screw, position belts over fan hub and drive pulleys.

3. Tighten adjusting screw to obtain proper tension of drive belts. See Table 14-5.

Table 14-5: Belt Tension Inch [mm]

Belt Width		Deflection Per Ft. [0.3 m] of Span	
1/2	[12.70]	13/32	[10.14]
11/16	[17.46]	13/32	[10.14]
3/4	[19.05]	7/16	[11.11]
7/8	[22.23]	1/2	[12.70]
1	[25.40]	9/16	[14.29]

4. Torque fan hub shaft-to-bracket nut to 400 to 450 ft-lb. [55.3 to 62.2 kg m]. Do not overtighten. Back off adjusting screw 1/2 turn.
5. As an alternate method, tighten nut hand tight; rotate 75 deg., mark bracket in line with corner of nut and turn one full hex or 60 to 70 deg.

Oil Spray Nozzles

1. Lubricate new "0" rings with clean lubricating oil and position on nozzle using ST-835 "O" Ring Loader. Be sure "O" rings are not twisted in groove.

2. Insert nozzles in block and secure. Using a screwdriver adapter torque slotted screw to 5 to 8 ft. lb. [0.7 to 1.1 kg m] . Torque Hex Head capscrews to 16 to 21 ft. lb. [2.2 to 2.9 kg mi.

Note: Identification numbers stamped on the mounting flange of oil spray nozzles are: No. 5 FFC Series Engines, No. 1 all others.

Remove Engine From Stand

1. Attach lifting arrangement and remove engine from stand; mount front and rear supports to engine.
2. Remove engine stand support plates from water header and replace with proper gaskets and cover plates.

Oil Gauge Bracket

Install oil bayonet gauge bracket, using new gaskets.

Water Manifold And Thermostat Housing

1. With "O" ring on water manifold connection, slip connection into manifold. Grease new water manifold and thermostat housing sealing rings and place rings in cylinder heads; position and secure water manifolds to cylinder head.
2. Position and secure assembled thermostat housing to front section of water manifold and install water crossover, if used.

Exhaust Manifold

1. Assemble sections of exhaust manifold and install new steel exhaust manifold gaskets. Side of gasket marked "OUT" must be installed outward or next to manifold.
2. Coat capscrew threads with anti-seize compound. On turbocharged engines, if heat shield is used, install special capscrews with threaded heads. These capscrews are used to mount both heat shield and manifold.
3. Torque mounting capscrews to 25 ft-lb. [3.5 kg m] Bend lockplate tangs up against capscrew heads. When washers or lockplates are not used, increase torque to 40 ft-lb. [5.5 kg m] and install heat shield if used.

Thermostat Housing By-Pass Connection

Water Pump Mounted Oil Filter Remove by-pass connection from thermostat housing, insert transfer tube into oil filter housing. Position and secure by-pass connection to thermostat housing.

Compressor Water Lines

Install water supply and drain lines to compressor, cylinder block and water by-pass connections. Tighten just enough to bring brass sleeves snugly against nuts; this will compress rubber grommets and provide a positive seal.

Lubricating Oil Cooler/Filter

1. Install water pump to thermostat housing by-pass tube. Secure with hose clamps.
2. Install water inlet support bracket to cylinder block. Start capscrews with lockwasher into block, do not tighten. Position water inlet assembly to water pump and support bracket. Torque water inlet to water pump capscrews to 30 ft-lb. [4.1 kg m].
3. Tighten support bracket to block and bracket to inlet housing capscrews. Install water header cover plate.
4. Coat "O" rings with clean lubricating oil, position on water transfer tube. Be sure "O" rings are not twisted. Position water transfer tube in water header cover.
5. Install oil cooler to block bracket. Do not tighten capscrew. Position oil cooler assembly to block and transfer tube. Torque cooler support, bracket to housing, and bracket to block capscrews to 30 ft-lb. [4.1 kg ml . Install water return to thermostat housing tube (FFC Series).
6. Using new sealing "O" ring and filter element, position oil filter can to oil cooler housing. Torque center bolt to 25 to 35 ft-lb. [3.5 to 4.8 kg m] .

Generator Or Alternator

1. Secure generator or alternator mounting bracket to cylinder block. Position hardened steel washers or spacers as needed between alternator or generator and mounting bracket.

Note: Do not use lockwashers or sott steel washers when securing generator or alternator to bracket or adjusting link.

2. Check capscrew size and torque mounting capscrews to values in Table 14-6.

Table 14-6: Torque Values (To Bracket)

Nominal Bolt Size Inch	Torque Ft-Lb [Kg ml	
3/8	29 to 31	[4.0 to 4.3]
7/16	63 to 65	[8.7 to 9.0]
1/2	77 to 80	[10.6 to 11.1]

3. Position adjusting link to alternator or generator termination point. Install capscrew and hardened washer securing adjusting link to alternator, do not tighten. Install belt(s), pry unit away from block to tighten belt(s) to operation tension. Torque capscrews to values in Table 14-7.

Table 14-7: Torque Value (To Adjusting Link)

Nominal Bolt Size Inch	Torque Ft-Lb [Kg ml	
5/16	15 to 19	[2.1 to 2.6]
7/16	25 to 30	[3.5 to 4.1]
1/2	50 to 55	[6.9 to 7.6]

Note: If generator or alternator pulley has been removed or a new pulley is installed, use hardened steel washer and locknut. Torque to values in Table 14-8.

Table 148: Torque Values (Pulley to Alternator or Generator)

Nominal Thread Size Inch	Torque Ft-Lb [Kg m]	
1/2	50 to 60	[6.9 to 8.3]
5/8	55 to 65	[7.6 to 9.0]
3/4	90 to 100	[12.4 to 13.8]

Note: Exception to the above limits are:

Delco-Remy Alternators	Torque Ft-Lb [Kg *ml*	
1 0 DN 150		
25 SI	70 to 80	[9.7 to 11.1]

Belt Tension

1. Installation:
2.

a. When two or more identical belts are used on the same drive, they must be replaced as a matched set.

b. Shorten distance between pulley centers and install belt(s). Do not roll or pry belt over pulley.

c. Pulley misalignment must not exceed 1/16 inch [1.59 mm] for each foot [304.8 mm] of distance between pulley centers.

d. Belts should not bottom on pulley grooves, nor should they protrude over 3/32 inch [2.38 mm] above top edge of groove.

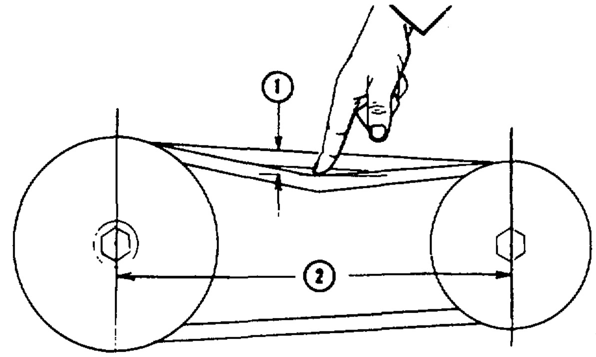
e. Belt riding depth should not vary over 1/16 inch [1.59 mm] on matched belt sets.

f. Do not allow belts to rub against any adjacent part.

2. Adjusting:

a. Use ST-968 for 3/8 to 1/2 inch [9.53 to 12.70 mm] width belts. Use ST-1138 for 11/16 to 7/8 inch [17.46 to 22.23 mm] width belts.

b. When belts are installed, tighten until a reading of 90 to 110 lb. force is obtained. New belts will loosen after running for an hour or more and may require re-adjustment. Recheck belt tension and re-adjust to 90 to 110 lbs. if reading is less than 80 lbs.
c. As an alternate method, tighten belts so pressure of index finger extended straight down, Fig. 14-24 will depress belt to the value shown in Table 14-5. Force applied (1) will be approximately 13 lb. [5.9 kg] for each foot [0.30 ml of free span (2).



1. Belt Deflection
2. Belt Free Span

Fig. 14-24, (N11471). Checking belt tension manually

ADJUST INJECTORS, CROSSHEADS AND VALVES

Before adjusting injectors and valves be sure to determine if rocker housings are cast iron or aluminum and use appropriate setting.

Two methods of adjusting injectors and valves are described in this manual. The preferred method is Uniform Plunger Travel. This method involves adjusting plunger with ST-1270 Injector Indicator Kit (consists of ST-1170 Dial Indicator, ST-1 193 Actuator and ST-1251 Actuator) to a specified travel. The second method involves setting plunger adjusting screw to a specified torque setting. It is essential that injectors and valves be in correct adjustment at all times.

Injector "Plunger Free Travel," as described below, must be checked before adjustments are made.

Check Plunger Free Travel
In order to prevent excessive loading of injector actuating train and possible failure, check as follows:

1. Back injector adjusting screw out 1-1/2 turns from normal operating position, tighten locknut.

2. With ST-1170 Dial Indicator extension on injector plunger top, bar engine and record total amount of each plunger travel. This is called "Plunger Free Travel" and MUST NOT exceed 0.206 inch [5.23 mm] on any one (1) cylinder of engine.

3. On engines with plunger Free Travel exceeding 0.206 inch [5.23 mm] the Torque Method of adjustment must be used unless component changes (rocker levers and/or cam followers) are made which will allow 0.206 inch [5.23 mm] limit of Free Travel to be obtained.

Temperature Settings

The following temperature conditions provide the necessary stabilization of engine components to assure accurate adjustments.

Cold Setting

Engine must have reached a stabilized temperature (oil and/or component temperature to be within 10 deg. F of ambient air temperature).

Note: At rebuild period this setting is obtained through normal room temperature.

Hot Setting

1. Set injectors and valves immediately after the engine has reached normal stabilized operating oil temperature.

2. If oil temperature gauge is unavailable, set injectors and valves immediately after engine has operated at rated speed and load or at high idle for a period of 40 minutes. If slotted thread adjusting screws are used, 20 minutes is sufficient.

Adjustment After Engine Rebuild

During rebuild, adjust injectors and valves using appropriate values in the "Cold Set" column. The engine must then run until normal oil operating temperature has been obtained to allow stability of structural components as affected by gasket replacements. Recheck injectors and valves. See Engine Test Procedure, Phase 4,

INJECTOR AND VALVE ADJUSTMENT
DIAL INDICATOR METHOD USING ST-1170

1. If used, pull compression release lever back and block in open position while barring engine, this allows crankshaft to be rotated without working against compression.

2. Bar engine until "A" or 1-6 "VS" mark on pulley, Fig's.14-25 and 14-26, is aligned with pointer on gear case cover. Remove block from compression release. In this position, both valve rocker levers for cylinder No. 5 must be free (valves closed). Injector plunger for cylinder No. 3 must be at top of travel; if not, bar engine 360 deg., realign marks with pointer.

3. Turn adjusting screw down on cylinder being adjusted until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup. Loosen adjusting screw two full turns.

4. Set up ST-1170 Indicator Support with indicator extension on injector plunger top at No. 3 cylinder, Fig. 14-27. Make sure indicator extension is secure in indicator stem and not against rocker lever,

Note: Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only. Any cylinder combination may be used as a starting point, see Table 14-9 and firing order Table 14-10.

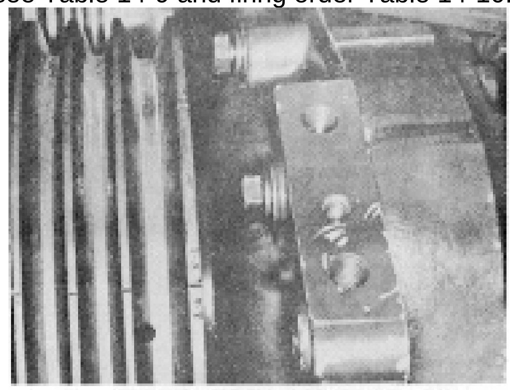


Fig. 14-25, (N114220). Valve set timing mark

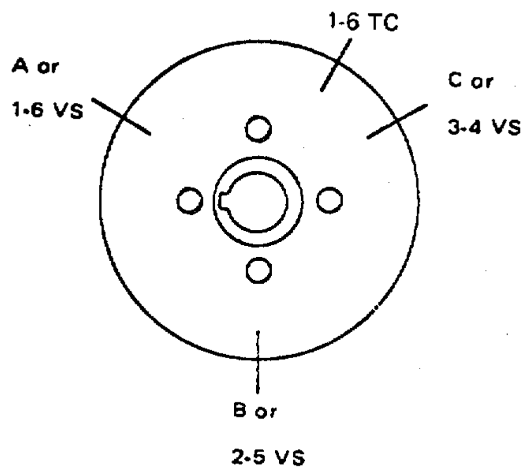


Fig. 14-26, (N114230). Accessory drive pulley markings

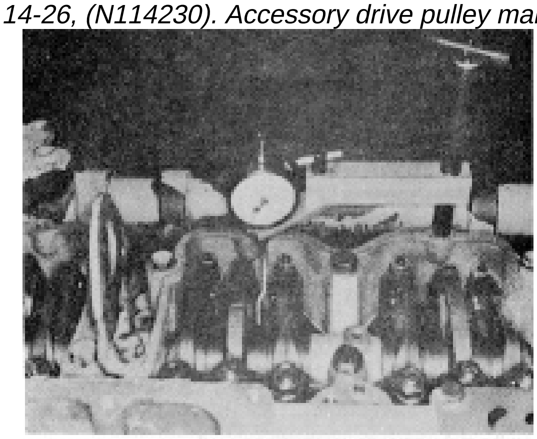


Fig. 14-27, (N I14231). Dial indicator in place - extension contact with plunger

Table 14-9: Injector and Valve Set Position

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A or 1-6VS	3	5
Adv. To	B or 2-5VS	6	3
Adv. To	C or 3-4VS	2	6
Adv. To	A or 1-6VS	4	2
Adv. To	B or 2-5VS	1	4
Adv. To	C or 3-4VS	5	1

Table 14-10: Engine Firing Order - Inline

Right Hand Rotation	Left Hand Rotation
1-5-3-6-2-4	14-2-6-3-5

5. Using ST-1193 Rocker Lever Actuator, Fig. 14-28, or equivalent, bar lever toward injector until plunger is bottomed. Allow injector plunger to rise, bottom again, set indicator at zero (0). Check extension contact with plunger top, turn adjusting screw until Adjustment Value, Table 14-11 is obtained.

6. Bottom plunger again, release lever; indicator must show travel as indicated.

7. Tighten locknut to 30 to 40 ft-lb. [4.1 to 5.5 kg m] and actuate injector plunger several times as a check of adjustment. Tighten to 25 to 35 ft-lb. [3.5 to 4.8 kg m] when using ST-669 Adapter.

Table 14-11: Uniform Plunger Travel Adjustment Limits

Oil Temp.	Injector Plunger Travel Inch [mm] Adj. Value	Recheck Limit	Valve Clearance Inch [mm] Intake	Exhaust
Aluminum Rocker Housing				
Cold	0.170 [4.32]	0.169 to 0.171 [4.29 to 4.34]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 [4.32]	0.169 to 0.171 [4.29 to 4.34]	0.008 (0.201	0.023 [0.58]
Cast Iron Rocker Housing				
Cold	0.175 4.45]	0.174 to 0.176 [4.42 to 4.471	0.011 (0.281	0.023 [[0.58]
Hot	0.175 [4.45]	0.174 to 0. 176 [4.42 to 4.47]	0.008 10.20]	0.023 [0.58]

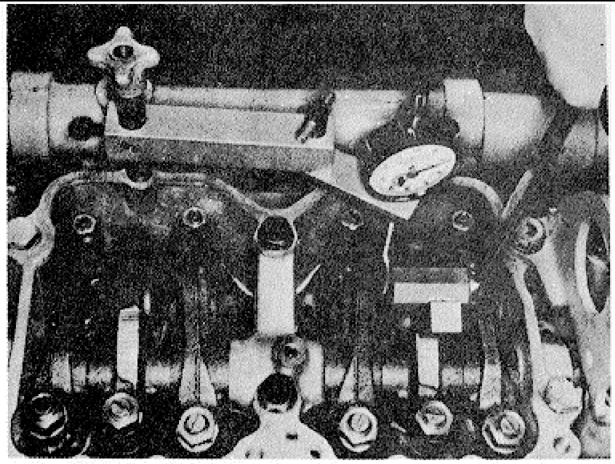
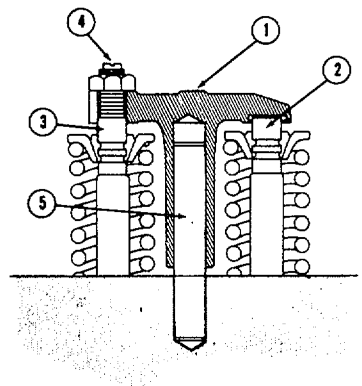


Fig. 14-28 (N114237), Bottoming Injector plunger in cup

Crosshead Adjustment

1. Loosen valve crosshead adjusting screw locknut and back off adjusting screw, Fig. 14-29, one turn.



1. Crosshead
2. Valve Stem
3. Valve Stem
4. Adjusting Screw
5. Crosshead Guide

Fig. 14-29, (N21461). Valve croshead

2. Use light finger pressure at rocker lever contact surface(1) to hold in contact with valve stem (2). Turn down adjusting screw until it touches valve stem (3).

3. Advance setscrew an additional 20 to 30 deg. to straighten stem on its guide. Using ST-669 Torque Wrench Adapter, tighten locknuts to 22 to 26 ft-lb. [3 to 3.6 kg m] . If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25 to 30 ft-lb. [3.5 to 4.1 kg m].

4. Check clearance between crosshead and valve spring retainer with wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance.

Valve Adjustment

The same engine position (VS Mark) used to adjust injectors is used for setting intake and exhaust valves, however, the valves to be adjusted are not the same cylinder as injectors. In this position adjust valves for cylinder No. 5. See Table 14-9.

1. While adjusting valves, make sure compression release, on those engines so equipped, is in running position.

2. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and crosshead. Valve clearances are shown in Table 14-11. Turn screw down until lever just touches gauge and lock in this position. Tighten locknut to 30 to 40 ft-lb. [4.1 to 5.5 kg m] torque. When using ST-669, torque to 25 to 35 ft-lb. [3.5 to 4.8 kg m]

3. Always make valve adjustment after injector adjustment. Move to next cylinder as indicated in Table 14-9 and repeat adjustments.

ADJUST INJECTORS AND VALVES (TORQUE METHOD)

1. If used, pull compression release lever back and block in open position while barring engine, this allows crankshaft to be rotated without working against compression.

2. Loosen the injector rocker lever adjusting nut on all cylinders. This will aid in distinguishing between cylinders adjusted and not adjusted.

3. Bar engine in direction of rotation until a valve set mark (Fig's. 14-25 and 14-26) aligns with the boss on the gear case cover. Example: A or 1-6 "VS."

4. Check the valve rocker levers on the two cylinders aligned as indicated on pulley (Example: 1 and 6 cylinders for A or 1-6 "VS"). On one cylinder of the pair, both rocker levers will be free and valves closed, this is cylinder to be adjusted.

5. Adjust injector plunger first, then crossheads and valves to clearances indicated in the following paragraphs.

Injector Plunger Adjustment - Torque Method

The injector plungers are adjusted with a torque wrench and a screwdriver adapter to a definite torque setting. **See** Fig. 14-30.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.

2. Loosen adjusting screw one turn; then, tighten adjusting screw making two or three passes with torque wrench, to values shown in Table 14-12.

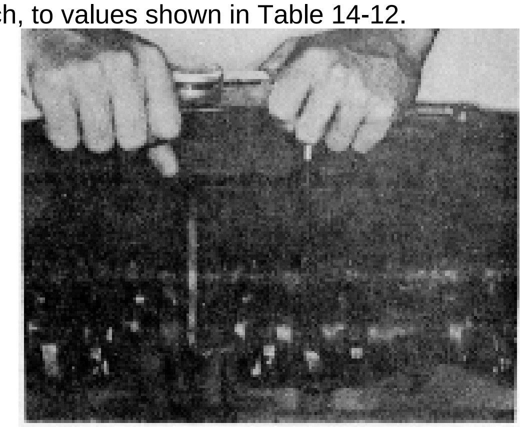


Fig. 14-30, (N1 1466). Adjusting injector plunger

Note: Set ST-753-1 Torque Wrench on value required and pull to "O". Break adjusting screw loose and pull torque to value shown on each tightening pass.

Table 14-12: Injector Adjustment (Oil Temperature)

Cold Set	Hot Set
Cast Iron Rocker Housing	
48 inch-lb	72 inch lb.
[0.6 kg ml	[0.8 kg ml
Aluminum Rocker Housing	
72 inch-lb	72 inch-lb
[0,8 kg ml	[0.8 kg ml

3. Tighten locknut to 30 to 40 ft-lb. [4.1 to 5.5 kg ml torque. If ST-669 torque wrench adapter is used, torque to 25 to 35 ft-lb. [3.5 to 4.8 kg mi.

Croshead Adjustment

See Crosshead Adjustment (Dial Indicator Method)

Valve Adjustment - Torque Method

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. While adjusting valves, make sure that the compression release, on those engines so equipped, is in running position.

2. Loosen locknut and back off adjusting screw. Insert feeler gauge between rocker lever and crosshead. Valve clearances are shown in Table 14-13. Turn screw down until lever just touches gauge and lock in this position. Fig.14-31. Tighten locknut to 30 to 40 ft-lb. [4.1 to 5.5 kg m] torque. When using ST-669 torque to 25 to 35 it-lb. [3.5 to 4.8 kg mi.

3. Continue to bar engine to next "VS" mark and adjust each cylinder in firing order. See Table 14-10. After injector and valve adjustment is completed, bar or crank (in chassis overhaul) engine several revolutions to

Table 14-13: Valve Clearance - Inch [mm] (Torque Method)

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]
Cast Iron Rocker Housing			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]

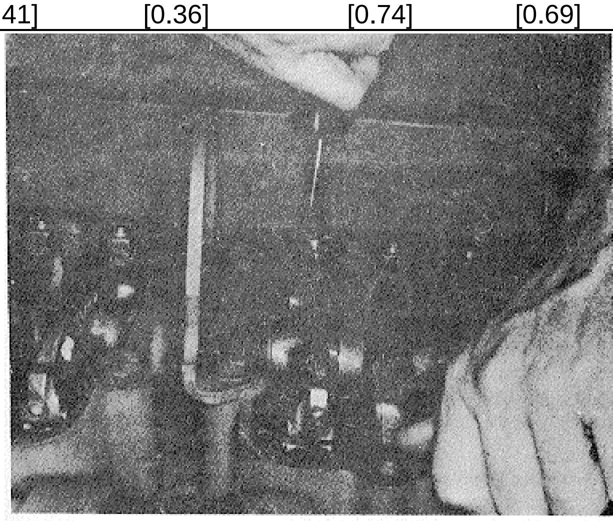


Fig. 14-31, (N114215). Adjusting valves

properly seat adjusting screws, plunger links, push tubes, etc. to mating surfaces. Take break-away torque reading on injector plunger adjusting screws. Break-away torque must be the same as adjustment torque. See Table 14-12. Re-adjust as necessary.

Jacob's Brake

Install Jacob's Brake, if used. See Group 20.

Rocker Housing Covers
Position covers and gaskets on rocker housings or Jacob's Brake. Tighten all cover capscrews using combination cork and rubber gaskets to 75 to 95 inch-lb. [0.9 to 1.1 kg ml, tighten all cover capscrews using cork gaskets to 12 to 17 ft-lb. [1.7 to 2.4 kg ml torque.

Note: Check current Parts Catalog for correct cover-gasket combination.

Breather Tube
Install breather tube, if used, to rocker housing cover and secure to block with clamp.

Cranking Motor
1. Check cranking motor; see that it is the same type as removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear.

2. Mount cranking motor (and spacer if used) to flywheel housing.

Note: When wet type clutch is used, use "O" rings and Nylok capscrews when installing starter.

Water Filter
1. Secure water filter head to engine, or mounting bracket, attach shut-off valves and lines in proper position.
2. Install pre-charge element, tighten until seal touches filter head then tighten an additional 1/2 to 3/4 turn.

Turbocharger

1. Coat turbocharger mounting stud or capscrew threads with anti-seize compound. Place gasket on exhaust manifold with convex side toward turbocharger.
2. Install turbocharger to exhaust manifold and secure with hug-lock nuts. Oil drain line must always be in a vertical or down position or within 30 deg. of that position.
3. Connect No. 6 oil inlet line or equivalent size tubing from top of turbocharger to oil cooler or transfer housing.
4. Connect No. 16 oil drain line or equivalent size tubing from turbocharger to large boss on side of cylinder block.

Note: If turbocharger "vee clamp" is loosened to align oil drain line, tighten to 32 to 36 inch-lb. [0.37 to Q.41 kg *ml* torque.

5. Install air intake crossover between turbocharger outlet and air intake manifold or aftercooler. Install new rubber tubing connection and T-bolt type clamps.

Electric Connections

Secure electric connections to mounted equipment, using wire as specified. See engine wiring diagram.

Fan Installation

Note: When installing fan to fan hub 5/16 inch [7.94 mm] capscrew must have 15/32 inch [11.91 mm] thread engagement, 3/8 inch [9.53 mm] capscrews must have 9/16 inch [14.29 mm] thread engagement, 1/2 inch [12.70 mm] capscrews must have 3/4 inch [19.05 mm] thread engagement. Check decal on fan hub or water pump pulley for proper thread length. The fan may be installed before or after engine dynamometer testing.

ENGINE TESTING

Engine break-in and testing are accomplished simultaneously. Break-in on a new or rebuilt engine is necessary because it provides an operating period during which moving parts acquire their final finish and mating surfaces reach a full seat. Engine testing helps detect possible assembly errors, need for adjustments as engine "break-in " and establishes a period for final adjustments for best engine performance.

Priming The Fuel System

1. Fill fuel tanks and filter(s) with clean No. 2 diesel fuel oil meeting the specifications in Group 18.

a. With PT (type G) fuel pump, fill pump through plug next to tachometer with clean fuel.

2. If injector and valve or other adjustments have been disturbed, be sure they have been properly adjusted before starting engine.

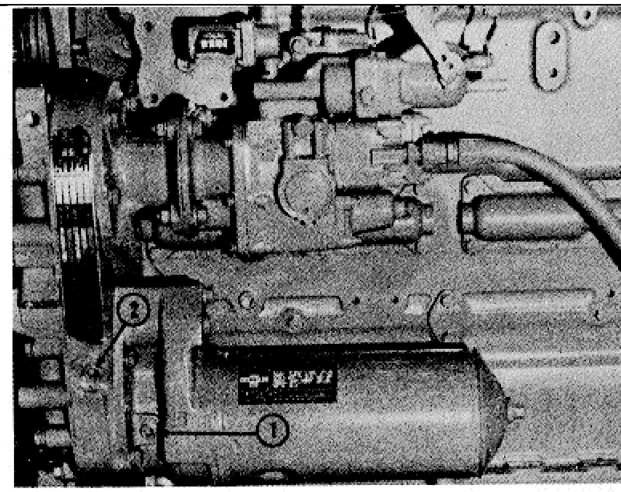
Priming The Lubricating System

Note: If engine is equipped with a turbocharger, remove oil inlet line and lubricate bearing with approximately 2 to 3 oz [60 cc] of clean engine lubricating oil. Reconnect oil inlet line.

1. Fill crankcase to "L" (low) mark on dipstick. See Lubricating Oil Specifications, Group 18.

Note: Some engine dipsticks have dual markings with high and low level marks; static oil marks on one side and engine running at low idle speed marks on opposite side. Be sure to use proper scale.

2. Remove plug from head of lubricating oil filter housing or gear case to prime system. (See 1 or 2, Fig. 1433.)



1-2. Priming Points

Fig. 1433, (N11963). Lubricating system priming point

CAUTION

Do not prime engine lubricating system from bypass filter.

3. Connect a hand or motor driven priming pump line from source of clean lubricating oil to plug boss in housing. Prime until a 30 psi [2.1 kg/sq. cm] maximum pressure is obtained.

4. Crank engine at least 15 seconds (with fuel shutoff valve closed or disconnect to prevent starting), while maintaining external oil pressure at a minimum of 15 psi [1.1 kg/sq. cm].

5. Remove external oil supply line and replace plug.

WARNING

Clean area of any lubricating oil spilled while priming or filling crankcase.

6. Finish filling crankcase to "H" (high) mark on dipstick.

Lubricating Cranking Motor And Generator

Use 6 or 8 drops of clean lubricating oil to lubricate cranking motor and generator or alternator bearings (if required), Avoid excessive oiling which would cause damage to wire insulation.

equipped with hydraulic governed fuel pumps. This governor uses lubricating oil (of the same weight as used in the engine) as an energy medium. Oil level in governor sump must be at full mark on dipstick, or halfway level on inspection glass.

Engine Dynamometer

Check dynamometer capacity, Make sure capacity is sufficient to allow testing at 96 to 100% maximum engine horsepower. If capacity is insufficient, testing procedures must be modified to prevent damage to dynamometer

INSTALLATION OF ENGINE

1. Place engine on dynamometer test stand, secure engine mounting pads to engine support risers.
2. Position dynamometer drive shaft flange to engine flywheel. Check for proper alignment per manufacturers instructions.
3. Connect water supply and return hose to the water cooling arrangement.
4. Attach ST1190 Fuel Consumption Measuring Device to engine.
5. If engine is equipped with an aneroid control, disconnect fuel pressure and fuel return line and plug lines. The aneroid is reconnected just after "power check" is made.
6. Connect throttle linkage instruments, exhaust piping and air intake piping to engine.
7. On naturally aspirated engines, plug vent holes in cylinder heads before making blowby check. After testing, remove pipe plugs.
8. Install ST487 BlowBy Checking Tool in crankcase breather opening or special rocker cover. Use water manometer and fill to "O" mark at middle of scale. Close all openings that would allow blowby pressure to escape.
9. Start engine, see "Starting Procedure," open coolant supply to engine water connection. Introduce water to dynamometer per manufacturer's instructions. Check all tubing, hose, lines, fittings and plugs for leaks. Correct as necessary. See "Check Turbocharger Oil Flow" following.
10. For engine run-in, see "Test Procedure.

Check Turbocharger Oil Flow

1. Disconnect turbocharger oil drain line.
2. Start engine and maintain rpm at low idle.
3. Observe oil drain. Oil should flow in 10 to 15 seconds. If no oil flows in 30 seconds, shut down engine and correct fault.
4. Reconnect oil drain line when flow is established.

STARTING PROCEDURE

Normal Without Cold-Starting Aid

1. Set throttle for idle speed, open manual fuel shutdown valve, if used. Electric fuel shutdown valves operate automatically.

Note: The manual override knob provided on forward end of electric shutdown valve, allows valve to be opened in case of electric power failure or if power is not available during testing. To use, open by turning fully clockwise.

2. Pull compression release if so equipped, press starter button or turn switch key to "start" position. After three or four seconds of cranking, close compression release and continue to crank until engine fires.

CAUTION

Do not crank engine continuously for more than 30 seconds. If engine does not fire, wait two to five minutes before repeating to avoid cranking motor damage.

Cold Start With Preheater

1. Set throttle in idle position, turn glow plug toggle switch to "ON" position. (Red indicator light must be on.) After red' light has been on for 20 seconds, start cranking engine. As soon as engine begins rotating, operate preheater priming pump to maintain 80 to 100 psi [5.6 to 7.0 kg/sq. cm] fuel pressure. (Use of primer before 20second interval will wet and cool glow plug and prevent heating.)

Note: On engines equipped with an oil pressure switch, the fuel bypass switch must be In "START" position before use of priming pump. Hold in "START" position until engine oil pressure reaches 7 to 10 psi [0.5 to 0.7 kg/sq. cm]then move to "RUN" position.

2. If engine does not start within 20 seconds, stop cranking, wait two to five minutes and repeat cranking operation.
3. After engine starts, pump primer slowly to keep engine idling smoothly. Do not accelerate engine.
4. When engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch.

Failure To Start

1. If engine gives no indication of starting during first three full strokes of preheater pump, check intake manifold for heat. If there is no heat, check electric wiring. If wiring is all right, remove pipe plug from manifold and observe glow plug. Glow plug should be white hot; if not, connect plug to a six or twelve volt source and check amperage which should be 30 (minimum). If glow plug is all right, check manual switch and resistor; replace if necessary.

TEST PROCEDURE

Horsepower Ratings

1, The maximum horsepower ratings at rpm shown in Table 1414, "Dynamometer Test Chart," are for engines operating at No. 1 Curve or intermittent duty applications at sea level, 60 deg. F [16 deg. C] intake air temperature and 29.92 inch [760.0 mm] Hg (Mercury) barometric pressure.

2. Where it is necessary to derate because of high altitude operation, the derating may be done by reducing maximum governed rpm or maximum fuel rate. Refer to FUEL PUMP SYSTEM

3. Naturally aspirated engines must be derated 3% for each 1000 ft. [304.8 ml altitude above sea level, and 1% for each 10 deg. F [6 deg. C] ambient temperature rise above 60 deg. F [16 deg. C].

4. Turbo-charged engines do not require fuel derating below maximum altitudes shown in the "Dynamometer Test Chart." Above maximum altitudes, derate at 4% for each 1000 ft. [304,8 ml additional altitude and 1% for each 10 deg. F [6 deg. C] air temperature rise above 12 deg. F [52 deg. C].

5. New or newly rebuilt engines during dynamometer tests are not required to deliver more than 96% of maximum horsepower at power checks.

BREAKIN RUN

Initial Starting

Start engine and idle at approximately 800 rpm no load for five to ten minutes. Check oil pressure and water circulation; look for leaks.

At Each Phase

1. Apply dynamometer load to (+10%) horsepower at (+5%) speed shown in Table 1414 "Dynamometer Test Chart".

2. Check crankcase pressure (blowby) with ST487. If pressure continues to drop, reduce run-in time by half; otherwise, run engine for time period shown on dynamometer chart.

At Phase 1

1. Run engine until normal oil operating temperature has been obtained.

2. Add lubricating oil to bring level up to "H" mark on bayonet gauge, allow oil temperature to stabilize.

At Phase 2

Set engine Idle, governed speed and fuel rate.

At Phase 3

If blow by rises, reduce load to preceding phase and run for 30 minutes; then return to original phase specifications.

At Phase 4

1. Run at speed and horsepower indicated.

2. Check for leaks and tighten all exposed capscrews.

3. Recheck valves and injectors. Use "Hot Setting," refer to Tables 1411, 14.12 and 1413.

Note: Readjustment after 1 hour operation is necessary to assure lowest smoke potential and avoid excessive injector train loads.

POWER CHECK

1. Run engine at rated speed for 5 minutes. It should develop 96% of rated horsepower at standard fuel rate. Check crankcase pressure (blowby). If pressure exceeds value shown in Table 1414 reduce engine speed and load to preceding phase; run engine 30 to 45 minutes.

2. Repeat procedure described above until engine develops 96% rated horsepower at standard fuel rate within permissible crankcase pressure limit.

3. After power check is completed, remove pipe plugs in naturally aspirated engine cylinder heads and install vent plugs. On turbocharged engines connect aneroid, if used.

CHECKS DURING RUNIN TEST

During the period of engine runin, the following checks should be made frequently.

Lubricating Oil

1. Lubricating oil pressure should remain at or near a constant figure at constant engine speed and load (see Table 1415) after normal operating temperature has been reached. Abnormally high pressures may indicate blocked lubricating oil lines. Abnormally low pressures indicate an insufficient supply of lubricating oil from the pump or increased oil clearances which may be due to bearing failure.

2. If oil temperature rises sharply above 225 deg. F [107 deg. C] shut down engine and correct as necessary.

3. New lubricating oil filter elements will absorb oil; therefore, engine must be shut down after five or ten minutes of operation and additional oil added to bring oil level to "H" mark on bayonet oil gauge. Check oil level every phase during runin test.

Smoke Level

See Service Tool Instructions,

Engine Coolant

After engine is started, add coolant as necessary to completely fill cooling system and replace entrapped air. Coolant should not exceed 200 deg. F [93 deg. C] or drop below 160 deg. F [71 deg. C] during engine operation. Do not turn engine off immediately after a load run. Heat stored in the iron masses will boil coolant in the jackets if air and coolant circulation is immediately stopped while engine is hot. Allow engine to idle for a few minutes before shutting down.

Table 14-14: Dynamometer Test Chart

Engine Model	HP @ RPM	Rated HP @ RPM 500 Ft. Altitude	Fuel Rate Lb./Hr.	Air Manifold Pressure In./Hg.	Altitude Max. HP Alt.	Turbo.	Crankcase Pressure With ST-487	Phase 1 To Temperature HP @ RPM	Phase 2 15 Min. HP @ RPM	Phase 3 15 Min. HP @ RPM	Phase 4 15 Min. HP @ RPM	Power Check 5 Min. HP @ RPM	Torque Ft./Lb. Sea Level	Torque Ft./Lb. 500 Ft. Altitude
NTC-290	290 @ 2100	290 @ 2100	105	16/22	12,000	VT-50	12	145 @ 1575	218 @ 2100	247 @ 2100	261 @ 2100	278 @ 2100	825	825

NOTES:

1. Naturally aspirated engines must be derated 3% for each 1000 ft. [304.8 m] above sea level, and 1% for each 10 deg. F [6 deg. C] ambient temperature rise above 60 deg. F [16 deg. C].
2. Turbocharged engines do not require fuel derating below altitude shown in column entitled "Rating @ Altitude Maximum." Above maximum altitude, derate at each 1000 ft [304.8 m] additional altitude by 4%.
3. Crankcase pressure with ST-487 is given in inches of water.
4. See Bulletin No's. 983505 or 983725 for Rated HP @ RPM and fuel rate for derated engines not listed above.

Table 1415: Normal Lubricating Oil Pressure

Idle (525620rpm} PSI [kg/sq. cm]	Rated Speed PSI [kg/sq. cm]
10 [70] Minimum	40/75 [2.80/5.25]

Note: Individual engines may vary from above pressures.

Fuel Pressures

For fuel pressure reading and adjustment, refer to Fuel Pump Calibration

Overspeed Stop

Overspeed stops, when used, are set to trip and shut off fuel supply when engine exceeds maximum rated speed by approximately 15%. After determining and correcting cause of overspeed stop trip, reset in running position.

Engine Fuel Rate

ST1190 Fuel Consumption Measuring Device operates by drawing fuel from fuel tank, then through flow meter. Return fuel from injector drain is routed through float tank so when float tank is filled, float valve opens and allows return fuel flow to flow meter. Makeup fuel or amount of fuel being consumed by engine will flow through flow meter thus showing rate of fuel consumption in pounds per hour. See fuel pump calibration manuals.

Blow-By Readings

1. Manometer readings must be taken frequently during runin test so mechanic will note any blowby increase at a given speed and load. If there is any indication of blowby increase, engine speed must be reduced for a few minutes and then brought back to the original setting.

2. During each power check, keep a constant check on the manometer; if pressure rises, more runin is required.

Representative pressure limits for engine running at governed speed and pulling 96 to 100% of rated horsepower are given in Table 1414. If pressure is greater than values listed at end of testing period, engine should be checked as follows:

a. Naturally aspirated engines:

Operate 30 minutes extra at 96 to 100% rated load and rpm. If there is no rapid change in excess of 1 inch [25.4 mm] of water and maximum reading does not exceed 100% of representative pressure, blowby is acceptable.

b. Turbocharged engines: Operate 30 minutes extra at 96 to 100% rated load and rpm. If there is no rapid change in excess of 2 inches [50.8 mm] of water and reading does not exceed 100% of representative pressure, blowby is acceptable.

Note: Manometer readings not exceeding 0.3 inch [7.62 mm] surge are desirable.

CHASSIS DYNAMOMETER TESTS

If the engine is installed In equipment, it may be tested on a chassis dynamometer as follows:

1. Check instruments, follow manufacturer's instructions.
2. Perform all phases of engine dynamometer BreakIn Run. See Table 1414.

Maintenance Of Dynamometer

Follow manufacturer's maintenance instructions to service dynamometer.

Calibrating Instruments

Keep beam or spring scales properly calibrated. Follow manufacturer's recommendation when recalibrating or instrument adjustment is necessary.

In-Chassis Run-In

Inchassis repaired engines should receive runin equivalent to that on an engine dynamometer. Follow procedure given below after an inchassis repair or rebuild.

1. Start engine. Idle at 800 to 1000 rpm, noload, for 5 to 10 minutes. Check oil pressure and water circulation. Correct any leaks.
2. Operate at 1/4 to 1/2 throttle for first 5 to 10 hours.
3. Operate at 1/2 to 2/3 throttle for next 45 to 50 hours.
4. After 50 hours of operation, do not operate engine at full load and speed in excess of 5 minutes continuously at any time. After 5 minutes full power run, drop back to 3/4 throttle.
5. During the first 100 hours' service:

a. Do not idle engine for long periods.

b. Watch instruments closely. Decrease engine rpm if oil temperature reaches 250 deg. F [121 deg. C] or if coolant temperature exceeds 190 deg. F [88 deg. C] .

c. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

6. Check exhaust restrictions (back pressure) as follows:

a. Using a mercury or water manometer, take readings when engine is developing maximum horsepower at maximum engine speed.

b. Maximum permissible back pressures are:

All Models

(1) 3.0 inch [76 mm] Hg. or 20 inches [508 mm] of water for all naturally aspirated engines.

(2) 3.0 inch [76 mm] Hg. or 25 inches [635 mm] of water for all turbocharged engines.

7. Check smoke level,

ANEROID CONTROL ADJUSTMENT

The aneroid bellows spring is preset and sealed at Cummins Engine Company, Inc. The following adjustment can be made while the engine is on a dynamometer.

1. Start engine and check idle speed. In most cases, idle will be low and must be adjusted upward with fuel pump governor idle screw.
2. Check engine rated power and speed. If smoke is not excessive during first 15 seconds of full throttle operation, but becomes excessive thereafter, aneroid is not at fault.
3. Check fuel system and turbocharger before readjusting aneroid control.
4. If hard starting is encountered, the aneroid pressure valve may be sticking in open position, closed position will result in excessive smoke. Replace if necessary.

PAINT ENGINE

1. Prior to painting, clean surface for maximum paint adherence. Dry with compressed air.
2. Cover all openings, pulley grooves, instrument faces and belts. Cover all data plates, exposed threads, wire terminals, hose fittings and pipe openings with water proof paper or tape.
3. Cover clutch contact surface on flywheel with antirust compound, if engine is not going into immediate service.
4. Spray outside surfaces of castings and corrodible parts with a primer coat of yellow lacquer to serve as a base for the second coat of engine enamel.

ENGINE STORAGE

On any engine not in service, the unpainted machined surfaces are subject to rust and corrosion. The rate of corrosion varies with climatic conditions. An engine stored in a climate with a high amount of moisture in the air will corrode more rapidly than an engine stored in a dry climate.

Temporary Storage

If an engine remains out of service for three or four weeks (maximum six months), special precautions should be taken to prevent rust. The operations listed below are required to minimize or prevent damage to temporarily stored engines.

1. Engine must be started and operated until thoroughly warm. Disconnect fuel lines to engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil.
2. Start engine with fuel line to filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After engine is running smoothly, switch fuel line to container with preservative oil. Operate five to ten minutes on preservative oil. Stop engine and reconnect the fuel lines.
3. Drain oil sump, fuel filters and fuel tank and reinstall drain plugs. Sump may remain empty until engine is ready for use, tag engine with warning tag.
4. Disconnect electrical wiring and turn full pump manual shutoff valve fully counterclockwise. Spray lubricating oil into intake manifold and air compressor while cranking engine slowly.
5. Cover all openings with tape to prevent entrance of dirt and moisture.
6. Drain coolant from cooling system unless it is permanent type antifreeze with rust inhibitor added.
7. Store engine in dry and uniform temperature area.
8. Bar engine crankshaft two or three revolutions each three to four weeks.

Permanent Storage

1. When engine is to be stored six months or more, the lubricating system, cooling system, fuel system, crankcase and external parts must be protected against rust and corrosion.
2. Start engine and operate at fast idle until the engine is thoroughly warm. Stop engine and drain old oil.
3. Fill crankcase to full mark on bayonet gauge or dipstick with preservative oil, U. S. Military Specification MILL21260, Type P10, Grade 2 SAE 30.

416 WVICE MANUAL 4. Disconnect fuel lines to engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil U. S. Military Specification MI LL644 Type P9.

5. Start engine with fuel line to filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After engine is running smoothly, switch fuel line to container with preservative oil. Operate five to ten minutes on the preservative oil. Stop the engine and reconnect the fuel lines.
6. Drain oil sumps of pumps, compressors, coolers, filters and crankcase, etc. Replace all plugs after draining.
7. Remove intake and exhaust manifolds. Spray all intake and exhaust ports, including air compressor intake port, with preservative oil. Replace intake and exhaust manifolds.
8. Inspect cooling system if coolant is contaminated, drain and flush, fill with rust preventive compound.
9. If air starter is used, remove exhaust plate, spray with preservative oil and replace plate. Loosen V belt tension.
10. Rush or spray a film of rust preventive compound on all exposed, unpainted surfaces of engine. Use a rust preventive conforming to Type P2, Grade 1 or 2, U.S. Military Specification MILC16173C.Remove cylinder head covers and spray rocker levers, valve stems, springs, guides, crossheads and push tubes. Replace cover.
11. Cover all engine openings with heavy paper and tape. Tag engine to indicate that it has been treated with preservatives and crankshaft should not be barred over.Tag should show coolant has been removed, date of treatment and indicate that engine is not ready to run.
12. Store engine in an area where air is dry and temperature uniform.

Note: Engines in storage more than 24 months should be flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventive materials. Periodically inspect engines for rust or corrosion. Take corrective action if necessary.

13. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean, the accumulated deposits should be removed after being allowed to settle.

PREPARING A STORED ENGINE FOR SERVICE

When an engine is removed from storage and put into service, the following operations should be performed.

Clean Engine

1. Clean accumulated dirt from exterior of engine. Remove covers, tape and wrappings.

2. Use suitable cleaner to remove rust preventive compound from unpainted surfaces.
3. Refill crankcase with clean lubricating oil. Flush and fill cooling system.

Inspection

1. When an engine has been stored for six months or less, it is necessary to adjust injectors, valves and belts, tighten cylinder head capscrews and connections; replace filters and check air filter and screens.
2. When an engine has been stored for six months or more, the following procedure should be followed:

a. Flush fuel system with clean fuel oil until all preservative oil is removed.
b. Remove plug from oil gallery and force hot, light mineral oil through the oil passages to flush away all preservative oil. Bar over engine crankshaft three or four revolutions during flushing operation.
c. Replace all filters and clean all screens before engine is started.
d. After inspecting engine and parts, make sure all preservative oil and gummed oil has been flushed away. Start engine as described in Engine Testing.

INSTRUCTIONS FOR USE OF SERVICE TOOLS

Smoke Level Check With ST1294 Model 101 B Celesco Opacity Meter

1. Engine must be at normal oil operating temperature.

2. Apply dynamometer load as rpm is increased; (shift to direct drive gear when chassis dynamometer is used) until rated rpm and H.P. is reached and load is stabilized. Refer to Table 1414.

3. Using 020 scale on opacity meter zero the meter and place on exhaust stack(s); record readings. Remove meter after readings are completed.

Note: An accurate smoke reading can usually be obtained in ten to fifteen seconds.

4. Increase load until rpm is reduced to 60 percent of rated rpm.
5. Recheck zero on opacity meter, place on exhaust stack(s); record readings and remove meter

6. Reduce load and rpm.

7. Accelerate engine to rated rpm, no load (when chassis dynamometer is used shift to a lower gear that would allow full acceleration in approximately 3 to 5 seconds.) Return to idle.

8. Using 0100 scale on opacity meter, zero the meter and place on exhuast stack(s).

9. Accelerate to rated rpm, no load, record the “highest” opacity reading. Remove meter.

Note: When rechecking zero during a test and the readjustment to zero is off by more than two (2) percent clean lenses on opacity meter before rezeroing the scale.

Federal Tests require averaging five (5) one half (1/2) second smoke peak intervals for lug down tests and fifteen (15) second smoke peak intervals for acceleration, to determine smoke levels. Consult Local Air Pollution Agency for environmental regulations covering smoke opacity limits.

Instrument and Control Group 15

TACHOMETER

Rated engine speed is the rpm attained at full load. Governed engine speed is the highest rpm a properly adjusted governor will allow the engine to turn, no load. Governed engine speed must never be exceeded on downgrades or any other condition in which the load drives the engine.

Operate at partial throttle in continuous duty situations to give required torque with the tachometer showing rpm approximately 15 percent below governed speed.

OIL TEMPERATURE GAUGE

The oil temperature gauge normally should read between 180 deg. F [82 deg. C] and 225 deg. F [116 deg. C] for best lubrication. Any sudden increase in oil temperature which is not caused by load increase is a warning of possible mechanical failure and should be investigated at once.

WATER TEMPERATURE GAUGE

A water temperature of 165 deg. to 195 deg. F [74 deg. to 91 deg. C] is the best assurance that cylinder liners are heated to the proper .temperature to support good combustion and that working parts of the engine have expanded evenly to the most favorable oil clearances.

Overheating problems require mechanical correction. It may be caused by loose water pump belts, a clogged cooling system or heat exchanger, or insufficient radiator capacity. Report cases of overheating to the maintenance department for correction; 200 deg. F [93.3 deg. Cl maximum engine coolant temperature should not be exceeded.

OIL PRESSURE GAUGE

The oil pressure gauge indicates any drop in lubricating oil supply or mechanical malfunction in the lubricating oil system. The operator should note loss of oil pressure immediately and shut down the engine before the bearings are ruined. Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition. Instruments and gauges show at all times how to get the most satisfactory service from an engine. Safety controls are used on Cummins Engines to shut down the engine because of high coolant temperature, low or loss of lubricating oil pressure and engine speeds above rated rpm.

NASON SAFETY CONTROLS

The Nason (formerly Hawk) Safety Control System provides protection from low lubricating oil pressure and excessively high coolant temperature of preset values. When either is exceeded, the controls disrupt the electrical circuit to the fuel solenoid shutdown valve and shuts down the engine. The oil pressure safety control is mounted directly in the main oil gallery. The temperature safety control mounts directly into the water manifold.

During cranking of engine a permissive start switch is used to bypass the low lubricating oil pressure safety control.

Actual cranking is accomplished by use of a push button type starting switch wired into the cranking circuit. See wiring diagram Fig’s. 151, A and B.

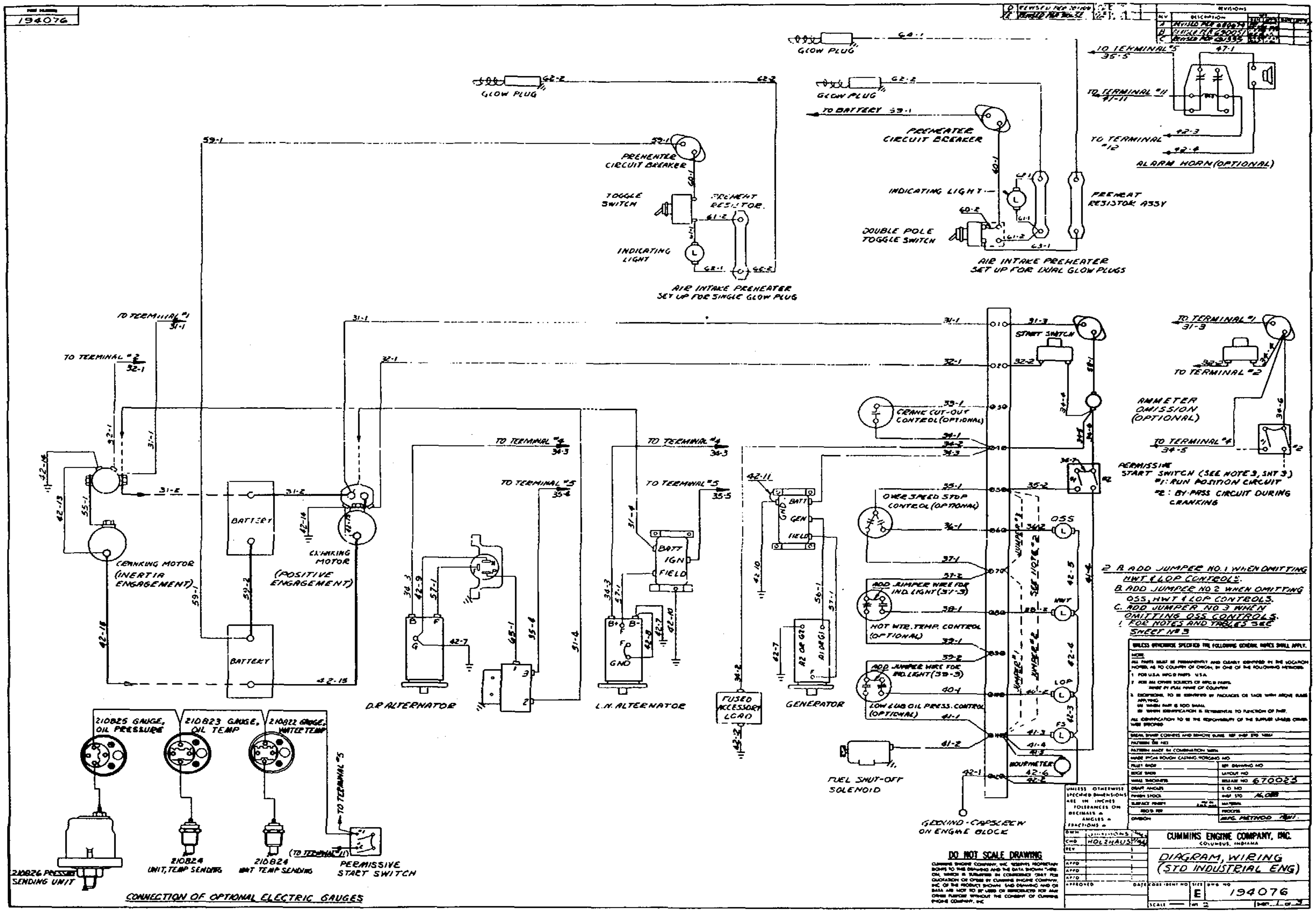


Fig. 15-1 (VI1306). Wiring diagram

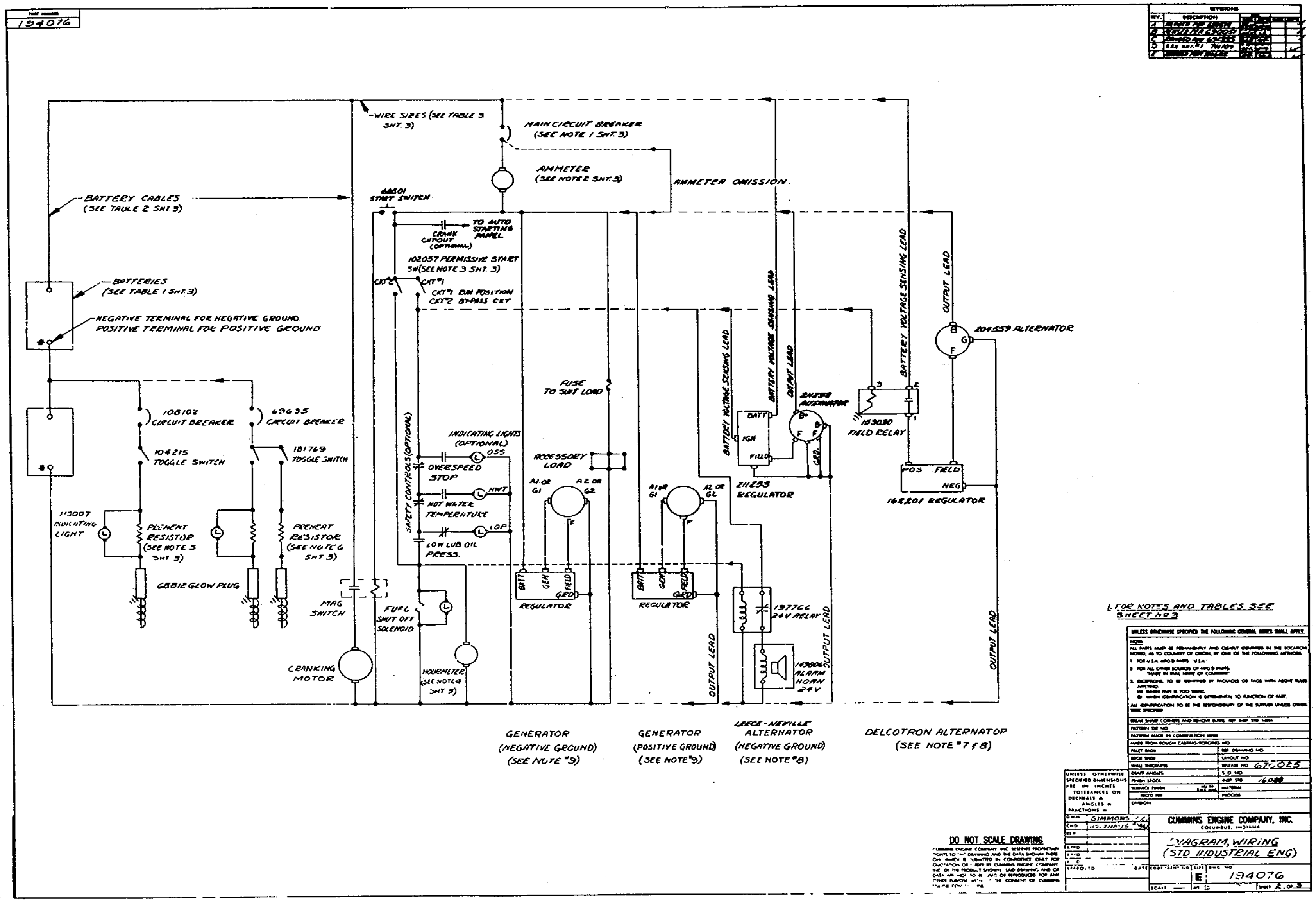


Fig. 16-1A (V11306A). Wiring diagram (cont'd.)

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TABLE N° 1 — MINIMUM BATTERY CAPACITY IN AMPERE-HOURS							
CUMMINS ENGINE SERIES	MAX ENGINE DISPL CU. IN	WINTER CLIMATE 0°F MIN. ENGINE TEMPERATURE			MILD CLIMATE 32°F MIN ENGINE TEMPERATURE		
		12V	24V	30V	12V	24V	30V
C	464	400#	200	130	300#	150	90
V6 (VAL) V8 (VALE)	378 504	[illegible] 300#	[illegible] 200	[illegible]	300# #	150 150	
V6 (VIM) V8 (VINE) V903	588 785 903	340# 400# 400#	170 200 200	150 170 —	260# 300# 300#	130 150 150	100 130
H & NH NH-6	743 855	400# 520#	200 260	170 200	300# 340#	150 170	130 150
NH-6 K-6 V-12	927 950 1710	— —	400 400	340 340	— —	260 260	260 260

MINIMUM CAPACITY FOR 12 VOLT HIGH OUTPUT TYPE STARTERS ONLY.

TABLE N° 3 — WIRE SIZES	
CIRCUIT DESCRIPTION	AWG GAUGE SIZE
BATTERY-STARTER CABLES	SEE TABLE N° 2
GLOW PLUG PREHEATER — SINGLE	10
GLOW PLUG PREHEATER — DUAL	6
● BATTERY CHARGING GENERATOR/ALTERNATOR OUTPUT LEADS (TOTAL LENGTH OF OUTPUT LEADS TO BE UNDER 16 FT)	
(24V SYSTEM ONLY) - 25 AMP. MAX	14
(12 & 24V SYSTEM) - 55 AMP MAX.	8
(24V SYSTEM ONLY) - 100 AMP. MAX.	6
● SENSING LEAD: BATTERY VOLTAGE-REGULATOR (ALTERNATOR ONLY)	10
ALL CONTROL CIRCUIT WIRING, INCLUDING GENERATOR/ALTERNATOR FIELD LEAD	14
ACCESSORY LOAD	AS REQ'D BY LOAD

● FOR EXPLANATION OF CIRCUIT DESCRIPTION SEE SHEET N° 2

Ⓔ

TABLE N° 2 — BATTERY TO STARTER CABLE SIZES **					
CIRCUIT DATA		TOTAL LENGTH ALLOWABLE IN CRANKING MOTOR CIRCUIT USING CABLE SIZES GIVEN BELOW (A.W.G. GAUGE — LENGTH IN FEET)			
CIRCUIT VOLTAGE	MAXIMUM CIRCUIT RESISTANCE	#00	#000	#0000 OR TWO #0	TWO #00
12 V	0.0012 OHM	UP TO 12	12 TO 16	16 TO 20	20 TO 25
12 V HIGH OUTPUT STARTING MOTOR	0.00075 OHM	UP TO 7	7 TO 9	9 TO 12	12 TO 14
24V TO 32V	0.002 OHM	UP TO 20	20 TO 27	27 TO 35	35 TO 45

** NOTE: TWO STRANDS OF #0 CABLE MAY BE USED IN PLACE OF ONE #0000 CABLE PROVIDED ALL CONNECTIONS ARE CAREFULLY MADE. THIS IS TO INSURE THAT CURRENT IN EACH PARALLEL CABLE WILL BE EQUAL. THE CROSS SECTIONAL CIRCULAR MIL AREA OF #0000 CABLE IS DOUBLE THAT OF #0 CABLE.

9. INDUSTRIAL TYPE ENGINES WILL BE SUPPLIED WITH A NEGATIVE GROUND SYSTEM UNLESS SPECIFICALLY ORDERED OTHERWISE.

10. POLARIZATION SEQUENCE - GENERATORS ONLY
AFTER A BATTERY CHARGING GENERATOR HAS BEEN INSTALLED AND WIRED IT MAY HAVE TO BE POLARIZED. THIS ALLOWS A SURGE CURRENT TO FLOW THROUGH THE FIELD WINDINGS, WHICH INSURES THAT THE POLARITY OF THE GENERATOR WILL MATCH THE POLARITY OF THE BATTERY. THIS SHOULD BE DONE BEFORE THE ENGINE IS STARTED.

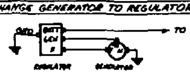
TYPE "A" CIRCUIT CHARGING SYSTEM (STANDARD ON INDUSTRIAL ENGINES)

(A) TEMPORARILY INSULATE THE GROUND BRUSH FROM THE COMMUTATOR WITH A PIECE OF CARDBOARD OR OTHER SUITABLE INSULATING MATERIAL TO AVOID EXCESSIVE CURRENT THROUGH THE ARMATURE.

(B) MOMENTARILY CONNECT A JUMPER LEAD BETWEEN THE "BATT" (BATTERY) AND "GEN" (ARMATURE) TERMINALS ON THE VOLTAGE REGULATOR. THERE WILL BE A SMALL SPARK AND THE GENERATOR IS NOW POLARIZED.

TYPE "B" CIRCUIT CHARGING SYSTEM.
OPTIONAL BATTERY CHARGING SYSTEMS MAY BE OF THE TYPE "B" CIRCUIT DESIGN. IF THE AMMETER DOES NOT INDICATE ANY GENERATOR OUTPUT WHEN THE GENERATOR IS WIRED PER THIS DIAGRAM AND SUBJECTED TO THE POLARIZATION SEQUENCE FOR TYPE "A" CIRCUITS PROCEED AS FOLLOWS:

(A) CHANGE GENERATOR TO REGULATOR WIRING AS FOLLOWS:



(B) DISCONNECT THE FIELD LEAD FROM THE VOLTAGE REGULATOR AND MOMENTARILY TOUCH THIS LEAD TO THE "BATT" (BATTERY) TERMINAL ON THE VOLTAGE REGULATOR.

Ⓔ 11. BATTERY CHARGING GENERATOR SYSTEM AS SHOWN SUPPLIED WITH LEECE-NEVILLE GENERATOR.

12. CRANKING MOTOR SYSTEM AS SHOWN SUPPLIED WITH:
Ⓐ LEECE-NEVILLE FOR INERTIA ENGAGEMENT TYPE STARTERS
Ⓑ LEECE-NEVILLE OR DELCO-REMY FOR POSITIVE ENGAGEMENT TYPE-STARTERS.

8. CAUTION: DO NOT POLARIZE A BATTERY CHARGING ALTERNATOR.

7. FOR WIRING DIAGRAM OF OTHER "DELCOTRON" ALTERNATORS SEE WIRING DIAGRAM 160019.

6. WHEN DUAL GLOW PLUG PREHEATERS ARE USED (I.E. VT-12 ENGINES) SPECIFY.
(A) NO PREHEAT RESISTORS WHEN TAPPING OFF 6V FROM BATTERY SUPPLY
Ⓒ (B) 118763 PREHEAT RESISTOR ASSEMBLY FOR 12V SUPPLY.

5. WHEN GLOW PLUG PREHEATER IS SPECIFIED USE:
(A) NO PREHEAT RESISTOR WHEN TAPPING OFF 6 VOLT BATTERY SUPPLY
(B) 68813 PREHEAT RESISTOR FOR 12 V SUPPLY

4. WHEN HOURMETER IS USED, CONNECT BLACK WIRE TO NEG, RED WIRE TO POSITIVE

3. WITH SAFETY CONTROLS IN SYSTEM HOLD PERMISSIVE START SW IN THE "START" POSITION UNTIL LUBE OIL PRESSURE HAS BUILT UP.

2. REVERSE AMMETER CONNECTION IF AMMETER INDICATES:
(A) DISCHARGE WITH ENGINE RUNNING AND
(B) INDICATES CHARGE WITH ENG STOPPED & WITH THE PERMISSIVE START SW IN THE "RUN" POSITION

1. MAIN CIRCUIT BREAKER TO BE SELECTED AT APPROX 25% ABOVE RATED BATTERY CHARGING GENERATOR OUTPUT, 50% ABOVE RATED ALTERNATOR OUTPUT.

UNLESS OTHERWISE SPECIFIED THE FOLLOWING GENERAL NOTES SHALL APPLY.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± ANGLES ± FRACTIONS ±

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

DIAGRAM, WIRING (STD INDUSTRIAL ENG)

SIZE E DWG NO 194076

RELEASE NO 670023

Fig. 15-18 (V11306B). Wiring diagram (cont'd.)

Specifications and Wear Limits Group 18

Worn limits as stated in this manual indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. All engine models are the same unless otherwise stated. Limits are given in U.S. and Metric measurements. All Metric units are enclosed in brackets [].

WEAR LIMITS

Part or Location	New Minimum	New Maximum	Worn Limit
GROUP 1. CYLINDER BLOCK			
Installed Camshaft Bushing Inside Diameter	1.999 [50.77]	2,0005 [50.813]	2.0015 [50.838]
Camshaft Bushing Bore in Block	2.1285 [54.064]	2.1295 [54.089]	2.1305 [54.115]
Cylinder Liner Counterbore			
Inside Diameter	6.5615 [166.662]	6.5635 [166.713]	
Counterbore Depth	0.350 [8.89]	0.352 [8.94]	0.412 [10.46]
Liner Protrusion	0.003 [0.08]	0.006 [0.15]	
Liner-to-B lock Clearance			
Lower Bore	0.002 [0.05]	0.008 [0.20]	
Cylinder Block Lower Liner Bore	6.124 [155.55]	6.126 [155.60]	
Main Bearing Bore	4.7485 [120.612]	4.750 [120.65]	4.7505 [120.663]
Main Bearing Bore Alignment	See Page	347	
Main Bearing Capscrew			
Tightening Ft-Lb. [kg m]			
1. Tighten to	145 [20.05]	155 [21.44]	
2. Advance to	300 [41.49]	310 [42.87]	
3. Loosen	All	All	
4. Tighter to	140 [19.36]	145 [20.05]	
5. Advance to	30 deg	30 deg	
Cylinder Block Height From Main Bearing			
Bore Center Line	19.004 [482.70]	19.006 [482.75]	18.994 [482.45]
From Top of Alignment Bar	16.629 [422.38]	16.631 [422.43]	16.619 [422.12]
Cylinder Liner Counterbore	0.350 [8.89]	0.352 [8.94]	0.412 [10.46]
Cylinder Liner Counterbore Shims			
Part No. 143938	0.0063 [0.160]	0.007 [0.18]	
Part No.,143939	0.0072 [0.183]	0.0088 [0.223]	

Part or Location	New Minimum	New Maximum	Worn Limit
Part No. 143946	0.0081 [0.206]	0.0099 [0.251]	
Part No. 143947	0.018 [0.46]	0.022 [0.56]	
Part No. 143948	0.028 [0.71]	0.034 [0.86]	
Part No. 143949	0.056 [1.42]	0.068 (1.73]	
Cylinder Liner			
Cylinder Liner Inside Diameter	5.4995 [139.6871	5.501 [139.73]	5.505 [139.83]

Note: New cylinder liners dimensions at 60 to 70 deg F [16 to 21 deg C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.

Part or Location	New Minimum	New Maximum	Worn Limit
Cylinder Liner Protrusion	0.003 [0.081	0.006 [0.15]	
Bearings			
Standard Size (Thickness)			
Main Bearing (All)	0.123 [3.12]	0.1238 [3.144]	0.1215 [3.086]
Connecting Rods (855 Series)	0.0724 [1.839]	0.0729 [1.852]	0.071 [1.80]
Journal Clearance			
Main	0.0015 [0.038]	0.005 [0.13]	0.007 [0.18]
Connecting Rods	0.0015 [0.038]	0.0045 [0.114]	0.007 [0.18]
Crankshaft Thrust Ring Thickness			
Part No's.: 157280	0.245 [6.22]	0.247 [6.27]	
157281	0.255 [6.48]	0.257 [6.53]	
157282	0.265 [6.73]	0.267 [6.78]	
Crankshaft End Clearance	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
Vibration Dampers			
Misalignment of Index Marks		0.0625 [1.587]	
Wobble and Eccentricity	Refer to Page 403		
Connecting Rods			
Nut Tightening (855 C.I.D Series)	Refer to Table 1-1 (19).		
Crankpin Bore	Refer to Table 1-1 (6).		
Out-of-round			0.0015 [0.038]

Part or Location	New Minimum	New Maximum	Worn Limit
Piston Pin Bushing	2.001 [50.83]	2.0015 [50.8381	2.0025 [50.863]
Connecting Rod Length			
Center to Center	11.998 [304.75]	12.000 [304.80]	
Connecting Rod Alignment			
Without Bushing			0.008 (0.20)
With Bushing			0.004 [0.10]
Twist			
Without Bushing			0.020 [0.51]
With Bushing			0.010 [0.25]
Connecting Rod Bolt (855 C.I.D Series)			
Minimum O.D	0.541 [13.74]	0.545 [13.84]	0.540 [13.72]
Pilot O.D	0.6245 [15.852]	0.625 [15.87]	
Bolt Hole Inside Diameter Pilot			
855 Series Rod	0.6243 [15.857]	0.6248 [15.870]	0.6249 [15.872]
Cap	0.6246 [15.865]	0.6251 [15.877]	0.6252 [15.880]
Piston and Piston Rings			
Ring Gap	Refer to Table 1-1 (14).		
Piston Skirt Diameter at 70 deg F [21 deg C]	Refer to Table 1-1 (12).		
Piston Pin Bore			
Aluminum	1.9985 [50.762]	1.9989 [50.772]	1.999 [50.77]
Piston Pin Diameter	1.9988 [60.7691	1.999 [50.77]	1.9978 [50.754]

Part or Location	New Minimum	New Maximum	Worn Limit
Camshaft			
Journal Diameter	1.997 [50.72]	1.998 [50.75]	1.996. [50.70]
Camshaft Support Bushing	1.3725 [34.861]	1.3755 [84.938]	1.370 [34.80]
Camshaft Outboard Bearing Support	1.751 [44.48]	1.754 [44.55]	1.757 [44.63]
Gear Case Cover			
Accessory Drive Bushing			
Part No 132770	1.565 [39.75]	1.569 [39.85]	1.571 [39.90]
Part No 132771	1.555 [39.41]	1.559 [39.60]	1.561 [39.65]
Part No 132772	1.545 [39.24]	1.549 [39.34]	1.551 [39.40]
GROUP 2. CYLINDER HEAD			
Height	4.370 [111.00]	4.380 [111.25]	4.340 [110,24]
Injector Sleeve			
Top Inside Diameter	1.145 [29.08]	1.155 [29.34]	
Injector Cup Protrusion	0.060 [1.52]	0.070 [1.78]	
Valve Seat Insert			
Run-out			0.002 [0.05]
Sizes Available	Refer to Table 2-1 (8).		
Valve Crossheads and Guides			
Crosshead Stem Inside Diameter	0.434 [11.02]	0.436 [11,071	0.440 [11.18]
Guide Outside Diameter	0.433 [10.99]	0.4335 [11.011]	0.432 [10.97]
Guide Assembled Height	1.860 [47.24]	1.880 [47.75]	
Depth Valve Stem Pocket	0.120 [3.05]	0.140 [3.56]	
Valve, Guides and Springs			
Valve Stem Outside Diameter	0.450 [11.43]	0.451 [11.46]	0.449 [11.40]
Valve Guide Inside Diameter	0.4525 [11.493]	0.4532 [11.511]	0.455 [11.56]
Valve Guide Protrusion	1.315 [33.40]	1.325 [33.65]	
Valve Spring Data	Refer to Table 2-1 (9).		

Part or Location	New Minimum	New Maximum	Worn Limit
GROUP 3. ROCKER LEVERS			
Bushing Inside Diameter	1.1245 [28.562]	1.1275 [28.638]	1.1286 [28.664]
Shaft Outside Diameter	1.123 [28.52]	1.124 [28.55]	1.122 [28.50]
GROUP 4. CAM FOLLOWERS			
Shaft Outside Diameter	0.7485 [19.012]	0.749 [19.02]	0.748 [19.00]
Bushing Inside Diameter	0.7495 [19.037]	0.7505 [19.063]	0.7515 [19.088]
Cam Roller			
(Injector Inside Diameter)	0.503 [12.78]	0.504 [12.80]	0.505 [12.83]
(Injector Outside Diameter)	1.249 [31.72]	1.251 [31.78]	1.247 [31.67]
(Valve Inside Diameter)	0.5005 [12.713]	0.5015 [12.738]	0.503 [12.78]
(Valve Outside Diameter)	1.249 [31.72]	1.250 [31.75]	1.247 [31.67]
Pin Outside Diameter	0.4995 [12.687]	0.500 [12.70]	0.497 [12.62]
Push Tubes			
Ball End Radius	0.623 [15.82]	0.625 [15.87]	
Socket (Spherical Inside Diameter)	0.505 [12.83]	0.520 [13.21]	
GROUP 5. FUEL SYSTEM	**Refer to Fuel Pump Section**		
GROUP 6. INJECTOR	**Refer to Injection Section**		
GROUP 7. LUBRICATING SYSTEM			
Lubricating Oil Pan			
Capacities	Refer to Table 7-1		
Drain Plug Torque ft-lb. [kg m]	60 [8.30]	70 [9.68]	
Lubricating Oil Dipstick			
Dipstick Length (Blank)	Refer to Page 373		
Lubricating Oil			
Hose Size	Refer to Tables 7-2 and 7-3		
Lubricating Oil Pump			
Flange-Mounted Horizontal Filter			
Bushings	0.6165 [15.659]	0.6175 [15.654]	0.6185 [15.710]
Idler and Drive Shaft Outside Diameter	0.615 [15.61]	0.6155 [15.634’	0.6145 [15.608]

Part or Location	New Minimum	New Maximum	Worn Limit
Double Lubricating Oil Pump			
Body, Filter Head and Cover			
Idler Gear Bushing Inside Diameter	0.6165 [15.659]	0.6175 [15.684]	0.6185 - [15.710]
Idler and Drive Shaft Outside Diameter	0.615 [15.62]	0.6155 [15.634]	0.6145 [15.608]
Single Scavenger Pump			
Idler Gear Drive Shaft and Cover Bushing Inside Diameter	0.6165 [15.659]	0.6175 [15.684]	0.6185 [15.710]
Idler and Drive Shaft Outside Diameter	0.615 [15.61]	0.6155 [15.634]	0.6145 [15.608]
Double Scavenger Pump			
Idler Gear Drive Shaft and Cover Bushing Inside Diameter	0.840 [21.34]	0.8405 [21.349]	0.841 [21.36]
Idler and Drive Shaft Outside Diameter	0.8375 [21.272]	0.838 [21.29]	0.837 [21.26]
Single Double Capacity Lubricating Oil Pump			
Body and Cover Bushing Inside Diameter	0.8767 [22.268]	0.8777 [22.293]	0.879 [22.33]
Drive Shaft	0.8745 [22.212]	0.875 [22.22]	0.873 [22.17]
Idler Shaft Outside Diameter	0.8745 [22.212]	0.875 [22.22]	0.873 [22.17]

GROUP 8. COOLING SYSTEM

Part or Location	New Minimum	New Maximum	Worn Limit
Water Pump			
Impeller to Shaft Press-Fit			0.001 [0.03]
Impeller to Body Clearance	0.020 [0.51]	0.040 [1.02]	
Fan Hub			
End Clearance	0.003 [0.08]	0.010 [0.25]	
Bearing to Shaft Press-Fit	0.000 [0.00]	0.001 [0.03]	
Thermostats			
Operating Range			
Low	160 deg F [71 deg C]	175 deg F. [79 deg C]	
Medium	175 deg F [79 deg C]	185 deg F [85 deg C]	
High	180 deg F [82 deg C]	195 deg F [91 deg C]	

Part or Location	New Minimum	New Maximum	Worn Limit
GROUP 9. DRIVE UNITS			
Fuel Pump and Compressor Drive			
Bushing Inside Diameter	1.312 [33.32]	1.315 [33.40]	1.321 [33.55]
Drive Shaft Outside Diameter	1.3115 [33.312]	1.312 [33.32]	1.310 [33.27]
End Clearance	0.005 [0.13]	0.010 [0.25]	
GROUP 10. INTAKE AIR SYSTEM			
Cold Starting Aids	Refer to Page 388		
Air Cleaner			
Restriction (Inch/Water) Naturally Aspirated			
Oil Bath		15 [381.001	
Dry Type (Normal Duty)		10 [254.00]	20 [508]
Dry Type (Medium Duty)		12 [304.80]	20 [508]
Dry Type (Heavy Duty)		15	20
All Turbocharged Engines 25 in.H20	[	381.00]	[508]
Turbocharger			
VT-50	Refer To Turbocharger Section		
GROUP 11. EXHAUST SYSTEM	**See Page 390**		
GROUP 14. ENGINE ASSEMBLY AND TESTING			
Crankshaft End Clearance	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
Cylinder Liner Protrusion	0.003 [0.08]	0.006 [0.15]	
Cylinder Liner Out-of-round			
Top/inch [25.40]		0.003 [0.08]	
Lower Area		0.002 [0.05]	
Connecting Rod Side Clearance	0.0045 [0.114]	0.013 [0.33]	
Gear Backlash - Gear to Gear			
Crankshaft, Camshaft, Fuel Pump Drive, Idler, and Lubricating Oil Pump Gears	0.002 [0.05]	0.009 [0.23]	0.020 [0.50]
Camshaft End Clearance	Refer to Table 14-1 (7).		
Injection Timing	Refer to Table 14-3, Page 397		
Injector and Valve Adjustment	Refer to Page 407		

Part or Location		New Minimum	New Maximum	Worn Limit
Engine Firing Order		Refer to Table 14-10, Page 408		
Belt Tension		Refer to Table 14-5, Page 404		
Main Bearing Capscrew		Refer to Table 1-1 (18).		
Connecting Rod Nuts ft. lb. [kg m]		Refer to Table 1-1 (19).		
Injector Hold-down Capscrew ft. lb. [kg m]				
Nylock Capscrews		11 [1.52]	12 [1.66]	
Rocker Housing Capscrews ft. lb. [kg ml		55 [7.61]	65 [8.89]	
Note: Refer to Fig. 14-9 for Torque Sequence.				
Fuel Filter ft. lb. [kg ml		20 [2.771	25 [3.46]	
Flywheel Housing Capscrews ft. lb. [kg m]		150	[20.74]	
Flywheel Capscrews ft. lb. [kg ml		190	200	
(Lockwire)		[26.28]	[27.66]	
(Hardened Flatwashers)		200 [27.66]	220 [30.43]	
Camshaft End Clearance				
(with thrust plate)		0.001 [0.03]	0.003 [0.08]	
(with outboard bearing support)		0.008 [0.20]	0.010 [0.25]	
Crankshaft Flange Capscrew ft. lb. [kg ml				
Engine Model	Part No.			
NT Series	196653 Capscrew 196654 Retainer	250 [34.9]	270 [38.8]	
Vibration Damper Capscrews ft. lb. [kg ml			60	
Vibration Damper and Pulley ft. lb. [kg ml			[8.30]	
Pulley to Damper			85 [11.76]	
Damper and Pulley to Crankshaft			85 [11.76]	
Accessory Drive Pulley Nut ft. lb. [kg ml		90 [12.45]	110 [15.21]	
Fan Hub Nut ft. lb. [kg ml		400 [55.30]	450 [62.23]	
4 Bolt Fan Hub to Mounting Bracket ft. lb. [kg ml			50 [6.91]	
Idler Pulley Nut		45 [6.22]	55 [7.60]	
Exhaust Manifold Capscrews ft. lb. [kg ml		25 [3.46]		
Oil Cooler and Filter Assembly		Refer to Page 405		
Rocker Housing Cover Capscrews				
Combination cork and rubber gaskets in. lb. [kg ml		75 [0.861	95 [1.09]	
Cork Gaskets ft. lb. [kg ml		12 [1.66]	17 [2.35]	

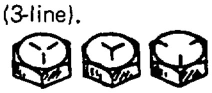
Part or Location	New Minimum	New Maximum	Worn Limit
Engine Testing	Refer to Page 411		
Dynamometer Test Chart	Refer to Table 14-14, Page 414		
Lubricating Oil Pressure			
Idle Speed P.S.I. [kg/sq. cm]	5 [0.35]	20 [1.41]	
Rated Speed P.S.I. [kg/sq. cm]	40 [2.80]	75 15.25]	
Blow-by Refer to Page 414			
Back Pressure	Refer to Page 415		
Smoke Level	Refer to Page A17		

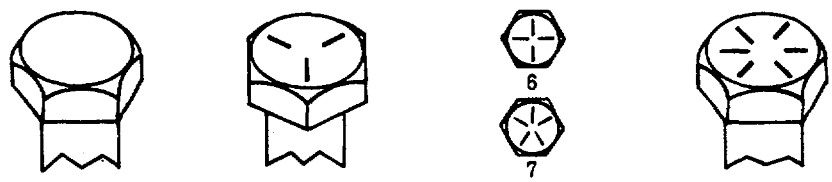
CAPSCREW MARKINGS AND TORQUE VALUES

SAE Grade Number	1 or 2	5	6 or 7	8

Capscrew Head Markings

Manufacturer's marks may vary. These are all SAE Grade 5 (3-line).





Capscrew Body Size (Inches) – (Thread)	Torque Ft-Lb [kg m]	Torque Ft-Lb [kg m]	Torque Ft-Lb [kg m]	Torque Ft-Lb [kg m]
1/4 – 20	5 [0.7]	8 [1.1]	10 [1.4]	12 [1.7]
– 28	6 [0.8]	10 [1.4]		14 [1.9]
5/16 – 18	11 [1.5]	17 [2.4]	19 [2.6]	24 [3.3]
– 24	13 [1.8]	19 [2.6]		27 [3.7]
3/8 – 16	18 [2.5]	31 [4.3]	34 [4.7]	44 [6.1]
– 24	20 [2.8]	35 [4.8]		49 [6.8]
7/16 – 14	28 [3.8]	49 [6.8]	55 [7.6]	70 [9.7]
– 20	30 [4.2]	55 [7.6]		78 [10.8]
1/2 – 13	39 [5.4]	75 [10.4]	85 [11.8]	105 [14.5]
– 20	41 [5.7]	85 [11.8]		120 [16.6]
9/16 – 12	51 [7.1]	110 [15.2]	120 [16.6]	155 [21.4]
– 18	55 [7.6]	120 [16.6]		170 [23.5]
5/8 – 11	83 [11.5]	150 [20.8]	167 [23.1]	210 [29.0]
– 18	95 [13.1]	170 [23.5]		240 [33.2]
3/4 – 10	105 [14.5]	270 [37.3]	280 [38.7]	375 [51.9]
– 16	115 [15.9]	295 [40.8]		420 [58.1]
7/8 – 9	160 [22.1]	395 [54.6]	440 [60.9]	605 [83.7]
– 14	175 [24.2]	435 [60.2]		675 [93.4]
1 – 8	235 [32.5]	590 [81.6]	660 [91.3]	910 [125.9]
– 14	250 [34.6]	660 [91.3]		990 [136.9]

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

LUBRICATING OIL

The use of quality lubricating oil, combined with appropriate oil drain and filter change intervals, is an important factor in extending engine life. Cummins Engine Company, Inc. does not recommend any specific brand of lubricating oil. The responsibility for meeting the specifications, quality and performance of lubricating oils must necessarily rest with the oil supplier.

Oil Performance Specifications

The majority of lubricating oils marketed in North America (and many oils marketed worldwide) are designed to meet oil performance specifications which have been established by the U.S. Department of Defense and the Automobile Manufacturers Association. A booklet entitled "Lubricating Oils for Heavy Duty Automotive and Industrial Engines" listing commercially available brand name lubricants and the performance classification for which they are designed, is available from Engine Manufacturing Association, 111 East Wacker Drive, Chicago, Illinois 60601.

Following are brief descriptions of the specifications most commonly used for commercial lubricating oils.

API classification CC is the current American Petroleum Institute classification for lubricating oils for heavy duty gasoline and diesel service. Lubricating oils meeting this specification are designed to protect the engine from sludge deposits and rusting (aggravated by stop and go operation) and to provide protection from high temperature operation, ring sticking and piston deposits.

API classification CD is the current American Petroleum Institute classification for severe duty lubricating oils to be used in highly rated diesel engines operating with high loads. Lubricating oils which meet this specification have a high detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation.

API classification SC, SD and SE were established for the Automobile Manufacturers Association. They require a sequence of tests for approval. The primary advantage of lubricating oils in these categories is low temperature operation protection against sludge, rust, combustion chamber deposits and bearing corrosion. The test procedure for these specifications are published by the American Society for Testing and Materials as STP315.

Break-In Oils

Special "BreakIn" lubricating oils are not recommended for new or rebuilt Cummins Engines. Use the same lubricating oil as will be used for the normal engine operation.

Viscosity Recommendations

1. Multigraded lubricating oils may be used in applications with wide variations in ambient temperatures if they meet the appropriate performance specifications and ash content limits shown in Table 181. Multigraded oils are generally produced by adding viscosity index improve additives to a low viscosity base stock to retard thinning effects at operating temperatures. Poor quality multigraded oils use a

Table 18-1: Oil Recommendations

Light Service Only (Stop-and-Go) All Diesel Models	Naturally Aspirated Diesel Models	Turbocharged Diesel Models	All Natural Gas Models All Service
API Class CC/SC[2/5]	API Class CC[1]	API Class CC/CD[2]	API Class CC
1.85% Maximum	1.85% Maximum	1.85% Maximum	.03 to .85%
Sulfated Ash Content[3]	Sulfated Ash Content[3]	Sulfated Ash Content[3]	Sulfated Ash Content[4]

1 API classification CC and CD quality oils as used in turbocharged engines and API classification CC/SC quality oils as used for stop-and-go service are satisfactory for use in naturally aspirated engines.

2 API classification CC/SC and CC/CD indicate that the oil must be blended to the quality level required by both specifications. The range of oil quality permitted by the CC classification is so broad that some oils that meet the classification will not provide adequate protection (varnish and ring sticking) for engines operated in certain applications. For example, turbocharged engines require the additional protection provided by the CD classification. Engines operated in stop-and-go service require the additional protection provided by the SC classification.

3 A sulfated ash limit has been placed on all lubricating oils for Cummins engines because past experience has shown that high ash oils may produce harmful deposits on valves that can progress to guttering and valve burning.

4 Completely ashless oils or high ash content oils, are not recommended for use in gas engines; a range of ash content is specified.

5 SD or SE may be substituted for SC.

viscosity index improve additive which has a tendency to lose its effectiveness after a short period of use in a high speed engine. These oils should be avoided.

2. Oils which meet the low temperature SAE viscosity standard (O deg. F [18 deg. C]) carry a suffix "W." Oils that meet the high temperature viscosity SAE standard (210 deg. F [99 deg. C]) as well as the low temperature carry both viscosity ratings example: 2020W. See Table 182.

Table 18-2: Operating Temperatures Vs Viscosity

Ambient Temperatures	Viscosity
10 deg F. [-23 deg. C] and below	See Table 18-3
10 to 30 deg. F. [-23 to - 1 deg. C]	1OW
20 to 60 deg. F [-7 to 16 deg. C]	20-20W
40 deg. F. [4 deg. C] and above	30

Arctic Operations

For operation in areas where the ambient temperature is consistently below 10 deg. F [23 deg. C] and there is no provision for keeping engines warm during shutdowns, the lubricating oil should meet the requirements in Table 18-3.

Table 18-3: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API class CC/SC API class CC/CD
SAE Viscosity Grade	10W-20, 10W-30, 10W-40
Viscosity @ -30 deg (ASTM D-445)	F 10,000 Centistokes Maximum
Pour Point (ASTM D-97)	At least 10 deg F [6 deg C] below lowest expected ambient temperature
Ash, sulfated (ASTM D-874)	1.85 wt % Maximum

Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is void, and SAE 5W oils should not be used.

GREASE

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners, Contact lubricant supplier for grease meeting these specifications.

TEST	TEST PROCEDURE
High-Temperature Performance	
Dropping point, deg F	ASTM D 2265 350 min.
Bearing life, hours at 300 deg F 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0 deg F	15,000 max.
Run at 0 deg F	5,000 max.
Rust Protection and Water Resistance	
Rust test	ASTM D 1743 Pass
Water resistance, %	ASTM D 1264 20 max.
Stability	
Oil separation, % 30 Hours @ 212 deg F	*FTM 321 5 max.
Penetration	
Worked	ASTM D 217 250-300
Bomb Test, PSI Drop	
100 Hours	10 max.
500 Hours	25 max.
Copper, Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc	*FTM 3005
25 Micron +	5,000 max.
75 Micron +	1,000 max.
125 Micron +	None
Rubber Swell	*FTM 3603 10 max.

*Federal Test Method Standard No 791a.

CAUTION

Do not mix grease and lubricating oil as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow lubricant to be thrown out, due to rotate speed.

FUEL OIL

Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties

Viscosity (ASTM D-445)	Centistokes 1.4 to 5.8 @ 100 deg. F (30 to 45 SUS)
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	At least 125 deg for legal temperature if higher than 125 deg F.
Gravity (ASTM D-287)	30 to 42 deg A.P.I at 60 deg. F (0.815 to 0.875 sp gr.)
Pour Point (ASTM D-97)	Below lowest temperature expected.
Active Sulfur-Copper Strip Corrosion (ASTM D-130)	Not to exceed No 2 rating after 3 hours at 122 deg F.
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 675 deg F. All of the fuel should evaporate at less than 725 deg F.

Coolant

Water should be clean and free of any corrosive chemicals such as chloride, sulphates and acids. It should be kept slightly alkaline with pH value in range of 8.0 to 9.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleet guard DCA Water Filter on the engine. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

1. In summer, with no antifreeze, fill' system with water.
2. In winter, select an antifreeze, all except Dow there 209 are compatible with DCA, use with water as required by temperature.

Note: Some antifreezes also contain anti-leak additives such as inert inorganic fibers, polymer particles or ginger root, these antifreezes should not be used in conjunction with the water filter. The filter element will filter out the additives and/or become clogged and ineffective.

3. Install or replace DCA Water Filter element as follows and as recommended in Cummins Engine Operation and Maintenance Manuals.

Engines Equipped With DCA Water Filters

1. New engines shipped from the Factory are equipped with water filters containing a "DCA pre-charge" element. See Table 18-4. This element is compatible with plain water or all permanent-type antifreezes except Dowtherm 209.

Table 18-4: Spin-On Type D C A Water Filter

Cooling System U.S. Gal.	D C A Pre-charge Element	D C A Service Element	Corresponding Obsolete Chromate Element
0 to 8	299082	299080	209604
8 to 1 5	299083	299080	209604
15 to 30	299084	299080	209605
30 to 60	(2) 299084	(2) 299080	(2) 209605

2. At the first "B" Check (oil change period) the DCA Precharge element should be changed to DCA Service Element. See Table 184.
3. Replace the DCA Service Element at each succeeding "B" Check except under the following conditions:
   a. If makeup coolant must be added between element changes, use coolant from a pretreated supply, as stated In "MakeUp Coolant Specifications", in Group 2 of Operation and Maintenance Manual.
   b. Each time system is drained revert back to precharge element.

4. To insure adequate protection have the coolant checked at each third element change or oftener.

Engines Now In Service With Spin-On Type Chromate Corrosion Resistor Element

1. Remove chromate element.
2. Flush cooling system.

3. Install pre-charge DCA element and operate engine to next "B" Check. See Table 18-4.

4. Install DCA Service Element; replace DCA Service Element at each succeeding "B" Check, except under the following conditions'

a. If make-up coolant must be added between element changes use coolant from a pre-treated supply.

b. Each time system is drained revert back to pre-charge element.

Table 18-5: Package or Canister D C A Water Filter

DCA Pre-Charge Canister		DCA Service Canister		Corresponding Obsolete Chromate Canister or Bag
None *		299071		132732, 299001
None *		299074		171645, 299004
None*	(2)	299091	(2)	132732, 299021

***299050 (DCA4) Pre-Charge Containers To Be Used With Service Elements Are:**

Cooling System U.S. Gal.	Service Element 299074	Service Element 299071	Service Element 299091 (2)	Service Element 299091
0-5	1			
5-9	2	1		
9-13	3	2	1	
13-17	0	3	2	
17-21	0	4	3	1
21-25	0	5	4	2
25-28	0	0	5	3
28-32	0	0	6	4
32-36	0	0	7	5
36-40	0	0	8	6
40-45	0	0	0	7
45,49	0	0	0	8
49-53	0	0	0	9
53-57	0	0	0	10
57-61	0	0	0	11
61-65	0	0	0	12
65-69	0	0	0	13
69-73	0	0	0	14
73-79	0	0	0	15

Engines Now In Service With Package (Bag) Or Canister Type Chromate Corrosion Resistor Elements

1. Remove chromate package or canister, discard package element and plates or canister, retain spring for use with DCA service element.

2. Flush cooling system.
3. Pre-charge system with coolant and dri-charge, Part No. 299050, (DCA 4), according to Table 18-5 using applicable service canister.
4. Install DCA Service Element; replace DCA Service Element at each succeeding "B" Check, except under the following conditions:
   a. If make-up coolant must be added between canister changes use coolant from a pre-treated supply.
   b. Each time system is drained revert back to Step 3 instructions.

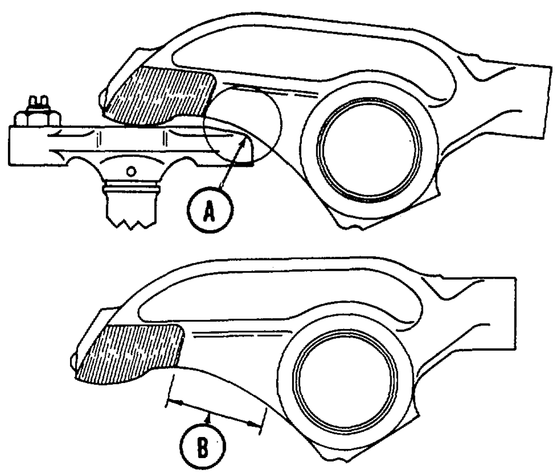
Vehicle Braking Group 20

COMPRESSION BRAKE

Jacobs Brake (Compression)

CHECK CROSSHEAD.TO ROCKER LEVER CLEARANCE

Barr engine in direction of rotation until valves are closed on each cylinder as checked through firing order, hold lever in contact with Jacobs Brake crosshead and check interference between crosshead and lever, clearance must be as shown in Fig. 202 (A). If feeler gauge will not pass



A. 0.060 Inch [1.524 mm] Clearance
B. Grind Area

Fig. 20-2. (N12045 J). Clearance area between lever and crosshead

through area, remove rocker lever and grind sufficient clearance in area (B), grinding must cover complete area in a continuous arc. Grind smooth all sharp edges.

INSTALLATION

1. Install new gaskets and Jacobs Brake units to rocker housings.

Note: If studs were removed from rocker housings, replace and tighten to 65 to 75 ft-lb. [9.0 to 10.4 kg m] torque in sequence as shown in Fig. 14-9.

2. Install special locking plates on two studs located in center of each housing. Tighten nuts to 55 to 60 ft-lb. [7.6 to 8.3 kg m] torque in sequence as shown in Fig. 14-9.
3. Bend long tab of each special locking plate down over housing surface, bend one short tab up against flat of each hex nut.

Slave Piston Adjustment Procedure

Loosen and back off locknut, Insert socket head wrench and back slave piston adjusting screw out of housing until slave piston seats in it’s bore.

Slave piston adjustment must be made with the engine stopped (warm or cold) and the exhaust valves closed. Bar the engine in direction of rotation until "A" or "16 V.S." mark on accessory drive pulley lines up with the timing mark on the gear case cover. With the engine in this position, the exhaust valves of cylinders 16 are closed.
Insert a 0.18" feeler gauge between the slave piston and the crosshead, turn the adjusting screw in until a slight drag is felt on the feeler gauge. Continue turning engine in direction of rotation and set slave piston clearance on cylinders 25 and 34.

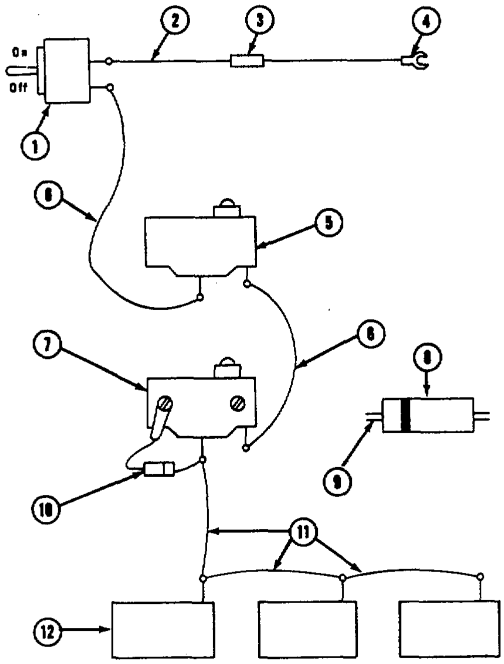
To bleed brake units for immediate operation, manually depress solenoid armature five or six times in succession with engine running to permit oil to fill passages in housing.
Attach electrical harness to terminal in Engine Brake housing.

Mount fuel pump switch and actuating arm using capscrews on fuel pump to secure switch.

Actuating arm may be bent or relocated to contact switch when throttle lever is in idle position.

Adjustment
Adjust screw in actuating. arm so that audible "click" is heard when throttle arm moves to an idle fuel position.

Note: Check PT Fuel Pump throttle shaft to insure that throttle pedal will move throttle shaft to full fuel position after installing the actuating arm.



1	Dash Switch	8	Diode-Exploded View
2	Black	9	To Switch Terminal For Negative Ground
3	Fuse	10	Diode Position For Negative Ground
4	To Key Switch	11	Red
5	Clutch Switch No. 1495	12	Brake Units
6	Green		
7	Fuel Pump Switch		

Fig. 20-5. (N12032 J). Wiring diagram

OPERATION

Energizing the Jacobs Brake effectively converts a power producing diesel engine into a power absorbing air compressor. This is accomplished when desired by motion transfer through a master slave piston arrangement which opens cylinder exhaust valves near the top of the normal compression stroke releasing the compressed cylinder charge to exhaust.

The blow down of compressed air to atmospheric pressure prevents the return of energy to the engine piston on the power stroke, the effect being a net energy loss since the work down in compressing the cylinder charge is not returned during the expansion process.

Exhaust blow down occurs as follows:

1. Energizing the solenoid valve permits engine lubricating oil to flow under pressure through slave piston control valve to both the master piston and slave piston.
2. Oil pressure causes the master piston to move down, coming to rest on injector rocker arm adjusting screw.
3. The injector rocker arm adjusting screw begins upward travel (as in normal injection cycle) forcing the master piston upward and creating a high pressure oil flow to the slave piston. The ball check valve in the control valve imprisons high pressure oil in the master slave piston system.
4. The slave piston under the influence of high pressure oil flow moves down, momentarily opening exhaust valve, while the engine piston is near its top dead center position, releasing compressed cylinder air to the exhaust manifold.
5. Compressed air escapes to atmosphere completing a compression braking cycle.

Operating A Vehicle With Jacobs Brake

In order to retard a vehicle on a downgrade using the Jacobs Compression Brake, and if the engine speed exceeds maximum rated R.P.M. for a desired road speed, a lower gear should be selected. The selection of a lower gear will generally allow complete control of the vehicle by the Jacobs Compression Brake, leaving the vehicle service brakes in reserve to be used for emergency stops.

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FRAMES

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GENERAL

Since the frame is depended upon to keep the major components of a vehicle in their relative positions, it is highly important that the frame be kept in good condition at all times.

TYPES

Because International chassis are manufactured with frame rails of either cold rolled steel, heat treated steel, or aluminum alloy, each must be handled in a specific manner to assure maximum service life.

IDENTIFICATION

No unusual difficulty should be encountered in identifying aluminum alloy frames. These side rails and cross members are made of thicker material than are the components of a comparative size steel frame. If there is any doubt, use a file to expose the material hardness or color. There are several methods of identifying heat treated frame rails, the most common of which is a stencil marking on the inside middle section of the rail or a stencil mark on one of the cross members. The stencil notes that the rail is heat treated and rail flanges must not be drilled or welded. This is to caution against the welding of addi-tional brackets or crossmembers or the weld-ing of full length reinforcement rails. Minor repairs as indicated in later paragraphs are acceptable.

A number of the heat treated frame rails have small patches covering "Brinell" test mark along the inside (web) of the rail. These patches are at about three or four foot intervals. The patch can be removed to expose the "Brinell" marking.

Some rails are stamped "H" for heat treat-ed, on the upper face of the rail flange about three inches from the rail end.

ALIGNMENT

Method Of Checking

A satisfactory method of checking the frame and axle alignment, particularly when a body and cab is on a chassis, is to mark on a level floor all points at which measurements are to be taken. Tack or tape pieces of paper to the floor directly under each point of measurement on the chassis as indicated by the letter "K" in Figs. 2. Use a plumb bob since the points of measurement must be accurately marked in relation to the frame in order to obtain a satisfactory alignment check.

After each measurement point has been carefully marked on the floor, proceed as follows:

1. Locate center line of chassis by measuring front and rear end widths, using marks on floor. If frame widths check, draw center line on floor, full length of chassis. If frame widths do not check, lay out center line as follows:
2. Center line can be drawn through the inter-section of any one pair of equal diagonals (A-A, B-B, C-C, D-D) and center point of one end of frame or through points of intersection of any two pairs of equal diagonals.
3. Measure distance from center line to opposite points marked over entire length of frame. Measurements should not vary more than 1/8" at any point.
4. Measuring diagonals (A-A, B-B, C-C, D-D) will indicate point where misalign-ment occurs. If diagonals in each pair check within 1/8", that part of frame included between points of measurement may be considered in satisfactory align-ment. These diagonals should intersect within 1/8" of center line.

Axle Alignment With Frame

After determining that the frame is properly aligned, the axle alignment with the frame should be checked by comparing diagonals.

Dimensions for side elevation of frame should be checked at the points indicated and should not vary more than 1/8".

REPAIR AND REINFORCEMENTS
(Non Heat Treated Frames)

Cutting

Whenever it is necessary to cut the frame, the side rail should be cut at an angle of 45 degrees. This method distributes the cut and weld over a greater area than a cut made at right angles with the rail.

Reinforcing

Reinforcements can be made with flat, channel or angle stock. Because of difficulties encountered when inserting channel reinforcements into the frame side rails, the use of angle reinforcements is acceptable. When ever possible, the reinforcement should extend from the front axle to slightly beyond the rear spring front mounting bracket

This procedure, of course, may

be impractical because of the position of attached units and existing crossmembers. The reinforcement thickness should not exceed that of the side rail to be reinforced.

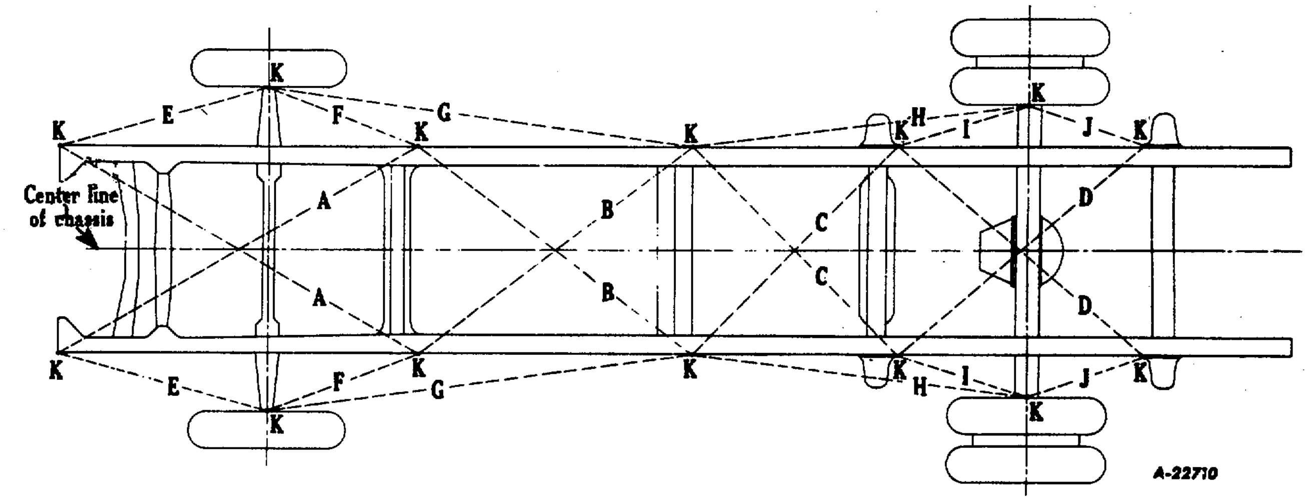

Fig. 2.

Riveting

Hot rivets are acceptable, as they can be more easily driven with hand tools. Cold rivets should only be used where tools of sufficient power to properly set the rivets are provided.

Rivets should be from 50% to 100% as heavy in diameter as the total thickness of the plates to be riveted.

Welding

Electric arc-welding is recommended for all frame welding.

The reinforcements should be welded to the frame after the reinforcements are riveted. All unused holes should be filled with welding material. The welding rod should be substantially the same material as that used in the frame.

Preparation Of Frame For Repair

Before welding the reinforcement to the cracked section of the frame side rail, certain preparations are necessary to insure strength and stableness of repair. To prevent further spreading of the crack, a hole should be drilled at the starting point of the crack, Fig. 4. Widen the crack its full length, using two hacksaw blades together. Groove or bevel both sides of the crack to permit the weld to penetrate to the surface and establish a solid contact between the reinforcement and the frame side rail. Grooving can be accomplished by grinding or with a cape chisel.

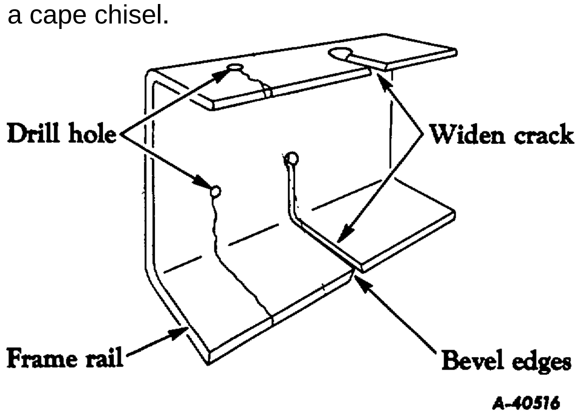

Fig. 4 Showing Method of Drilling Frame Rail to Stop Progress of Crack. Also shows Method of Preparing Crack for Welding.

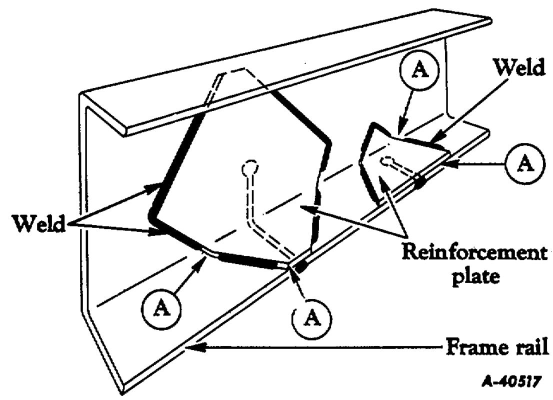

Fig. 5 Suggested Types of Reinforcing Plates and Method of Attaching to Frame Rail.

IMPORTANT: Do not weld into the corners of the frame or along the edges of the frame side rail flanges "A", Fig. 5. Welding at these points tends to weaken the frame and encourage development of new cracks.

Use only the shielded-arc method for all frame welding. Heat generated during welding is localized and burning of material is minimized whenever this method is used. (Fig. 6) Additional advantages are that the finished weld can be ground, filed, and drilled as necessary.

With the reinforcement positioned in the frame side rail, follow the welding patterns shown in Fig. 5 as closely as possible.

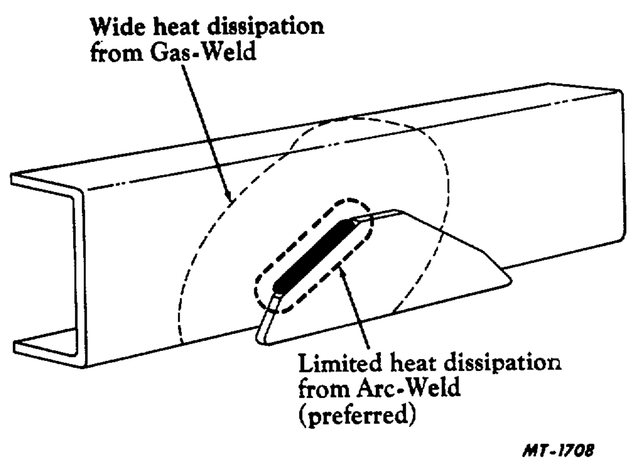

Fig. 6 Weld Sample Showing Lower Heat Dissipation Possible with Shielded Arc Welding.

Important

In addition to the specific recommendations given in these paragraphs, always remember the following general rules of welding "good housekeeping".

1. Surface areas and edges to be joined must be clean and free of oil or grease.

2. Always avoid craters, notching, and undercutting.

3. Peen new welds to relieve stresses caused by shrinkage.

Positioning of Frame Reinforcements

Whenever practical, the welding of frame reinforcements should be confined to the web of the side rail rather than the flanges. This procedure provides the strongest possible assembly.

Avoid at all times welds made square with the side rail, either on webs or flanges. When welds are made at an angle of at least 30 degrees from square, there is less possibility of setting up dangerous stress concentrations in the rail. Physical tests of the strength of various welds have shown that a weld made at an angle of at least 30 degrees from the direc-tion of strain will retain the original physical properties of the complete rail section.

Frame Straightening

Use of heat is not recommended when straightening frames. Heat weakens the structural characteristics of frame members and all straightening should be done cold. Frame members (except aluminum) which are bent or buckled sufficiently to show cracks or weakness after straightening, should be replaced or reinforced.

Repair and Reinforcements
(Aluminum Alloy Frames)

The cutting and welding of aluminum alloy frames for repair or reinforcement can be accomplished providing correct procedures are followed and proper welding equipment is utilized. The use of heat for straightening aluminum frame rails is not recommended.

BOLT SPECIFICATIONS AND TORQUES

While most IH frames are of riveted construction, there are some frames which are assembled with bolts and nuts. Bolting, though more costly does provide the field with a time saving advantage when replacing cross-members or frame attaching parts.

If bolting is used for altering or adding to the frame, the following precautions must be observed.

NOTE: Bolts to be used for installing fifth wheels must be 5/8" diameter high strength material such as I. H. type 8 (SAE grade 8) bolts. Type 8 bolts can be identified by the six radial lines on the head of the bolt. Nuts must be of corresponding type.

The torque value for tightening these bolts is 220-250 ft. lbs. and is based on new bolts and nuts lubricated with engine oil. If frame components are aluminum, flat washers must be used next to the aluminum whether under head, nut or both.

Proper tightening of bolts and nuts is most important, since the strength of the joint depends on the maximum clamping force between the members.

REPAIR AND REINFORCEMENTS
(Heat Treated Frames)

With the use of heat treated frame rails in International vehicles, it becomes advisable to outline some of the procedures to be followed whenever these frames require repair.

Heat treated frame rails must not, of course, be intermixed with non-heat treated rails. If one side rail is to be replaced, the new rail material must match the old frame rail.

Preparation Of Frame For Repair

A good method to follow when repairing a cracked frame where the crack is accessible from both sides is as follows:

a. Grind a V notch or groove extending along the full length of the crack and slightly beyond each end of the crack. A heavy copper strip or "chill" should be clamped to the rail side away from the groove to help control the temperature and cooling rate. See Fig. 7. NOTE: Discarded short lengths of heavy copper electrical bus bars make suitable chills.

b. Preheat the frame rail along the crack area to 500-600 degrees to burn off excess oil or paint then permit heated area to cool to 200 degrees or below before welding is started. Under no circumstances should the rail be heated to a temperature exceeding 900-950 degrees F. since this is the tempering temperature of the rail.

c. Either alternating current or direct current reversed polarity, combined with a short arc and a beading or narrow weave technique may be used.
Direct current reversed polarity is recommended or preferred.

d. Slag should be removed after each pass and an interpass or constant temp

e. When sufficient metal has been deposited, the weld bead should be ground flush, Fig. 7, with the surface being repaired.

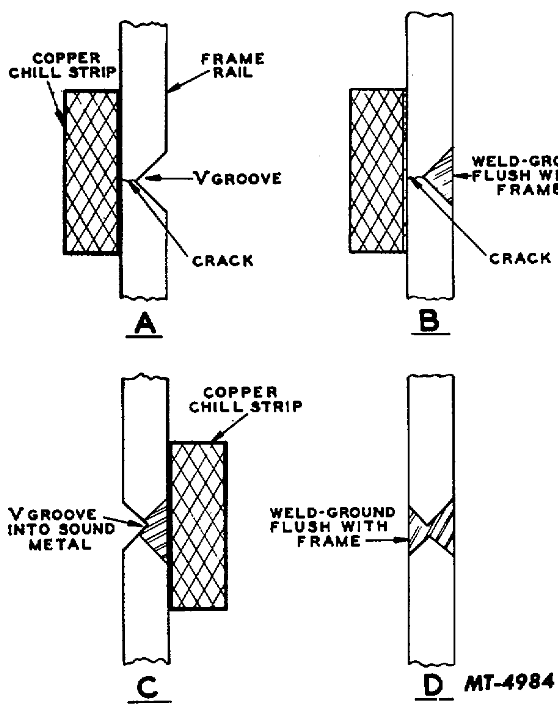

Fig 7.

f. Where both sides of the frame rail are accessible, a V-groove is ground from the side opposite the repair and the procedure outlined above repeated. Dependent upon accessibility, "chill" strips should be used wherever possible. The V-groove ground on the opposite side of the repair should be deep enough to enter the sound metal of the first weld repair "C" of Fig. 7.

Frame

Welds on heat treated material tend to reduce physical properties in the weld heat-affected zone. Because of this, it is recommended that all reinforcements be designed so that all welds are parallel, rather than perpendicular to the frame rail edges. Welds perpendicular to the flange edges will reduce the carrying capacity of the rail, Fig. 8 and 9.

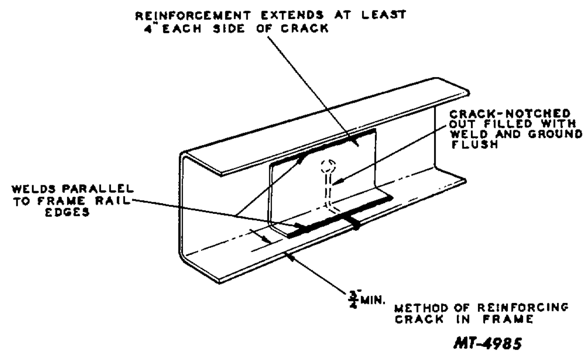

Fig. 8.

The edge of the reinforcement flange to the edge of side rail flange dimension should be held to a minimum of three quarters of an inch to keep the heat-affected zone from extending to the sidemember flange edge. Wherever possible, it is recommended that plug welds of the type shown in Fig. 9, be substituted for edge welds when assembling the reinforcement to the side rail. Plug welds offer the advantages of a reduced heat-affected zone plus increased flexibility and reduced stress concentrations. When using this method, one half inch (minimum) diameter holes should be drilled and chamfered in the reinforcement on 2" center to center distances. At no time should these holes be drilled in the frame rail being repaired. The reinforcement should then be installed in its proper position on the sidemember and the holes filled with weld material.

Again a minimum dimension of 3/4" should be maintained between the weld and the edge of the sidemember flange. The voltage, amperage and pre-heat specifications listed below should be followed.

Welding Position	Amperes	Voltage
Downhand	13 0/140	21/23
Overhead	130/140	21/23
Vertical Up	110/120	22/24

Use low hydrogen electrodes which have superior crack resistance and notch toughness similar to AWS-E-11018. This type electrode should be stored in a moisture-free container to avoid porosity during welding.

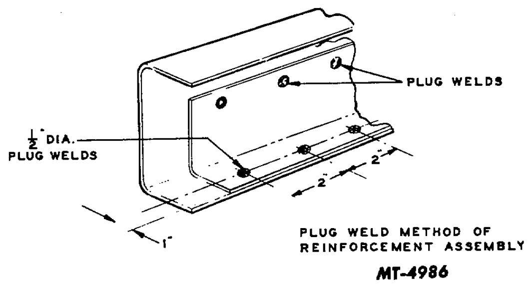

Fig. 9

Full Length Reinforcement

When heat treated frames are to be rein-forced over a greater portion of their length, frame channel reinforcements should be in-stalled using bolts. Bolts of high strength material conforming to SAE grade 5 or better should be used. The bolts and nuts should be inspected periodically and kept tight, since the strength of the reinforcement depends some-what on the maximum clamping force between the members.

Drilling

The drilling of heat treated frame rails presents no unusual difficulty. Standard high speed drills of good quality will serve provided they are sharpened properly and not overheated during sharpening or use. There are, however, special high speed twist drills available having special materials which will hold a cutting edge longer. These drills are expensive and require especially rigid support, otherwise drill breakage will result.

When drilling heat treated rails, like in any other drilling operation, sufficient pressure must be applied to the drill bit to maintain continuous cutting. The drill point should frequently be drenched with cutting oil (soluble oil) to help cool the drill. Avoid letting a drill bit turn in the work without cutting. To do so will usually overheat and ruin the drill.

The drill must be held steady during the drilling operation. Avoid wobble or change of drill angle during the drilling operation.

Frame Straightening

When heat treated frame rails have been bent or twisted, they should not be heated for straightening. This work should be done with the frame rails cold. Heating for straighten-ing purposes is likely to destroy the rail temper in localized areas, which will bring about rail failures.

AIR CLEANER

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Subject Page

AIR CLEANER

GENERAL

Air must be clean if engine is to de-liver proper performance throughout its life span. Dirty air introduced into the engine may ruin the carefully engineered close tolerance of the engine.

Air cleaners are designed to supply clean air to the engine; and if not kept clean, the supply of air will become restricted. This will cause loss of power, sluggish performance and poor gas mile age.

Dry Type Air Cleaner

The dry type air intake filter, Fig. 1) em ploys a dry type paper element which is sealed at the outlet end so that all air drawn into the engine must enter through the element. There is no oil used in this unit, hence, the reference to "dry type." The direction of air flow in this filter is from the outside to the inside of element, permitting excess foreign particles to fall free from the outside of the element during road operations. This action prolongs the service period of the filter.

AIR CLEANER SERVICE INSTRUCTIONS

Dry Type Air Cleaners

Heavy-duty: Shown in Figure 2
Loosen clamps and remove dust cap, wipe out dust and clean gasket. Do not use solvents, gasoline or oil to clean cup. Daily inspection of the air cleaner dust cup should be made if dusty conditions warrant. Do not allow dust deposits to build up past 2" level in cup.

Do not strike the bottom rim of the cartridge against any hard surface. Damage could result to the rim and affect the sealing at reassembly.

The dry type filter element can be washed with a nonsudsing household detergent. Use warm water (120°-140°F). Flush filter with gentle stream until drain water is clean. Air dry filter before using. Also inspect after every cleaning for damage or rupture. Re-place filter every 10, 000 to 20, 000 miles depending on dust conditions. Wipe all internal parts clean before reassembly. Replace gaskets regularly.

These air cleaners are equipped with an evacuator valve as shown in Fig. 2, item 6.

The vacuator valve should be inspected at regular intervals to be sure the valve is not plugged due to the presence of lint, chaff, etc. which may collect in the valve. The vacuator valve can easily be removed and cleaned.

Do not allow dust level in cup to build up to within ½" of slot (cutaway lip on baffle flange) in the cup baffle.

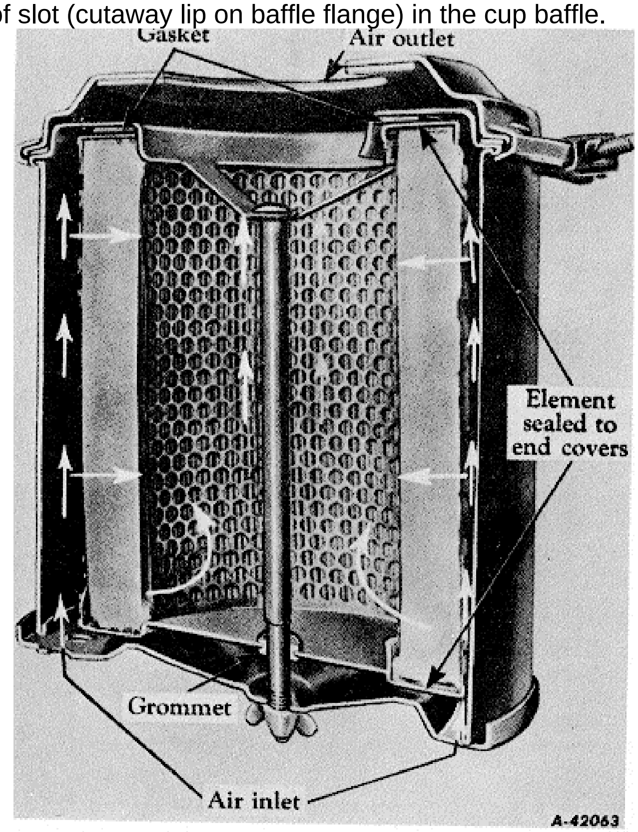


Fig. 1 Dry Type Air Cleaner

Excessive smoke or loss of power are good indications that the filter element should be re-placed or cleaned. Clean or replace every 5, 000 to 25, 000 miles or every 150 to 750 hours depending upon dust conditions.

The filter element can be cleaned several times before replacement is necessary. Recommended cleaning methods for the filter element are:

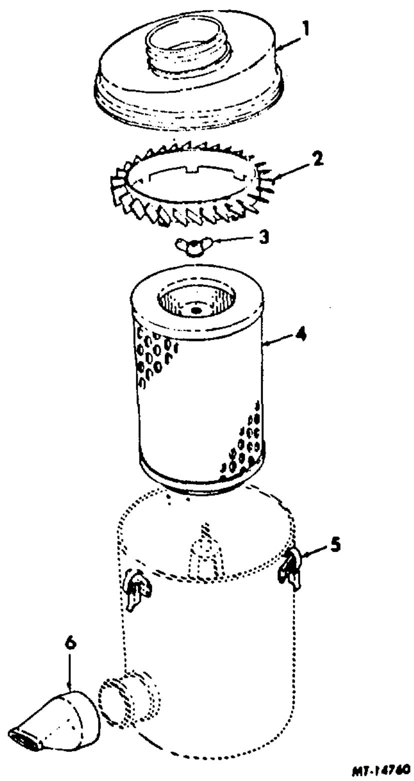


Fig. 2 Heavy Duty Dry Type Air Cleaner

Legend for Fig. 2.

1	COVER, Air Cleaner
2	RING, Fin
3	NUT, W/Gasket, Wing
4	ELEMENT, Air Cleaner
5	CLAMP, Cover (3 Required)
6	VALVE, Evacuator

Compressed Air:

Direct a jet of dry, clean air against inside or clean air side of the filter element. Holding nozzle about six inches away from element, move nozzle up and down, rotating element until no dust is visually being removed (approxi-mately 10 minutes). Direct air perpendicularly to pleats using 100 psi maximum air pres-sure. Do not damage element with the air flow from nozzle.

Washing:

Filter element can be cleaned by washing in water using a nonsudsing detergent. Proportions are 2 oz. of cleaner to 1 gallon of water. For best mixing results use a small amount of cool tap water, then add to warm (70° - 140°F) water to give proper proportions. The warmer (100°F) the solution, the better the cleaning. Soak element for 15 minutes, then rotate element back and forth with clean water. If a hose is used to wash or rinse the filter, be careful not to rupture the paper with the water jet. Rinse the filter element until drain water be-comes clear. Proper rinsing is very important. Let filter element air dry completely before using. Do not use compressed air for drying.

IMPORTANT: After cleaning filter element using either of the above recommended methods, inspect the filter element for damage:

1. Dust on downstream (inside) or clean air side,
2. Slightest ruptures.
3. Damaged gaskets.

Ruptures can be detected on any dry type element by placing a light inside the filter element. Inspection of the element on the outside will then disclose any holes or ruptures. Any hole in the filter element, even the smallest, will pass dust to the engine and cause engine wear.

Injectors
PT type

Shop Manual

Table of Contents

Injector Service Tools

Tool No.	Description	Injector Type or Engine Series
ST-668	Spray Angle Tester	All Injectors
ST-708	Orifice Burnishing Tool	PT (type B, C & D)
ST-790	Test Stand	All Injectors
ST-838	Test Stand Adapter	PT (type D) 5/16" diameter series
ST-990	Leakage Detector	All Injectors
ST-095	Cup Wrench	PT (type D)
ST -1072	Crowfoot Cup Wrench	PT (type D)
ST-1089	Plunger Extension	PT (type D)
ST-1090	Orifice Torque Wrench	PT (type B, C & D)
ST-1129	Flowmeter Kit	All Injectors
ST-1145	Installation Torquing Tool	All Injectors
ST-1210	Master Injector (132 cc flow)	PT (type D)
ST-1058 Adapter		**PT (type D)**
ST-1298	Injector Assembly Stand	All Injectors
ST-1306	Master Injector (178 cc flow @ 80%)	PT (type D)
ST-1332	Orifice Plug Gauge	PT (type B, C & D)
3375000	Ultrasonic Cleaner	All Injectors
3375048	Cup Wrench	7/8" 6 splined type
3375084	Injector Assembly Stand	All Injectors
3375086	Testing Adapter Pot Spring Tester	PT (type D)

Injector test stands (ST-790) are available in many different voltages. When a test stand is installed, be certain the voltage being supplied matches the voltage requirements on the name plate.

The following list represents the voltages available in ST-790 injector test stands.

ST-790-A	220 Volt, 3 Phase, 60 Cycle
ST-790-F	230 Volt, 1 Phase, 60 Cycle
ST-790-G	115 Volt, 1 Phase, 60 Cycle
ST-790-J	220 Volt, 3 Phase, 50 Cycle
ST-790-M	380 Volt, 3 Phase, 50 Cycle
ST-790-P	230 Volt, 1 Phase, 50 Cycle
ST-790-U	208 Volt, 3 Phase, 60 Cycle

Operating Principles
The PT fuel system is used exclusively on Cummins Diesels. The identifying letters, "PT," are an abbreviation for "pressure time."

Injector Description
The PT Injector is a simple mechanical unit which receives fuel from the fuel pump under pressure and meters, injects and atomizes it through fine injector cup spray holes into the combustion chamber.
The general description "PT Injectors" is used only to indicate that the injector is used with the PT fuel system and not with the former Cummins Disc fuel system.

Cylindrical PT (type D) Injectors
The PT (type D) Injector is a refinement of the PT (type B and C) cylindrical injectors used in Cummins engines with internal fuel drillings. The PT (type D) top stop injector is shown in Fig. 6-1-5.
By parts design changes, the PT (type D) provides more parts interchangeability and those areas subject to wear are localized in smaller parts for easier servicing. Former injectors have a body with the moving part or plunger running the full length, the PT (type D) has a short barrel and plunger to provide the same function. The shorter barrel plunger bore made possible use of materials with greater wear resistance and results in smaller replacement assembly. The barrel/plunger assembly is made up of a coupling (3, Fig. 6-1-5), plunger (11) and barrel (12); the coupling and plunger are swaged assembly.

The "Top-Stop" injector functions like the standard PT (type D) injector except the upward travel of the injector plunger is limited by an adjustable stop. The stop is set before the injector is installed in the engine. Fig. 6-1-5.

Injector Parts-PT (type D)
Adapter

In Fig. 6-1-5, the adapter (2) houses the plunger return spring (1), adjustable orifice (5), orifice gasket (4), fuel screen (6) and screen retainer (7) and carries the "O" ring seals (8) on the outside which seal against the head to form fuel inlet and drain passages. Fuel enters through orifice (5) and flows to barrel (12), pass check ball (10) to the cup-to-barrel passage up to the metering orifice where it is metered into the cup (14). Fuel not used circulates past the metering orifice, around the plunger and out the drain passage while the plunger is seated in the cup. The cup, adapter and barrel are held in assembled position by the cup retainer (13).

Metering Orifice of PT (type D) Injector
The metering orifice near the cup end of the barrel is of fixed size and must not be altered In any way, barrels differ for engine model In relation to the size of the metering orifice as governed by engine fuel requirements

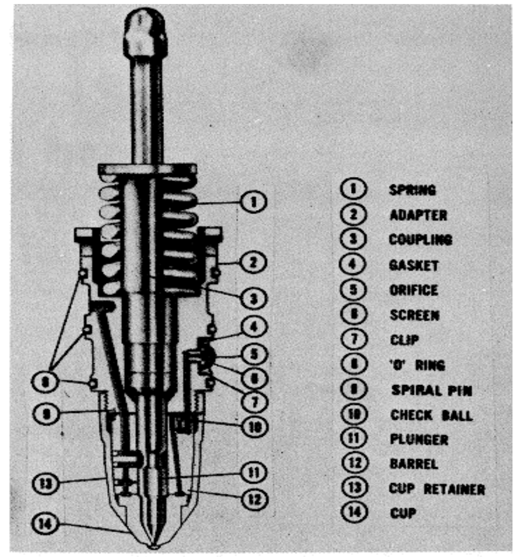


Fig. 6-1-5, FWC27. Cylindrical PT (D) injector cross-section

Top Stop Parts
The top stop injector parts are the same as the standard PT (type D) except the adapter (2, Fig. 6-1-5) is longer to accommodate the stop. The plunger coupling top is smaller, allowing it to pass through the stop. The injector spring washer (15), adjustable stop screw (16) and stop screw locknut (17) are parts required only for top stop injectors.

Disassembly
The disassembly, cleaning, inspection, repair and assembly procedures described on the following pages are those operations that may be performed in a clean, well equipped shop. Operations other than those described must be performed in a qualified Cummins Rebuild Station.

PT (type D) Injectors

1. Lift out injector plunger and spring. Remove spring from coupler and test as described on the following pages
2. Store plunger by standing on coupling end.

   Note: Injector barrels and plungers are class fit, do not interchange.

3. Remove "O" rings from injector adapter and discard.

4. Remove button-style screen retainer ring, and remove screen. Check screen and discard if damaged.

Note: Do not remove adjustable orifice plug from inlet groove.

5. Insert injector into loading fixture.

6. Slide 3375102, Body Wrench, over flats on injector. Place ST-995, Retainer Wrench, on injector.

7. Activate air cylinder or tighten special screw to hold injector in place. Loosen cup retainer but do not remove. Fig. 6-1-9.

8. Deactivate air cylinder or loosen special screw.

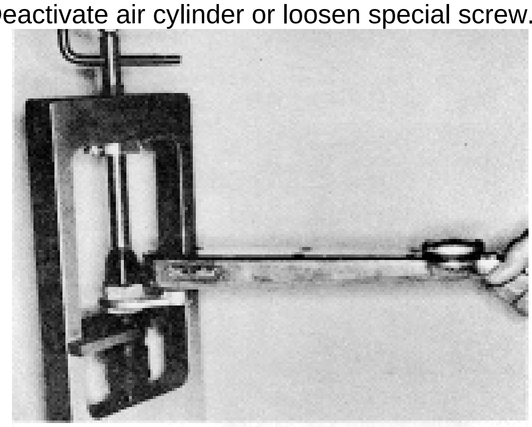


Fig. 6-1-9, F60197. Loosening cup retainer

9. Remove injector clamp and ST-995 from fixture.

10. Another method of loosening retainer is to use a 1-¼ inch box or open end wrench on ST-995 and a 1 inch wrench or injector.

11. Screw off cup retainer and remove cup, barrel and discard gasket. DO NOT LOSE CHECK BALL.

12. Remove check ball from top of barrel. Fig. 6-1-10.

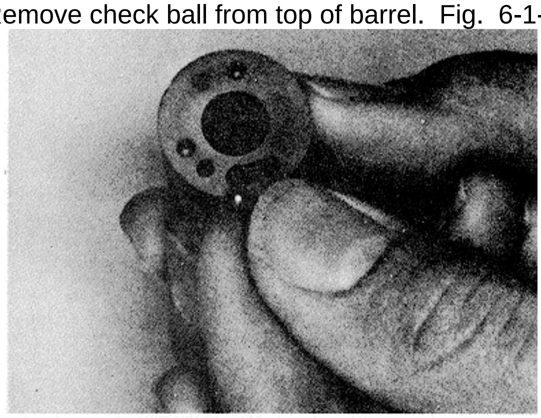


Fig. 6-1-10, F60190. Removing check ball

Cleaning and Repair

1. Clean injector parts thoroughly of any carbon varnish by soaking in a solvent such as "Bendix Metal Cleaner," "Kelite Formula 1006" or equivalent. Ultra-sonic cleaning in service tool 3375000 is recommended for barrel, plunger and cup.
2. Neutralize solvent after cleaning by dipping parts in mineral spirits.
3. Dry with clean compressed air.

Caution: Do not use drills or other instruments to clean cup holes that will alter size of holes. Wires may be used if a smaller size wire is used than the spray hole.

4. A clean shop; clean tools and good cleaning practices are essential to good injector repair. Most injector failures occur because of dirt. Clean all parts before assembly.

PT (type D) Injectors Plunger Link

Replace plunger link if worn excessively. See Fig. 6-1-23.

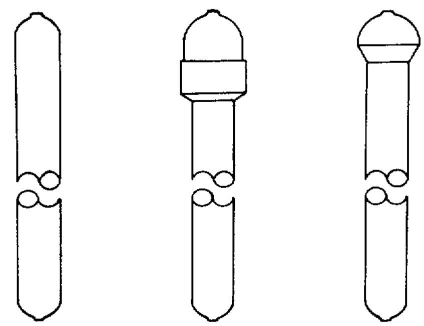


Fig. 6-1-23, F60188. Plunger link wear

Injector Plunger-Coupling

1. Check closely for metal seizure. As a rule this is the only true indication of scuffing or scoring.
2. Bright spots or surface disruption at top of machined area plunger, on opposite side at bottom of plunger or at mid-point, usually are normal results of rocker lever thrust action. Unless metal is displaced or wear is measurable at these points, the plunger may be reused. If worn excessively return barrel and plunger to a Cummins Rebuild Station for fitting of a new plunger.
3. Narrow streaks running the length of the plunger usually are the result of the varying thickness of penetrant treatment used to prevent rusting. Plunger is satisfactory for reuse unless a surface disruption is evident.
4. Check area where plunger is swaged to coupler for cracks and looseness, by attempting to rotate by hand.
5. Excessive wear or fretting may be found on spring contact area of coupling flange.

Table 6-1-4: Injector Spring Data

	Approximate		Wire	Load Required to Compress Springs to Length			
Part No.	**Free Length Inches [mm]**	**No. Coils**	**Dia. Inches [mm]**	**Length Inch [mm]**	**New Min. Lb. [kg]**	**New Max. Lb. [kg]**	**Worn Limit Lb. [kg]**
166009	1.95 [49.7]	8	0.187 [4.75]	1.663 [42.2]	143,25 [65]	158.75 [72]	138 [63]

6. Check socket for wear or cracking

Caution: Handle injector plunger with care to prevent damage which could render it useless.

Injector Spring

1. Check spring for excessive wear or mutilation.

2. Test spring tension on spring tester, Fig. 6-1-15, that is capable of very accurate measurements of spring lengths and applied load by means of standards and dial indicator gauge. Table 6-1-4

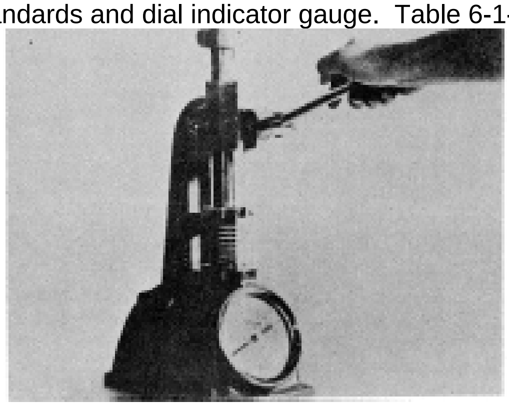


Fig. 6-1-15, F60163. Testing injector spring

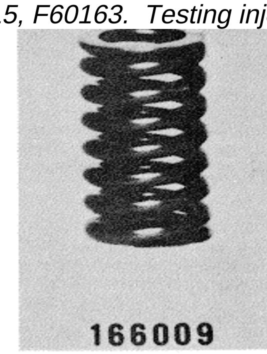


Fig. 6-1-16, Injector spring

3. If injector springs compress to dimensions shown, at less than load indicated under "worn limits," springs must be discarded.

Injector Cup

1. Inspect injector spray holes and tip with magnifying glass. Compare with new cup shown in Fig, 6-1-17. Discard cup if any of following conditions exist.

a. Abrasive wear. This wear can begin internally, therefore, inspect both interior and exterior. Fig. 6-1-18.

b. Corrosion damage and effect of excessive heat: This condition usually results from high acid or sulphur content in fuel or overload operating conditions. Fig. 6-1-19.

c. Enlarged or distorted spray holes. Caused by cleaning with drills or other instruments.

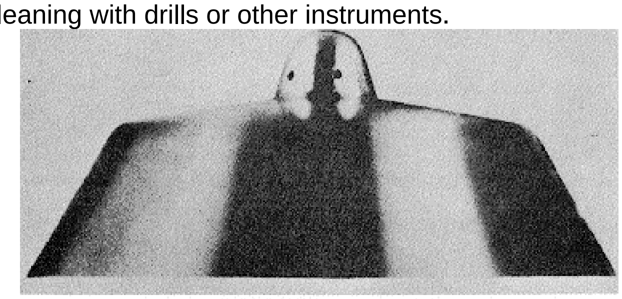


Fig. 6-1-17, F60105. New injector cup tip

Fig. 6-1-18, F60223. Cup tip damaged by wire brushing

2. Inspect cup for plunger seat pattern. If plunger seat covers 40 percent continuous area around cup cone or plunger bore, it is possible cup may be reused, but it must pass the ST-990 cup-to-plunger leak test. Seat location is not important. Fig. 6-1-20.

Caution: Never alter size of injector cup spray holes.

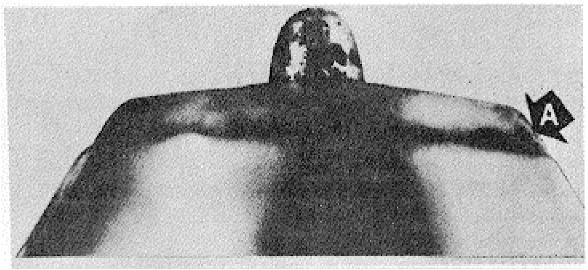


Fig. 6-1-19, F60107. Corroded injector cup tip

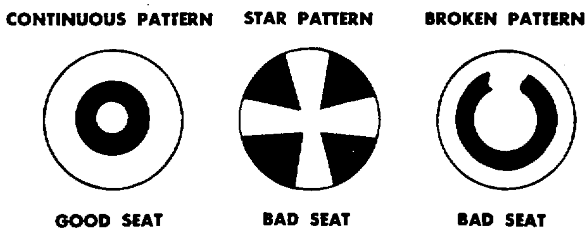


Fig. 6-1-20, F60108. Seat pattern of plunger In cup

3. Check injector cup barrel surface for mutilation and flatness.
a. For mutilation check in area (black area) as shown in Fig, 6-1-21.

b. Using a flat steel plate (preferably a lapping plate) and "bluing" to check for surface flatness.

c. If mutilation or unevenness are found, mark for repair.

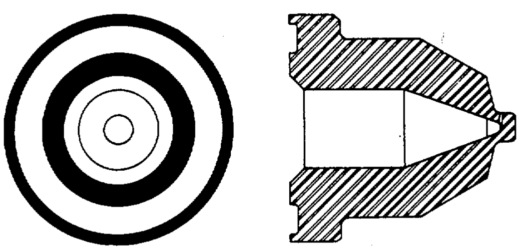


Fig. 6-1-21, F60161. Cup surface at body contact area

4. PT (type D) injector cups with black finish, are improved material, and are completely interchangeable with "old-style" stainless steel cups.

Cup Retainer

1. Inspect the threads for damage.

2. Check outside cone area for nicks or burrs which could prevent proper seating with sleeve in head.

3. Inspect inside of cone area on cup seating ledge for nicks or burrs which could prevent cup seating.

Injector Barrel - PT (type D) Injectors

1. Inspect injector barrel plunger bore for scoring. If injector will pass the ST-990 leakage test, barrel is useable. If leakage is too high barrel and plunger must be replaced.
2. Use strong magnifying glass to check for burrs, carbon and distorted radii in orifice. When metering orifice is damaged, the injector will not function properly. Do not attempt cleaning with wires, plug gauges, etc.; use solvent cleaners.
3. Check fuel passage plugs for looseness and barrel for cracks.
4. Check injector barrel surfaces for mutilation and flatness in black area as shown in Fig. 6-1-24.

a. Thoroughly clean and dry barrel of all oil film before bluing.

b. Using a surface plate (preferably a lapping plate) and "bluing," check for surface flatness.

Table 6-1-6: Cup Contact Area of Barrel

"A" Dia Inch [mm]	"B" Dia.	"C" Dia.	"D" Dia.
0.400 [10.16]	0.540 [13.72]	0.710 [18.03]	0.820 [20.83]
0.337 [8.56]	0.480 [12.19]	0.650 [16.51]	0.706 [17.93]

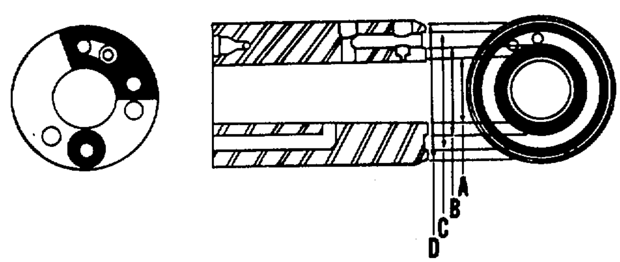


Fig. 6-1-24, F60191. Barrel surface at cup contact area

c. If mutiliation or unevenness are found, lap to repair.

d. Do not use crocus cloth or wire brush on barrel and cup contact area.
5. If 5/16 type injector has been overheated, the barrel to adapter gasket can melt. Loss of injector cup retainer torque will occur; therefore, the following items should be suspected:

a. Lubricating oil dilution or blocked injector spray holes.
b. Damaged injector sleeves or damaged injector plungers.

CHECK BALL AND SEAT

1. Check the ball seat for nicks or burrs.
a. Do not attempt to improve the checkball seat by inserting a ball and tapping. The barrel is as hard as the ball and will damage the ball if attempted.
b. If the seat is marred, lap the barrel.
2. If any wear or mutilation is found, replace the ball. PTD injector check balls are made of special material. 'Do not attempt to substitute with a commercial made ball.

ADAPTER

1. Check balance orifice for burrs or other obstructions.
2. Inspect both fuel passages to be certain they are open.
3. Inspect cup retainer threads for damage.
4. Check "O" ring areas for nicks or burrs which could damage "O" rings during installation.
5. Inspect barrel mating surface for nicks or burrs. If damage is found, lap to repair.

ASSEMBLY

PT (TYPE D) INJECTORS

The ST-1298 and 3375084 are two types of loading fixture tools.

The ST-1298 has been redesigned so cup to plunger, alignment pressure is maintained by an air cylinder. The air cylinder reduces injector assembly time.

If you have ST-1057 or 3375084 and wish to add the air cylinder attachment, it is available as ST-1298-5111.

1. Drop check ball into top of barrel.

CAUTION: Be certain all mating surface parts are clean and free of burrs or other imperfections which could result in incorrect flow or torque. Lap to repair.

2. In repair of the injector, the gasket between the barrel and adapter is required for 5/16 type only.
3. Hold barrel with check ball up and place new adapter spiral pins into barrel. (Roll pins are no longer used.)
4. Turn adapter and barrel with barrel up and place cup on barrel.
5. Lubricate cup retainer threads and cup flange contact area with 20 or 30W lube oil and assemble to adapter. Screw retainer down finger tight and loosen ¼ turn.

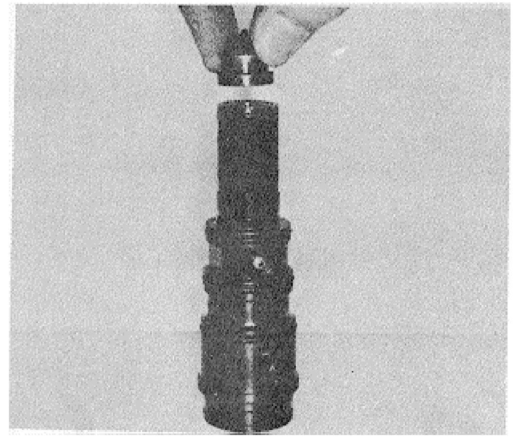


Fig. 6-1-32, F60194. Installing cup on barrel

6. Immerse injector plunger in clean injector test oil and install in adapter without spring.
7. Raise 3375103 Special Stud in 3375084 Holding Fixture.
8. Insert injector into loading fixture.

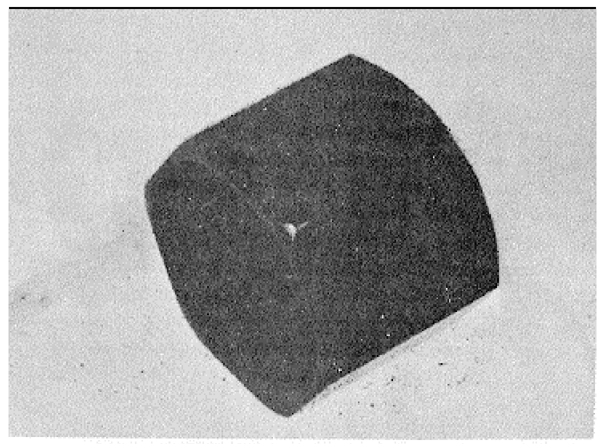


Fig. 6-1-30, Injector Cup Wrench - ST-995

9. Slide 3375102 Body Wrench over flats on injector adapter.
10. Place ST-995 retainer wrench upon injector retainer (Fig. 6-1-30).
11. Lubricate threads of 3375103 stud and screw in 3375084 Loading Fixture stand far enough to hold injector (Fig. 6-1-33).
12. Tighten stud in 3375084 to 75 in. lbs. (8.5 N.m), Fig. 6-1-34, or activate air cylinder on ST-1298 to 70 psi (483 kPa) to align cup and plunger. Fig. 6-1-35.
13. Tighten cup retainer with ST-1072, Crowfoot Wrench, and ST-995, Retainer Wrench, to 50 ft. lbs. torque (Fig. 6-1-36).

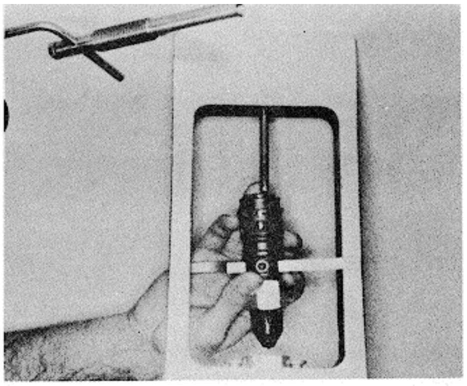


Fig. 6-1-33, F60195. Installing retainer wrench on injector

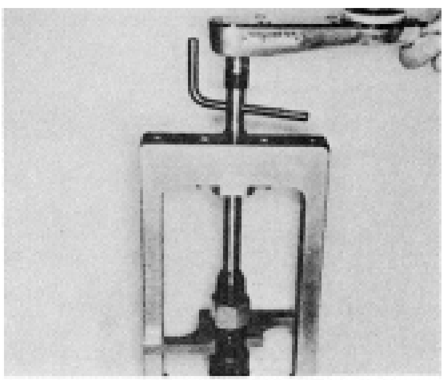


Fig. 6-1-34, F60196. Torquing loading fixture stud of 3375084

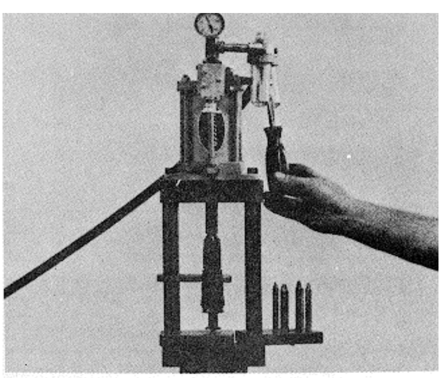


Fig. 6-1-35, F60235. Adjusting air pressure on ST-1298

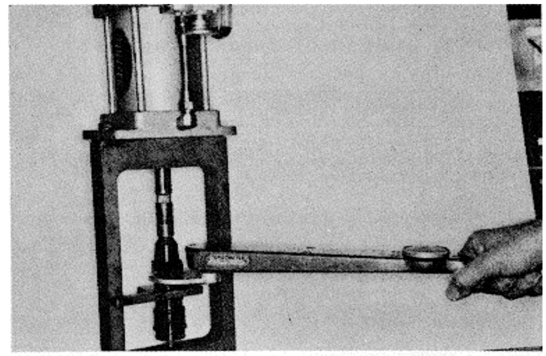


Fig. 6-1-36, F60197. Torquing cup retainer - injector in ST-1298

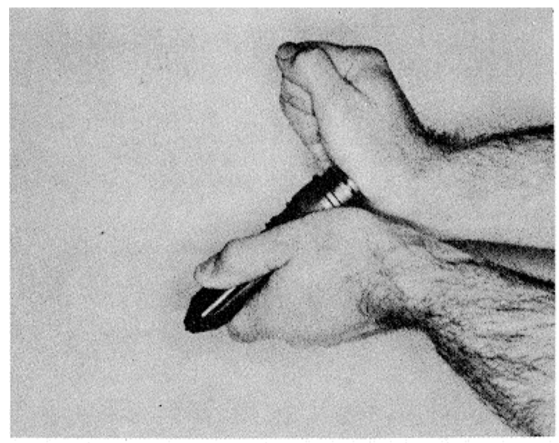


Fig. 6-1-38, F60198. Checking plunger to cup binding

14. Remove injector from loading fixture being careful not to hit cup on stud.
15. To check cup to plunger alignment, remove plunger and coat with clean fuel oil or test oil again. Install ST-1089 on plunger.
16. Hold injector in vertical position (cup down) and allow plunger to drip a few drops of test oil into cup.
17. Insert plunger about 1/2 inch (12.7 mm] into barrel to be certain plunger is started straight.
18. Jam coupling with palm of hand to seat plunger in cup and rotate 90 deg. while holding plunger firmly against cup seat.
19. Hold injector with cup up and plunger should slide out when injector is lifted quickly.
20. If plunger does not slide out, remove plunger, coat tip and repeat test.

21. If plunger sticks because of misalignment, loosen cup retainer, rotate cup one fourth turn, and retorque. Repeat as necessary.
22. Remove plunger from adapter and lubricate plunger with test oil. Install spring on plunger and insert into adapter.
23. Check plunger leakage on ST990 or ST570 as described c the following pages.
24. Check cup spray pattern on ST668 as described on the following pages.
25. Another method of checking open cup spray holes is follows:
    a. Remove plunger and spring.
    b. Fill barrel and cup full of fuel oil.
    c. Insert plunger with ST1089, less spring, into inject(forcing fuel out spray holes. Fig. 6138.

    Caution: At anytime fuel is forced from cup spray holes be sure to keep hands or body out of pray stream to prevent injury.

    d. Remove plunger and install spring.
26. Lubricate and install new "Viton" "O" rings into proper grooves in adapter.
    Note: Viton "O" rings are identified by a green band.
27. Install new fuel inlet screen and retainer. Fig. 6142.
28. After assembly, store in clean place until ready for leakage test.

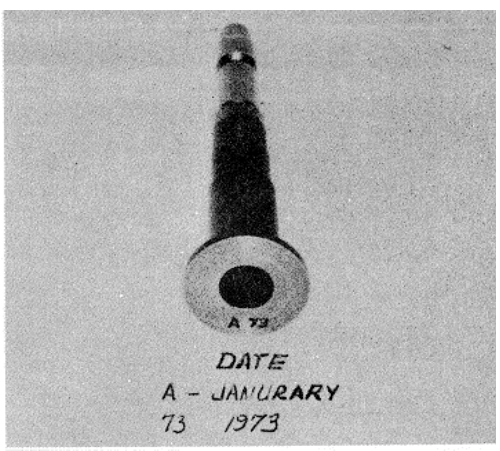


Fig. 6-1-39, F60199. Marking location on plunger

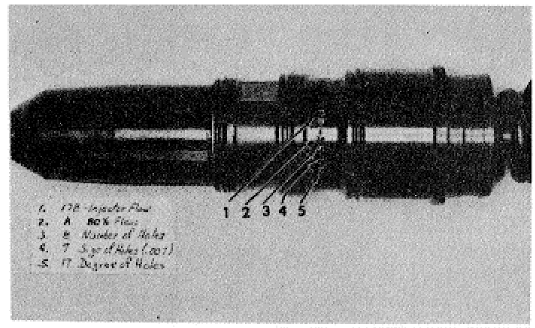
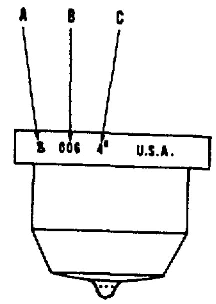


Fig. 6-1-40, F60200. Size location on Injector adapter



A HOLES B SIZE C ANGLE

Fig. 6-1-41, F60201. Size marking on Injector cup

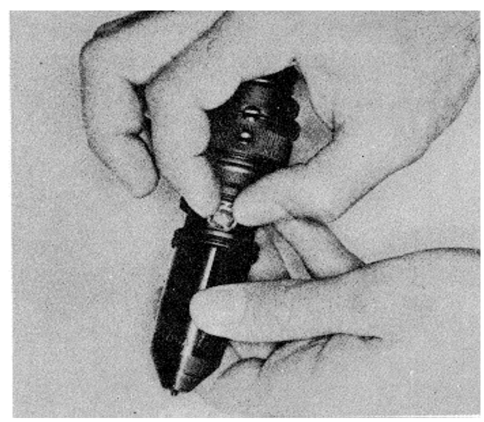


Fig. 6-1-42, F60202. Fuel inlet screen and retainer

Leakage Checks

The plunger to body and plunger to cup leakage check gives a measurement of fuel bypass between plunger body and plunger cup to help determine if injector is to be rehoned or can be calibrated and reused in an engine.

ST990 Injector Leakage Tester

The ST990 Injector Leakage Tester was developed and released in order to make available to the field a standard tool to accurately determine the degree of acceptability of used injectors. Fig. 6144.

The ST990 performs tests on all current Cummins PT injectors except L series. These tests are as follows:

1. Body to plunger leakage in area below the metering orifice. With the plunger retracted off the cup seat by approximately 0.048 inch [1.22 mm], air is forced through the cup spray holes past the body to plunger clearance and is measured with a precision flow meter. This check supersedes the body to plunger leakage test on the ST790, In which injector delivery with a 0. inch [1.3 97 mm] restrictor orifice is compared to delivery with the standard 0.011, 0.013 or 0.020 inch [.28, .33 or .51 mm] orifices (depending upon injector model).
2. Cuptoplunger seat. The plunger is seated in the cup with 200 lbs. [90.72 kg] load. Any leakage is measured in bubbles which are released under a fluid. level.

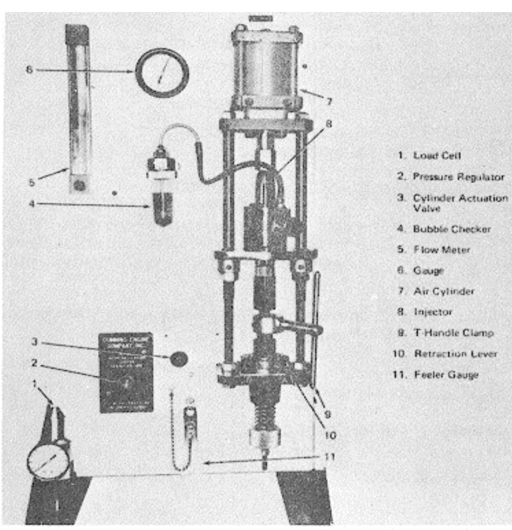


Fig. 6-1-44, F60167. ST990 injector leakage tester

This check was incorporated into the ST990 as a time and labor savings. Very little extra time is required to check the cup to plunger seat while the injector is installed in the machine for the body to plunger tests. This check is preferred over the ST570 leakage check.

Installation

Requirements Of ST990

The following facilities are necessary for acceptable installation of the ST990:

1. A clean area with good lighting. An enclosed fuel systems area is preferred. When a tightly enclosed room is used, due to the extreme sensitivity of the air flow meter, the ball float will fluxuate slightly during opening and closing of the door. Other than not being able to obtain an accurate reading during actual swinging of the door, such a room has no adverse effects and is desirable.
2. A work bench of standard height which is not subject to pounding or other heavy work. The bench must not have a vise or other shop equipment which is generally subject to impacts.
3. An air supply of 80 psi [552 kPa] minimum pressure. The air line to the ST990 should not be in a location where intermittent pressure drops are caused by actuation of other shop air equipment.

Assembly And Installation Of ST990

1. Mount rubber isolation pads to feet with capscrews provided.
2. Mount feet to panel. When feettopanel capscrews are snug, panel must be installed in a vertical position to insure proper operation of air flow meter.
3. Fill air cylinder oiler 1/3 to 1/2 full of injector test oil. Fig. 6145. Make sure sealing ring is in place before tightening bowl retainer.

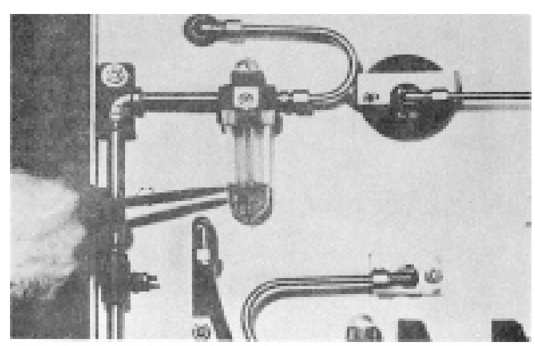


Fig. 6-1-45, F60168. Air cylinder oiler oil level

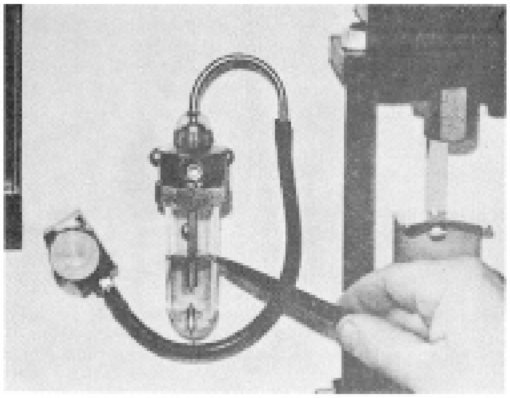


Fig. 6-1-46, F60169. Bubble check or bowl oil level

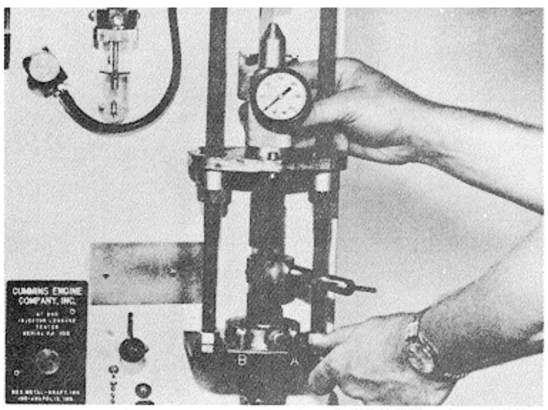


Fig. 6-1-47, F60170. Installing ST-990 load cell

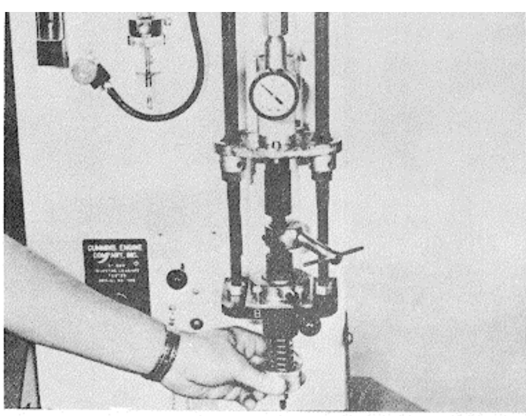


Fig. 6-1-48, F60171. Adjusting load cell pressure

4. Fill bubble checker bowl with injector test oil to oil level marker. Fig. 6-1-46. To more easily fill bowl to specified level, it may be filled approximately 3/4 full and then drained to proper level through valve at bottom of bowl.
5. Use a vise-grip wrench while connecting air supply line to prevent disturbance to threads.
6. Install T-handle clamping mechanism backed out approximately 1/2 thread turn from snug position.
7. Install retraction handle and lock into position with jam.
8. Set pressure regulator at 60 psi [414 kPa].
9. Operate air cylinder a few times and set final pressure at precisely 60 psi [414 kPa]. The air pressure must be held at 60 psi [414 kPa] during all tests.
10. The velocity of air cylinder piston rod may be adjusted as desired with small valve at rear of panel. Loosen locknut and screw valve stem in to decrease piston speed or back screw out to increase piston speed. Lock the nut on the stem when desired piston speed is attained.
11. With retraction lever in "A" position, install load cell and clamp into position. Fig. 6147.
12. Adjust knurled knob until load cell reads 200 psi [1379 kPa]. Fig. 6148. The psi [kPa] reading on load cell is a direct reading in pounds [kg] load, since load cell piston area equals 1 square inch [6.45 sq cm]. Adjust knurled a knob to obtain 200 lbs [90.7 kg) load during several clamping cycles.
13. With load cell clamped at 200 lbs. [90.7 kg) load, use the feeler gauge to adjust locknuts into position and tighten. Clamping mechanism should be checked daily with load cell and locknuts adjusted If necessary. Do not adjust locknuts unless load cell is used.

ST-990 Plunger-To-Barrel And Plunger-To-Cup Check

PT (type D) Injector

1. Remove ST10583 locating screw from Service Tool 3375086 or ST1058 Adapter Pot Assembly. Oil injector "0" rings. Install ST1089 Plunger Extension on plunger. Remove spring.
2. Align injector delivery orifice with locating screw hole or burnishing hole in adapter pot.
3. Using hand pressure, ST1298 or 3375084, press injector into pot until it bottoms. Fig. 6156.
4. Insert and tighten locating screw.
Note: When testing Service Tool 3375089 or ST10586 Spacer must be used.

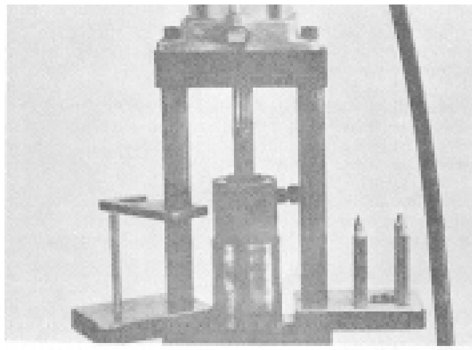


Fig. -1-56, F6234. Inserting injector into ST-1058 pot

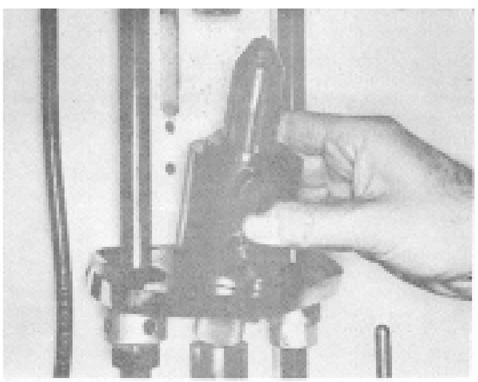


Fig. 6157, F60204. Installing injector in ST-990

5. Plug fuel inlet port with ST66814.
6. Install injector into ST990 and clamp into position. Support plate may be tilted for easier installation of injector. Fig. 6157.
7. Adjust knurled knob to obtain proper clearance with feeler gauge between knob and locknuts. See Fig. 6159. Do not adjust locknuts.
8. Install and tighten transfer line in injector drain port. This is the port on operator's right, facing front of test stand.
9. Tighten T-handle clamp. See Fig. 6-1-60.
10. Shift retraction lever from "A" to "B" position. See Fig. 6161. This removes load from plunger and allows it to be retracted from cup seat by approximately 0.048 inch [1.22 mm] . Make sure plunger retracts. The adherence of mating surfaces between plunger and cup sometimes holds plunger Fig. 6160, F60174. Tighten T-handle clamp In cup seat.
11. In this position presence of bubbles in bubble-checker is disregarded. Read air flow meter at top of ball float.

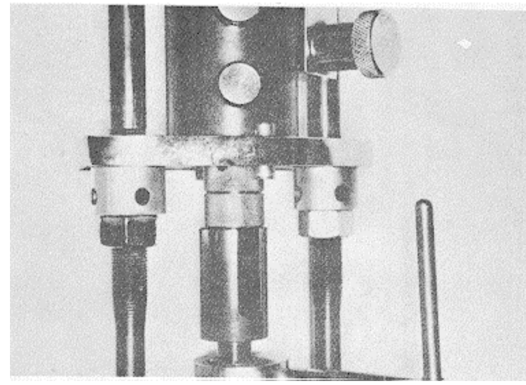


Fig. 6-1-58, F60205. ST1089 spacer used with injector

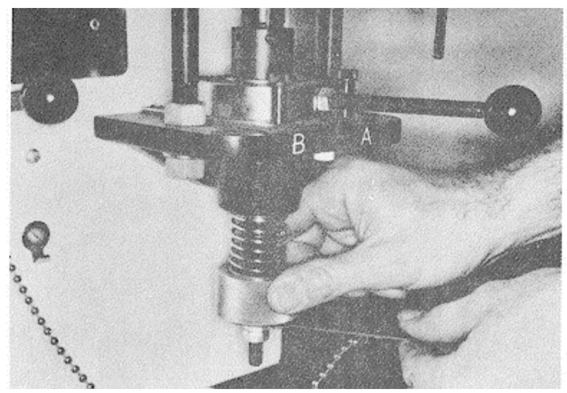


Fig. 6-1-59, F60173. Adjusting knurled nut for feeler gauge clearance

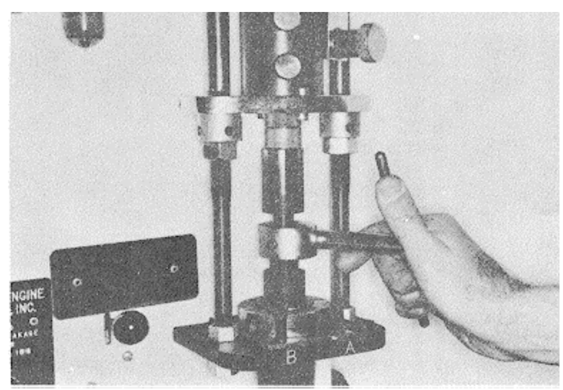
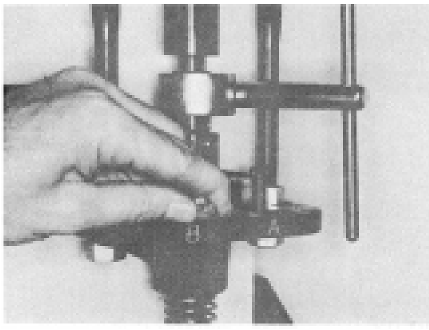


Fig. 6-1-60, F60174. Tighten T-handle clamp



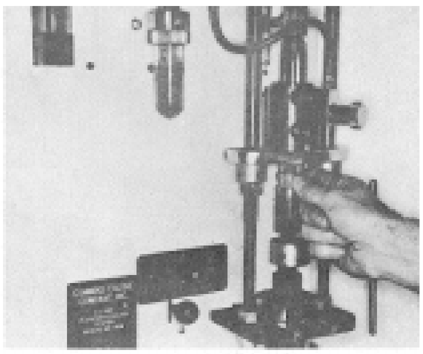


Fig. 6-1-62, F60176. Rotating plunger coupling and spacer

12. Rotate plunger top in clockwise direction by very small increment and observe flow meter reading. See Fig. 6162. Do not touch plunger top or any part of clamping mechanism while taking reading since external forces will disturb plunger from its normal position and may affect barrel-to-plunger leakage in cup area.
13. Continue to rotate plunger by small increments to fin, highest reading on flow meter.
14. Maximum readings on injectors which will satisfactorily perform throughout another service period are listed in Table 6-1-13.

Table 6-1-13: ST990 Leakage Tester Data - Units of Leakage

Injector Model	Size	New	Worn Limit
PT (Type D)	3/8 Plunger	2.5	4.5
PT (Type D)	5/16 Plunger	2.2	4.5

15. If maximum leakage of injector being checked exceeds specified values, injector barrel must be sent to a rebuild station for re-plungering.
16. If maximum leakage does not exceed values listed In Table 6113, shift retraction lever back to "A" position and loosen T-handle clamp. This applies 200 lbs. (90.7 kg] load to plunger.
17. The cup-to-plunger seal is acceptable if no bubbles occur in 10 seconds or if time interval between consecutive bubbles of air observed in bubble checker exceeds 5 seconds.
18. If the cup seat is damaged In any way and the Injector does not pass the ST990 cup-to-plunger seat test, the plunger may be lapped into the cup to obtain good seating. This lapping is to be done in a careful manner, without using the body or barrel. Use no greater than 600 grade paste lapping compound: Applying light pressure, oscillate the plunger in the cup back and forth for approximately one minute.
    Caution: After lapping, both the cup and plunger must be cleaned thoroughly, lapping compound will damage fuel system parts unless removed. The most effective cleaning process is the use of an "ultrasonic cleaner" and an after rinse in fuel oil.
19. With checks completed and retraction lever in "A" position disconnect transfer line, exhaust the air cylinder and remove injector.
20. Remove plunger, reinstall spring and plunger.

Altitude Compensation

The ST990 is an altitude sensitive device and when it Is used to check the body or barrel to plunger leakage, unit readings should be corrected to allow for altitude variations. For every 1,000 feet [305 m] altitude rise above 600 feet [183 m], 0.2 units should be subtracted from the unit reading. For example, if your shop is 6,600 feet [2012 m] above sea level, you should subtract 1.2 (6 x 0.2) units from your unit measurement. The altitude does not affect the cup to plunger leakage check.

Maintenance

1. ST990 injector leakage testers are checked for gauge and flow meter accuracy, leaks, operation and compatibility with other ST990's before release to the field.
2. It is strongly recommended that each ST990 location select a clean used injector which has a maximum leakage in the 8 to 10 unit area and record the maximum reading. When an injector such as this is selected and carefully kept in a secure place, it can be periodically used as an indicator of test stand condition over extended periods of use. The careful selection and safe keeping of an injector such as this is a very important troubleshooting tool in event that discrepancies arise.

3. Drain sediment from air inlet trap daily or weekly as required depending upon amount of contamination in air lines.
   A yellow indicator will appear in upper bulb when sintered filter becomes clogged with foreign matter. The filter must then be removed and cleaned with solvent.
4. Do not obstruct flow meter vent in any way. Oil and oil mist must never be allowed to enter either the drain of inlet of flow meter as this will cause float to stick to the sides of tube.
5. Do not readjust or move injector plate supports on rods.

These have been adjusted at the factory for proper alignment and must not be disturbed.

6. Maintain air cylinder oiler at 1/2 to 1/3 full of injector test oil at all times to insure proper cylinder action.
7. All fittings, filter oiler and bubble-checker bowls (upper and lower) must be kept tight and free from air leaks.
8. Any oil that collects in bowl of separator mounted by dry type filter must be drained regularly. This separator also contains a sintered filter which must be cleaned in solvent at least twice yearly according to all available data.
9. All available data indicates that dry type filter element should be changed twice yearly under normal conditions if sediment bowl adjacent is drained regularly.

Cup Spray Pattern Check

Injector Spray Pattern - ST-668

Two models of ST668 are being used to check cup spray patterns, the first was released in 1960 and contains black-oxide plated seat and seat spacers; the current tool contains "bright" cadium plated seat and seat spacers. The latter unit can be used with all Cummins injectors, while the earlier model cannot be used with 2 degree spray angle injector cups. To check L series injector cups with the latest tool, use ST849 cup seat or black seat from original ST668 tool.

If you have ST668 with black oxide finish seat and spacer, it may be brought up to date by purchasing ST668, Details 36, 2, 1, 17, 18, 19, 20, 22, 23, 24, 25, 4, 37 and 3 from your nearest Cummins Distributor.

The following instructions are written with the understanding that all ST668 Spray Test Fixtures have been brought uptodate.

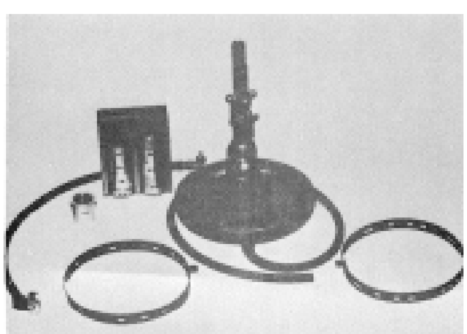


Fig. 6-1-65, F60119. ST668 spray test fixture

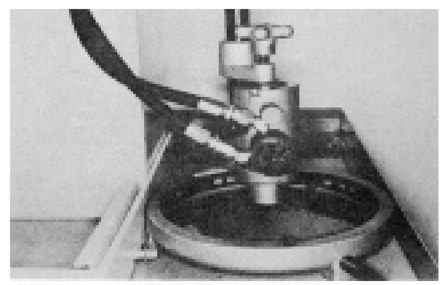


Fig. 6-1-36, F60207. PT (type D) Injector in ST668

1. Locate ST668 on or near ST790 Injector Test Stand, (or other source of 22 psi [152 kPa] constant fuel pressure) so injector inlet connection of test stand will reach Injector to be spray checked. Use injector test oil or fuel oil to perform test.
2. Attach drain hose to ST668 base and place loose end in ST790 drain pan.
3. Assemble applicable cup seat spacer (see Table 6114) to seat bracket bore.
4. Place "H2" seat . in seat spacer and bracket bore (seat bracket bore only, if 2 deg. cups are to be checked) or if L Series cups are to be checked use ST849 (black) seat.
   Check cup markings as shown in Fig. 6-1-40. indicates 7 holes, 0.007 inch [.178 mm] diameter and 17 deg. spray angle).
5. Check cup markings for number of spray holes and place applicable target ring in base of ST668. Target rings are marked on the "handle" (6 and 9 holes or 5, 7 and 8 holes).

6. Insert PT (type D) Injector in Service Tool 3375086 or ST-1058 Adapter. Fig. 6-1-36,
   Note: ST-10585 and ST-1058-6 spacers are not required with ST-668, for PT (type D) injectors.
   Note: Use plunger bore plug assembly ST-668-5012 for PT (type D) injectors.
7. Remove plunger assembly and spring from injector.
8. Select correct size plunger bore plug and rubber seal and; install in injector plunger bore. Protect injector plunger from dirt or damage during tests.
9. Install the solid knurled plug in injector drain opening, Service Tool 3375086.
10. Place injector in ST668 seat and adjust holddown bracket into position required, then tighten thumb screw.
11. Tighten knob against plug and seal in plunger bore so it seals thoroughly.
12. attach fuel inlet line from ST790 or other pressure source to injector inlet On PT (type D) injectors use ST1 058 adapter.
13. Start ST790 Test Stand or other source of fuel and set pressure to 22 psi [152 kPa].
14. Shift target ring in base of tool so one spray stream hits center of No. 1 or index window. This is tallest window and is next to target slide handle. This window provides +3 degrees tolerance on injector spray stream location.
    On 1974 and later injector cups, +2 degrees tolerance must be maintained on all streams.
15. Each spray stream must hit a window in the target ring on 1974 and later cups.
    Note: For a cup to be acceptable no more than one stream must require the increased tolerance of the No. 1 window.
17. After testing, assemble plunger with spring in body adapter 'and store in clean place until ready for flow test.

Table 6-1-14: ST-668 Cup Seat Spacer

Cup Spray	Spacer	Spacer	
Angle	Marking	Height	Inch [mm]
10 deg.	H-10	0.563/0.569	[14.30/14.45]

ST-790 Test Stand Installation and Calibration

Injector Test Stand ST790

The ST790 Injector Test Stand is the recommended calibration equipment for testing and calibrating Cummins injectors, but it must be properly installed and calibrated to obtain the highest accuracy possible.

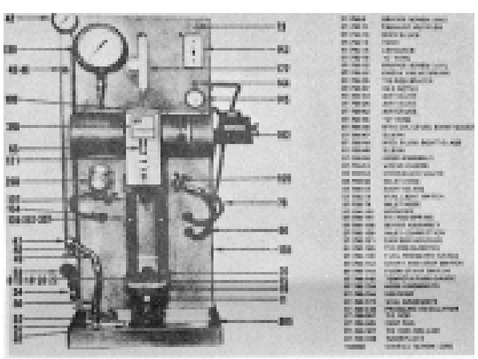


Fig. 6-1-68, F60122. Injector test stand ST-790

ST790 Injector Test Stand (Fig. 6-1-68) is used to test all Cummins PT injectors. ST790 flow tests the complete injector assembly by measuring fuel delivery. The injector is actuated under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes, supplying fuel at a specified pressure, thereby measuring the delivery in a glass graduate.

The ST590 Test Stand was used prior to release of ST790 and may be converted, see your Cummins Distributor. ST790 provides more accurate results, better clamping arrangement and easier operation. The accuracy and advantages of ST790 Test Stand make it very important that ST590 Test Stands be converted; meanwhile, your nearest Cummins Distributor can calibrate Cummins Injectors to the latest specifications.

Test Stand Installation ST790

The ST790 must be located near hot and cold water connections. Water temperature, controlled by a mixing valve, is used to maintain test oil at an 90/95 deg. F [32/35 deg. C] temperature range. If temperature exceeds 95 deg. F [35 deg. C] increase cold water flow. If temperature exceeds 135 deg. F [57 deg. C] drain and replace with new test oil.

1. Fill test oil tank 3/4 full of test oil and maintain this level or higher during test. Test oil capacity is approximately five gallons. It is available from Cummins Engine Company as Part No. 9901168 or Mobil Oil Company No. MCL-41.
2. Fill the hydraulic fluid reservoir to half level in sight bulb with clean Type A automatic transmission fluid. Be careful not to allow oil to enter the standpipe in center of reservoir.
3. Fill cambox with SAE 30 nondetergent lubricating oil to top of sight glass. Refill when oil level gets low in sight glass.
4. Plug electrical connection into receptacle carrying the necessary voltage to operate the test stand.

Description Of Operation ST790

1. A motor driven shaft and a cam are housed in the cam box. The cam actuates the vertical push rod at the bottom of the housing.
2. The push rod is connected to the injector by a link so the injector plunger will be actuated by cam action just as it is in the engine. Fig. 6169.
3. Injectors are clamped in the test stand by hydraulic pressure from the cylinder, piston rod and injector seat. The injector seat contains a removable orifice to restrict the metered fuel flow and cause a back pressure simulating, compression pressures as found in the engine. Be sure to use; correct size orifice. Fig. 6170.
4. Before clamping the injector in the test stand, the cam must be timed by rotating the timing wheel so the wheel mark and pointer are aligned. Fig. 6171.
5. Shop air pressure regulated by air regulator is used to apply a balanced force on the hydraulic system. Fig. 6172. The air gauge at top of hydraulic reservoir is used as a reference indicating that pressure has not changed, after being set using a load test cell during test stand calibration.

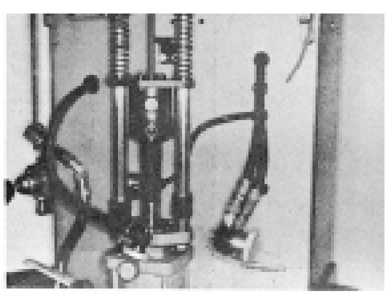


Fig. 6-1-69, F60208. Link and injector in position

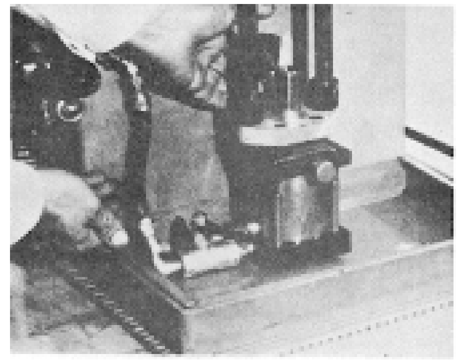


Fig. 6-1-70, F60124. Clamping cylinder and seat

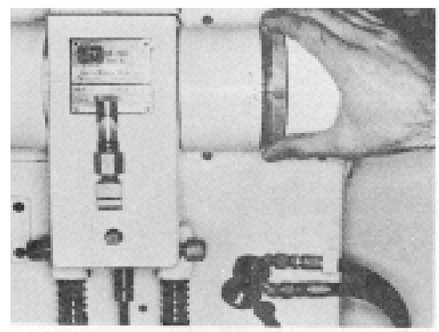


Fig. 6-1-71 F60125. Aligning timing wheel mark

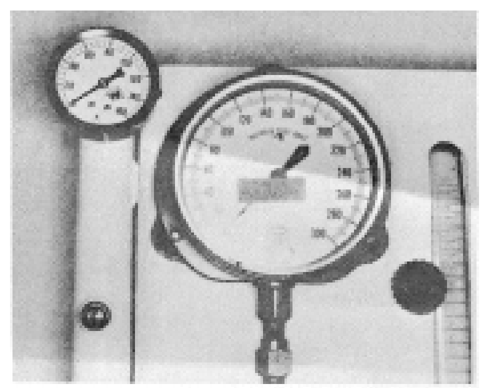


Fig. 6-1-72, F60209. Air pressure and fuel pressure gauges.

6. When the air valve is opened, air travels up the pipe in the center of the tube type hydraulic reservoir and exerts a downward pressure against the column of hydraulic fluid.
7. When both the air valve and the hydraulic valve are opened, hydraulic fluid is admitted under the piston in the cylinder and lifts the injector into clamped position. Any leak in the hydraulic clamping system will directly affect injector loading and must not be permitted.
8. In clamped position and with the appropriate link in place, tension on the injector is the same as it is in the operating engine. Use of the improper link will affect clamp load and upset delivery values.

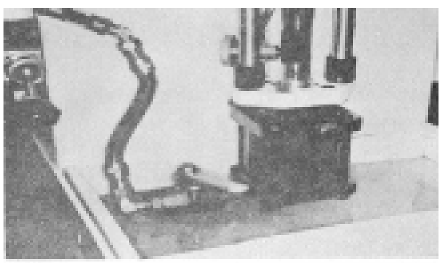


Fig. 6-1-73, F60127. Hydraulic valve

9. Fuel is delivered to the injector through the inlet connector. Fuel pressure here is controlled at this point by a connecting line and pressure regulator. Fig. 6-1-74.
10. The second connection with the clear plastic line is the injector drain connection which carries drain fuel from the injector back to the tank.

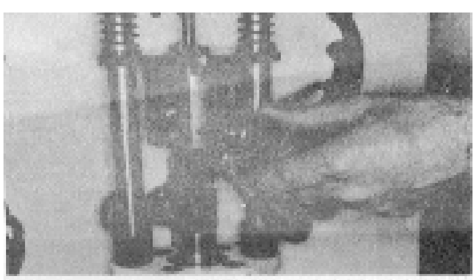


Fig. 6-1-74, F60128. Fuel inlet connector

11. During test stand operation, the operator starts a test cycle which diverts fuel to the vial so the amount of fuel being injected can be measured. Fig. 6-1-75.

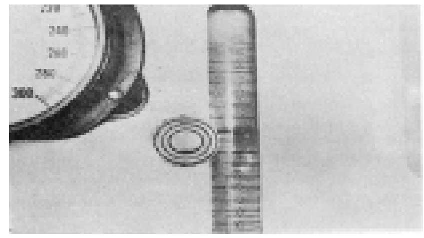


Fig. 6-1-75, F60129. Measuring fuel in vial

12. Fuel is delivered to the vial during a measured number of strokes as recorded by the counter.
13. A master injector which has been previously calibrated at the factory is used in setting the test stand prior to adjusting other injectors for fuel delivery. The master must never be tampered with.
    Note: A cylindrical injector in a pot provides the same conditions as the flanged injectors.

Injector Test Stand Maintenance ST-790

To obtain best service life from the ST790 Injector Test Stand, the following maintenance practice must be observed.

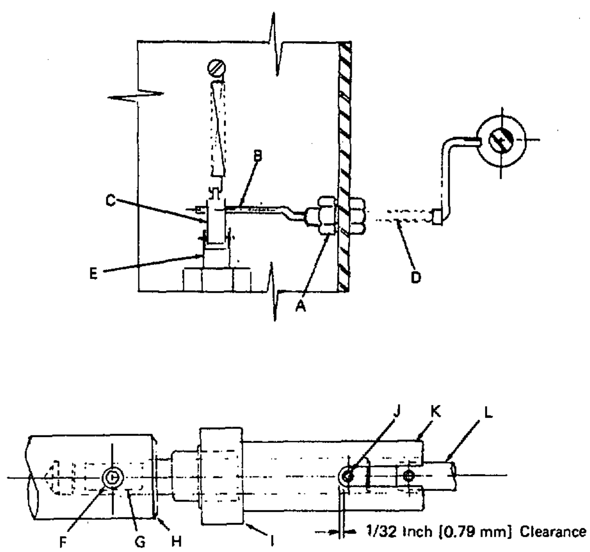
Roller Tappet And Cam Assembly

The roller tappet and cam assembly will wear, just as any moving assembly and will require maintenance.

1. If tappet is worn, it should be replaced as soon as possible to prevent excessive wear on cam. An improved tappet has been used in test Stands built after Serial No. 0576, using a needle bearing roller instead of the former bronze bushed roller.
2. Do not assemble a new tappet with a scuffed cam. If the scuffing cannot be removed with a fine hone, the cam must also be replaced.
3. If the cam is worn into the shaft by more than 0.002 inch [.051 mm] the shaft must also be replaced, as this condition will cause undue loading on cam, tappet and bearings.
4. Align the cam to track 100% on the tappet roller.
5. Torque clamp type ring to 12 to 15 ft-lbs [16 to 20 N m] or tighten setscrew in cam hub securely and install a second setscrew on top of the original one as a "jam screw"

Clutch Adjustment

1. Manually engage clutch by fully depressing solenoid plunger (shown above In "Clutch Arm Removal Procedure"). With clutch held in this position, the cross pin (J, Fig. 6-1-77A) should clear the driver U-slot by approximately 1/32 inch as shown in the drawing.
2. Tighten set screw (F, Fig. 6-1-77A) against flat provided on clutch shaft (G, Fig. 6-1-77A).



A. Nut	E. Plunger	I. Collar
B. Clutch Arm	F. Set Screw	J. Cross Pin
C. Plunger Link	G. Clutch Shaft	K. Driver
D. Clutch Arm	H. Camshaft Shaft	L. Counter Shaft

Fig, 6-1-77A, F60160. Clutch arm removal and clutch adjustment

Gauge Damping And Mounting

One area in which increased compatibility can be realized between factory and field test stands, is fuel pressure gauge hand stability. Erratic action of gauge hand is a result of'

one or both of the following factors:

1. Hydraulic pulsations being carried into the gauge because of damping valve not being properly adjusted. With the adjustable damping valve it is impossible to insure that all test stands can be adjusted to the same degree of damping.
2. Mechanical vibration being transmitted into gauge as a result of one of the following conditions.

a. Operation of test stand with gauge mounts broken.

b. Gauge line positioned so it "pulls" or "pushes" on gauge and in effect becomes a rigid member between gauge and test stand frame.

c. Gauge line contacting frame or other member of test stand thereby transmitting mechanical vibration into gauge.

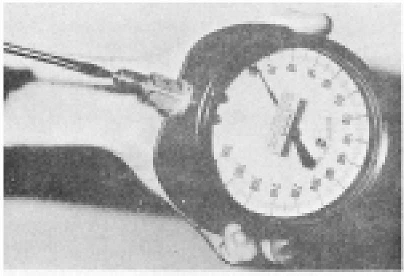


Fig. 6-1-78, F60181. Removing snubber from gauge stem

Removing Air From Fuel Pressure Gauge

1. Remove gauge from test stand. Remove snubber from gauge stem. Fig. 6-1-78.
2. Fill the gauge filling tube with gauge oil or injector test oil and screw it into gauge stem. Hold gauge In position so the 210 psi [1448 kPa] graduation is the lowest point on dial face. While holding gauge in this manner, squeeze tube and release it. When tube is squeezed, gauge hand will be actuated indicating fuel is entering gauge. When tube is released air bubbles will come up through fluid contained in tube indicating air inside gauge is being displaced by fluid Continue to squeeze and release tube several times After air bubbles cease to appear, an additional 5 cycles will insure gauge is completely filled with fluid. Fig. 6179.

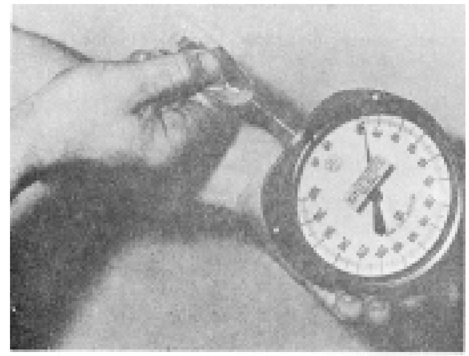


Fig. 6-1-79, F60182. Filling gauge to remove air bubbles

3. Turn gauge so the stem Is in an up position and remove gauge filling tube. Continue to hold gauge stem upright and finish filling internally threaded portion of gauge stem with fluid.
   Note: The gauge must be held with stem In upright position until installation of gauge on test stand.

4. Screw snubber back into gauge stem.
5. Place an injector into operating position In test stand. Start the test stand. When solid fuel begins to flow from the snubber, turn gauge upright quickly and assemble to snubber. Let test stand run while gauge is tightened securely to snubber.
6. Assemble gauge to mounts secure with machine screws and nuts.
7. Start test stand and observe gauge hand rise from 0 to 120 psi [0 to 827 kPa]. It should take approximately 2 to 3 seconds for hand to rise to 120 psi [827 kPa]. If gauge hand is slow to rise and fall, carefully repeat Steps 1 through 6.
8. Check for gauge hand vibration, it should not occur if copper line is properly routed and adjusted.

a. Tubing must be adjusted so it is neither "pulling" or "pushing" on the gauge.
b. Tubing on the gauge must not contact any member of test stand such as frame, motor or gear pump cover.
c. Contact of tubing to any member of test stand will transmit mechanical vibration into gauge and defeat purpose of snubbers and gauge mounts.

Changing Oil And Filter

When changing oil and filters in test stand, adjust regulator to lowest possible pressure during pump pickup to prevent air from being forced into gauge line. If slow gauge hand response does occur, it is an indication air entered the system and the bleeding process Steps 1 through 6 must be performed.

Calibrating The ST790 Test Stand

1. Before operating the test stand make sure that the cam box is filled to the top level of the sight glass with clean SAE 30 nonfoaming lubricating oil.
2. Fill the hydraulic fluid reservoir to bulb level with clean Type A automatic transmission fluid. Be careful not to allow oil to enter the standpipe in the center of the reservoir.
3. The test oil tank on the stand must be kept at least 3/4 full of Cummins 9901168 test oil or Mobil Oil Company No. MCL41.
4. Align timing mark (Fig. 6171) and open the hydraulic valve. Place the load cell, ST7905111, in the test stand and clamp in place by opening the air valve. Fig. 6181.

Note: Never operate test stand with load cell in position.

5. Adjust air pressure by turning the knurled button on the air regulator until the load cell indicates within marked band on load cell gauge. Lock the knurled button in place with the locknut. Note the air gauge pressure (gauge at top of Hydraulic Reservoir). Fig. 6182. Load cell should read between 370 and 390 when adjusted within marked band on dial.

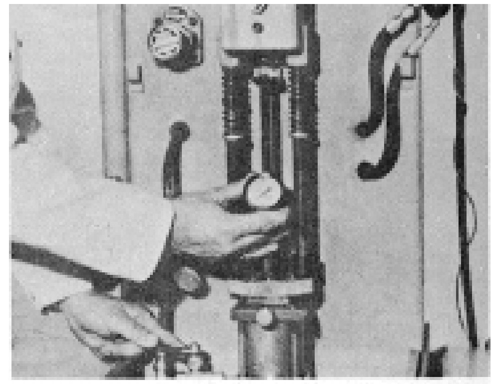


Fig. 6-1-81, F60131. ST789 load cell

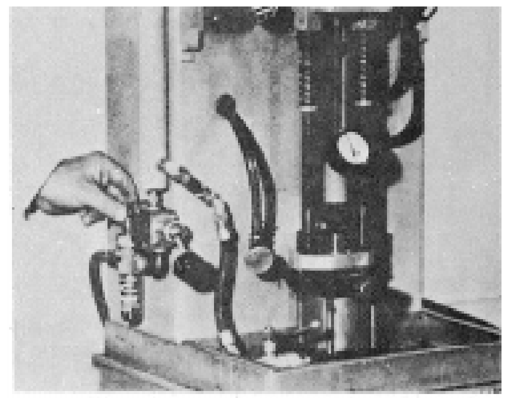


Fig. 6-1-82, F60132. Air pressure adjustment

6. Remove the load test cell by returning the air valve knob to center position. With the cylinder rod in down position, check to make sure the hydraulic fluid shows in the hydraulic oil level.
7. Open the air valve. While the cylinder rod is at the top of its travel check to make sure there is no air in hydraulic fluid sight glass. Fig. 6183.
8. Make sure Injector seat contains 0.020 inch [.51 mm] restrictor orifice when calibrating test stand. Fig. 6184.
9. Place adapter plate over master injector, ST768, ST1210, ST1262 or ST1306, and engage locator In injector mounting holes. Make sure seat is retracted and timing marks are aligned at timing wheel. Fig 6171.
10. Position test stand link (marked NVH, NH, H) over injector plunger link and place assembly in injector seat, tip back until link is below machine push rod. If necessary, adjust bracket so link is aligned but not rubbing.

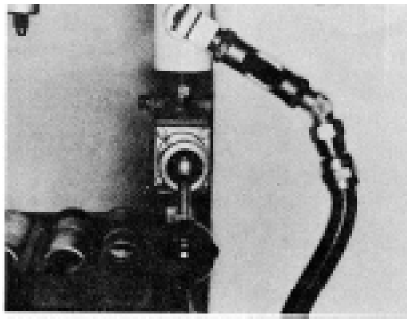


Fig. 6-1-83, F60133. Hydraulic fluid sight glass

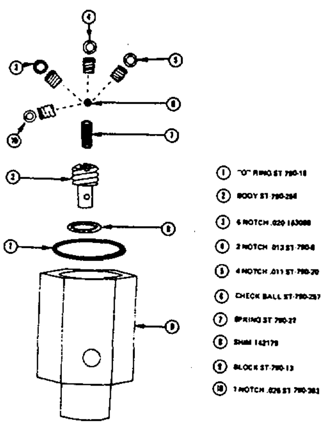


Fig. 6-1-84, F60134. Injector seat restrictor orifice

11. the air valve and as the injector goes in clamped position make sure the link is properly aligned and engaged. Fig. 6185.
12. Check the air pressure gauge at top of hydraulic reservoir as originally established with the load test cell. Close the hydraulic valve to lock the injector in clamped position. Connect the inlet and drain connectors to the injector. Fig. 6186.

Caution:
To avoid damage to master injector, do not use ST708 Burnishing Tool when setting up test stand.

13. Start the test stand motor.

Note: Test oil must be a minimum of 90 deg. F [32 deg. C] . If temperature is not up to 90 deg. F [32 deg. C] test stand must be warmed up on a standard injector, not the master injector. If temperature exceeds 95 deg. F [35 deg. C], increase cold water flow. If temperature exceeds 135 deg. F [57 deg. C] drain and replace with new test oil.

14. Adjust the fuel pressure by turning the regulator knob until the pressure gauge shows 120 psi [827 kPa] . If this pressure cannot be achieved, the trouble probably is due to a sticking air regulator, or to a worn gear pump. Fig. 6-1-87.

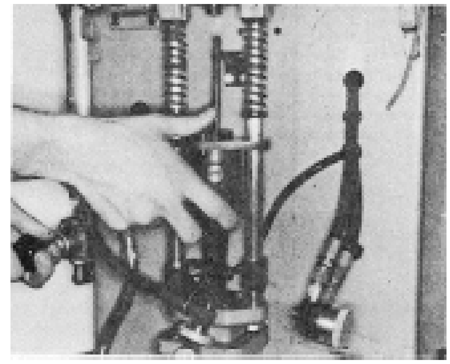


Fig. 6-1-85, F60135. Position assembly

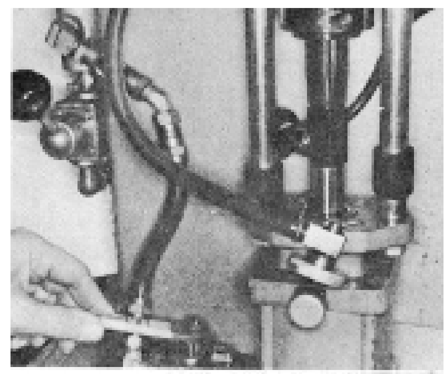


Fig. 6-1-86, F60136. Close hydraulic valve

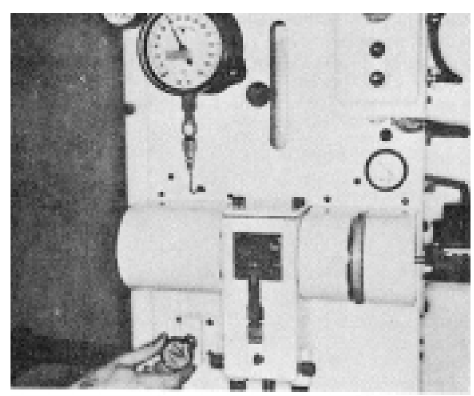


Fig. 6-1-87, F60137. Adjust to 120 psi

Pressure (120 psi [827 kPa]) must be maintained at all times during calibration and testing.

15. All counter wheels must be set at zero (0) as a starting point. Fig. 6188.
16. Shift the silver-colored counter wheels to the right, rotate as necessary then release them to indicate 1020 strokes. Rotate empty vial into position by turning vial knob.
17. Clear the counter by rotating with thumb screw for one complete revolution. All white counter wheels must show zero (0). Fig. 6189.
18. Engage the counter and divert fuel to the vial for measurement by pressing and releasing the red flow start switch.
19. Stir the fuel with a rod to settle out the foam, then, check the amount collected in the vial at the end of the 1020 countstrokes.
20. Look directly into the vial at fuel level to avoid parallax. If this reading shows 129 cc which is 3 cc below the correct injector master delivery specifications (132 cc @ 120 psi), or another value, repeat test. Fig. 6190.
21. Dump the fuel from the vial and repeat the test at least twice to insure consistent results.
22. If 3 cc low, it will be necessary to set the counter up to approximately 1043 strokes or about 7 to 8 strokes for each cc. Roll the counter back, all white counter wheels must show zero (0).

Note: If the counter is set beyond 1050 strokes, it is a good indication test stand is not properly installed or calibrated.

23. Repeat the tests and adjust the counter as necessary, to obtain 132 cc delivery at 120 psi [827 kPa] with fuel temperature at 90 deg. to 95 deg. F [32 to 35 deg. C], while the master injector is in the test stand. Check readings for three cycles to insure repeatability. After each four cycles, reclamp injector to insure maximum accuracy. At this point the test stand is correctly calibrated.

Note: In reading the level of fuel in vial, be certain to read it at the fuel level. Fig. 6190. When reading at "C" height, you are too high. The reading at "B" is the correct height. You are not looking up or down at the fuel level, thereby avoiding parallax. Read the correct cc at the point where fuel appears to change color.

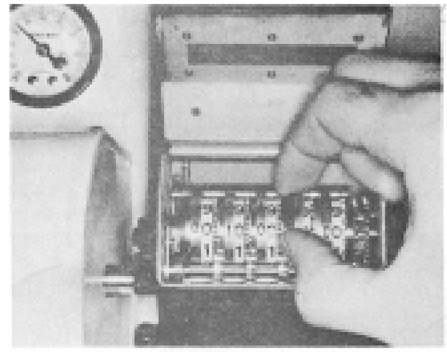


Fig. 6-1-88, F60138. Start counter at zero

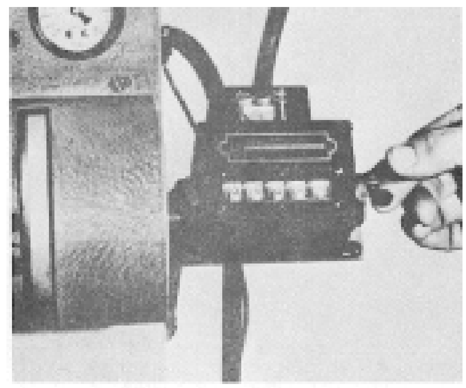


Fig. 6-1-89, F60139. Clear counter

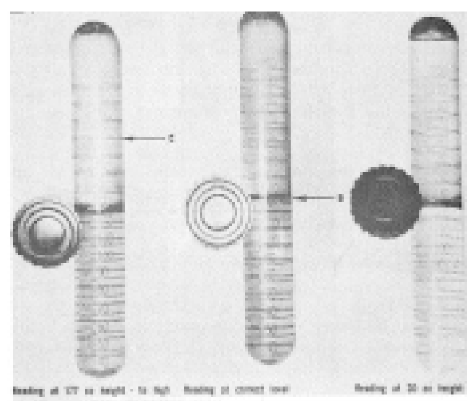


Fig. 6-1-90, F60210. Read vial fuel level

Flow Testing PT Injectors On ST-790

Flow Testing Adjustable Delivery Injectors On ST-790

Test Stand is used to flow test the complete injector assembly by measuring fuel delivery. The injector is actuated under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes, supplying fuel at a specified pressure, thereby measuring the delivery in a glass graduate.

1. Remove master injector ST1210, or ST1306 from test stand after calibrating test stand. Install correct restrict orifice in cup seat, see Table 6115, Fig. 6192, and tighten to 6 in-lbs [Nm .
   a. 0.0115 inch [.292 mm] orifice has four notches.
   b. 0.013 inch [.33mm] orifice has two notches.
   c. 0.020 Inch [.51 mm] orifice has six notches.
   d. 0.026 inch [.66 mm] orifice has one notch.

Note: Delivery for injectors listed in Table 6115 under heading "Approx. Strokes" as 20% is established by setting ST790 Stand with ST1210, Master Injector; then turning back the counter by 20%. For example, if test stand counter was read at 1050 with master, the injectors to be tested would be run at 840 counter strokes.

Comparing Injector Flow With ST1129

A new flowmeter, ST1129, is available to provide a quick comparative indication of injector flow on the ST790 Test Stand without running through a complete test cycle.

However, this flowmeter is in no way meant to replace the present method of measuring injector delivery. Fig. 6193.

Operating Instructions

1. the first injector of the set to be flowed into the ST790 stand per normal procedure and complete calibration.
2. Before removing injector from ST790, note flowmeter value.
3. Install second injector and start test stand, do not hit flow start button, observe flow value. Compare with previous injector and burnish orifice until reading is slightly below first injector.
4. Complete calibration of injector. A little practice with the flowmeter will save considerable time In "burnishing in" injectors to reach the correct flow value.

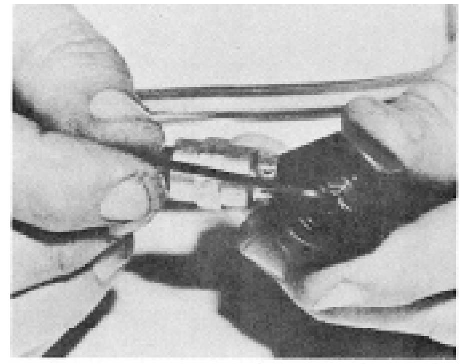


Fig. 6-1-92, F60142. Installing restrictor orifice

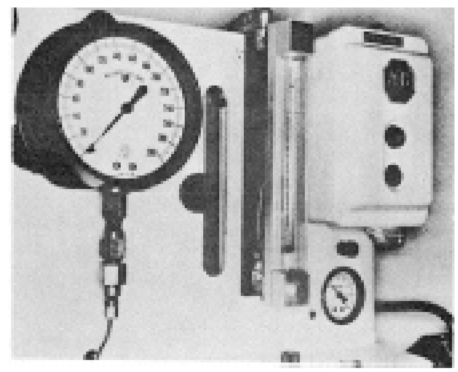


Fig. 6-1-93, F60221. Front view of ST790 with ST1129 installed

PT (type D) Injectors

ST790 Test Stand is used to flow test the complete injector assembly by measuring fuel delivery. The injector is actuated. under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes, supplying fuel at a specified pressure, thereby measuring the delivery in a glass graduate.

1. Remove master injector from test stand after calibrating test stand. Install restrictor orifice In cup seat, see Table 6115, Fig. 6192 and tighten to 6 inchpounds [.7 Nm]. pounds [.069 kg mi .
   a. 0.020 inch [.51 mm] orifice has six notches.
   b. 0.026 Inch [.66 mm] orifice has one notch.

Table 6-1-15: Part and Delivery Values — PT (type D) Injectors (ST-790 Test Stand and ST-1210 Master Injector)

AR-No. Complete Injector	AR-No. Barrel & Plunger	Reference Barrel Part	Cup Part No.	Cup Spray Holes No.—Size X Angle	Delivery No. cc at 1000 Strokes	Flow Code at 120 PSI	Test Stand Seat Orifice	Approx. Orifice Size Before Burnishing
40118	40065	190190	208423	8—.007 x 17 deg	182-183	183	.020	.024-.025

Note: Delivery for injector with approximate strokes of 800 in Table 6115 is established by setting ST790 Stand with master injector, then turning back the counter by 20%. For example, if test stand counter was read at 1050 with master, the injectors to be tested would be run at 840 counter strokes.

2. Lubricate inside of Service Tool 3375086, ST1058 or Body with test oil so Injector "0" rings will slide into adapter without damage to "0" rings.

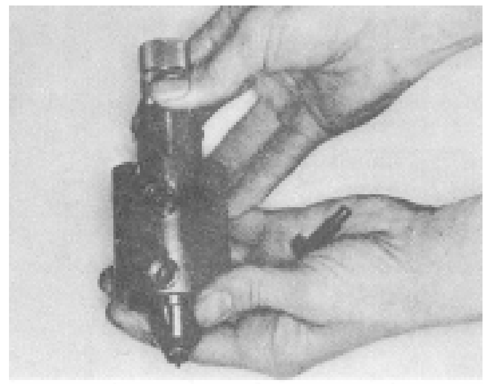


Fig. 6-1-109, F60203. Center injector inlet in ST1058 inlet hole

3. Seat injector in body so injector Inlet aligns with body inlet hole. Fig. 61109. Tighten locating screw. Fig. 61110.
4. Remove spring and plunger from injector adapter. Leave spring off and install plunger into adapter.
5. Perform ball valve seating check before calibrating injector.

a. Attach test stand inlet pressure line to drain connection of Service Tool 3375086, ST1058 Body.

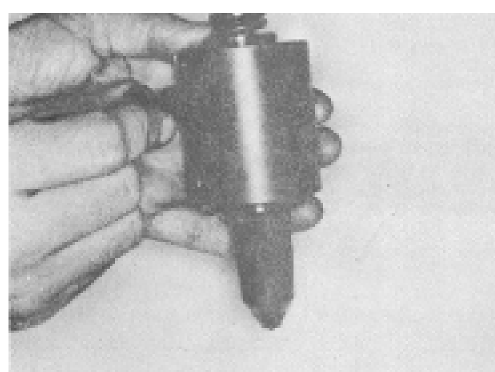


Fig. 6-1-110, F60212. Tighten ST1058 locating screw

b. Hold injector plunger down against its seat in injector cup with injector in a vertical position. Assembly may be held in hand, do not place in test stand holding device. Fig. 6-1-111.

Note: Be sure ST-708-1 Needle is retracted.

c. Turn on test stand, and adjust pressure to 150 psi [1034 kPa .

d. Check orifice plug inlet opening of Service Tool 3375086, ST-1058 Body for leakage past ball valve.

Note: Make sure plunger is seated in cup.

e. If leakage is observed, the ball must be replaced. Slight seepage is not harmful.

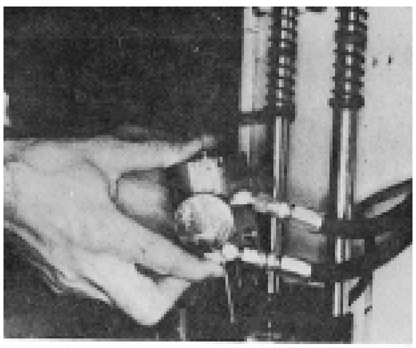


Fig. 6-1-111, F60213. Check leakage at inlet port

6. Install injector in Service Tool 3375086, ST-1058 or Body. Disconnect Inlet pressure line from drain connection of body. Remove injector plunger.
7. Seat injector so injector inlet aligns with body inlet hole after injector adapter is located in sleeve.
8. The location screw must seat in hole of adapter.
9. Check to be sure injector inlet is centered in body inlet hole to prevent breaking ST7081 Burnishing Tool points when installed later.
10. Install spring and plunger into injector.
11. Assembly retainer plate over injector with pins engaging in body.
12. Position injector in test stand with correct adapter link. See Table 611.8.

Table 6-1-18: ST-790 Test Stand Link Data PT (type D)

Length Inch [mm]	Link Marking
6.5 [165]	ST-790-331

Note: All tests on test stand are performed without a screen on injector.

13. Assemble ST-708 Burnishing Tool into test stand injector inlet connector. Retract the needle by pulling out small knob. With needle retracted ST-708 tool may be left in connector during all test operations.

Note: Injector delivery is adjusted by burnishing the inlet orifice plug with ST-708 instead of changing the plug.
The replaceable needle point, ST-708-1, is the burnishing member.

14. Install connector and ST-708 tool into Service Tool 3375086, ST-1058 Body inlet by screwing in the large knob section. Fig. 6-1-112.

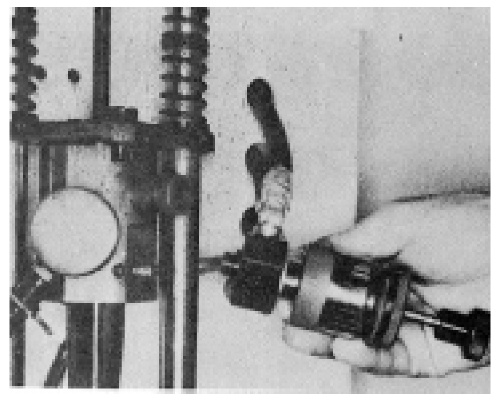


Fig. 6-1-112, F60214. ST-708 installed in inlet connection

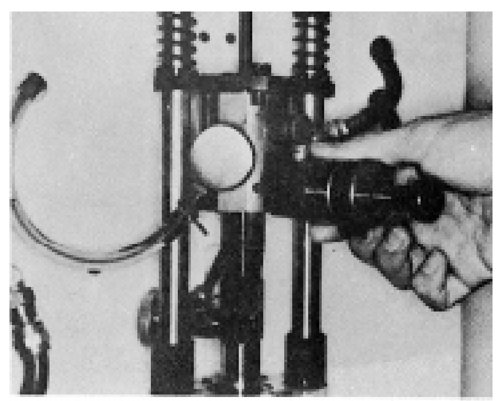


Fig. 6-1-113, F60215. Assemble ST-70a tool to pot

15. Install drain connection.

Run injector through a test cycle and check the cc delivery. If delivery is lower than specifications given in Table 6-1-15, turn the knob with indicator point until it is spaced 3/8 inch [9.5 mm] from the large knob. Fig. 6-1-114.

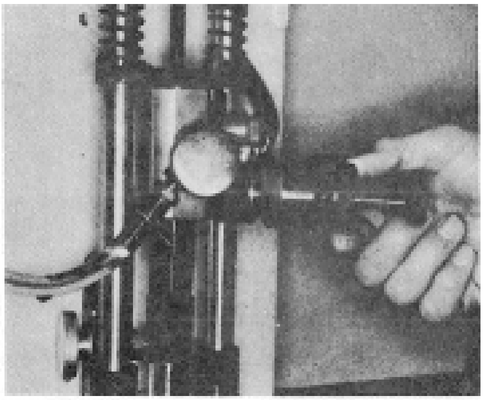


Fig. 6-1-114, F60216. Knob spacing

16. Slowly push the small knob in until you feel the needle enter the orifice plug inside diameter. Then turn the knob counterclockwise to lock the needle shaft to the larger knob with the indicator. Turn the indicator knob in until you feel the needle contact the plug. Index the indicator with a mark on the largest knob and advance one mark.

Note: Test stand must be running while burnishing orifice with ST-708.

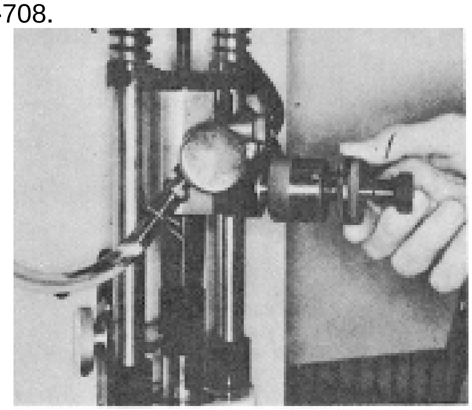


Fig. 6-1-115, F60217. Burnishing operation

Note: A very useful tool for checking orifice inside diameter is available directly from the Datcon Inst. Co. East Petersburg, Pa. 17520, or their dealers as "Kwik Chek Hole Gauge", Model No. 10-0, Part No 39899. Another version of this tool is available from the Coventry Gauge and Tool Co. Ltd., Coventry, England. Order size No. 1 for 0.010 inch [25 mini] to 0.040 Inch [1.02 mm] orifice plugs and No. 2 for 0.030 inch [.76 mm] to 0.080 Inch [2.03 mm] orifice plugs. These tools are especially helpful If orifice plugs become mixed. Measure orifice at base end (not wrench end) as shown in Fig. 6-1-94. This tool is now available from Cummins as ST1332.

17. Back off adjusting screw and retract needle, then check delivery.

Table 6-1-16: Injector Orifice Plugs

Straight Part Number	Inside Diameter Inch	[mm]	Flanged Part Number	Inside Diameter Inch	[mm]
163065	0.015	[0.38]	177283	0.015	[0.38]
163066	0.016	[0.41]	177284	0.016	[0.41]
163067	0.017	[0.43]	177285	0.017	[0.43]
148338	0.018	[0.46]	177286	0.018	[0.46]
163068	0.019	[0.48]	177287	0.019	[0.48]
163069	0.020	[0.51]	177288	0.020	[0.51]
163070	0.021	[0.53]	177289	0.021	[0.53]
163071	0.022	[0.56]	177290	0.022	[0.56]
149726	0.023	[0.58]	177291	0.023	[0.58]
163072	0.024	[0.61]	177292	0.024	[0.61]
163073	0.025	[0.64]	177293	0.025	[0.64]
163074	0.026	[0.66]	177294	0.026	[0.66]
163075	0.027	[0.68]	177295	0.027	[0.68]
163076	0.028	[0.71]	177296	0.028	[0.71]
163077	0.029	[0.74]	177297	0.029	[0.74]
163078	0.030	[0.76]	177298	0.030	[0.76]
163079	0.031	[0.79]	177299	0.031	[0.79]
128132	0.032	[0.81]	179332	0.032	[0.81]
128133	0.033	[0.84]	179333	0.033	[0.84]
128134	0.034	[0.86]	179334	0.034	[0.86]
128135	0.035	[0.89]	179335	0.035	[0.89]
131092	0.036	[0 91]	179336	0.036	[0.91]
131093	0.037	[0.94]	179337	0.037	[0.94]
131094	0.038	[0.97]	179338	0.038	[0.97]
131095	0.039	[0.99]	179339	0.039	[0.99]
131096	0.040	[1 02]	179340	0.040	[1.02]
131097	0.041	[1.04]	179341	0.041	[1.04]
131098	0.042	[1.07]	179342	0.042	[1.07]
132800	0.043	[1.09]	179343	0.043	[1.09]
132801	0.044	[1.12]	179344	0.044	[1.12]
132802	0.045	[1.14]	179345	0.045	[1.14]
131099	0.046	[1.17]	179346	0.046	[1.17]
131100	0.047	[1.19]	179347	0.047	[1.19]
131101	0.048	[1.22]	179348	0.048	[1.22]
131102	0.049	[1.24]	179349	0.049	[1.24]
131103	0.050	[1.27]	179350	0.050	[1.27]
131104	0.051	[1.29]	179351	0.051	[1.29]
131105	0 052	[1.32]	179352	0.052	[1.32]
131106	0.053	[1.35]	179353	0.053	[1 35]
131107	0.054	[1.37]	179354	0.054	[1.37]
131108	0.055	[1.40]	179355	0.055	[1.40]
132803	0.056	[1.42]	179356	0.056	[1 42]
132804	0.057	[1.45]	179357	0.057	[1.45]
132805	0.058	[1.47]	179358	0.058	[1.47]
132806	0.059	[1.50]	179359	0.059	[1 50]
132807	0.060	[1.52]	179360	0.060	[1.52]
132808	0.061	[1.55]	179361	0.061	[1 55]
132809	0.062	[1.57]	179362	0.062	[1.57]
132810	0.063	[1.60]	179363	0.063	[1.60]
132811	0.064	[1.63]	179364	0.064	[1.63]
132812	0.065	[1.65]	179365	0.065	[1.65]
132813	0.066	[1.68]	179366	0.066	[1.68]
132814	0.067	[1.70]	179367	0.067	[1.70]
132815	0.068	[1.73]	179368	0 068	[1.73]
132816	0.069	[1.75]	179369	0.069	[1.75]
132817	0.070	[1.78]	179370	0 070	[1.78]

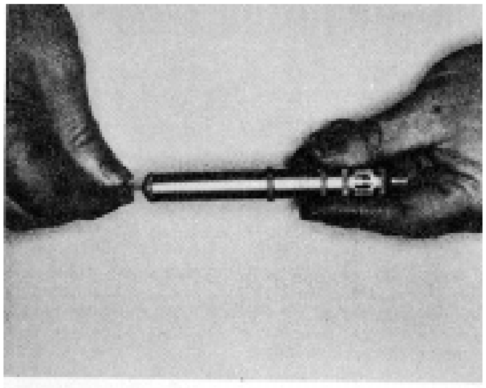


Fig. 6-1-94, F60143. Orifice size gauge

18. If delivery is more than specified cc (Table 6-1-15), a new adjustable orifice must be installed in the injector. See Table 6-1-16. Tighten orifice plug to 8 to 10 inch-pounds [.9 to 1.1 N m] torque.

Note: Orifice plugs have flanges and require a gasket between flange and adapter.

19. New inlet orifice plugs contain enough stock in the inside diameter so a small displacement of metal by burnishing will increase delivery. The amount of displacement is limited so several orifice plugs are required to cover the delivery for all the engine models from low to high horsepower. See Table 6116.
20. After each four cycles, reclamp injector to insure maximum accuracy. When delivery is correct, remove inlet and drain connection.
21. Remove injector from test stand.
22. Remove plunger and spring.
23. Remove adapter plate and body from injector adapter.
24. Install plunger and spring in injector adapter.
25. Insert disc screen over orifice and assemble retainer ring to hold screen in place.
26. Insert link in plunger coupling and store in a clean plate until needed.
27. When 5/16 inch [7.9 mm] link is used, always keep part number up. This link has a 5/16 inch [7.9 mmj ball on both ends.
28. A new 1/2 inch [12.7 mm] diameter ball link is currently being used to improve the wear resistance of the upper ball end. This new link has several optional shapes of the upper end. The 1/2 inch [12.7 mm] diameter may be from 3/4 Inch [19 mm] to 2 inch [51 mm] long, down the link. These 1/2 inch [12.mm] links may be mixed in an engine. Do not use new 1/2 Inch [12.7 mm] links with old rocker levers unless they are converted to take new 1/2 inch [12.7 mm] sockets.

Injector Removal And Installation in Head

PT (type D) Injectors

1. Remove injector holddown plate or yoke.
   a. Use ST1297 to remove injectors from cylinder head.
   b. On NH, NT and V12 series engines you may insert a 3/816 capscrew in tapped hole in holddown plate and jack injector from head.
2. Remove all carbon from injector copper sleeves.
   a. Do not use anything metal to scrape the sleeves.
   b. Use a wooden stick with a clean cloth wrapped around the end.
3. Lubricate the "O" rings with 20 to 30 weight lube oil. Do not use Lubriplate.
4. Start injector into bore, guide by hand until aligned in bore and not binding.
   a. It is not required to line up any plugs or rotate injector around in any position. The PT (type D) will perform at any position.
5. Place a clean blunt object on injector body and "seat" injector by giving a quick hard push. A snap should be heard and felt as cup seats in copper sleeve.

Note: Do not use a wooden hammer handle or similar tool to install injectors. Dirt or splinters from the handle may drop into plunger link seat causing early failure of link or plunger socket.

Caution: If injector is not completely seated, the "O" rings may be damaged if pulled down with the mounting capscrews.

6. Install holddown plates or yokes, lockwashers and capscrews.

Caution: Be certain plates or yokes do not contact crosshead stems.

7. Torque capscrews in alternate steps to 11 to 12 ftlb [15 to 16 N. mi.

Nylok capscrews may be used Torque them alternately to 12 ftlb [15 to 16 No m] .

8. Test injector plunger for movement after torquing holddown capscrews. If plunger is not free, retorque capscrews.

ST-790 Trouble Shooting

ST790 Trouble Shooting/Maintenance

This section of the manual should be fully understood by the Injector Test Stand operator, and through this knowledge he should be able to correct the test stand problems and subsequently produce a properly calibrated injector.

The ST790 Injector Test Stand is the recommended calibration equipment for Cummins injectors and was developed to provide accurate balancing and testing of Cummins injectors in order to produce the desired engine performance.

Injector calibration on the ST790 Injector Test Stand combined with fuel pump calibration on Cummins Fuel Pump Test Stands with flow meters has produced widespread acceptance of fuel system accuracy. There have been reports of erratic results, but investigations have revealed that the cause for such problems fall into three basic categories.

1. Mechanic and/or Tester Error: (Not confined to injector calibration alone. Includes pump calibration, engine and chassis dynamometer checks, etc.)
2. Instrumentation Errors: (Range all way from gauge used on cuptoplunger seat check to load indicator on chassis dynamometer.
3. ST790 Maintenance Status These three problem areas are itemized as follows:

a. Mechanic and/or Tester Error
1. Calibrating a specific injector model to the wrong flow value.
2. Calibrating a specific fuel pump model to the wrong value.
3. Lack of familiarity with this bulletin and/or Bulletin No. 3379068, 983505, 3379084 and No. 983533.
4. Use of wrong injector assembly in a specific engine model.
5. Use of camshaft and pistons other than those shown in CPL.
6. Restricted intake air to engine.
7. Excessive exhaust back pressure.
8. Restricted fuel supply to engine.
9. Aerated fuel supply to engine.
10. Excessively high oil level in engine crankcase.

b. Instrumentation Errors (Other than ST790) 1. Erroneous fuel manifold pressure gauges on engine and/or chassis dynamometer.
2. Erroneous flowmeters.
3. Erroneous dynamometer load indicators.

c. Neglect of ST790 Maintenance.
1. Use of hose lengths, diameters, and resiliencies other than those which are specified.

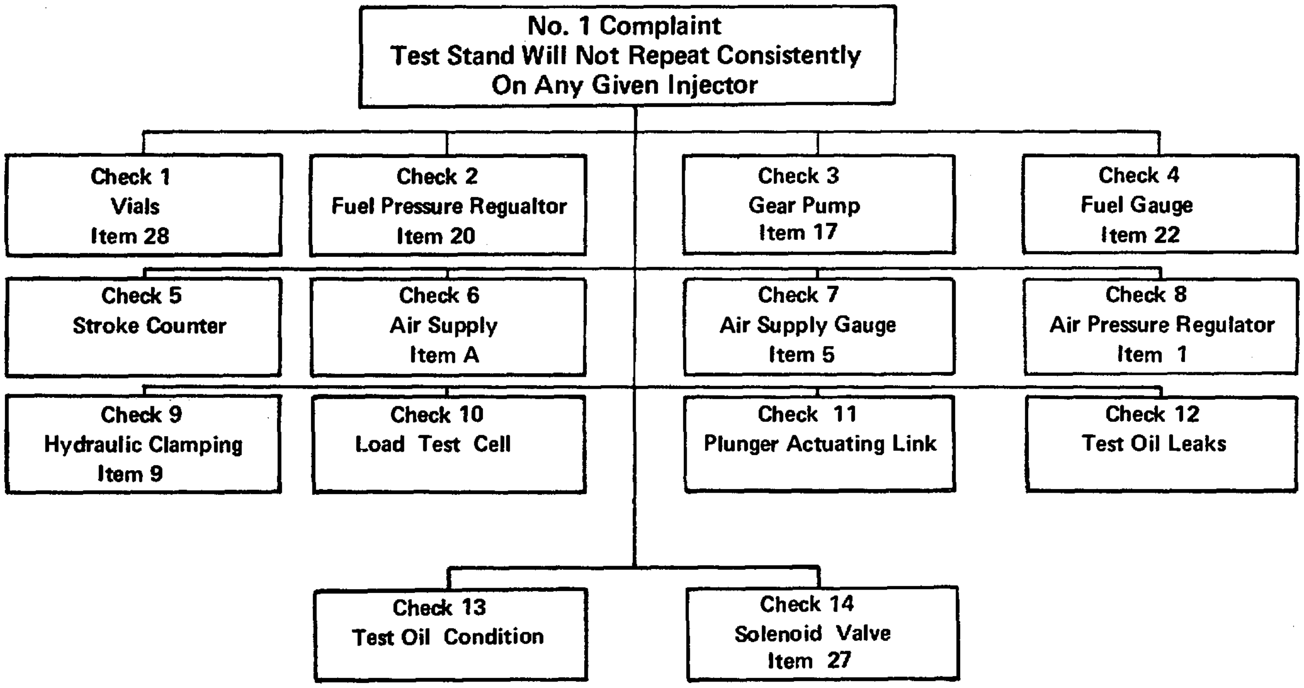
Caution: Do not replace any hoses or lines on the ST790 Test Stand with other than the correct ST hose as specified in the tool catalog. Hoses on ST790 should be replaced periodically since rubber in the hose hardens with age causing resonance variables.

2. Fuel routing which is not to specifications.
3. Filter assemblies which have a different dampening effect on the system.
4. Critical components of the test stand such as check valve, gauge and hydraulic injector clamping poorly maintained.

Trouble Shooting The ST790

Injector calibration problems are discovered by inconsistent results in service injectors or inability to flow injectors which have been calibrated at the factory or at other locations to the proper specifications. When an injector calibration problem is indicated, the following troubleshooting guide is to be used in the diagnosis and correction of the problem. All injector calibration complaints have been found to fall into the six basic categories as follows.

1. Stand repeatability. Stand will not repeat consistently on any given injector.
2. Poor results on all injector models. Injectors do not perform well in engine and do not correlate with injectors calibrated on other stands.
3. NHRS, NRT injectors heavily overfueled. PT (type B) and PT (type D) injectors slightly underfueled. Reasonable results on all other injectors.
4. All PT (type B) (type C) and PT (type D) injectors overfueled. Reasonable results on all other injectors.
5. NHRS, NRT and all PT (type B) (type C) and PT (type D) injectors overfueled. Results are reasonable with all other injectors.
6. All PT (type B) (type C) and PT (type D) injectors underfueled.



Complaints And Corrections

Charted on the following pages are the complaints, showing the items to check for correction of the complaints. Each check is numbered, and the item numbers from Fig. 61121 are given for quick location, so you may go immediately to the tabulated description of the causes and corrective action as necessary.

Check 1-Vials

Cause

Differential of 1 cc or more between the vials.

Metered fuel partially missing vials.

Foam preventing accurate reading of fuel delivery in vials.

Correction

Remove the vials and check the relative accuracy by filling one to various levels and pouring into the other vial. If there is significant variation between the two vials, mark the vials (spot of paint on one) and record the relative variation for future reference in troubleshooting.

If the differential is significant at 132 cc, choose one vial (the one marked with a spot of paint above) for machine calibration use and when trouble-shooting the machine.

Replace with correctly calibrated vials as soon as possible.

Adjust solenoid outlet line so that 100% of the metered fuel enters the vials. (For minimum fuel foam, direct stream of fuel against side of vial.)

Foam will settle in approximately one minute. To prevent this time loss a 1" diameter hole may be cut in the top panel (with panel removed) and the foam may be stirred with a wire or rod.

Check 2 - Fuel Pressure Regulator

Cause

Regulator sticking. (Indicated fuel pressure erratic.)
Regulator not plumbed into the fuel circuit per conversion instructions.

Check 3 - Gear Pump

Cause

Pressure regulator is operating properly but pressure in excess of 120 psi [827 kPa] cannot be obtained with an NHRS injector installed.

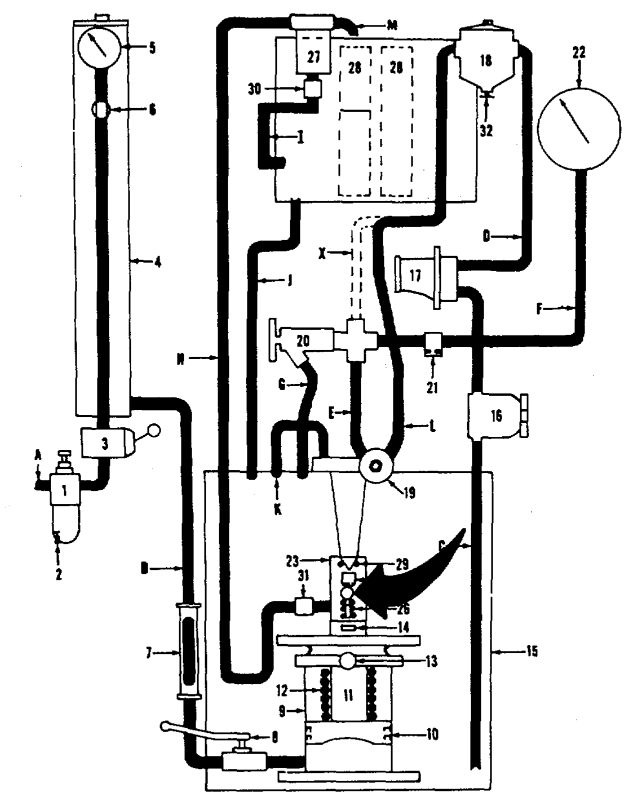


Fig. 6-1-121, Test stand hydraulic system

Correction

Clean and/or replace regulator as required to maintain pressure at 120 psi [827 kPa] .
Change plumbing to the right size and length.

Correction

Change gear pump as required. (For gear pump delivery specifications and gear pump checking procedure see Complaint No. 6.)

ST-790 TEST STAND HYDRAULIC SYSTEM LEGEND

1. Air Regulator and Filter
2. Filter Drain
3. Air Valve
4. Hydraulic Reservoir
5. Air Pressure Gauge
6. Hydraulic Oil Level Gauge
7. Sight Glass
8. Hydraulic Lock Up Valve
9. Hydraulic Loading Cylinder
10, Piston
11. Piston Rod
12. Piston Return Spring
13. Cylinder Breather
14. Bleed Plug
15. Fuel Tank
16. Fuel Strainer
17. Gear Pump
18. Fuel Filter (Part No. 105204)
19. Injector Inlet Connector
20. Pressure Regulator
21. Dampening Valve
22. Fuel Pressure Gauge
23. Injector Seat Assembly
24. Restrictor Orifice
25. Check Ball
26. Spring
27. Solenoid Valve
28. Vials
29. O-Ring (Goshen Part No. GRG-27-12) (Parker Part No. 2-114)(Lincar Part No. 11-114)
30. .035 Orifice
31. Secondary Check Valve
32. Filter Drain Cock

A. Air In.
B. Hydraulic Fluid
C. Fuel From Tank To Pump
D. Fuel From Pump To Filter Inlet (Stratoflex #213 M.H.P. #4 21" Length)
E. Fuel From Injector Inlet To Pressure Regulator (Stratoflex #213 M.I.P.
'4 21 Length)
F. Fuel From Pressure Regulator To Pressure Gauge (3/16 X 18" Copper Tubing)
G. By-Pass Fuel From Pressure Regulator (3/16 I.D. X 3/8 O.D. X 9 1/2" Long
Clear Vinyl Tubing)
H. Metered Fuel To Vials (3/16 I1.D. X 3/8 O.D. X 46" Long Clear Vinyl Tubing)
I. By-Pass Fuel From Solenoid Valve (3/16 I.D. X 3/8 O.D. X 7" Long Clear
Vinyl Tubing)
J. Drain Fuel (5/16 I.D. X 1/2 0.D. X 14" Long Clear Vinyl Tubing)
K. Injector Return Fuel (5/16 I.D. X 1/2 O.D. X 22" Long Clear Vinyl Tubing)
L. Fuel From Filter Outlet To Injector Inlet Connector (Stratoflex -213 M.II.P.
04 37 1/2" Length)
M. Fuel From Solenoid To Vial (1/8 X 2 1/4" Long Copper Tubing)
X. Original Plumbing (Omit)

CHECK 4 FUEL GAUGE

Cause

Excessive gauge vibration due to machine vibration carrying through gauge mounts.

Hydraulic pulsations being carried into gauge because of damping valve not being properly adjusted.

Excessive gauge hand vibration due to improper damping in gauge line.

Gauge out of calibration

Improper plumbing

Correction

Install new gauge mounts.

Adjust the adjustable damping valve.

Fig. 6-1-116.

With ST1210 or ST768 Master Injector running in the test stand adjust the needle valve in gauge line until gauge hand flutter is eliminated but gauge hand is responsive to any change in pressure. This adjustment should be made only with the ST1210 or ST768 Master Injector and before the machine if calibrated with the master.

Check with dead weight tester or a master gauge at 120 psi (827 kPa), which is operating pressure. Adjust dial hand with adjusting screw.

Make sure plumbing agrees with Fig. 61121.

Do not add extra fittings, lines, etc.

CHECK 5 STROKE COUNTER

Cause

Stroke counter improperly set

Stroke counter engagement faulty

Stroke counter fails to disengage.

Stroke counter gears damaged or worn.

Correction

Counter wheels must be set and locked for correct number of strokes; the numbers must then be cleared to "O" by rotating with thumb screw for at least one complete revolution.

Align counter shaft with drive shaft.

See Fig. 6-1-122.

Increase tension on counter return spring at rear of panel.

Check visually while holding cover back and correct as required.

CHECK 6 AIR SUPPLY

Cause

Shop air pressure of less than 80 psi (552 kPa).

Air supply on common line with air actuated equipment which causes intermittent pressure drop.

Correction

Supply air pressure of 80 psi (552 kPa) or more.

Rearrange equipment so that ST790 is on a circuit which has constant air pressure.

CHECK 7 AIR SUPPLY GAUGE

Cause

Psi setting does not agree with load test cell reading.

Air gauge hangs up at a certain point regardless of regulated pressure.

Air gauge is erratic; does not repeat consistently when actuated several times at same pressure.

Correction

Check both air gauge and load test cell when relationship between gauge and cell changes by more than 3 psi (21 kPa).

Clean, adjust hand to clear face or replace as necessary.

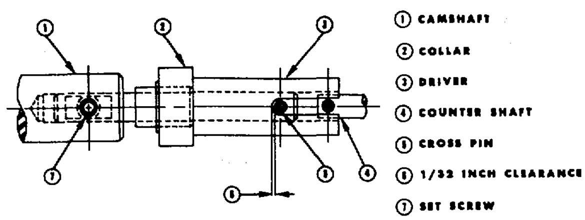
Check inlet for obstruction, gauge hand for hanging up and correct or replace as necessary.

Check 8 - Air Pressure Regulator
Cause
Excessive moisture.

Regulated pressure "creeps."

Check 9 - Hydraulic Clamping
Cause
Leaks-(hydraulic clamping system).
This may be verified by the following check:

(1) Clamp the load-cell in the stand.
(2) If after 3 minutes the load-cell reading should change position by more than 20 lbs [9.07 kg].
(3) Dry all plumbing connections and watch for seepage with
air valve closed and with it open.
(4) If no external seepage is indicated and the condition still
persists, one of the following exists.



If 1/32 inch clearance has been affected because of loose set screw or any other condition, the following steps should be taken to obtain proper clearance.

1. Loosen set screw so that shaft slides freely in housing.

2. Manually engage clutch by fully depressing solenoid (inside main housing). With clutch held in this position, the cross pin in the clutch shaft should be positioned to clear the end of the "U" slot in clutch driver by approximately 1/32 inch.

3. Tighten set screw against flat on clutch shaft.

4. Check operation, if solenoid is noisy (loud hum or chatter) recheck Step No. 2.

Fig. 6-1-122, F601060. Position of collar and drive clutch

Correction
Drain regulator bowl each day by releasing spring loaded valve.
Clean filter by removing bowl, wash in solvent and air dry.
Remove the top housing, valve seat and valve assembly.
Inspect the disc and seating surface of valve seat.
Inspect the valve guide and valve guide recess for foreign particles. Clean all parts thoroughly.
While the top housing is removed for the preceding step, check the diaphragm and slip ring and replace faulty parts.

Correction

(See below for specific corrections.)

Check for leaks at bleed plug and correct as required.

Correct as required.

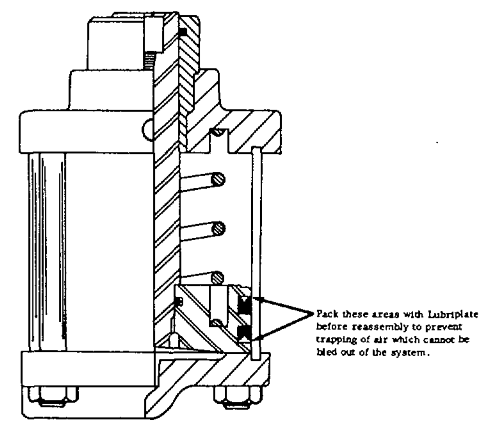


Fig. 6-1-123, F60159. Hydraulic loading cylinder

(a) Leakage past the piston sealing rings. (This is accompanied with loss of fluid from the reservoir and appearance of oil out the cylinder vent when the piston is actuated to top travel.)

(b) Hydraulic lock-up valve leaking. (This may be checked by placing valve in closed position and applying air pressure. Indicated travel of piston rod verifies leaking hydraulic lock-up valve.)

Check 10 - Load Test Cell

Cause

Gauge on load cell has become miscalibrated as a result of mis-handling such as dropping or excessive loading.

Check 11 - Plunger Actuating Link

Cause

Use of wrong injector model link causing hydraulic piston return spring to be worked at a height other than that when checking the load cell. Plunger actuating link binding on link guide bracket.

Plunger actuating link distorted or cracked on socket and causing cocking during operation of stand.

Check 12 - Test Oil Leaks

Cause

Cup seat O-ring leaking. (Leak may appear as mist.)

Cup seat block-to-solenoid line (line H in Fig. 6-.1-121) leaking in between tank and front panel. (To check this, route line H temporarily in front of panel and operate test stand.)

Visual leaks.

Check 13 - Test Oil Condition

Cause

Improper fuel or dilution.

Replace sealing rings as required. (See Fig. 6-1-122 for assembly instructions.)

Repair or replace as required.

Correction

Check the load cell on a valve spring tester at 380 lbs [172 kg] load. The load cell should read 380 lbs [172 kg] .

Correct the gauge with the recalibration screw on the gauge face.

Correction

Use correct link for injector being calibrated.

Align link guide bracket so that it does not contact link at any point. Inspect link visually and during running of stand and
replace if necessary.

Correction

Replace O-ring with new one. If an O-ring of a larger crosscut diameter is used, the injector may bounce on the cup seat and thus affect transfer groove and metering orifice timing. Any bouncing of the injector on the cup seat must be corrected.

Correct as necessary, remove rear panel.

Correction

Keep tank 3/4 full of Cummins 99011-68 test oil or Shell Injector Oil No. 66631. Use of oil not meeting these specifications or diluted until viscosity or specific gravity values are affected will cause improper calibration.

Fuel brown in appearance.

Dirty fuel.

Fuel Aerated.

Low oil level in tank.

Air not completely expelled from system after filter change or after having lines disconnected for other reasons.

Air leak between supply tank and gear pump suction.

(a) Strainer cap loose or cap gasket missing.

(b) Air leaks in strainer-to-gear pump section line or at connections.

Check 14 - Solenoid Valve

Cause

Solenoid leaking fuel into by-pass line during test cycle.

Improperly installed solenoid valve (incoming fuel line connected to discharge port and vial line connected to inlet port) causing excessive restriction on metered fuel.

Solenoid valve sticks and fails to divert fuel to vials at instant counter actuating switch is depressed. The 0.035 inch (.89 mm) orifice below the solenoid is partially clogged with foreign particles causing excessive restriction which expands injector-to-solenoid line (line H, Fig. 6-1-121) while fuel is being by-passed but regains normal size and empties excess fuel into vial when test

New oil is clear in appearance and becomes amber during use, never use when brown,

Based on 8 hours per day, clean filter and change oil monthly or after 160 hours operation.

It is normal for the drain on flange-type injectors to appear "milky."

The PT (type B) (type C) and PT (type D) drain should normally be clear. Fuel in the cup seat block-to-solenoid line (line H, in Fig. 6-1-121)must always appear clear with all injector models.

It must be possible to disconnect the injector inlet lines immediately after shutting off the test stand without evidence of any compressed air in the system.

Fill tank to 3/4 or above.

Without breaking fuel line connections, remove the filter assembly from its mounting bracket. 'With the filter assembly in inverted position and the test stand running at low pressure, bleed the filter at the drain cock until oil is free of air.

Correct as required.

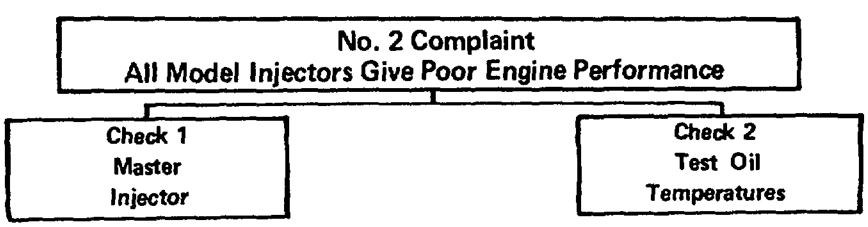
Correction

Check for foreign particles and pitted valve or seat and clean, repair or replace as necessary.

Check identification on solenoid valve inlet port to which line from injector cup tip must be connected is stamped IN. Directly opposite is discharge port which must be connected to vial line. Correct if necessary.

Clean valve until it operates freely or replace.

Clean as required.



Check 1 - Master Injector

Cause

Master injector out of calibration.

Correction

This can be substantiated or disproved by calibrating a set of injectors at 132 cc and engine testing them. If the fuel rate vs. manifold pressure relationship is not within specifications, a miscalibrated master injector is verified. During this check the utmost accuracy is required in weighing the fuel and recording the manifold pressure. The correct camshaft and pistons as listed on the CPL must be used during this test.

Replace the faulty master with a new master ordered from the Factory. Clean and correct the faulty master, and use it in an engine. Never use an injector as a master after it has been taken apart or changed in any way.

Check 2 - Test Oil Temperature

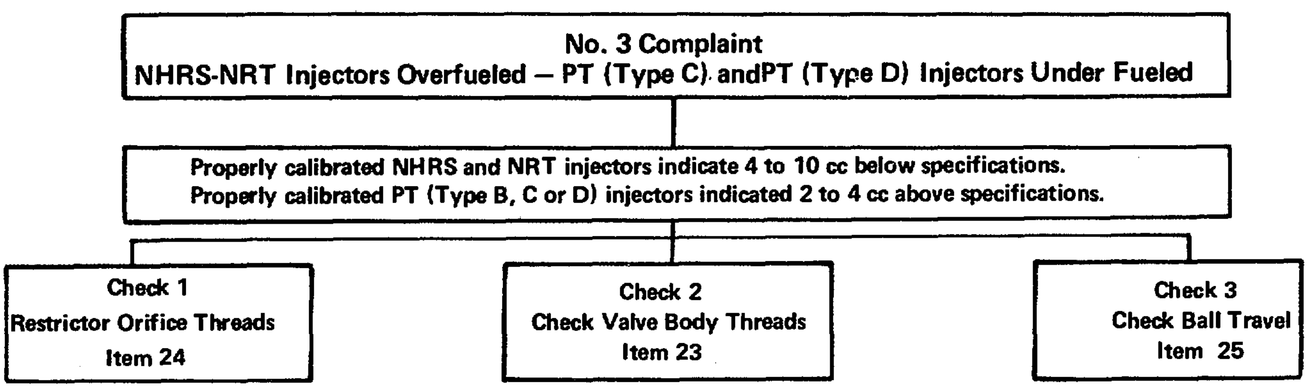
Cause

Test oil at excessively high or low temperature.

Correction

Setting up test stand or calibrating injectors while test oil is at excessively low or excessively high temperatures.

Check test oil temperature indicator against master thermometer and compensate as necessary for any existing differential. It may be necessary to connect cold or hot water lines to heat exchanger at back of tank to maintain test oil temperature at the required 90 deg. to 95 deg. F [32 to 35 deg. C]. If temperature exceeds 95 deg. F [35 deg. C] increase cold water flow. If temperature exceeds135 deg. F[57 deg. C] drain and replace with new test oil.



Check 1 - Restrictor Orifice Threads

Cause

Leakage around restrictor orifice threads.

Correction

Torque resistor orifice into check-valve body at 6 inch-lbs [.7 N. m].

Check 2 - Check Valve Body Threads

Cause

Leakage around check-valve body threads.

Correction

Use gasket (0.030 inch [.76 mm] throttle adjusting shim) under check-valve body. Torque check-valve body into cup seat block at 10 to 12 inch-lbs [1.1 to 1.4 N. m}.

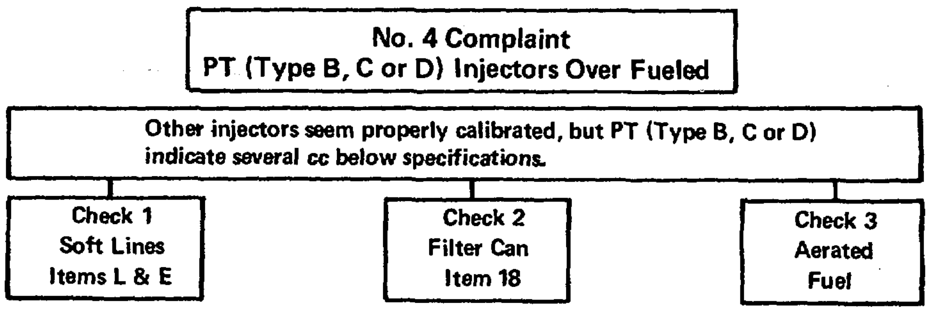
Check 3 - Check Ball Travel

Cause

Loss of ball-travel caused by over-tightening of restrictor orifice and consequent stripping of orifice threads.
Caution: Never try to attain the proper ball travel by loosening the orifice as this will cause leakage around the threads and defeat the purpose of the restrictor orifice and check valve.

Correction

Orifice must be replaced if threads are damaged, Orifice torque is 6 in-lbs [.7 No ml. Ball travel is 0.020 to 0.030 inch [.51 to .76 mm] with orifice torqued in position (for assembly diagram refer to Fig. 6-1-84).



Check 1 - Soft Lines

Cause

Use of filter-to-injector and injector-to-regulator lines (lines L and E in Fig. 6-1-121) which are softer and more resilient than those supplied with test stand.

Check 2 - Filter Can

Cause

Original filter has been replaced with one which is larger or has a softer can, such as Cummins throwaway filter.

Check 3 - Aerated Fuel

Cause

Aerated fuel.

Correction

Install lines of material and length shown in Fig. 6-1-121.

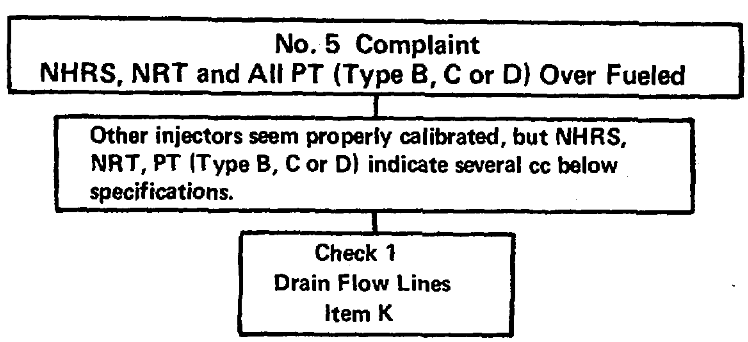
Correction

Replace with standard filter per Fig. 6-1-121.

Note: Be sure that filter is installed in correct location in the circuit.

Correction

See Causes and Corrections under Check 13 of "Test Stand will not repeat consistently on any given injector."



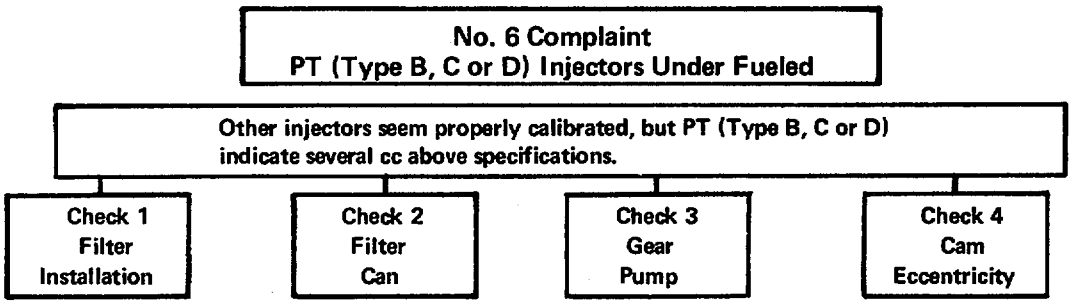
Check 1 - Drain Flow Lines

Cause

Use of a line with less than 5/16 inch [7.95 mm] I.D. or crimp caused by sharp bend in drain line.

Correction

Replace per line K in Fig. 6-1-121.



Check 1 - Filter Installation

Cause

Removal of the filter assembly from the circuit.

Correction

Install filter.

Cause

Installation of the filter assembly in the suction side of the gear pump.

Correction

Filter assembly must be in specified location as shown.

Check 2 - Filter Can

Cause

Installation of a smaller or more rigid than standard filter can.

Correction

Filter must be of specified type.

Check 3 - Gear Pump

Cause

Low gear pump delivery.

Correction

With the pressure regulator by-pass line (line G, in Fig. 6-1-121) completely blocked, check the gear pump against a 0.045 inch [11.1 43 mm] orifice installed in line L.

The gear pump is acceptable if it delivers 80 to 120 psi [552 to 827 kPal during this check.

If the gear pump delivers less than 80 psi [552 kPa], check the fuel strainer for clogging end consequent pump suction restriction and clean if necessary; the gear pump must be replaced.

Check 4 - Cam Eccentricity

Cause

Cam base circle eccentricity.

Correction

Check as follows:

(a) Align timing wheel mark and pointer.

(b) Install ST-790-5111 load cell with regulated air pressure to give 380 lbs. [172 kg] load. Repeat the clamping several times to assure that the setting of the clamping load is correct.

PT (type D) Injector Trouble Shooting The following list of problems is of importance when trouble shooting PT (type D) injectors:

Check 1 - Unable To Get Correct Plunger To Cup Alignment

Cause

Defective or dirty cup.

Improper assembly techniques.
Defective plunger.
Defective barrel face surfaces.
Damaged retainer cup seating shoulder or threads.
Improper interpretation of cup alignment.

Check 2 - Defective Barrel To Adapter Seal

Cause

Gasket, when required, torn or creased at time of assembly.

Adapter or barrel face damaged.
Roll pins or spiral pins damaged, preventing barrel and gasket from seating properly.

Check 3 - Fuel Leaking Around Retainer

Cause
Barrel cracked.
Leaking barrel plugs.
Defective barrel to cup seal.

Check 4 - Plunger Sticks Or Scuffed

Cause

Cup to plunger misalignment.

(c) Close the hydraulic valve while the load cell is clamped in position and turn the timing wheel slowly by hand.
(d) If the load cell indicates more than 50 lbs. [22.7 kg] increase above the clamping load, the cam and/or shaft and/or cam follower must be replaced.

Correction
Test cup spray pattern on ST-668. Clean, inspect and repair. Assemble with correct tools and procedure.
Clean and inspect.
Clean, inspect and repair.
If damaged areas cannot be cleaned up, replace part.
Check cup to plunger alignment.

Correction
Install new gasket each time barrel is removed from adapter on 5/16 inch [7.94 mm] type injectors. All 3/8 inch [9.52 mm] type injectors built after January, 1969 do not require gasket. Lap surface.
Inspect and replace if interference occurs.

Correction
Inspect and replace with barrel plunger assembly.
Stake plugs with punch.
Lap surface.

Correction
Assemble correctly.

Check 5 - Loose Or Broken Plunger, Coupling Swage Joint

Cause

Coupling not swaged deep enough into plunger.

Wrong spring used.

Check 6 - Excessive Link Wear

Cause

New link placed in old socket.

5/16 inch [7.94 mm] link turned end for end at time of assembly.

Check 7 - Bright Polished Spots At Top And Bottom Of Plunger 180 deg. Apart

Cause

Bearing pattern on plunger.

Correction

Attempt to rotate by hand-replace if defective.

J and C injector springs could be mixed with PT (type D) springs. PT (type D) springs are 1/16 inch [1.59 mm] longer, have 0.187 inch [4.75 mm] diameter wire with a slightly larger O.D.

Correction

Mark links when removed.

Part number should be installed in up position.

Correction

This is normal wear. Unless metal is displaced or wear is measurable, plunger may be reused.

FUEL PUMP
PT REBUILDING

TABLE OF CONTENTS

PT Fuel Pump Group

OPERATING PRINCIPLES

The operation os the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the size of passage the liquid flows through. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors for each cylinder. Fig. 5-1.

2. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so the individual cylinders will receive the right amount of fuel for the power required of the engine.

3. Fuel passages of the proper size and type so that the fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.

4. Injectors to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantity and proper condition to burn.

<u>Fuel Pump</u>
The fuel pump is coupled to the compressor or fuel pump drive which is driven from the engine gear train. The fuel pump main shaft turns at engine crankshaft speed on most engines. The main shaft turns about 78% of engine RPM in V555 series engines. The main shaft drives the gear pump, governor and tachometer shaft.

<u>PT (type G) Fuel Pump</u>
The PT (type G) fuel pump can be identified by the absence of the return line at the top of the fuel pump. The pump assembly is made up of three main units.

1. The gear pump which draws fuel from the supply tank and forces it through the pump filter screen to the governor.

   NOTE : The fuel pump inlet on V6140, V8185, V504 and V555 series engines may be through a fitting into the top of the fuel pump in line with the tachometer drive. Fuel flows from the main housing to the gear

The PT fuel system is used exclusively on Cummins Diesels. The identifying letters, "PT" are an abbreviation for "pressure-time."

pump via the main shaft passage and main housing to gear pump by-pass passage.

2. The governor which controls the flow of the fuel from the gear pump, as well as the maximum and idle engine speeds.

3. The throttle which provides a manual control of the fuel flow to the injectors under all conditions in the operating range. The location of the fuel pump components is indicated in Fig. 5-3.

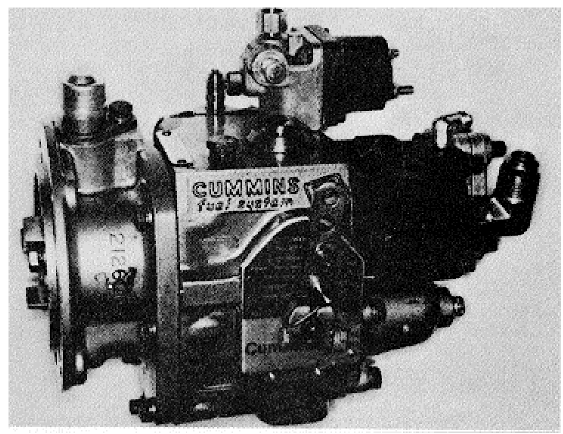


Fig. 1, F5295. PT (type G) AFC fuel pump

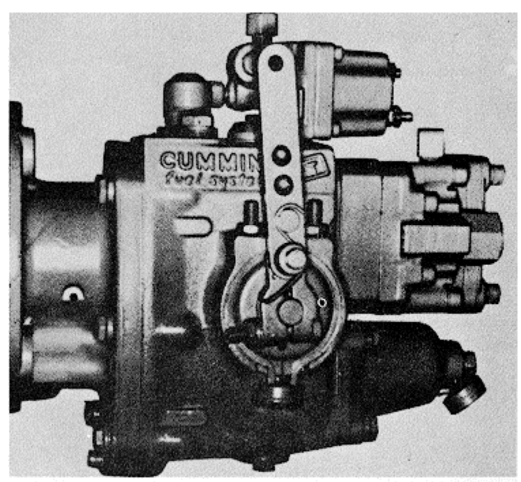


Fig. 3, F5235. PT (type G) fuel pump

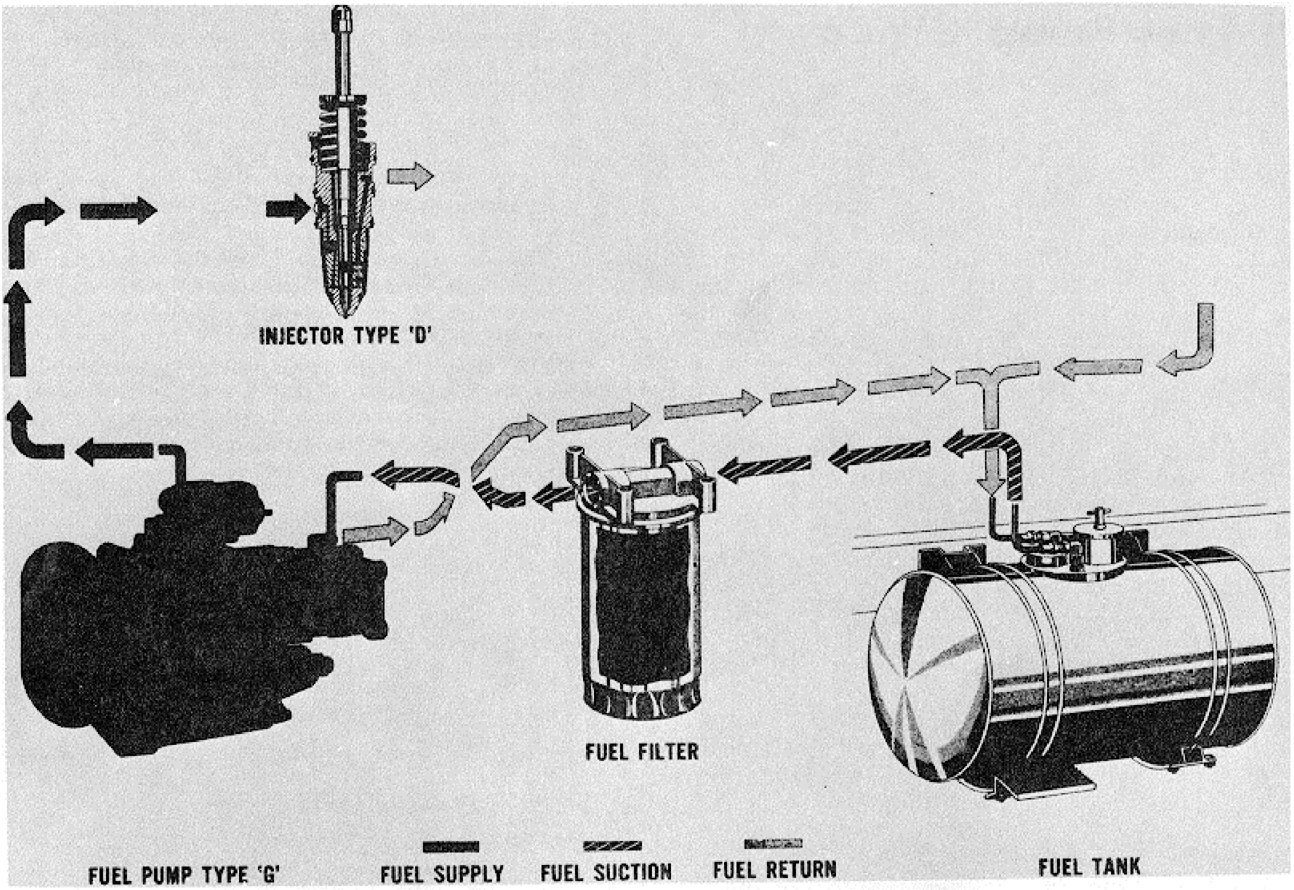


Fig. 5.1, FWC-33. Fuel flow in PT fuel system

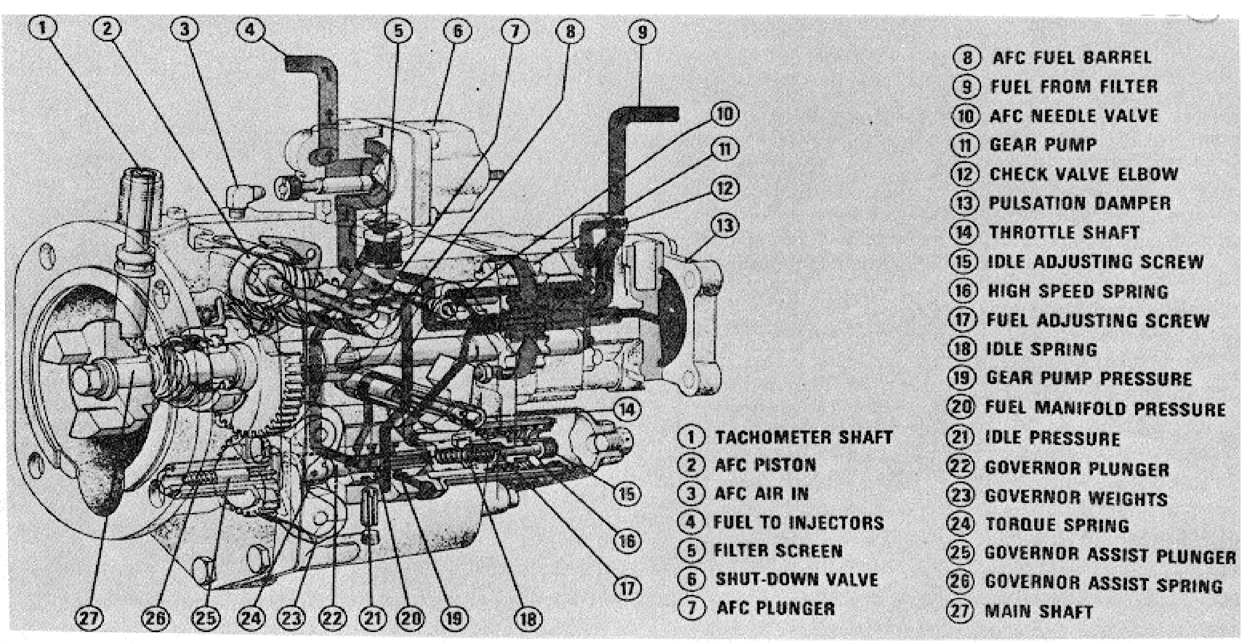


Fig. 5-3, FWC-37. PT (type G) fuel pump cross-section and fuel flow

Gear Pump And Pulsation Damper
The gear pump is driven by the pump main shaft and contains a single set of gears to pick-up and deliver fuel throughout the fuel system. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow through the fuel system.
From the gear pump, fuel flows through the filter screen and.
In the PT (type G) fuel pump, to the governor assembly as shown in Fig. 5-3.
Currently, PT (type G) gear pumps are equipped with a bleed line (to the engine injector return line or to tank) which prevents excessive fuel temperatures within the fuel pump. The bleed line functions primarily when the pump throttle is set at Idle speed but when gear pump output is high, due to engine rotative speed, as occurs during down hill operation. A special check valve and/or fitting is used In the gear pump to accomplish the bleed action.

Pressure Valve
The pressure valve is used only In PT (type G) VS governor fuel pump. The valve is located near gear pump drive shaft. It restricts return fuel coming from governor barrel thereby creating low fuel pressure in housing.

Throttle
In both fuel pumps, the throttle provides a means for the operator to manually control engine speed above Idle as required by varying operating conditions of speed and load.
In the PT (type G) fuel pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the throttle shaft.

Shut-Down Valve
Either a manual or an electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, the control lever must be fully clockwise or open to permit fuel flow through the valve.

With the electric valve, the manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through the valve.

Governors
Idling And High-Speed Mechanical Governor
The mechanical governor, sometimes called "automotive governor," is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle springs in the governor spring pack positions the governor plunger so the idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.
During operation between idle and maximum speeds, fuel flows through the governor to the injectors in accord with the engine requirements as controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT (type G) fuel pumps. When the engine reaches governed speed, the governor weights have moved the governor plunger to close the fuel passages to injectors. At the same time another passage is opened and fuel is dumped back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the pump flows through the shut-down valve, supply lines and cylinder head drillings into the injectors.

Removal Of Fuel Pump Units
Clean And Mount
1. Clean outside of fuel pump thoroughly with an approved solvent. Remove lockwires and seals if used.
Note: Many solvent cleaners are injurious to aluminum. Make sure your cleaner is suitable before using it on aluminum.
2. Remove pulsation damper from gear pump and discard "0" ring. Older style dampers are fitting mounted and are removed by screwing damper from fitting on gear pump,
3. To remove gear pump from main housing, tap sides of gear pump with a plastic hammer to loosen from dowel. Remove gear pump discard gasket.

PT (type G) Fuel Pump Service Cooling Kit
1. Remove check valve and orifice elbow assembly from bottom or back side of fuel pump.
Note: Current pumps have the check valve located at the gear pump and older pumps should be changed over at any time a new gear pump is used.
2. Clean parts in clean fuel oil and dry with compressed air blown through both ends.

Shut-Down Valve, Pulsation Damper And Gear Pump
1. Remove shut-down valve from top of main housing and discard "O" ring.

Front Drive Cover And Governor Plunger

1. To remove drive cover from main housing, tap edge of cover lightly with a plastic hammer to loosen. Lift cover off dowels and discard gasket.

Note: Never use a steel hammer on aluminum, or on a finished surface, it can cause extensive damage.

3. Remove weight assist plunger, spring and shims from weight carrier assembly. Slide governor plunger from barrel.

Caution: Place plunger where it will not be damaged, a slight nick can cause extensive damage.

Throttle Assembly - Drive Screw Cover Plate Type

1. Remove snap ring from inside housing. Remove drive screws securing cover plate. Pull throttle assembly from housing. Remove "O" ring and discard.

Filter Screen

1. Screw off screen cover on top of main housing. Lift cap, spring and filter screen assembly from main housing; discard "O" ring.

Tachometer Drive

1. Remove tachometer drive cover screws.
2. Lift drive cover from main housing or front cover. Discard gaskets, when used.
3. Carefully drive tachometer drive assembly from pump, using a brass punch and hammer or use ST-667-10 collet with ST-667 Dowel Puller or use ST-1326 to pull tachometer seal, shaft and bushing. Fig. 5-15.
4. Remove oil seal and dust seal, when used, from shaft and discard.

Throttle Assembly-Retaining Ring Type

Compress throttle plate retaining ring and remove from groove. Pull throttle assembly from pump. The throttle shaft is a select fit in its sleeve and sizes are identified by color code.

Note: Handle throttle shaft with care.

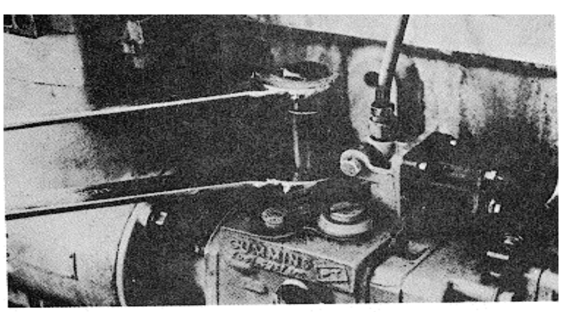


Fig. 5-15, F5300. Removing tachometer drive assembly with ST- 1326

Governor Spring-Pack Cover

1. Remove spring-pack cover from main housing, lift off cover and discard gasket.
2. For disassembly of spring-pack, see Spring-Pack section.

General

Fuel pump sub-assembly repair, cleaning, inspection and rebuild instructions are listed in the following sections. Worn replacement limits are given to help the mechanic decide when to replace parts or to use parts that have many hours or miles of useful life.
However, parts that are worn beyond replacement limits must not be re-used.

Cleaning

A clean shop, clean tools and good cleaning practices are essential to good quality fuel pump repair. Special care must be taken when cleaning aluminum alloy parts since some cleaning solvents will attack and corrode aluminum. However, cleaning time is always well spent. Most fuel pump failures occur because of dirt. Clean all parts before rebuild or assembly.

Inspection

Time spent on inspection is profitable. It can save many dollars worth of parts and also prevent failure of the rebuilt pump.
Too often inspection is performed too lightly or not performed at all. Proper tools are essential to do a satisfactory job of inspection.

Tools

Using proper tools has many advantages. The fuel pump consists of several aluminum parts, which makes it light; but the parts may be easily damaged if the right tool is not used to perform the job being done.

Note: Aluminum parts must be handled carefully.

Service tools may be purchased from your Cummins Distributor if you perform your own rebuild work.
An arbor press should be used for all pressing operations to control pressure and alignment. Always make sure that the part is properly supported when pressing in another part, the parts can easily be damaged beyond repair if not properly supported.

Pressing Lubricant

A high pressure lubricant should be used on mating surfaces In all pressing or driving operations. The lubricant prevents galling or scoring during assembly. Be sure to remove all burrs from mating parts before pressing together.

Capscrews And Washers

Capscrews used in connecting a part to aluminum should have an engaging thread length two times the diameter. Observance of this rule will prevent stripping threads with a capscrew that is too short or breaking a part from using a capscrew that is too long.

Lockwashers must never be used next to aluminum. Always use a flat washer between the lockwasher and aluminum part.

FUEL PUMP FILTER SCREEN

Cummins engines are equipped with single or double fuel screens, located in fuel pump housing.

Disassembly And Inspection

Two types of screens are used on PT Fuel Pumps.

1. The standard automotive screen assembly mounts in top of fuel pump housing. Fig. 5-16.

a. Remove upper retainer, the top retainer contains a magnet to pick up any iron particles that may have entered the fuel pump. Some screens are one piece.
b. The lower retainer and screen has hole In center to permit fuel flow.
c. Clean retainer in fuel oil and blow dry with compressed air. Visually inspect retainer and magnet for damage or excessive wear.
d. Proper cleaning of the filter screens can best be accomplished by soaking In a carbon-dissolving agent, followed by flushing in a sonic cleaner unit, or clean the screen and retainer portion in fuel oil and dry with compressed air.
e. Visually Inspect screen for holes or imbedded metal particles in mesh.
f. Discard damaged or worn parts and replace with new parts.

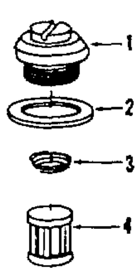


Fig. 5-16, F5183. Fuel filter screens

Filter Screen Optional Replacements

Two new fuel filter screens, both with a 40 micron mesh rating, are available for use in the PT fuel pumps. Filter screen, Part No. 200004, is used to replace screen, Part No. 146483, when additional protection is desired in single screen type fuel pumps.

Use of the new screen also provides a good check on the primary fuel filter to see If the filter is performing its proper filtration functions. Tests with a good primary filter indicated the 200004 Screen should be cleaned at 50,000 mile or 1600 hour intervals. However, when a questionable primary filter was used, the screen cleaning periods had to be moved up to much closer intervals to prevent clogging.

FUEL PUMP HOUSING

The fuel pump housing is the largest part of the fuel pump and contains the governor barrel, throttle shaft

The drive shaft bushing, throttle sleeve, governor barrel and spring pack housing still remain in the fuel pump main housing.

The drive shaft bushing and governor barrel can be removed if damaged. The throttle sleeve was honed to size after assembly to the housing, and due to the close tolerances must be returned to a Cummins Distributor for repair or replacement. Exchange housings are available to reduce downtime to a minimum, as this is a specialized repair and only performed by Factory Repair Stations.

Drive Shaft Bushing

1. Check drive shaft bushing for sign of seizure or burrs.
2. Check drive shaft bushing 1.D. with inside micrometers; If worn beyond 0.7525 Inch [19.11 mm] replace bushing.
3. Remove worn bushing using a gouge chisel or half Inch pipe tap, After tapping bushing, screw a half inch pipe cap on a close nipple and screw the half inch nipple into the bushing. Insert a punch through the rear of the housing and drive out the bushing.
4. Apply a thin coat of high pressure lubricant to a new front drive shaft bushing; press bushing into housing flush with housing bore using an arbor press.
5. Line ream bushing to 0.7495 to 0.7505 inch [19.04 to 19.06 mm] with ST-490 Ream Fixture, and a well oiled 0.750 inch (3/4 inch [19.05 mm]) reamer, Fig. 5-17. Check bushing I.D.

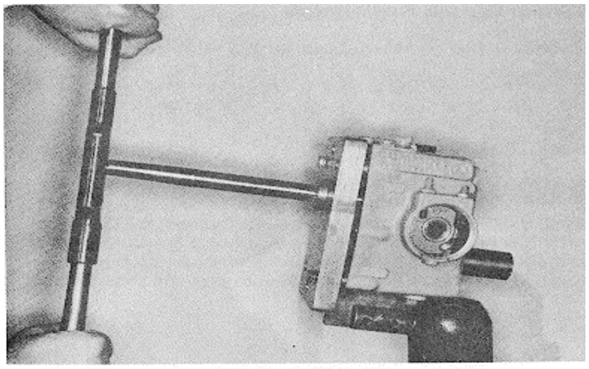


Fig. 5-17, F514. Reaming drive shaft bushing with ST-490

Governor Barrel, Plunger And Spring Pack Housing

Inspection

1. Check governor barrel and plunger visually for wear.

2. If worn, replace governor plunger with a new plunger of same class size as etched on face of governor barrel

Note: Due to hardness of governor barrel sleeve, it wears very little. If worn excessively or if plunger shows signs of scoring, barrel should be replaced.

Standard Governor Barrel Replacement

1. If governor barrel is worn or shows signs of scoring, it will be necessary to heat housing in oven to 30° deg. F [149 deg. C) and press out governor barrel. Heat will expand the aluminum housing and permit the steel barrel to be pressed out with less chance of damaging housing bore.

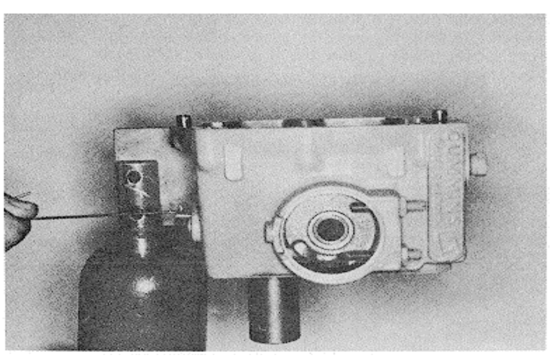


Fig. 5-18, F5135. Removing locking pin from bottom of barrel

Note: Check through plug hole In bottom of PT (type G) pump for spring dowel which secures barrel In fuel pumps built after May 1963, before attempting to remove governor barrel. Sometimes a wire hook, Inserted into the hole provided, will pull the spring dowel. Fig. 5-18.

2. Check barrel bore in housing to determine whether standard (1.5020 to 1 5025 inch [38.15 to 38 16 mm] O.D.) barrel, 0.010 inch [0.25 mm] or 0.020 Inch [0.51 mm] oversize must be used. Minimum 0002 inch [0.05 mm] interference fit is required. Check bore for score marks, remove If found.

Assembly And Fitting

1. To locate a new governor barrel in the housing, scribe a center line on barrel and housing, lining up the fuel passages so fuel flow will not be restricted. Fig. 5.19 and 5-20.

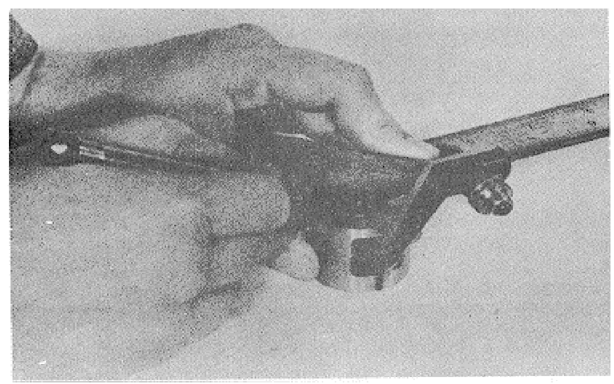


Fig. 5-19, F516. Scribe center line on governor barrel

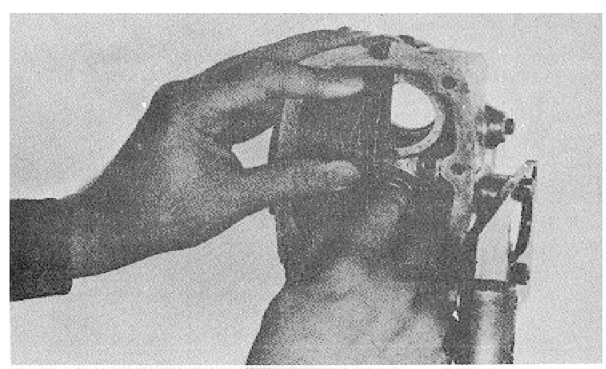


Fig. 5-20, F5136. Scribe center line on fuel pump housing

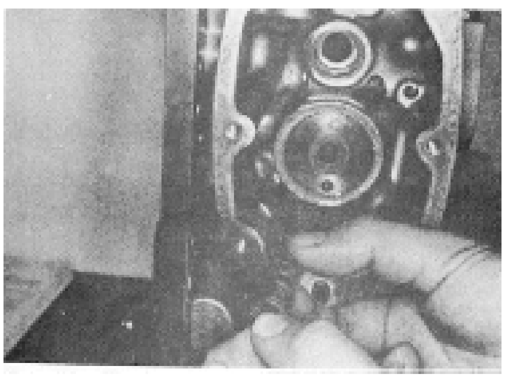
2. Heat housing in oven to 300 deg. F [149 deg C].

3. Coat new governor barrel with high pressure lubricant. Drop spring pack housing In place.

Table 5-1: Current PT (type G) Governor Plungers

Code Size 0	Red
Part No.	182530

4. Place governor barrel In housing bore with chamfered end first and location pin hole on bottom side, lining up scribe marks, then press barrel In housing with arbor press until It bottoms against spring pack housing. This is Important to align barrel retaining pin holes.
5. Select a new Class 2 (green color code) plunger and attempt to fit it in barrel, if plunger enters, try a Class 3 (yellow). Keep trying larger sizes until one will not enter barrel, then select plunger two sizes smaller than last plunger which did enter for use. Plunger must drop into bore of its own weight. Remark governor barrel with class size of plunger used. See Tables 51 or 52 for class sizes and color codes.
6. Install spring dowel into bottom of barrel with ST-853 driver with slot of pin to front of housing.



Fig, 5-23, F5139. Removing torque spring

Governor Plunger

1. If necessary, remove torque spring (torque spring used on PT (type G) governor plungers only) by twisting spring off shoulder. Do not use a straight pull which will stretch spring beyond its elastic limit so it has to be replaced. Fig. 5-23.
2. If governor plunger outside diameter is worn, replace with new plunger of same class size as etched on barrel face. See "Governor Barrel and Plunger"
3. If only thrust washer is worn, drive retainer pin from plunger and pull governor plunger drive from plunger.

Note: The chamfer on small diameter of thrust washer is provided as a relief for fillets of plunger driver.

4. If It is necessary to remove stop sleeve, press stop sleeve off shaft.

Assembly

1. If stop sleeve was removed, press stop sleeve on plunger with notched end going on plunger first (notches toward governor barrel).
2. Assemble plunger driver through thrust washer and drive into plunger. Driver must have interference fit In plunger.

Note: The plunger has a lubrite finish. Protect it by laying the plunger on a copper jawed vise or V-block to prevent damage to the finish when installing pin.

3. Drive retainer pin through the plunger and plunger driver.

Note: The chamfered side of thrust washer must be installed next to driver. There must be at least 0.002 to 0.005 inch [0.05 to 0.13 mm] clearance between washer face and driver so washer will ’float."

4. Install torque spring and shims as required, put the small end of the spring on the shoulder end of the plunger with a twisting motion to avoid distorting the spring.
5. If torque spring is replaced with new one, select from specification sheets pertinent to the fuel pump being rebuilt, see fuel pump calibration data In Bulletin No. 3379068, 3379077 or 983533, "PT (type G) Fuel Pump Calibration," and Table 53 following.
6. One type of plunger failure is caused by excessive heat from contact of the stop collar and sleeve during long periods of overspeeding. Plunger stop collars machined from glass filled teflon eliminate this type of failure.

Because of the large outside diameter of the teflon stop collar it is Impossible to use a torque control spring if it is required, therefore, the teflon stop collar is to be used only In PTG. fuel pumps that do not require a torque control

Table 5-3: Torque Springs and Specifications

Part Number	Color Code	Wire Dia. Inches [mm]	Number Coils	Pounds Load [kg]	Inches [mm] @ Length	Free Length Inches [mm]
138782	Red/Blue	.047 [1.19]	5.2	5.40/5.76 [2.5/2.6]	@ .340 [8.64J	.640/.660 [16.26/16.76]

spring. Use thrust washer, Part No. 188713, with teflon stop collar, Part No. 188714.

Air Fuel Control

Fuel pumps with Air Fuel Control (AFC) must be mounted to Swivel Vise, ST-302, with front cover Mounting Plate, No. 3375133. Fig. 5-10.

Disassembly

1. Remove AFC cover plate. Fig. 5-24.
2. Carefully lift bellows away from sealing surface around AFC cavity and pull bellows, piston and plunger assembly from AFC barrel. Fig. 5-25.
3. Remove AFC bellows spring and steel shim between spring and fuel pump housing. Fig. 5-26.
4. Remove AFC barrel retaining ring. Fig. 5-27.
5. Remove AFC barrel, discard barrel "O" rings.
6. Remove plunger jam nut and unscrew plunger from center bolt.
7. Remove center bolt jam nut, washer, and gasket; remove bellows from piston. Fig. 5-9.
8. Slide "Glyd" ring and "O" ring seal assembly from the AFC throttle plunger.

AFC Assembly Installation

1. Lubricate barrel "O" rings and Install in grooves in barrel, press barrel Into housing and secure with snap ring.

Note: Lightly coat all "O" rings with a 50-50 mixture of a lubricating oil additive (such as STP) and clean lubricating oil just before installation. Fig. 5-27.

2. Place steel shim in bellows spring seat groove.
3. Install spring with small end in housing. Fig. 5-26.
4. Lubricate "O" ring and install over throttle plunger using installation tool No. 3375146 then install "Glyd" ring over tool and plunger on top of "O" ring. Install plunger assembly in seal-ring forming tool No. 3375147, leave in tool and complete Steps 5 through 7.
5. Assemble center bolt, gasket, washer (rounded edge toward bellows), bellows (with part number toward piston), piston, washer and jam nut.
6. Hold assembly by hex on center bolt and center bellows piston and washers, without twisting bellows tighten jam nut to 30 to 40 in-lbs [3.4 to 4.5 N•m] torque. Make sure parts are centered.
7. Wrap plunger threads with teflon tape and screw plunger into center bolt until threaded end of plunger is flush with center bolt surface. Install jam nut, leave loose.

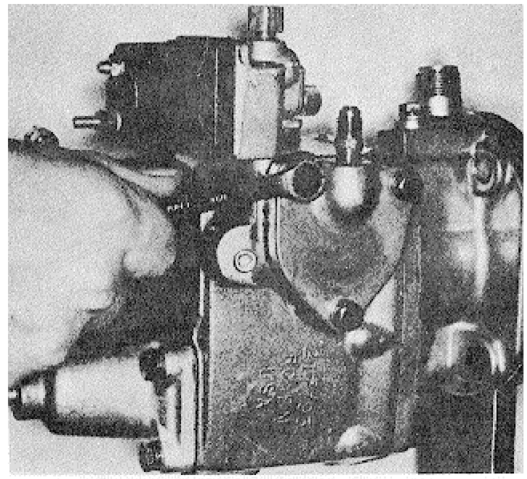


Fig. 5-24, F5301. Removing AFC side cover plate

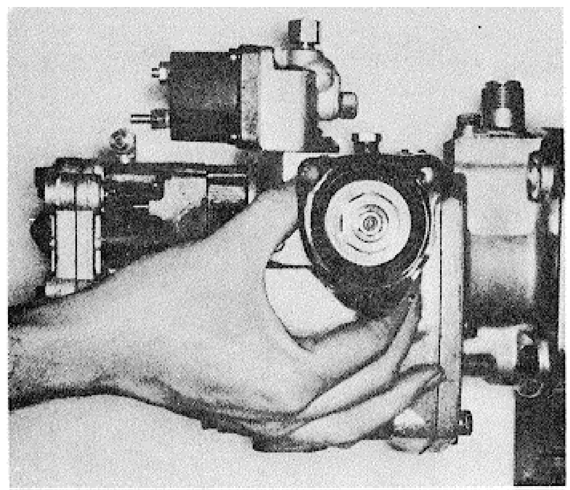


Fig. 5-25, F5302. Removing AFC bellows and piston assembly

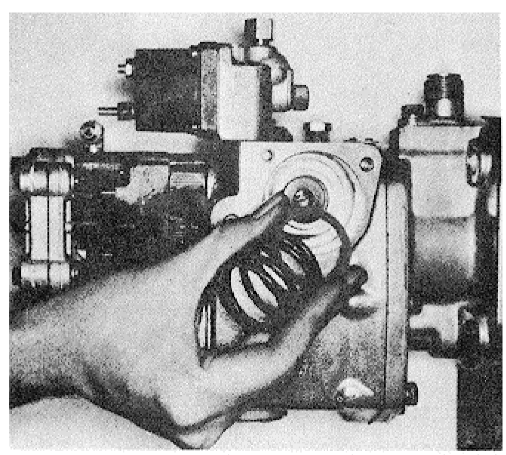


Fig. 5-26, F5303. Removing AFC bellows spring and washer

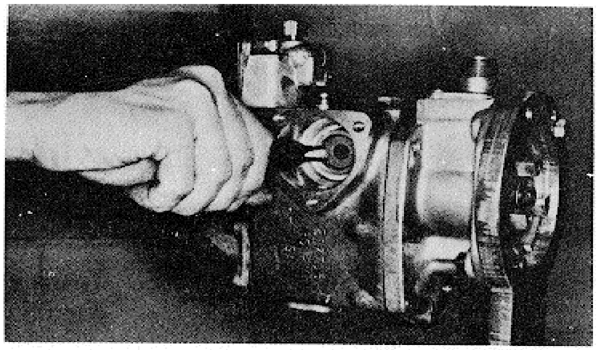


Fig. 5-27, F5304. Removing AFC barrel retaining ring.

8. Slide plunger and piston/bellows assembly from tool and into barrel. Insert very carefully to avoid damage to the "Glyd" ring. Fig. 5-25.

Caution: Make sure plunger and "Glyd" ring assembly have been in forming tool for a minimum of thirty minutes to establish a contoured form.

9. Cup bellows downward between piston and housing to insure bellows does not wrinkle when cover is installed.

10. Line up bellows holes with housing and cover plate holes, install capscrews and washers. Capscrews are to be tightened to 30 to 35 in-lbs [3.4 to 4.0 N•m] torque after setting AFC on test stand. Fig. 5-24.

11. Install lubricated "O" ring on needle valve using assembly tool No. 3375148 and screw into housing above throttle shaft until it bottoms in housing; install jam nut loosely until set on test stand.

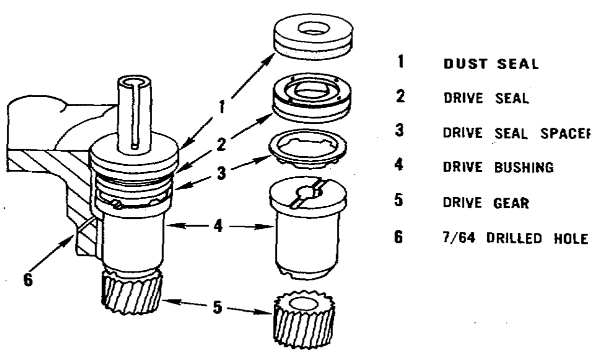


Fig. 5-28, F5214. Tachometer drive parts in housing

Tachometer Drive - Mechanical

Disassembly

1. Remove felt seal, when used, and oil seal from tachometer drive shaft.

2. Press tachometer drive shaft from drive gear and bushing, if the gear is badly worn or shaft and bushing are galling or scoring. Check shaft outside diameter and bushing inside diameter. Replace if necessary. Table 5-4.

Assembly

Place bushing on tachometer shaft with chamfered end of bushing toward gear end. Press gear onto shaft until flush

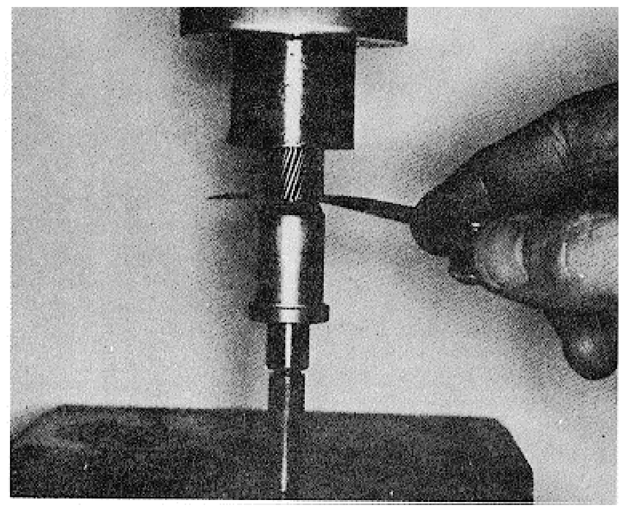


Fig. 5-29, F537. Pressing tachometer gear on shaft

Table 5-4: Tachometer Drive Parts Specifications

Part Description	*In. [mm]*
Front Cover Mounted	
Tachometer Shaft	.3950/.3955 [10.033/10.046]
Shaft Bushing	.3963/.3970 [10.066/10.084]
Housing Mounted	
Tachometer Shaft	.3100/.3105 [7.874/7.887]
Shaft Bushing	.3120/.3130 [7.925/7.950]

with end of shaft. Fig. 5-29. Check to see that shaft turns freely in bushing. Maximum clearance between gear and bushing is 0.005 Inch [0.127 mm].

Note: Check gear to make sure it matches with tachometer drive gear. Fig. 5-30.

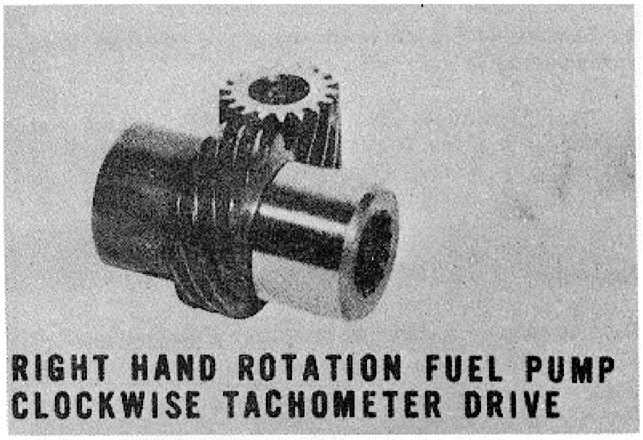


Fig. 5-30, F5140. Tachometer and matching drive gears

Right Hand And Left Hand Rotation Housings

Do not use a right hand rotation fuel pump housing with a left hand rotation gear pump. The fuel passage from the gear pump to the fuel filter is located up and to the right of the main shaft in a right hand rotation housing. (Looking at gear pump end of housing.)

The fuel passage is located up and to the left of the main shaft In a left hand rotation housing.

GEAR PUMP AND PULSATION DAMPER

The gear pump draws fuel from the tank through a filter and supplies the fuel to the fuel pump. Fuel at a given pressure is then routed to the injectors.

Gear Pump

PT (type G) fuel pumps currently have gear pumps with hollow idle shafts and the gear pump cover is drilled for cooling as described under "Gear Pump"

Note: Special C.I.T.E. fuel gear pumps will have the BM or AR number stamped on the side of the gear pump.

Caution: Engines with integral cooling gear pumps (Fig. 5-31) must not be run with the fuel bleed hole plugged.

Disassembly

1. Remove capscrews securing gear cover to gear body.

2. Drive against dowels with flat end punch to remove gear over from dowels In gear body. Discard gasket

3. Lift drive and driven gears and shafts from gear pump body.

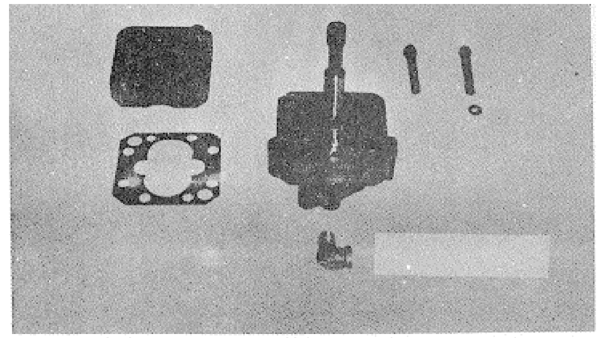


Fig. 5-31, F5141. Gear pump with integral cooling

Cleaning And Inspection

1. Check pump shafts for wear or scoring, discard if damaged. Replace shaft If worn smaller than 0.4998 to 0.5001 inch [12.695 to 12.703 mm] diameter.

2. Check gear width. See Table 5-5. If gears are scored or worn badly, the gears must be replaced.

3. Check gear body and cover for scoring or wear, replace parts as needed. Check gear pocket depth. See Table 5-5. Fig. 5-32.

4. Shaft bore in cover and body should be 0 5013 to 0.5016 Inch [12.733 to 12.740 mm] I.D. In 3/4 inch [19.05 mm] current cast Iron bearing gear pumps. If gears are removed from shaft, press

Table 5-5: Gear Width And Pocket Depth - Fig. 5-32.

Pump Size Inch [mm]	Gear Width Inch [mm]	Gear Pocket Depth In. [mm]
3/4 [19.05}	0.7483/0.7486 [19.006/19.014]	0.7478/0.7483 [18.994/19.006]

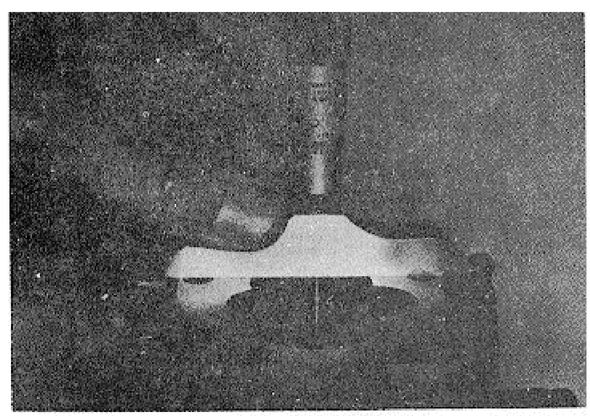


Fig. 5-32, F523. Gear pump pocket depth gears on shaft 0.680 to 0.690 Inch [17.27 to 17.53 mm] from body end of shaft. Oil shaft before assembly.

5. Check lubrication holes in cover and body; they must be clean.

6. Clean cooling kit components, if used, and dry with compressed air.

Assembly 1. Lubricate and slide shafts and gears into cover. Make sure parts are clean.

2. Position new gasket and install body to cover. Align locating notches together. Fig. 5-33.

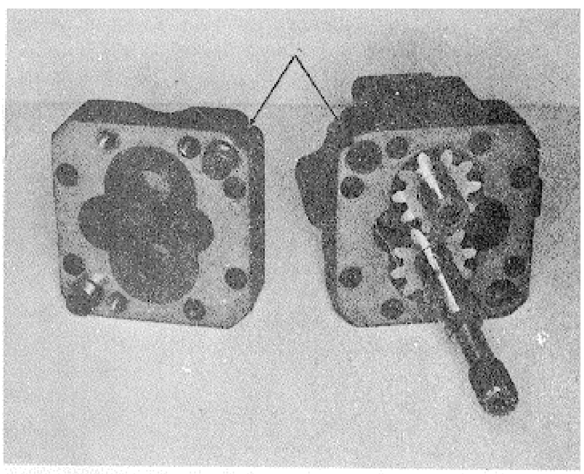


Fig. 5-33, F524. Locating notches for right hand pump.

Note: Location of notches and drive shaft determines pump rotation.

3. When a right hand rotation pump is being assembled, place the driven gear shaft of the gear pump in the pocket nearest the locating notches. Place the driving gear shaft in the other pocket. The ring dowel is always located around drive shaft.

4. Secure cover and body with dowels, tighten capscrews to 11 to 13 foot pounds [15 to 18 N. m]. Check to see that pump turns freely with finger pressure.

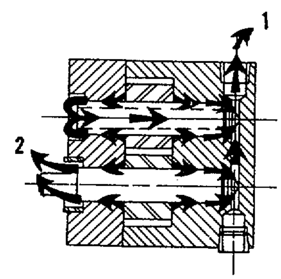
Note: Total gear backlash must be 0.001 to 0.004 inch [0.025 to 0.102 mm] The drive shaft must protrude 2.370 to 2.412 inch [60.2 to 61.3 mm] from the body. End clearance should not exceed 0.0015 inch [0.0377 mm] nor be less than 0.0009 inch [0.0228 mm]. Gaskets are available in .0020 inch [.051 mm] (red) and .0015 inch [.038 mm] (purple). If pump binds or has excessive play, check for error in assembly which must be corrected to prevent early pump failure.

5. If cooling feature is used, install elbow and/or check valve. If 1/8 inch [3.17 mm] pipe plugs is used, torque to 10 to 13 foot pounds [14 to 18 No m].

Integral Type PT (type G) Fuel Pump Cooling

The small amount of fuel which is routed back to fuel tank, previously was recirculated internally, Therefore, this method of cooling does not use any of normal delivery of gear pump and present fuel pump calibration specifications will still apply.

This bleed fuel is that fuel which flows through and lubricates gear pump bearing bores. Previously, this fuel was dumped back into suction side of gear pump. With integral bleed gear pump, the lubricating fuel flow through three gear pump bearings is bled off through an external tapped drain hole. The former internal pump drillings which permitted this fuel to return to the suction side, have been eliminated. Fig. 5-34.



1. TO INJECTOR DRAIN LINE OR FUEL TANK
2.TO FUEL PUMP HOUSING

Fig. 5-34, F5157. Gear pump fuel flow

The inboard main shaft bearing bore still returns its fuel to the gear pump suction. The inboard idler shaft bearing fuel flows through the hollow idler shaft to the external drain line. As can be seen from the sketch, both outboard gear pump bearings drain externally.

Since three of the bearing bores drain externally, it is apparent that both tapped holes in the gear pump housing cannot be plugged. Plugging both tapped openings will prevent lubricating and cooling fuel flow through the three bearing bores and gear pump seizure will occur.

Both ends of through drain drillings are tapped so that gear pumps can be converted from R.H. to L.H. In normal manner.

Caution: Under no circumstances should the pump be operated with cooling return flow plugged. This fuel flow is necessary to lubricate the bearing surfaces within the gear pump.

1. Fuel pumps with the integral cooling feature may be identified by a 1/8 inch N.P.T.F. hole In top of gear pump.
2. Install elbow-check valve, Part No. 175836, in 1/8 inch drain hole in gear pump. A 1/8 inch N.P.T.F. brass street elbow and a check valve, Part No. 179037, may be used as a substitute for valve combination.

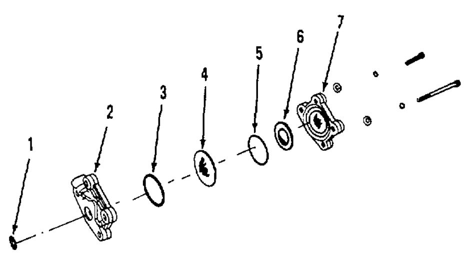
Note: The spring-loaded check valve is necessary to prevent fuel in pump from draining away and causing hard starting.

Pulsation Damper

Disassembly And Inspection

1. Remove housing from cover. Remove spring steel diaphragm. Discard "O" rings and nylon washer.

Note: Diaphragm must be kept clean prior to assembly.



1 SEAL	**5 '0' RING**
2 BODY	**6 NYLON WASHER**
3 'O' RING	**7 PLATE**
4 DIAPHRAGM	

Fig. 5-36, F5132. Pulsation damper - exploded view

2. Check for corrosion, excessive wear or cracks In cover or diaphragm. Replace if necessary. Fig. 5-36.

Assembly

1. Install new "0" rings In grooves and new nylon washer.
2. Coat the diaphragm with a good grade of 10W or 20W oil and lay in cover.
3. Assemble cover to housing, torque capscrews to 11 to 13 foot pounds [15 to 18 No m].

SHUT-DOWN VALVES

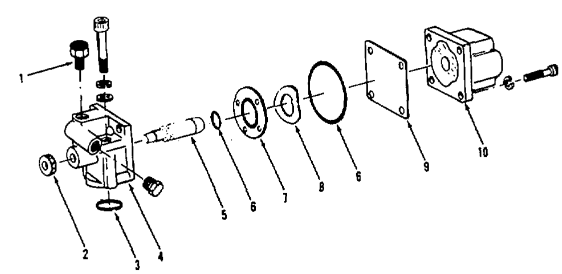
The shut-down valve, electric or manually operated, controls flow of fuel from the pump to the injectors. The electric valve is equipped with a knob which will open the valve. In case of electrical power failure, keep in counterclockwise position to operate electrically.

Electric Shut-Down Valve

The electric shut-down valve is held open while current is flowing through the electric coil, or solenoid. When current is not flowing, valve will shut unless the shut-down valve is locked open manually.

Disassembly

Remove coil housing from valve housing. Remove coil housing, fuel shield and discard "O" ring. Remove spring washer and plate-type valve. Remove manual override knob, and unscrew override shaft from coil end. Discard shaft and "O" ring. See Fig. 5-37.



1 CONNECTION	**6**	**'0' RING**
2 KNOB	**7**	**VALVE**
3 SEALING RING	**8**	**SPRING**
4 HOUSING	**9**	**SHIELD**
5 SHAFT	**10**	**COIL**

Fig. 5-37, F5143. Electric shut-down valve - exploded view

Cleaning And Inspection

1. Clean all parts except the coil assembly in mineral spirits.

Note: Do not wet the coil with solvent; instead, wipe it clean with a lint free cloth.

2. Visually check valve and valve seat for wear, bonding failure or corrosion. Replace if necessary. Valve seat should have a minimum seat 0.015 inch [0.38 mm] wide. Fig. 5-38.
3. Check coil assembly with an Ohm meter, replace if below values given in Table 5-6.

Caution: Be sure starting switch is in off position when checking coil.

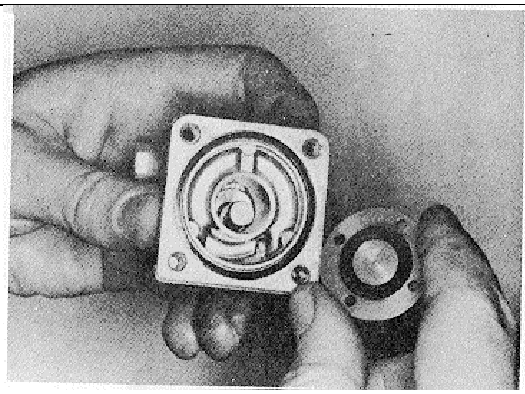


Fig. 5-38, F528. Inspecting plate type valve

Table 5-6: Coil Resistances

Coil Part No.	Voltage And Type	Coil Resistance (Ohms)
134072	12 V.D.C. Single Terminal	7.5 ± 0.5

Assembly

1. Install a new "O" ring on new override shaft and coat with lubricant. Fig. 5-39.
2. Screw shaft into housing until it reaches bottom of its bore. Use depth micrometer set at 0.118 Inch [2.997 mm] and check distance from face of valve housing to tip

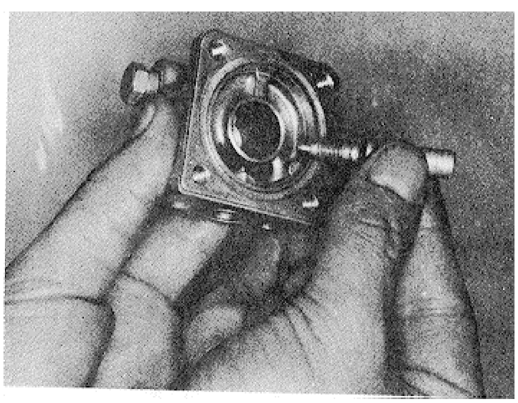


Fig. 5-39, F529. Installing override shaft

of shaft. If necessary, screw shaft out until it is 0.118 inch [2.997 mm] below housing face. Do not move shaft and press on knob until it contacts valve housing which will act as a stop. Fig. 5-40.
3. Place valve into valve housing with rubber side toward, housing.

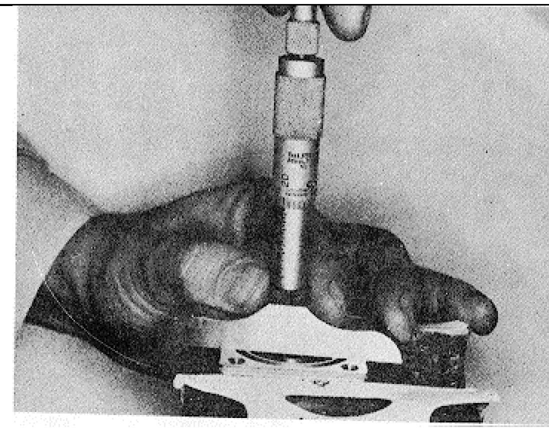


Fig. 5-40, F530, Checking shaft tip depth

4. Apply lubricant to housing "O" ring and seat in groove.
5. Drop spring washer on valve with concave side up and piloted around valve locator. Fig. 5-41.
6. Place fuel shield on valve housing and tighten screws to 25 to 30 inch pound [2.8 to 3.4 N- ml torque.
7. Energize valve and pump fluid through valve at 300 psi [2068 kPa]. De-energize valve and valve should withstand the 300 psi [2068 kPa] load with no leakage through valve.
8. Should leakage exist, check the main body for nicks or depressions where body and plate come in contact. Check the rubber seal in the plate for swelling or other defects.

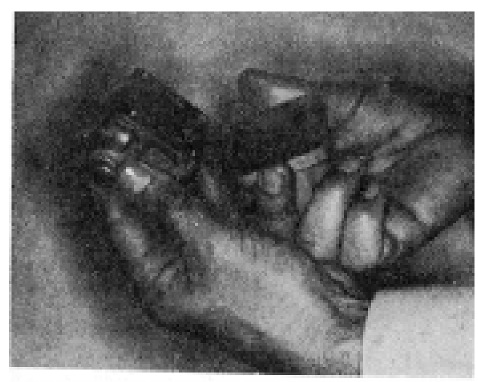


Fig. 5-41, F531. Assembling shut-down valve

High Pressure Fuel Shut-Down Valve

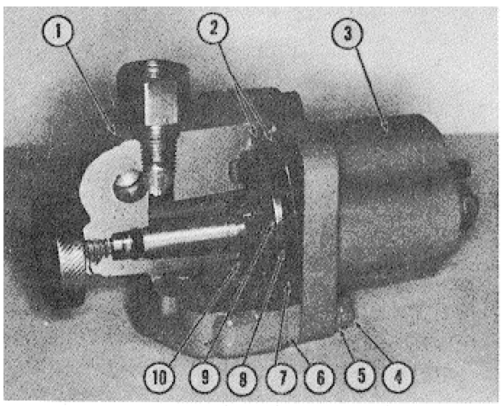
Some applications and/or approval tests require that rapid successive engine starts be made. Starts are attempted as soon as the flywheel stops. Rapid starting in this manner places an overload on the solenoid valve, since it must open against pressure that has not dissipated from the previous operating cycle. Fire engine applications are an example of this requirement.

Kit, Part No. AR-05592, enables valve to operate against the higher fuel pressure plus the spring load.

The orifice disc, with the center hole, restricts the fuel pressure loading on the spring loaded disc. This allows the spring loaded disc to operate like the standard disc without the fuel pressure effect.

The high pressure valve will be valuable In applications having shut-down controls where immediate starts are required after a control has broken the electrical circuit. The engine may be started with this kit as soon as the operator desires.

Arrangement of AR-05592 kit in the shut-off valve is shown in Fig. 5-44.



1 HOUSING ASSEMBLY	5 S607 LOCKWASHER	8 129768 SPRING
2 19888 "O" RING	4 RED	9 196056 DISC, ORIFICE
3 OIL ASSEMBLY	6 19605 5 SPACER	10 19605117 DISC PILOTING
4 S1215 CAPSCREWS (10-24X3/4)4 - REQD.	7 129839FUELSHIELD	

Fig. 5-44, F5232. High pressure fuel shut-down valve Assembly

1. Remove solenoid from valve body. Discard standard disc in valve body. Retain wave spring and stainless steel plate.
2. Place spacer block on valve body with "O" ring groove toward solenoid. Make sure "O" rings are in grooves In valve body and spacer block.
3. Insert orifice disc, with hole In center, in valve body. Insert piloting disc, with no center hole, In spacer block.
4. Place wave spring on raised portion of top disc fuel shield. Place stainless steel plate on wave spring and attach solenoid with 10-24 x 3/4 Inch [19 mm] screws supplied.

Front Cover Assemblies

Front cover assemblies consist of the cover, main shaft and bearing, and the governor weight carrier assembly. Most front covers built after Jan. 1975 will contain the tachometer drive. The cover may be flange mounted to the compressor or fuel pump drive, or the pump bracket mounted to the engine.

Disassembly And Inspection Of Standard Cover

1. Check governor weight carrier shaft in Its bushing before removal. Excessive wear can be felt by moving shaft from side to side in the bushing.
2. Observe gear backlash between weight shaft gear and drive gear. Normal backlash is 0.005 to 0.009 Inch [0.13 to 0.23 mm] .

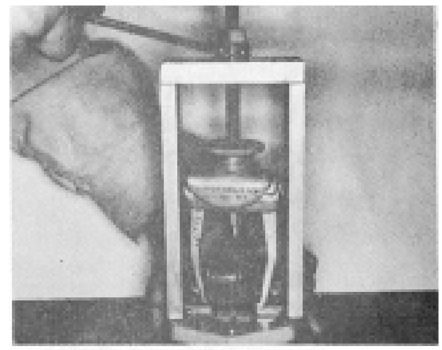


Fig. 5-47, F538. Using ST-709 to pull governor weight assembly

Note: Remove weight assist plunger If not previously removed.

3. To remove governor weight carrier assembly from drive cover use ST-709 Puller to pull weight shaft assembly and bushing from front cover. Fig. 5-47. The bushing is locked on shaft with a snap ring and will usually come out of cover with weight shaft assembly, however, if snap ring pulls off shaft leaving bushing In front cover, use an internal engaging puller of ST-709 to pull bushing. If shaft pulls off of cast carrer, use ST-667 to remove shaft and bushing.
4. Remove fuel pump drive coupling retainer capscrew and washers. If cover contains tachonmeter drive, pull coupling with ST-709 puller or pull spline drive coupling with ST-1249.
5. If cover contains tachometer shaft, remove drive cover retaining screw and lift off drive cover.
6. Use ST-667 dowel puller or brass punch to remove tachometer shaft, seal and bushing from front cover; discard seal.
7. Remove large snap ring from. pump end of drive shaft between drive cover and drive gear with hose clamp pliers or grind a small groove in a pair of needle nose pliers. Fig. 5-48.
8. If cover does not contain tachometer drive, Install a longer capscrew In place of drive coupling retainer capscrew, press on capscrew to remove drive shaft bearing and shaft assembly from front cover. Fig. 5-49.
9. Press drive shaft oil seals from drive cover.

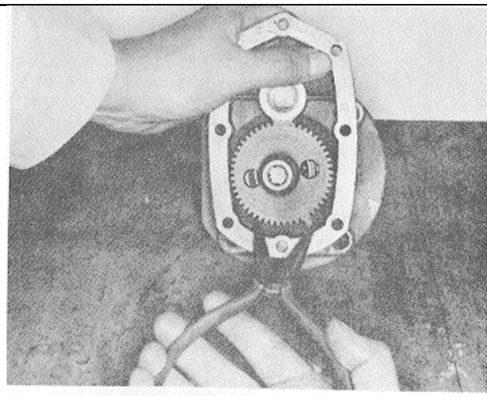


Fig. 5-48, F539. Removing snap ring from groove

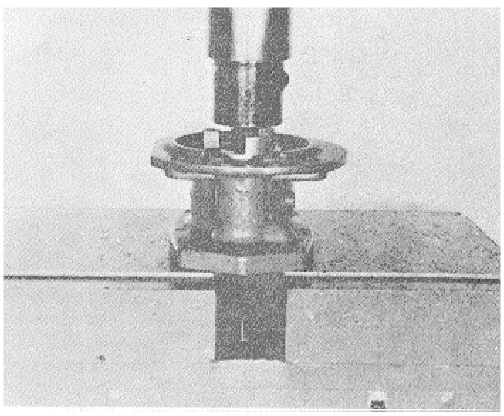


Fig. 5-49, F5144. Press drive gear assembly from front cover

10. Governor assembly can be disassembled to change gear and bushing. The governor qarrier, weights and shaft can only be replaced as an assembly. If bushing is worn larcer than 0.504 onlych [1280 mm],be replace bushing.

Governor Weight Carrier

Welded and cast governor weight carrier assemblies must be purchased as a complete unit. These pins cannot be replaced.

1. If cast carrier shaft has pulled off in removal from cover, press shaft into carrier until end of shaft is flush to 0.005 inch [0.13 mm] below carrier surface (weight side).

Note: Do .not reuse parts unless there is a minimum of 0.0005 Inch [0.013 mm] interference fit between shaft and carrier.

2. If removed, press on gear Do not press against carrier as it may be damaged. Press against inside end of the carrier
shaft, If possible. The rough edge of gear goes toward carrier weight.

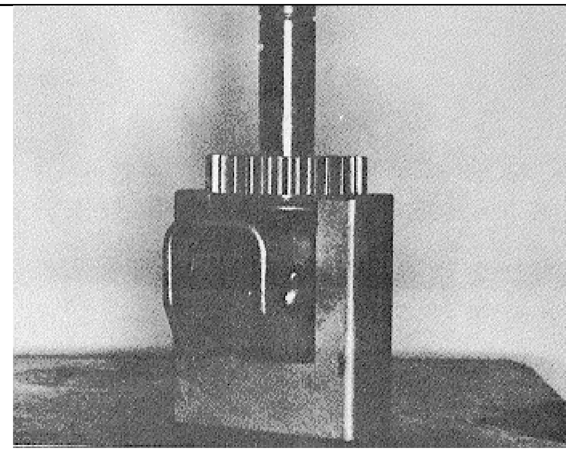


Fig. 5-50, F5285. Removing gear from weight carrier with ST-1231

3: Slip governor carrier bushing on the carrier shaft with flanged end of bushing next to gear and secure bushing withsnap ring.

Drive Shaft
Disassembly

1. Press gear pump drive coupling or tachometer drive gear, when used, and governor drive gear from drive shaft. Fig. 5-52.
2. Remove front cover tachometer drive gear with small gear puller, remove key.

Note: Press away from bearing because shaft has a shoulder under bearing.

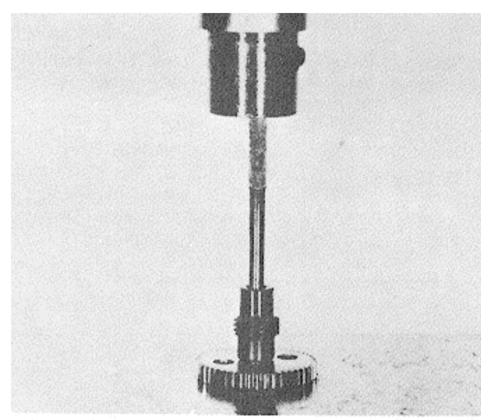


Fig. 5-52, F5146. Press shaft from gears

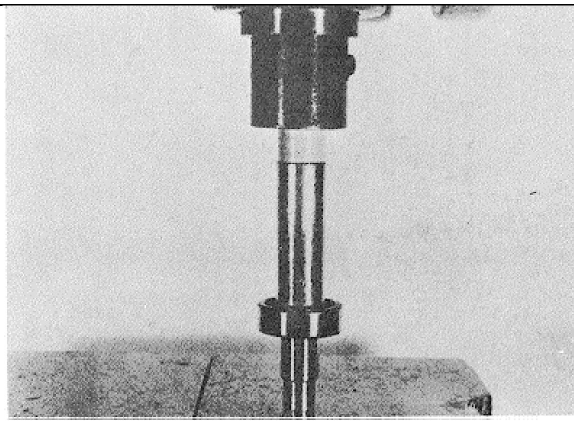


Fig. 5-53, F541. Pressing drive bearing on shaft

3. Press drive bearing from shaft only If bearing is rough or shaft has worn grooves.

Assembly

1. If bearing or shaft is replaced, lubricate shaft with high pressure lubricant and press bearing over shaft, pressing against Inner race of bearing. Fig. 5-53.
2. Press governor drive gear to drive shaft bearing over shaft.
3. Lubricate shaft and bore before pressing gear pump drive coupling or rear tachometer drive gear, when used, on shaft; press against governor drive gear. Fig. 5-54.

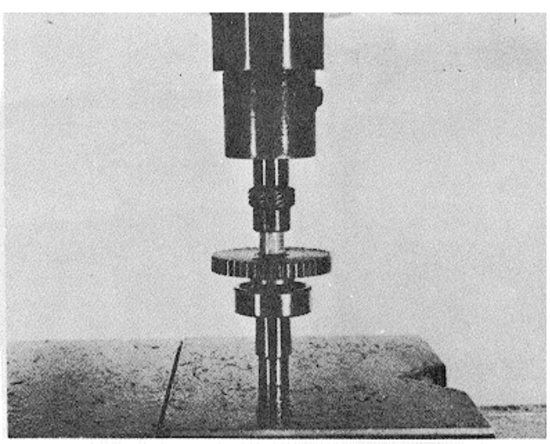


Fig. 5-54, F542. Pressing tachometer gear on shaft

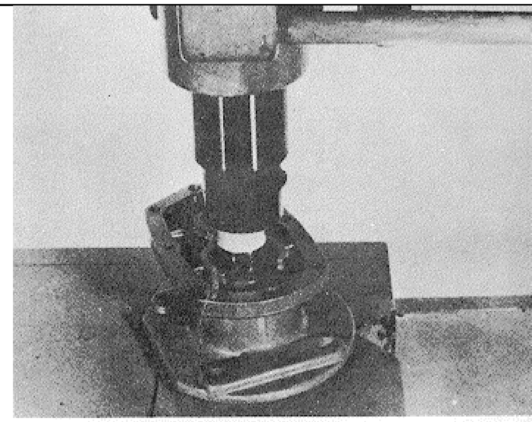


Fig. 5-55, F543, Installing drive cover oil seal

Note: Check gear to make sure it matches with *tachometer* gear to give proper rotation. Fig. 5-30.

4. Check to see if parts are firmly seated. Insert snap ring between ball bearing and governor drive gear.

Drive Cover Assembly Of Standard Cover and Cover With Tachometer Drive

1. Clean all parts thoroughly with mineral spirits or equivalent.
2. Press first oil seal into drive cover with lip toward outside of pump, and press second oil seal into drive cover with sealing lip toward inside of fuel pump. Seals must be spaced so the "telltale" hole is not covered, Fig. 555.

Note: Field installation of front cover tachometer drive fuel pumps to engines not previously equipped, may require air compressor modifications 011 must be allowed to splash from the air compressor housing into the fuel pump front cover cavity to lubricate the tach drive gears. If an oil seal is used on the fuel pump side of the compressor drive shaft, the seal must be removed, and any oil drain holes plugged prior to fuel pump installation. If *interference* exists *between Cummins single* cylinder compressor air outlet plumbing and the tachometer cable, use an air compressor head with offset air outlet port.

3. Lubricate ST-419 Assembly Tool and install tool over main shaft. Place snap ring between drive gear and bearing. Press main shaft assembly into front cover and through seals. Secure snap ring in cover groove. Fig, 5-57.

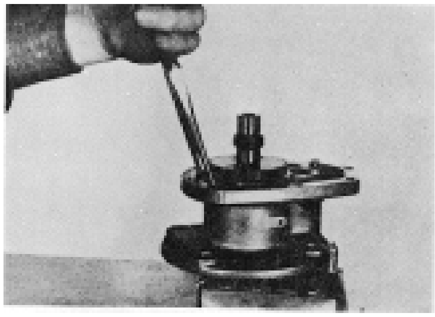


Fig. 5-57, F544. Securing snap ring in groove

4. Line up oil groove in top of tachometer drive bushing with fuel pump drive shaft. Press bushing, shaft and gear
assembly into cover until bushing bottoms.
5. Install spacer on top of bushing with slotted edge down. Install new oil seal, with spring side down. Spacer must bottom on bushing.

Caution: Do not overpress spacer. It can be flattened eliminating its effectiveness.
6. Cover top of seal with a thin coat of lubricating oil. Secure tachometer housing to cover.
7. 'Install key, press coupling and front tachometer drive gear into position on drive shaft. Press slow and straight. Be certain tachometer gear teeth are aligned.
8. Install coupling retainer flatwasher, lockwasher and capscrew to shaft and tighten in place. Hold coupling or main shaft in a copper-jawed vise while tightening.
9. Coat governor-carrier bushing with high pressure lubricant and press welded carrier assembly into front cover with ST-1231. Press cast carrier assembly into front cover using a driver contacting carrier and shaft between weights. Mesh gears to avoid gear tooth damage. The bushing must seat against housing. Rotate weight assembly, with weights opened out, to be sure it will turn completely in housing.
10. Install shims, when required, spring and governor assist plunger between governor weights and into bore of governor weight carrier shaft. Fig. 5-58.
Note: Always check and assemble weight assist plunger with smallest end of plunger to weights. This will prevent weights from sticking. Governor assist plunger is used only on PT (type G) fuel pumps.
11. Use enough shims back of spring to make governor assist plunger protrude above gasket face of front cover. Gauge protrusion with a dial depth gauge having a base approximately 4 inches long or use ST-1120 or ST-1241.
Note: Refer to calibration data for weight assist protrusion pertinent to pump being rebuilt.

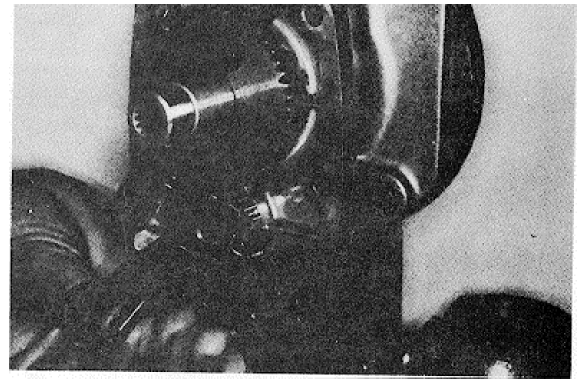


Fig. 5-58, F5305. Installing weight assist plunger in cast weight carrier.

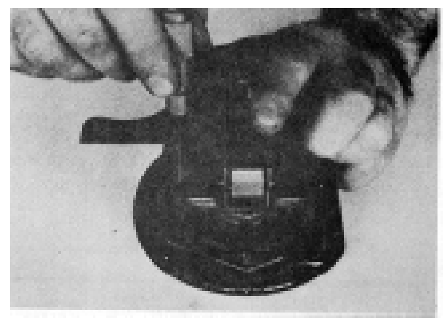


Fig. 5-67, F546. Measuring assist plunger protrusion

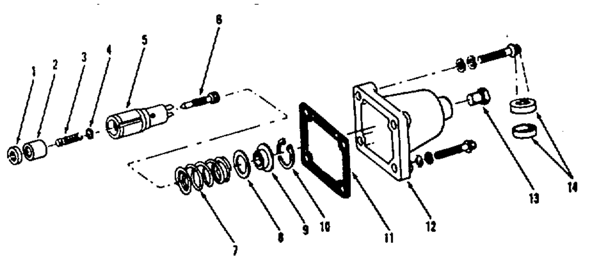
CHECKING PROTRUSION WITH DEPTH MIKE
1. Place one leg of the depth mike base of pedestal across the carrier walls and measure down to the front cover gasket surface (no gasket). Fig. 5-67. Move the depth mike to the opposite side of the carrier and again measure to the front cover gasket surface directly across the cover from the previous measurement (do not turn carrier or cover). Average these two measurements. This procedure is necessary to eliminate any possible influence of uneven carrier wall heights.
2. Position the depth mike across the carrier directly over the weight assist plunger. Measure down to the plunger. Do not depress spring.
3. Subtract "Step 2" from the average determined under "Step 1". The result is the weight assist protrusion. If weight assist protrusion is below specifications, (see Fuel Pump Calibration Data) add shims. If the weight assist protrusion is above specifications, remove shims or grind the exposed end of the weight plunger (grind only if no shims are being used).

GOVERNOR SPRING PACK

The governor spring pack consists of the idle and maximum or high-speed springs, plungers, adjusting screw and shims. The springs control engine speed and adjustments are made by the shims or adjusting screw. Fig. 5-68

Standard Automotive Spring Pack Disassembly

1. Remove snap ring which holds governor spring pack in sleeve with a pair of snap ring pliers.



1	ADOPTER	6	ADJUSTING SCREW	11	GASKET
2	IDLE SPRING PLUNGER	7	HI-SPEED SPRING	12	COYER
3	IDLE SPRING	8	SHIM	13	PLUG
4	WASHER	9	RETAINER	14	SEAL
5	GUIDE AN CLIP	10	SNAP RING		

Fig. 5-68, F5148. Standard governor - exploded view

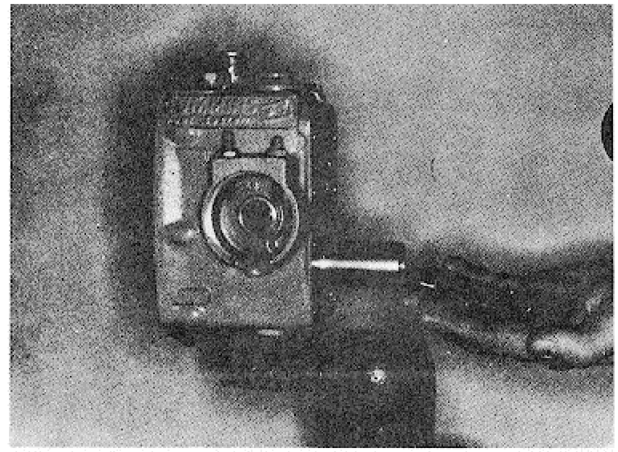


Fig. 5-70, F510. Removing standard spring pack assembly

2. Remove high-speed spring, spring retainer and shims from spring-pack housing.
3. Remove idle-spring plunger guide (adapter when used), idle spring or springs, idle spring plunger and spring rest washer. Fig. 5-70.

See Fuel Pump Assembly section for assembly of governor spring pack to fuel pump.

Table 5-10: Governor Springs

Part Number	Color Code	Replaces	Wire Dia Inch [mm]	Number Coils	Pounds Load [kg]	Inches Length @ [mm]	Free Length Inch[mm]
Maximum or High Speed Springs and Specifications							
*143251	Blue/Purple	70711B	086[2.18]	8.4	11.65/10.75[5.28/4.89]	@ 1.06[25]	1.487[37.8]
*Formerly color coded - 143251 Red/Black and Blue/Brown							
Weight Assist Springs and Specifications							
143847	Blue		028[.711]	9.7	3.30/3.70[1.50/1.68]	@ .325[8.2]	584114.8]
Idle Springs and Specifications							
144195	None	(Idle) Std. Auto	032[.813]	12	0.69/0.85[.31/.38]	@ .955[24]	1.025[26.0]

FUEL PUMP ASSEMBLY

The pump assembly requires all parts to be dirt free, and the actual operations performed with the utmost care, to insure proper and trouble-free performance.

Vise And Holding Fixture

Mount the fuel pump on Holding Fixture ST-546 or 3375133 and Swivel Vise ST-302.

Tachometer Drive In Housing The life of tachometer drive seal can be significantly improved by keeping maximum clearance between gear and bushing to .005 inch [0.127 mm] and by correctly installing drive assembly into fuel pump housing.

1. Line up oil groove in top of bushing with fuel pump drive shaft. Press bushing, shaft and gear assembly into housing with ST-1032 Driver until bushing bottoms.

Note: Using any tool but ST-1032 Driver may cause indentations In oil seal which leads to premature seal failure.

2. Install spacer on top of bushing with slotted edge down. Install new oil seal, with spring side down, with ST-1032 Driver. Spacer must bottom on bushing.

Caution: Do not overpress spacer. It can be flattened eliminating its effectiveness.

3. Cover top of seal with a thin coat of lubricating oil. Install new felt dust seal with white side up. Secure tachometer cover with new gasket to housing.

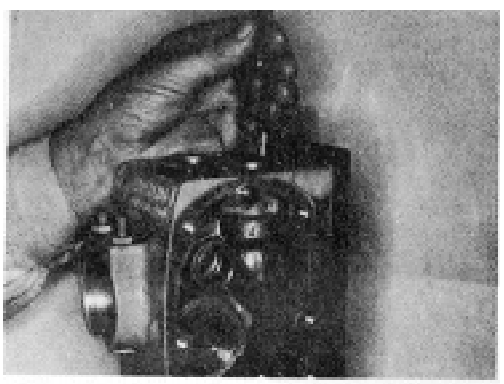


Fig. 5-94, F556. Installing tachometer drive

Filter Screen
Single Screen Types

1. Assemble the filter screen assembly into top of standard housing, hole in retainer goes down. Fig. 5-95.

2. Install "O" ring using grease to hold in place.

3. Position spring and tighten cover in place. Torque cap to 8 to 12 foot pounds [11 to 16 No m]. Overtightening is not necessary or desirable.

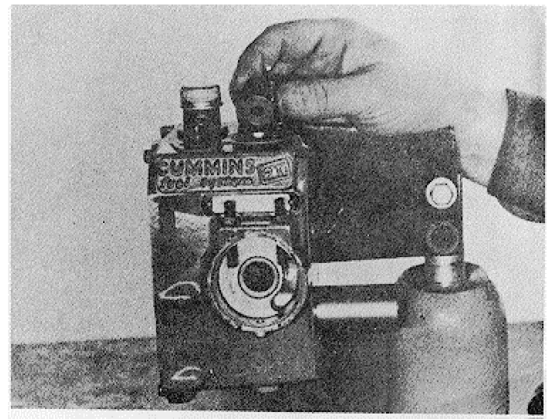


Fig. 5-95, F557. Installing fuel screen in standard housing

Double Screen

1. Install lower screen (one with holes in each end), install screen retainer and new "0" ring.
2. Install upper screen, hole down; install spring.
3. Lubricate new "O" ring and plate on cap, torque cap 8 to 12 foot pounds [11 to 16 N. ml.

Governor Spring Pack
Automotive Governor
PT (type G) Fuel Pump

1. Assemble idle screw into plunger guide, place small washer over screw point inside guide. Fig. 5-97. Place small idle spring into guide and place idle plunger (button) against spring in guide. Fig. 5-98.

Note: When assembling governor spring pack, the new improved plunger should be used. Fig. 5-99.

2. The size of counterbore changes with different engine models. See pump calibration data for correct plunger to use. The plunger controls maximum fuel pressure produced by the fuel pump.

Spring Pack Notes

Note: There are different maximum-speed springs available and each is identified by color stripes. See Governor Spring Pack section, Table 5-10, for tabulation and specifications.

Note: Shims are available In 0.005, 0.010 and 0.020 inch [0.13, 0.25 and 0.51 mm] thickness. The final number of shims must be determined during fuel pump calibration.

Install the spring pack cover and new gasket. Secure cover to housing, torque capscrews to 9 to 11 foot pounds [12 to 15 N•m]

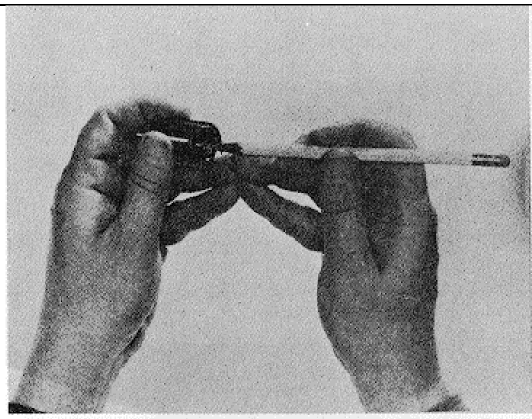


Fig. 5-97, F558. Installing washer over idle screw

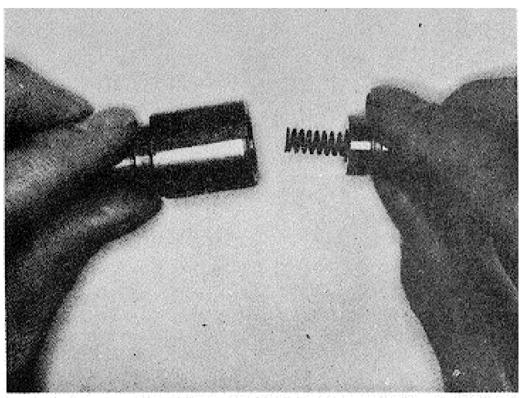


Fig. 5-98, F559. Installing idle plunger button

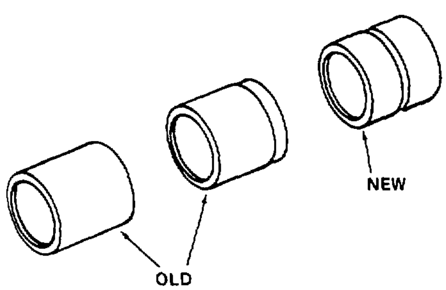


Fig. 5-99, F5149. Old and new design idle plunger buttons

Throttle Shaft

Fuel Adjusting Screw Type

1. Lubricate "O" ring and slide on fuel adjusting screw.
2. Insert fuel adjusting screw into throttle shaft about 6 turns. Do not- restrict throttle shaft fuel port. Fig. 5-101.
3. Lubricate "O" ring and slide on throttle shaft.

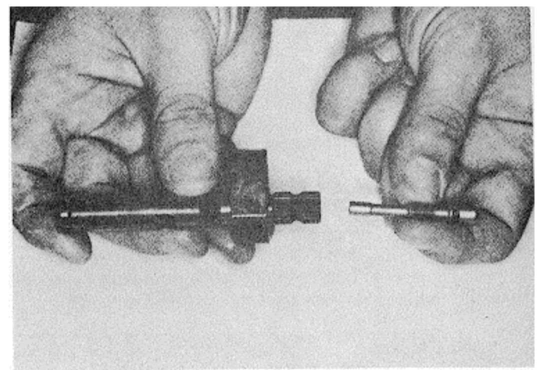


Fig. 5-101, F5307. Installing fuel adjusting screw in throttle shaft

4. Insert throttle shaft in housing with counterbored port down and throttle stop slanted down in standard automotive pump.
5, Instali snap ring on end of throttle shaft. Fig. 5-102.

Restriction Plunger Type

Throttle shafts vary with applications. Replace with *same* type throttle shaft, if needed. Table 5-12 and 5-13.

1. Install new "0" ring on throttle shaft using ST-835 Sleeve for 1/2 inch [12.7 mm] (ST-422 for larger) shaft to avoid damage to "0" ring. Lubricate before assembly.

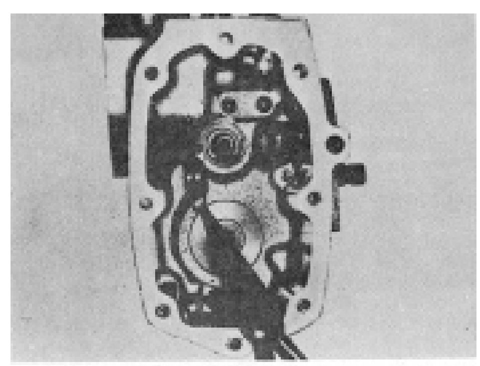


Fig. 5-102, F5299. Installing snap ring in throttle shaft

Note: Install enough shims to bring the plunger flush with the fuel passage leaving it completely open for pump calibration, Fig. 5-103. Some throttle shafts do not have a restriction plunger.

2. Install restriction plunger in the throttle shaft, if used. Torque plug to 40 to 55 inch pounds [4.5 to 6.2 No m].

3. Install washer over shaft. Insert the throttle shaft In sleeve so the "ears" of the stop are curved downward or if pin is used so open side of pin is down, lubricate with fuel oil.

Note: Counterbored port on PT (type G) throttle must go
4. Install the snap ring and lock in the groove in front of the throttle shaft cover plate.

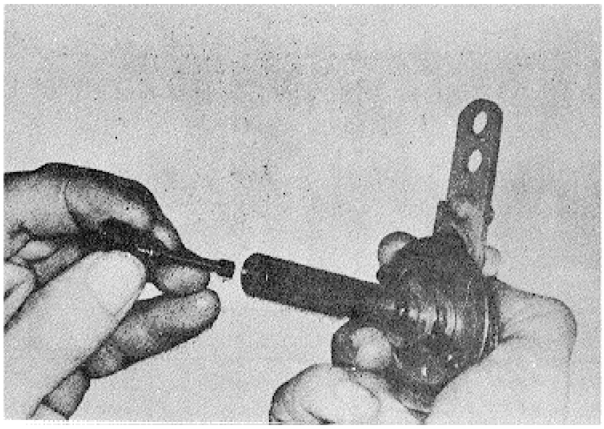


Fig. 5-103, F564. Installing throttle restriction plunger

Table 5-12: Throttle Shafts 1/2" PT (type G)

Code	Red
Size	0
Part No.	149030

Throttle Lever

Install the throttle lever on throttle shaft and tighten securely. Throttle levers are available in lengths of about 1-1/4 to 5 inches (31.7 to 127 mm]; use the correct length for the pump application.

The spring loaded throttle lever is used to prevent throttle shaft bushing wear and scoring that can occur when excessive pressure is applied to the throttle lever In full fuel position. The spring loaded lever is designed to collapse under this excessive pressure and then spring back when the pressure is released.

This will also prevent the throttle lever from turning on the shaft and mutilating the serrated shaft diameter.

Note: The throttle lever stop in the vehicle chassis should be adjusted so there will be a minimum or negligible amount of collapsing of the throttle lever. Otherwise, the purpose of the spring loaded lever will be defeated as the lever can collapse only so far. When the throttle linkage stop is not properly adjusted, the spring loaded lever may permit the bell crank in the linkage mechanism to go "over center," locking the throttle in full fuel position.

Governor Plunger

1. Lubricate with engine oil and install the plunger into barrel. Fig. 107. Make sure plunger is correct fit and change

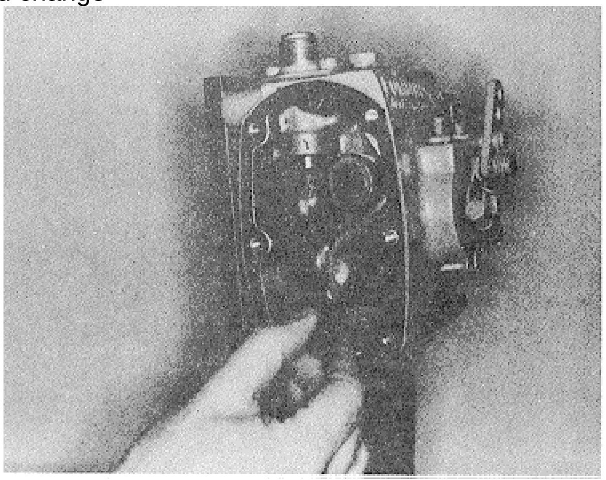


Fig. 5-107 F566. Installing governor plunger

number if replaced. Remark governor barrel if oversize plunger is used, so size of barrel and plunger correspond.

Drive Cover Assembly

1. Place a new gasket over the pump housing dowel pins.

2. Place the assist plunger In the weight shaft bore with spring and shims, when required.

3. Hold the governor weights in to hold the assist plunger while assembling cover to housing, meshing with tachometer gear.

4. Position plunger drive tang horizontally position weight carrier horizontally.

Note: The weights straddle the governor plunger driver.

5. Torque capscrews 9 to 11 foot pounds [12 to 15 No m], securing cover to housing.

6. Rotate drive shaft to be certain tachometer gear meshes.

Gear Pump

1. Assemble the gear pump to the main housing using a new gasket. Locate notch for right hand or left hand rotation. For right hand rotation locate notch to upper right hand corner (looking from behind the fuel pump); for left hand rotation locate the notch to bottom left hand corner.

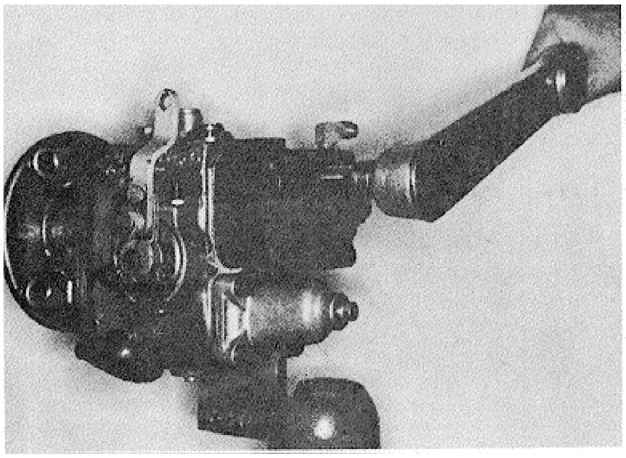


Fig. 5-109, F562. Torquing gear pump capscrews

Note: Use correct gasket and be sure it is positioned correctly. Be certain housing fuel holes match gear pump holes.

2. Torque capscrews in increments to 11 to 13 foot pounds [15 to 18 N. m]. Fig. 5-109. Check gear pump rotation freedom.

3. Install fuel inlet connection with same type threads as gear pump. Current gear pumps use a 3/4 inch-16 UNF threaded connection with an "O" ring. Previous gear pumps had 3/8 inch NPTF inlet connection. Don’t let pipe sealer, used on NPTF type, enter gear pump. Use sealer sparingly to keep out of pump. Cover connection to keep out dirt.

4. Install cooling check valve and/or elbow into top of gear pump if used.

Shut-Down Valve And Pulsation Damper

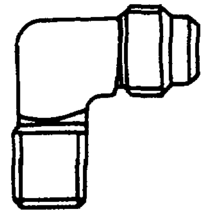
1. Install the shut-down valve with new "0" ring on fuel pump housing.

2. Install damper with new "0" ring to the gear pump. Torque capscrews to 11/13 foot pounds [15 to 18 N. m].

Fuel Pump Cooling Kit PT (type G)

Cooling kit is used to prevent maximum fuel temperature from exceeding 250 deg. F [121 deg. C] under any operating conditions. Fig. 5-110

Note: This kit is required when long periods of down hill operations are encountered.



6 175836 ELBOW-CHECK VALVE

Fig. 5-110, F5159. Fuel flow check valves

Assembly

1. Install orifice assembly, consisting of elbow and orifice plug in 1/8 inch [3.17 mm] hole in bottom or back side of fuel pump housing. See Table 5-14 for correct orifice assembly.

Table 5-14: Cooling Kits

Pump Size Inch [mml	Kit Part Number	Check Valve	Orifice Assembly
3/4 [19.0]	BM-96293	177279	BM-93301

2. Attach check valve, Part No. 177279, to elbow. End of valve containing ball must be toward orifice assembly.

Note: Check valve will prevent fuel pump from being drained at engine shutdown.

3. Assemble No. 4 hose or tubing to valve and run to fuel tank.

Note: All engines using flanged type PT injectors, vented or not vented, must have cooling kit drain line returned directly to the fuel tank. Any engine with cylindrical injectors may have cooling kit drain line connected to injector drain line or be returned to fuel tank.

CALIBRATION

REFER TO FUEL PUMP CALIBRATION.

Tachometer Cable

The tachometer drive is a standard SAE size operating at 1/2 engine speed. Fill cavity with clean, heavy grease before attaching cable. Do not force tang into slot. If fit is incorrect, change tang to a new, standard SAE type. When tachometer cable outer casing is plastic, do not route near exhaust manifold or other "hot" areas.

Fuel Pump Throttle Travel

The most sensitive adjustment on units using a hydraulic governor is fuel pump throttle travel. Do not change the idle throttle stop screw setting (front). Using a protractor or ST-1162, Fig. 5-126, set the fuel pump lever idle position centerline at 55 deg. from vertical on centerline of fuel pump throttle shaft. Lock throttle lever screw. Set the centerline of the fuel pump lever in the maximum position at 27 deg. from vertical. Lock rear adjusting screw. Recheck throttle lever centerline travel, it must be 28 deg., or as specified, between idle and full throttle.

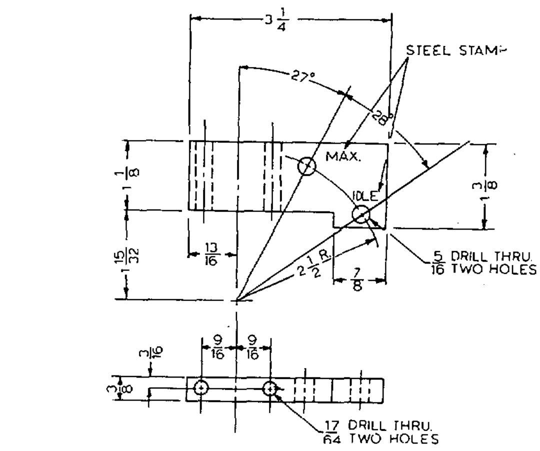


Fig. 5-126, F-5187.ST-1162 fuel pump throttle adjustment template

For PT Fuel Pump calibration and speed setting refer to FUEL PUMP CALIBRATION.

Governor Shaft And Linkage Adjustment

1. Governor-to-fuel-pump linkage must be connected with both fuel pump throttle and governor terminal shaft levers in fuel shut-off or Idle position. The fuel pump throttle lever will be all the way down against stop (full clockwise) and the governor terminal shaft away from the engine will be in extreme clockwise position.

2. Adjust control linkage to a length (about 9-1/2 inches [241 mm]) which will permit installation of unibals in levers without any movement of levers.

Caution: Be sure linkage and levers are not binding.

3. Start engine and adjust low speed stop screw (atop governor head) for desired idling speed.

INDEX

FUEL PUMP PT (TYPE G) CALIBRATION INSTRUCTIONS

Table of Contents

Test HP @ RPM	CPL	Code No.	Torque Rise %
NTC-290			
290 @ 2100	101	2764-A	15

Control Parts List CPL NO. 0101

INJECTOR	CAMSHAFT	PISTON	TURBO.	ENGINE MODELS
AR-40079	* 143450	203090	AR-8319	NTC-290
BM-98251	* 152960	*216020	* AR-10076	NHHTC-290
BM-78831	128470			NTF-295
* AR-40118	152950			NT-855-280

CYL. HEAD	TIMING	EXHAUST	INTERCOOLER
* 135541	C(–.0335)	Dry	No
*184586			
152650			

PUMP CODE	TYPE GOVERNOR	ANEROID		PUMP CODE	TYPE GOV.	ANEROID
2362	PT-G Auto	FE	AR-40304	2650	PT-G Auto	FE AR-40304
2433	PT-G Auto	FE		2672	PT-G MVS	FE
2495	PT-G Auto	FE		2674	PT-G MVS	FE
2512	PT-G Auto	FE		2594	PT-G MVS	FE
2528	PT-G MVS	FE		2613	PT-G Auto	FE
2488	PT-G Auto	FE		2635	PT-G Auto	FE
2501	PT-G Auto	FE		2718	PT-G Auto	FE
2562	PT-G MVS	FE				
8040	PT-G VS	FE		2758	PT-G Auto	FE
8362	PT-G VS	AR-40404		2761	PT-G Auto	FE
8433	PT-G VS	AR-40404		2764	PT-G Auto	FE
8228	PT-G VS	AR-40404		2765	PT-G Auto	FE
8107	PT-G VS	AR-40404		2785	PT-G Auto	FE
8171	PT-G VS	AR-40404		2789	PT-G Auto	FE
				2884	PT-G Auto	AR-40304
				2881	PT-G Auto	AR-40404

* Identifies current production parts on smoke certified CPL's.

PT (Type G) FUEL PUMP CALIBRATION VALUES – TEST STANDS WITH FLOWMETER ISSUED 6-75

PUMP CODE DATE	ENGINE MODEL CONTROL PARTS LIST	TEST HP RATED RPM	FUEL RATE LB. HR.	ENGINE FUEL PRESSURE	GOVERNOR CUTOFF RPM	THROTTLE-LEAK-CC (TRAVEL - DEG)	IDLE SPEED PSI @ RPM	MANIFOLD PSI @ RPM FLOW READING	CHECK POINT 1 PSI @ RPM FLOW READING	CHECK POINT 2 PSI @ RPM FLOW READING	WEIGHT ASSIST PSI @ RPM FLOW READING	WEIGHT ASSIST SETTING	GEAR PUMP GEAR SIZE	IDLE PLUNGER CODE NO.	TORQUE SPRING PART NO. (SHIMS) COLOR CODE	GOV. SPRING PART NO. – COLOR GOV. TYPE	GOV. WEIGHT GOV. PLUNGER PART NOS.	NOTES
2764-B 7-74	NTC-290 101	278-290@ 2100	110 115	138 150	2130 2160	75 (28)	22@ 600	146@ 2100 480	103-109 @1500 295	51-57 @1000 245	Omit	.840	3/4	47	138782 R-BI	143251 BI-Pur Auto	AR-797 182530	1974 EPA certified

Calibration Test Equipment
Cummins ST-848, ST-775, and ST-445 (with ST-773 conversion) fuel pump test stands have the following features to provide accuracy:

1. Large dial, laboratory accurate gauges. However, gauges are only accurate if properly maintained and should, therefore, be checked at regular intervals.

2. Accurate tachometers, either electric on ST-445, ST-775 and ST-848 or hand tachometer ST-774 for use with ST-445. A digital tachometer is now In ST-848.

3. A flow-meter, which permits the tester to adjust each fuel pump for total flow and correlate it with pressure calibration. The "fuel manifold pressure" thus obtained on the test stand will duplicate fuel manifold pressure on the engine.

Test Stands
Cummins fuel pump test stands equipped with a flow-meter are ST-848,ST-775 and ST-445 (with ST-773 conversion kit.) These test stands provide the most accurate method of calibrating the PT fuel pump, but due to some older engines being built on special, "one time" orders cannot be applied to all engines which have been built with PT fuel pumps.

Test Oil
Cummins fuel pump test stands must be filled with clean Cummins Test Oil No. 99011-68 or equivalent since all calibration data has been established using this test oil.

Note: Hydraulic oils are not suitable to use as test oils in Cummins test stands.

Duplication of factory test methods and materials is the key to correct calibration and insures uniform results wherever the fuel pump is adjusted.

General Requirements

The material shall be a straight oil or a blend of oils containing parafinic, aromatic or naphenic compounds, but not olefininc compounds, which show little or no change in physical properties during storage or use. The use of various additives and/or inhibitors to stabilize the oil is left

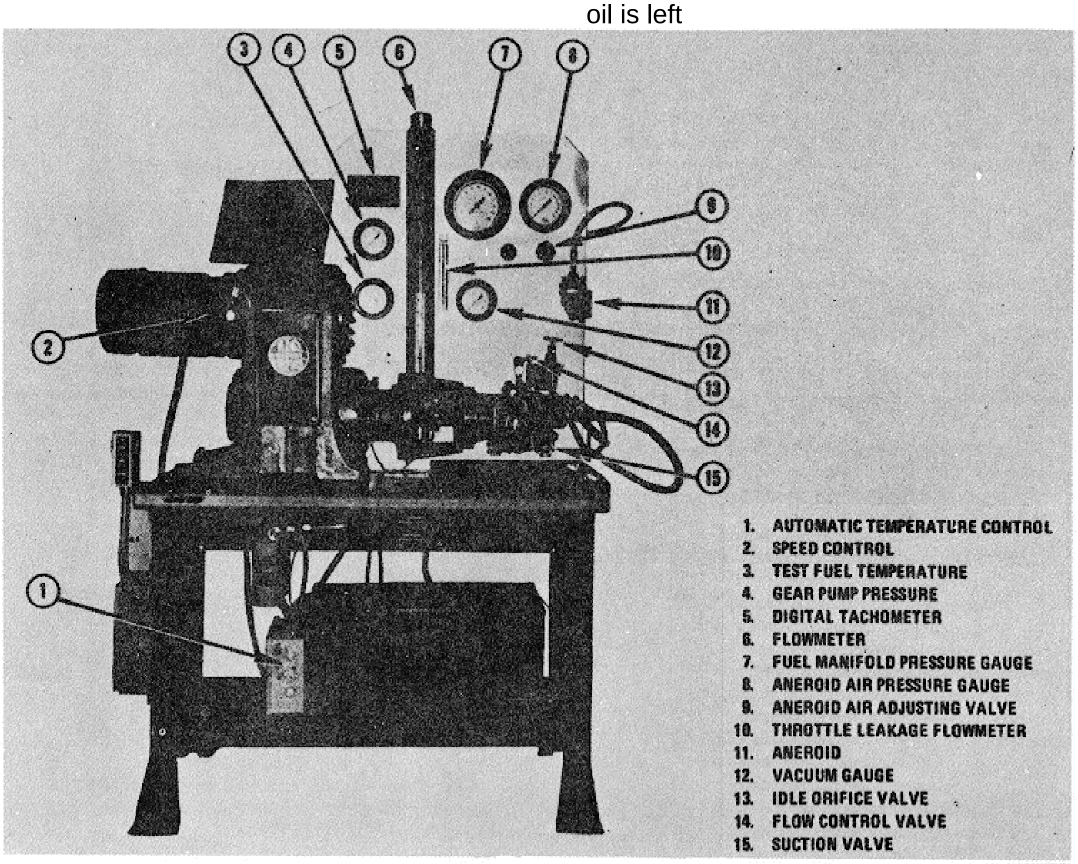


Fig. 5-1-1, F5100. Cummins ST-848 Fuel pump test stand to the discretion of the supplier. The additives must be antifoaming, anti corrosive antigumming. The fuel, additives, and color dye must be non-toxic and non-harmful to personnel.

Chemical And Physical Requirements

Kinematic Viscosity at

100 deg F Centistokes, ASTM D445.................... 2.5 3.3

Viscosity at 100 deg F [38 deg C] Saybolt Universal

(SUS), ASTM D2161.. 34.4 37.0

Specific Gravity at 60 deg. F, ASTM D287......... 820.830

Gravity, Degrees API, 60 deg F, ASI M D287........ 41-39

Flash Point, P.M., Closed Cup, ASTM D93 160 deq F Min).

Color, ASTM D1500 .... 2 Max.

Water ASSTM D01796... .005

Corrosion, ASIM D130....................... Must Pass Class 1

Galvanic Corrosion, ASTM-5322-1 .... Must Pass

Sulphur % Weight, ASTM-P129, D1552 .... 0.4

Distillation at 20% point, ASTM-D86 ...... 440 deq. F Min,

Sediment - Using a 10 Micron filter, 22,260 particles per millileter are permissible. Using a 40 Micron filter, 195 particles per millileter are permissible. Using a 50 Micron filter, 5 particles per millileter are permissible.

Mobile Oil Company Type MC L-41 is one source that meets the above requirements.

Instruments

A fuel pump cannot be calibrated with any greater precision than that of instruments on the test stand. Pressure, speed and flow measurements must be very accurate, since these are the factors which determine the pump characteristics.

The instruments on a fuel pump test stand and engine test stand have the accuracy required for precision calibration and testing when new, but this accuracy must be periodically checked and maintained.

General

CAUTION

Cummins Engine Company, inc. assumes no responsibility of damage if fuel pump is calibrated to a different specification than listed for a specific engine model and Pump Code.

Formula to Determining SAE Brake Horsepower

Evaluation of engine performance during testing is for the most part, based on accurate horsepower readings. Therefore, it is imperative that the following formulas be used with test procedures. The basic formula to determine brake horsepower is as follows:

$$\text{Brake Horsepower} = \frac{\text{Torque In (Ft. Lbs.)} \times \text{Engine RPM}}{5252}$$

Most engine dynamometer manufacturers provide a figure known as a "brake constant" with each dynamometer. The constant simplifies the process of computing brake horsepower since only engine rpm and the scale reading (in pounds) need be found by the test mechanic. The formula used with a known constant Is

$$\text{Brake Horsepower} = \frac{\text{Lbs. (on Dyno. Scale)} \times \text{Engine RPM}}{\text{Dynamometer Constant}}$$

Example: Dynamometer in operation has brake constant of 500. Scales show a reading of 50 pounds and tachometer shows engine rpm of 1600.

$$\text{Brake Horsepower} = \frac{50 \times 1600}{500} = 160$$

The above formulas apply to engine dynamometers only. Where chassis dynamometers are used, a factor of approximately 25% must be used to compensate for gear ratios, tire size, etc.

Procedures of Converting Horsepower

1. All horsepower ratings In fuel pump data are Cummins test ratings. Cummins test horsepower ratings are made at 500 ft. [152 m] altitude and 80 deg, F [26.7 deg. C] temperature, therefore, test horsepower is about 4% below the ratings made at sea level and 60 deg. F [15.6 deg. C]. To convert sea level horsepower ratings to your location (see Table 5-1-1) deduct 3% per 1000 ft. [305 m] above Sea Level and 1% per 10 deg. above 60 deg. F [15.6 deg. C].

Notes:

a. Turbocharged engines develop the stated horsepower from sea level to the altitude given in engine operators manuals.

b. All engines derated in power only, or in power and speed combined, need not be converted for any difference between Cummins and Sea Level standards.

2. Data given in Table 5-1-1 is Intended as a guide to be used In the conversion of horsepower as expressed in one system to that of another system. Standard test conditions vary from one system to another as noted.

Note: The Din (German) horsepower ratings includes fan horsepower whereas the other systems listed do not include the horsepower required to drive the engine cooling fan or the battery charging generator. In general, approximately 10 percent adjustment of horsepower rating will make up the difference, When the horsepower required to drive the fan and the generator is known, the exact adjustment in net horsepower may be made.

3. Including differences in altitude and temperature in the standard test conditions, the following conversion must also be made in addition to the conversion from the difference in Ft. Lbs./Sec., so the total conversion becomes

Cummins, SAE or British HP = Metric or Din (German) HP x .9863

Metric or Din (German) HP = Cummins, SAE or British HP x 1.0139

Note: The above conversion disregards the very slight percent difference in relative humidity between Cummins and SAE or British systems.

4. Units of measurement conversions from one system to another.

a. Altitude or Elevation Conversion
100 feet = 30.48 meters
b. Barometric Pressure Conversion
1 inch Hg. = 25.4 millimeters Hg.
c. Temperature Conversion
°F = 9/5 x °C + 32
°C=F -32 x 5/9
d. Horsepower Conversion
Mkg./Sec. x 7.233 = Ft. Lb./Sec.
Ft. Lbs./Sec. -. .13825 = Mkg./Sec.

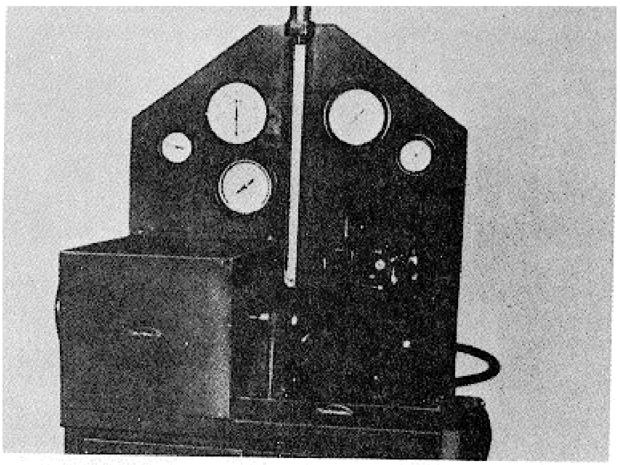


Fig. 5-1-3, F5164. Cummins ST-445 Fuel pump test strand

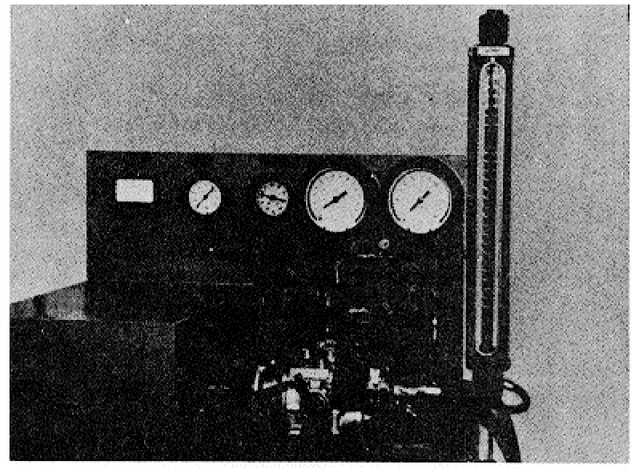


Fig. 5-1-2, F5163. Cummins ST-755 Fuel pump test strand

Table 5-1-1: Test Standards For Conversions

	Altitude or Elevation		Barometric Pressure		Degrees Temperature and Humidity			Horsepower	
Measurement System	Feet	Meters	In. Hg.	Mm. Hg.	Fahrenheit	Centigrade	Relative Humidity	Mkg./Sec	Ft.Lb./Sec.
Cummins	500	152.4	29.38	746.25	85°	29.4°	30%	76.04	550.0
SAE	500	152.4	29.38	746.25	85°	29.4°	50%	76.04	550.0
British	500	152.4	29.38	746.25	85°	29.4°	50/%	76.04	550.0
Din (Germany)	984	300.0	28.88	733.55	68°	20.0°	60%	75.00	542.5
Metric	984	300.0	28.88	733.55	68°	20.0°	60%	75.00	542.5
Sea Level	Sea Level	Sea Level	29.92	759.97	60°	15.55°	Dry Air	*76.04	*550.0

Horsepower for Metric or Din will be 75.00 Mkg/Second or 542.5 Ft.Lb./Sec.

Calibration Instructions

Pump Hookup

1. Install the proper drive coupling to test stand, which matches pump drive shaft coupling, so pump being tested may be driven. See Fig. 5-1-4 and 5-1-5.

2. Before mounting fuel pump, check the location of the mounting holes; it may be 'necessary to change the test stand adapter plate.

3. Mount fuel pump on the test stand mounting bracket leaving about 1/16 inch [0.0625 mm] between fuel pump coupling and test stand drive coupling.

Note: To obtain the 1/16 inch clearance, it may be necessary to adjust the test stand coupling.

4. Squirt some clean test oil into the gear pump inlet hole, so pump will pick up faster, then connect suction line. Fig. 5-1-6.

5. Fill fuel pump housing with clean test fuel through the plug hole on top of pump (fuel inlet fitting on V6-140/V8-185 engines). Reinstall plug or fitting.

6. Connect line to fuel pump shut-down valve.

7. Connect a No. 4 hose to the cooling bleed check valve on

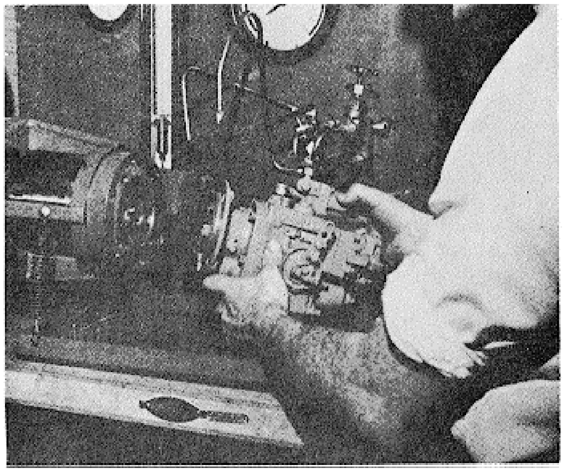


Fig 5-1-4, F5168. Mounting fuel pump with buffer type drive

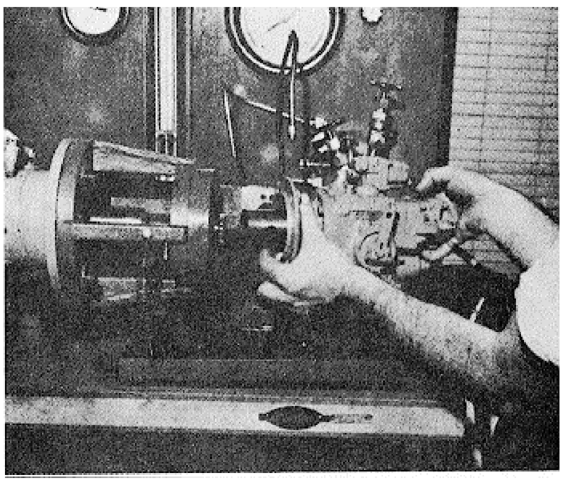


Fig. 5-1-5, F5169. Mounting fuel pump with spline drive

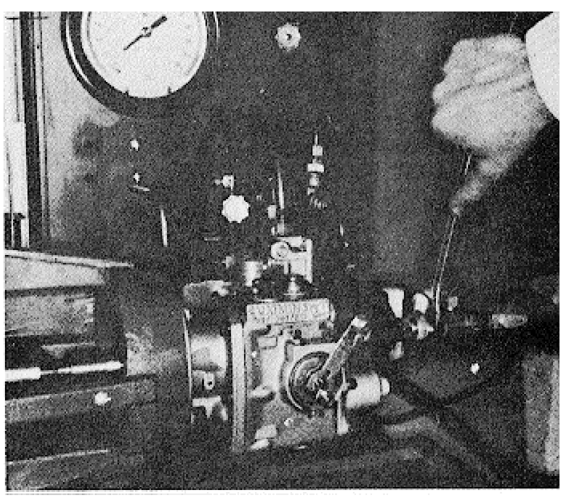


Fig 5-1-6, F5102 Connect gear pump suction line

pump housing or on gear pump, if used. Drain into splash tray under pump.

CAUTION

Never operate gear pump having cooling drain with the drain plugged.

8. Never remove fuel pressure damper either during testing or operation as it will cause erratic pump performance and accelerate wear.

9. Use ST-774 Tachometer at the fuel pump tachometer shaft connection to obtain most accurate speed readings (unless using ST-775 or ST-848 stand).

10. The ST-848 test stands with 60-cycle current require only that the reverse or forward start button be pressed depending on right or left hand pumps. Fig. 5-1-7.

11. The ST-848 test stands with 50-cycle current requires a change in motor brush location to reverse, motor for left hand fuel pumps. Fig. 5-1-8. Rotate cover shown to position required by loosening two cover screws.

12. Remove fuel pump mounted fuel filter and replace with Fuel Filter Adapter, Service Tool No. 3375014, and gasket 3375015.

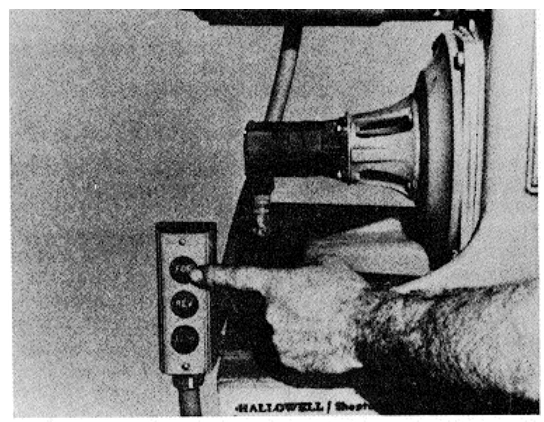


Fig. 5 1 7, F5170 60 cycle motor buttons

Check Pump Name Plate

1. The first item in top line is Control Pair Its List. 0101.

2. The next five spaces will be Shop Order Number. 0101-11521.

3. The next six or eight Spaces give fuel pump Serial No. 0101-11521-846067 or 0101-11521-DP205361.

4. The first space on bottom line will be stamped "L" when pump is left handed. Some "V" series right hand rotation engines require left hand pumps. Right hand fuel pumps will not be stamped.

5. The next seven spaces will be fuel pump BM or AR number. 0101-11521-846067 L-BM-70486.

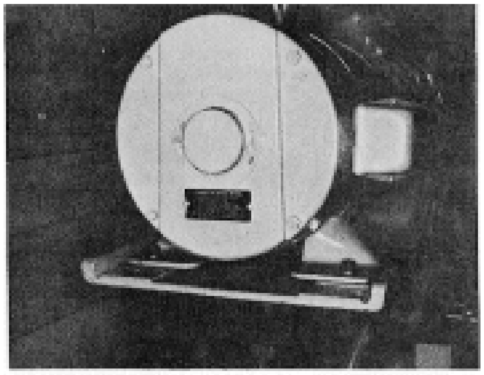


Fig. 5 1-8, F5103. 50 cycle motor brush location to reverse motor

6. The last six spaces on the second line give the calibration card number and suffix letter. 0101-11521-846067 L-BM-704862433C.

7. On fuel pumps with torque modification device, a second nameplate will show regulator code number and setting in thousandths of an inch.

Note: On Woodward governor pumps, the BM or AR number will be for fuel pump only.

Run-In

1. Remove throttle lever cover snap ring and pull shaft from housing. Inspect restriction plunger to b(e certain hole is shimmed completely open. Fig. 5-1-11. This is not necessary if calibration is being checked as a trouble shooting step. Replace shaft.

2. Move and hold throttle control lever to full fuel position, it may be necessary to adjust the throttle screws to Insure that the fuel port in the throttle is fully open and indexed with the fuel passage in the fuel passage in the body. It is not necessary to adjust the throttle screw If the calibration is merely being checked as a trouble-shooting step.

3. Open completely the fuel pump shut-down valve, by turning knob clockwise (manual button, Fig. 5-1-12) and flow control valve. Open throttle, wide open positron, (secure open with a spring) start and run pump at 500 rpm

4. If pump is newly rebuilt or has been opened, run at slightly over rated speed for five minutes to flush, allow bearings to seat and to purge all air from the system.

5. Before starting calibration, check pump fuel flow in the flow-meter for air. If air is present, correct leak before continuing test.

6. The test oil or fuel temperature must be 90 deg. to 100 deg. F [32 deg. to 38 deg. C].

7. Set gear pump at 8 inch [203 mm] Hg. vacuum during run-in.

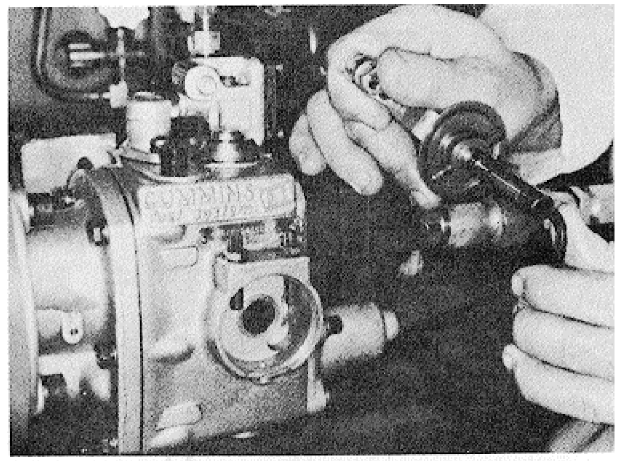


Fig. 5-1-11, F5104. Shim throttle restriction plunger

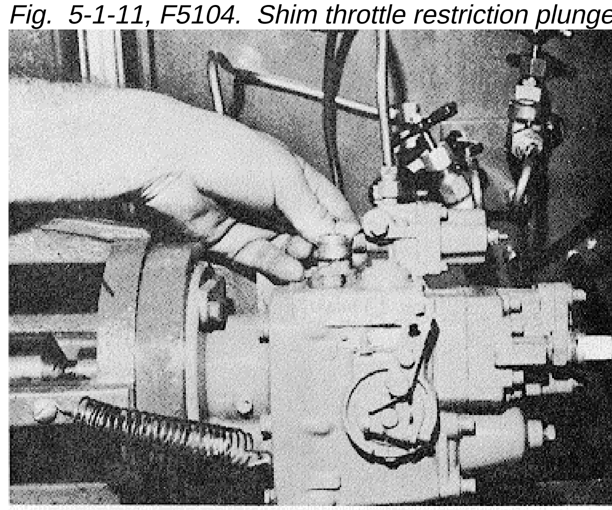


Fig. 5-1-12, F5171. Opening shut-down valve

Calibration Procedure Flow Meter Method

Set Governor Cut-Off Speed
Standard Automotive Governor

1. Close idle, leakage and pressure valves. Open flow control or needle valve wide open.

2. Increase pump speed to engine rated speed.

3. Adjust vacuum valve in fuel pump suction line to obtain 8 inch [203 mm] Hg. on vacuum gauge. Fig. 5-1-14.

4. If you cannot obtain 8 inch [20.8 check of vacuum, check for restriction min test stand filter or fuel supply line.

5. Close the fuel manifold orifice valve or main flow control needle valve until the flow-meter shows the flow specified under "Flow-Meter" in the calibration data (425 Ib/hr on an NH-22Q pump). There must be no air visible in the flow-meter. Fig. 5-1-15. Disregard change in vacuum readings at this setting.

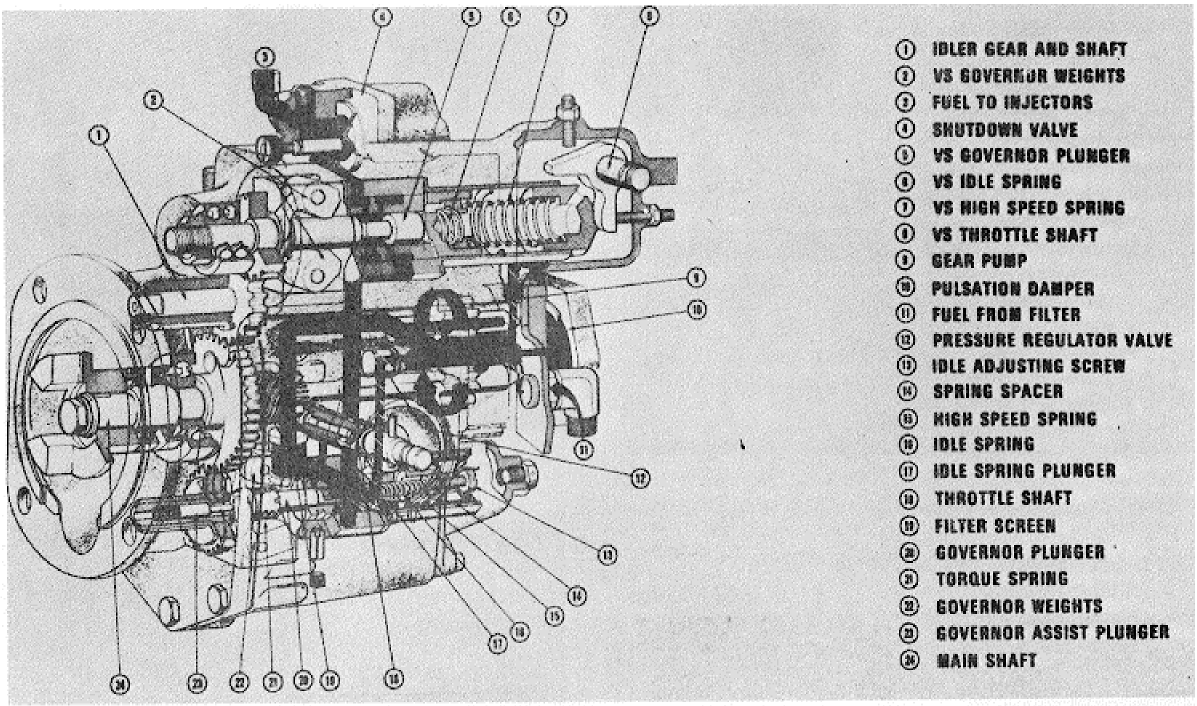


Fig. 5-1-13, FWC-31. PT Type G) Fuel pump cross-section and flow

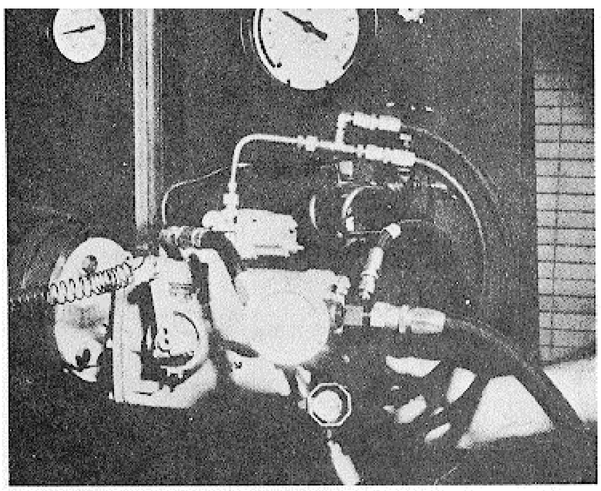


Fig. 5-1-14, F5106. Adjust vacuum on suction restriction

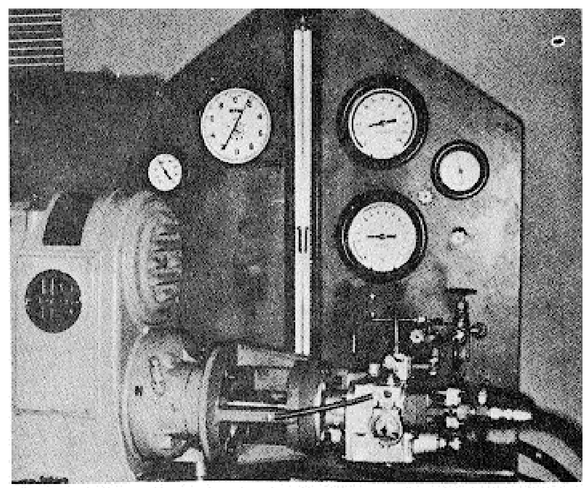


Fig. 5-1-15, F5107. Adjust manifold orifice valve for flow

Table 5-1-2: Governor (Automotive or High Speed) Springs and Specifications

Part Number	Color Code	Replaces	Wire Dia. Inch [mml	Number Coils	Pounds Load In[kg]	@	Inches Length [mm]	Free Length Inch[mm]
*143251	Blue/Purple	70711B	.086[2.18]	8.4	11.65/10.75[5.28/4.89]	@	1.00[25]	1.487 [37.8]

*Formerly color coded - 143251 Red/Black and Blue/Brown

6. If flow value cannot be obtained and held, check idle plunger (button) and governor break. The difference between plungers is about 5 to 10 psi. Be certain adapter, Part No. 144676, is used with plungers code 170 and over. Inspect pulsation damper diaphragm.

7. Open fuel pressure gauge valve. With throttle in full fuel position, increase pump speed until point at which fuel pressure just begins to decrease (peak point). This should occur at speed indicated by "Governor Cut-Off RPM". For example' 2130/2150 rpm on 2100 rpm pump. Fig. 5-1-16.

8. If speed is lower than specified, add shims between governor spring and retainer. Check Table 5-1-2 for spring specifications. To reduce speed, remove shims. Each 0.001 inch shim thickness will change speed approximately 2 rpm on NH Engines. Fig. 5-1-17, Shims are available in 0.005, 0.007, 0.010 and 0.020 inch [0.13, 0.18, 0.25 and 0.51 mm] .

Note: When pump is opened to make adjustments, open main control valve to flow-meter wide open and move throttle lever back and forth until flow-meter shows no air, so air may be expelled more rapidly from system. After air is expelled, reset flow-meter flow as outlined in "Set Pump Flow."

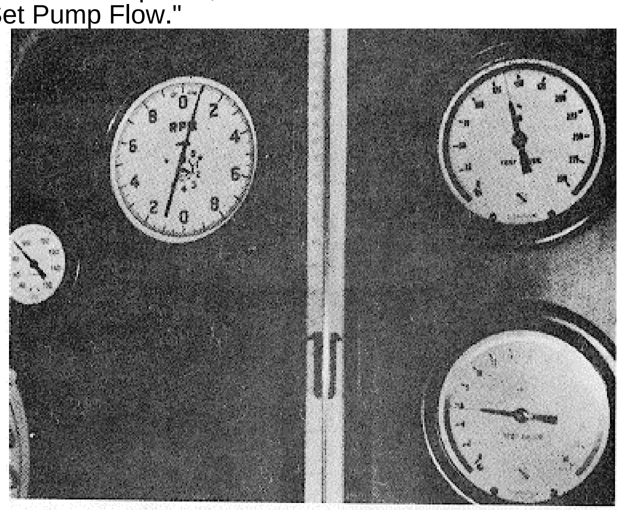


Fig. 5-1-16, F5108. Check governor cut off speed.

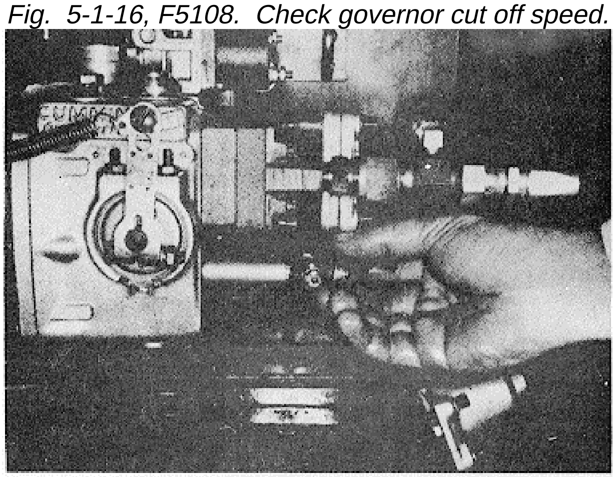


Fig. 5-1-17. F5109, Shim governor spring

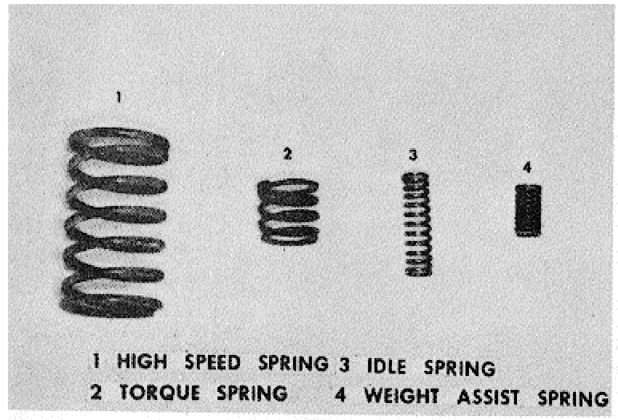


Fig. 5-1-18, F5240. Comparison of fuel pump springs

Set Throttle Leakage Standard Automotive Governor

Note: Make sure fuel is up to temperature when setting throttle leakage.

1. Make throttle leakage setting on pumps with front throttle screw fully open.

2. Move throttle toward gear pump and hold firmly against. stop.

3. Open leakage valve at end of orifice block wide open, close main-flow and idle valves.

4. Run test stand speed up to pump rated speed.

5. With 200 cc graduate check fuel delivery for one minute. Do not keep at this setting any longer than absolutely necessary. Fig. 5-1-19.

6. CC delivery should be as specified by "Throttle Leakage" in the calibration data. If not to specifications, screw front Fig. 5-1-16, F5108. Check governor cut off speed.

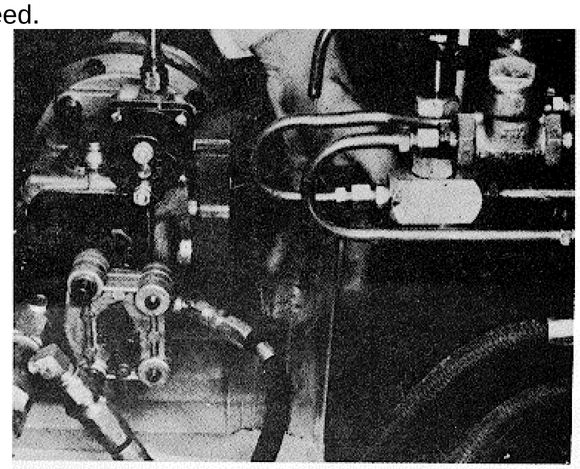


Fig. 5-1-19, F5111. Measure throttle leakage throttle stop screw in or out until cc delivery comes to specifications. This setting is extremely important as it affects the deceleration time of the engine. All pumps must be capable of attaining 15 cc minimum leakage. Fig. 5-1-20.

7. Check leakage with light and heavy lever load, If leakage is increased by additional pressure in the throttle closed position, set leakage under these conditions.

8. If test oil temperature exceeds 100 deg. F [38 deg. C], stop test stand and allow test oil to cool. If temperature exceeds 135 deg. F [57 deg. C], drain and replace with new test oil.

9. Lock screw when setting is correct and recheck.

10. Close throttle leakage valve, open main flow control valve.

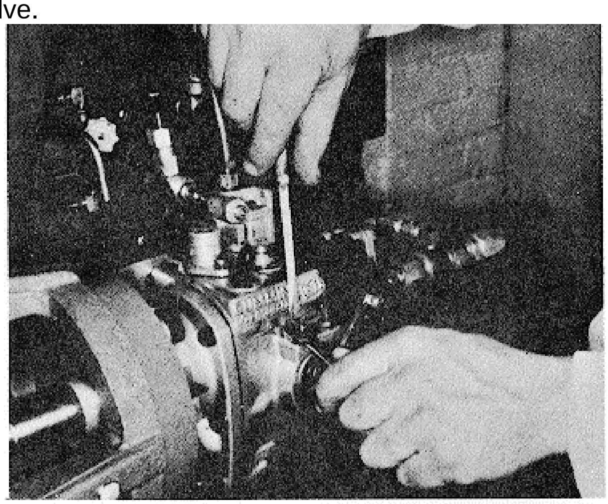


Fig. 5-1-20, F5112. Adjust throttle leakage rate

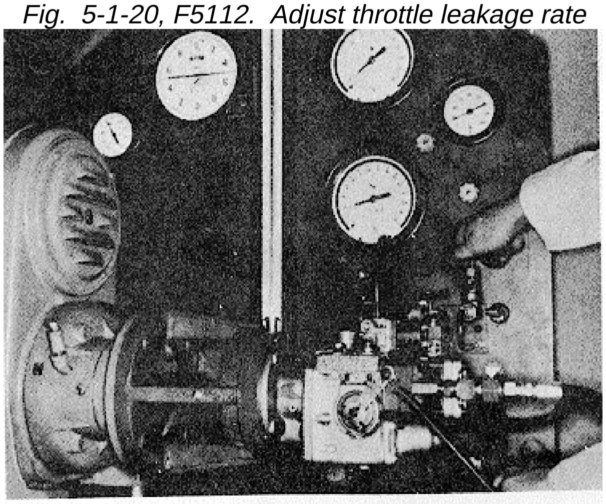


Fig. 5-1-21, F5113. Open idle orifice valve

Set Idle Speed Standard Automotive Governor

1. Close main flow control valve and open idle orifice valve. Fig. 5-1-21.

2. Set throttle shaft in idle position (toward gear pump) and hold firmly against stop.

3. Run test stand at speed indicated by "Idle Speed" In the calibration data.

4. Check pressure on fuel manifold pressure gauge, it should be indicated by "Idle Speed." If pressure is low, screw idle adjusting screw in with ST-984, this screw is located inside governor spring pack housing. To lower pressure back out screw, Fig. 5-1-22. For example: 22 psi at 500 rpm.

Note: In rare cases, where high assist settings are used (if screw bottoms in guide and pressure is still low), It may be necessary to add washer on the spring end of the idle screw.

G-1. Adjust Fuel Manifold Pressure With Internal Throttle Shaft Plunger

1. Place throttle in full fuel position. Close the idle orifice valve and open the main-flow valve.

2. Run test stand speed up to rated speed of pump as indicated by "Manifold psi @ rpm" in the calibration data.

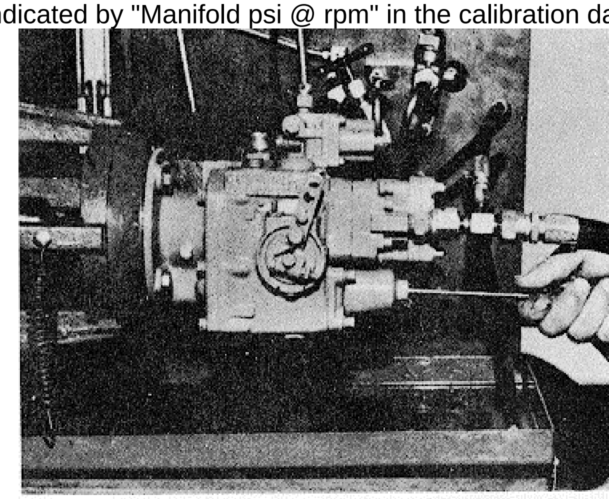


Fig. 5-1-22, F5175. Adjusting automotive governor idle

Table 5-1-3: Idle Spring Plunger Data (Button)

Code No.	Part No.	Counterbore Diameter Inch [mm]
50	140925	.2985/.3015 [7.58/7.66]

3. Adjust fuel flow-meter to specified flow in calibration data. Check fuel pressure on fuel manifold pressure gauge.

Adjust suction valve to 5" Hg. or as close as possible.

4. To adjust pressure to specifications, stop test stand and remove the throttle shaft.

5. Remove shims from the restriction plunger inside the throttle shaft and replace assembly in fuel pump. Reset suction restriction valve to 5 inch [12.7 cm] Hg. after setting internal throttle restriction. Repeat pressure check and continue to remove or add shims until pressure indicated is 3 to 6 psi above "Manifold psi @ rpm value stated.

a. After each adjustment, reset flow as specified in calibration data, while maintaining vacuum at 5 inch 12.7 cm Hg.

b. If throttle shaft does not contain the restriction plunger, turn pump rear throttle screw until fuel manifold pressure and pump rpm is indicated by "Manifold psi @ rpm" in the calibration data. Lock throttle rear screw in place.

G-2. Adjust Final Fuel Manifold Pressure With Rear Throttle Screw

1. After Step G1, where throttle shaft contains the internal restriction plunger, with pump running at speed indicated by “Fuel Manifold Pressure”, turn in rear throttle screw until fuel pressure is reduced to value indicated. Fig. 5-123. Lock screw in place.

2. Steps G-1 and G-2 are both necessary to properly position the rear throttle screw where the throttle shaft contains the internal restriction plunger.

3. Recheck governed speed and pressures

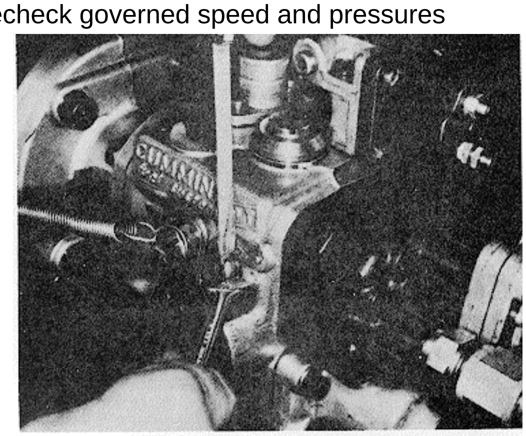


Fig. 5-1-23, F5115, Final fuel manifold pressure adjustment

Adjustments With Torque Modifying Device

1. The throttle restriction plunger is set at 3 to 6 psi [21 to 41 kPa] above the specified rail at torque peak rpm. (Normally 1300 rpm on PT-270 engines, pump code No. 2953.)

2. Set remaining throttle restriction at same rpm with rear throttle adjusting set screw.

3. Increase pump speed to rated rpm, normally 2100, adjust test stand flow if necessary and check manifold pressure.

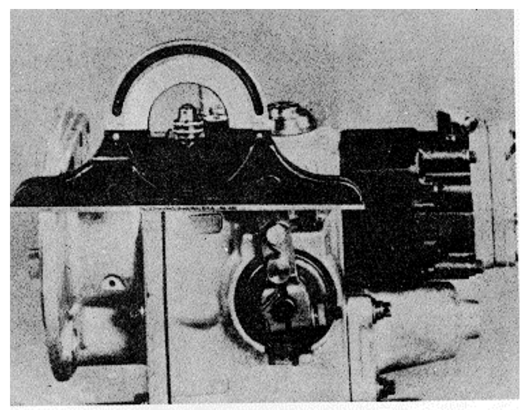
4. Shimming in TMD may be changed, in increments of .005 inch [0.13 mm], to adjust manifold pressure at rated speed.

Special Throttle Travel

On engines with hydraulic governors or other throttle lever travel requirements the fuel pump throttle shaft calibration Steps G-1 and G-2 are reversed as follows:

1. Using a protractor or ST-1162, set the fuel pump lever idle position centerline at 55 deg. from vertical on centerline of fuel pump throttle shaft. Lock throttle lever screw. Set the centerline of the fuel pump lever in the maximum position at 27 deg. from vertical. (Step G-2 on automotive fuel pump.) Lock rear adjusting screw. Recheck .throttle lever centerline travel; it must be 28 deg., or as specified, between idle and full throttle. Fig. 5-1-24 and 5-1-25.

Note: Do not adjust front throttle stop screw to set throttle lever travel.



Fig, 5-1-24, F5239, Setting throttle travel with protractor

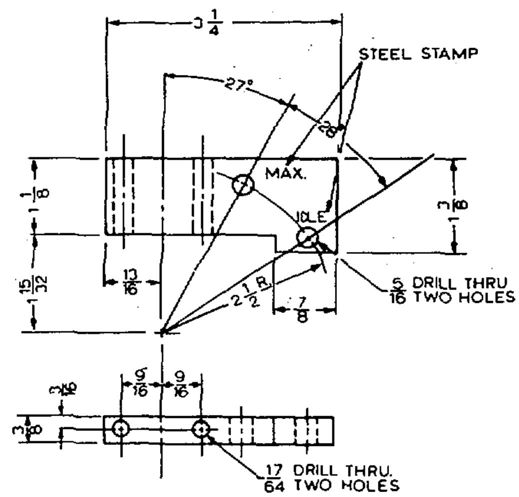


Fig. 5-1-25, ST-1162. Throttle travel template

Compare Check Point Pressure

1. Reduce speed to that specified by "Check Point 1" in the calibration data.

2. Adjust flow meter to that specified under check point.

3. Check pressure at fuel manifold pressure gauge, "Check Point" pressure should be within the range Indicated.

4. If the pressure is above or below range, check the torque spring on the governor plunger, it may not be seated, improperly shimmed, or the wrong spring. See part number indicated in calibration data, If spring Is chained, recalibrate fuel pump. Check weight assist protrusion or pressure to determine If it Is influencing the check point pressure. Torque spring shims are available In 0.002, 0.0()5, 0.010 and 0.020 Inch [0.051, 0.127, 0.254 and 0.508 mm] .

5. Reduce speed to that specified by "Check Point 2" In the calibration data. If out of specifications, adjust flow meter and check weight assist but maintain pressure indicated at 800 rpm under "Weight Assist" following.

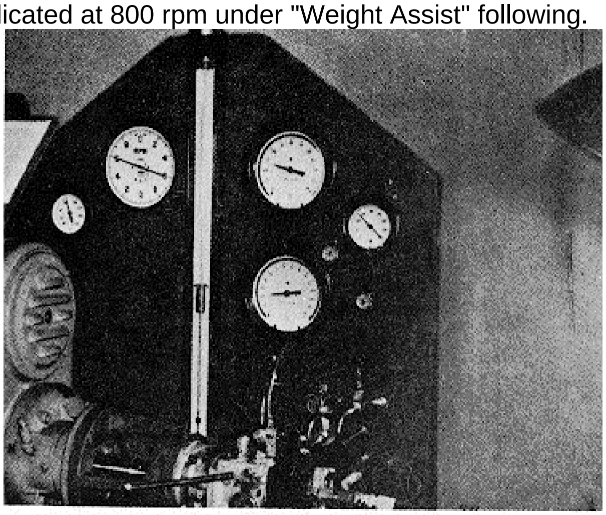
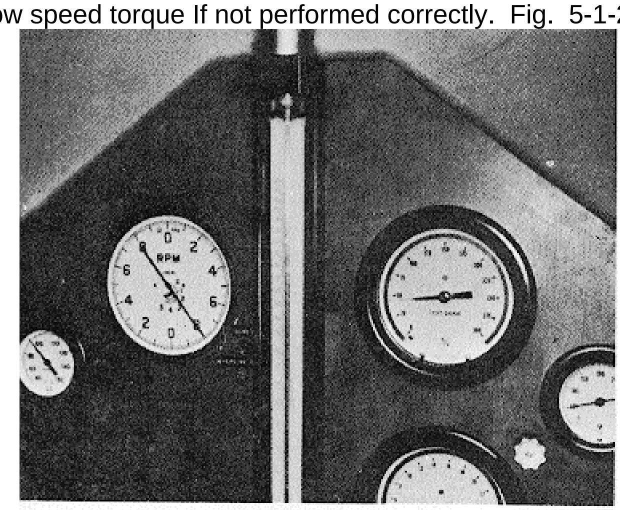


Fig. 5-1-26, F5116, Check point pressure readings

Weight Assist Pressure Check

This check applies to fuel pumps with the governor weight assist plunger and is used as a check to be certain shimming is correct which will affect the engine low speed torque If not performed correctly. Fig. 5-1-27.



Fig, F-1-27, F5117. Check weight assist effect

1. Decrease pump speed to 800 rpm. Adjust flow meter If not as specified.

2. The fuel manifold pressure should be as specified by "Weight Assist" In the calibration data.

3. If fuel pressure is low, add shims behind the governor weight assist plunger in the governor weight carrier. To decrease pressure remove shims. If adjustments are required, recheck entire pump calibration. Shims are available in 0.007 and 0.016 [0.178 and 0.406 mm] .

Note: Governor weight assist plunger protrusion can be checked and set by using ST1241 checking tool.

CAUTION

Weight assist plunger must be installed with the smallest end to governor plunger.

Table 5-1-4: Torque Springs and Specifications

Part Number	Color Code	Wire Dia Inches [mm]	Number Coils	Pounds Load In[kg]	Inches [mm] @Length	Free Length Inches [mm]
138782	Red/Blue	047 [1.19]	5.2	5.40/5.76 [2.5/2.6]	@ .340 [8.64]	640/.660 [16.26/16 761

Table 5-1-5: Weight Assist Springs and Specifications

Part Number	Color Code	Wire Dia Replaces	Inch[mm]	Number Coils	Pounds Load In[kg]	Inches Length @[mmj	Free Length Inch[mm]
143847	Blue		028[.711]	9.7	3.30/3.7011.50/1.681	@ .32518.2]	584[14.8]

Check Pressurizing Valve

Loosen the variable speed throttle adjusting screw jam nut (top screw) and locknut. Fuel should leak around the screw if the pressure valve is properly pressurizing the housing. This can also be done by loosening the plug in the standard governor spring pack housing cover. Fig. 5127B.

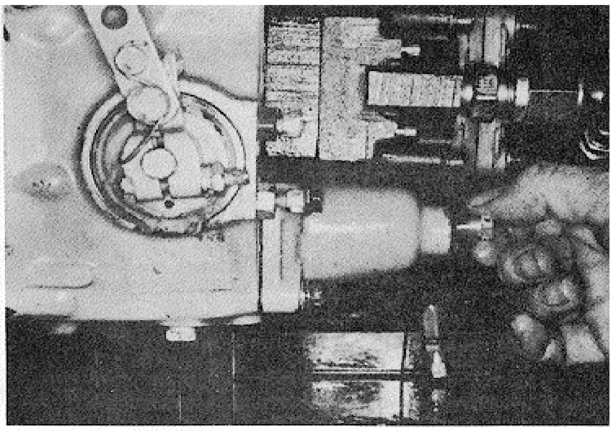


Fig. 5127B, F5272. Spring pack cover plug removed, pump at 600 RPM.

Set Governor Cut Off

1. Set lower governor cutoff as indicated in standard automotive pump calibration to value listed in fuel pump calibration.

2. With pump operating at rated RPM, turn VS maximum speed screw (top screw) in until pressure starts to drop. Tighten the locknut.

3. Check by increasing RPM until pressure starts to drop. Set per VS governor cutoff in calibration.

Set Throttle Leakage

Set throttle leakage as shown in standard automotive pump calibration. Adjust top screw of lower throttle shaft to set leakage.

Set Idle Speed

1. Set idle speed as shown in standard automotive pump calibration with VS lever in full fuel position.

2. Return standard automotive throttle lever to full fuel position. Move VS throttle lever to idle position and hold.

3. Adjust rear VS throttle adjusting screw to set idle at same speed as the standard automotive governor or as specified. Tighten locknut on jam nut.

Adjust Fuel Manifold Pressure

Adjust fuel manifold pressure as indicated In standard automotive pump calibration.

Compare Check Point Pressures

Compare as indicated in standard automotive pump calibration.

Weight Assist Pressure Check

Check as Indicated In standard automotive pump calibration.

Recheck Specifications

1. When a PT (type G) fuel pump is calibrated on one test stand and rechecked on another test stand, the calibration values may vary. This can occur because test stands are not exactly alike, due to manufacturing tolerances, gauge tolerances, test oil viscosity variations, etc.

2. This variance can also occur with a pump is adjusted on the engine and then checked on a test stand.

3. The current Calibration Unit program is aimed at reducing test stand variations to an acceptable limit of +2 PSI from a given base line by correcting gauging and plumbing errors and checking procedures.

4. A tolerance has been established on fuel pump calibration values for rechecking pump' (A) On another fuel pump test stand or; (B) On any fuel pump test stand after it has been calibrated on a test stand and then readjusted on engine. These tolerances are listed on the following pages.

5. If fuel pump is not within the tolerances listed under "B" above, one or more of the following is indicated.

a. Injectors are not properly calibrated and/or installed and/or adjusted.
b. Intake, exhaust or fuel suction restrictions are excessive.
c. Engine has incorrect components for the particular fuel pump calibration involved. (Injector cups, camshaft, pistons, etc.) d. Pump was adjusted on engine to give other than specified fuel manifold pressure and fuel rate.
e. Test stand used for the recheck is not within acceptable limits.

Table 5-1-7: Idle Springs and Specifications

144195	None	(Idle) Std	Auto	032[.813]	12	0.69/0.85[.31/.38]	@	955[24]	1.025[26.0]

Table 5-1-8: Calibration Recheck Specifications

Check	Recheck A-One test stand to another	Recheck B-Tested and readjusted on engine to fuel pump test stand
Governor Cut-Off RPM values	-O to +10 RPM from published rated speed	Rated speed to 50 RPM above
Manifold pressure at idle speed	+10%or+ 1 PSI which ever is larger	+ 30% from published value
Manifold pressure at rated speed	+- 2 PSI from published value	Same variance as on engine manifold pressure tolerance plus an additional +2 PSI
Throttle Leakage	+ 15cc If 100 cc/min or less + 15cc to -35cc/min if over 100 cc/min.	
Idle Setting	-2 to + 4 PSI	
First manifold pressure check point	+- 1 PSI from published values Rated speed manifold pressure must first be to spec. by adjusting flow valve.	
Second manifold pressure check point	A If first check point is +1 PSI, second check point to be from published min. spec to +1 PSI above published max. B If first check point is -1 PSI, second check point to be from published max. spec to -1 PSI below published min. C If first check point is within published spec. second check point must be within published spec.	
Manifold pressure at Wt. Assist check point	-+ 1 PSI from published value.	

Pump Specifications

1. Governor Cutoff R.P.M.

The governor cutoff R.P.M. is defined as the RPM where the manifold pressure starts to decrease from the maximum observed pressure as the speed is increased.

a. When checking from one test stand to another, cutoff speed can vary _ 10 RPM from the published cutoff RPM (i. .; 2520-2540 RPM cutoff speed, reflow can be 2510-2550 RPM).

Suction vacuum must be set at 5 inch Hg.

b. Recheck from engine test to test stand, cutoff speed can be from rated speed to 50 RPM above rated speed (i.e.; rated speed 2500 RPM, cutoff speed at reflow can be 2500-2550 RPM).
Suction vacuum must be set at 5 inch Hg.

2. Throttle Leakage

Throttle leakage is set with the throttle lever held firmly closed. The pump is operated at rated speed and the fuel delivery is measured for one minute.

Recheck from one test stand to another or from tested engine to test stand can vary +15 cc from published value (I.e.; 35 cc throttle leakage can be 20 to 50 cc at reflow), If leakage is 100 cc/min, or less. When leakage is 100 cc/min. or over, It can vary +15 cc to - 35 cc/min. (I.e., 150 cc/min. leakage can be 115 cc to 165 cc/min. at reflow).

3. Idle Speed Manifold Pressure

a. Recheck from one test stand to another, manifold pressure can vary _ 10% from specifications or + 1 PSI whichever is larger, (i.e.; 20 PSI @ 500 RPM can be 18-22 PSI at recheck or 3 PSI @ 500 RPM can be 2-4 PSI at recheck).

b. Recheck after engine adjustment, manifold pressure can vary + 30%/0 from specifications, (i.e., 20 PSI @ 500 RPM can be 14-26 PSI at recheck).

4. Manifold Pressure at Rated Speed

a. Recheck from one test stand to another, manifold pressure can vary + 2 PSI from published specifications, (i.e., 126 PSI manifold pressure can be 124-128 PSI at reflow).

Suction vacuum must be set at 5 inch Hg.

b. Recheck after engine adjustment; manifold pressure can vary the same as the on engine fuel pressure tolerance plus an additional + 2 PSI, (i.e.; if on engine pressure specification is 114-126 PSI or 6 PSI the tolerance for the manifold pressure at recheck is (+ 6) + (+ 2) = + 8 PSI. Then 126 PSI manifold pressure can be 118-134 PSI at reflow).

Suction restriction must be set at 5 inch Hg.

5. Manifold Pressure Check Point

Recheck pump at rated speed and obtain exact manifold pressure per calibration specification by adjusting the flow control valve.

Suction restriction must be set at 5 inch Hg.

I. First check point can vary ± 1 PSI from the published specifications, (i.e.; 100-106 PSI @ 2000 RPM can be 99-107 PSI at reflow).

II. Second check to be as follows:

a. If pump checks + 1 PSI at first check point, it must be at published minimum specifications to + 1 PSI above published maximum specifications at second check point, (i.e.; 75-81 PSI @ 1500 RPM can be 75-82 at recheck).
b. If pump checks - 1 PSI at first check point, it must be published maximum to - 1 PSI below published minimum

specifications at second check point, (i.e.; 7581 PSI @ 1500 RPM can be 7481 at recheck).

c. If pump checks within the published tolerance at first check point, it must check within the published tolerance at second check point.

6. Manifold Pressure At Weight Assist Check Point

Recheck of the manifold pressure at the weight assist check point can vary ± 1 PSI from the published specification. (i.e. 35-41 PSI manifold pressure can be 34-42 PSI at reflow)

Check Pump Seals

1. With test stand operating at 500 rpm, close vacuum value in fuel pump suction line till vacuum gauge reads 15 inches vacuum. The fuel flow control or needle value should be open during this check.

2. Put a small amount of Lubriplate or light cup grease over the vent or "weep" hole at main shaft seal bore of fuel Pump cover. Fig. 5132.

3. If the lubricant is sucked into the hole at the 15 inch vacuum setting, it is an indication that the seal will not permit proper engine performance and should be replaced.

4. The above check may also be performed on the throttle shaft to check the shaft "O" ring. Apply lubricant at the throttle bushing to shaft outside diameter.

5. Fill the tachometer seal bore with test oil from test stand, If the fluid is drawn Into the pump, replace the seal.

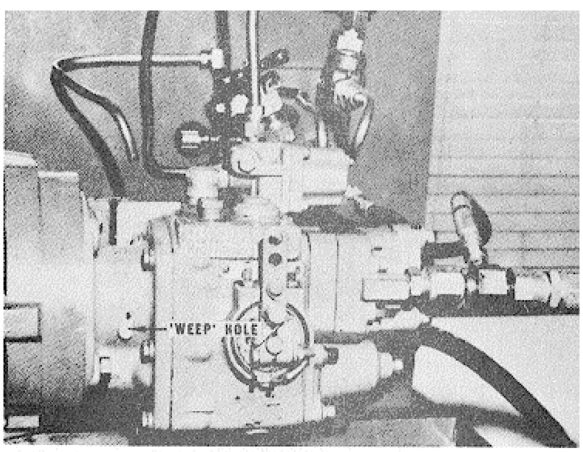


Fig. 5132, F5172, Checking "weep" hole for leakage

7. During above checks, observe flowmreter for air in the meter which may or may not indicate air leakage into pump. Air may be entering lines between tank and pump. A slow leak may not show up promptly as air in the meter. Observe fuel level in tank for possibility of low fuel causing air bubbles.

8. Leakage may occur at the gear pump to pump housing gasket if gear pump is not positioned correctly.

9. Tighten all car)screws, hose connections, pipe plugs and filter screen cap.

Housing Porosity Check

1. Fill fuel pump with clean fuel or test oil.

2. Remove suction fitting at gear pump and install fittings so an air pressure hose may be attached.

3. Air supply hose line must be equipped with a valve and gauge to control air pressure at a maximum of 20 psi.

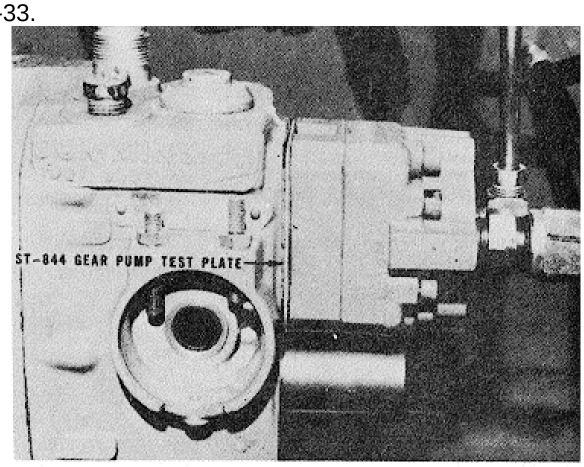
4. Apply 20 psi air pressure; do not exceed 20 psi or damage to seals may result.

5. Pour fuel or test oil over pump and examine carefully for air bubbles, indicating leaks. Alternately wipe pump or specific area dry and check for wet seepage. Do not use this check for seals.

Gear Pump Test

1. Use a "dummy" fuel pump built up with only the parts required to drive the gear pump, minimum of pump body, with tachometer drive and a complete front cover assembly. If desired, a complete fuel pump can be used if the governor plunger and weight assist plunger and spring assembly are removed and pump housing is filled with fuel; this will prevent any possible damage to governor plunger or governor barrel. Gear pump may be mounted directly to test stand with adapter bracket.

2. Install ST844 gear pump block plate, with gasket on each side, between' gear pump and fuel pump body. Fig. 5-1-33.



Fig, 5133, F5166. ST844 gear pump block plate

3. Remove gear pump damper from gear pump and connect copper line from orifice block to gear pump pressure tap.

4. Connect the fuel suction line to the suction side of the gear pump. Run a line from the gear pump bleed connection to the fuel supply tank.

5. On gear pumps not tapped, use a damper with a tapped hole to make this connection.

6. Shut off the fuel manifold pressure gauge to prevent damage from over pressure.

7. The valve in the suction line and the valve controlling the main flow orifice are to be fully open. All other valves must be completely closed. With the valves in this position, fuel will be routed through the manifold orifice.

8. Start the pump drive in the proper direction and run the pump at 400 to 450 RPM. The gear pump must pick up at this speed without the aid of priming. Any gear pump which fails to pick up fuel must be reworked or replaced. The remaining steps of this check need not be made on any pump failing to pick up.

9. Increase pump speed for the following checks:

Any gear pump with delivery below the listed value should be reworked or replaced. Any gear pump which is wet to touch after this check should be reworked or replaced.

Table 5-1-9: Gear Pump Flow

Gear Pump	RPM	Minimum Total Flow
3/4 [19.05]	2100	850 Lbs./Hr.

10. Any gear pump with a delivery above the listed minimum is to be considered acceptable for fuel pump operation, and it can be installed on a fuel pump for proper calibration.

11. The following check should be made if the gear pump delivery is just above the listed minimum described in Step 9.

a. The unrestricted manifold pressure should be checked for a 10/15% higher pressure at rated speed than the manifold pressure. If it is too low or too high, it may be necessary to change idle plunger (button) to give the correct unrestricted pressure of 10/15% above final manifold pressure.

Note: The idle plunger (counter bore diameter) may be decreased in size to increase the amount of pressure available at the calibration set point.

CAUTION

Step 11 is to be used only if gear pump is worn preventing it from delivering enough pressure for proper calibration. Never change idle plunger to exceed the 10 to 15% unrestricted manifold pressure.

Fuel Pump Trouble Shooting With ST775 or ST848

This portion of the manual should be fully understood by the Fuel Pump Test Stand Operator, and through this knowledge he should be able to produce a properly calibrated Fuel Pump.

Fuel Pump calibration on the ST848 Fuel Pump Test Stand combined with injector calibration has produced widespread acceptance of fuel system accuracy. There have been reports of erratic results, but investigations have revealed that the cause for such problems fall into three basic categories: (1) Mechanic and/or Testor Error, (2) Instrumentation Errors or (3) Maintenance Status.

1. Mechanic and/or Testor Error

a. Misapplication of specifications and parts:

(1) Calibrating a specific fuel pump model to the wrong value.

(2) Calibrating a specific injector model to the wrong flow value.

(3) Lack of familiarity with this bulletin (4) Use of camshaft and pistons other than those shown in fuel pump calibration specifications.

Note: Pistons, camshafts and injectors are sometimes superseded by others requiring a different calibration.

(5) Use of wrong injector assemblies in a specific engine model.

(6) Use of governor and torque springs other than those specified in fuel pump calibration data.

b. Engine Test (1) Restricted intake air in engine.
(2) Excessive exhaust back pressure.

(3) Restricted fuel supply to engine.

(4) Aerate a fuel supply to engine.

(5) Excessive high oil level in engine crankcase.

(6) Incorrect injector adjustment.

(7) Dirt entering balance orifice.

2. Instrumentation Errors a. Erroneous fuel manifold pressure gauges on engine and/or chassis dynamometer.

b. Erroneous flow meters.

c. Erroneous dynamometer load indicators.

d. Incorrect tachometer.

3. Neglect of Maintenance

a. Use of hose lengths, diameters and residencies other than those which are specified.

b. Fuel routing which is not to specifications.

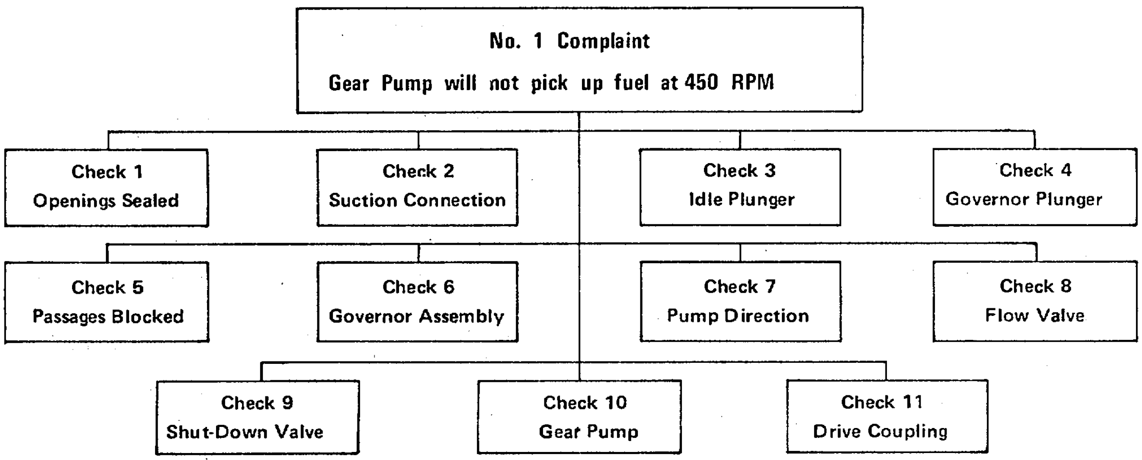
c. Filter assemblies which have a different dampening effect on the system.

d. Critical components of the test stand such as check valve, gauge and hydraulic injector clamping poorly maintained.

e. Failure to make checks with master ST768 gauge snubbers.

Complaint and Corrections

Charted on the following pages are the complaints, showing the items to check for correction of the complaints if the Fuel Pump Test Stand has been properly maintained leaving no Test Stand error. Each check is numbered, so you may go immediately to the tabulated description of the causes and corrective action as necessary.



Cause

Check 1: Openings not sealed correctly.

Check 2: Suction connection is not tight or is damaged.

Check 3: Idle Plunger dirty.

Idle Plunger worn.

Check 4: Governor Plunger dirty.

Governor Plunger worn.

Check 5: Blocked fuel passages.

Check 6: Faulty governor assembly.

Check 7: Pump turning wrong direction.

Check 8: F low valve not open.

Correction

Seal all openings and use new gaskets where necessary.

Tighten suction connection or replace if mutilated.

Check face of Idle Plunger (pressure control button) for any foreign material.

Change Idle Plunger to give a square fit with governor plunger (use same Idle Plunger code number).

Clean Idle Plunger mating face of foreign material.

Change Governor Plunger to give a square fit with Idle Plunger.

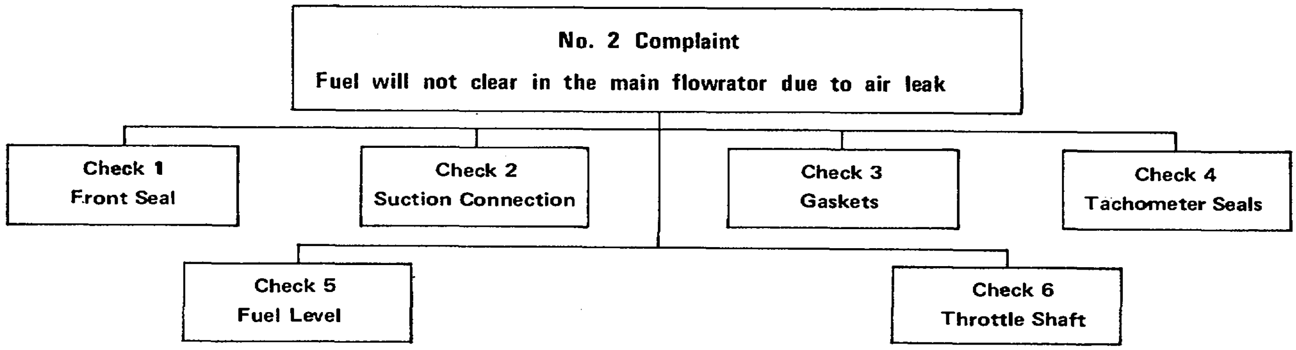
Clean fuel passages so they are all open.

Check governor assembly for proper assembly.

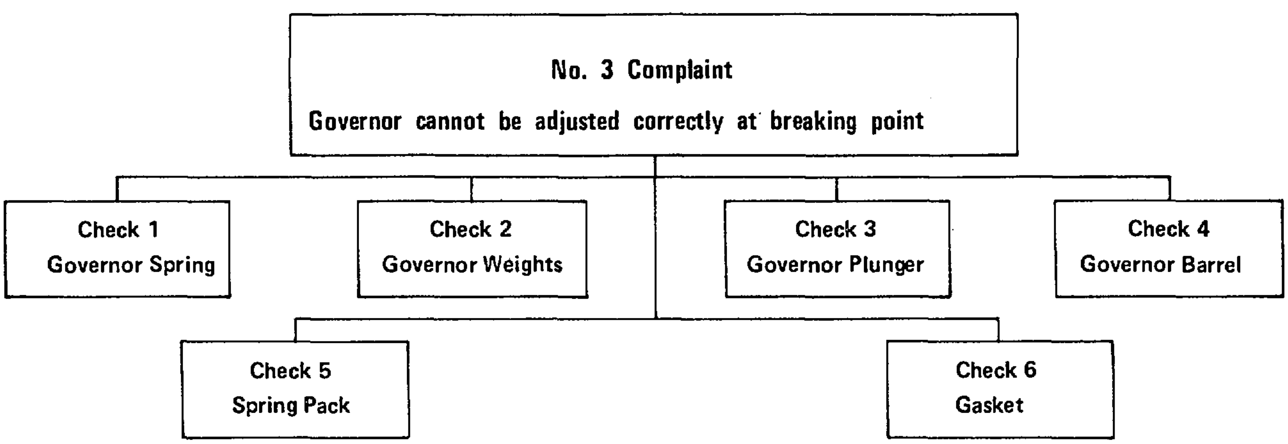
Check pump for right or left hand rotation and set test stand accordingly.

Open test stand flow valve to allow fuel to enter gear pump.

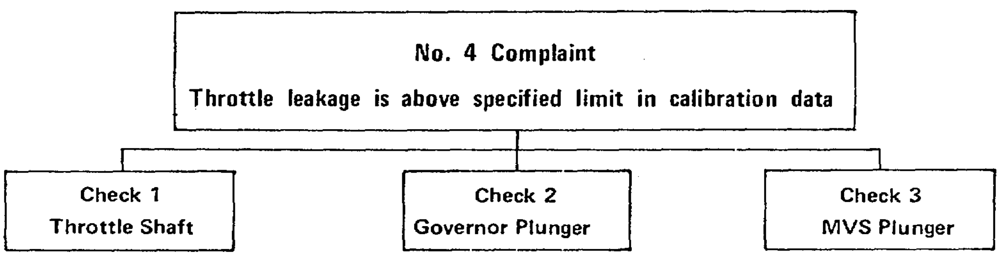
Check 9: Shut-down Valve not open.	Open shut-down value on top of fuel pump.
Check 10: Gear pump worn.	Replace gear pump if it will not deliver required flow.
Check 11: Drive coupling not in mesh.	Mesh fuel pump and test stand drive couplings.



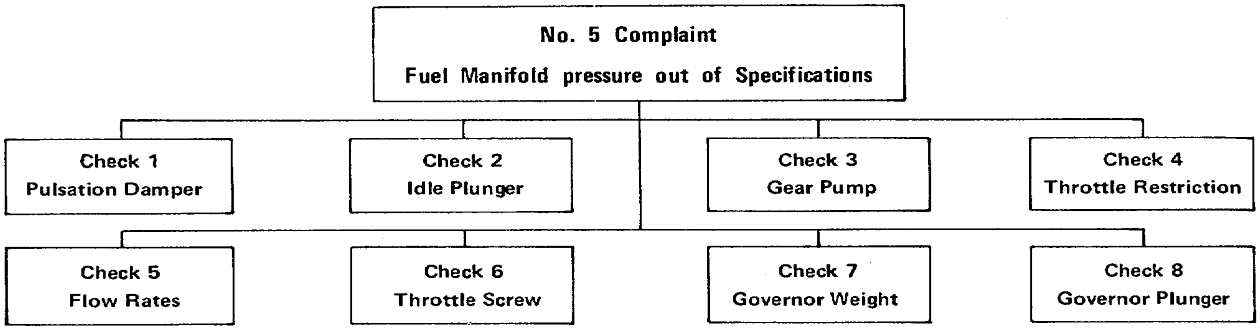
Cause	Correction
Check 1: Front Seal leakage. This can be determined by covering "weep hole" in front cover with Lubriplate which stops air entertainment.	Remove fuel pump from test stand then remove front cover and install new seals in cover.
Check 2: Suction connection not tight or is damaged. This can be determined by pouring lube oil over suction connection.	Tighten suction connection or replace if mutilated.
Check 3: Main housing or spring pack housing gasket leaking air.	Replace gaskets as required.
Check 4: Tachometer drive seals leaking. Check by pouring lube oil over tachometer drive housing.	Remove fuel pump from test stand and disassemble pump enough to replace tachometer drive oil seal in main housing.
Check 5: Fuel level in test stand reservoir low.	Fill fuel reservoir with Cummins test oil.
Check 6: Throttle shaft "O" rings or housing leakage can be determined by pouring fuel oil over housing.	Replace "O" ring on throttle shaft or replace housing if leaking.



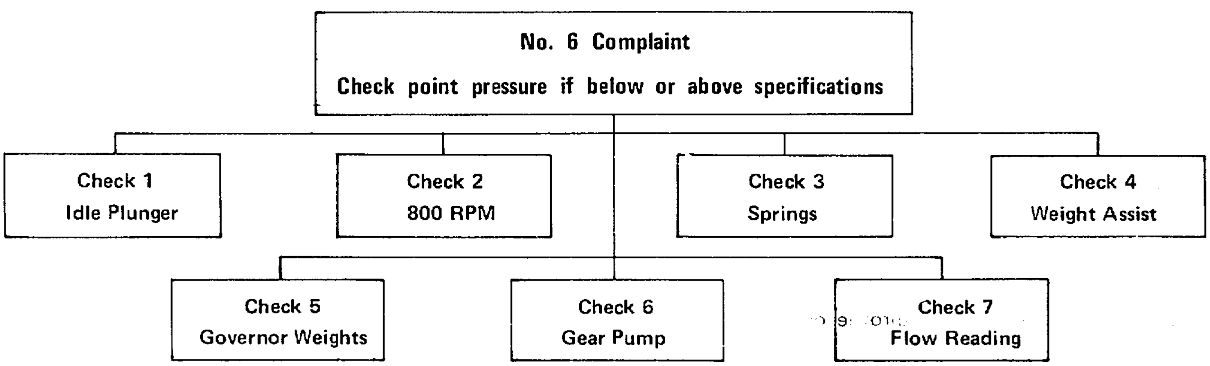
Cause	Correction
Check 1: Governor Spring incorrect due either to wear or incorrect Governor Spring.	Replace spring if worn beyond limits listed in Table 5- 1-2.
Check 2: Loosen or broken weights. Broken weld, weight pins or carrier.	Replace with new parts as necessary.
Governor weights incorrect for that specific pump.	Governor weights, of the correct weight, should be installed (heavy or shaved).
Check 3: Governor plunger improper fit in governor Barrel.	Refit the governor plunger to the Barrel. This usually requires a plunger one or two classes larger than previously used and must be lapped to fit with No. 80 fine grit lapping compound. Remove ail lapping compound after use.
Sheared governor plunger drive tangs.	Replace drive tangs on plunger assembly.
Check 4: Governor Barrel not located in housing correctly, preventing fuel passages from lining up.	Line up the fuel passages as not to restrict fuel flow. This may be done by heating housing in oven at 300 deg. F (149 deg. C) and removing Barrel and then reinstalling in housing.
Governor barrel not pinned into position.	Make sure fuel passages are lined up and install pin into governor barrel.
Check 5: Spring pack lock ring out of position.	Lock ring must be in groove to correctly adjust governor.
Check 6: Gasket leakage between fuel pump housing and gear pump.	Gasket should be replaced or relocated. Correct gasket must be used.



Cause	Correction
Check 1: Throttle shaft scored or incorrect fit in throttle sleeve.	Install next size larger throttle shaft, if neccessary. Fit to bore must be free without sticking tendency when rotating or moving in or out of bore by hand. If oversize shaft does not correct leakage, send housing to rebuild center.
Check 2: Governor plunger incorrect fit in governor barrel.	Install next size larger plunger. Fit to bore must be free with out sticking tendency when rotating or moving in or out of the bore by hand.
Check 3: Leakage past MVS plunger if MVS is used.	Install next size larger plunger or remove shims between snap ring and governor housing.



Cause	Correction
Check 1: Low fuel manifold pressure.	Replace fractured pulsation damper diaphragm.
Check 2: Fuel manifold pressure too high or too low because of incorrect Idle Plunger (Button) or surface finish.	Replace Idle Plunger (Button) with correct plunger if incorrect plunger was used. Polish surface of plunger if rough, burrs or chipped areas are found on surface of plunger.
Check 3: Gear Pump fails to obtain delivery and pressure.	Replace gear pump.
Check 4: Wrong throttle restriction.	Set throttle restriction to correct values.
Check 5: Test Stand set at wrong flow rate.	Set test stand at flow rate indicated in calibration data pertinent to fuel pump being calibrated.
Check 6: Throttle screw out of adjustment.	Adjust throttle screw.
Check 7: Governor Weight Carrier assembly incorrect or faulty.	Replace with correct new governor weight carrier assembly.
Check 8: Scored governor plunger.	Replace with new governor plunger and lap to fit.



Cause	Correction
Check 1: Idle plunger or governor plunger rough or voids.	Polish surface with oil stone or replace if necessary.
Check 2: 800 RPM Checkpoint.	Check 800 RPM checkpoint under Complaint No. 7 to be sure It is within specifications before proceeding.
Check 3: Incorrect torque or governor spring.	Remove front cover and check for proper torque or governor spring and free length of spring. Shim torque spring.

Check 4: Incorrect weight assist protrusion.

Make correct weight assist setting by proper shimming, adjusting or replace front cover assembly.

Check 5: Incorrect weights or worn weight carrier assembly.

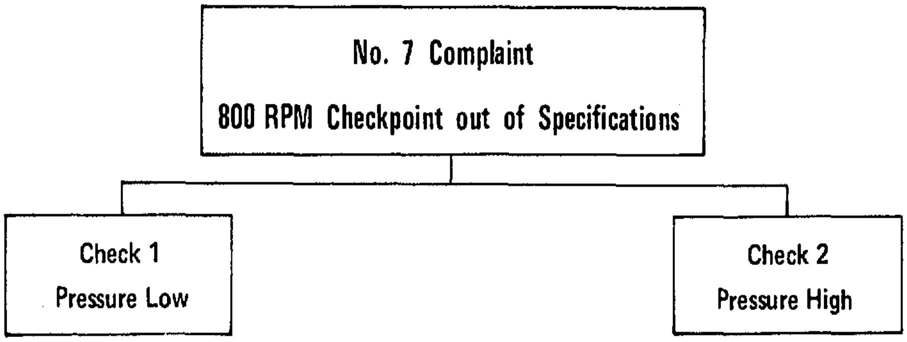
Replace with correct new weight carrier assembly.

Check 6: Gear pump delivery low.

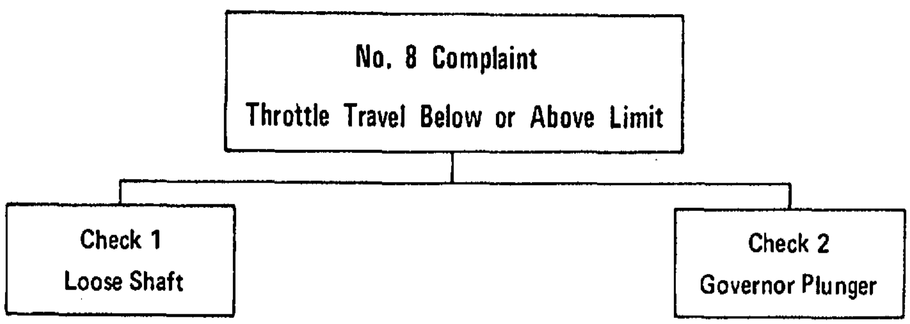
Check gear pump delivery.

Check 7: Flow reading incorrect.

Adjust flow meter valve.



Cause	**Correction**
Check 1: Checkpoint pressure is too low.	If weight assist protrusion is within specifications, one or more shims may be added to assembly or turn adjusting screw to obtain correct checkpoint pressure.
Check 2: Checkpoint pressure is too high,	Remove weight assist shims or adjust as required to decrease pressure. If no shims can be removed, install new weight assist assembly or front cover



Cause	**Complaint**
Check 1: Throttle shaft too loose.	Remove and check fit in throttle sleeve.
Check 2: Pressure drop across throttle shaft over 20%.	Check fit of plunger and install correct size plunger to giv correct pressure drop for degree of throttle travel.

Note: Be sure to re-mark throttle; or governor sleeve if different size shaft or plunger has been installed.

Aneroid

Aneroid Adjustments

Aneroids must not be removed, disconnected or otherwise rendered ineffective on these engines, nor should settings be altered to exceed those specified for the aneroid as shown In Table 521.

Description

1. During acceleration or rapid engine load changes, turbocharger speed (intake manifold pressure) change inherently lags behind the power or fuel demand exercised by opening of the throttle.

2. This lag does not exist in fuel system. therefore, an over rich or high fuel to air ratio, usually accompanied by heavy smoke, , occurs until the turbocharger "catches up "

3. The function of the aneroid is to create a lag In fuel system so response is equivalent to that of turbocharger, thus controlling engine smoke level.

Fuel Flow

1. Fuel from outlet side of fuel pump enters aneroid and goes through starting check valve area (5, Fig. 522). Aneroid AR40600 series does not have a starting check valve but must have a fuel check valve in supply line.

2. The starting check valve (3) prevents aneroid from bypassing fuel at engine cranking speeds. For speeds above cranking, fuel pressure forces the check valve open, allowing fuel to flow to valve port (4) of shaft (9)

3. Shaft (9) and Its bore form the bypass valve This shaft and bore allow passage or restriction of fuel flow in a similar manner as throttle shaft and sleeve In PT fuel pump

4. allowed to pass through bypass valve is returned (2) to suction side (inlet fitting) of PT gear pump The bypassed fuel reduces fuel pump output to engine and reduces fuel manifold pressure In proportion to the bypass rate. Fig. 521.

5. The shaft and sleeve are bypassing fuel when arm (10) of lever is resting against adjusting screw (1). The amount of fuel bypassed is adjusted by this screw, which protrudes from bottom of aneroid.

6. The lever arm connected to piston (8) by actuating shaft (6)., rotates shaft, closing valve port. The lever is rotated by action of air Intake manifold pressure (11) against piston and diaphragm (7), moving actuating shaft downward against resisting spring force. Fig. 522.

7. Anytime engine Intake manifold air pressure is above preset bellows "air actuation pressure," aneroid is "out of system.

8. The aneroid begins dumping when Intake manifold air pressure drops below preset value as happens after deceleration In traffic, deceleration during gear shifts, down grade motoring with closed throttle or down grade operation on light load portion of governor droop curve.

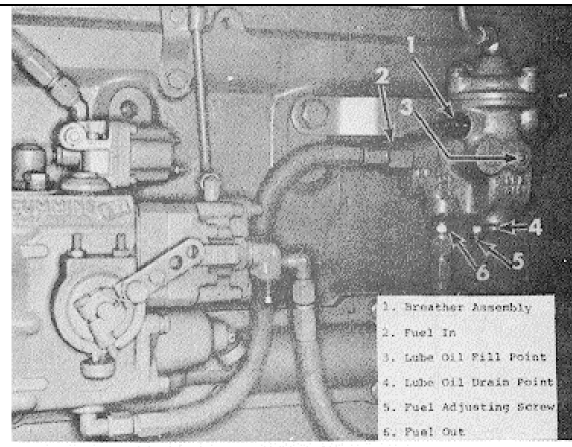


Fig 52 1, N 11026 Aneroid mounted on engine

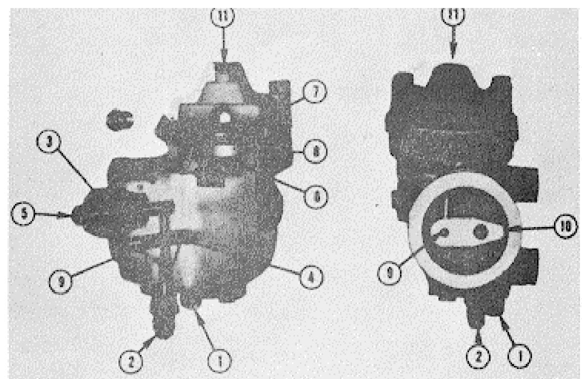


Fig 522, F5244 Aneroid cutaway

9. The aneroid does not by-pass fuel under full throttle lug down conditions until speed is low enough to reduce intake manifold air pressure to aneroid operating range (usually below engine stall-out speed.)

Installing Aneroids On Fuel Pump Test Stands

Precision setting and/or checking of Aneroids is accomplished by simulating engine operation on a fuel pump test stand. Cummins ST848 Fuel Pump Test Stand must be equipped as follows

1. Fabricate a suitable bracket or mount the aneroid on fuel pump test stand. This .bracket may be used to mount an air regulator, such as used on ST790 or ST990 Injector Test Stands, and a mercury manometer of suitable scale length or 30 inch pressure gauge of known accuracy.

2. Air pressure from regulator must be piped to top of aneroid to actuate bellows.

3. Tee off regulator air line (outlet) Into manometer or pressure gauge. Service Tool is ST1256.

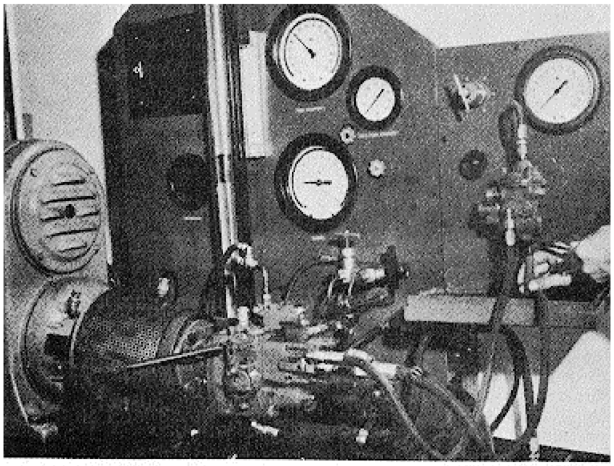


Fig. 5-2-3, F5287. Adjusting aneroid fuel screw

Testing Aneroid

Adjusting Fuel Screw

1. Mount a fuel pump on. fuel pump test stand which has been calibrated to the same code as that on, or will be used, on engine. For instance, if aneroid is intended for use on an engine equipped with fuel pump calibrated to code No.2049, use a pump set at same code (2049) to set aneroid.

2. Plumb aneroid to fuel pump in the normal manner. Fig. 525

3. Start fuel pump test stand and purge all air from system.

4. Adjust air regulator to apply 30 inch [76.2 cm] Hg. pressure on aneroid bellows.

5. Set fuel pump at rated speed calibration point (Manifold PSI @ RPM and Flow Reading) specified for pump code.

CAUTION

The flow control valve setting must not be altered during the following checks. Altering flow will give false adjustments,

6. Reduce test stand speed to that shown in Table 5-2-1 under BHP @ Speed.

7. Set air regulator to "O" inches of mercury. Adjust screw in bottom of aneroid housing to value specified under "Fuel Manifold Pressure" for pump and aneroid code shown in Table 5-2-1. Fig. 5-2-3.

Note: See section entitled, "Engine Altitude Derate and Aneroid Settings" If engine requires a fuel pressure setting lower than specified in Table 5-2-1 because of altitude.

8. Return air pressure to 30 inches [76.2 cm] Hg. Decrease air pressure slowly while observing fuel pressure gauge. When aneroid by-pass has just opened, a fuel pressure decrease is noted. Compare air pressure to that shown in Table 5-2-1. This check must always be made with decreasing pressure only. Internal friction in aneroid bellows, spring and linkage causes air pressure requirements

Table 5-2-1: Engine and/or Fuel Pump Aneroid Setting — No Air On Diaphragm

New Aneroid	Old Code	CPL	Engine Model	Reference Pump Code	No Air Setting BHP@RPM	Fuel Mfld. Pressure PSI See Note (1)	Altitude Limit Ft.	Bellows Spring	Color Code	Bellows Air Actuation Press. In. Hg.
AR-40304	AC	101	NTC-290	2433	218@1600	86	8,500	124033	Green	4.0-4.5

at by-pass opening or closing to differ depending upon whether air pressure is increasing or decreasing.

A. If air actuation pressure is to high, screw two piece shaft 1/4 turn, remove aneroid shims, Part No. 144921, or add a washer, Part No. 67684 as shown in assembly drawing. If air' actuation pressure is too low, add shims or lengthen shaft. If capscrew securing shaft to bellows is removed, retorque 20 to 25 in. lbs. (2.3 to 2.8 Nm) B. The proper aneroid spring must be employed as specified. Table 522.

Table 5-2-2: Aneroid Bellows Spring Specifications

Part No	Color Code	Coils	Free Length In [mm]	Wire Dia In [mm]	Load Lb. @ In [kg @ mm]
124033	Green	6	1.375 [35]	088 [2.24]	8.18@1.00 [3.71@25.4]

Checking Starting Check Valve

1. To check aneroid starting check valve action, stop fuel pump test stand and set air regulator to 0 inches of mercury. Disconnect aneroid fuel return line at fuel pump and plug opening In gear pump inlet suction fitting.

2. Move aneroid supply line from bottom of housing to fuel pressure check point on shutdown valve. Plug hole In bottom of housing.

Note: The current check valve, Part no 216737, Is not interchangeable with the older style check valves.

3. Open rail flow valve on test stand completely, open rail flow snubber valve and hold pump throttle wide open.

4. Start test stand at lowest possible speed setting, rail pressure must be less than 10 psi (69 kPa).

5. Observe fuel discharge from aneroid hose. There should be only a slight dribble of fuel which Is leakage. If valve is stuck open, free flow of fuel will occur.

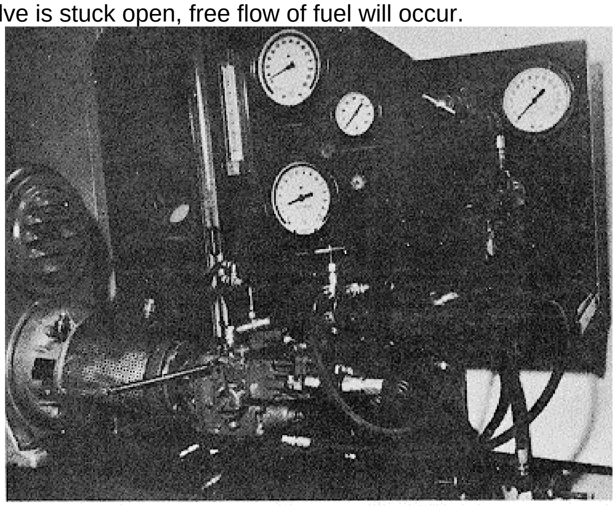


Fig 5-2-4, F5288 Checking starting check valve,

6. To check valve opening pressure, gradually close rail flow valve to increase rail pressure.

7. Watch rail pressure gauge and fuel discharge from aneroid line. When starting check valve opens, a significant flow increase will occur. Fig. 524

8. Check for any tendency of aneroid starting valve to stick by repeatedly opening and closing of rail flow valve.

See Table 523 for starting check valve spring opening pressures.

Table 5-2-3: Starting Check Valve Spring Specifications

Part No.	Free Length Inch [mm]		Opening Pressure psi [kPa]	
114745	1.75	[44.4]	23-31	[159214]
120073	1 39	[35 3]	12-20	[83-138]
216737	Assembly	13-18	[90-124]	

Factory Aneroid Settings, AR And Code (Ref. Table 5-2-1)

Aneroid Assembly Number And Code

1. The 40000 series AR numbers identify the aneroid air setting.

2. The last two numbers of the AR Is the aneroid air setting.

3. Factory aneroid calibration procedures can be made in the field If engine is on an engine dynamometer

A. Air actuation pressure is set by manometer on a fuel pump test stand to the value indicated under "Bellows Air Actuation Pressure" In table.

B. The bottom screw (fuel pressure) setting is made at engine test so that engine develops power indicated under setting "BHP @ Speed" in Table 521. Remove air line from air intake manifold.

Note: The above procedure can and should be employed In the field, If engine is on an engine dynamometer

4. All aneroids shipped as service parts will be set and ready for engine installation.

Aneroid Plumbing

Fuel hose size - No. 5 on all engine models

Line connection points'

Standard Automotive PT (type G) and VS. See Fig. **5-2-5.**

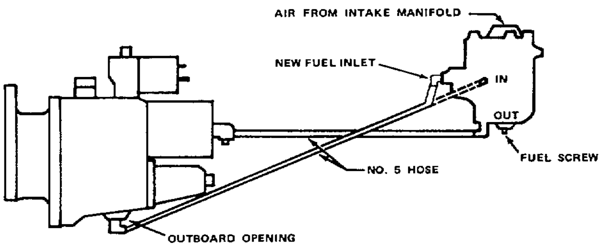


Fig. 5-2-5, F5245. Aneroid piping for PT (type G) fuel pump

Engine Altitude Derate And Aneroid Settings
Fuel Pump Derating

Depending upon engine model, rating and turbocharger used, there is a maximum altitude limitation beyond which engine must be derated. This is necessary to avoid excessive exhaust temperatures and turbocharger speed. The magnitude of derate is 4% of the sea level BHP per 1000 feet [305 m] above specified altitude limitation.

Example: Engine model NTC335 rated at 335 H.P.

Altitude limitation 12,000 feet [3657 m] Altitude at which engine must operate 17,000 feet, [6181 in] , or 5,000 feet [1524 in] above limitation. Magnitude of derate 4% x 5 = 20% or 0.20 x 335 = 67 BHP. Rule of thumb to determine amount of fuel pressure reduction is simply, fuel pressure @ rated sea level BHP x 0.20.

In this example of an NTC335, fuel pump code 2312A fuel pressure is 183 psi. The engine fuel pressure at 17,000 feet [6181 ml should be (183(183 x 0.20) = 146 PSI.

Aneroid Derating

When fuel pump on an engine is derated, the aneroid "fuel pressure" setting is automatically reduced proportionately.
This may or may not provide proper smoke level reduction. Usually an additional reduction is required.

"Fuel Pressure Setting"

Note: The aneroid fuel pressure setting is always adjusted and checked with the air line from the air intake manifold to the aneroid bellows disconnected.

1. Acceleration smoke level of aneroid equipped engines increases with increasing altitude: It will be necessary to adjust "aneroid fuel pressure" or bottom screw as dictated by particular altitude to maintain an acceptable smoke level.

2. If engine is to operate permanently at elevated altitude or if some municipalities through which vehicle operates are at elevated altitudes and have smoke level ordinances, adjust aneroid to that altitude.

3. Engines operating at construction and mine sites must have "aneroid fuel pressure" or bottom screw adjustment made at the "In Service Inspection" if altitude compensation is required. Readjustment. also may be necessary If equipment is moved to another location of differing altitude.

4. An approximate rule to determine amount of "aneroid fuel pressure" reduction for a given altitude is to reduce fuel pressure setting 3% per 1000 ft [305 ml above 500 ft [152 ml. For instance, on an NTC335 which will operate at 6000 ft [1829 m] "aneroid" fuel manifold pressure shown in Table 521 should be reduced 125 x 5.5 x 003 = 20.6 psi [142 kPa].

5. Set to this specification in the shop and readjust in the field as necessary.

Air Actuation Pressure Setting Of Turbocharger Engines

The intake manifold pressure of turbocharger engines remains constant with increasing altitude thus "air actuation" pressure setting requires no compensating adjustment with changes in altitude. This setting should never be altered.

Aneroid Assembly, Disassembly And Repair

Disassembly and assembly is very simple in sequence shown in exploded view. No special tools are required.

A. Bellows Replacement

This can be accomplished without changing aneroid settings if precautions are taken to assure that same bellows spring and shims or 2 piece shaft length is the same when reinstall led.

1. Grind or file away upset end of rivet seal, Part No. 125111 or cut seal wire.

2. Remove cover, Part No. 114947, nut, Part No. 108074 and washer, Part No. 114754.

3. Remove piston and bellows assembly.

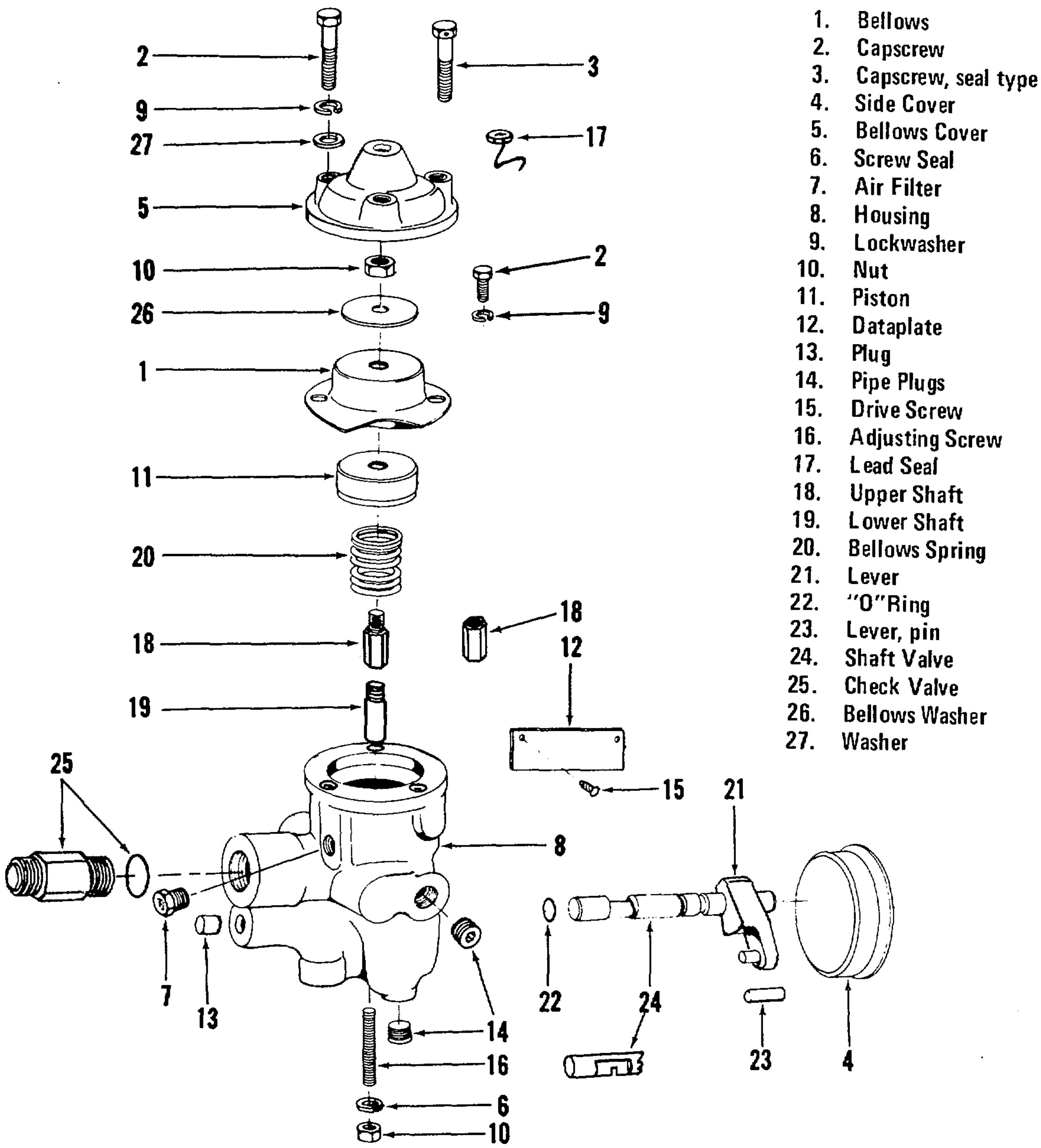


Fig. 5-2-7, F5249. Aneroid exploded view

4. Dip new bellows in lube oil (SAE 20 or 30) and reassemble In reverse sequence making sure capscrew holes In bellows align properly with corresponding holes in aneroid body. The piston shaft nut or capscrew torque is 20 to 25 Inch lbs [2.3 to 3.5 Nm] and the cover capscrew torque is 30 to 35 inch lbs 13.4 to 4.5 N. m .

CAUTION

If bellows is wrinkled during assembly or if cover capscrews are over torqued, bellows will prematurely fail.

B. "O" Ring 114791 Replacement

This can be accomplished without changing aneroid settings if the bottom screw position is not altered and same bellows spring and shims or 2 piece shaft length is the same' when reused.

1. Drain oil and remove side cover, Part No. 114773 (this is pressed into aneroid body).

2. Use a pencil or rod of suitable length inserted through aneroid air inlet opening to depress piston slightly and pull shaft, Part No. 140358.

3. Replace "0" ring, lubricate with lube oil and reassemble in reverse sequence.

4. Clean cap bore In housing Use a new side cover, Part No. 114773.

5. Apply a thin coat of Permatex Aviation Forma gasket around cover O.D. and drive it into housing by tapping uniformly around rim until flange contacts housing.

Note: Do not drive or press against cupped portion of cover. Distortion will cause binding of shaft, Part No. 140358.

6. Retail with oil after mounting an engine.

Maintenance, Trouble Shooting And Repair
Maintenance

1. Assure that body is initially filled with oil of same grade as that used in engine.

2. Check oil level and replenish every 2nd or 3rd engine oil change period.

A. If evidence of rust appears in drained oil, remove aneriod from engine.

B. Remove pressed side cover and wash cavity with solvent.

C. Install as previously described in “O” ring replacement.

3. Occasionally check to determine if oil leakage is occurring at bottom adjusting screw or side cover, Part No. 114773.

4. Replace the aneroid bellows at 125,000 to 150,000 miles 1200 000 to 240 000 km].

5. Every 30,000 to 50,000 miles [48 000 to 80 000 km], replace breather. Torque to 10 to 13 ft-lbs.[14 to 18 N. m .

Trouble Shooting
Engine Will Not Start
Aneroid starting check valve may be stuck open.

1. Disconnect intake manifold to aneroid air line at aneroid. Used a pencil or rod of suitable length to depress the aneroid piston fully. Have someone attempt to start the engine.

2. If engine starts, aneroid check valve is stuck open. Remove, clean and polish check valve with crocus cloth. Check for binding In bore. Replace new style valve.

3. If engine does not start, when aneroid piston is depressed, aneroid is not fault.

Excessive Acceleration Smoke
1. Engine fuel rate will be excessive if pump calibration is above specs.

2. Aneroid check value stuck close.

a. Disconnect aneroid fuel outlet line at aneroid and plug end. Attach a hose at aneroid i outlet connection and run into a bucket. Start engine and observe for fuel discharge from hose as engine no load speed is increased. Fuel should be discharged at or slightly above idle (600 rpm). See Table 5-2-3 for starting check value opening pressure

b. If no fuel is discharged, replace new style valve or remove, clean and polish starting check valve. Check for binding in bore.

c. Disconnect air line at top of aneroid. With a pencil or rod of suitable length, determine if piston is stuck down If so, remove aneroid and repair.

d. If fuel is discharged, check valve is riot at fault.

3. Obstruction in aneroid hoses or fitting.

Check for unauthorized tampering that renders the aneroid ineffective.

4. Aneroid "fuel pressure" setting too high.

5. Aneroid air actuation pressure too low.

a. Wrong spring in use (too tight).

b. Aneroid spring shimmed too lightly or 2 piece shaft too long.

6. High altitude.

"Aneroid" fuel pressure setting should be reduced.

Low Power
If exhaust smoke is dense, at full power, aneroid is not at fault.

1. Aneroid "fuel pressure" setting too low.

Check for tampering.

2. Aneroid air actuation pressure too high.

Check for tampering. Check for air leaks between aneroid cover and bellows.

3. Aneroid bellows ruptured.

Remove breather and apply 20 psi [138 kPa] maximum air pressure at aneroid air inlet. If continuous air leakage is noted at breather hole, bellows is ruptured.

4. Breather plugged.

Clean or replace.

5. Aneroid piston and linkage mechanism stuck In up position.

With a pencil or rod of suitable length inserted through aneroid air inlet opening, check for piston, aneroid shaft or linkage binding. An indented pressed side cover will rub valve lever.

Air In Fuel System

1. "0" ring, Part No. 114791 leaking.

a. Disconnect aneroid air inlet line and impose restriction on gear pump suction. Attach manometer at breather opening or otherwise determine if vacuum is being drawn In aneroid oil reservoir

Note: Aneroid oil level will be low if leakage Is occurring at "O" ring b A quick check to determine if aneroid is or is not the source, disconnect aneroid fuel outlet line at aneroid and plug end of hose and opening in aneroid. If air entry into fuel system continues, aneroid is not at fault. If air entry stops, aneroid is at fault

2. Seal, Part No. 102827 leaking.

Check in usual manner

Adjustment On Engine

Accuracy of the following adjustments depend on the condition of the engine, parasitic loads and accuracy of the instruments used. At no time should adjustments be made on a cold engine. The engine should be run before making adjustments until oil temperature reaches 165 deg. F. and with the valves and injectors set according to specifications.

Pump Hook-Up

If the fuel pump has been removed from engine for calibration, proper hookup is necessary.

1. Install fuel pump to accessory drive or to compressor with new gasket and proper rubber buffer, nylon buffer or spline coupling and tighten securely.

Note: Use black rubber buffer (spider) for engines rated at or below 2800 rpm. Use white nylon above 2800 rpm.

2. Squirt some clean lube oil into gear pump inlet hole. This aids gear pump fuel pickup.

3. Connect the fuel pump line from the pump shutoff valve to the fuel manifold or to front or rear of engine.

4. The throttle lever linkage should not be connected to the throttle lever, thus leaving the throttle free for pump adjustments.

5. Install accurate tachometer to fuel pump tachometer drive shaft connection or use ST774 hand tachometer.

6. Connect the shutoff valve electrical connections properly, leaving the manual control button in a closed position (screwed out).

7. Connect pump cooling line to check valve elbow on gear pump.

Checking And Adjusting
The Fuel Pump On The Engine Before making fuel system checks or adjustments on engine, be sure the following rules are observed:

1. Engine is at operating temperature. Fuel temperature is not above 110 deg. F [43 deg. C] .

2. Engine parts are the same as those listed on Control Parts List and in good condition. Timing, valves and injectors are properly adjusted.

3. Instrumentation (gauges and tachometers) must have high accuracy.

CAUTION
Do not alter pump settings to satisfy gauges and tachometers of unknown accuracy.

4. Vehicle throttle control linkage is adjusted so full throttle is obtained and when released throttle is stopped by front throttle adjusting screw (throttle leakage adjusting screw).

Note: Vehicle throttle control linkage should have a maximum throttle stop, so when fuel pump full throttle is obtained override pressure will not be on throttle shaft.

5. When fuel pump has been properly calibrated, very little adjustment should be required after installation on the engine except idle since this setting is dependent on parasitic loads. Fine adjustment of governor settings and fuel manifold pressure is permissible within the specified limits if justified by engine performance tests.

Governor Settings
Idle Speed

1. After fuel pump installation, engine must be operated a sufficient period of time to purge all air from the fuel system and to bring engine up to operating temperature (at least 165 deg. F [74 deg. C] oil temperature).

Note: Idle speed adjustment should never be made on a cold engine.

2. Remove pipe plug from spring pack cover.

3. The idle adjusting screw is held in position by a spring clip. Turn screw in to increase or out to decrease the speed. Use ST984 to adjust idle speed while engine is running. This tool seals the spring pack housing, permitting an accurate adjustment.

4. Replace pipe plug when idle speed is correct.

7. Some problems with excessive vibrations have occurred at engine idle speeds particularly in truck applications that also have power takeoffs. This is particularly true of applications with cement mixers.

8. In these cases it has been found that a substantial amount of vibration can be eliminated by an adjustment of the engine idle speed to compensate for component cyclic vibrations p)resent In each particular application.

9. These are recommended speeds and are intended as reference points. Slight deviations can be made from these speeds although it should be noted that extreme care must be taken so that new problems are not created by extreme variations in idle speed.

10. Problems such as difficult gear engagement can be encountered with excessively high idle speeds. Poor load pickup can be a problem if idle speeds are adjusted to low.

12. Before concluding that the governor plunger is the cause of idle surge, check the weight assist protrusion against specifications.

High Speed

1. A means of loading the engine must be used to perform in this check. The tachometer and fuel manifold pressure gauge must be of high accuracy. The engine fuel system must be purged of all air and at operating temperature.

2. The preferred method of checking governor setting is to "load" the engine on an engine or chassis dynamometer.

3. Maximum engine speed is adjusted by adding or removing shims under the high speed governor spring. Normally, this adjustment is made on the fuel pump test stand as the fuel pump is calibrated and does not need to be changed on the engine.

Cutoff Setting

1. At full throttle increase load until the speed is)pulled down to at least 100 rpm below engine rated speed, then decrease the load gradually while observing the fuel manifold pressure gauge. (The fuel manifold pressure will increase with decreasing load until the governor begins restricting fuel and then the pressure will begin decreasing with decreasing load.)

2. Continue decreasing load until fuel manifold pressure reaches its peak and decreases 1 to 2 psi. This is the so called "governor goes dead", "governor break or "governor cutoff" point. This speed is between 30 to 50 rpm higher than engine rated speed to assure that governor restricting before rated speed. (Example1 on a 2100 rpm engine this speed should be 2130 to 2150 rpm.)

3. If the governor cutoff point is higher or lower than specifications, shims should be removed or added from behind governor high speed spring accordingly.

4. Recheck the governor cutoff point adjustment.

Engine Hi-idle or Maximum No-Load Speed

1. Operate engine to purge all air from fuel system arind bring up to operating temperature.

2. With transmission in neutral or the clutch disengaged, open throttle and hold fully open. Note the inaxilLimum engine speed. This speed will be 10 to 12% greater than the governor "cutoff" speed, depending upon engine parasitic loads (fans, pumps, etc.)

3. This check should not be used to check or make governor speed adjustments. This check is of secondary importance and must be considered as such unless the no-load speed is significantly greater than specifications in which case the governor assembly should be examined for malfunction or improper parts.

Checking and Adjusting Fuel Manifold Pressure

Listed below are three methods of checking fuel manifold pressure. The engine must be at operating temperature and fuel system purged of all air.

1. The preferred method of checking engine manifold pressure is to load engine on an engine or chassis dynamometer as follows.

a. Check governor cutoff as detailed previously.

b. At full throttle, increase load until engine is pulled down to rated speed (accurate tachometer must be used). Read fuel manifold pressure. If engine fuel manifold pressure is below minimum or above maximum specifications, make the following adjustments.

To Raise Pressure

(1) Screw out maximum throttle opening stop screw and utilize throttle restriction thay may be present.

CAUTION

Do not screw the screw out beyond maximum throttle opening point otherwise a dead throttle travel may occur.

(2) Remove throttle shaft and add fuel adjusting shims as required. To Decrease Pressure (1) Remove throttle shaft and remove shims as required.

CAUTION

Under no circumstances should engine manifold pressure be set above maximum specifications. Doing so will void engine warranty.

(2) It should not be necessary to adjust fuel manifold pressure on a newly calibrated pump more than + 2 psi [0.14 kg/sq. cm]. If adjustments greater than this are required, fuel pump test, injector test stand or engine problems may exist.

2. The next best method of checking maximum engine fuel manifold pressure is to note maximum pressure while accelerating at full throttle when going up through the transmission ratios. With proper gauge snubbing, this method can be relatively accurate, especially if a heavy load

is being pulled and engine acceleration in the higher gears is slow.

3. The least preferred method of checking maximum engine fuel manifold pressure is the so called "snap" pressure check method.

a. The "snap" method is not as reliable as method 1 and 2 because the pressure reading is of very short duration. Gauge inertia and/or the degree of throttle manipulation also reduces the reliability of snap pressure readings.

b. To take snap pressure readings, attach the ST435 pressure gauge at the shutdown valve in the usual manner. Fig.531

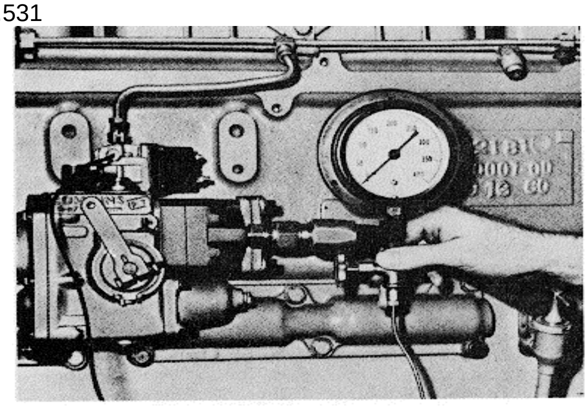


Fig. 531, F5178. Checking fuel manifold pressure

c. Disconnect the vehicle throttle control linkage at the throttle lever. Move lever clockwise against stop.

d. Start engine and run engine speed up to 200 to 300 rpm above idle by opening throttle slightly, then snap throttle to fully open position and permit engine to accelerate to maximum speed while observing pressure gauge. Note momentary maximum pressure. Take this reading several times.

Notes:

(1) Due to its poor reliability and inherent inaccuracy this check should not be used to gauge fuel pump test stand calibration accuracy.

(2) On turbocharger engines having aneroid, it is necessary that fuel routing through the aneroid be blocked or removed when making snap pressure checks.

Checking And Adjusting Aneroid Fuel Pressure Setting

1. Plumb an ST435 pressure gauge into injector supply line (fuel pressure check pipe plug in shutdown valve).

2. Operate engine until all systems are up to temperature.

3. Disconnect air line between aneroid bellows and intake manifold.

4. Operate engine at full throttle at setting BHP speed shown in Table 521, and adjust bottom screw In aneroid (back the screw out) until fuel pressure Is reduced the required amount as calculated under "fuel pump derating," in aneroid section of manual, for particular altitude.

Note: This can be done by snap fuel pressure readings if necessary but engine loaded method is preferred.

5. Tighten locknut on adjusting screw and reconnect air line between aneroid and Intake manifold.

Checking and Adjusting Engine Fuel Rate

Engine fuel rate (fuel consumption) in lbs. per hr. is measured by using ST1190 Flow Rater. Fig. 532 is a typical installation of checking fuel with ST1190.

1. The fuel rate specified on fuel pump calibration specifications is at full throttle and rated speed.

2. An engine dynamometer, chassis dynamometer or other controlled means of loading engine must be used. Accurate fuel manifold pressure and speed readings must also be taken.

3. To check engine fuel rate, load engine to full throttle until engine speed is pulled down to and kept at rated speed (check governor cutoff speed as previously described while loading engine). Note fuel manifold pressure at rated speed. Hold engine speed and load stable at rated speed long enough for the flow meter float to stabilize. Take the fuel rate reading.

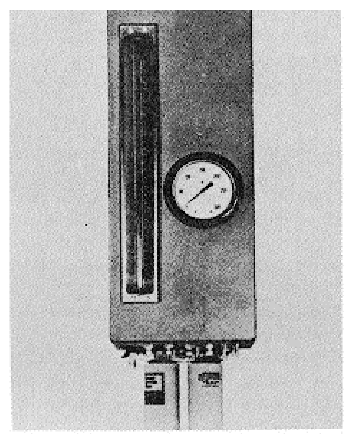


Fig. 532. F5247. Checking fuel rate with ST1190

Throttle Leakage

1. The purpose of throttle leakage is to keep fuel lines or supply drillings and injector drillings full of fuel during closed throttle engine motoring.

2. Throttle leakage prevents engine response hesitation

when throttle is opened after down grade closed throttle motoring and prevents the engine from stalling when it decelerates to idle.

a. Excessive throttle leakage will cause engine to decelerate too slowly.
b. Insufficient throttle leakage will cause engine response hesitation after closed throttle motoring and stalling after decelerating to idle.

Note: If throttle leakage is adjusted correctly on fuel pump test stand, adjustment after fuel pump installation on engine is not required.

3. If throttle leakage adjustment on engine is required, it should be performed in the following manner.

4. Engine must be operated long enough to purge all air from fuel system and at operating temperature.

CAUTION
Never check engine deceleration or adjust throttle leakage on a cold engine. Engine will decelerate faster when cold due to greater friction drag.

5. Vehicle throttle linkage must be adjusted so pump throttle just contacts the front throttle stop screw when throttle is closed.

6. A fuel manifold pressure gauge must not be in use.

7. A stop watch or other suitable timer and tachometer must be used to perform the following check.

8. With transmission in neutral or clutch disengaged, open throttle fully and let engine run at hi-idle (maximum no load speed).

a. Release or move throttle to closed position quickly and start stop watch simultaneously.
b. Stop the stop watch when engine reaches 1000 rpm and note deceleration time. Repeat several times.
c. If engine begins to stall (idle governor does not catch engine) after decelerating from hi-idle, throttle leakage must be increased.

(1) Note position of throttle leakage adjusting screw (front throttle stop screw).

(2) Turn screw in while checking engine deceleration as described previously until deceleration time is increased 1 to 2 seconds. Lock screw in this position and recheck idle speed. Readjust as necessary.

9. If engine decelerates too slowly, it may be necessary to decrease throttle leakage. Before decreasing throttle leakage, be sure it is required by first checking deceleration time when shutdown valve is closed (engine is shutdown) while running at hi-idle. If deceleration is no faster by this method, throttle leakage is not the problem. If deceleration is significantly faster by this method, throttle leakage should be reduced.

a. Note position of throttle leakage adjusting screw.

b. Back screw out while checking engine deceleration as described previously until engine tends to stall after decelerating from hi-idle. Turn screw in until deceleration time is increased 1 to 2 seconds. Lock screw in position and check idle speed. Adjust idle speed as required.

Adjusting Dual Power Torque Limiting Valve

This valve must be adjusted when engine is on a dynamometer.

1. When fuel pump is calibrated, the valve solenoid is energized or valve adjusting sleeve is bottomed, allowing full fuel flow.

2. Normal engine testing may be completed with valve locked open in this manner.

3. To adjust valve, remove aneroid fuel lines and plug holes, remove valve solenoid wires and remove sealing plug from front of valve body.

4. With solenoid De-energized, start engine and increase speed to high idle.

5. Apply load on dyno until 1200 rpm is reached. Adjust valve sleeve until your application specification is obtained.
6. Install valve sealing plug and record value obtained
7. Connect solenoid wires, remove aneroid plugs and replumb aneroid.
8. Recheck engine power at rated speed.

Engine Power

1. Engine power cannot be gauged accurately in any way except on an engine dynamometer. Any other method of gauging engine power requires the use of assumptions, feel, opinions regarding accessory drive train power losses and load measuring equipment accuracy.

2. Fuel pump adjustments should not be made based on estimated power arrived at by this means unless full performance data (fuel manifold pressure, fuel rate, speed settings, smoke, coolant temperature, combustion smoothness, exhaust restriction, fuel quality, air intake restriction, crankcase oil level and engine power derate factors) also indicates the adjustments are justified. Under no circumstances should these specifications be exceeded.

Note: As in all fuel systems and engine performance checks, accurate instruments must be used.

3. Engine rated power (maximum power at engine rated speed) should be checked in the same way as "checking and adjusting engine fuel manifold pressure" and "checking and adjusting engine fuel rate" as previously described.
4. Check governor cutoff setting to assure this is not influencing rated power

Fuel Filter Restriction

1 Fuel filter restriction can be checked using ST434 Vacuum Gauge. Fig. 534.

2. Connect gauge using the special adapter furnished in ST434.

3. If restriction reads 8 inch vacuum while engine is running at full speed and load, filter must be changed or other sources of restriction remedied. Sight glass gauge, (ST998), will show air bubbles with air entrainment and possible gasket or other leaks.

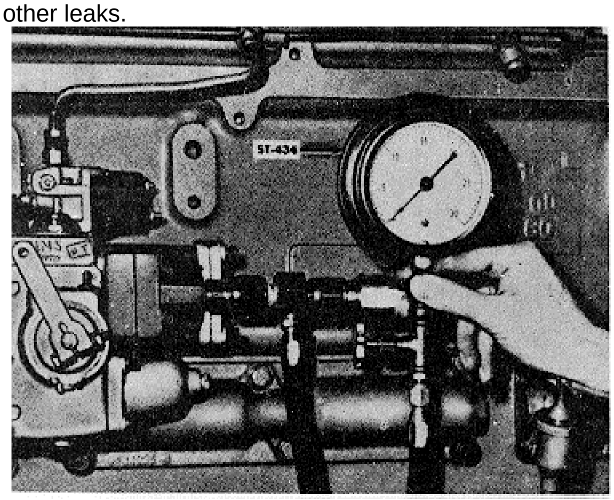


Fig. 534. F51 80. Checking fuel restriction

4. If air bubbles are persistent and the engine is over 400 brake horsepower, check the float valve assembly in the float tank (if so equipped). The gear pump may be pumping more fuel than the float valve will allow to pass into the float tank. A new interchangeable float valve is available with sufficient capacity to meet this requirement.

Seal Fuel Pump

1. To prevent unauthorized adjustments of the fuel pump after final adjustments are made, seal the spring pack. housing lower capscrews and the rear throttle screw or throttle cover and spring pack cover plug. Fig. 535.

2. Spring Pack Housing Seal.

a. Install bottom capscrew with drilled hole in head. Install plug with drilled hole into spring pack housing.
b. Insert seal wire through capscrew and plug.
c. Twist the seal wire ends together until connection is secure and wire is tight.
d. Bent twisted wire into seal and press on top half of seal.

3. Drive Cover Seal.

a. Use a longer wire to reach a lower capscrew on the drive cover.

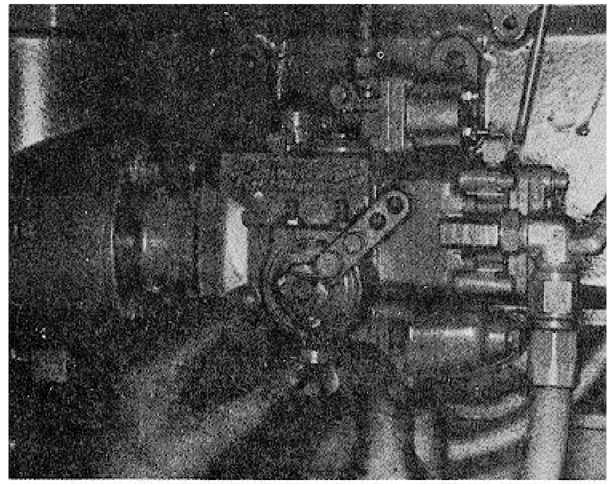


Fig. 535 F5181. Sealing fuel pump

b. Wire the spring pack as in Step 2 except before sealing, run wire through capscrew hole in lower drive cover.

c. Twist wire and seal as in Step 2.

4. Throttle Adjusting Setscrew Seal.

a. Install acorn nuts on setscrews.
b. Insert wire through drilled hole in acorn nuts.
c. Twist wire down to throttle shaft.
d. Place wire behind throttle lever and straddle throttle shaft.
e. Twist wire and insert through lower hole in throttle shaft cover.
f. Bend twisted wire into seal and press on top half of seal.

5. An optional spring pack cover, without idle adjustment .access hole, is available.

a. After pump is calibrated, remove the cover with access hole and install plain cover.
b. Install lockwire through capscrew hole and secure seal as before.

6. To further protect fuel pumps from tampering; a new countersink drill (ST1175), a twistoff countersink capscrew (204925) and a countersink lockwasher (204926) is available.

a. Remove one or more capscrews, lockwashers and flatwas'hers from the front cover and/or spring pack cover.

b. Use st-1175 countersink drill to counterbore the cover so the twist-off capscrew will be flush with the surface, Fig 5-3-5.

c. Apply Loctite to capscrew counterbore surface and install capscrews and countersunk lockwashers in covers.

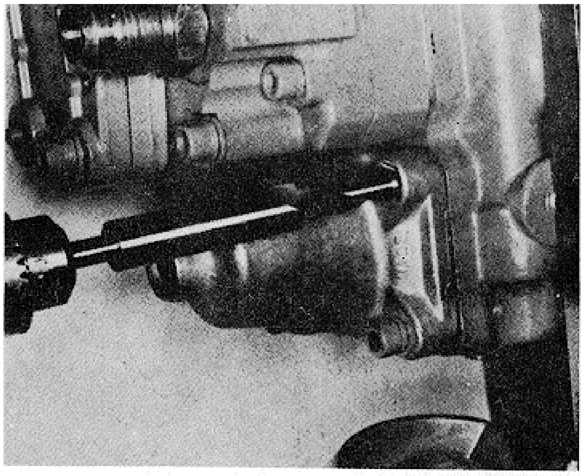


Fig. 5 3 6. F5241. Drilling spring pack housing with ST1175

d. Torque the other cover capscrews to 90/95 inch pounds. The twistoff capscrews will twist off at about 105 inch pounds.

e. To remove the twistoff capscrew, use an electricarc to weld a nut to the top of the capscrew.

CAUTION

Weld the nut in the thread area. Do not overheat the aluminum covers.

f. The heat from the weld will weaken the retaining compound; therefore, disassemble immediately while hot.

g. Due to the hardness of the twistoff capscrews; do not attempt to drill them out.

7. The spring pack guard is designed to protect the spring pack from tampering. The spring pack guard mounts on the rear of the spring pack housing. Fig. 537. The Tetraseal is to be fitted over the shoulder at the small end of the guard.

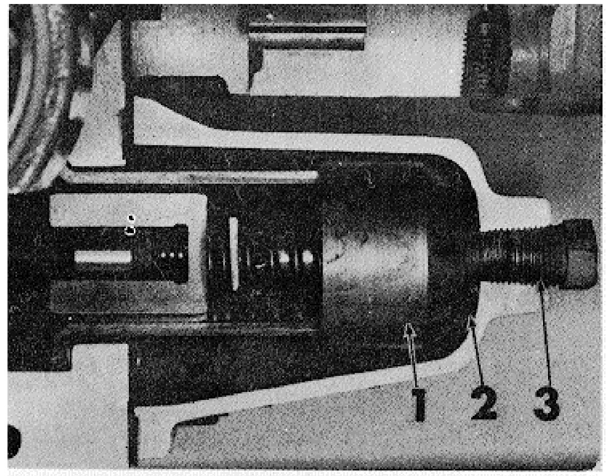
Install as follows:

a. Remove spring pack cover and discard gasket. Install spring pack guard and Tetraseal.

b. Install spring pack cover with a new gasket leaving the mounting hold for break away seal screw open.

Note: When using a spring pack cover having a plug, saw off plug flush with cover.

8. Remove standard snap ring securing throttle shaft cover and replacing with snap ring, Part No. 21461, Fig 5-38.



1. Spring pack housing guard
2. Tetraseal
3. Spring pack housing plug

Fig. 537. F5290. Spring Pack Housing Guard and Tetraseal Installed

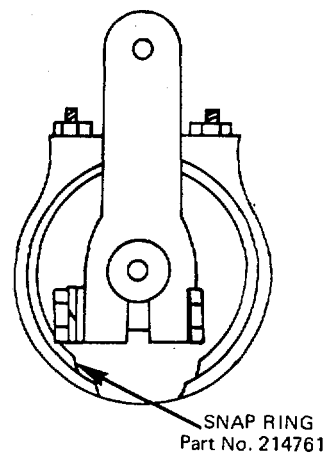


Fig. 538. F5291. Throttle Shaft Snap Ring Installed

TURBOCHARGER

TABLE OF CONTENTS

Intake Air System Group

A turbocharger is a mechanical unit, driven by exhaust gas, used to force more air into an engine cylinder than the engine would receive operating naturally aspirated. The additional air and an increased fuel charge enables the engine to develop more horsepower and/or operate more efficiently.

VT-50 Turbochargers

Description

Cummins VT-50 Turbochargers, Fig. 102, are designed so weight and size are held to a minimum, therefore, the turbocharger adds a very small percentage to the overall weight of the engine, which results in a higher horse power to weight ratio.

The turbocharger consists of turbine wheel and a compressor wheel separately encased, but mounted on, and rotating with, a common shaft. The turbine side of the turbocharger mounts to the exhaust manifold outlet flange and the compressor wheel side connects with the air intake manifold. Lubrication and cooling is obtained from filtered engine oil through flexible lines or tubing.

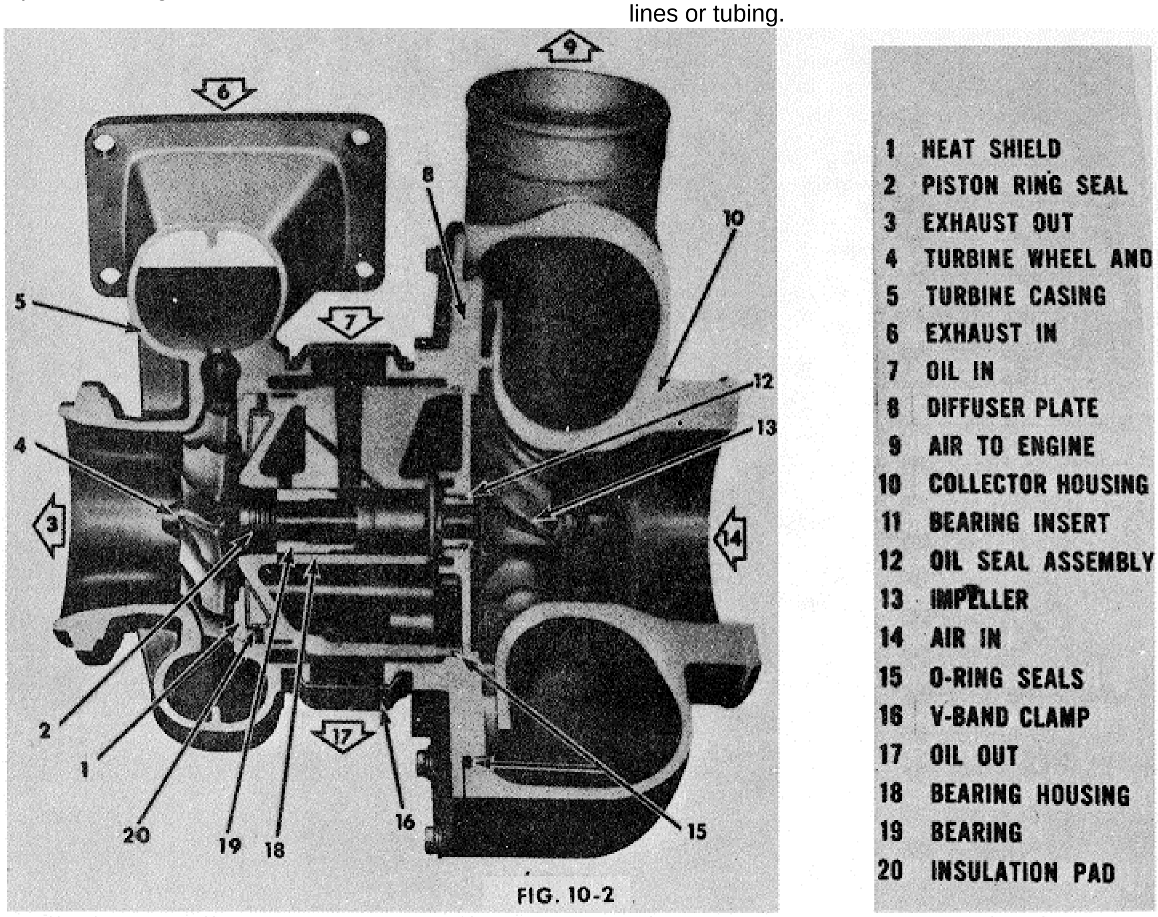


FIG. 10-2

The power to drive the turbine wheel which in turn drives the compressor wheel is obtained from energy of exhaust gases. The rotating speed of the turbine wheel changes as the energy level of exhaust gases change so the engine is supplied with enough air to burn fuel for its load requirements.

The part number, serial number, model number, and other pertinent information appears on the nameplate attached to the turbocharger.

Operation and Maintenance

Correlated action of compressor and turbine automatically adjust speed and output of turbocharger to compensate engine speed and load changes.

Consideration need not be given to direction of turbocharger rotation when applied to right-hand-left-hand engines Turbocharger rotates in only one direction, regard less of direction of engine rotation.

Under continuous load operation, exhaust smoke from a turbocharged engine should not be too dense, however, rapid acceleration may cause a turbocharged engine to show exhaust smoke of greater density for a few seconds until the turbocharger rpm catches up with sudden increase in fuel supply.

Starting And Initial Checks

1. Prelubricate turbocharger by pouring clean lubricating oil through inlet opening. Turn rotating assembly by hand to coat bearings and thrust washer with oil.

2. Install oil inlet line and fill with clean lubricating oil. Use wire braid hose with minimum inside diameter of 5/16 inch [7.9 mm] (SAE No. 6) that will withstand up to 450 deg. F [232 deg. C] oil temperatures.

3. During initial starting, check for oil pressure at inlet connection to turbocharger (10 psi [69 kPa] minimum at idle).

4. Disconnect oil drain line to determine If oil is flowing through turbocharger. Reconnect line.

5 Remove air inlet connection from turbocharger and observe rotation of turbocharger rotor. The rotor must be entirely free of any evidence of rubbing or binding.

6. Shut down engine momentarily to determine If rotor coasts freely to a stop

7. Restart engine and check full speed and load.

8. Recheck all connections and piping for tightness.
If no leakage of oil, air or exhaust gas can be noted, the engine is ready for operation.

9. Performance of turbocharger must be observed at reasonable intervals. Data and conditions to be observed are noted in following paragraphs

Engine Shut-Down

It Is important to Idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil to carry heat away.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation, but If the engine is stopped suddenly, the turbocharger temperature may rise as much as 100 deg. F [38 deg. C] .

The results of extreme heat may be seized bearings, bearing housing deformation or burned "0" ring oil seals.

Place warning decal (Bulletin No. 983361B), Fig 103, In a conspicuous location.

CAUTION
PROTECT THE TURBOCHARGER DURING

START-UP BY NOT OPENING THROTTLE OR ACCELERATING ABOVE 1000 RPM UNTIL NORMAL ENGINE IDLE SPEED OIL PRESSURE REGISTERS ON GAUGE.

SHUT-DOWN BY IDLING THREE (3) MINUTES BEFORE SHUT-OFF.

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201
Bulletin No. 983361-B 7-70

Fig. 10-3, T-335-A. Shut-down decal 983361-B

Lubricating Oil Flow

To check lubricating oil flow at turbocharger, loosen oil drain line to see that oil is flowing while engine is running Turbocharger oil must be kept clean by regular changing of engine oil filter elements.

Turbocharger Speed

Ordinarily, attention need not be given to the speed of the turbochargers, since this varies automatically with speed and load of engine. If turbocharger runs too fast, it indicates the engine is being overfueled. Overfueling may cause turbocharger failure.

Vibration

If noticeable vibration develops in turbocharger, shut down engine and find cause. Vibration might be caused by damage to compressor wheel, shaft or turbine wheel.

Inlet Air Restriction

If inlet air restriction exceeds 25 inches [635 mm] of water under conditions stated below, air flow to cylinders will not be sufficient and a loss of power will occur. Excessive exhaust smoke and excessive exhaust temperatures will also accompany loss of power.

1. Check inlet air restriction by attaching a vacuum gauge or water manometer in air intake piping. Adapter must be perpendicular to air flow and one pipe diameter upstream from turbocharger in a straight section of tubing. Fig. 104.

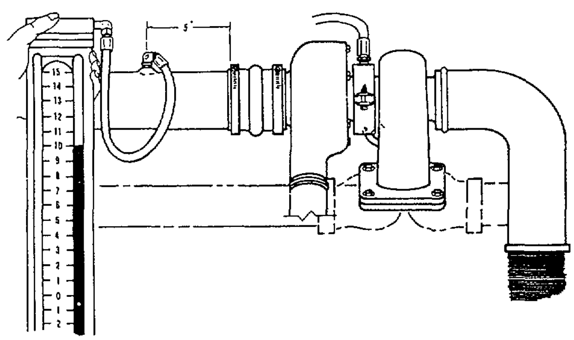


Fig. 104, TA2. Checking air inlet restriction

2. Operate engine until normal operating temperature is reached.

3. Operate engine at rated speed and full-load; take reading from vacuum gauge or manometer.

4. If air restriction exceeds 25 inches [635 mm] of water:

a. Clean or replace dry-type cleaner element.

b. Replace damage air piping, rain shield or housing.

c. Remove excessive bends or other source of restriction in air piping.

5. Air restriction readings may be taken at air cleaner outlet connection plug. If reading is taken at air cleaner, restriction must not exceed 20 inches [508 mm] of water.

Note: Engines with a properly operating restriction gauge mounted in the air cleaner outlet need not be checked in the preceding manner Refer to applicable Engine Maintenance Manual for further details.

Exhaust Back Pressure

Exhaust back pressure is a significant indication of exhaust system conditions and piping layout. High pressure indicates restrictions caused by foreign objects or excessive bends in exhaust piping or use of piping smaller than exhaust outlet of turbocharger. The lowest pressure obtainable is desired.

If exhaust back pressure exceeds 2 inches [50.8 mm] of mercury, early engine failure and poor performance may be expected. To check exhaust back pressure,

1. Point of measurement must be as close as possible to turbocharger outlet flange in an area of uniform flow such as a straight section of pipe at least one pipe diameter from any changes in flow area or flow direction. Where it is impossible to locate point of measurement in a straight section, it is permissible to measure on side of a bend where flow is uniform and equivalent to flow along centerline. Do not measure on inside or outside radius of bend as flow is not uniform at these points. Fig. 105.

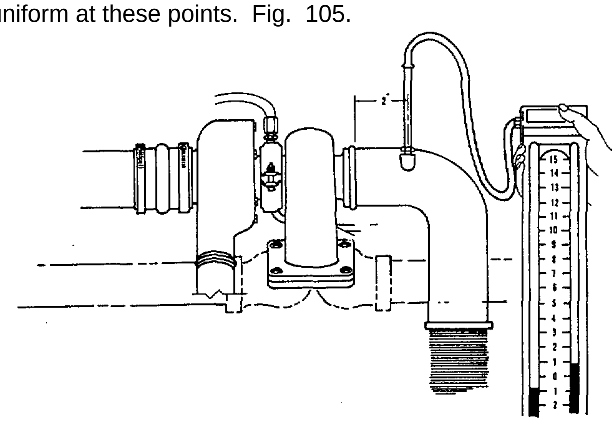


Fig. 105, TA3. Checking exhaust back pressure

2. At point selected, weld a 1/8 inch [3.18 mm] pipe coupling to exhaust tubing. Drill through tubing with a 1/8 inch drill. Remove all burrs. Mount 90 deg. Weather head fitting to coupling, then use 3 ft. [0.9 m] of 1/8 inch I.D. copper tubing (to resist heat) plus 10 ft. [3 m] of 3/16 inch [4.8 mm] I.D. soft rubber hose to manometer. The manometer may be mercury filled or water filled.

Note: It Is Important that line to manometer be size and length as given to minimize variation in reading due to a standing wave phenomenon which occurs in a manometer line. A change in length of material of this line can significantly change reading obtained.

Maintenance

Compressor wheel and compressor housing must be kept clean for best turbocharger performance. Any buildup of dirt or soil sludge on compressor wheel will substantially reduce compressor efficiency, increase rotor imbalance and reduce intake manifold air pressure. This may ultimately lead to a failure. Possibility of mechanical failure and loss of performance demands periodic inspections.

Under normal operating conditions, turbocharger is subject to very little wear since rotor is only moving part. Rotor must be accurately balanced due to its high rotative speed and extremely close running clearances. It is very important that this balance not be disturbed and that running clearances be maintained Operate engine at rated output, and listen for unusual turbocharger noise. If a shrill whine (over and above normal turbine whine) is heard, shut down immediately. Whine is indicative of Imminent turbocharger bearing failure.

Remove turbocharger ,for overhaul. Other unusual noises would result from improper clearance between turbine wheel and turbine housing. If such noises are head, turbocharger must be removed from the engine, disassembled, and inspected.

Service Periods

1. Clean turbocharger compressor wheel as listed in Maintenance Section.

a. Remove air Intake to turbocharger connection, air inlet piping to turbocharger and compressor casing to expose compressor wheel. Use Bendix cleaner, or a similar type solvent, and a bristle brush to clean carbon from compressor wheel and compressor casing.

Caution: Never use a caustic solution that may attach aluminum. Such solution may either weaken parts or destroy their balance. Also, never use a wire brush scraper or abrasive air jet to clean compressor wheel.

b. Dry unit carefully and reassemble compressor casing to bearing housing. Torque "V" band clamp nuts to proper torque specifications. See Specifications.

c. Reconnect air piping and secure with clamps.

d. Check compressor wheel for oil sludge build-up. Determine cause and correct such items as undersized oil bath air cleaner, air restriction, over-filling oil cup, etc.

2. Check bearing clearance as described under "Rotor End Clearance" In Maintenance Section.

Major Cleaning Operation

When it is evident that major cleaning operation is necessary to remove heavy carbon deposits, remove turbocharger from the engine and disassemble, clean, Inspect, repair or replace and reassemble as described in Rebuild Instructions.

Rotor End Clearance

Check end clearance as listed in Maintenance Section. This can be done without removing turbocharger from engine by using a dial indicator to indicate end clearance of rotor shaft.

Checking Procedure

1. Remove exhaust outlet connection and Intake piping from turbocharger to expose both ends of rotor assembly.

2. Attach a dial indicator to compressor casing. Push shaft as far as possible to rear. Register indicator point against end of rotor shaft and zero indicator, push shaft from rear toward indicator point and note indicator reading. It cannot exceed limits listed in Dimensions and Specifications.

3. If end clearance is not within limits, turbocharger should be removed from the engine and replaced by a new or rebuilt unit.

Trouble Shooting

Initial Performance Check

Trouble	Probable Cause	Remedy
1. No oil flow through turbocharger	Clogged oil lines or oil passages in main casing.	Remove oil lines Chef k arid lean oil lines and oil passages in main casing
	Improper type of hose used.	Replace inlet hose with SAE No. 6 wire braid hose with Teflon liner and outlet with SAE No. 16 wire braid hose with Teflon liner or 7/8 inch [22.2 mm] O.D. steel tubing. Fluid temperature range of hose should be -100 deg. F [-73 deg. C] to 450 deg. F [232 deg. C].
2. Rotor tails to turn on initial start of engine.	Rotor blocked by foreign object	Remove inlet and exhaust connections, remove foreign object (s).
	Piping strains transmitted to turbocharger causing casing distortion.	Install new piping separately supported and check turbocharger for damage.
	Rotor rubbing on turbine casing, compressor casing or both.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
3. Rotor turns freely by hand but falls to run when cranking engine	Exhaust manifold or exhaust piping blocked or closed off.	Remove restriction.
4. Rotor fails to coast freely to stop after Initial engine start.	Rotor rubbing casings.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
	Carbon build-up on oil seal or back of turbine wheel	Remove turbocharger from engine, disassemble, clean and replace worn parts.
	Tight bearings or oil seals.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
	Foreign object In turbocharger	Remove turbocharger from engine. disassemble, inspect and repair or replace with new turbocharger.

Field Troubles

Trouble	Probable Cause	Remedy
1. Low frequency pulsation from turbocharger	Compressor surging due to restricted air flow.	Check intake and exhaust systems and remove restrictions.
	Turbocharger mis-matched to engine air requirement.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
2. Intake manifold pressure fluctuating sharply.	Rotor rubbing Intermittently.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
]	Turbocharger surging.	Remove restriction In Intake or exhaust system.
3. Excessive vibration In turbocharger	Rotor out of balance.	Remove and rebalance or replace rotor assembly.
	Rotor rubbing.	Remove turbocharger and make necessary repairs or replace with new turbocharger
4. Lubricating oil in intake manifold or exhaust stack.	Excessive oil seal clearance In turbocharger.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
	Restricted crankcase breather.	Clean or replace breather.
	Restriction in air intake.	Check air intake piping for restriction
	Oil drain line angle in excess of 30 deg. from vertical.	Turn bearing housing to proper angle.
	Excessive blow-by.	Check for worn piston ring seals.
	Restriction of oil drain.	Check oil drain lines and fittings; replace if necessary.
5. Oily or dirty appearance in compressor wheel flow passage.	Oil pull-over from oil bath air cleaner.	Check oil level in cleaner and size of cleaner. Check for possible entry of water In air cleaner.
6. Oily appearance on bearing housing or on V Bands	Loose oil inlet or drain fitting	Use Teflon tape-on fitting. Tighten to proper torque.
7. Turbocharger speed and intake manifold pressure low. Exhaust temperature high and excessive smoke.	Accumulation of dirt on compressor wheel	Remove and clean
	Oil pull-over from air cleaner.	Check air cleaner for oil level and size of cleaner.
	Leaks in Intake or exhaust piping.	Repair leaks.
	Air cleaner too small or restricted.	Clean or replace as required.

Field Troubles (Continued)

Trouble	Probable Cause	Remedy
	Insufficient fuel supply from fuel pump.	Check fuel rate and reset pump.
	Back pressure on turbocharger exhaust too high.	Reduce restriction in exhaust stack.
	Turbocharger rotor rubbing.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
8. Turbocharger speed slightly high, exhaust smoking. Exhaust temperature high.	Engine receiving insufficient air due to restricted air inlet.	Remove restriction.
	Dirty air cleaner.	Clean air cleaner.
	Fuel pump delivering too much fuel to engine.	Reset fuel pump.
	Leaking exhaust valves.	Reset or repair bad valves.
9. Turbocharger speed high, intake manifold pressure correct.	High-altitude operation.	Derate engine fbr continuous duty at this altitude.
10. Drooping torque characteristic.	Improper fuel pump setting.	Reset fuel pump.
11. Loss of engine power, smoky exhaust. Exhaust temperature high.	Turbocharger rotor rubbing.	Remove turbocharger and make necessary repairs or replace with new turbocharger.
	Dirty compressor wheel.	Clean compressor wheel.
	Air intake restricted.	Remove restriction.
12. Low turbocharger speed, low power, clean exhaust.	Insufficient fuel supply to engine.	Reset fuel pump.

Rebuild Instructions

Exterior of turbocharger should be cleaned before disassembly. Mark compressor casing, diffuser plate, turbine casing, bearing housing and clamps to facilitate assembly in same position.

Disassembly

1. Remove fittings from lubricating oil inlet and outlet ports.

2. Remove self-locking nut from compressor end of rotor shaft. Fig. 10-6.

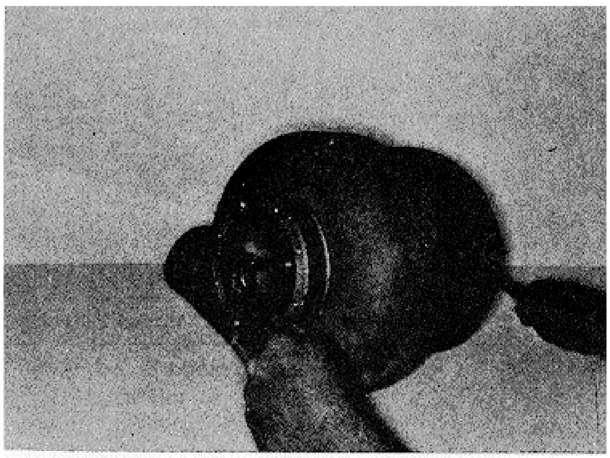


Fig. 10-6, T-428. Removing self-locking nut from compressor end of rotor shaft

3. Remove self-locking nuts, flatwashers and bolts securing V clamp to turbocharger. Fig. 10-7. Lift off V clamps; discard self-locking nut, flatwashers and bolts.

4. Using ST-647 Puller, secure clamp to collector housing with end of puller bolt on rotor shaft. Pull collector housing, oil seal diffuser plate and compressor wheel from bearing housing Fig. 10-8.

5. Remove capscrews, lockwashers, securing collector housing to oil seal/diffuser plate.

6. Tap gently to loosen and remove diffuser plate from the collector housing. Fig. 10-9. Remove and discard sealing ring. Lift out compressor wheel.

7. Remove teflon bearing insert and floating bearing from rotor shaft. Fig. 10-10. Remove "O" ring from bearing housing; discard "O" ring and Teflon bearing insert.

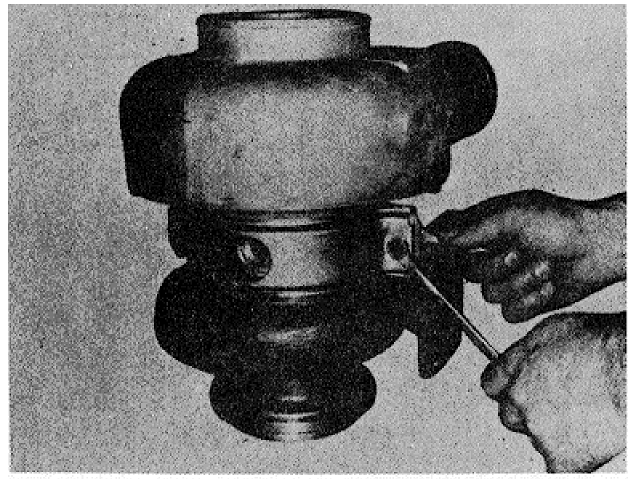


Fig. 10-7, T-416. Removing "V" clamps

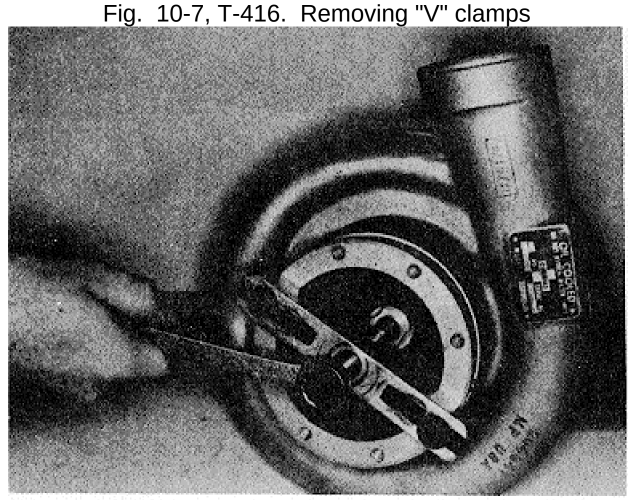


Fig. 10-8, T-516. Pulling impeller from rotor shaft

8. Position ST-881 Bearing Support over bearing housing and against turbine casing. Fig. 10-11. Place assembly on press. Fig. 10-12. Press rotor assembly and bearing housing from turbine casing.

9. Invert bearing housing and gently tap rotor shaft on workbench, Fig. 10-13, to remove rotor assembly from bearing housing. Lift out rotor assembly.

10. Remove heat shield and insulation pad from bearing housing.

11. Remove sealing sleeve assembly from oil seal/diffuser

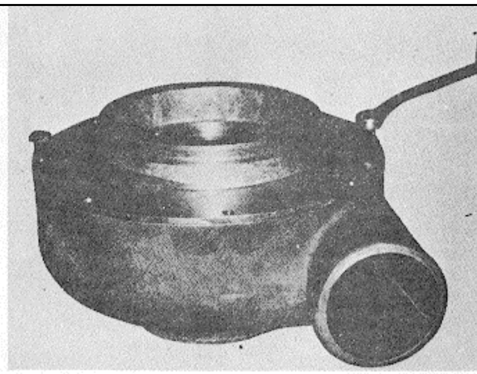


Fig. 10.9, T-418. Removing oil seal diffuser plate

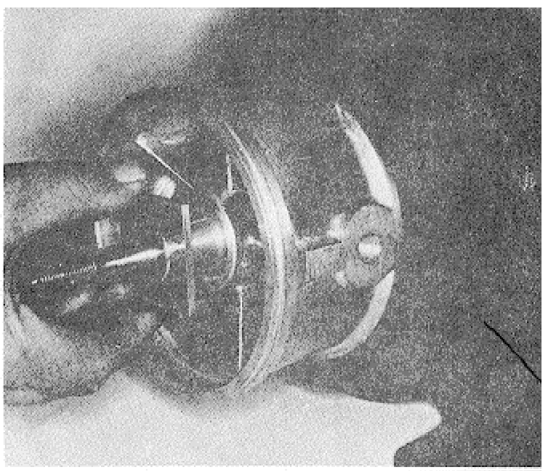


Fig. 10-10, T429. Removing teflon bearing insert and floating bearing form rotor shaft.

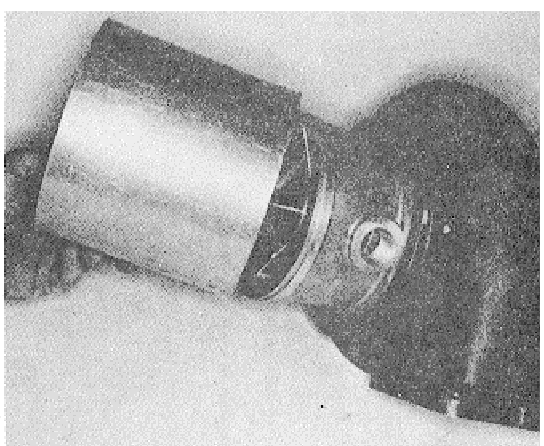


Fig. 10-11, T-518. positioning St-881 bearing support over bearing housing and against turbine casing

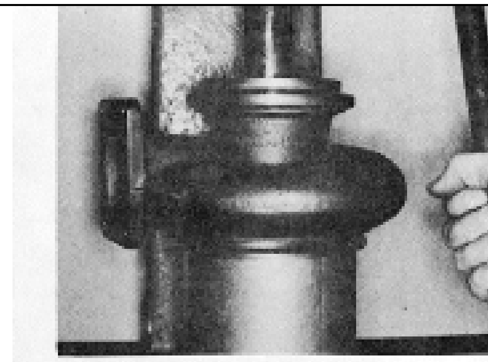


Fig. 10-12, T-519. Pressing rotor assembly and bearing housing from turbine casing

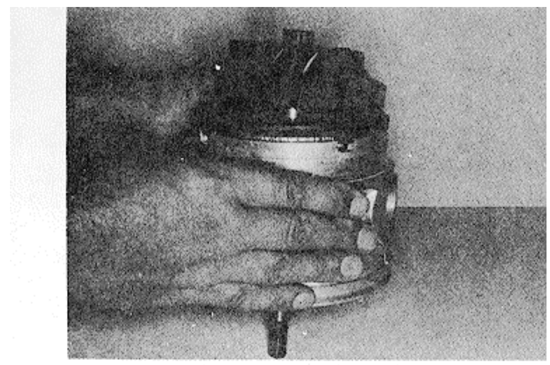


Fig. 10-13, T-430. Removing rotor shaft from bearing housing

plate. Dsicard seal assembly.

12. Remove sealing rings from grooves in rotor shaft. Discard sealing rings.

Cleaning
Turbocharger parts accumulate hard, glazed carbon deposits that are difficult to remove with ordinary solvents. The cleaner used must be capable of removing these stubborn deposits without attacking the metal.
1. Place all parts in a divided wire basket so parts will not be damaged through contact. Do not pile in basket. Be careful to avoid damage to all precision-ground surface.
2. Immerse parts in Turko Super-Carb or similar solvent.

Caution: Never use a caustic solution or any type solvent that may attack Aluminum, Stellite or Ni-Resist alloys.

3. Allow parts to soak as needed to remove carbon. A soft bristle brush may be used, if necessary, to remove heavy deposits. Never use wire or other type brushes with stiff bristles.
4. Flush out oil passages in bearing housing from drain end to remove dirt loosened by soaking.
a. Leave parts submerged in solvent for a minimum of twelve hours and preferable twenty-four hours. Agitate solvent for maximum cleaning.
b. After completion of Step "a", pump solvent through passage again to flush out any loose particles.
5. Remove parts from tank. Drain and steam clean thoroughly to remove all carbon and grease. Apply steam liberally to oil passages in bearing housing.
6. Blow off excess water and dry with moisture-free compressed air.
7. Place parts carefully in clean basket to avoid damage and dirt.

Caution: Do not use glass bead cleaning methods.

Inspection And Repair
Inspect all parts carefully before assembling. All parts within specifications can be reused safely for another service period. Damage to floating bearing may necessitate replacement of bearing housing with a new part.

Turbine Casings
1. Inspect turbine casing mounting flange for cracks, Fig. 10-14, distortion and burning.

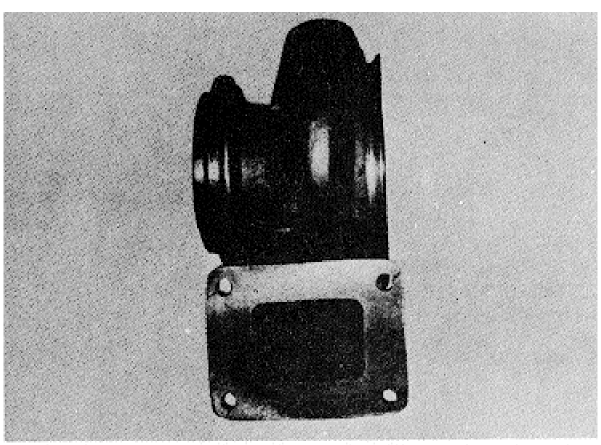


Fig. 10-14, T-399. Cracks In turbine easing mounting flange

2. Inspect for external cracks. Fig. 10-15.

Bearing Housing
1. Inspect bearing housing for cracks In oil passages (inlet and outlet ports), pitting and distortion on turbine end. Discard, if damaged.

2. Using gauges, take reading of sealing ring bores, Fig. 10-16, and floating bearing bores. Discard housino If worn beyond replacement limit given in Specifications.

3. Measure outside diameter of turbine end of bearing housing, discard if limits exceed that in specifications.

4. Inspect bearing housing turbine casing seating area stop ledge for wear, wire edging and distortion, discard If damaged and if sharp edges cannot be removed. See specifications for dimensions.

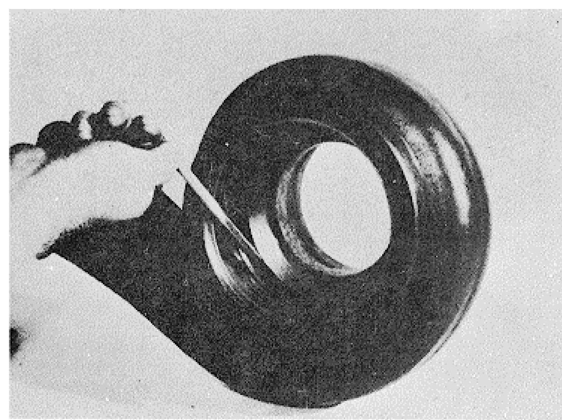


Fig. 10-15, T-31 1. Inspecting turbine casing

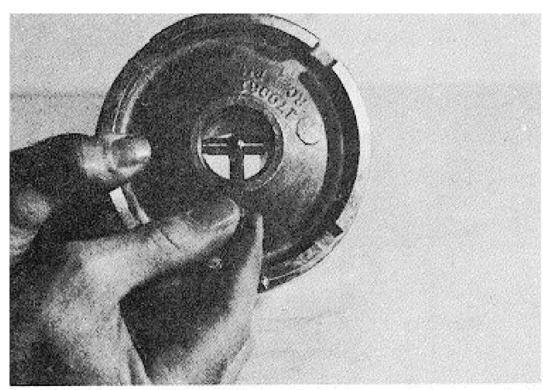


Fig. 10-16, T-365. Checking sealing ring bore in bearing housing

Heat Shield

Inspect heat shield for cracks, distortion and burned condition, discard, If damaged. Cracks on bore of heat shield less than 1/2 inch [12.7 mm] long are not cause for replacement.

Oil Seal Plate/Diffuser Plate

1. Inspect oil seal/diffuser plate for cracks, burrs and distortion, discard, If damaged.

2. Check oil seal/diffuser plate bore for burrs and scoring. Fig. 10-17.

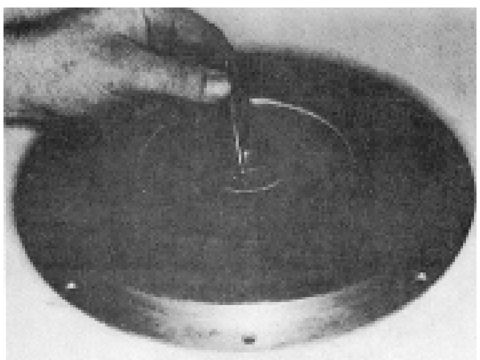


Fig. 10-17, T-524. Checking sealing ring bore in oil seal/diffuser plate

Rotor Assembly The rotor assembly consists of turbine wheel and shaft, sleeve, compressor wheel and locknut. This is an accurately balanced assembly; therefore, if any of the above parts exceed limits given in Specifications, replace with new parts

Compressor Wheel

Compressor wheel cannot be reused, if vanes are cracked, broken or have rubbed compressor casing. Check for cracks with dye penetrant. If new compressor wheel is required, rotor assembly does not have to be balanced

Turbine Wheel And Shaft

Inspect sealing ring grooves for extensive damage. Small grooves or marks are acceptable, but deep grooves are not. Smooth with polishing cloth before reusing. Check turbine thrust shoulder for scoring. Fig 10-18. Check for turbine wheel cracks with dye penetrant. Cracks in the turbine wheel render assembly unfit for further use.

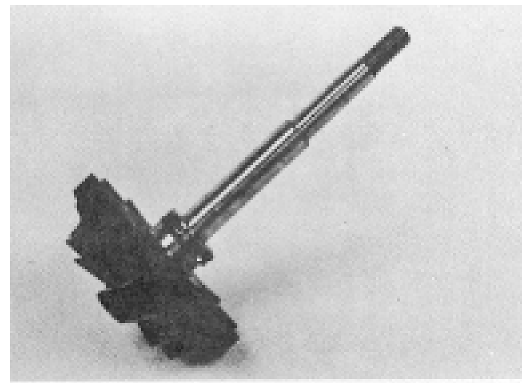


Fig. 10-18, T-431. Checking rotor thrust surface

Check shaft bearing journal diameters for wear. Fig. 10-19. The turbine wheel and shaft may be reused if not worn beyond limits given in Specifications If shaft is worn, new shaft and turbine wheel assembly must be installed.

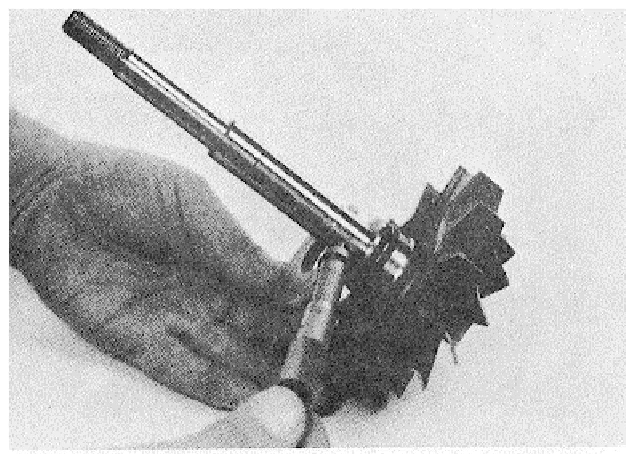


Fig. 10-19, T-432. Measuring rotor shaft

Floating Bearing

1. Check bearing length for wear, chips and cracks. If dimension is worn less than limits shown in Specifications, bearing must be discarded.

2. Measure O.D. and I.D. of bearings. Fig. 10-20. If either diameter Is worn beyond limits shown in Specifications, bearing must be discarded.

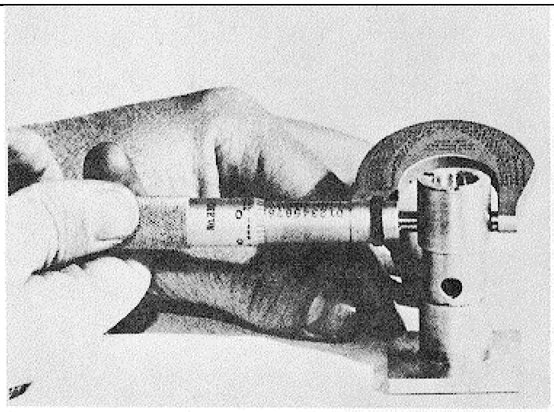


Fig. 10-20, T-316. Measuring floating bearing O.D.

Collector Housing

Collector housing that is deeply scored from contact with the compressor wheel, cannot be reused. Collector housing contour is critical to proper turbocharger performance. Fig.10-21.

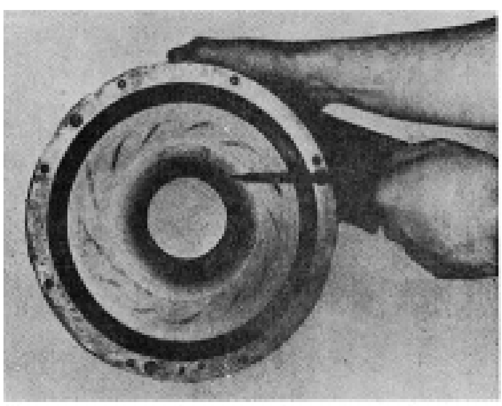


Fig. 10-21, T-419 Inspecting compressor casing

If slight scratches or nicks are present, they may be smoothed out with a very fine polishing cloth and the collector housing may be reused. Discard If cracked or distorted.

Miscellaneous

"V" clamps may be cleaned and reused unless they are damaged.

Assembly

Caution: All parts and work area must be free of grease, oil and dirt to keep abrasives out of turbocharger during assembly and to obtain correct dimensional stack-up of parts and prevent premature turbocharger failure.

1. Use a piece of tubing or mandrel on shoulder of shaft and check floating bearing end clearance on shaft. It should be 0.005 to 0.009 inch [0.13 to 0.23 mm].

2. Position new metal covered insulation pad on turbine end of bearing housing. Fig. 10-22.

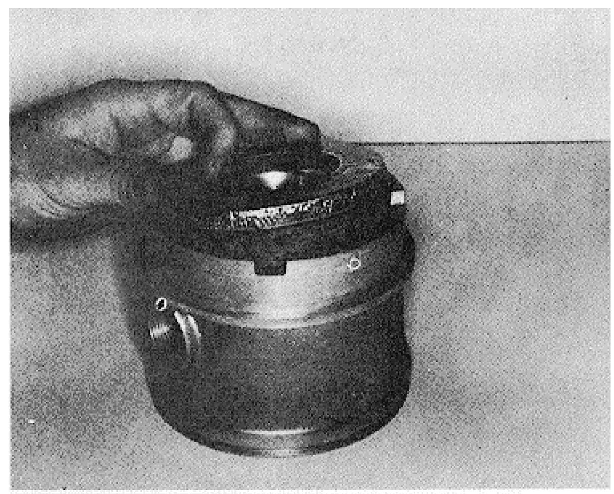


Fig. 10-22, T-529. Installing insulation pad

3. Install heat shield on bearing housing. Fig. 10-23.
4. Position sealing rings In grooves on turbine end of rotor shaft. Fig. 10-24.

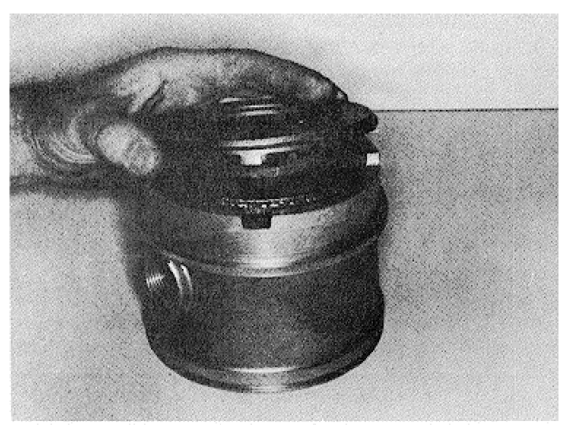


Fig. 10-23, T-530. Installing heat shield

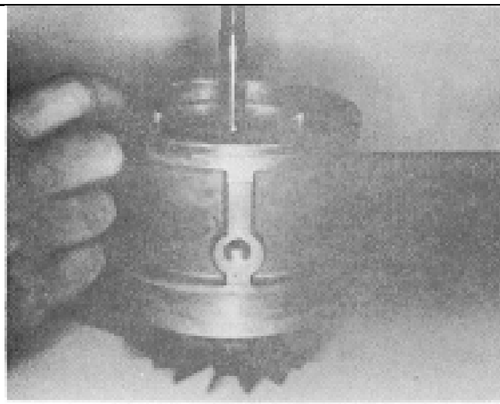


Fig. 10-28, T-536. Installing "O" ring on bearing housing

Keep piston ring compressed until assembly is started in oil seal plate bore. Fig. 10-29

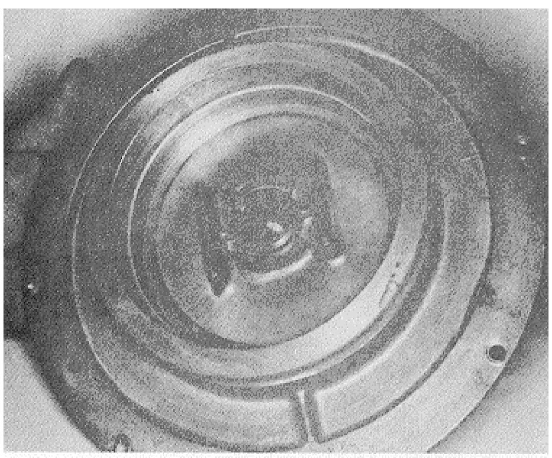


Fig. 10-29, T5-37. Installing oil sleeve assembly in oil seal/diffuser plate

Note: Install seal assembly from inside of oil seal/diffuser plate (sides with bearing stops) piston ring must be to

10 Lubricate and install new sealing ring on lip of oil seal/diffuser plate, Fig. 1 0-30 and 10-31; coat bearing housing bore with vaseline. Place Oil seal plate over shaft and align so retainer of oil seal plate straddles sides of floating bearing flange Fig 10-32. Push oil seal/diffuser plate on bearing housing until plate seats on shoulder.

Note: Stops on oil seal plate should be turned so that they seat on bearing flange 90 deg. from disassembled position.

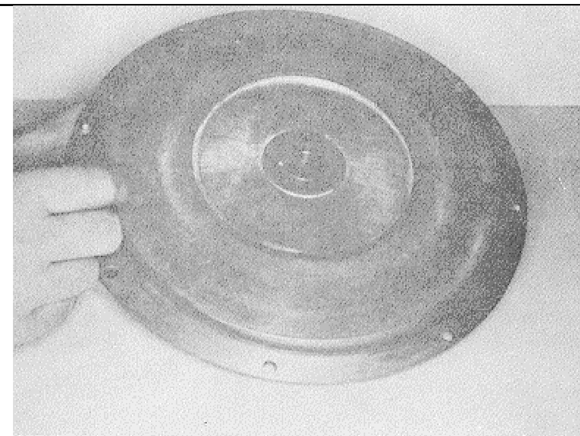


Fig. 10-30, T-538. Installing sealing ring on ST oil seal/diffuser plate

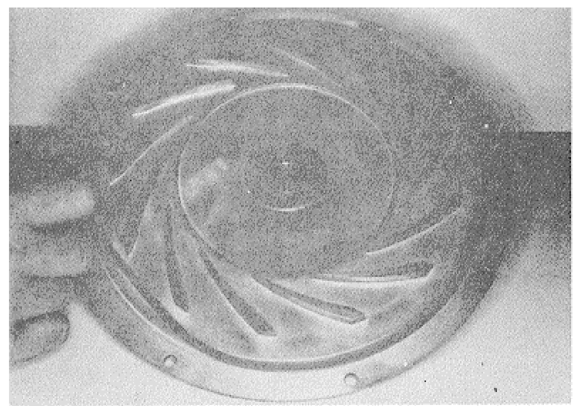


Fig. 10-31, T-539. Installing sealing ring on VT oil seal/diffuser plate

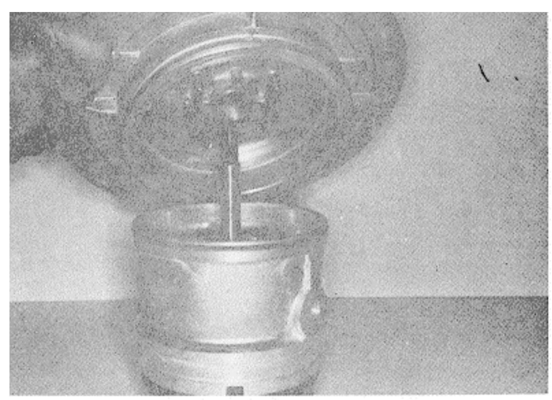


Fig. 10-32, T-436. Installing oil seal/diffuser plate on bearing housing

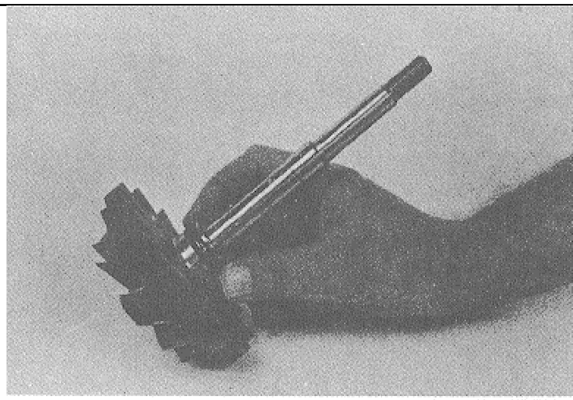


Fig. 10-24, T-433. Installing sealing ring

5. Coat bore of bearing housing with STP oil or equivalent; Insert rotor shaft in housing. Fig. 10-25.

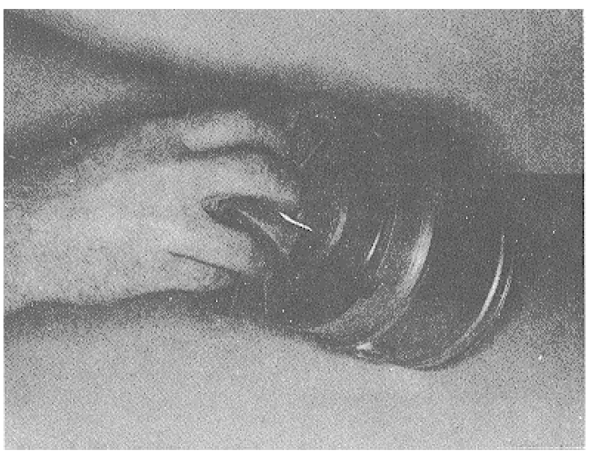


Fig. 10-25, T-532. installing rotor assembly

Note: Care must be taken to start sealing rings in chamfer of bore to properly compress ring during installation.

6. Lubricate rotor shaft and floating bearing with STP oil or equivalent. Insert floating bearing over shaft and into bearing housing bore. Fig. 10-26.

7. Position Teflon bearing insert over flange of floating bearing. Fig. 10-27.

Note: Two floating bearing and oil seal sleeve assemblies are being used for service repair. One assembly consists of a floating bearing, thrust washer and oil seal sleeve and piston ring assembly; the second consists of a floating bearing and

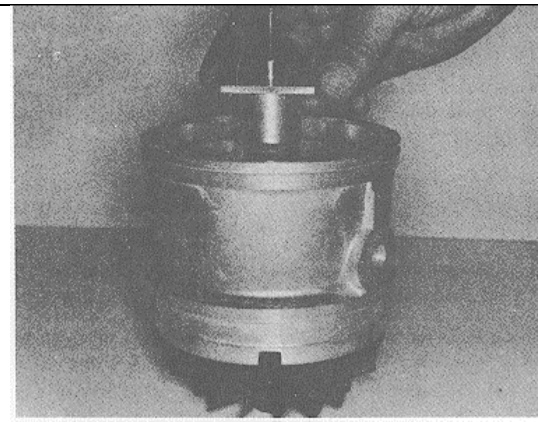


Fig. 10-26, T-434. Installing floating bearing

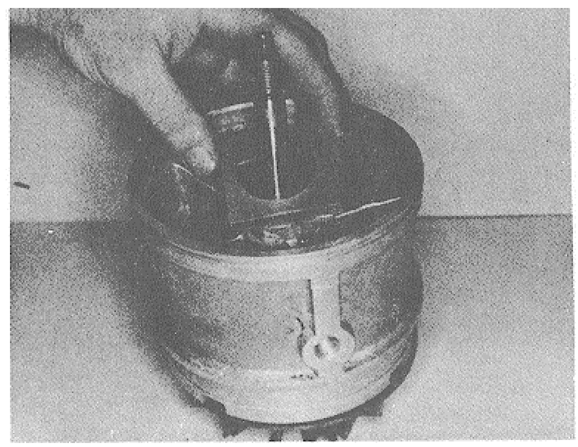


Fig. 10-27, T-435. Installing teflon bearing insert

oil seal sleeve and piston ring assembly. The second assembly may be Identified by the thrust surface area of floating bearing which is same outside diameter as oil seal sleeve assembly and oil seal sleeve is 0.715 to 0.717 inch [18.16 to 18.21 mm] long.

Complete assemblies are interchangeable but parts cannot be intermixed.

Caution: Coat thrust washer with clean lubricating oil; handle only on edges of thrust washer. Thrust washer must be retained in plastic enclosure until time of assembly.

8. Lubricate new red "0" ring lightly with clean engine lubricating oil and install in groove of bearing housing. Fig.10-28.

9. Lubricate bore of oil seals and oil seal/diffuser plate with STP oil or equivalent and insert oil sealing sleeve assembly;

11. Carefully move assembly and rotor support to a press.
12. Lubricate rotor shaft O.D. with STP oil or equivalent, position compressor wheel on shaft. Using a suitable mandrel, place compressor wheel on shaft until wheel seats against sleeve shoulder. A press may be necessary.
13. Install self-locking nut on rotor shaft. Place ST-1095 on torque wrench, hold nut with end wrench and turn shaft with torque wrench to 20 to 24 ft-lb [27 to 33 N•m] maximum torque. Fig. 10-33.

Caution: Over-torquing nut will deform shaft, distort thrust washer (if used) and cause oil leakage.
14. Install collector housing on oil seal/diffuser plate and bearing housing assembly, Fig. 10-34, align index marks, secure with lockwashers and capscrews. Tighten to 5 to 7ft-lb [7 to 10 N•m] torque. Fig. 10-35.

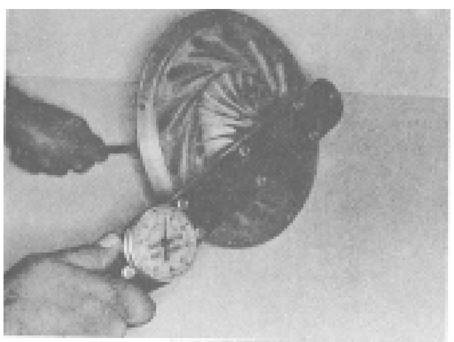


Fig. 10-33, T-437. Torquing self-locking nut on rotor shaft VT assembly

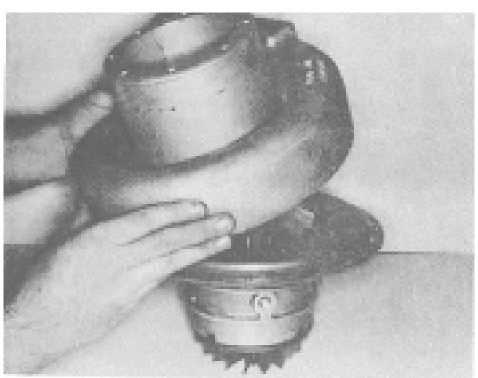


Fig. 10-34, T-542. Installing oil seal/diffuser plate and baring housing assembly in collector housing

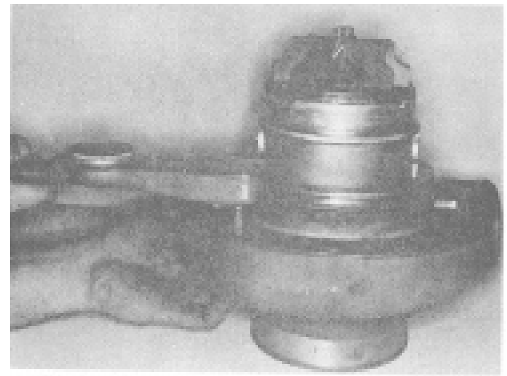


Fig. 10-35, T-543. Torquing oil seal/diffuser glate caoscrews incollector housing

15. Lubricate turbine casing bore with a heat-resistant antiseize compound. Insert bearing housing and rotor assembly in bore of turbine casing, aligning marks scribed during disassembly until assembly seats on shoulder.
16. Position "V" bands around casings, centering openings -of "V" bands over oil supply and drain ports, secure with new bolts, flatwashers and self-locking nuts; torque nuts to values listed in Specifications. Tap lightly to seat "V" band while torquing nuts. Fig. 10-36. Check clearance between turbine casing and V-band clamp. There must be a minimum of 0.035 inch [0.89 mm].
Caution: Do not exceed recommended torque; this causes clamp distortion and clamp loosening. Clamp is not to be retorqued during operation.
17. Check radial clearance at turbine end and compressor end of turbocharger as follows:

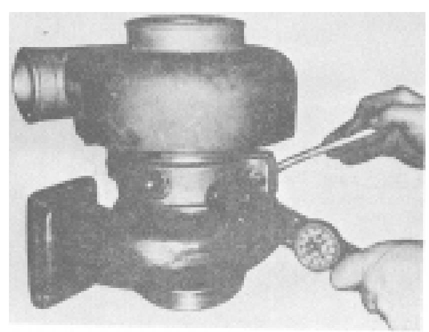


Fig. 10-36, T-421. Torquing "V" clamp bolts and nuts

a. Push shaft toward side of the bore.
b. Using a feeler gauge, check minimum distance between tip of wheel vanes and bore. Clearance should be 0.005 to 0.033 inch [0.13 to 0.84 mm] on compressor end and 0.011 to 0.043 inch [0.28 to 1.1 mm] on the turbine end. Fig. 10-37.

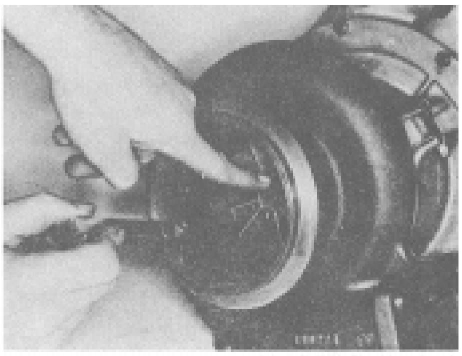


Fig. 10-37, T-5,44. Checking radial clearance on turbine end

18. Check total end clearance with a dial indicator. Fig. 10-38. End clearance should be 0.006 to 0.017 inch [0.15 to 0.43 mm].
19. Turn rotor by hand to make sure no internal interference is present.
20. Cover all oil, air and exhaust inlet and outlets to prevent entry of foreign material during storage.

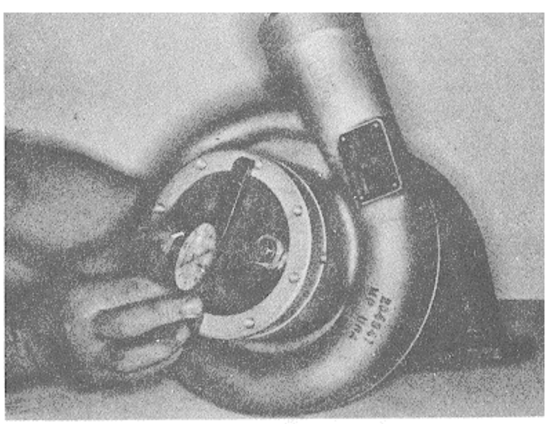


Fig. 10-38, T-545. Checking rotor end clearance

Installation

The ST-50 and VT-50 turbocharger may be mounted in any location without various combinations of turbine and collector housings. Simply change relative positions of turbine casing and collector housing on bearing housing to obtain desired location of exhaust inlet and outlet. Band nuts must be retorqued if loosened.

In all mounting arrangements of the turbochargers.

1. Wrap fittings with Teflon tape (a minimum of 5 threads must be coated with tape) and install in bearing housing; tighten to torque listed in Specifications. Fig. 10-39.

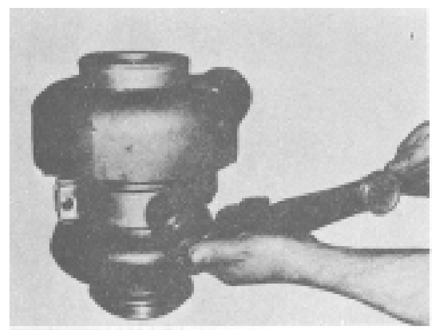


Fig. 10-39, T-425. Torquing oil drain connection

2. Check position of turbocharger oil drain. This drain must always be In a vertical or down position or within 30 deg. of that position when turbocharger is mounted on the engine. Fig. 10-40. Deviation from this position can cause flooding of the bearing housing and turbine seal leakage.
3. Install gasket and position turbocharger against exhaust manifold flange. Secure turbocharger to exhaust manifold flange with capscrews.
4. Install oil drain line from bottom of turbocharger to boss provided on engine block or oil pan. Use SAE Type 100R5 wire braid hose with minimum inside diameter of 7/8 inch [22.2 mm] (SAE No. 16).
5 Pre-lubricate turbocharger by pouring clean engine lubricating oil with STP oil or equivalent mixture through inlet opening.
6. Install oil inlet line. Use Teflon type wire braid hose with minimum inside diameter of 5/16 inch [7.9 mm] (SAE No. 6) and that will withstand up to 450 deg. F [232 deg. C] oil temperatures.

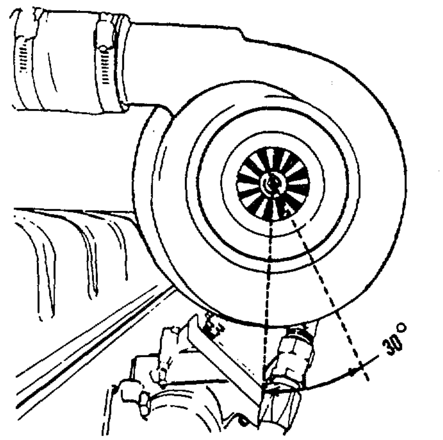


Fig. 10-40, T-333. Turbocharger mounting

7. Install hose connecting air outlet of turbocharger to engine intake manifold connection.
8. Install air cleaner and exhaust piping.
9. Check crankcase breather condition; excessive crankcase pressure will cause turbocharger leakage.

Air And Exhaust Pipe Supports Both the air and exhaust connections to a turbocharger require support within a reasonable length to avoid excessive bending moments on the turbocharger casing. They also require a flexible joint between the turbocharger and the support to compensate for movement, misalignment and thermal expansion. The following are recommendations:

1. Exhaust Piping
a. The maximum bending moment of unsupported piping at the outlet plane should not exceed 10 ft. lbs. [14 N•m .

b. A minimum of 12 inches [305 mm] of flexible connection or two ball joints should be provided within the first 4 ft. [1.2 m] of exhaust piping on turbocharged engines to allow for thermal growth and to avoid overstressing turbocharger components.
c. No more than 4 ft. [1.2 m] of unsupported exhaust tubing or flexible connection should be attached to the turbocharger.
2. Air Piping
a. The maximum bending moment of unsupported piping at the compressor inlet plane should not exceed 5 ft. lbs. [7N•m].

b. A flexible connection (hump hose or molded elbow) should be provided between the turbocharger and support point of the piping to prevent the compressor casing from being rigidly retained.

c. No more than 5 ft. 9 inches [1.8 ml of unsupported air intake tubing should be attached to the turbocharger.

VT-50 Specifications

Part or Location	Min. Inch [mm]	Max. Inch [mm]	Wear Limit Inch [mm]
Bearing Housing Sealing Ring Bore	1.275 [32.391	1.276 [32.41)	1.274 to 1.278 [32.36 to 32.461
Bearing Housing Heat Shield Slots	0.460 [11.681	0.500 [12.701	1.500 [38.10]
Bearing Housing Bore/OIl Seal Bore (Turbine End)	1.275 [32.39]	1.276 [32.41]	1.274 to 1.278 [32.36 to 32.461
Bearing Housing O.D. (Compressor End)	5.3975 [137.10]	5.4005 [137.17]	5.3965 to 5.4025 [137.071 to 137.224]
Bearing Housing O.D. (Turbine End)	5.050 [128.27]	5.052 [128.32]	5.049 to 5.055 [128.25 to 128.40]
Bearing Housing Length (Overall)	4.005 [101.731	4.010 [101.85]	3.990 to 4.012 [101.35 to 101.90]
Bearing Housing Length (Compressor stop to turbine stop)	2.989 [75.921	2.992 [76.00]	2.986 to 2.994 [75.84 to 76.05)
Bearing Length	3.078 [78.18]	3.080 [78.231	3.0765 to 3.081 [78.14 to 78.26]
Bearing Flange Thickness	0 138 [3.51]	0.142 [3.61]	0.136 to 0.143 [3 45 to 3.631
Bearing Flange Width	1 920 [48.77]	1.950 [49.53]	1.850 to 1.960 [46.99 to 49.78]
Bearing I.D	0.75 [19.10]	0.7525 [19.11]	0.7515 to 0.7530 [19.09 to 19.13]
Bearing O.D	1 272 [32.30]	1.273 [32.33]	1.271 to 1 274 [32 28 to 32.36]
Rotor Shaft Journal O.D	0.750 [19.05]	0.7505 [19.06]	0.7495 to 0.7505 [19.04 to 19.06]
Compressor Housing I.D	5 402 [137 21]	5.404 [137.26]	5.400 to 5.406 [137.16 to 137.311
Turbine Casing I.D	5.055 [128.40]	5.057 [128.45]	5.053 to 5.058 [128.35 to 128.47]
Turbine Casing Depth	1.195 [30.351	1.200 [30.481	1.1935 to 1 202 [30.31 to 30.53]
Total End Clearance	0.006 [0.15]	0.017 [0.43]	0.005 to 0.018 [0.13 to 0 46]
Turbine Wheel Radial Clearance	0.011 [0.28]	0.043 [1.09]	0.011 to 0.043 [0.28 to 1.091
Compressor Wheel Radial Clearance	0.005 [0.131	0.033 [0.84]	0.005 to 0.033 [0.13 to 0.841
Oil Seal Bore In Oil Seal/Diffuser Plate	1.000 [25.401	1.002 [25.451	0.0999 to 1.004 [25.37 to 25.50]
Oil Seal Sleeve Ring Groove	0.125 [3.181	0.127 [3.23]	0.131 [3.33]
Oil Seal Ring	0.123 [3.12]	0.124 [3.15]	0.122 [3.101
Shaft Ring Groove	0.126 [3.201	0.128 [3 251	0 132 [3.351

Assembly Torque Specifications

V-Band Clamp Tension	32/36 inch-lb	[3.6 to 4.1 N•m]
Rotor Assembly Lock nut Tension	20/24 ft-lb	[27 to 33 N•m]
Lubricating Oil Drain Fitting	50 ft-lb	[68 N•m]
Oil Inlet Fitting	20 ft-lb	[27 N•m]
Diffuser Plate Capscrew Torque	5-7 ft-lb	[7 to 10 N•m]

Note: Many parts grow due to swedging action or shrink after operation, therefore. the wear limits are established to allow for these stress relaxation changes.

INSTRUMENT GROUP

INDEX

DESCRIPTION

Standard instruments on a vehicle include an ammeter or charge indicator, fuel gauge, oil pressure gauge, temperature gauge and speedometer. Other gauges such as air, vacuum and tachometer may be included on vehicles of various types. However, all these gauges or receivers come under the classification of instruments.

Electrical instrument gauges as well as the panel lights of the cluster are connected to the vehicle electrical system either by individual wires or printed circuit boards, Fig. 1.

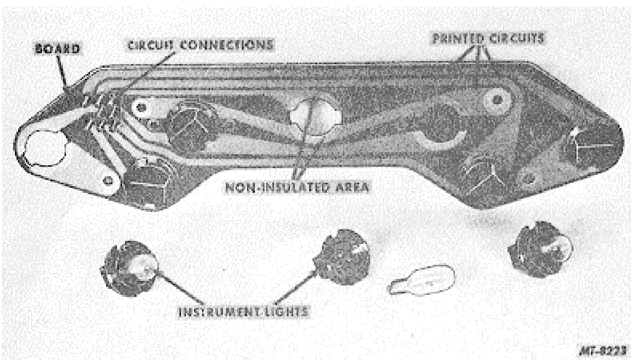


Fig. 1. Electrical Instrument Gauge Printed Circuit Board.

The printed circuit board consists of a composition board on which metallic strips are placed through a photographic process. The board is then covered with an insulating material except where contact with

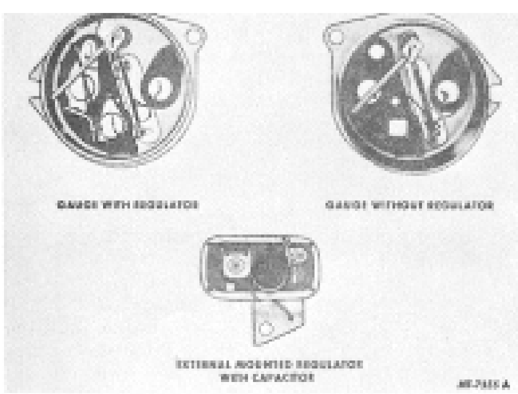


Fig. 2. Internal View of Receivers with and without Voltage Regulator. View of External Mounted Regulator.

In addition, some instruments are vapor pressure or pressure expansion type. The vapor pressure instrument operates from heating ether type liquid in an immersion bulb, causing the gauge to change the location of the pointer. Pressure expansion type gauges operate by direct pressure through a line which connects to the gauge.

Fig. 3 illustrates a typical wiring diagram with an external mounted constant voltage regulator.

SPEEDOMETER

The speedometer unit is only serviced complete and includes the magnet, speedcup, cross gears and face dial.

A speedometer is used on a vehicle to indicate speed in miles per hour as shown by the pointer on face dial and to record distance traveled by means of an odometer. The speedometer is driven through a flexible shaft connected to a set of gears in the vehicle transmission. These gears are designed for the particular vehicle model and take into consideration the tire size and rear axle ratio. The flexible shaft, which connects the transmission driven gear to the speedometer, consists of an outer casing and inner core.

The odometer records up to 99, 999.9 miles and automatically returns to zero.

There are occasions when, due to change in axle ratio or tire sizes, it is necessary to make compensating corrections in the speedometer drive gear. For method of speedometer adapter calculations, see page 2 of this section.

TACHOMETER

A tachometer is installed on a vehicle to record engine RPM speeds and enable the driver to keep engine within efficient operating range.

The magnetic type tachometer is driven by a flexible shaft connected to the vehicle distributor shaft by means of a drive joint or adapter and records the RPM from the distributor shaft on the face dial through a magnetic coupling within the unit.

There are two additional types of tachometers available, namely, centrifugal, with a maximum RPM hand, and electrical.

The centrifugal tachometer works on the weight-type governor principle and is driven from the distributor shaft in the same manner as the magnetic type. The centrifugal type also has a maximum RPM hand on the tachometer head to record maximum speed of engine.

For diesel engines, the electric tachometer is a two-unit combination consisting of a tachometer head and a sender. The head is mounted on the instrument panel and the sender unit is mounted on the engine using the tachometer drive take off.

SPEEDOMETER AND TACHOMETER CABLES

Two different types of speedometer and tachometer drive cables have been used on IH vehicles. They are the flexible shaft (wrapped type cable) and the semi-rigid types (covering of polypropylene or polyethylene on cable).

The flexible shaft cable consists of two major assemblies: a flexible outer casing with nuts and ferrules at both ends and a wire-wound flexible inner coil assembly with squared ends or crimped on tip.

The semirigid type cable assembly consists of an inner liner of nylon, then a wire braid followed by an outer covering of polypropylene or polyethylene(plastic). It is fabricated so that the three separate processes, Fig. 17, become a single unit. The core is a wire-wound flexible inner coil assembly.

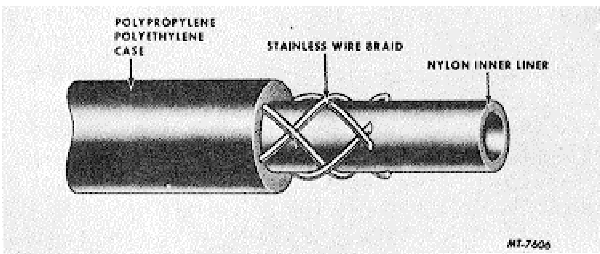


Fig. 17. Semi-Rigid Speedometer Cable.

In addition, some of the semirigid type cables use a "floating tip" at the lower end. This floating tip is detachable from the cable assembly and when attached allows the core to float, thereby minimizing the thrust on the head of the speedometer, Fig. 18.

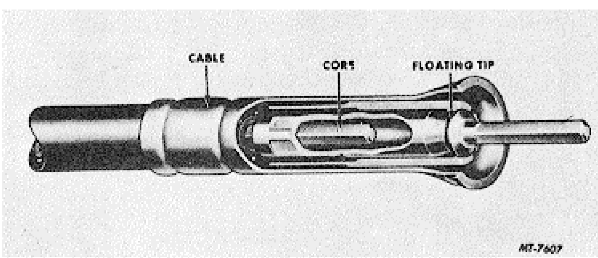


Fig. 18. Semi-Rigid Cable Floating Tip.

Three popular sizes of speedometer cable cores are available through regular service parts channels in bulk form. The three sizes of cores are . 130", .150" and .187". In addition to the three sizes of cores, various tips are also available which can be used in making different core assemblies.

The following procedure has been prepared to assist in making a new core assembly.

Fabricating Flexible Cable Cores

1. Determine correct part number of core from the Motor Truck Parts Catalog.
2. Locate this part number in the numerical list in the Parts Merchandising Catalog (MT-86), group 10.
3. Select proper core size and cut to correct overall length, using the swaging cutting fixture.
4. Select correct tips and position tips on core.
5. Check overall length to be sure the core was cut to the correct length.

   NOTE: It is very important that the core is not too long, since a long core wile produce a thrust on the head of the speedometer when installed on the vehicle.
6. Swage ends in place on core.
7. Lubricate core; refer to "**LUBRICATION** Flexible Shafts".
8. Install bushing at upper end of core if required.

REPAIRING SPEEDOMETER AND TACHOMETER FLEXIBLE AND SEMI-RIGID SHAFTS

Disconnect both ends of the shaft and remove from the vehicle. Pull the core out of the casing and check for kinks by rolling on a flat surface. If a flat surface is not available, take an end in each hand and roll core between fingers. In either case, a core kink will show up as a "hop" at the kinked point, Never reuse a kinked core, because it will cause fluctuation of the speedometer or tachometer pointer. Also, check for frayed spots by running it loosely through your fingers. Do not use a frayed core. A kinked or frayed core usually indicates a casing with very sharp bend.

NOTE: Under no circumstances should a casing have less than a six-inch radius bend.

LUBRICATION - Flexible Shafts

Flexible Cable: Every 15, 000 to 25, 000 miles apply a thin coat of graphite impregnated non-hardening grease on the core only. Lubricate only 3/4 of the way up the core (starting at the lower end) and leaving the top 1/4 free of grease to eliminate any possibility of grease getting into the instrument head. Hold the casing with one hand and feed the core with lubricant into casing.

Semi-Rigid Cable: Apply a thin coat of "Lubriplate 110" or equivalent at reassembly or overhaul. Clean core. With about a teaspoon of lubricant in one hand, feed the core (lower end first) through the lubricant back into the casing, leaving only a thin coating on the core. When lubricating the core, leave four inches free of lubricant to prevent lubricant entering the instrument head.

Speedometer and Tachometer Heads

Some speedometer and tachometer heads include provision for lubrication. Examine the tachometer head, and where lubricant openings are provided in the rear of the head at the cable take-off, lubricate as follows.

Inject 1 to 2 drops of "3 in 1" oil every 15, 000 to 20, 000 miles of operation. Under severe service or extremely hot climate lubricate more often.

AC MANUFACTURED INSTRUMENT GAUGES

The water temperature, oil pressure and air pressure gauges are mechanical with Bourdon tube type construction. The electrical gauges are the fuel level and battery-generating system indicator (voltmeter) utilizing the air core type construction. All gauges have direct lighting.

Gauge Operation and Servicing

Water Temperature Gauge:

The mechanical temperature gauge operates on a Bourdon tube motion which is transmitted to a pointer through a sector and pinion gear linkage. The temperature gauge, unlike the mechanical air and oil pressure gauges, is a hermetically sealed unit consisting of a gauge, a capillary tube and a temperature bulb which is filled with ether, Fig. 19.

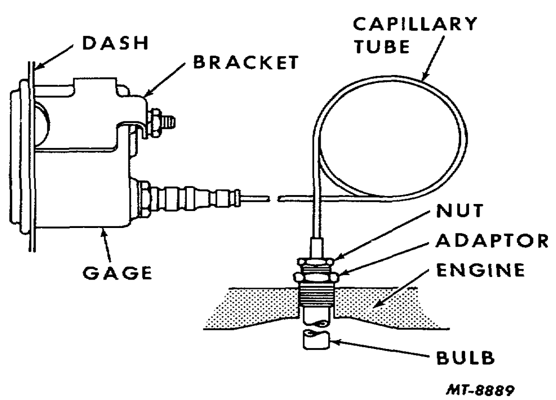


Fig. 19. Water Temperature Gauge

When the bulb temperature increases as a result of engine operation, the contained ether vaporizes, exerting a vapor pressure on the inlet of the Bourdon tube, Fig. 20. The pressure causes the tube to straighten out. The indicator point, which is attached to the Bourdon tube by the gear linkage, then rotates across the dial in an upscale direction.

The gauge achieves a temperature scale, reading corresponding to the engine operating temperature. When the engine is shut off, the ether vapor condenses and settles in the bulb as the engine cools.

General gauge operation can be checked by removing the sending bulb from the engine block. Submerge the bulb in cold water; the gauge should descend downscale. Submerge the bulb in boiling water; the gauge should ascend upscale. Because of the construction of the gauge, if either of these tests proves unsatisfactory, replace the temperature gauge assembly.

Oil Pressure Gauge:

During engine operation oil is pumped throughout the lubricating channels of the engine block. The level of pressure in the system depends upon the temperature, oil supply and the condition of the system itself.

The oil pressure gauge measures the system's oil pressure. The gauge operates with a Bourdon tube motion transmitted through a pointer by way of a sector and pinion gear linkage, Fig. 20.

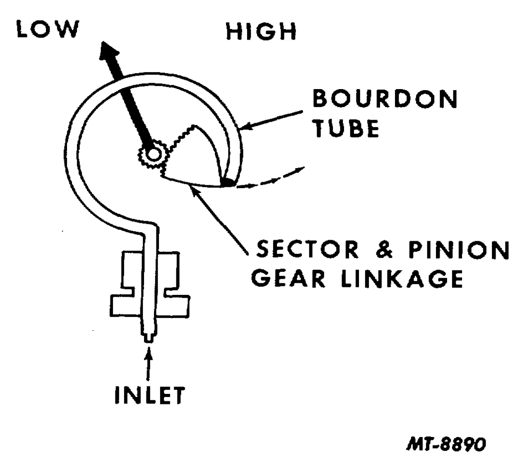


Fig. 20. Oil Pressure Gauge

During engine operation oil enters the connecting tube and exerts a pressure on the inlet of the Bourdon tube. As the oil pressure increases, the Bourdon tube mechanism within the oil gauge tends to straighten. The indicator pointer, which is attached to the Bourdon tube by the linkage, then rotates across the face of the dial in the upscale direction. When the oil pressure decreases, the Bourdon tube relaxes and the pointer rotates in the downscale direction. A steadily applied oil pressure holds the Bourdon tube and the pointer at a fixed scale reading corresponding to the applied pressure.

1. If the gauge is reading high:

   a. Disconnect the gauge from the system.

   b. If pointer does not return to the lowest scale reading (for instance, the pointer stays at 40 psi), the Bourdon tube has been damaged. Service by replacing with new gauge,

2. If the gauge is reading low:

   a. Examine the connecting tube for dirt restricting the oil from entering the Bourdon tube.

   b. If connections and tubing are secure and free from dirt, the gauge is damaged. Service by replacing with new gauge. **NOTE:** Be certain that engine oil pump is delivering correct pressure before discarding gauge.

Air Pressure Gauge:

The mechanical air pressure gauge operates on the Bourdon tube principle as does the mechanical oil pressure gauge. The air pressure gauge, as is implied, uses air as a pressure source rather than oil. For a description of the operation, refer to the mechanical oil pressure gauge.

For servicing procedure, refer to the mechanical oil pressure gauge.

Battery- Generating System Indicator Gauge:

The battery-generating system indicator gauge indicates the condition of the battery, alternator and the voltage regulator.

The gauge is divided into two sections, one marked "BATT" (battery), the other marked "GEN" (generating system).

Before starting the engine with key switch off, the gauge will show the condition of the battery. The battery section of the gauge is subdivided into three colored segments:

GREEN - a well-charged battery
YELLOW - a low battery charge
RED - a very low battery charge

With the engine running at operating speeds the gauge will show the condition of the generating system. The generating section of the gauge is divided into two colored segments:

GREEN - generating system working properly
RED - voltage output too high

Constant reading in either RED area indicates that a complete check of the battery and generating system should be made.

Terminal identification is as follows, Fig. 21:

1. The ground terminal is tin plated.

2. The ignition terminal is the first terminal counterclockwise from the ground terminal (looking at back of gauge).

3. The ignition terminal and the tie-in terminal are copper colored and are joined by a calibrating resistor.

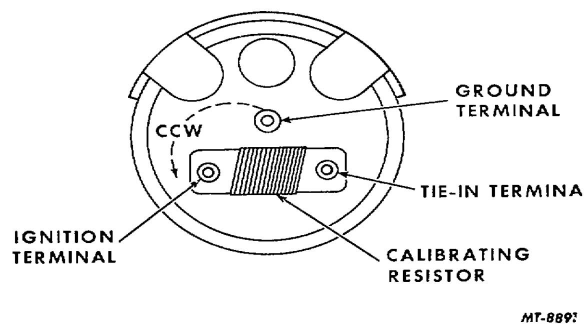


Fig. 21. Battery-Generating System Indicator Gauge

Connect a known voltage source (battery) to the voltmeter terminals.

The voltmeter should indicate the voltage supplied by the source (battery) ± .5 volt.

If this test proves UNSATISFACTORY, service the voltmeter by replacement.

If test is SATISFACTORY, the problem is in the wiring; CHECK CAREFULLY.

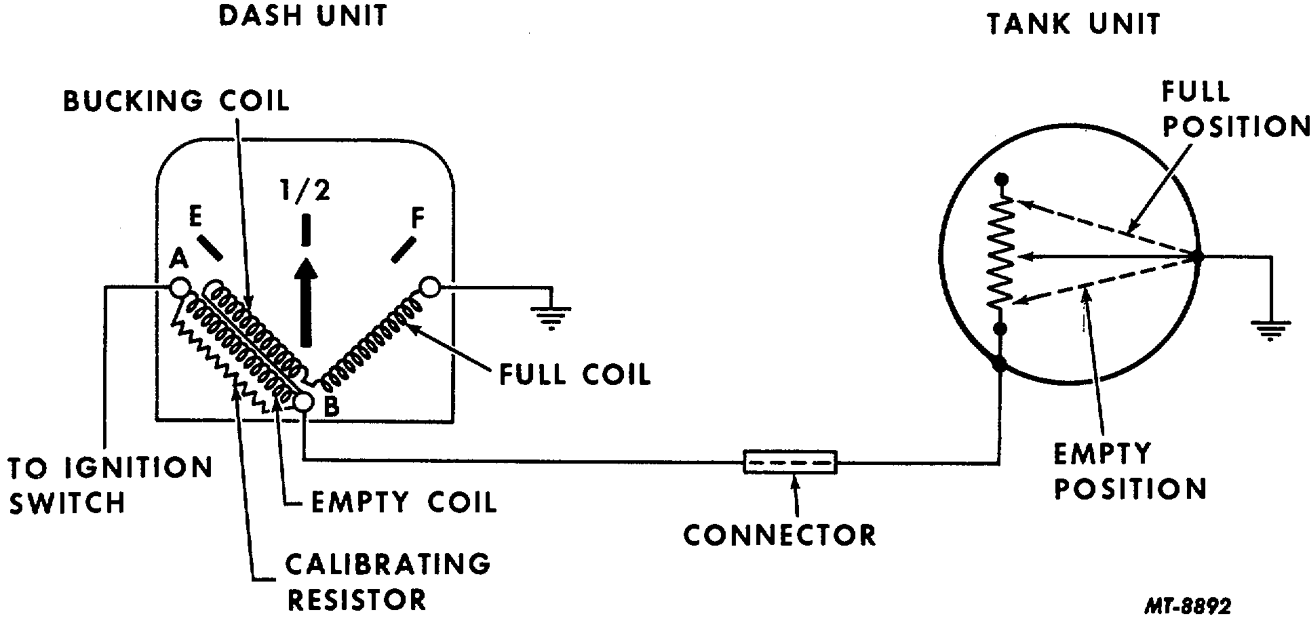


Fig. 22. Fuel Gauge Circuit

Fuel Level Gauge:

The electric fuel gauge system consists of two basic components the dash gauge and the gas tank sending unit. The dash gauge indicates the quantity of fuel in the gas tank, while the tank unit controls the gauge. The two units are connected electrically as shown in Fig. 22.

The fuel gauge is of the air core type. The air core gauge consists of three (3) copper wire coils that are wound around a plastic bobbin containing a magnet and spindle assembly. Attached to the magnet and spindle assembly is a pointer which indicates the fuel level. The fuel gauge requires a 0 to 90 ohm resistance sender to operate. The sender is the tank unit. The tank unit consists of a float and arm assembly and a variable resistor. The sender’s resistance is controlled by the position of the float and arm assembly. A full fuel tank raises the float to its highest position. At this position the variable resistor has a resistance of 88 to 92 ohms. With an empty fuel tank the float assumes its lowest position, creating a sender resistance of less than 1 ohm.

Electrical current, supplied by the battery, travels through the ignition switch and enters the fuel gauge at point A, Fig. 22. At point A the current divides between the "calibrating resistor’[and the "empty coil" as it flows to point B. From point B two possible paths exist to complete the circuit to ground. The current flows through the series connection of the "Bucking Coil" and the "Full Coil" to ground or it can travel through the tank unit. Since current will travel through the path of least resistance, the flow is determined by the resistance of the sender.

When the fuel tank is empty, the tank unit has a resistance of 0 ohms. Since this resistance is smaller than the combined resistance of the bucking and full coils, the current flows through the tank unit. The current flow through the empty coil creates a magnetic field around the coil. This field attracts the magnet which is on the same spindle as the indicating pointer and rotates the pointer toward the empty scale reading. When the fuel tank is full, the tank unit has a resistance of 90 ohms. As the current reaches point B, it seeks a path through the series connection of the bucking coil and the full coil to ground, since their combined resistance is less than that of the tank unit. All of the three coils now have a magnetic field induced by the current flow; however, the empty coil and the bucking coil are wound in opposite directions. This causes their respective magnetic fields to cancel each other. The remaining effective field around the full coil attracts the magnet, thus rotating the pointer to the full scale reading.

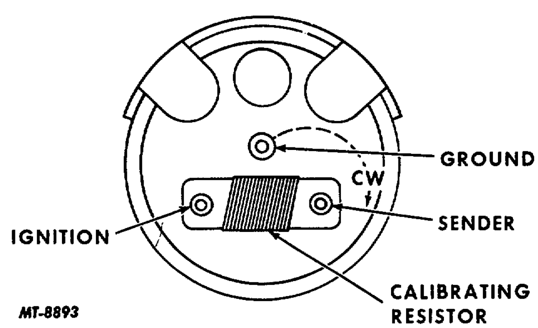


Fig. 23. Fuel Level Gauge

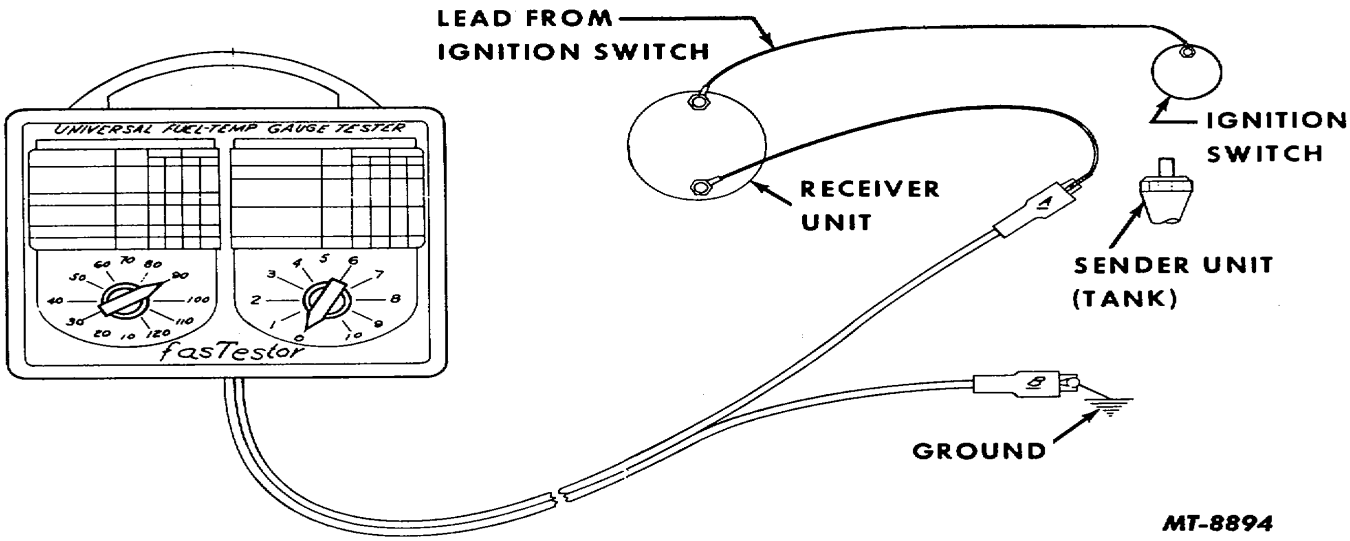


Fig. 24. Checking Fuel Level Gauge System Components

As the tank unit resistance varies between the extremes of 0 and 90 ohms due to changes in the fuel level, current flow divides proportionately between the two possible paths from point B to ground. The resultant magnetic fields around the coils control the position of the magnet and pointer through the range of scale readings from empty to full.

The sender and ignition terminals are connected by a calibrating resistor, Fig. 23. The odd terminal is the ground terminal.

The sender terminal is the first terminal clockwise from the ground terminal when viewed from the back side of gauge. **NOTE:** The ground terminal provides a ground between the gauge and its housing or cover. The housing is grounded to the chassis through the mounting studs. When the key switch is turned off, the pointer will not necessarily return to the empty position. This is inherent in the instrument and does not indicate a faulty part.

To determine faulty component, proceed as follows:

1. Disconnect wire at tank sender unit, Fig. 24.

2. Connect SE-2081 Fastestor lead "A" to end of sender unit wire and Fastestor lead "B" to ground.

3. Turn ignition switch to "on."

4. Set Fastestor left-hand control knob to "90" and right-hand control knob to "0. " Fuel gauge should read slightly above "full. " If tests are satisfactory, indication is that receiver unit and wiring from tank unit to receiver is functioning properly and that tank unit is faulty or is insufficiently grounded to tank.

5. Disconnect Fastestor and reconnect wire at tank unit.

6. If receiver unit does not respond properly to above tests, disconnect tank sender unit to receiver wire from receiver unit terminal, Fig. 25.

7. Connect Fastestor lead "A" to receiver unit at sender terminal and lead "B" to ground.

8. Turn ignition switch to "on."

9. Set Fastestor left-hand control knob to "90" and right-hand control knob to "0. " Gauge should read slightly below "empty. " Turn ignition switch "off." **NOTE:** A standard test light may be used to check wire continuity. Replace any units or wiring found defective.

Oil Temperature Gauge:

The electrical oil temperature gauge consists of two basic components--the dash gauge and a thermister sending unit. The gauge indicates the oil temperature, while the sender controls the gauge reading. The two units are connected electrically as shown in Fig. 8.

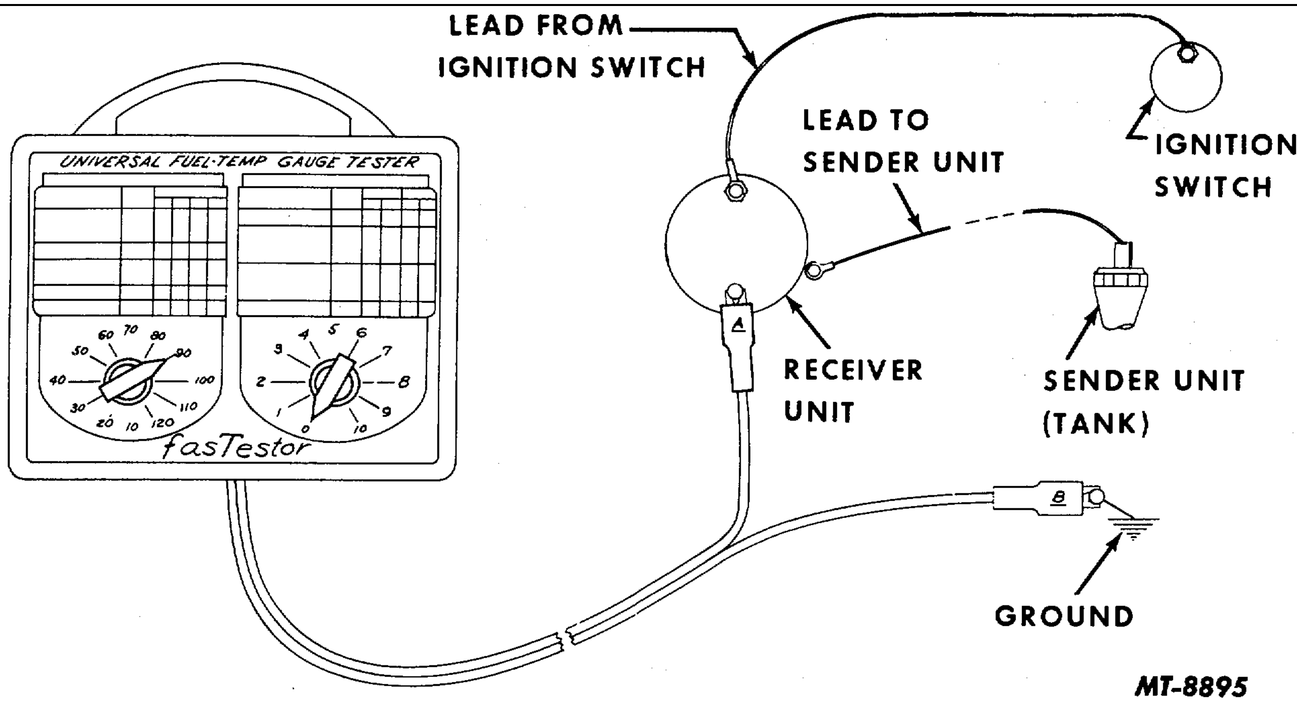


Fig. 25. Checking Fuel Level Gauge System Components

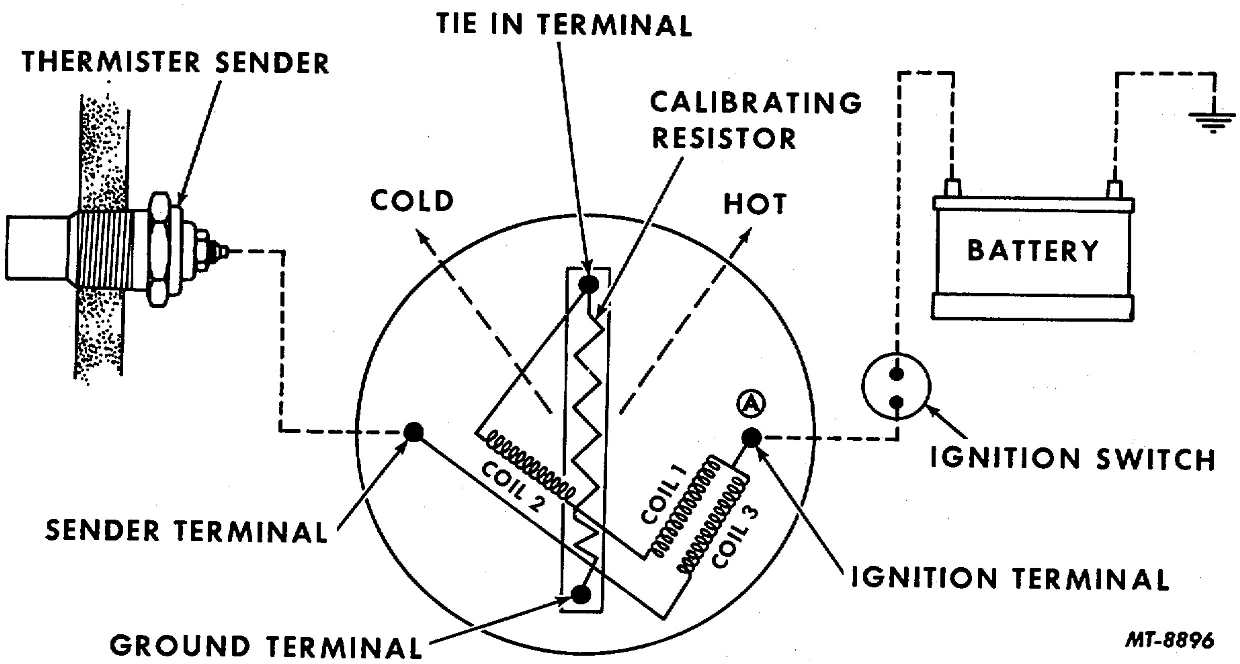


Fig. 26. Oil Temperature Gauge

The oil temperature Gauge is of the air core type. The air core gauge consists of three (3) copper wire coils that are wound around a plastic bobbin containing a magnet. Attached to the magnet is a spindle and pointer assembly which indicates the oil temperature. The thermister is merely a variable resistor. Its resistance depends upon the temperature to which it is exposed. When it is cold

Electrical current supplied by the battery travels through the ignition switch and enters the gauge at point A (see Fig. 26). From point A two possible paths exist to complete the circuit to ground. The current can flow through the series connection of Coil 1, Coil 2, and the calibrating resistor to ground; or it can travel through Coil 3 to the sender. Since current will travel through the path of least resistance, the flow path is determined by the resistance of the sender as follows.

When the oil is cold, the sender's resistance is high. The current will, therefore, flow through Coil 1, Coil 2 and the calibrating resistor to ground, which offers less resistance than the sender path. A small amount of the current, however, follows the path through Coil 3 and the sender. (When current flows through a coil, a magnetic field is developed around the coil.) Since Coils 1 and 3 are oppositely-wound, their resulting magnetic fields oppose each other. The remaining field around Coil 2 has an attraction for the magnet. Since the magnet is on the same spindle as the indicating pointer, the spindle rotates toward the colder scale reading corresponding to the oil temperature.

When the oil is hot, the sender's resistance is low. Thus, the majority of the current will flow through Coil 3 and the sender. The remaining current will travel the alternate path and create weak magnetic fields around Coils 1 and 2. The magnetic field around Coil 3 dominates the attraction for the magnet. This field rotates the pointer to the higher temperature scale reading corresponding to the oil temperature.

Various combinations of current flow divided between the two alternate paths result from changes in the sender's resistance. The magnetic fields around the coils in each respective case position the pointer at the appropriate scale reading.

The calibrating resistor connects the ground terminal with the tie-in terminal, Fig. 27.

The ground terminal is tin coated for identification. This terminal grounds the gauge to the housing or cover. The housing is grounded to the chassis through the mounting studs.

The sender terminal is the first terminal clockwise from the ground terminal (when viewed from the back side). The ignition terminal is directly opposite from the sender terminal.

To determine faulty component parts, proceed as follows:

1. Disconnect sender wire at sender unit (point A), Fig. 27.
2. Connect one lead of Fastestor to sender wire and the other lead to a good ground.
3. Set Fastestor left-hand knob at "120" and right-hand knob at "0. " Turn ignition switch "on. " Gauge should read approximately 170°F.
4. Turn Fastestor left-hand knob to "30" and right-hand knob to "3." Gauge should read approximately 300°F. Turn ignition switch "off." Reconnect sender wire to sender unit (point A).

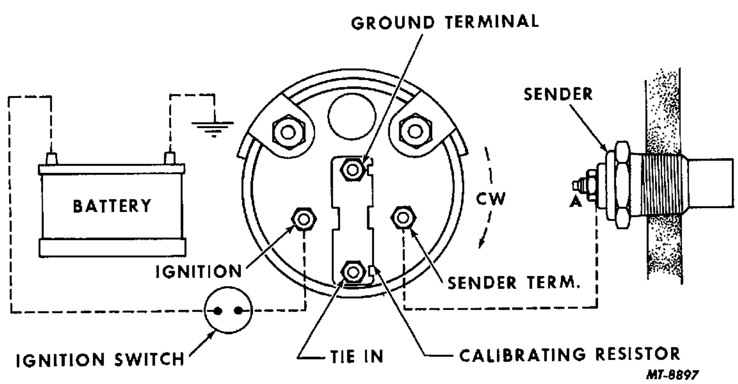


Fig. 27. Oil Temperature Gauge Circuit

If results are satisfactory, problem lies in sender unit. If results are unsatisfactory, problem is with wiring or gauge.

5. Disconnect sender wire at sender terminal on gauge, Fig. 27.

6. Connect one lead of Fastestor to gauge sender terminal and the other lead to a good ground. Repeat steps 3 and 4. If results are satisfactory, problem lies in wire to sender unit.

NOTE: A standard test light may be used to check wire continuity.

7. Replace components where necessary.

NOTE: When the key switch is turned off, the pointer will not necessarily return to the lowest value. This is inherent in the instrument and does not indicate a faulty part.

LUBRICATION

FOR LUBRICATION INTERVALS REFER TO OPERATORS MANUAL

New vehicles are properly lubricated at the factory and before they are delivered. After the vehicle is placed in operation, regular lubrication intervals, based on the type of service and road conditions, should be established. Thorough lubrication at definite intervals will add greatly to the service life of the vehicle and will reduce the overall operating expense.

The interval between lubrication periods, oil changes, etc., depends entirely upon operating conditions. The loads carried, speed, road and weather conditions all contribute to the frequency of lubrication periods. In some types of operation, and where operating conditions are extremely severe, the vehicle may require lubrication after every twenty-four (24) hours of operation.

In some operations, such as in deep water, mud, or unusually dusty conditions, the interval of inspection and lubrication should be more frequent.

Only lubricants of the best quality, having proper body or viscosity, and supplied by reputable manufacturers, should be used. The use of inferior or non-compatible products might reduce the service life of the vehicle or result in failure of its components.

The International Harvester Company Truck Division does not attempt to specify any particular manufacturer's product. Highgrade lubricants can be obtained from any reputable oil company.

The lubrication specifications refer only to the viscosity (SAE) agd type to be applied. The viscosity numbers have been adopted by the Society of Automotive Engineers to classify lubricants according to "body" or "thickness" and do not cover any other properties.

IMPORTANT: When adding lubricant, it should be the same weight and viscosity which is already being used.

For recommended lubrication intervals, refer to Truck Operator's Manual.

DESCRIPTION	LUBRICANT
	Differential: SP type lubricant, SAE-90 viscosity year around, meeting MIL-L-2105B specification. *(SP must not contain zinc.)* For abnormally high temperature, severe service (hot climate, off highway operation where vehicle is in low speed, heavy hauling for prolonged periods), use SAE-140. ***NOTE:*** *Trac-Lok axles, add/20 cm3 (2/3 ounce) of IH-LS additive for each .47 liter (pint) of SP lubricant used.*
Drive Joints:) King Pin Bushings:)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

AXLE - REAR

DESCRIPTION		LUBRICANT
Power Divider:	)	
Rear Axle:	)	SP type lubricant, SAE-90 viscosity year around, meeting MIL-L-2105B specifications. (SP must not contain zinc.) For abnormally high temperature, severe service (hot climate, off highway operation where vehicle is in low speed, heavy hauling for prolonged periods), use SAE-140. ***NOTE:*** *Traction equalizer axles, add 20 cc (2/3 ounce- of IH-LS additive for each .47 liter (pint) of SP lubricant*.

BODY - CAB

DESCRIPTION		LUBRICANT
Cab Latch:		Light engine oil.
Cab Lock Levers:		IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Cab Tilt Pump:		Low temperature hydraulic fluid MIL-H-5606B.
Door Check:		IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Door Hinges:		Light engine oil.
Door Latch:	)	
Door Latch Striker Plate:	)	Stick lubricant.
Door Lock Cylinders:		Lock oil.
Hood Latch:	)	
Hood Linkage:	)	
Hood Pivot Bar Bracket:;	)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Seat Adjuster Slides:	)	
Window Regulator:	)	

BRAKES

DESCRIPTION		LUBRICANT
Brake Camshafts:	)	
Brake Shoe Anchor Pins:	)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Brake Shoe Cams:	)	

BRAKES (Continued)

DESCRIPTION	LUBRICANT
Parking Brake Cylinder:	Light engine oil.
Parking Brake Linkage:	IH 251H EP grease or equivalent NLGI #2 multi- purpose grease.
Pedal-to-Brake Valve Linkage:	Light engine oil.
Slack Adjusters:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

COOLING

DESCRIPTION	LUBRICANT
Radiator Shutter and Linkage: (Kysor)	Vehicles equipped with automatic modulated control radiator shutters (thermostat element mounted in bottom tank of radiator). Do not oil pins and sliding surfaces at frequent intervals. ane bearings should be cleaned with light or penetrating oil and blown out with air only when servicing complete shutter assembly.
Cadillac:	Do not oil Cadillac shutters.

ELECTRICAL

DESCRIPTION	LUBRICANT
Alternator:	Ball bearing lubricant.

ELECTRICAL (Continued)

DESCRIPTION	LUBRICANT
Starting Motor:	Light engine oil.

ENGINE

DESCRIPTION	LUBRICANT
Accelerator Linkage:	Light engine oil.

ENGINE (Continued)

DESCRIPTION LUBRICANT

Crankcase

Cummins:

Oil Recommendations

Light Service Only (Stop-and-Go) All Diesel Models	**Naturally Aspirated Diesel Models**	**Turbocharged Diesel Models**	**All Natural Gas Models All Service**
API Class CC/SC [2/5] 1.85% Maximum Sulfated Ash Content [3]	API Class CC [1] 1.85% Maximum Sulfated Ash Content [3]	API Class CC/CD [2] 1.85% Maximum Sulfated Ash Content [3]	API Class CC .03 to .85% Sulfated Ash Content [4]

1 API classification CC and CD quality oils as used in turbocharged engines and API classification CC/SC quality oils as used for stop-and-go service are satisfactory for use in naturally aspirated engines.

2 API classification CC/SC and CC/CD indicate that the oil must be blended to the quality level required by both specifications. The range of oil quality permitted by the CC classification is so broad that some oils that meet the classification will not provide adequate protection (varnish and ring sticking) for engines operated in certain applications. For example, turbocharged engines require the additional protection provided by the CD classification. Engines operated in stop and go service require the additional protection provided by the SC classification.

3 A sulfated ash limit has been placed on all lubricating oils for Cummins engines because past experience has shown that high ash oils may produce harmful deposits on valves that can progress to guttering and valve burning.

4 Completely ashless oils or high ash content oils, are not recommended for use in gas engines a range of ash content is specified.

5 SD or SE may be substituted for SC.

ENGINE (Continued)

DESCRIPTION	LUBRICANT

Crankcase (Continued)
Cummins

Operating Temperatures Vs. Viscosity

Ambient Temperatures	Viscosity
-23° C (-10° F) and Below	See Table A
-23 to -1° C (-10 to 30° F)	10W
-7 to 16°C (20 to 60° F)	20-20W
4° C (40° F) and Above	30

Table A - Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API Class CC/SC or API Class CC/CD
Viscosity	10,000 Centistokes Maximum @ -34° C (-300 F) 5.75 Centistokes Minimum @ 99° C (2100 F)
Pour Point (ASTM D-97)	At least -12° C (10° F) below lowest expected ambient temperature.
Ash, Sulfated (ASTM D-874)	1.85% by Weight Maximum

IMPORTANT: Due to extreme operating conditions, oil change intervals should be carefully evaluated paying particular attention to viscosity changes and total base number decrease. Oil designed to meet MIL-L-10295-A, which is now void, and SAE 5W mineral oils should not be used.

INSTRUMENTS

DESCRIPTION	LUBRICANT
Speedometer Cable:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Speedometer Head:	Three-in-one (3 in 1) oil or equivalent.
Tachometer Cable:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Tachometer Head:	Three-in-one (3 in 1) oil or equivalent.

POWER TAKE OFF

DESCRIPTION	LUBRICANT
Shift Control:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

PROPELLER SHAFT

DESCRIPTION	LUBRICANT
Center Bearing:) Slip Joint:) Universal Joints:)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

SPRINGS

DESCRIPTION	LUBRICANT
Auxiliary Springs:) Spring Pins:) Spring Shackles:)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

SUSPENSION

DESCRIPTION	LUBRICANT
Spring Seat Connecting Tube Bearing:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

STEERING

DESCRIPTION	LUBRICANT
Drag Link Ball Joints:) Drag Link Ends:)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Power Steering Pump Reservoir: (Sheppard Gears)	SAE 10W-30 engine oil.

STEERING (Continued)

DESCRIPTION	LUBRICANT
Steering Column--	
Flexible Coupling:)	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Mounting Bracket:)	
Slip Joint:)	
Universal Joint:)	
Steering Gear Relay Lever Pillar Block Bearing:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Tie Rod Ends:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.

TRANSMISSION

DESCRIPTION	LUBRICANT
Transmission (AUTOMATIC):)	Dexron Automatic Transmission Fluid.

TRANSMISSION (Continued)

DESCRIPTION		LUBRICANT	
Transmission Manufacturer	Type Lubricant	Grade	Temperature
*Spicer (Dana)	Engine Oil (SE, CC, CD)	SAE-30 SAE-50, 40,30	Below -180 C (0° F) Above -180 C (0° F)

* The use of oils other than those listed must be approved through Spicer (Dana).

WHEEL BEARINGS

DESCRIPTION	LUBRICANT
Grease:	IH 251H EP grease or equivalent NLGI #2 multipurpose grease.
Oil:	SAE-30 heavy duty engine oil or rear axle gear lubricant.

PROPELLER SHAFT

GENERAL SERVICE INSTRUCTIONS

INDEX

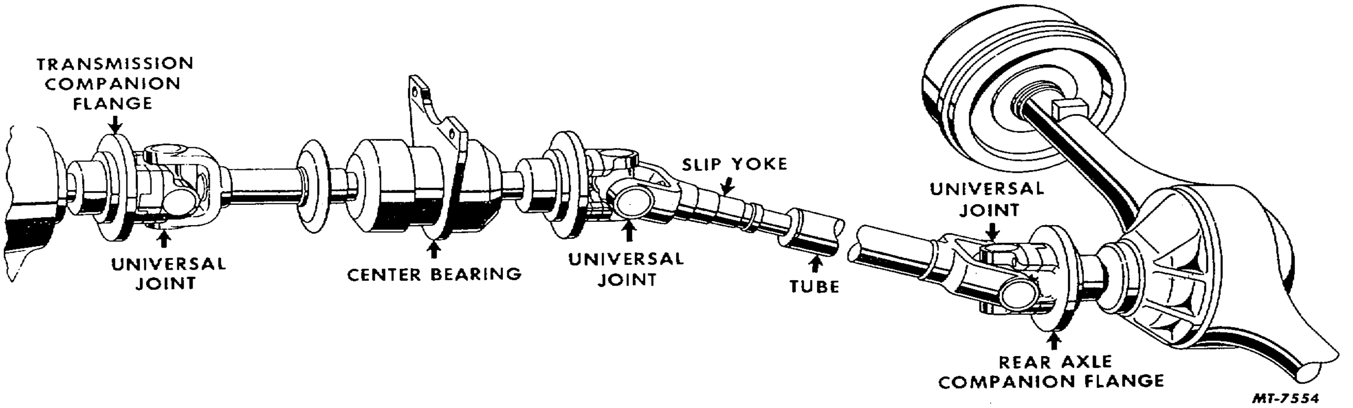


Fig. 1 Typical Propeller Shaft Installation

GENERAL

One of the major problems encountered in the early production of motor vehicles was the transmission of power from the engine through a gear box to the driving wheels.

It was soon learned that because of the various angles involved in mounting the engine, gear box and driving wheels, it would be necessary to develop a means of transmitting a smooth flow of power regardless of the angles encountered through spring deflection and frame flexing during vehicle operation.

The chain drive was used to solve these problems; however, it brought about problems of other natures- such as short service life caused by the inability to keep an exposed chain clean and adequately lubricated.

The search for an improved method of power transmission continued and eventually brought about the use of the propeller or drive shaft with universal joints. With the propeller shaft all bearing surfaces are protected by dustproof housings and seals and can be properly lubricated, thus greatly extending the service life of its components. This eliminated the problems involved with the use of the chain drive.

The propeller shaft as we know it today is constructed of tubing rolled from flat steel and butt or seam welded. This insures a more uniform wall thickness, providing better balance than can be obtained from drawn tubing.

Propeller shafts of today's vehicles occasionally rotate at very high speeds and are sometimes quite long. These two factors have a tendency to induce shaft whirling, that is, flexing of the shaft from a true center line. To minimize this tendency, tubing wall thickness, di ameter, length and operating speed are all carefully considered during the development of propeller shafts. All propeller shaft assemblies have a critical speed because of the aforementioned factors; therefore, it can be readily accepted that propeller shafts are designed for specific applications. Disregard for correct application could result in propeller shaft failure with extremely violent and hazardous consequences. Shaft replacement must always be of the same design and material specification as the original equipment shaft to assure satisfactory service.

DRIVE LINE COMPONENTS

There are several important units which make up the propeller shaft or drive line, as it is often times referred to, Fig. 1. The shafts themselves are of tubular construction and have splined slip yokes which provide for shaft elongation. Universal joints, though they may vary as to manufacture, are of the same general design, and all have steel roller bearings. Companion flanges are of both the yoke type and disc type. The center bearing, provided on some models, is also a part of the drive line and helps to support the propeller shaft, providing a smooth delivery of power to the driving wheels. When all of the above units have been properly installed, satisfactory operation is assured. When something happens which may adversely affect any of them, drive line vibration may result. Vehicle speeds above those recommended may also cause vibration.

Companion Flanges: The companion flange mounting nuts and the bolts that attach the propeller shaft to the flange must be tight to assure drive line balance. The least degree of looseness in the flange mounting nuts or the shaft attaching bolts is enough to cause excessive (out-of-balance) vibration at high propeller shaft speeds. Where the flange also maintains the adjustment on the rear axle pinion bearings or propeller shaft center bearings, this adjustment is destroyed because of lack of torque on the nut. When a companion flange is removed from a transmission, center bearing or rear axle, the flange and shaft should be marked so that the flange can be reinstalled in the same position on the shaft. Be careful during the removal or replacement of companion flanges, as rough handling such as hammering on the trunnion mounting may bend or distort the flange.

Center Bearing: Tighten the propeller shaft center bearing mounting bolts. Should the center bearing insulator be deteriorated or oil soaked, it should be replaced. Loose mounting bolts or an oil-soaked or deteriorated insulator can cause excessive vibration. See "**PROPELLER SHAFT**, " Section A, CTS-2046.

Engine and Transmission Mountings: Tighten the engine and transmission mounting bolts. If the mountings are oil soaked or deteriorated, they should be replaced. Loose mounting bolts or oil-soaked or deteriorated mountings can cause excessive vibration.

Clutch and Flywheel: The light side of the flywheel is stamped with a letter "L" and should be lined up with the arrow or inspection mark (usually a white dab of paint) stamped on the heavy side of the clutch. (If no arrow is stamped on the clutch, it can be assembled to the flywheel in any position.) If these markings are not lined up, excessive vibration can result.

DRIVE LINE ARRANGEMENTS

There are two types of drive line arrangements that will satisfactorily transmit power to the driving wheels: the parallel joint type and the nonparallel or "broken back" type.

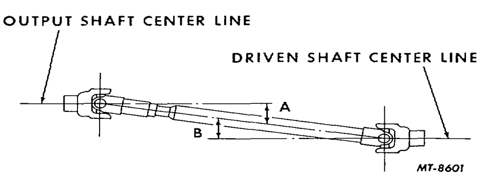


Fig. 2. Parallel Joint Type Drive Line

In the parallel joint type all companion flanges and/or yokes in the complete drive line are parallel to each other with the working angles of the joints ("A" and "B", Fig. 2) of a given shaft being equal and opposite. For instance, if the transmission mainshaft center line at the rear is down 5 degrees from a true horizontal plane, the center line at the front of the auxiliary mainshaft or rear axle pinion shaft must be 5 degrees up.

With the nonparallel or "broken back" type installation the working angles of the joints ("A" and "B", Fig. 3) of a given shaft are equal; however, the companion flanges and/or yokes are not parallel. Example: The flange or yoke of the main transmission is 3 degrees from a true vertical with the rear axle pinion flange or yoke at 12 degrees. The working angles of the universal joints of this propeller shaft are equal and the shaft will run smoothly, Fig. 3.

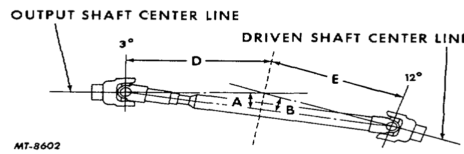


Fig. 3. "Broken Back" Type Drive Line

When the propeller shaft angle is determined in the nonparallel type installation, the rear axle is rotated about the axle shaft axis until the pinion shaft and transmission mainshaft extended center lines intersect exactly midway between the universal joints centers ("'D" and "E", Fig. 3). It can be readily seen that the pinion and mainshaft center lines may be quite different with respect to a true horizontal; however, the joint working angles ("A" and "B", Fig. 3) are identical.

UNIVERSAL JOINT WORKING ANGLES

The major prerequisite for obtaining troublefree and long-lasting operation of a drive line is consideration of the universal joint working angles.

Any given universal joint has a maximum angle at which it will still transmit power smoothly. This angle depends on the joint size and design. To exceed the maximum recommended working angle is to greatly shorten or immediately destroy the joint service life.

The universal joint working angles of both joints of a given propeller shaft should operate at the same angle with not more than one-half degree of variation.

If the working angles of a given propeller shaft are not equal, joint cancellation will not occur, resulting in destruction of the joint.

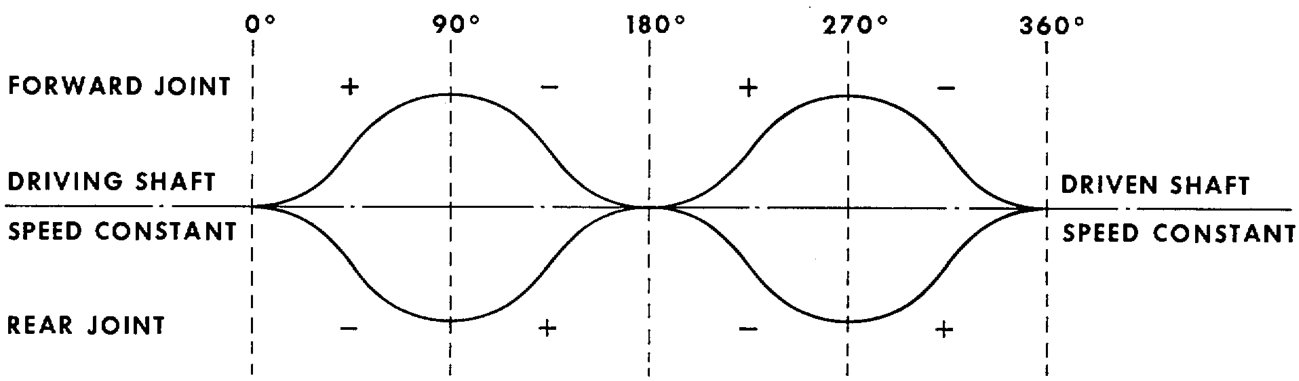


Fig. 4. Universal Joint Speed Fluctuations

UNIVERSAL JOINT CANCELLATION

A single universal joint operating between two shafts at a given angle will not turn at an even and constant speed; that is to say that, although the speed of the driving shaft is constant, the driven shaft speed is going to fluctuate up and down.

During the first 90 degrees of rotation, the forward universal joint speed will increase, Fig. 4. From 90 degrees to 180 degrees the speed will decrease to again match the driving shaft speed. This sequence is again repeated respectively from 180 degrees to 270 degrees and from 270 degrees to 360 degrees. This speed fluctuation is known as torsional excitation (winding up and unwinding) of the propeller shaft.

If two joints are placed in the drive line, one at each end of the propeller shaft, having equal working angles, the rear joint will provide the inverse condition of the forward joint. In other words, the rear joint will slow down by the same amount that the forward joint speeds up, resulting in joint cancellation. The driving and driven shafts will turn at constant and identical speeds.

PROPELLER SHAFT PHASING

Propeller shaft phasing is the relative positioning of one yoke or flange with another on the same shaft within a 360 degree revolution.

Correct phasing is equally important when compared with other factors governing proper drive line operation.

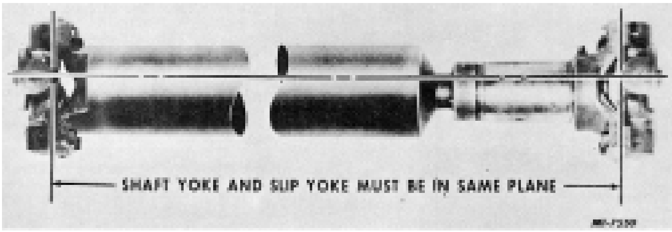


Fig. 5. Propeller Shaft in Phase

To compensate for the alternate increase and decrease in shaft length caused by rear axle suspension deflection, a slip joint is incorporated within the drive line.

The slip joint is splined to accept the shaft, and it is here that propeller shaft phasing can be altered through rotation of the slip joint.

A correctly phased propeller shaft is one in which the yoke bores or flange ears are in the same plane, Fig. 5.

Propeller shaft phasing affects joint cancellation in that an incorrectly phased shaft will induce torsional excitation (shaft windup and unwind).

It can be see in Fig. 4 that a propeller shaft is out of phase any time that the slip joint yoke bore or flange ear center line is rotated to any point between 0 and 180 degrees with respect to the yoke or flange at the opposite end of the shaft. Positioning the yoke at one end of the shaft at 0 degrees and the slip joint yoke at 90 degrees results in a maximum out-of-phase condition and torsional excitation will be greatest. Drive line vibration will be severe.

To provide correct propeller shaft phasing, the slip joint and shaft are marked with arrows or dots, Fig. 6. If these markings are not visible, mark shaft and slip joint before disassembling joint. During reassembly align slip joint arrow with shaft arrow.

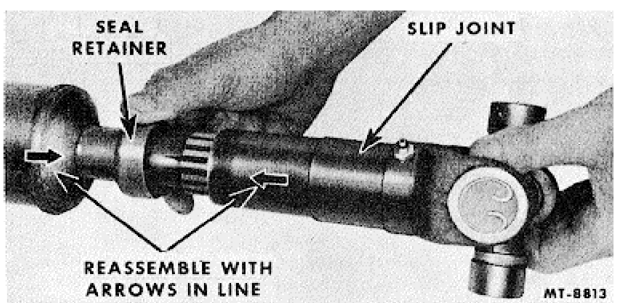


Fig. 6. Slip Joint Alignment Arrows

The propeller shaft will still be in phase if the arrows are 180 degrees apart; however, this is not standard practice. In other words, the position of the slip joint arrow with respect to the shaft arrow cannot be at any point except in line or 180 degrees from alignment.

CHASSIS VIBRATION

Vibration that is felt during vehicle operation will generally fall in one or more of the following categories. It can be readily seen that not all vibrations are caused by the propeller shaft assembly. The vehicle should be thoroughly road tested or supported on floor stands in an attempt to isolate the vibration cause.

1. Tires, Wheels, Brake Drums and Wheel Bearings
   Check for out-of-round tires, unevenly worn tires, tires and wheels out of balance, wheels and rims out of alignment or mismatched tires.
2. Engine, Clutch, Transmission and Axle

   Check for engine misfire on one or more cylinders, low compression, loose engine mounts, valves out of adjustment, loose flywheel, defective vibration damper, broken or bent fan blades, excess bell housing run-out, pressure plate out of balance, loose driven member hub, piece of lining broken from driven member, worn pilot bearings, worn or noisy transmission bearings, worn rear axle bearings, broken or chipped gear teeth, bent axle housing or worn front axle suspension and linkage.
3. Frame and Springs

   Check for mismatched springs, broken or shifted rear springs, broken spring seats, loose spring U-bolts or a bent, twisted or broken frame.
4. Propeller Shaft Assembly

   Propeller shaft vibrations and remedies are covered in detail herein.

UNIVERSAL JOINT AND PROPELLER SHAFT VIBRATION

Most propeller shaft troubles which cause drive line vibration are the result of something affecting either drive line balance or drive line alignment.

Vibration originating in the universal joint and propeller shaft assembly is usually present only at certain speeds and cycle as the shaft speed is raised and lowered. This intermittent characteristic differs from the generally constant noise set up throughout the vehicle's speed range by drive unit gears.

Propeller shaft vibration is a definite indication that a problem exists in the area of the shaft assembly. To prevent possible hazardous consequences and damage to other components, the vehicle should not be operated other than to isolate the trouble until the problem has been remedied.

The most common causes of vibration are:
1. universal joint flange or yoke misalignment; 2. parking brake drum out of balance; 3. Out of-balance propeller shaft assembly; 4. propeller shaft out of phase; 5. excessive flange run-out or distorted yokes; 6. loose flange or yoke rut; 7. excessive vehicle speed.

To correct drive line vibration the propeller shaft must be checked in such a manner that both balance and alignment are considered. Never change the drive line balance or alignment until a thorough check of the most common causes has been completed.

Drive line vibration can be checked by road testing the vehicle, spinning the drive line with the vehicle up on floor stands, or by pulling the rear axle shafts and spinning the drive line.

CAUTION: Be certain that vehicle is positively supported.

Start the engine and with the clutch disengaged and the transmission in gear to keep the clutch disc from spinning, bring engine speed up slowly to governed speed to determine if vibration is in the engine itself or due to an out-of-balanced clutch pressure plate assembly. If only normal vibration is evident, disconnect the front propeller shaft at the transmission companion flange and with the transmission in direct drive and the clutch engaged, slowly bring engine speed to governed speed to determine if vibration is caused by an out-of-balance clutch disc or out-of-balance transmission gears.

If both the above checks show only normal vibration, connect the front propeller shaft and use the following step-by-step procedure in balancing the drive line assembly.

BALANCING THE DRIVE LINE

There are three methods of balancing the drive line and these are:

1. By rotating the propeller shaft 180° in relation to the companion flange.

2. By adding a small weight to the parking brake drum.

3. By adding a small weight to the propeller shaft.

Each of these methods is covered in detail in the following paragraphs.

Before any balance weights are added to the brake drum or propeller shafts, disconnect the rear propeller shaft at the center bearing and rotate the shaft 180' in relation to the companion flange (vehicles without center bearing, rotate the shaft at the transmission). Reconnect the shaft, then road test the vehicle or spin the drive line and check for vibration.

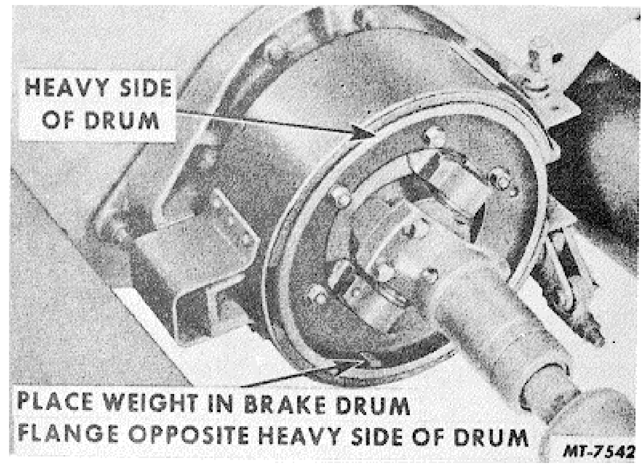


Fig. 7. Balancing Parking Brake Drum

If vibration is still present after the above changes, on vehicles with the brake drum at the center bearing place a lump of glazer's putty weighing approximately one-half ounce at-the brake drum flange, Fig. 7. (A small magnet can be used in the brake drum flange in place of putty; a 1/2 ounce magnet can be obtained by removing the magnet from a magnet drain plug.) Road test the vehicle or spin the drive line and, by changing the location of the weight, find the point of least vibration. Then increase or decrease this weight at that point to obtain as nearly as perfect a balance as possible. Weigh the glazer's putty (or magnetic weight) and install a piece of steel of the same weight in the same location by tack welding the weight to the inside of the brake flange. Hold the weld material to a minimum.

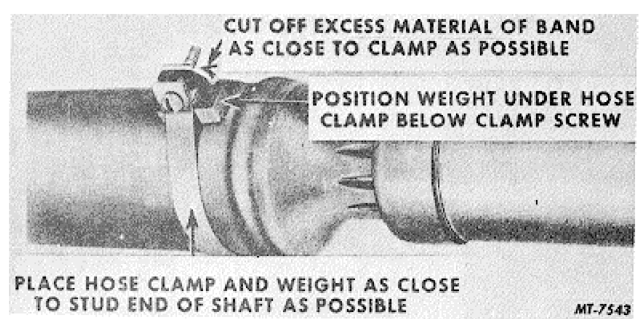


Fig. 8. Balancing Propeller Shaft

For vehicles without a brake drum at the center bearing use an adjustable hose clamp and a small metal weight (approximately 1/2 ounce). Clamp the weight to the rear shaft near the center bearing and cut off the excess material of the band as close to the clamp as possible. See Fig. 8. Road test the vehicle or spin the drive line; then, by moving the weight to various locations on the shaft, find the point of least vibration. Increase or decrease the weight at this point to obtain as perfect a balance as possible. Mark the location of the weight on the shaft and remove the hose clamp and weight. Weigh the weight and add 3/8 of an ounce for the clamp screw and nut. Select a piece of steel of this total weight and tack weld to the propeller shaft at the locating mark. Hold the weld material to a minimum.

For vehicles with a single propeller shaft use an adjustable hose clamp and a small weight (approximately 1/2 ounce). Clamp the weight to the front end of the shaft and cut off the excess material of the band as close to the clamp as possible. Road test the vehicle or spin the drive line; then, by moving the weight to various locations on the shaft, find the point of least vibration. Increase or decrease the weight at this point to obtain as perfect a balance as possible. Mark the location of the weight on the shaft and remove the hose clamp and weight. Weigh the weight and add 3/8 of an ounce for the clamp screw and nut. Select a piece of steel of this total weight and tack weld to the propeller shaft at the locating mark. Hold the weld material to a minimum.

CAUTION: When using hose clamps to attach loose weights to a propeller shaft (when checking for vibration), make sure that the weights are clamped securely to the shaft t avoid the hazard of weights flying off.

COMPANION FLANGE ALIGNMENT AND RUN-OUT

An important consideration for maintaining acceptable propeller shaft alignment is to keep all propeller shaft companion flanges or yokes parallel, Fig. 2. In other words, all flanges or yokes must be perpendicular in both vertical and horizontal planes to the engine crankshaft, Fig. 9. It should be noted, however, that the flanges of a "broken back" type drive line are not parallel in the vertical plane, Fig. 3.

These flange angles will be discussed later. For the moment we will consider the parallel joint type drive line.

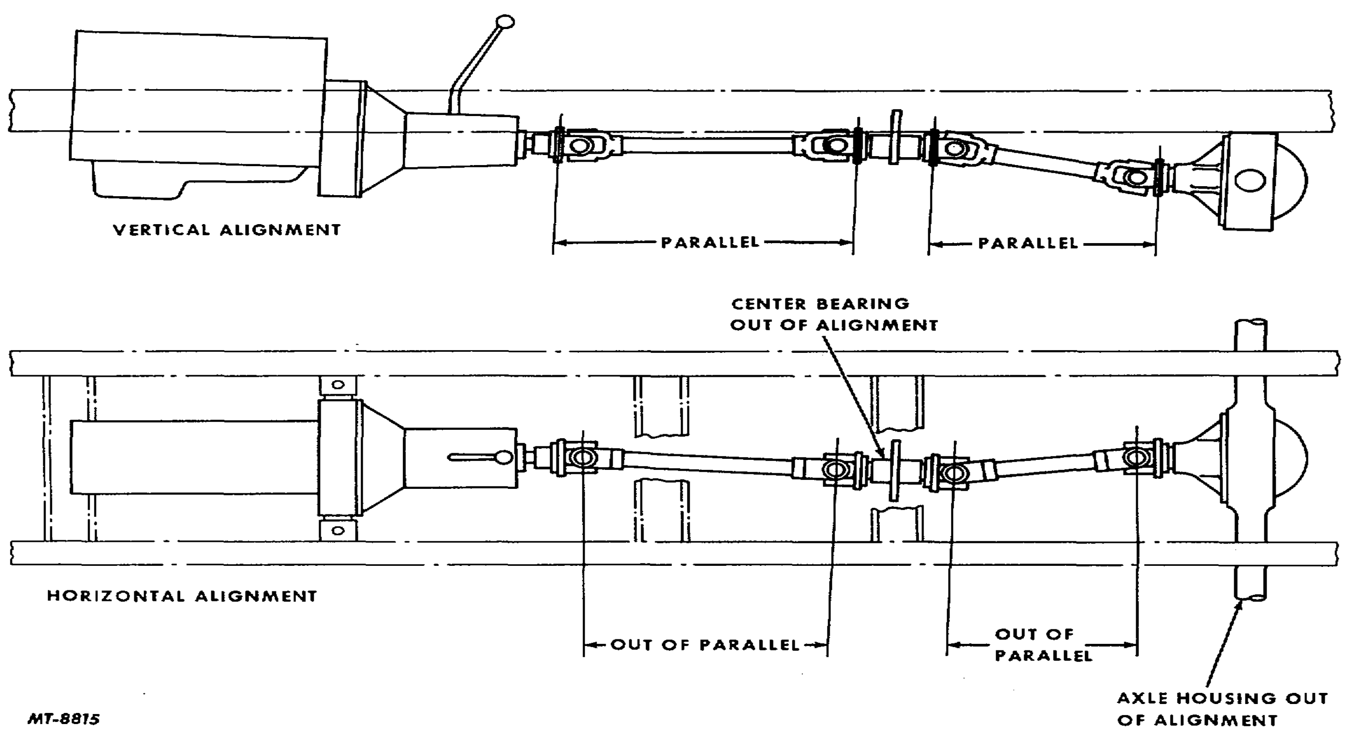


Fig. 9. Drive Line Horizontal and Vertical Alignment

Loose engine and main transmission to frame mountings will not affect vertical or horizontal alignment of the main transmission companion flange with respect to the flange being 90 degrees to the engine crankshaft center line. However, any change from the originally mounted position caused by loose mountings or otherwise, will result in the remaining drive line flanges working at a different angle, which is not permissible. Therefore, before checking the drive line companion flange angles, be certain that engine and transmission mountings are in good condition and are tight.

Propeller shaft alignment checking procedures given herein will apply to front as well as rear axle drive lines. The vertical alignment angle of all companion flanges, whether on the front axle or rear axle drive line, is 90 degrees from a true horizontal minus the number of degrees of engine declination (engine angle).

Main Transmission Companion Flange Run-Out

Because the angularity of the complete drive line must match with the main transmission companion flange, the flange itself must turn perfectly true, and its exact vertical angle must be known.

To check for run-out of the main transmission flange, securely mount a dial indicator to the transmission rear face. Position indicator stylus on the flange machined surface and rotate flange one complete revolution, Fig. 10.

Flange run-out must not exceed .005". If run-out is excessive, it may be eliminated by rotating the flange on the spline. If excessive run-out still exists, flange is distorted and must be replaced.

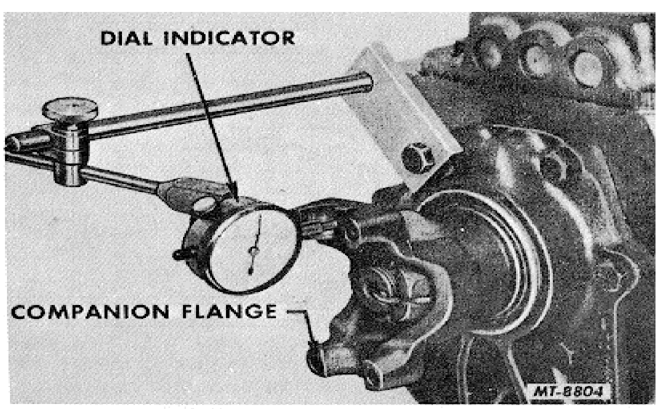


Fig. 10. Checking Companion Flange Run- Out

Main Transmission Companion Flange Vertical Alignment

The main transmission companion flange machined surface must turn in a vertical plane, that is, 90 degrees to the engine crankshaft center line.

The rear face of the engine crankcase as well as the front and rear faces of the flywheel housing, bell housing and main transmission are precisely machined 90 degrees to the engine crankshaft or transmission mainshaft, as the case may be.

Most engines are mounted in the chassis at so many degrees declination, i.e. the rear of the engine is lowered X number of degrees for among other reasons, to minimize the drive line universal joint working angles. It follows then, that the engine crankshaft center line and the main transmission mainshaft center line do not lie in a true horizontal plane. Since the transmission companion flange machined surface is 90 degrees with the mainshaft, the actual vertical angle will not be 90 degrees but X number of degrees from a true vertical, or in other words, the same number of degrees from a true vertical that the engine crankshaft center line is from a true horizontal.

One can now realize the importance of determining the exact, angle of the engine crankshaft center line when checking the main transmission companion flange vertical alignment.

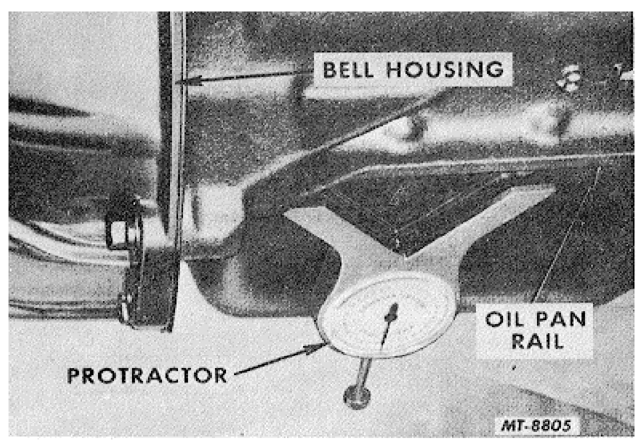


Fig. 11. Measuring Mounted Engine Angle

To determine the engine angle, park the vehicle on a level surface and disconnect the propeller shaft from the main transmission companion flange. Check the flange for looseness and tighten if necessary.

Place an SE-2067 magnetic base protractor on the horizontally machined surface of the cylinder head, crankcase oil pan rail or possibly along the flange of the rocker arm cover, Fig. 11. This angle establishes the correct vertical angle for all propeller shaft flanges and yokes.

Read and record the number of degrees of engine declination indicated on the protractor dial. This is the engine angle.

Place transmission shift lever in neutral position. Rotate transmission mainshaft to place flange C in a vertical position. Place SE2067 magnetic base protractor in a vertical position with one leg of protractor base on flange machined surface as shown in Fig. 12. Protractor reading should be 90 degrees minus the number of degrees of engine declination. If readings differ by more than 1/2 degree, the flange is misaligned in the vertical plane. In other words, the flange machined surface is not perpendicular (90°) to the engine crankshaft center line.

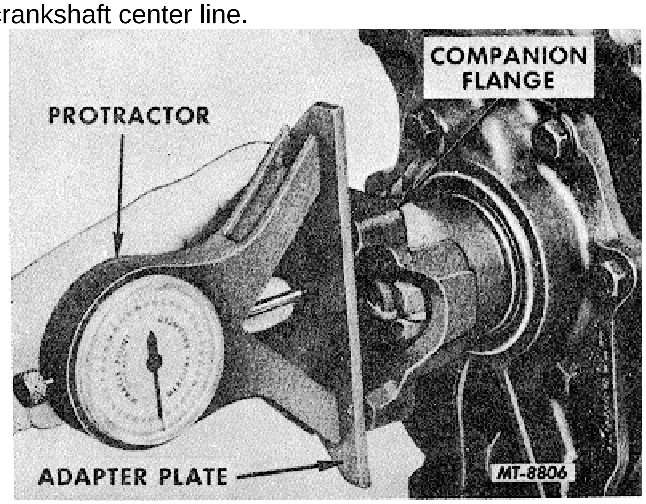


Fig. 12. Checking Main Transmission Companion Flange Vertical Alignment

If the companion flange run-out is within limitations but the vertical alignment is not, it indicates that the problem lies within the mating surfaces of the flywheel housing to engine, bell housing to flywheel housing or transmission housing to bell housing. Misalignment of any of these components is highly improbable, since the mating surfaces are machined to strict tolerances; however, since the possibility does exist, it will be dealt with herein.

To determine which component is at fault, remove the transmission and check the bell housing rear machined face for vertical alignment. Clean the face of all foreign material and place SE-2067 magnetic base protractor in a vertical position on this face. **NOTE:** When aluminum bell housings are encountered, the protractor will not adhere; therefore, it will be necessary to either hold protractor firmly or clamp a steel straight edge in a vertical position and place the protractor on the straight edge, Fig. 13. The protractor dial should read 90 degrees minus the number of degrees of engine declination.

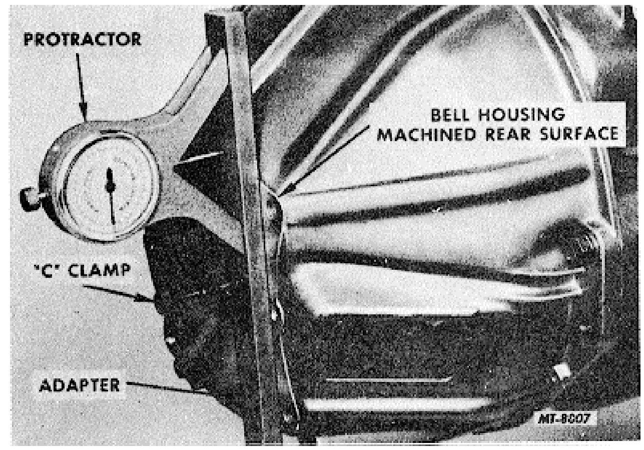


Fig. 13. Checking Bell Housing Vertical Alignment Using SE-2067 Magnetic Base Protractor

If misalignment still exists, it will be necessary to remove the bell housing and check the vertical alignment of the flywheel housing (if applicable) using same checking method as used with bell housing check.

Some engine models require a flywheel housing to be used between the engine rear machined face and the bell housing. If previous checks have not eliminated the vertical misalignment, remove the bell housing and clutch assembly. The rear machined face of the flywheel housing can be checked using a straight edge and SE2067 protractor held firmly in a vertical position. The reading should be 90 degrees minus the number of degrees of engine declination. In other words, this surface must be perpendicular (90 degrees) to the engine crankshaft horizontal center line. Misalignment of less than 1/2 degree at this point would indicate that the problem lies with the front and rear machined surfaces of the flywheel housing and bell housing not being parallel or that the front machined surface of the transmission is not perpendicular to the mainshaft. These conditions can be readily checked. It should be noted, however, that foreign material such as a piece of an old gasket not removed during a previous service operation will result in misalignment of the transmission flange in either a vertical or horizontal plane, depending upon its location.

Auxiliary Transmission Flange Vertical Alignment

As previously mentioned, the angularity of the complete drive line must match the main transmission companion flange; therefore, all remaining flanges must be checked to determine run-out and vertical alignment. Procedures required are the same as for checking run-out and vertical alignment of main transmission companion flange.

If the auxiliary transmission companion flange is not properly aligned vertically, check for loose or worn transmission mountings, as this will position the auxiliary transmission mainshaft on a horizontal plane that is not parallel with the main transmission mainshaft and engine crankshaft, Fig. 14. This causes the main transmission output shaft universal joint and the auxiliary transmission input shaft universal joint to operate at different working angles, which is not permissible. The center lines of the engine main and auxiliary transmissions must be parallel, Fig. 14.

Rear Axle Pinion Shaft Companion Flange Vertical Alignment

The center line of the rear axle pinion shaft should be parallel with the engine crankshaft, Fig. 16. However, manufacturing may elect to position the pinion shaft center line of the rear axle at any given angle. For instance, the propeller shaft and universal joints can form what is known as a "broken back" drive line between the transmission and rear axle.

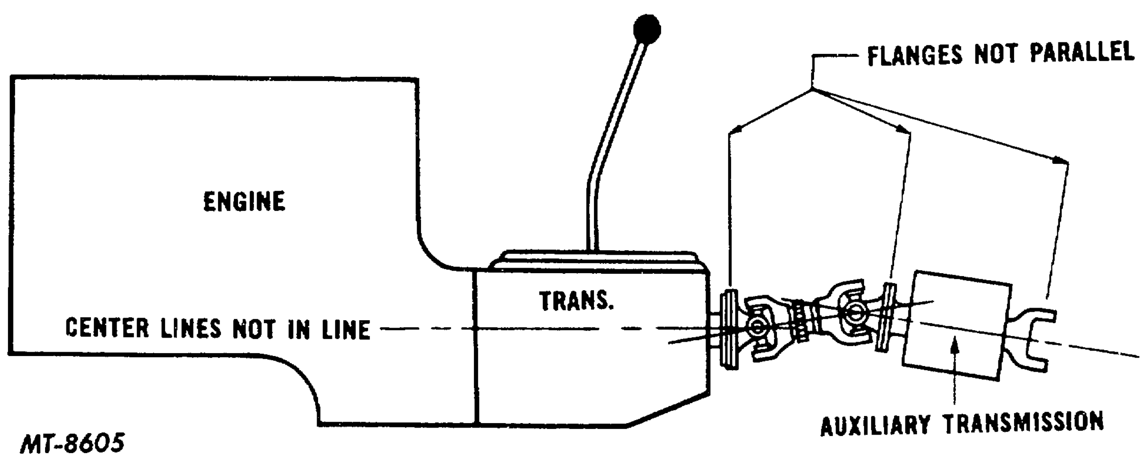


Fig. 14. Main and Auxiliary Transmission Center Lines Not Parallel

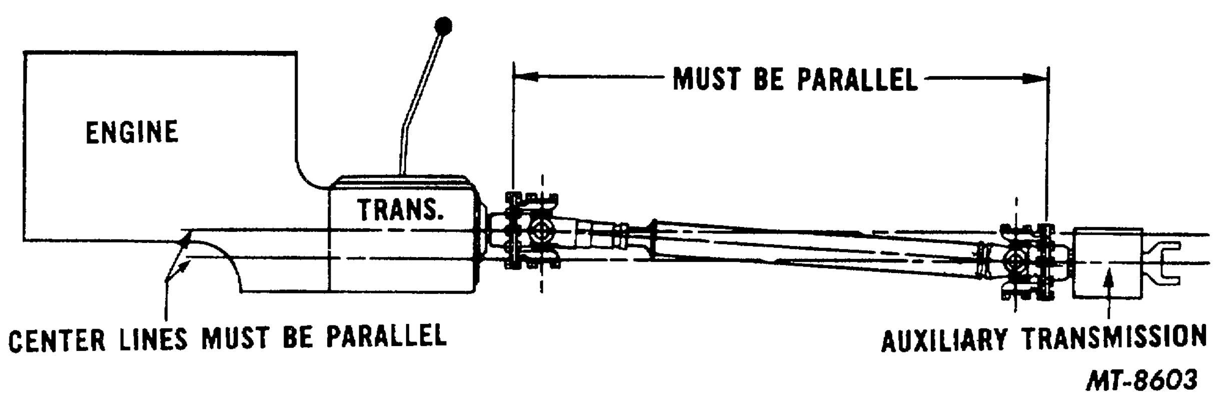


Fig. 15. Engine, Main and Auxiliary Transmission Center Lines Parallel

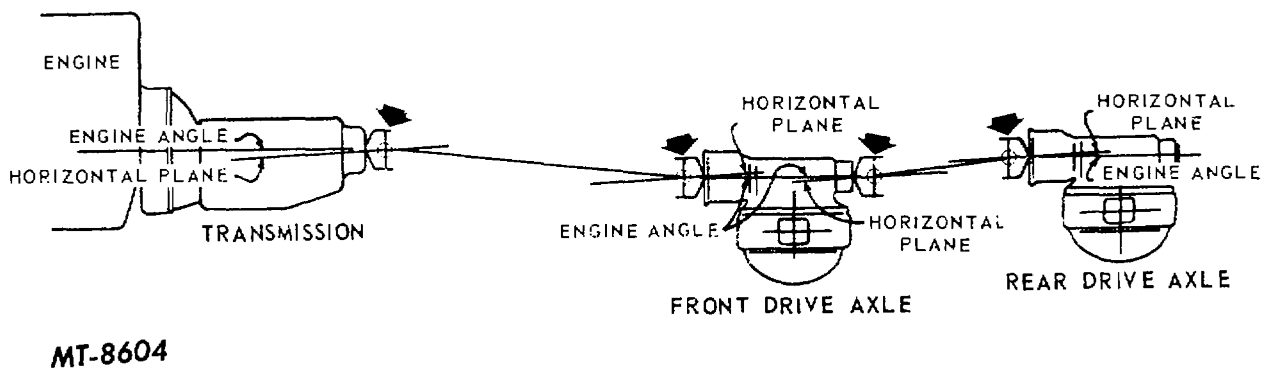


Fig. 16 Rear Axle Pinion Shaft and Engine Crankshaft Horizontal Center Lines Parallel

It should be remembered that even with the "broken back" drive line, the working angles of both universal joints are equal; however, the flanges will not be parallel. This condition is permissible and should provide satisfactory drive line operation.

To determine the correct vertical angle of a "broken back" type drive line flange, extend the center line of the driving (output) and driven shafts. These lines should intersect at a point exactly midway between the joint centers, Fig. 3.

Correction of a vertically misaligned rear axle pinion shaft flange can be accomplished by placing tapered shims or wedges between the spring pads and the springs to tilt the pinion shaft up or down. The angle of the shims or wedges will depend upon the amount of existing vertical misalignment.

Recheck flange alignment after shims or wedges have been installed.

NOTE: Be sure when installing wedges or shims that the same thickness is used at each spring pad to prevent inducing a strain on the axle housing or springs.

Main Transmission Companion Flange Horizontal Alignment

The horizontal alignment of all flanges is just as important as the vertical alignment.

Place the vehicle on a level floor.

Clamp a straight edge on the main transmission companion flange so it will project equally from each side of the flange. Place an SE-2067 magnetic base protractor on the straight edge to be sure that it is exactly horizontal, Fig. 17.

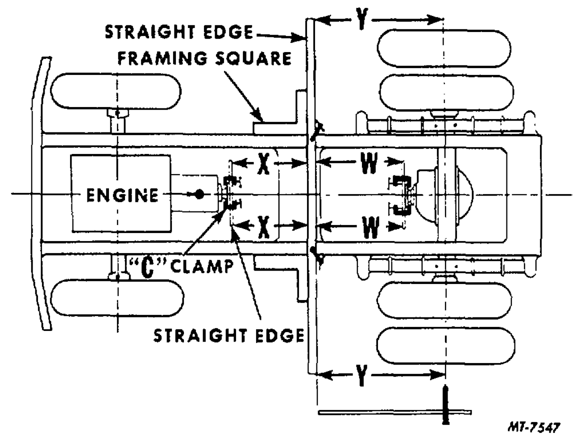


Fig. 17 Checking Horizontal Alignment of Propeller Shaft

Obtain a second straight edge at least 12" longer than the rear wheel track and clamp it at right angles across the frame side rails. Check this 90 degree angle with large framing squares, Fig. 17.

Measure distances "X", Fig. 17, between the two straight edges. These two dimensions should be within 1/16" of each other. If they are not, the flange is misaligned horizontally.

Auxiliary Transmission Companion Flange Horizontal Alignment

Checking the horizontal alignment of the auxiliary transmission companion flange requires the same procedure as does the main transmission flange. Measure distance "W", Fig. 17.

Rear Axle Pinion Shaft Companion Flange
Horizontal Alignment

To check the horizontal alignment of the rear axle pinion shaft companion flange, use lame procedure as for checking main or auxiliary transmission flange.

An alternate method for checking pinion flange horizontal alignment is by measuring the distance from the ends of a straight edge placed across the frame to the centers of the rear axle (distance "Y", Fig. 17). These measurements may not vary more than 1/8".

Horizontal misalignment of the pinion flange can be corrected by eliminating one or all of the possible causes, which are:

1. Loose or sheared spring seat dowels.
2. Loose spring clips.
3. Loose spring shackle brackets.

The rear axle pinion flange alignment can be checked by the same method as the forward rear axle.

YOKE ALIGNMENT AND DISTORTION

Correct alignment of universal yokes is as important as proper flange alignment. Before checking their angle, it is necessary to inspect the yoke for lug distortion or damage. The same standards of alignment, distortion and runout apply to yokes. As with a flange, a yoke can often be revolved on its splined shaft to improve concentricity.

Checking Yoke for Distortion and Run-Out

A straight piece of round bar stock which is a slip fit in the two universal joint bearing bores can be used as a gauge bar. If the gauge bar is a slip fit through both bearing bores simultaneously, the bores are properly aligned, and the yoke is not distorted or damaged. If the bar goes through one bearing bore but strikes the inner face of the opposite lug, the yoke is distorted and should be replaced.

If a gauge bar of correct diameter is not available, yoke distortion can be checked using a protractor. Some types of universal joints use a bearing cap separate from the trunnion bearing retainer, while others have the cap as an integral part of the bearing retainer.

When checking a yoke having a separate cap and bearing retainer, remove the lock strap and cap. Allow the trunnion bearing retainer to protrude approximately 1/8" beyond the yoke lug. Rotate the yoke until the "C" formed by the yoke is in a vertical position. Place an SE-2067 magnetic base protractor on the machined flat of the upper or lower bearing retainer transversely with the propeller shaft. Turn yoke until protractor dial reads zero degrees. Without moving the yoke, place protractor on the opposite bearing retainer. If protractor readings differ more than 1/2 degree, the yoke is probably distorted and should be replaced.

If bearing retainer has been removed, place protractor on machined flat of yoke. If cap is an integral part of bearing retainer, protractor may be placed on cap, providing cap is flat. If cap is dome shaped at all, remove cap and retainer and place protractor on machined flat of yoke.

All drive line yokes can be checked for distortion using either the bar stock or protractor, Fig. 18.

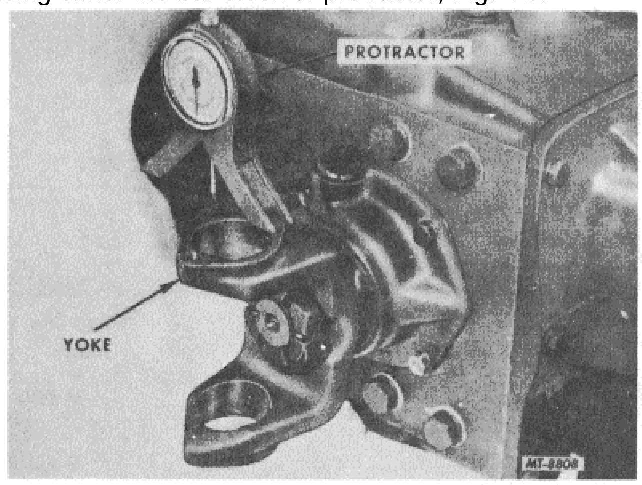


Fig. 18 Checking Yokes for Distortion

To check yoke run-out, disconnect the propeller shaft. Insert a straight piece of selectively fit round bar stock through the yoke bores so that it extends equally on each side of the yoke lugs. Securely mount a dial indicator so that the indicator stylus can be placed against the bar stock adjacent to the yoke lug. Set indicator to zero when stylus is on high point of bar stock. Rotate yoke 180 degrees and again position stylus on high point of bar stock. Dial indicator reading should be zero. Permissible runout should not exceed .005".

If bar stock is not available, an alternate method is to position dial indicator stylus against the machined outside diameter of the bearing retainer, Fig. 19.

NOTE: Expose bearing retainer only enough to accept dial indicator stylus, otherwise, retainer may cock in yoke bore and cause an erroneous indicator reading.

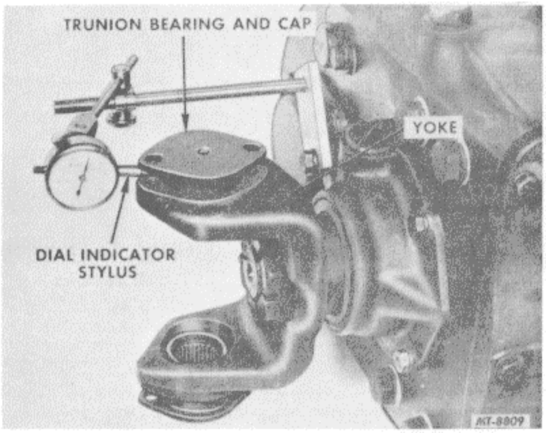


Fig. 19 Checking Yoke Run-Out

Yoke Vertical Alignment

Yoke vertical alignment can be checked at either the top or bottom lug, whichever is most accessible.

Locate the vehicle on a level floor and using an SE-2067 magnetic base protractor, determine the engine angle (same as when checking flange vertical alignment).

If cap and bearing retainer are separate pieces, remove lock strap and cap. Pull retainer out so that it extends approximately 1/8" beyond yoke lug.

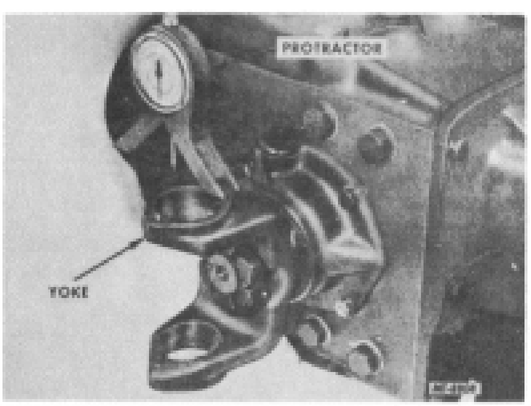


Fig. 20 Checking Yoke Vertical Alignment

Place protractor on bearing retainer at right angle to vehicle center line. Rotate yoke until bearing bores are vertical (dial reads zero). Without turning yoke rotate protractor 90 degrees, placing it parallel with the vehicle center line (in line with propeller shaft). Dial should indicate same number of degrees previously determined with protractor at engine (90 degrees minus engine angle).

If engine angle and yoke angle are not the same or within 1/2 degree of each other, check opposite lug before taking corrective measures.

If excessive misalignment still exists, replace yoke and recheck.

If bearing retainer and cap are integral, protractor may be placed on cap--providing cap is flat. If cap is dome shaped, remove cap and bearing and place protractor on outside machined surface of yoke lug, Fig. 20.

Yoke Horizontal Alignment

Procedures for checking horizontal alignment of a yoke are same as for checking a flange; however, a piece of round bar stock that is a slip fit in the yoke bearing bores is used in lieu of a flat bar straight edge.

If a slip fit gauge bar is not available, a piece of round stock slightly smaller than the yoke bearing bore inside diameter can be used.

Position the smaller stock through the bearing bores and tap a wooden wedge between it and the yoke shaft. Check with a protractor or square to see that the bar is exactly 90 degrees to the machined outside face of the yoke lugs.

Measure the distance between the gauge bar and straight edge clamped on the frame as when checking flange horizontal alignment.

Corrective measures for yoke horizontal misalignment are the same as for flange misalignment.

MULTIPLE DRIVE LINE ALIGNMENT

All vehicles having more than one propeller shaft or drive line require the same degree of accuracy for checking each component. This means that the flanges and yokes of all auxiliary units and tandem drive axles should be similarly checked.

UNIVERSAL JOINT LUBRICATION

Light- Duty Models

Joints with plugs or fittings: Lubricate under low pressure every 20, 000 miles. Too much pressure will damage oil seals. Use Lithium 12-Hydroxy Stearate EP grease. Joints without plugs or fittings: Every 50, 000 miles clean and inspect joints, repack with Lithium 12-Hydroxy Stearate EP grease. NOTE: Frequent use of vehicles in off-the-road operations that encounter mud and water, lubricate or repack joints every 12, 000 miles.

Medium and Heavy- Duty Models

Lubricate under low pressure every 3, 000 to 5, 000 miles. Use Lithium 12-Hydroxy stearate EP grease. NOTE: Too much pres-sure will damage seals.

SLIP JOINT LUBRICATION

All Models

Under low pressure force small amount of Lithium 12-Hydroxy Stearate EP grease into joint every 1, 000 to 2, 000 miles. Excessive pressure and lubrication will damage oil seal.

TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSE	REMEDY
Propeller Shaft Vibration	1. Excessive tire or wheel run-out.	1. Replace tire or wheel
	2. Tire and wheel out of balance	2. Balance wheel.
	3. Rough engine operation	3. Tune engine.
	4. Loose universal joint retain-ing bolts.	4. Tighten bolts.
	5. Worn universal joint or lack of lubricant therein.	5. Lubricate or replace joint.
	6. Propeller shaft out of balance	6. Balance shaft.
	7. Parking brake drum out of balance.	7. Balance parking brake drum.
	8. Propeller shaft out of align-ment.	8. Check and align drive line.
	9. Propeller shaft out of phase are aligned.	9. Rotate slip joint until arrows
	10. Unequal universal joint work-ing angles	10. Adjust driven component until working angles are equal.
Universal Joint Noise	1. Loose universal joint retain-ing bolts.	1. Tighten bolts.
	2. Lack of lubrication in joint	2. Lubricate joint.
	3. Worn universal joint	3. Replace joint.

PROPELLER SHAFT

UNIVERSAL JOINTS

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PROPELLER SHAFT

UNIVERSAL JOINTS

GENERAL

To insure long life and efficient operation of the propeller shaft, the universal joints must be inspected periodically and lubricated at regular intervals. See the truck operator's manual for specific recommendations. Because there are several types and sizes in use, there are also different procedures for disassembly. Typical example of the several kinds and sizes used on IHC trucks are shown in the illustrations which follows.

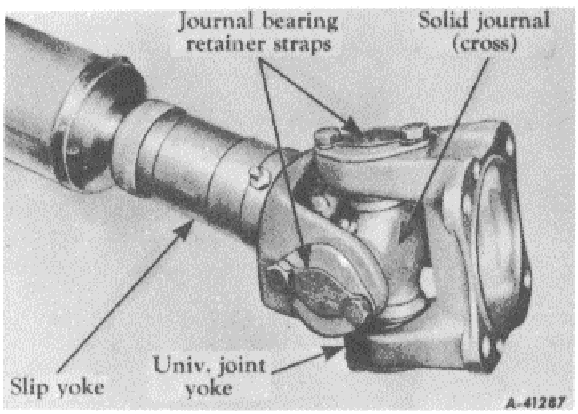


Fig. 13

DISASSEMBLY - SOLID CROSS TYPE

An optional universal joint having a solid journal or cross and using a metal strap retainer, Fig. 13, or exposed snap ring, Fig. 16, to hold the journal bearings in place, is also used on IHC trucks. Disassembly of this type joint is as follows:

a. Remove the oil seal retainer from the end of the slip joint and remove the slip joint assembly from the shaft. When replacing the slip joint, make certain that the arrows on the shaft and joint are in line,

c. Using a small punch, tap the end of the needle bearing assembly to loosen the snap ring. Move the needle bearing only enough to break the bearing assembly away from the snap ring, Fig. 16.

NOTE: Two types of Solid Cross type of Universal joints are used on IH vehicles. The Solid Cross type shown in Fig. 13 is disassembled in the same manner with the exception of removing snap ring as shown in Fig. 16. The journal bearing straps take the place of the snap rings. The removal of the journal bearings will have to be repeated on both halves of the universal joint assembly.

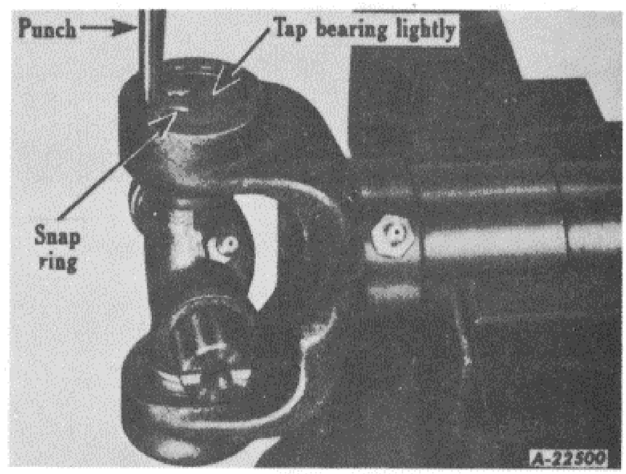


Fig. 16

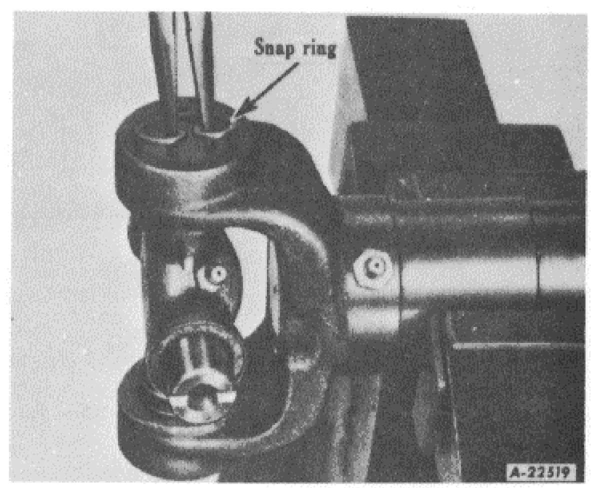


Fig. 17

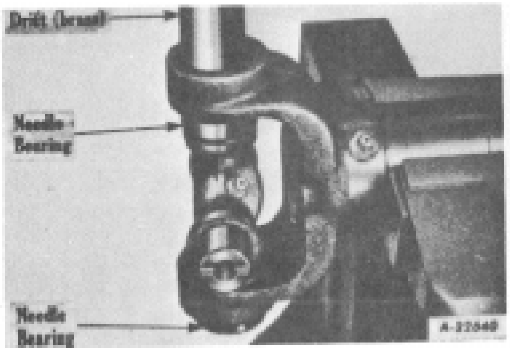


Fig. 18

d. Remove the snap ring from the slip joint or yoke. Turn the joint over and remove the opposite snap ring, Fig. 17.
e. Tap the needle bearing until the opposite needle bearing is free of the yoke, using a soft round drift (brass) with a flat face about 1/32" smaller than the diameter of the hole in the yoke to prevent damage to the bearing, Fig. 18.
f. Turn the yoke or joint over and tap on the exposed end of the journal or cross end to remove the remaining needle bearing, Fig. 19.

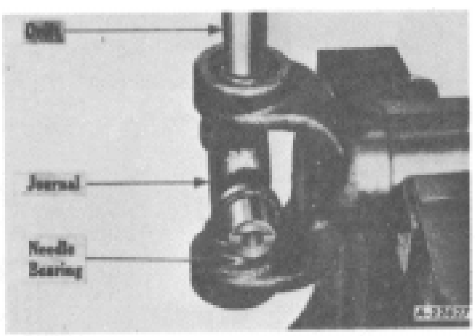


Fig. 19

g. Remove the journal cross from the yoke. Tip the cross as shown in Fig. 20 and lift it out of the yoke.

Fig. 20

CLEANING AND INSPECTION

1. Clean All Parts -Use a suitable cleaning fluid. Allow the parts to remain in the cleaner for some time to loosen up any particles of grease or foreign matter.
   Remove any burrs or rough spots from any machined surfaces.
2. Needle Bearing -Do not disassemble.
   Clean with a short stiff brush and blow out with compressed air. Work a small quantity of lubricant (See Operators Manual) into each needle bearing and turn the needle bearing on the trunnion to check wear. Replace if worn.
3. Journal Cross -Because worn needle bearings used with a new journal cross or new needle bearings used with a worn journal cross will wear more rapidly (making another replacement necessary in a short time), always replace the journal cross and four needle bearings as a unit.
4. Journal and Bearing Kit -To facilitate replacement of journals and bearings, a journal and bearing kit is available. The use of the kit insures having the correct individual parts when required and saves valuable time.

REASSEMBLY SOLID CROSS TYPE

Reassembling is merely a reversal of the foregoing disassembling operations. On joints without a lubrication fitting, repack the reservoir in the journal cross ends with a good grade of lubricant (See Operators Manual).
Make sure the reservoirs in each trunnion are filled. With the rollers in the race, fill the race, fill the race about one-third full.

SPRINGS

INDEX

Subject **Page**

DESCRIPTION

Constant Rate

Constant rate springs are leaf-type spring assemblies that have a constant rate of deflection. For example, if 500 lbs. deflect the spring assembly 1 inch, then 1000 lbs. would deflect the same spring assembly 2 inches. Thus, the rate of deflection is constant.

Constant rate springs are mounted to the axle with U-bolts, nuts and lockwashers. The front end of the spring is mounted to a stationary bracket while the rear end of the spring is mounted to a spring shackle. The shackle allows for variations in spring length during compression and rebound of the spring.

This type of spring assembly is used in both front and rear applications on IH vehicles.

Spring Shackles (Figs. 7 allow for variations in spring length during compression and rebound of spring. Shackles pivot on either lubricated spring bracket pins

Spring Bracket or Shackle Pins used on IHI trucks will be one of the following three types.

2. Pins that are driven into shackles or brackets.

TORQUE CHART
FOR ASSEMBLY OF SUSPENSION U-BOLTS
ROLLED THREAD U-BOLTS

7/8"-14	225 - 275
1" -14	325 - 400

SERVICING

Although the exact servicing procedures are different for each type of spring assembly and spring assembly application, the basic procedures are similar. The following is a general out line for servicing all spring assemblies used on IH vehicles.

Removal

1. Place floor jack under truck frame and raise truck sufficiently to relieve weight from spring to be removed.

2. Remove shock absorbers where used.

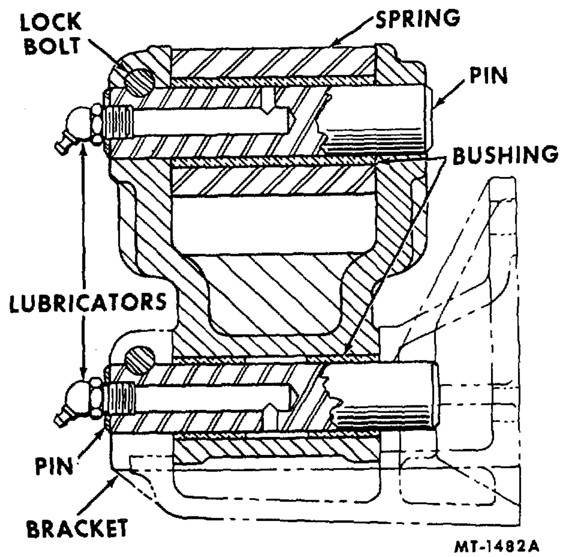


Fig. 7 Lubricated Spring Shackle (Driven-in type spring pin).

NOTE: When servicing suspension assemblies, all U-bolts must be thoroughly cleaned and lubricated with Tectyl 400-CWD or equivalent before reassembly.

3. Remove U-bolts, spring bumper and retainer or U-bolt seat.

4. Remove lubricators (not used on springs equipped with rubber bushings.

5. Remove nuts from spring shackle pins or bracket pins.

6. Slide spring off bracket pin and shackle pin.

7. If spring is rubber bushed, bushing halves may be removed from each side of spring and shackle eye.

Installation

NOTE: Before reassembly, all shackle bolts, U-bolts, etc. should be cleaned and lubricated for proper installation.

While the actual installation procedures will vary with each spring type, the pivot end of spring is usually fastened to frame bracket first. Shackle end can then be fastened by aligning shackle to other frame bracket. When installing U-bolts for securing axles, do not final tighten until springs have been placed under normal load. See TORQUE CHART for U-bolt torque specifications. Spring failures may occur at the center bolt hole if U-bolts become loosened. These bolts must be kept tight and checked frequently. Spring pins should also be checked periodically.

Disassembly

1. Clamp spring end in vise and remove old bushing from spring eye.

2. Reposition spring in vise so that assembly will be clamped near center.

3. If bolted type rebound clips are used, remove nuts, bolts and spacers; where clinch type rebound clips are used, bend tabs of clips up, being careful not to break them. Heating clips with torch will help avoid breakage.

4. Remove nut from spring center bolt.

5. Release vise to permit spring leaves to separate. Remove spring from vise and separate leaves from center bolt.

Cleaning, Inspection and Repair

1. Wash all parts in cleaning solvent or use steam cleaning equipment to remove grease and scale. Use a wire brush to hasten dirt removal.

NOTE: Do not immerse rubber spring bushings in cleaning solvent. Use a non-petroleum base type rubber lubricant on a clean cloth to wipe these parts clean.

2. Inspect all spring leaves for breakage and cracks. Also compare arch of leaves with new leaves and if leaves are flattened out, replace.
3. Spring pins must be replaced if they are worn, corroded or cracked.
4. Spring eye bushing and spring shackle bushing must also be replaced if defective.
5. Check spring brackets for cracks or for wear around mounting bolt or rivet holes. Replace bracket if damaged.
6. Always use new center bolts at each overhaul.

Assembly

1. Lightly lubricate spring leaves with a thin coat of graphite grease. Place spring leaves in proper order and align center bolt hole with a long drift.

2. Compress spring leaves sufficiently for installing center bolt and nut.

3. Place spring assembly in vise and compress spring leaves fully.

   CAUTION: When assembling spring leaves, be careful to prevent physical injury to personnel. The use of special holding fixtures or "C" clamps for holding spring leaves in place during assembly is strongly recommended.

4. Align spring leaves by tapping with hammer and position rebound clips on spring. If bolted type clips are used, install spacers, bolts and nuts Tighten enough to hold leaves in alignment but not enough to restrict free movement. If clinch type clips

are used, bend ends of clips down on top leaf. Heat clips with torch to help eliminate breakage.

Installation

While the actual installation procedures will vary with each spring type, the pivot end of spring is usually fastened to frame bracket first. Shackle end can then be fastened by aligning shackle to other frame bracket. When installing U-bolts for securing axles, do not final tighten until spring have been placed under normal load. See 'Torque Chart for U-bolt torque specifications. Spring failures may occur at the center bolt hole if U-bolts become loosened. These bolts must be kept tight and checked frequently.

Spring pins too, require special attention while installing as well as periodic checking after they have been installed. Spring leaf failure may occur at the spring eye, if the pin is improperly adjusted. If the pin is drawn up too tightly in the bracket or shackle, a bind will result. The paragraphs which follow give special instructions for each type spring pin.

2. Driven in type. Spring pins which are driven into bracket or shackle require that the pin be aligned so as to be able to install lock bolt through bracket or shackle with pin in place (Fig. 7).

TROUBLESHOOTING

The following list covers the most frequent causes for troubles which may occur in the suspension system. However, several items may overlap similar complaints and causes that are common to axle and wheel alignment trouble shooting.

COMPLAINT		POSSIBLE CAUSE	
1.	Truck wanders	a.	Front axle shifted on springs.
		b.	Broken spring.
		c.	Out of alignment.
2.	Truck bottoms	a.	Overloading.
		b.	Too much lubricant on spring leaves.
		c.	Broken spring leaves.
		d.	Defective shock absorbers.
		e.	Weak spring.
3.	Truck lopsided	a.	Broken spring leaves.
		b.	Wrong spring installed.
		c.	Weak spring.
4.	Frequent spring breakage	a.	Overloading or severe operation.
		b.	Loose U-bolts.
		c.	Loose center bolt.
		d.	Defective shock absorbers.
		e.	Improper adjustment on spring pin.
		f.	Tight spring shackle.
		g.	Too much lubricant on spring leaves.
5.	Noisy springs	a.	Loose U-bolts.
		b.	Loose center bolt.
		c.	Loose rebound clips.
		d.	Loose shackles.
		e.	Worn shackle bushings.
		f.	Loose, bent or broken spring bracket
		g.	Worn spring pins.
6	Erratic steering when braking	a.	Loose U-bolts.
		b.	Loose center bolt.

EQUALIZING BEAM SUSPENSION

(HENDRICKSON)

INDEX

SUSPENSION SYSTEM TORQUE CHART (NEWTON METERS)

LOCATION	THREAD SIZE RECOMMENDED TORQUE
Torque Rod Stud Nuts	339 N-m (250 ft. lbs.)
Torque Rod Bracket Mounting Bolt Nuts	339-373 N-m (250-275 ft. lbs.)
Spring Center Bolt	1/2-20 88-102 N-m (65-75 ft. lbs.)
Spring Pin Draw Key Nut	108-l02 N-m (80-90 ft. lbs.)
Spring Rear Hanger Rebound Bolt Nut	95-108 N-m (70-80 ft. lbs.)
Top Pad to Spring (Spring Aligning Set Screw)	136-203 N-m (100-150 ft. lbs.)
Top Pad to Saddle Bolt Nut	(373-407 N-m (275-300 ft. lbs.)
Saddle Cap Stud Nut	305-373 N-m (225-275 ft. lbs.)
Saddle Cap Stud	75-88 N-m (55-65 ft. lbs.)
Equalizer Beam End Bolt Nut	285-325 N-m (210-240 ft. lbs.)
Equalizer Beam End Tube Nuts	610-678 N-m (450-500 ft. lbs.)

To obtain maximum service life from the suspension system, mounting bolts and nuts should be checked periodically and tightened to specified torque.

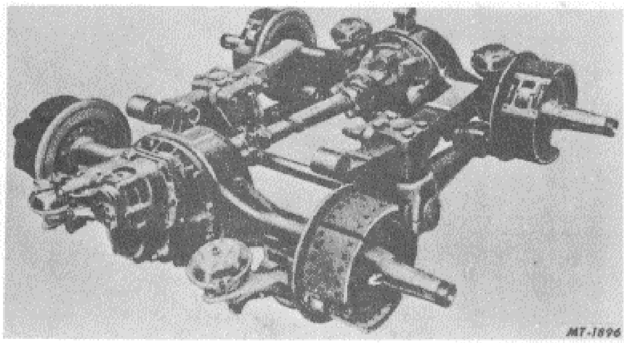


Fig. 1. Tandem Axle with Equalizing Beam Suspension

DESCRIPTION

Tandem drive axles require a special suspension which permits flexibility between the axles but still withstands rugged usage with long service life. The equalizing beam type suspension system described herein embodies these required characteristics. Types of equalizing beam suspensions used on IH trucks are: leaf spring type and rubber load cushion type. Air spring type, which uses rubber air bags in place of springs, is available as optional equipment.

Leaf Spring Type

The leaf spring type suspension (Fig. 2) uses semi-elliptic leaf springs to cushion load and road shocks. The springs are mounted on saddle assemblies above the equalizer beams and are pivoted at the front end on spring pins

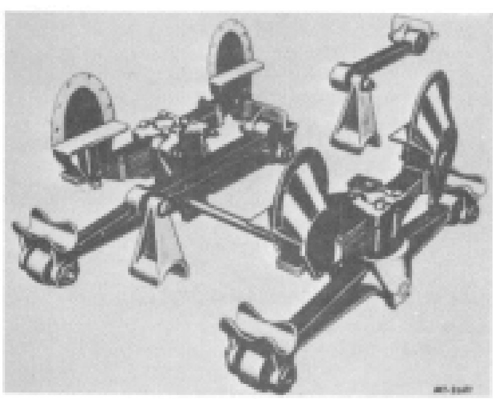


Fig. 2. Equalizing Beam Suspension Leaf Spring Type)

and brackets. Rear ends of springs have no rigid attachment to spring brackets, but are free to move forward and backward to compensate for spring deflection.

The equalizing beams utilize the “lever” principle to distribute the load equally between axles and to reduce the effect of bumps and road irregularities. The torque rods permit complete absorption of torque, which is the tendency of the axles to turn backwards or forward on their axis due to starting or stopping inertia. The cross tube connecting the equalizing beams assures correct alignment of the tandem and prevents damaging load transfer.

LUBRICATION

All oscillating parts with the exception of spring pins and optional bronze center bushings are rubber bushed. Since rubber bushings require no lubrication, lubrication points have been reduced to a minimum. Those suspensions equipped with spring pins and/or bronze bushings should be lubricated at the fittings provided with viscous chassis lubricant every 1000 miles or at the time of regular chassis lubrication.

DISASSEMBLY

Except for different suspension (leaf springs or rubber cushions) and slight variations in size, all equalizing beam suspension systems are disassembled in the same manner. There are several approaches to servicing the suspension system, but when a major overhaul is required, the complete tandem unit can be removed from the truck chassis. Torque arms, equalizer beams, springs and other parts, however, may be removed separately as required. When complete removal is performed, be careful when disconnecting torque rods, springs or rubber cushions from the frame since axle assemblies are free to roll or pivot at the equalizer beam ends. Use jacks and other equipment and block vehicle securely to prevent harm to personnel and to avoid damage to the unit.

Suggested disassembly procedure is as follows:

1. Disconnect propeller shafts, inter-axle lock control linkage (or piping), and brake lines from axles.
2. Place both rear axles on floor stands and remove wheels and tires.
3. Using overhead crane, raise truck frame sufficiently to relieve weight from suspension system. Block frame securely.
4. Disconnect torque rods from axle housing by loosening locknuts and driving the shaft from the bushing and the axle housing bracket.
5. Disconnect equalizer beams from axle housings:

<u>(Tube Type Beam End Mounting)</u>

   a. Remove equalizer beam end tube nuts.
   b. Pull or drive end tubes from axle housing brackets and beam end bushings. If end tube is frozen in bushing, install one nut on tube and tighten against bracket until tube breaks loose in bushing.

c. On vehicles with split-ring type bushing adapters, Fig. 6, a wrench is not required to hold the bolt nut. Place a bar between lugs projecting from adapter and use a wrench on bolt head.
6. Using roller jack, remove axle assemblies.
7. Support ends of equalizer beams and remove beam center bushing retainer caps from saddles. Remove equalizer beams and cross tube.
8. Separate equalizer beams from cross tube. Remove sealing compound or pipe plug from hole in outer end of beam center sleeve to break vacuum which may exist between center sleeve and cross tube.

9. Remove saddle assemblies:

(Leaf Spring Type)

a. Support spring and saddle assembly on floor jack. Loosen locknut on spring pin draw key. Back off nut sufficiently to protect draw key threads, then strike nut with soft hammer to loosen draw key. Remove draw key and drive spring pin out of spring and spring bracket. Lower spring and saddle assembly from frame and remove from jack.

b. Loosen spring aligning set screws. Remove bolts and nuts spring top pad to spring saddle. Remove spring pad and top pad slide. Remove spring from saddle.

CLEANING AND INSPECTION

Clean all dirt from suspension parts and inspect all parts carefully for cracks or damage.
Inspect rubber bushings for damage or deterioration. If the vehicle has been in service for a long time, it is advisable to replace all bushings.

REPAIRS

Most repairs to the suspension system consist of replacing worn or damaged parts. Rebuilding and rebushing of leaf type springs are standard procedures as covered in "Springs," General Section, CTS-2119. The major item which will concern the serviceman is removal and replacement of the rubber bushings.

While the bushings have long life and replacement will be limited, they can be replaced if damaged or deteriorated. Special service tools for performing this task are available and though recommended are not absolutely necessary. If press equipment is available, standard steel tubing having diameters to match the bushing sleeves (metal bands surrounding rubber bushings) can be used as adapters for removing and installing the bushings (see Adapter Chart). Press pressures required to remove the bushing and sleeve assemblies will generally be between 31 and 45 Mg (35 and 50 tons).

Suggested procedures for replacing the various bushings are outlined below:

REPLACING EQUALIZER BEAM BUSHINGS

CAUTION

When replacing equalizer beam bushings only the procedures outlined in this manual section should be exercised.

Welding, torching, drilling, tapping or attaching material to the equalizer beam must never be performed as such practice can result in equalizer beam failure. Equalizer beams are constructed of aluminum or nodular iron, metals which can easily become brittle with heat at quite low temperatures.

When replacing equalizer beam bushings the equalizer beams should be thoroughly inspected to ascertain if they have been heated, if cavities have been produced or otherwise damaged by improper servicing and if so, replace any components which are questionable.

(Equalizer Beam Removed)

Removing Equalizer Beam End Bushing

1. Cut off rubber bushing flush with equalizer beam, as shown in Fig. 7. Rubber must be removed to permit adapter to contact bushing sleeve squarely.
2. Remove bushing set screw, if used.
3. Support beam in press. Using a piece of standard tubing (which will contact the bushing sleeve) as an adapter, press the bushing from the beam. See Fig. 8.

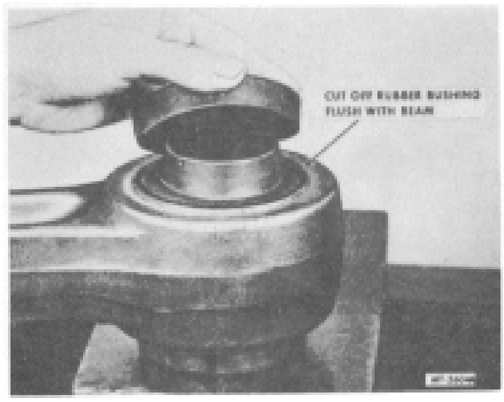


Fig. 7 Preparing for Removal of Beam End Bushing

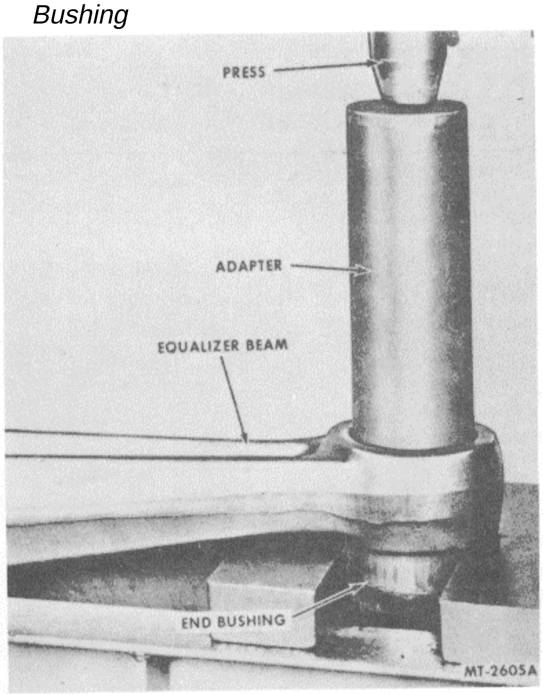


Fig. 8. Removing Equalizer Beam End Bushing

Installing Equalizer Beam End Bushing

1. Apply a thin coat of white lead to outer diameter of bushing sleeve.

2. Install sheave puller over bushing and compress rubber until puller jaws will seat on the end of the bushing sleeve. Refer to Fig. 9.

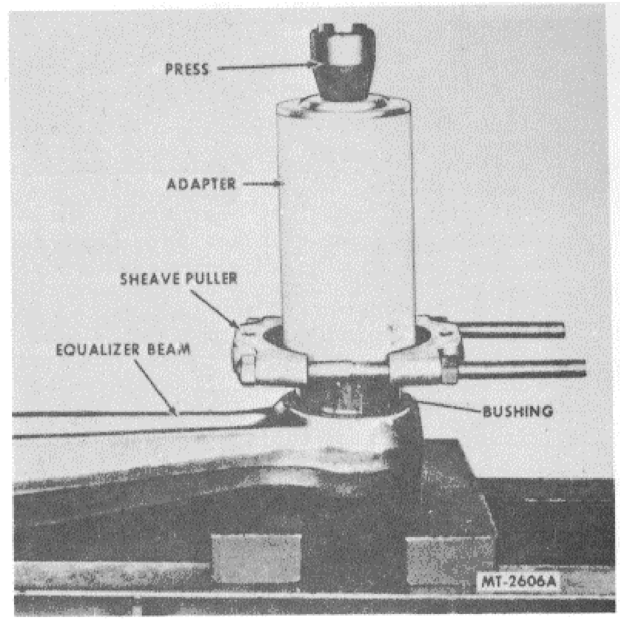


Fig. 9 Installing Equalizer Beam End Bushing

3. Continue pressing until bushing is centered in beam.

4. Install bushing set screw, if used.

Removing Equalizer Beam Center Sleeve and Bearing

1. Support beam in press, Using adapter made from appropriate size standard tubing to fit against center sleeve and bushing assembly, press out bushing assembly. See Fig. 10.

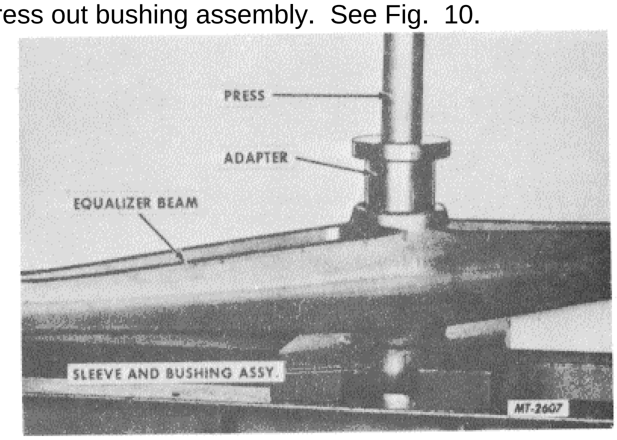


Fig. 10 Removing Equalizer Beam Center Sleeve and Bushing

Installing Center Sleeve and Bushing

1. Apply a thin coat of white lead to outside diameter of sleeve and bushing assembly.

   Support beam in press. Using adapter, press bushing and sleeve assembly into beam. See Fig. 11. Bushing and sleeve assembly should be centered in beam.

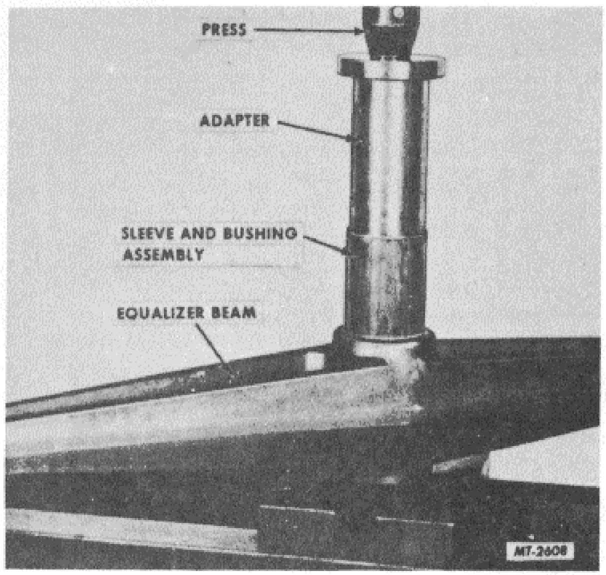


Fig. 11 Installing Center Sleeve and Bushing

REPLACING TORQUE ROD BUSHINGS

Removing Torque Rod Bushings

1. Cut off rubber bushing flush with torque rod, as instructed for equalizer end bushing removal. Refer to Fig. 7.
2. Support torque rod in press. Using a piece of tubing as an adapter, press bushing out of torque rod.

Installing Torque Rod Bushings

1. Apply a thin coat of white lead to outer diameter of bushing sleeve.
2. Install sheave puller over bushing and compress rubber until puller jaws will seat on end of bushing sleeve. Refer to Fig. 9.

3. Place adapter over end of bushing, resting on sheave puller. (See Fig. 12.) Press bushing into torque rod until bushing is centered in bushing bore.

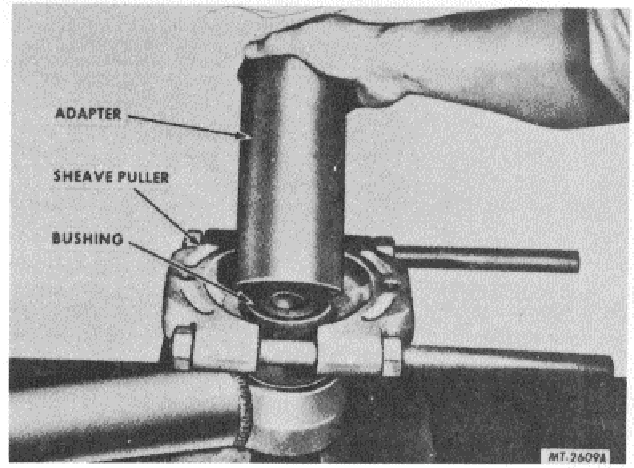


Fig. 12 Preparing to Press Bushing into Torque Rod

ASSEMBLY (Leaf Spring Type)

Assembling Spring to Saddle

1. Seat spring in spring saddle with head of spring center bolt positioned in hole provided in saddle.
2. Position spring top pad slide (Fig 13) over "cup" on main spring leaf.
3. Position spring top pad on spring making sure pad is properly seated.
4. Install saddle-to-top pad bolts and nuts. Run nuts up snug, but do not tighten completely at this time.
5. To properly position the spring in the saddle, tighten the spring aligning set screws to specified torque (see "Torque Chart"). Tighten aligning screw locknuts.
6. Tighten saddle-to-top pad bolt nuts to specified torque (see "Torque Chart").

Installing Spring and Saddle Assembly

1. Using roller jack, position spring (with saddle) in front and rear spring mounting brackets.
2. Align spring eye with spring pin bore in front bracket. Install spring pin, aligning draw key slot in pin with draw key bore in bracket.
3. Install draw key, lock washer and nut. Tighten nut to specified torque (see "Torque Chart").
4. Install lubricator fitting in spring pin. Lubricate pin with viscous chassis lubricant.

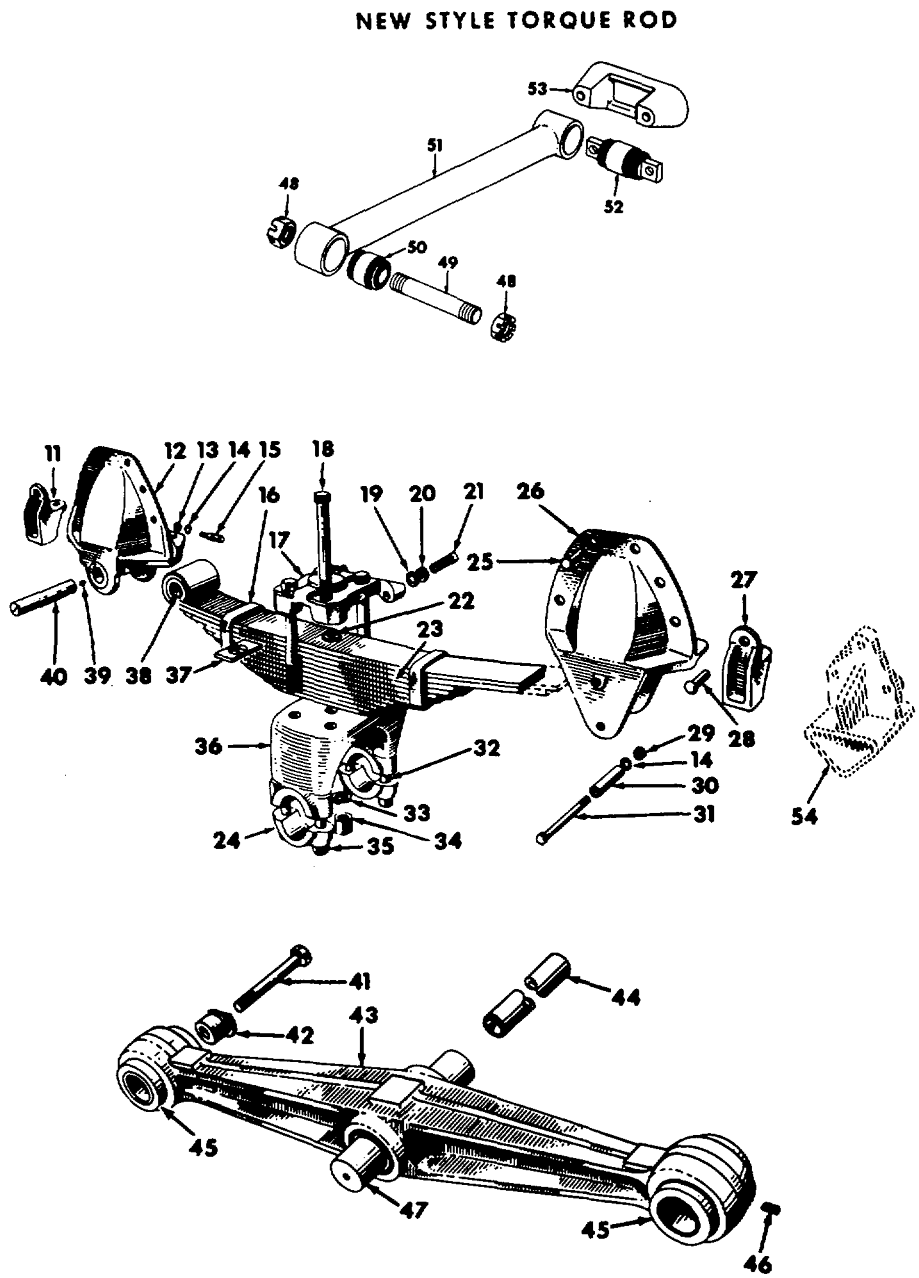


Fig. 13 Exploded View of Leaf Spring Type Suspension

Legend for Fig. 13

Key	Description	Key	Description	Key	Description
		19	WASHER, Lock	37	SLIDE, Top, Pad
		20	NUT	38	BUSHING, Spring Eye
		21	SCREW, Set	39	LUBRICATOR, Spring, Pin
		22	BOLT, Spring, Center	40	PIN, Spring, Front
		23	SPRING, Assembly	41	BOLT
		24	CAP, Retainer, Saddle	42	ADAPTER, Beam End
		25	RIVET, Bracket Mtg	43	BEAM, Equalizer
		26	BRACKET/, Spring, Rear	44	TUBE, Center, Cross
		27	STOP, Axle, Rear	45	BUSHING, Beam End
		28	RIVET	46	SCREW, Set
11	STOP, Axle, Front	29	NUT	47	SLEEVE, Beam, Center
12	BRACKET, Spring, Frt	30	SPACER	4.8	NUT
13	NUT	31	BOLT	49	SHAFT, Torque Rod
14	WASHER, Lock	32	STUD, Saddle, Cap	50	BUSHING, Torque Rod
15	KEY, Draw, Spring	33	WASHER, Lock	51	ROD, Torque
16	CLIP, Spring	34	NUT, Top, Pad, Bolt	52	SHAFT, W/Bushing Torque Rod
17	PAD, Top, Spring	35	NUT, Saddle, Cap Stud	53	BRACKET, Torque Rod
18	BOLT, Top, Pad	36	SADDLE, Assembly	54	BRACKET, Spring Rear Extended Leaf Only

CAUTION

Three types of equalizer beams are utilized in the manufacturing of International trucks equipped with equalizer beam suspensions. Although the appearance of the equalizer beams is similar, there is a substantial difference in the material of which they are manufactured.

The materials of the equalizer beams involved are aluminum, cast iron and nodular iron. Aluminum and cast iron equalizer beams are manufactured such that they can be stressed in either direction. Nodular iron equalizer beams are manufactured such that they can be stressed in one direction only. Thus, it is imperative that nodular iron equalizer beams be installed with the correct side up.

To aid in identification and facilitate installation of nodular iron beams, an arrow and the word UP have been molded on the side of nodular iron beams. Also, reinforcing gate pads have been designed into each end and middle of the top side of nodular iron beams.

Nodular iron equalizer beams must be installed with gate pads on top side of beam and the arrow molded on the beam side pointing upward.

Installing Equalizer Beams and Cross Tube

1. Place one equalizer beam in position in trunnion of spring saddle and install bushing retainer caps and nuts. Tighten the nuts only until the caps fit snugly against the bushing.

NOTE : Do not tighten bushing retainer cap nuts to specified torque until axles have been connected to equalizer beams.

2. Place cross tube seal assemblies in position on ends of cross tube (bronzed bushed models only).
3. Apply a light coat of chassis lubricant to the ends of the cross tube which fit into the beam center sleeves (bronze bushed models). On those models having rubber bushed center sleeves, wipe ends of cross tube clean and pack center bushing with approximately 2 ounces of viscous chassis lubricant.
4. Place one end of cross tube into center sleeve of installed equalizer beam. Be sure tube seats into sleeve.
5. Assemble other equalizer beam to cross tube and position beam in spring saddle. Install bushing retainer caps and nuts. Tighten the nuts only until the caps fit snugly against the bushings. (See "NOTE " above.)

6. Make sure cross tube seals assemblies are seated in equalizer beam center sleeves (bronzed bushed models only).

7. Install pipe plugs in ends of beam center sleeves or plug vent holes with sealing compound (Permatex No. 1 or equivalent).

Installing Axle Assemblies

1. Position axle assemblies under chassis frame.

2. Connect ends of equalizer beams to axle housing hanger brackets:

(Tube Type Beam End Mounting)

a. Apply a light coat of waterproof grease (Lubriplate 110 or equivalent) to outer diameter of end tubes.

b. Align the beam end bushings with hanger brackets and insert end tubes. Center tubes in bushings so that ends of tubes are equidistant from outer faces of hanger brackets.

c. Install end tube nuts. Make sure nuts are properly threaded on tubes. Tighten nuts evenly to specified torque (see "Torque Chart").

3. Tighten saddle cap nuts to specified torque (see "Torque Chart").
NOTE: Saddle cap nuts were not tightened completely when assembled to permit connecting of equalizer beams to axle housings. Therefore, nuts must be tightened after beams are connected to axles.

The cross center tube (44) is free to rotate or float in the bushing assemblies (47) at each side. However, in some cases where the vehicle has been operating in mud or perhaps water, the cross center tube may be found fast. Whether it is loose or fast will have no effect upon its purpose. The function of the tube is to assure alignment between the left and right equalizer beams (43).

The saddle caps serve to secure sleeve with bushing (47). The clamping effect of the caps against the sleeve and bushing has no effect upon the movement of the cross center tube.

4. Connect torque rods to axle housings and frame brackets. Tighten stud nuts to specified torque (see "Torque Chart").

5. Install wheels and tires. Connect propeller shafts, brake lines, interaxle lock control linkage or piping, etc.

6. On vehicles equipped with hydraulic brakes, bleed brake system and check for leaks. On vehicles with air brakes, check brake piping for air leaks.

REMOVING EQUALIZER BEAM BUSHINGS
(With Equalizer Beam in Place on Vehicles)

Special tool equipment (SE-1931) is available which can be used to replace the equalizer beam bushings without completely removing the equalizer beam from the chassis. The SE-1931 tool can also be used to replace the bushings with the equalizer beams removed. Operating instructions are furnished with the equipment.

ADAPTER CHART

Adapters which can be made locally from standard tubing for removing and installing rubber bushings. *Adapters to be used with sheave puller.	
Adapter Size	Application
6.9 cm O.D x 7.6 cm Long (2.75 in O.D x 3.0 in Long)	Torque Rod Bushing Remover
7.6 cm O.D x 7.6 cm Long* (3.0 in O.D x 3.0 in Long)*	Torque Rod Bushing Installer
11.0 cm O.D x 10.2 cm Long (4.25 in O.D x 4.0 in Long)	Equalizer Beam End Bushing Remover
11.4 cm O.D x 10.2 cm Long* (4.5 in O.D x 4.0 in Long)*	Equalizer Beam End Bushing Installer
13.7 cm O.D x 25.4 cm Long (5.38 in O.D x 10.0 in Long)	Equalizer Beam Center Sleeve Bushing Remover and Installer RT-500

POWER STEERING PUMP

(VICKERS)

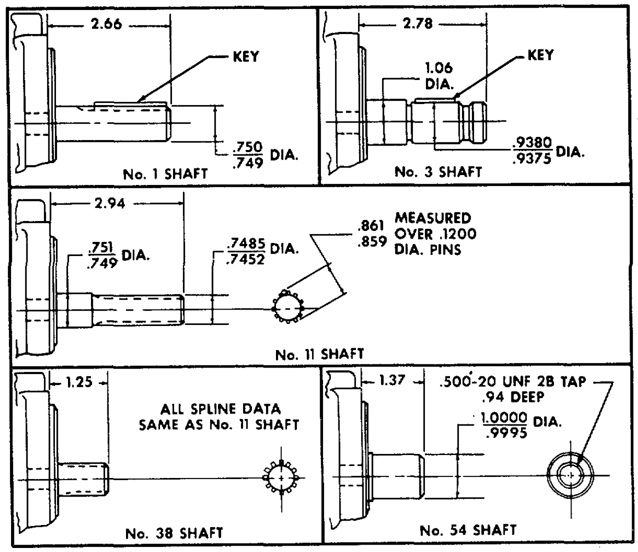
INDEX

SPECIFICATIONS

Manufacture	Vickers
Pump Type	Vane
Lubricant	SAE O1W-30
Truck Model	Paystar 5000 Series
Engine Model	All
Steering Gear Code	05298
Relief Valve Setting (PSI) with Engine RPM of 1000 to 1500	1750

Identification of Numbers and Letters

Which Appear on Body of Vickers Power Steering Pumps



V 20F 1 R 9 P 54 C

- V — VANE TYPE
- 20F — MODEL SERIES
- 1 — TYPE MOUNTING 1 = TWO BOLT FLANGE 4 = SIX SCREW ADAPTER
- R — INLET PORT CONNECTION
- 9 — FLOW CONTROL AT 1200 RPM AND 100 P.S.I. 9 = NINE GALLON PER MINUTE ETC.
- P — OUTLET PORT CONNECTION
- 54 — SHAFT TYPE (# 1-3-11-38-54 SEE FIG. 2)
- C — OUTLET PORT POSITION A = OPPOSITE SIDE OF INLET (COVER END)
  B = 90° COUNTERCLOCKWISE FROM INLET
  C = IN LINE WITH INLET (SAME SIDE)

6E 11 008 L

- 008 — PRESSURE PORT 3/8 NPT INSTEAD OF STANDARD 3/4-16 NF
- 11 (second digit) — MODIFICATIONS 0 = NONE 1 = ONE ETC.
- 11 (first digit) — DESIGN 1 = FIRST 2 = SECOND ETC.
- E — RELIEF VALVE PRESSURE (P.S.I.) C = 750 D = 1000 E = 1250 F = 1500 G = 1750
- 6 — GALLONS FLOW PER MINUTE 6 = SIX GALLONS 8 = EIGHT GALLONS ETC.
  NOTE: RELIEF VALVES HAVE A CODE STAMPED ON THE END OF THE VALVE PLUG. THESE CODES ARE DEFINED AS FOLLOWS 07 = 750 P.S.I. 10 = 1000 P.S.I. 15 = 1500 17 = 1750
- L — ROTATION L = LEFT HAND ROTATION VIEWED FROM SHAFT END. NO MARKING DESIGNATES RIGHT HAND ROTATION

DESCRIPTION

The pump illustrated in Fig. 1 consists principally of a ported body, a drive shaft supported by two ball bearings, a pumping cartridge and a pressure plate. The components of the cartridge are an elliptical ring, a slotted rotor splined to the drive shaft and twelve vanes fitted to the rotor slots. As the rotor is driven by the drive shaft, the vanes generate fluid flow by carrying fluid around the elliptical ring contour. Fluid enters the cartridge through the inlet port in the body and is discharged through the pressure plate to the outlet port in the cover,

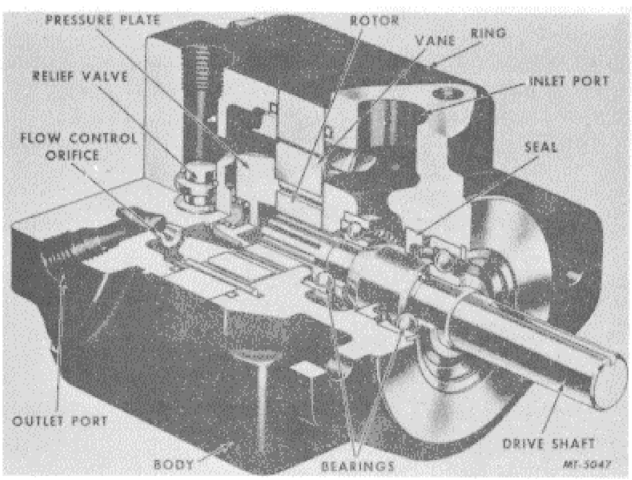


Fig. 1 Cutaway of Pump.

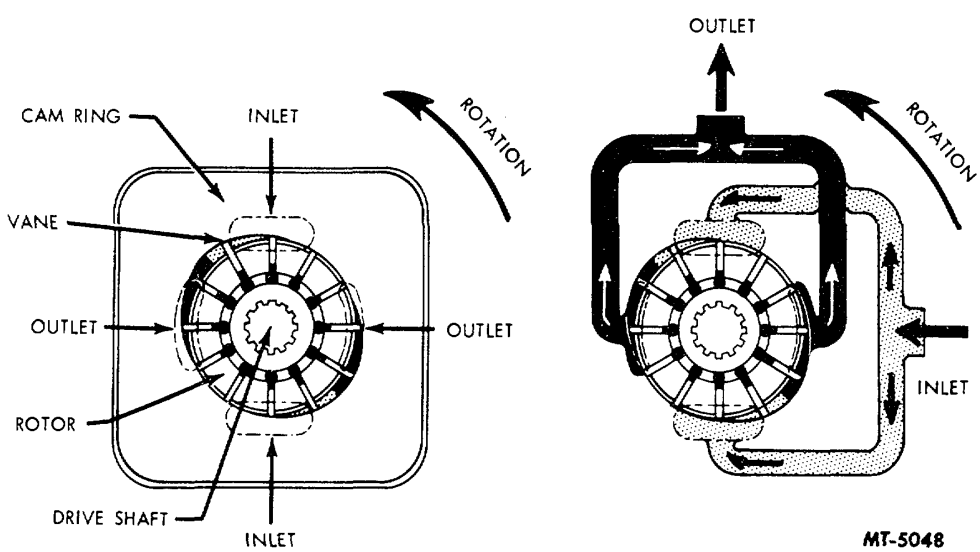
The pump cover incorporates the integral Flow Control and Relief Valve. This limits the fluid flow in the system to a maximum prescribed rate and prevents excessive pressure build-up. Fluid not required in the system is recirculated to tank.

OPERATION

The action of the pumping cartridge is illustrated in Fig. 2. The rotor is driven within the ring by the drive shaft, which is coupled to a power source. As the rotor turns, centrifugal force on the vanes causes them to follow the elliptical inner surface of the ring.

Radial movement of the vanes and turning of the rotor cause the chamber between the vanes to increase as the vanes pass the inlet section of the ring. This results in a low pressure condition which allows atmospheric pressure to force fluid into the chambers. (Fluid outside the inlet is at atmospheric pressure or higher).

This fluid is trapped between the vanes and carried past the large diameter or dwell section of the ring. As the outlet section is approached, the ring diameter decreases and the fluid is forced out into the system. System pressure is fed under the vanes, assuring their sealing contact against the ring during normal operation.



The pump ring is shaped so that the two pumping chambers are formed diametrically opposed. Thus, hydraulic forces which would impose side loads on the shaft cancel each other out.

The pressure plate seals the pumping chamber as shown in Fig. 3. A light spring holds the plate against the cartridge until pressure builds up in the system. System pressure is effective against the area at the back of the plate, which is larger than the area exposed to the pumping cartridge. Thus, an unbalanced force holds the plate against the cartridge, sealing the cartridge and providing the proper running clearance for the rotor and vanes.

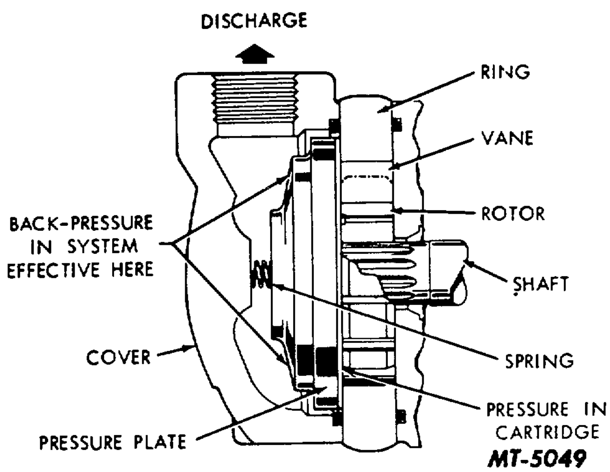


Fig. 3

Maximum pump delivery and maximum system pressure are determined by the integral flow control and relief valve located in the cover. This feature is illustrated schematically in Fig. 4.

An orifice in the cover limits maximum flow. A pilot-operated type relief shifts to divert excess fluid delivery to tank, thus limiting the system pressure to a prescribed maximum.

Fig. 4A shows the condition when the total pump delivery can be passed through the orifice. This condition usually occurs only at low drive speeds. The large spring chamber is connected to the pressure port through an orifice. Pressure in this chamber equalizes pressure at the other end of the relief valve spool and the light spring holds the spool closed. Pump delivery is blocked from the tank port by the spool land.

When pump delivery is more than the flow rate determined by the orifice plug, a pressure build-up forces the spool open against the light spring. Excess fluid is throttled past the spool to the tank port as shown in Fig. 4B.

If pressure in the system builds up to the relief valve setting, Fig. 4C, the pilot poppet is forced off its seat. Fluid in the large spring chamber flows through the spool and out of the tank. This flow causes a pressure differential on the spool, shifting it against the light spring. All pump delivery is thus permitted to flow to tank.

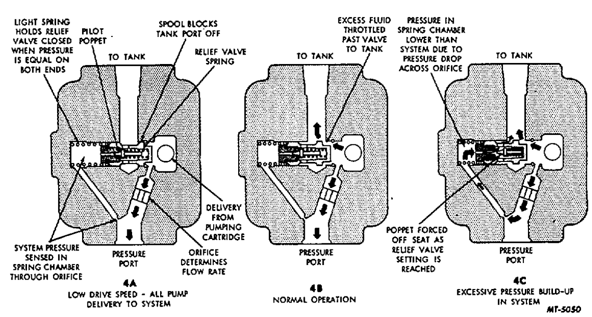


Fig. 4

DISASSEMBLY

During disassembly, pay particular attention to identification of the parts, for correct reassembly. Pump bearings are pressed in the body or on the shaft and should not be removed unless defective. Fig. 5 is an exploded view which shows the proper relationship of the parts for disassembly and reassembly.

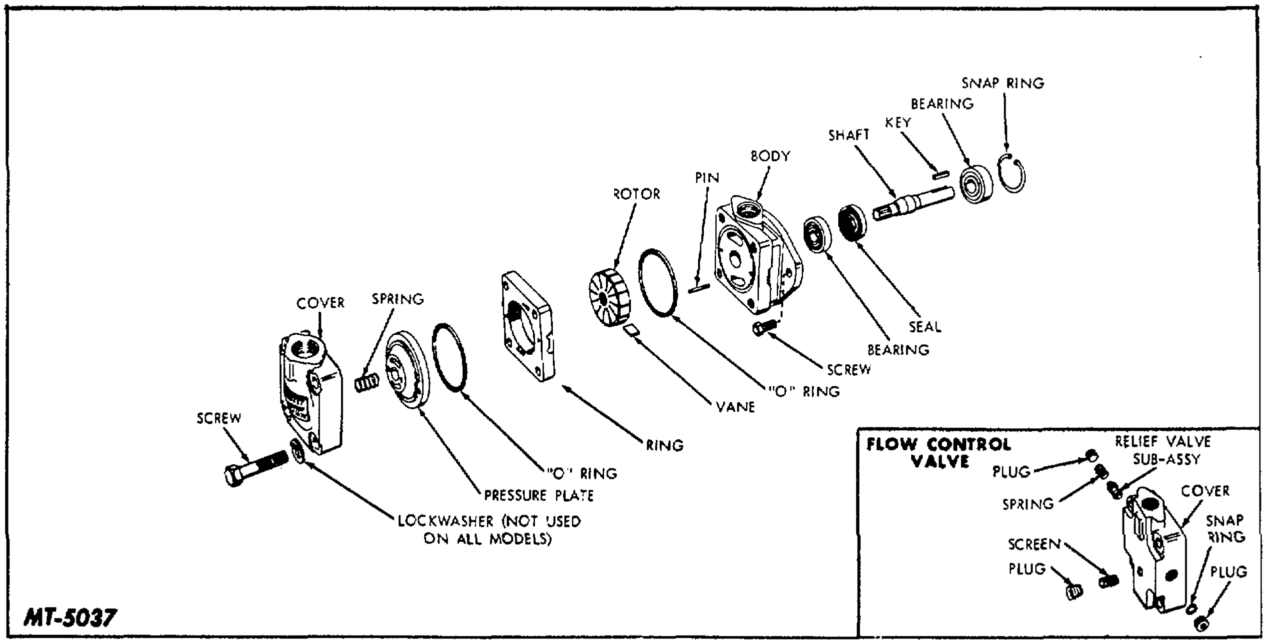


Fig. 5 Exploded View of Pump.

1. NOTE: Before disassembly scribe a line across the cover, ring and body as shown in Fig. 6. This will assure correct reassembly.

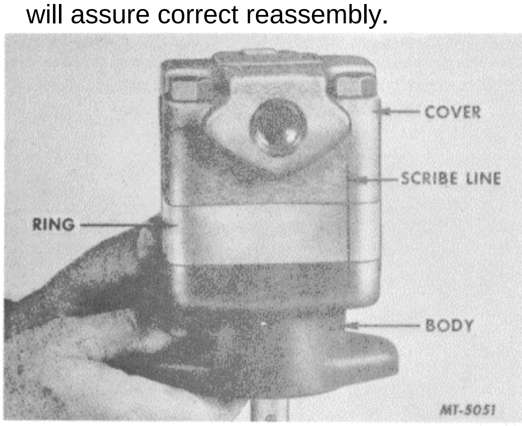


Fig. 6

2. Clamp the pump body in a vise (not too tightly) cover end up, and remove the four cover screws, cover and “O” ring, Fig. 7

3. Remove the pressure plated and spring, Fig. 8.

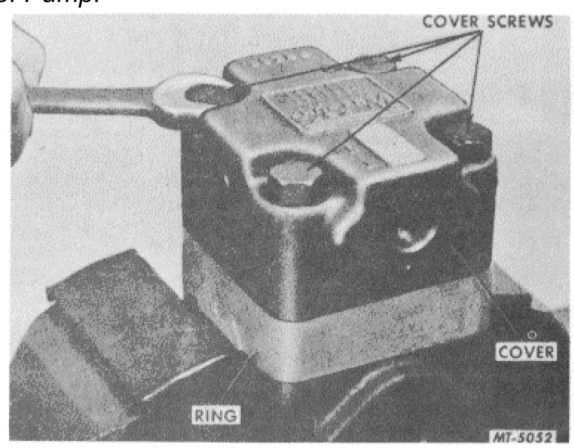


Fig. 7

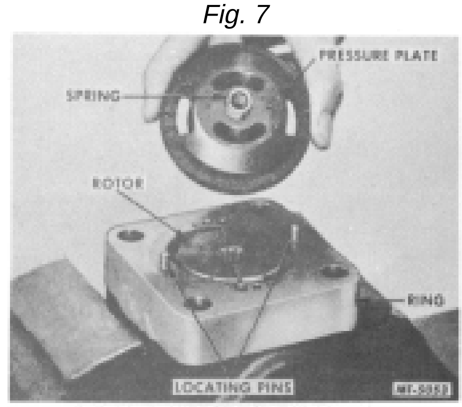


Fig. 8

4. Lift off the ring and remove the locating pins, Fig.9.

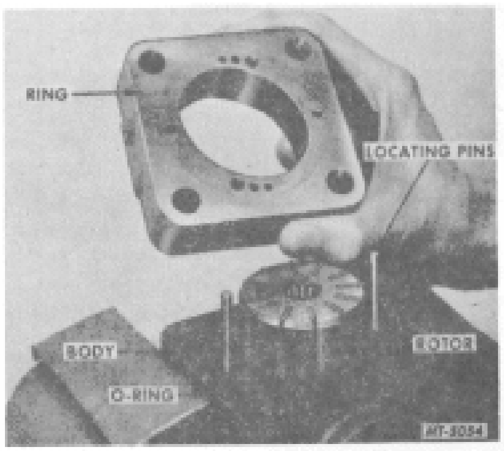


Fig. 9

5. Remove the **"110** ring from the body, Fig. 10.

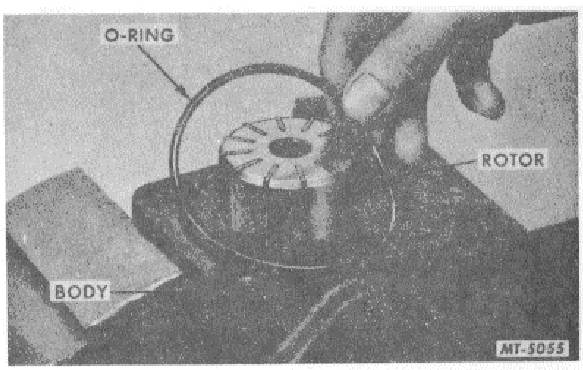


Fig. 10

6. Separate the vanes from the rotor and remove the rotor from the shaft, Fig. 11.

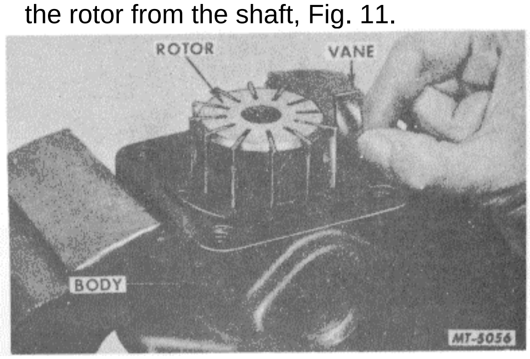


Fig. 11

7. Remove drive gear from shaft and key if so equipped.

8. Using Tru-Arc pliers remove the snap ring retaining the outer bearing in the body, Fig. 12.

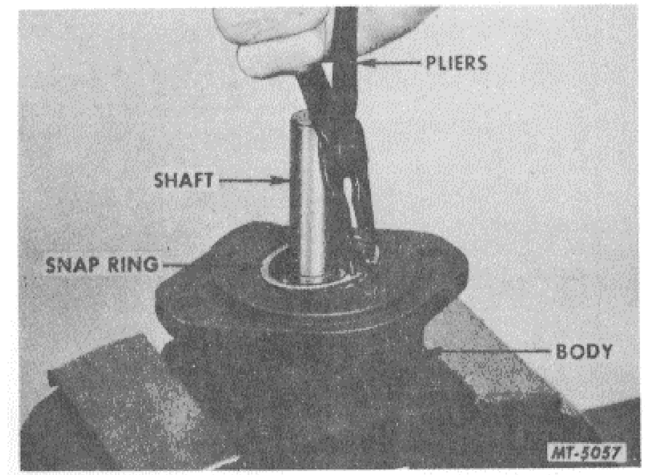


Fig. 12

9. With a soft hammer tap on the splined end of the shaft to force the shaft and

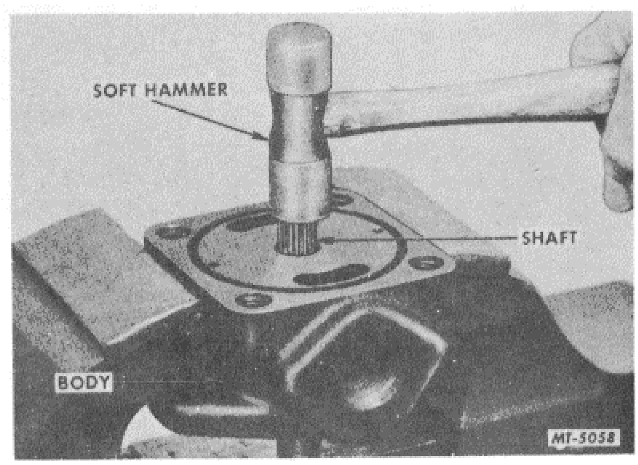


Fig. 13

10. Support the bearing inner race and press the shaft out of the bearing, Fig. 14.

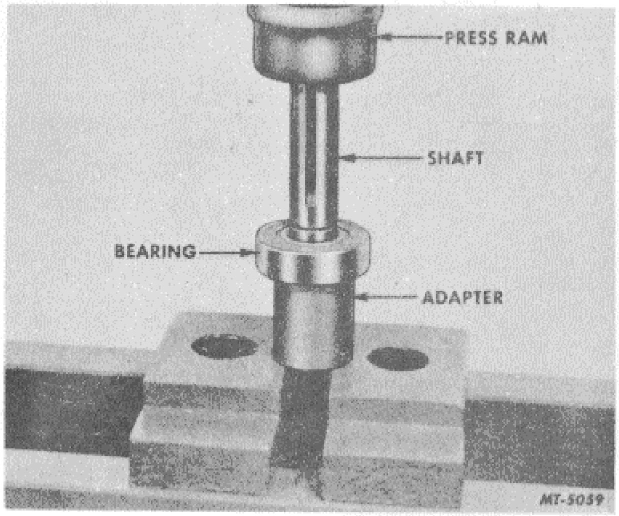


Fig. 14

11. Using puller SE-1961 remove shaft seal from body, Fig. 15.

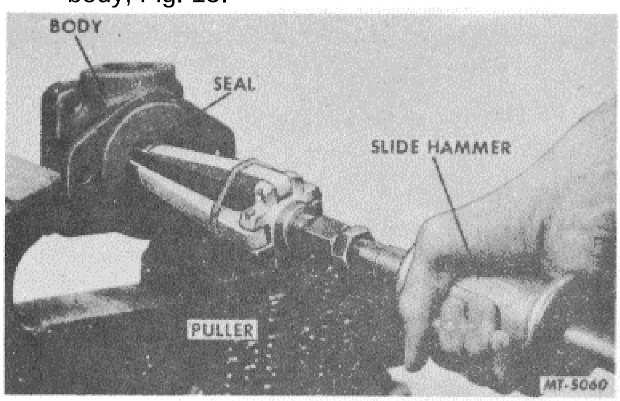


Fig. 15 Removing Shaft Seal Using Puller SE-1961.

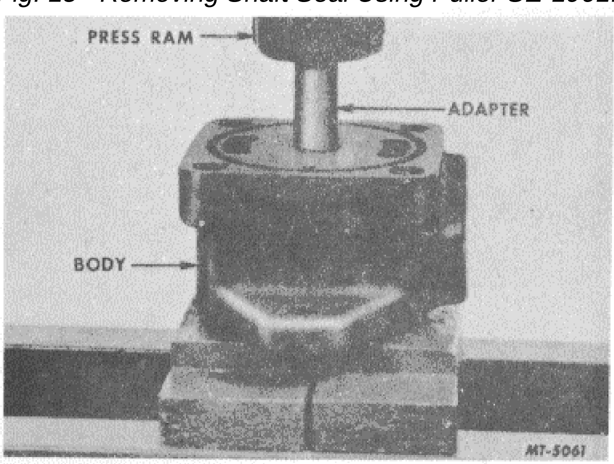


Fig. 16

12. With a suitable adapter press out the inner bearing from the body, Fig. 16.
13. Remove the plug and pull out the screen (see insert Fig. 5). Do not remove the orifice plug unless it is necessary.
14. Check whether there is a plug at each End of the relief valve bore in the cover. If the bore is blind, remove the plug and snap ring to release the valve and spring as shown in the insert in Fig. 5. If the bore is through the cover, remove only the one plug to release the spring and valve, Fig. 17. Leave the snap ring and the other plug in the cover.

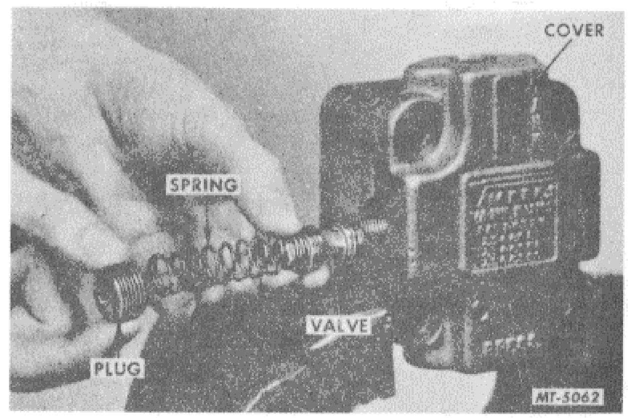


Fig. 17

INSPECTION AND REPAIR

Discard the used shaft seal and all "O" rings. Wash the metal parts in mineral oil solvent, blow them dry with compressed air and place them on a clean surface for inspection.

Check the wearing surfaces of the body, pressure plate, ring and rotor for scoring and excessive wear. Remove light score marks by lapping. Replace any heavily scored or badly worn parts.

Inspect the vanes for burrs, wear and excessive play in the rotor slots. Replace the rotor if the slots are worn.

Check the bearings for wear and looseness.

Rotate the bearings while applying pressure to check for pitted or cracked races. Inspect the oil seal mating surface on the shaft for scoring or wear. If marks on the shaft cannot be removed by light polishing, replace the shaft.

Check the relief valve sub-assembly for free movement in the cover bore. Remove burrs from the valve by polishing, but do not round off the corners of the lands. Do not attempt to rework the valve bore. If the bore is damaged, replace the cover.

REASSEMBLY

Coat all parts with hydraulic fluid to facilitate reassembly and provide initial lubrication. Use small amounts of petroleum jelly to hold "O" rings in place during assembly.

1. If the cover has a through bore, insert the valve in the bore, small land first. Then install the spring and plug. On pumps having a blind bore, first install the spring, then the valve with hexagon head end first. Follow this with the snap ring being certain it is firmly seated in the groove, then install the plug. Install the screen and plug in the cover.

2. Press the shaft into the front bearing while supporting the bearing inner race. NOTE: Bearing should seat against shoulder on shaft.

3. Press the inner bearing into the body, using a driver or adapter which contacts the outer race only. NOTE: Make sure the bearing is firmly seated in the body.

4. Before assembling the shaft seal, determine the correct position of the seal lip. Double lip seals are assembled with the spring toward the rotor end of shaft. Single lip seals have two pressure holes, which are assembled toward the drive end of the shaft.

5. Press the seal firmly in place and lubricate the lip with petroleum jelly.

6. Slide the drive shaft into the body until the bearing is seated. Tap lightly on the end of the shaft if necessary.

7. Install the bearing snap ring in body.

8. Install new "O" rings in the body and cover.

9. Insert the ring locating pins in the body and assemble the ring aligning the scribe marks previously made before disassembly.

10. Install the rotor on the shaft and insert the vanes in the rotor slots. Be certain the radius edges of the vanes are toward the cam ring.

11. Place the pressure plate on the locating pins and flat against the ring.

12. Apply a small amount of petroleum jelly to one end of spring and position in recess in the pressure plate.

13. Carefully install the cover aligning the marks previously made before disassembly. Install the cover screws and torque to 70 ft. lbs.

14. Turn the shaft by hand to insure that there is no internal binding. Then install the shaft key if so equipped.

LUBRICATION

Sheppard Steering Gears use SAE 10W-30 engine oil.

1. Fill reservoir to indicated level and replace cap.
2. Start engine and idle, turning wheels to the full left and right three times. Shut off engine and refill reservoir to indicated level.
3. Continue operation in step "2" until system maintains its proper indicated oil level.
4. Run engine at faster speed and continue turning wheels slowly from full left to full right and back again for approximately five minutes to check for leaks. This will bleed the system of air. Again refill the reservoir to the indicated level or to 1-1/2" below top of filler neck on reservoir without dipstick attached to filler cap.

NOTE: THE ABOVE INSTRUCTIONS ARE IMPORTANT.

TROUBLESHOOTING PROCEDURE

A. A thorough and orderly troubleshooting procedure will help you diagnose power steering troubles quickly. Troubles occur in many places, show uF in various ways; but with this procedure, you can eliminate many possibilities immediately, narrow down the cause of trouble, then make correct repairs promptly.

1. We have arranged the troubleshooting procedure into three-steps:
   a. Define the complaint.
   b. External inspection.
   c. Hydraulic system check.
2. This procedure is an overall one. By following it step by step, you should be able to identify nearly every trouble which may occur in a hydraulic power steering system. As you become more familiar with troubleshooting, you can leave out some steps on some jobs.

B. The first step in finding trouble is to define the complaint. Properly identifying the complaint will let you eliminate many possible causes at once. Just like a doctor, you must know what and where the trouble is before you can correct it.

1. When a driver brings in his truck with a complaint, ask him to explain the trouble in his own words. (Sometimes a driver expects easier steering than his system is designed to give.) As you talk with him, make notes of his comments, look the system over for obvious defects. You may spot at first glance such things as uneven tire wear, evidence of leakage or a frame out of line. Determine the type and arrangement of the power steering system.
   Here are some sample questions you should ask the driver:

   a. How does the steering act?
   b. Does it act this way all the time?
   c. Does it occur in only one direction?
   d. Under what conditions does it usually occur?
   e. Is it accompanied by unusual noises?
2. If after talking with the driver you are still unable to define the complaint, ask him to accompany you and drive the vehicle yourself. Observe steering action, think, visualize the system in operation. Perform actions in which the driver said trouble occurred; try other steering actions too, to give you a complete and accurate definition of the trouble. You may want to try these steering actions:

   a. Turn steering wheel while standing or moving slowly. (Standing with vehicle loaded, hydraulic power may not be sufficient.)
   b. Steer in both directions while moving.
   c. Turn steering wheel rapidly one or two turns in both directions.
   d. Observe action when traveling straight ahead.

C. The second step is an external inspection. Look for the obvious defects first to save time.

1. Check hydraulic fluid reservoir for correct level. Insufficient oil will cause loss of pressure and hard steering. An extremely low supply may allow air to enter the system causing a "growling" noise and a "lump" in steering, A reservoir overflow means it is too full, the filter is out of place or in bad condition.

2. Check tire pressure and tire wear due to improper alignment or balance. Faulty tires can cause hard steering and other undesired steering actions.

4. Check system over for external leakage. Leakage is usually indicated by an oilwetted area, oil dripping or oily dirt accumulation. Since air and fan draft have probably spread leaking oil, clean the entire system off thoroughly, then operate and watch for leakage. Usual points for leaks are around fittings or along hoses which have burst or split under stress and strain. Leakage can cause the same troubles as a low oil supply in the reservoir and a "lump" or hard spot in steering. Air occasionally causes shimmy too.

D. The third step is to check pump pressure.

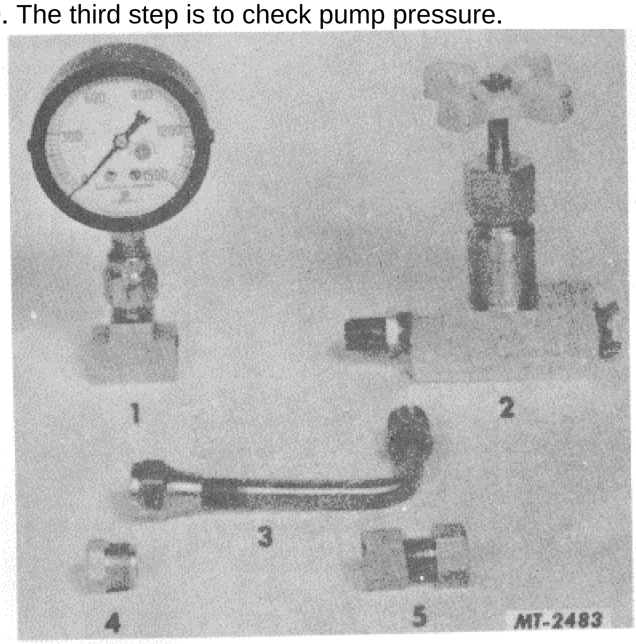


Fig. 18 Special Testing Equipment

PRESSURE CHECKING THE POWER STEERING PUMP SYSTEM

To check the hydraulic system, we use a pressure gauge and high pressure shutoff valve. Here is the specially designed testing equipment. Use standard hydraulic hose con .,/ nections with the testing equipment.

The special equipment as shown in Fig. 18 is designated as SE-1985 and consists of the following:

1.	SE-1985-1	Pressure Gauge
2.	SE-1985-2	Shutoff Valve
3.	SE-1985-3	90° Angle Tube Line Assembly
4.	SE-1985-7	Flared Plug
5.	SE-1985-8	Inverted Flared Cap

First check the entire system for pressure, then the components to isolate a malfunction.

1. Insert the pressure gauge and shutoff valve between the pump and control valve, as shown in Fig. 19.

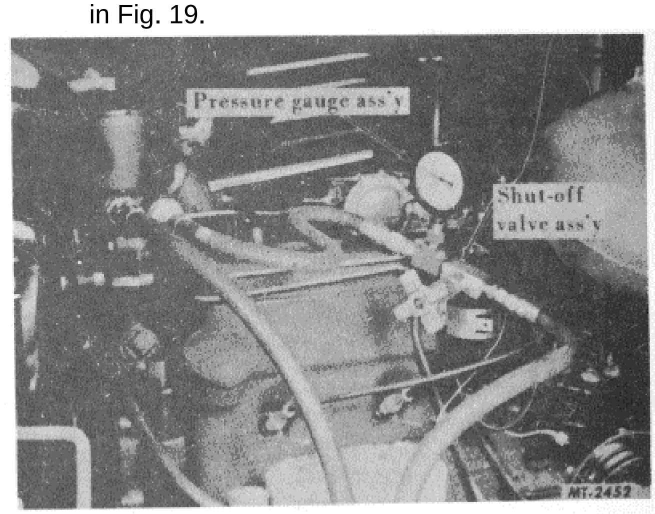


Fig. 19 Pressure Gauge Installed in System

a. With the engine running above idle, shutoff valve open, read the gauge while someone turns the steering wheel. If the correct pump relief valve pressure registers on the gauge when the wheels reach the end of full travel, the hydraulic system checks satisfactorily, and it is not necessary to go any further with hydraulic check. Trouble is probably mechanical or due to other causes such as abnormal front-end weight.

NOTE: System with a shuttle valve in the cylinder may register a sharp dropoff in pressure at end of wheel travel; this is normal.

b. If the specified relief valve pressure is not reached and steering is hard, our system is failing somewhere.

c. If our first check indicates low hydraulic pressure, we must test the components to pinpoint the place of trouble. Leave the pressure gauge and shutoff valve installed, front wheels stationary.

2. Check the pump first:

a. Gradually close the shutoff valve; pressure gauge should register relief valve pressure just before or just at closing of the valve. If it does, the pump is working correctly.

NOTE: Do not keep shutoff valve closed longer than 15 seconds; oil may overheat and damage pump and seals.

b. If the correct pressure does not register, the pump is faulty. Trouble may be any of the following: seized or "frozen" surfaces, scoring on end faces of gears or housing, binding, scored or damaged teeth, rotors or vanes, dirt or stickiness of flow control valve or pressure relief valve, a leaky pump shaft seal.

c. A hydraulic pump requires finely machined surfaces for operation. A clean workbench must be used for disassembly and repair. (Clean wrapping paper makes a good, disposable workbench top.) Clean pump off with clear, clean solvent before disassembly; blow dry with clean air. Lint from wiping rags can destroy the exact fit required of some surfaces.

3. If the pump is okay, check the steering control valve:

a. Disconnect the hydraulic hose at one cylinder port; cap the end of the hose using cap SE-1985-8 and plug the port using plug SE19857. Leave the shutoff valve open, engine running above idle; from a straightahead position have someone turn the front wheels approximately 1/4 turn to the left or until you feel pressure buildup; check the pressure gauge. Approximately 1/4 steering wheel turn to the right check gauge again. The specified relief valve pressure should register for both directions, indicating the steering control valve is okay.

b. If the specified pressure is not reached, the valve is faulty; we may have hard steering in either or both directions.

c. Valve trouble is usually internal leakage--most often caused by worn seals. Rusting, pitting or scoring of surfaces with which they contact affects greatly the life of seals. Check these surfaces when you disassemble a valve; minor damage can sometimes be touched up with crocus cloth; noticeable rough surfaces require replacement of the part.

d. Check for dirt and scoring; a valve must move freely and without sticking. Cleanliness and care are a must when working on a steering control valve. Forcing or abusing closely fitted parts of any components will probably damage them enough to requite replacement.

4. Assume in the first teat we found the hydraulic system was not maintaining enough pressure to give us power for steering, but our second test indicated the pump was working property, Our third pressure gauge check told us the coiitrol valve was also working correctly,

This leaves only the cylinder as the point of trouble, providing no other troubles such as binding or friction were missed in the previous checks. If not, we can conclude that our trouble is in the cylinder and proceed to locate the point of failure.

a. Cylinder trouble is usually leakage--internal due to scored cylinder walls or broken piston rings, or external around a bent, scored or binding piston rod or leaky rod seals.

b. A shuttle valve sticking open will cause a loss of pressure too. If the cylinder has a shuttle valve, be sure to check it.

c. A cylinder functioning improperly cannot apply sufficient power to the steering linkage. Hard steering is the result.

STEERING GEAR

WITH INTEGRAL POWER

VALVE AND CYLINDER
CODE 05298

INDEX

SPECIFICATIONS

IH Model	S-298
IH Code	05298
Ratio	18.8 to 1
Pitman Arm Travel (Available Degrees)	100
Power Steering Pump Relief Valve Setting (PSI) with Engine RPM of 1000 to 1500	1750

DESCRIPTION

The power steering gear *unit* is a self-contained assembly utilizing an integral power cylinder and control valve in the gear housing. Figs. 1 and 2 are external views of the steering gear.

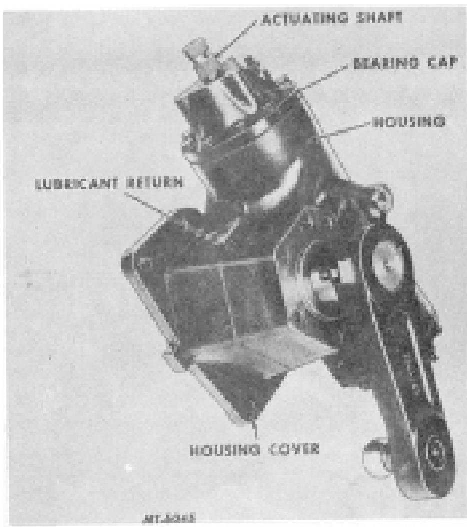


Fig. 1 External View

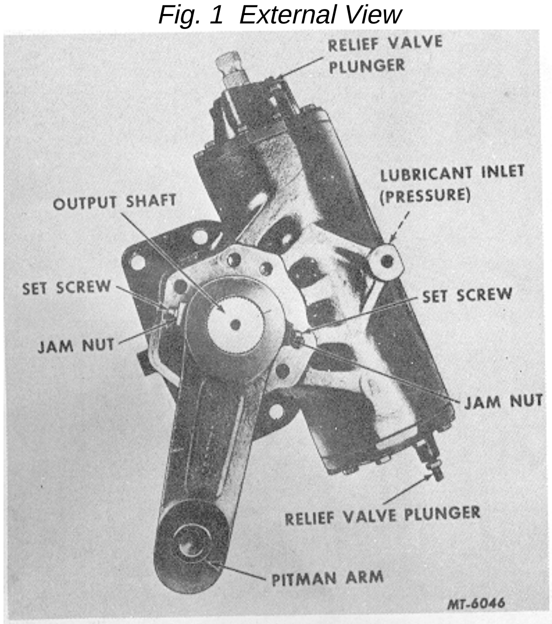


Fig. 2 External View

OPERATION

There are four basic parts in the steering gear assembly. They are the actuating shaft, valve, piston and the output shaft and pinion gear assembly, Fig. 3.

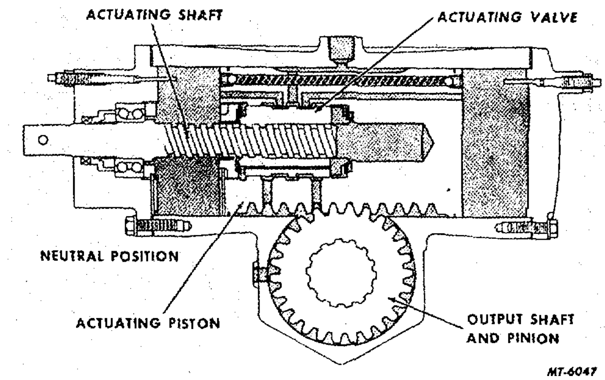


Fig. 3 Sectional View of Steering Gear Assembly

For steering gear operation, see Fig. 4.

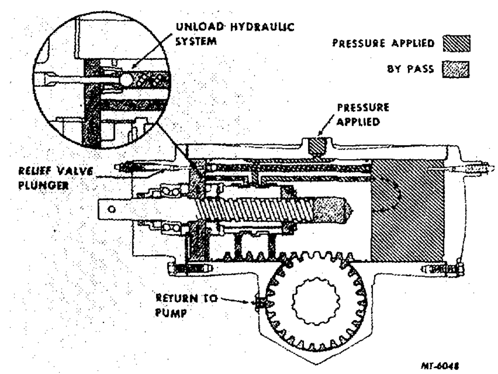


Fig. 4 Sectional View of Steering Gear Assembly in Applied Position

Actuating Shaft

The steering column is connected to the actuating shaft. This shaft is threaded with an Acme type thread. It is also retained in the bearing cap by locking nuts and operates on a heavy-duty double row ball bearing.

Actuating Valve

The actuating valve is threaded to accommodate the actuating shaft. The valve moves on the threads of the actuating shaft when the shaft is turned. The valve is housed in the -piston and retained there by a large indexed locking nut.

<u>Actuating Piston</u>

The actuating piston moves in the gear housing. There are two ports on the outside diameter of the valve which direct the oil flow through the piston. The valve has about 1/32" linear motion within the piston, which permits the edges of the ports to seat against mating edges on the inside of the piston, directing the oil flow to either end of the piston.

<u>Output Shaft and Pinion</u>

One side of the piston assembly is equipped with teeth (rack) which are engaged with the pinion gear on the output shaft. When the piston moves back and forth within the housing, the gear turns, providing the rotating action of the pitman arm, which is connected to the steering linkage.

Relief valve plungers (adjustable stops) are provided at the bearing cap and cylinder head location which automatically unload the hydraulic system when the wheels are turned to either extreme direction. This protects the mechanism from undue strain and damage in that a clearance is provided at the wheel stops, Fig. 4.

DISASSEMBLY

1. To drain oil from the steering gear assembly, disconnect the return hose from the pump and turn the steering wheel completely to the right and then to the left. This will remove most of the oil from the housing.

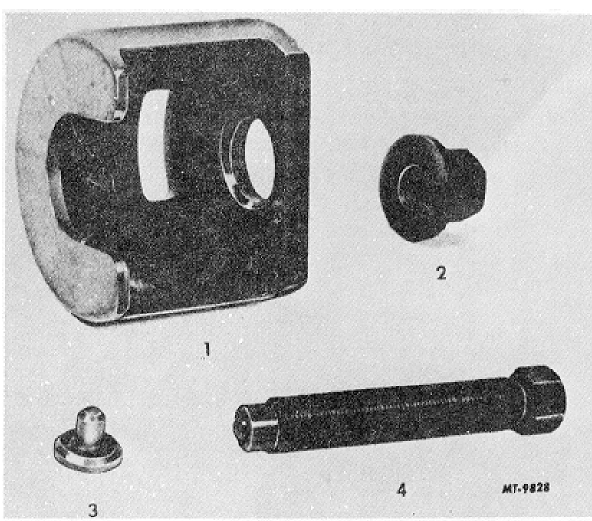


Fig. 5 Pitman Arm Puller

Consists of:

SE-2394-1 Puller Body (Fig. Ref. 1)
SE-2394-2 Hex Flange Nut (Fig. Ref. 2)
SE-2394-3 Forcing Screw (Fig. Ref. 3)
SE-2394-4 Adapter (Fig. Ref. 4)

2. Place steering gear in a suitable overhaul stand. NOTE: When disassembling the gear, make reference marks of your own so that the gear may be reassembled to the same adjustments.
3. Using pitman arm puller SE-2394, Fig. 5, remove pitman arm from output shaft as follows: The puller is applied to the arm as shown in Fig. 6. With the puller screw contacting end of levershaft, turn hex flanged nut to remove pitman arm. Additional pulling effort can be obtained by turning both the flanged nut and forcing screw. Where necessary install adapter at levershaft to provide a seat for the forcing screw.

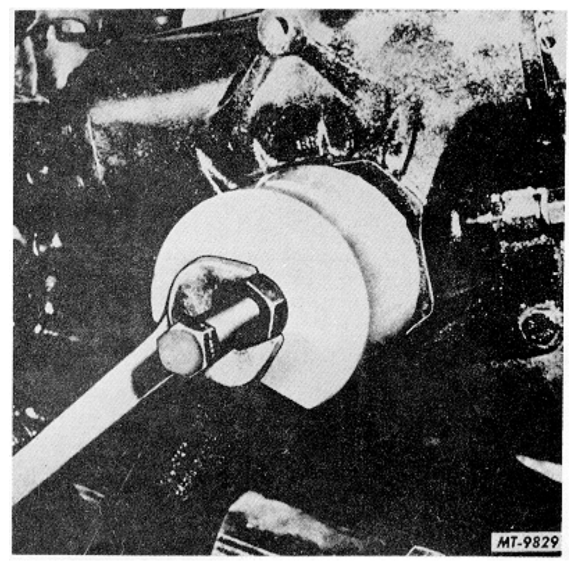


Fig. 6

4. Loosen jam nut on the relief valve plunger and remove the plungers from both ends of gear, Fig. 7.

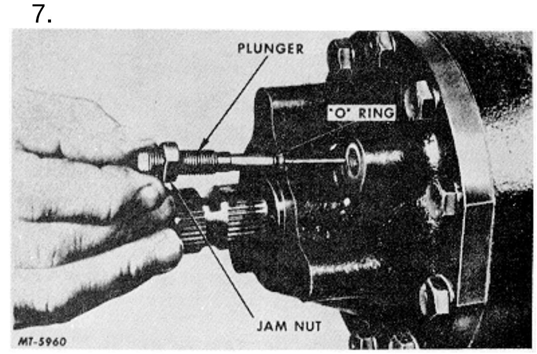


Fig. 7

5. Remove housing cover from steering gear assembly, Fig. 8. Use a soft hammer and tap on end of the output shaft to loosen cover. The output shaft and gear assembly may be removed with the cover. Observe the timing mark on the rack, which is located on the center tooth of the piston. This mark should be in alignment with the timing mark on the pinion gear when reassembly is performed.

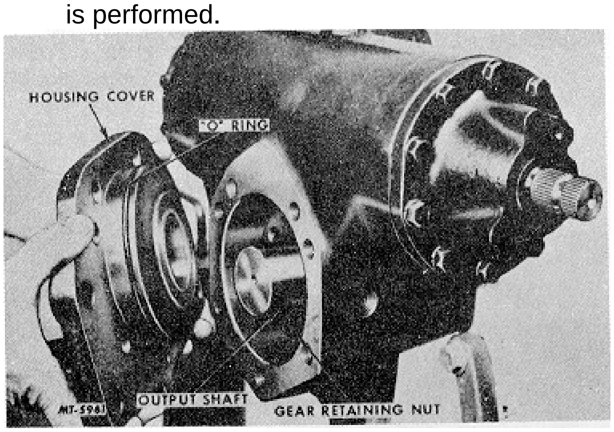


Fig. 8

6. Remove the capscrews from the output shaft gear using an Allen wrench. Then the gear retaining nut may be removed by turning it counterclockwise from the output shaft, Fig. 9.

NOTE: On late production series steering gears the pinion gear is retained on the output shaft by a retaining and roll pin arrangement. Remove roll pin. Drill out retaining pin with either 5/16", 7/16" or 1/2" drill depending upon hole size. Press pinion gear from output shaft.

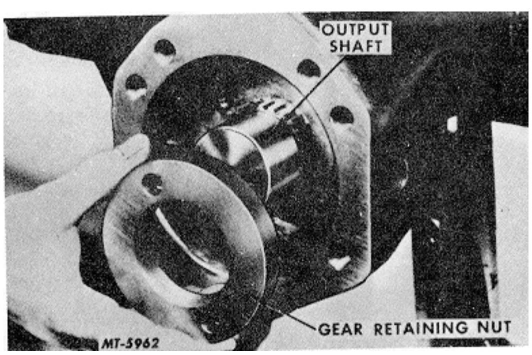


Fig. 9

7. Lift output shaft and gear assembly from the housing, Fig. 10.
8. If repairs are necessary, press output shaft (pinion) gear from shaft, Fig. 11.

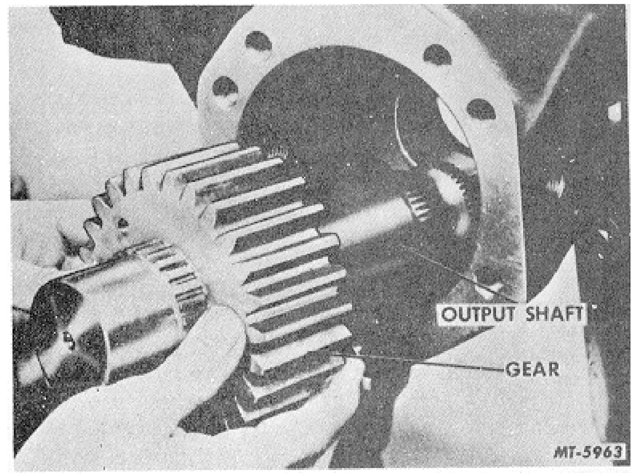


Fig. 10

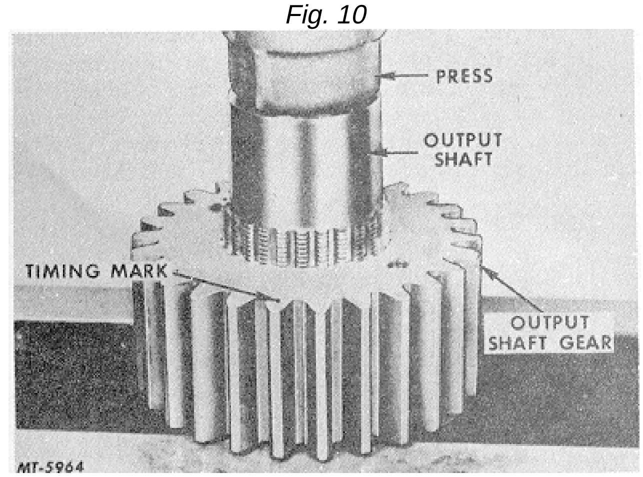


Fig. 11

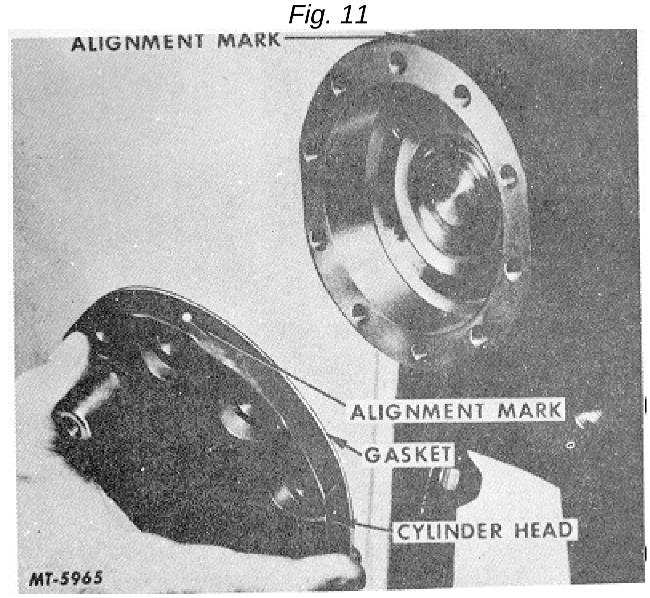


Fig. 12

9. Make reference marks on cylinder head, bearing cap and gear housing for reassembly purposes.
10. Remove cylinder head and gasket, Fig. 12.
11. Remove bolts from the bearing cap, then turn the actuating shaft and bearing cap out of the actuating valve, Fig. 13.

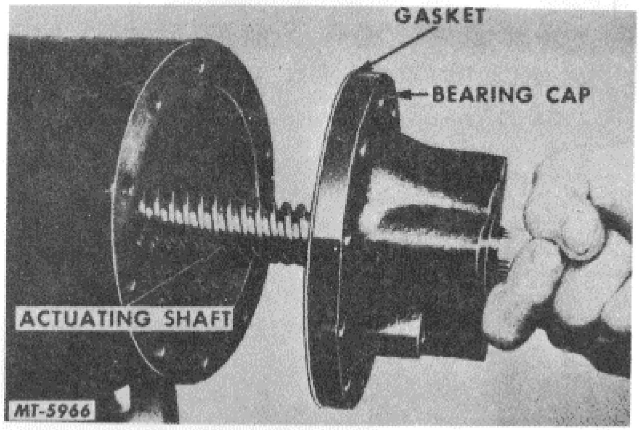


Fig. 13

NOTE: Some bearing caps may incorporate a seal and seal retainer to prevent the entry o f dirt at the input end of earn Fig 14.

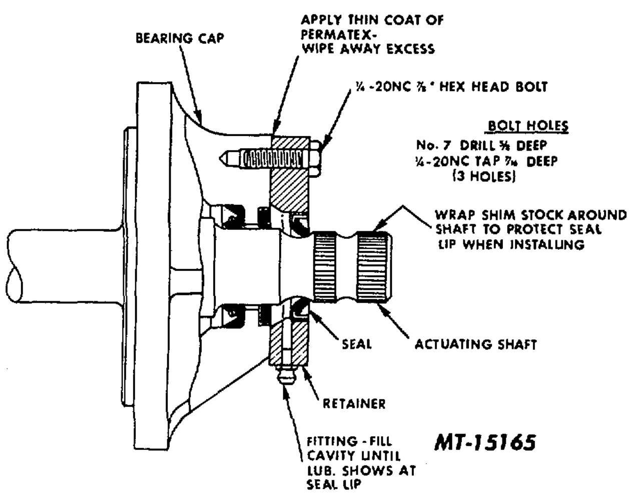


Fig. 14

12. Remove lock pin from the bear'ing retaining nut, Fig. 15.
13. Use a spanner wrench, SE-2279, to loosen the bearing retainer nut; then remove nut, Fig. 16.
14. Press actuating shaft from the bearing cap, Fig. 17. Do not dismantle the actuating shaft, as it is only furnished as an assembly.

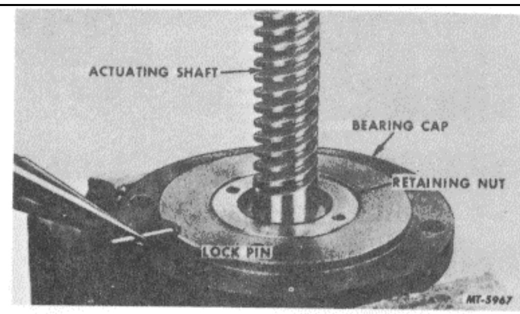


Fig. 15

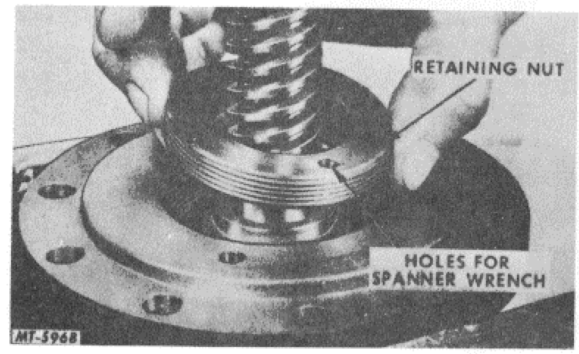


Fig. 16

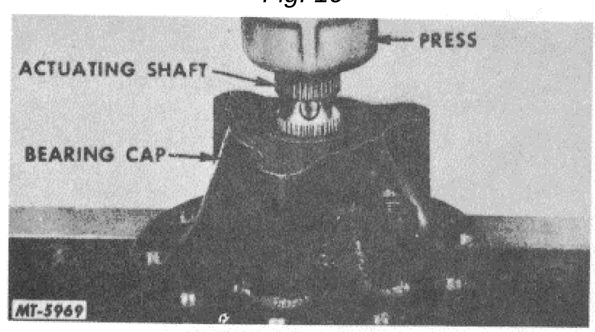


Fig. 17

[5. Pry dirt seal from the, bearing cap, Fig. 18.

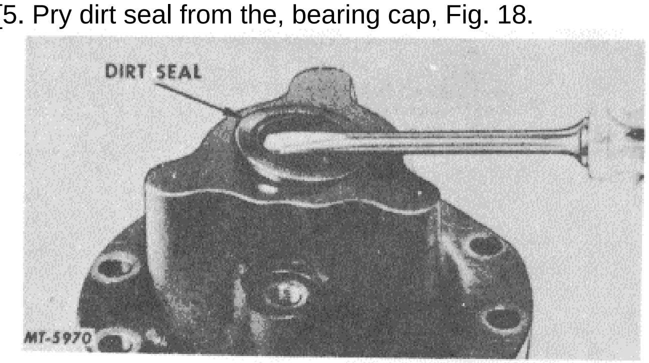


Fig. 18

16. Remove oil seal from bearing cap using a hammer and drift punch, Fig. 19.

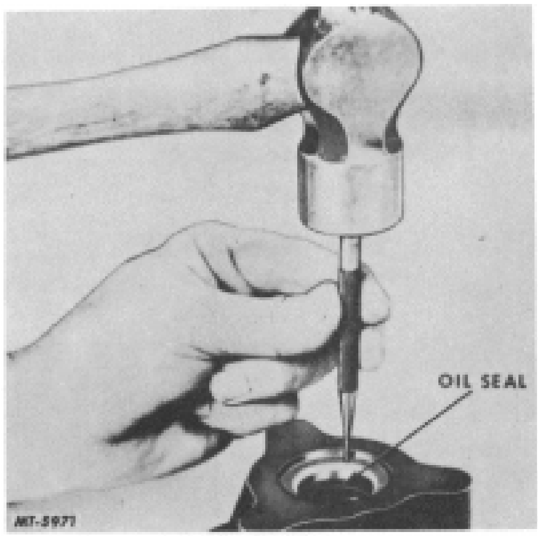


Fig. 19

17. Pull piston assembly from gear housing, Fig. 20.

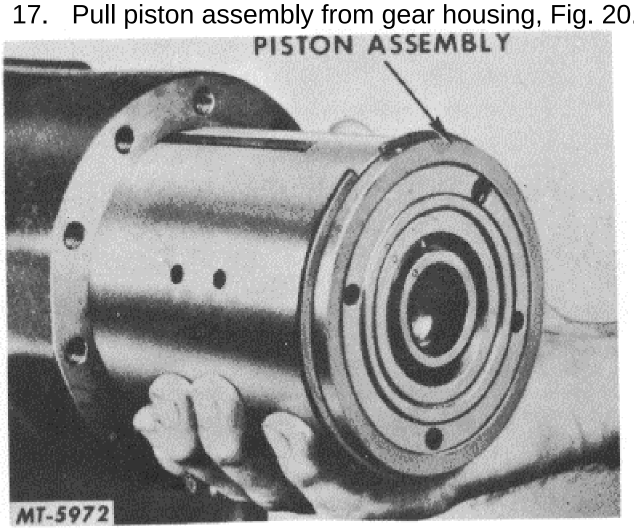


Fig. 20

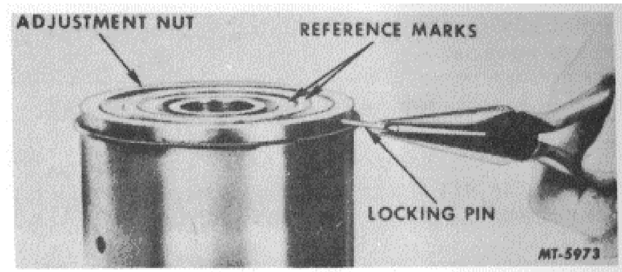


Fig. 2 1

18. Make reference marks on piston and adjustment nut. Then remove locking pin from valve adjusting nut, Fig. 21.
19. Remove valve adjustment nut from piston, Fig. 22.

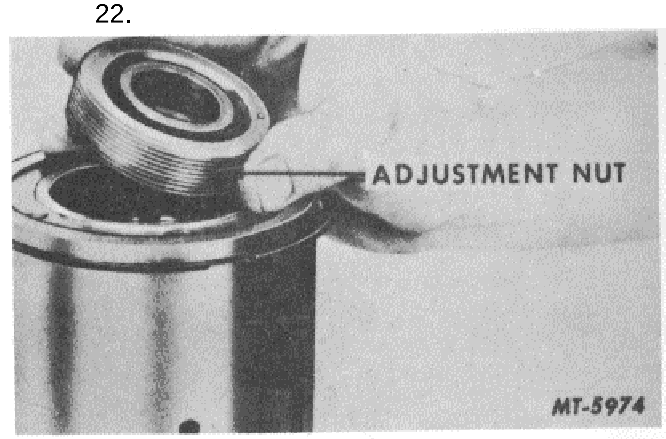


Fig. 22

20. Lift reversing spring from the actuating valve, Fig. 23.

Fig. 23

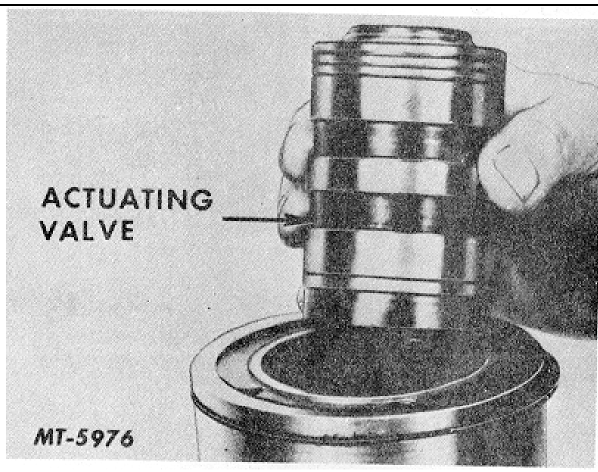


Fig. 24

21. Pull actuating valve from the piston. Do not force valve from the piston assembly, Fig. 24.
22. Remove valve positioning pin from the piston using a screwdriver, Fig. 25.

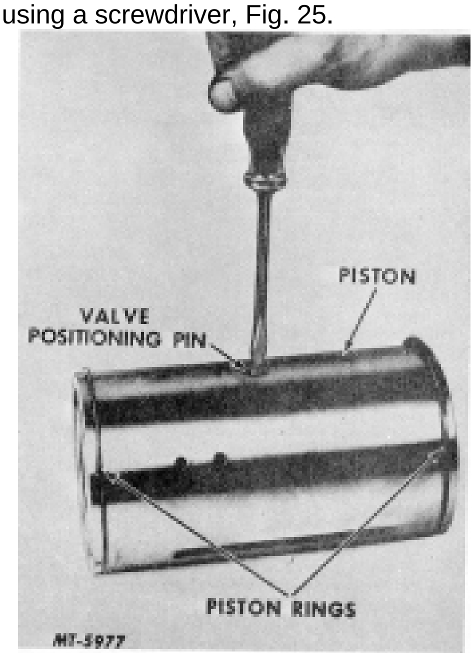


Fig. 25

23. Remove remaining reversing spring from the piston.
24. Remove piston rings from piston.

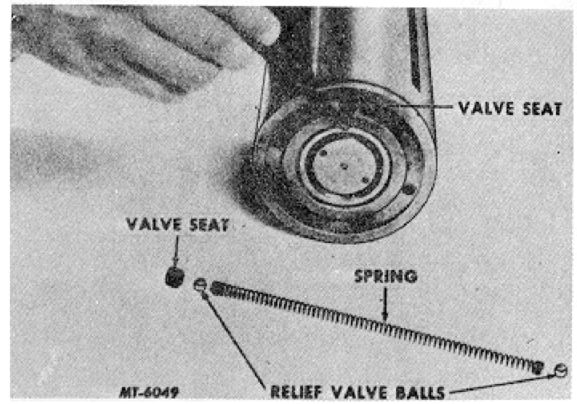


Fig. 26

25. Remove valve seats using a 3/16" Allen wrench, Fig. 26. NOTE: Do not lose relief valve balls, which are spring loaded. The relief valve spring can then be removed.
26. Remove seal (quad ring) from output shaft bore, Fig. 27.
27. If bushings in the housing or cover need replacing, they may be removed using a puller.

Fig. 27

CLEANING, INSPECTION AND REPAIR

Cleanliness is of utmost importance. Use clean solvent to wash grease, oil or dirt from all metal parts. Clean machined parts individually to avoid damage due to "bumping" togPther of parts. Use lint-free cloths dipped in a clean solvent to clean all machined surfaces. After all parts are cleaned, dry parts with compressed air.

A careful visual inspection of the steering gear parts is very important. Inspect components for burrs or nicks, especially on or near the rack (teeth) on the piston.

If a raised burr is found on the piston, it should be removed with a fine hand stone. All 0rings, seals and gaskets should be replaced Inspect the output shaft bushings for wear.

REASSEMBLY

1. Install new bushings (if removed) in the gear housing and cover, using a press and a straight line pushing action. The bushing is pushed into the gear housing, so that the inside face of bushing is flush with inside face of gear housing, Fig. 23.

When a new bushing is pressed into the cover, the face of the bushing must be flush with the cover, Fig. 24. When reinstalling bushing in output shaft bore of housing, if it goes in easily and heavy press resistance is not encountered, carefully remove bushing. Thoroughly clean bushing of oil and grease and clean bore of foreign material by scraping with a piece of brass sheet. Bushing and bore should then be completely washed and dried. Coat exterior of bore and bushing with Loc-tite high strength retainer compound. Reinstall bushing and allow a minimum of six hours curing time. When the curing time has elapsed, any excess Loc-tite in quad ring groove or elsewhere should be -removed by washing with naphtha.

2. Install a new quad ring in the groove in the gear housing.

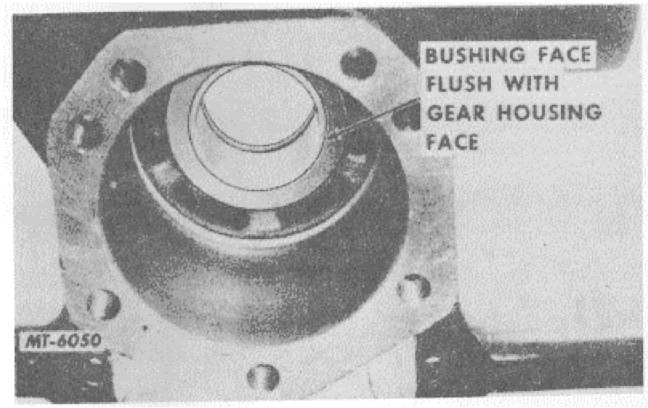


Fig. 28

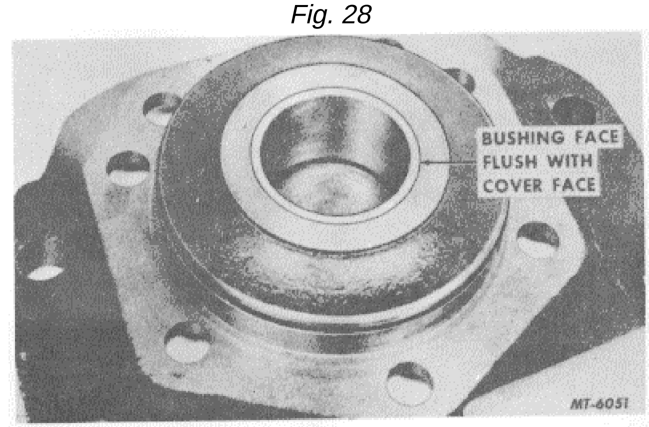


Fig. 29

3. Position the relief valve spring and one relief valve ball into the valve bore. Then using a 3/16" Allen wrench, install one of the valve seats. The valve seats must be tight and flush with or slightly below the end surface of the piston.

4. Install the second relief valve ball seat in the same manner.

5. Position one of the reversing springs in bottom of valve bore. Be sure spring is centered. The end of the valve must enter the inside diameter of the spring.

6. Install the valve positioning pin in the piston. Turn pin inward with a screwdriver until it is below the outside surface of the piston. The flats must enter into the piston 1/4" to engage the mating slot in the valve.

7. Carefully slide the actuating valve into the piston so that the slot on the end of the valve is positioned over the pin.

8. Position the remaining reversing spring on shoulder of the valve end.

9. Reinstall valve adjusting nut, turning it clockwise into the piston until it is against the spring. Align the reference marks on the nut and piston. Then lock nut in place by installing the locking pin. Be sure pin is below the outside edge of piston.

10. Install piston rings. NOTE: If piston rings are tapered on one side, install the taper outward to the piston end. if rings are marked "top" on one side, also assemble these rings with the marked side outward to the piston end. Rings which are neither marked nor tapered are not required to be installed on the piston in any special manner.

11. Install piston assembly using a ring compressor on each end. Fig. 30 illustrates ring compressor on second ring. Be sure piston is installed with the actuating shaft opening facing the bearing cap end. NOTE: Before installing piston, coat piston and cylinder walls with oil.

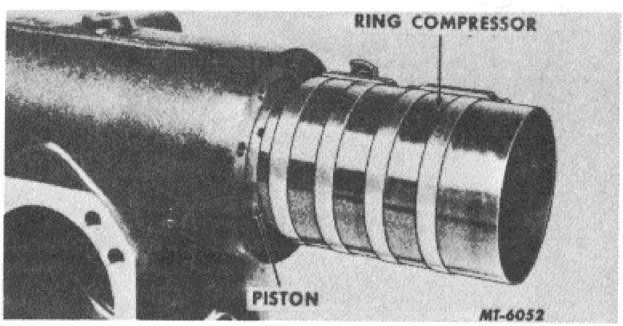


Fig . 30

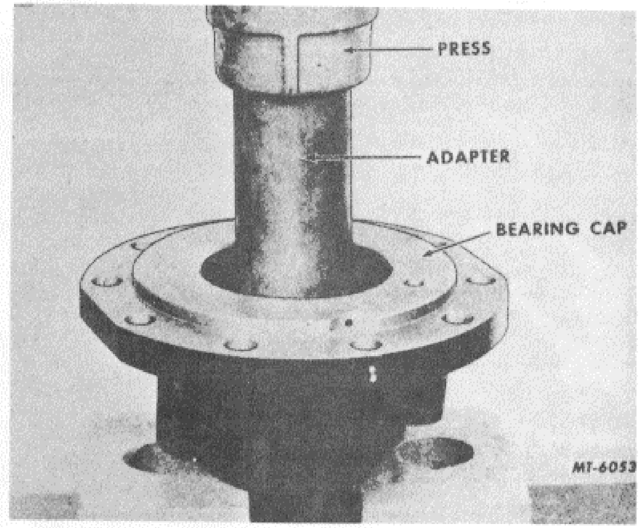


Fig . 31

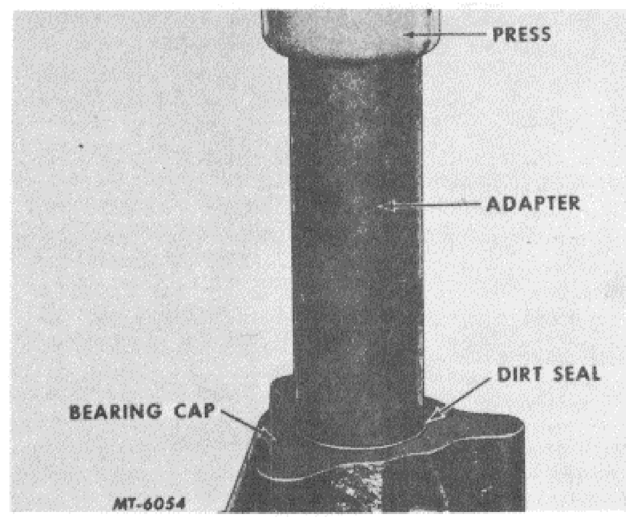


Fig . 32

12. Using a new gasket reinstall the cylinder head. The alignment marks will aid in reinstalling the head in the correct position. The opening for the plunger must be in alignment with relief valve in the piston. Check torque chart for bolt tightening,

13. Press a new oil seal and dirt seal into bearing cap, Figs. 31 and 32.

Lubricate surface between seals before installing actuating shaft assembly. (Use Ball Bearing Lubricant.)

14. Press actuating shaft assembly into the bearing cap, Fig. 33.

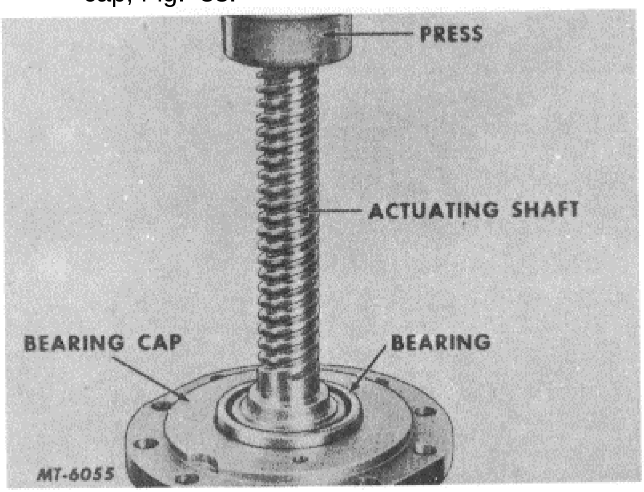


Fig. 33

15. Install bearing retaining nut. Insert locking pin through the hole in bearing cap and into the hole in nut. If a new nut is being used, drill a 3/32" hole in nut. The nut must be in place to drill this hole. Drill through the locking pin hole in the bearing cap and 3/16" into the nut.

16. Using a new gasket on the bearing cap thread actuating shaft into the valve. Line up punch marks on gear housing and bearing cap. Turn shaft until cap comes into place on the end of cylinder. Check plunger hole alignment with valve seat in the piston. Tighten bolts to specified torque.

17. Align the timing mark on output shaft gear with marked spline on the output shaft and reassemble. Use a press if necessary, Fig. 34.

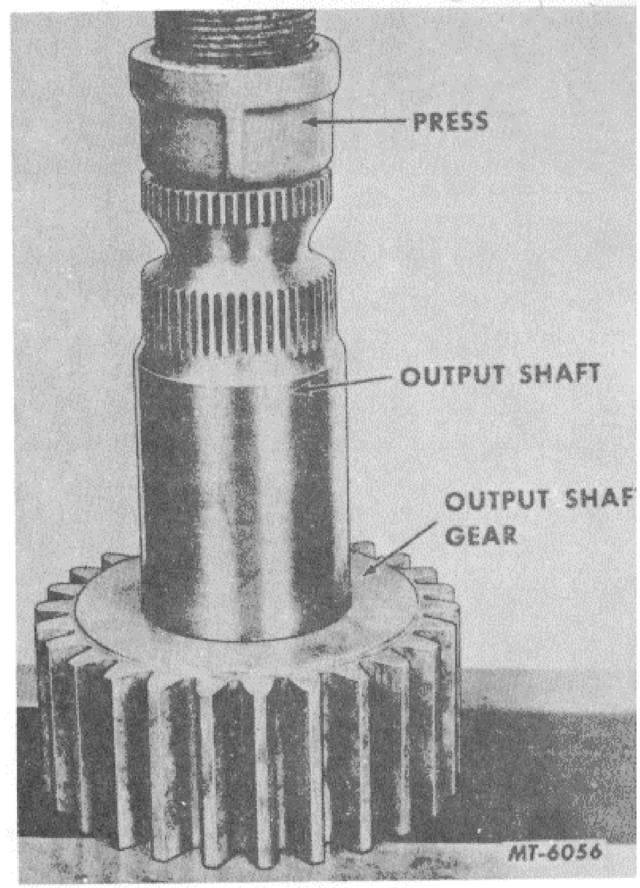


Fig. 34

18 Insert output shaft in gear housing aligning mark on the center tooth on the pinion with mark on the output shaft. NOTE: Be very careful so that the gear tooth and rack tooth are properly aligned. If a tooth on the pinion strikes the ground outside diameter' surface of the piston, a burr will be raised which will score the cylinder wall. This burr should be removed with a fine hand stone before further assembly.

19. Install the gear retaining nut. The nut must be tight against the output shaft gear. The capscrews are then installed in the retaining nut. If the holes do not line up with the gear, back the nut off until they do. Tighten the capscrews with an Allen wrench.

NOTE: On late production series steering gears install a new retaining pin to proper depth and replace roll pin.

20. Position a new 0ring seal on housing cover. Install cover assembly. It may be necessary to use a soft hammer to tap the cover in place.
21. Install the bolts and torque to proper specifications.
22. The relief valve plungers with the jam nuts may now be installed using new O-rings. Turn them approximately six turns. Final adjustment of the plungers is made when the steering gear is installed on the vehicle.

FINAL ADJUSTMENTS

Bleeding Air from System

After reinstalling the steering gear on the vehicle but prior to installing the pitman arm, bleed the air from steering system in the following manner:

1. Fill pump reservoir with SAE-10W-30 engine oil. It will be necessary to continue filling after starting the engine and during the bleeding operation until correct oil level is maintained.
2. Set parking brake or block wheels. Start engine and allow it to operate at fast idle speed.
3. With engine running turn steering wheel from left to right and return, making three complete cycles to remove all air from the steering system.
4. Stop engine.

PITMAN ARM INSTALLATION

NOTE: To provide proper alignment of the pitman arm to the output shaft, an arrow is stamped on the arm and a dot (or indentation) is on the output shaft end. These marks must always be in alignment when the pitman arm is installed on the output shaft.

There are two methods of retaining the pitman arm on the output shaft:

1. Two setscrews are threaded into the pitman arm and are tightened into a "V" type groove in the output shaft. Setscrews are either equipped with a Nylock insert or jam nut to secure setscrews in place, Fig. 35.

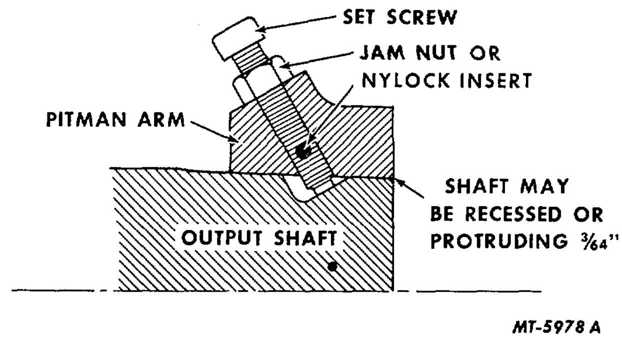


Fig . 35

With this method of retaining the pitman arm on the output shaft, two procedures are used when installing the arm.

If the output shaft is equipped with a 1/2" x 20ONF or 9/16" x 18NF hole, a bolt approximately 4-1/4" long, an adapter (large socket) and flat washer can be assembled as shown in Fig. 36. Tighten the bolt to force the pitman arm on the shaft. After the 1/2" bolt is tightened to 85 ft. lbs. or 9/16" bolt is torqued to 125 ft. lbs., the two setscrews are tightened to 15 ft. lbs. and then the jam nut tightened. The 1/2" bolt, adapter and washer are then removed.

If the end of the output shaft is not equipped with either a 1/2" or 9/16" threaded hole, the pitman arm should be forced on the output shaft with a hammer.

The setscrews are then tightened to 12 ft. lbs. If jam nuts are used, tighten them now.

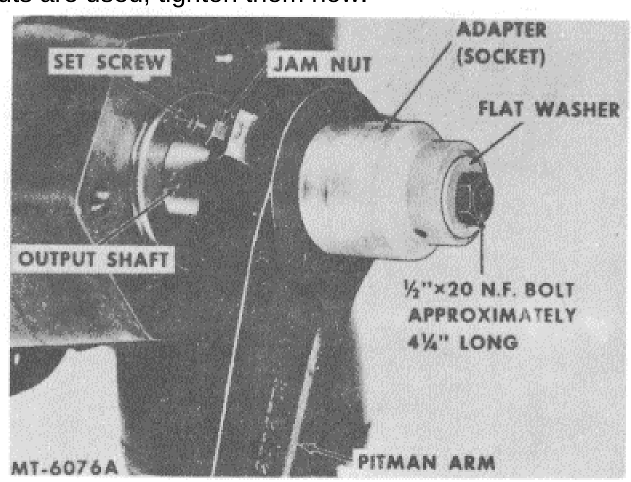


Fig. 36

NOTE: In either case the shaft may be recessed or protruding 3/64" maximum from outer face of pitman arm.

2. The second method of securing the pitman arm on the output shaft is with a large self-locking nut, which is threaded onto the end of the output shaft and tightened to specified torque to force the pitman arm in place, Fig. 37.

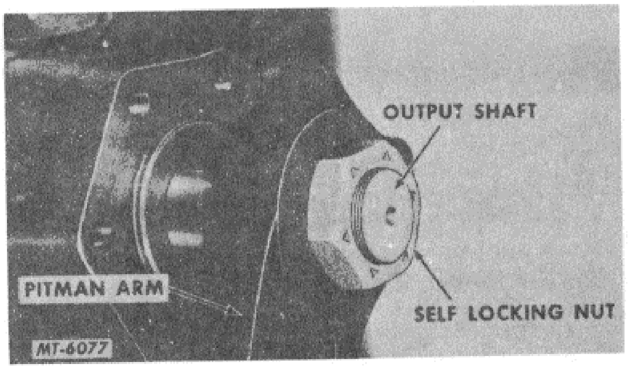


Fig. 37

ADJUSTING RELIEF VALVE PLUNGERS
(Adjustable Stops)

1. Turn bearing cap plunger and the cylinder head plunger into the gear until they bottom.

2. Start the engine and allow it to operate at fast idle speed.

3. With full weight of the vehicle on all wheels, turn the steering wheel until the bearing cap plunger opens the relief valve. Do not force the steering wheel. You can feel the valve open as the turning effort is increased. Adjust the bearing cap plunger outward and continue to turn the steering wheel until about 1/8" clearance is maintained at the wheel stops. Do not change the wheel stop adjustment. Lock the plunger with jam nut. The same procedure is repeated for the cylinder head plunger.

4. The vehicle is now ready for road testing.

LUBRICATION

Keep the power steering pump reservoir filled to indicator level with SAE10W-30 engine oil.

When filling, start the engine. With engine running, turn steering wheel from left to right and continue filling until proper level is maintained.

A replaceable type filter element is located in the pump reservoir. Every 20, 000 miles or 600 hours remove the reservoir cover and filter element. Clean inside of reservoir with a lint-free cloth. Install a new filter element and replace cover.

NOTE: Trucks operating in dusty areas will require changing the filter element more often.

Filling the Hydraulic System

1. Fill reservoir to indicated level and replace cap.

2. Start engine and idle, turning wheels to the full left and right three times. Shut off engine and refill reservoir to indicated level.

3. Continue operation in step "2" until system maintains its proper indicated oil level,

4. Run engine at faster speed and continue turning wheels slowly from full left to full right and back again for approximately five minutes to check for leaks. This will bleed the system of air. Again refill the reservoir to the indicated level or to 1-1/2" below top of filler neck on reservoir without dipstick attached to filler cap.

NOTE: THE ABOVE INSTRUCTIONS ARE IMPORTANT.

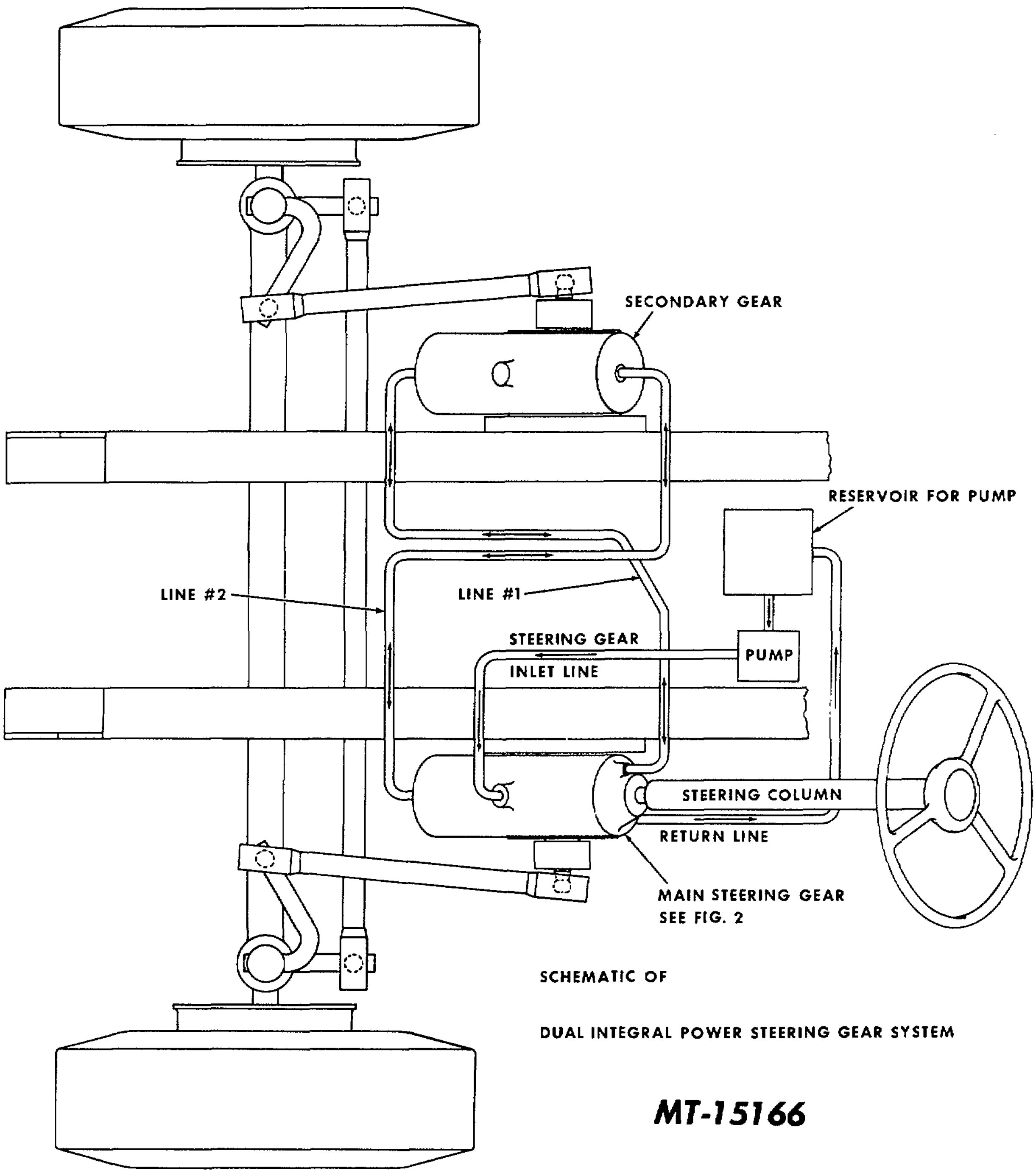

SECONDARY GEAR
RESERVOIR FOR PUMP
LINE #2
LINE #1
STEERING GEAR
INLET LINE
PUMP
STEERING COLUMN
RETURN LINE
MAIN STEERING GEAR
SEE FIG. 2
SCHEMATIC OF
DUAL INTEGRAL POWER STEERING GEAR SYSTEM
MT-15166

Fig . 38

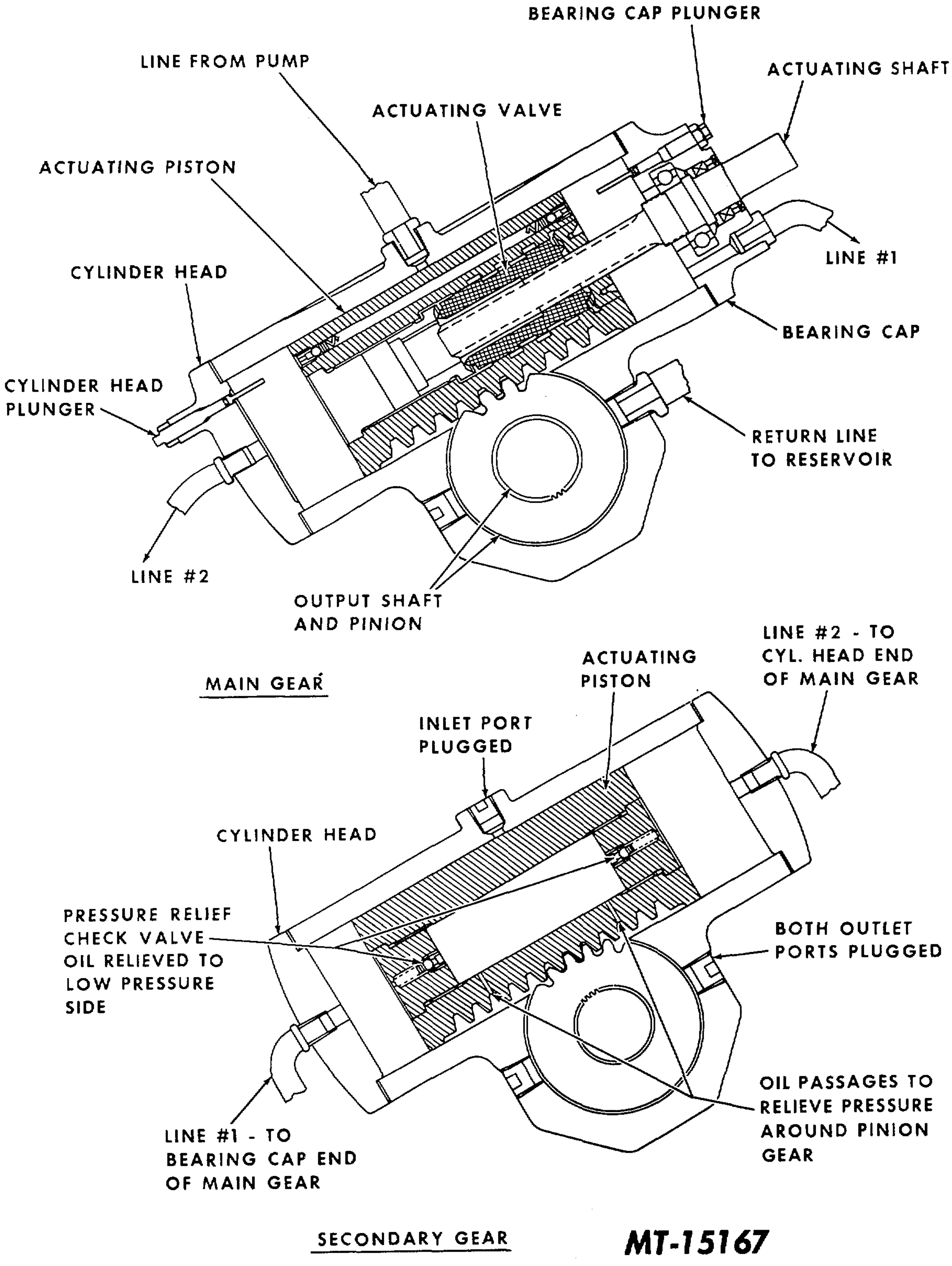

BEARING CAP PLUNGER
LINE FROM PUMP
ACTUATING SHAFT
ACTUATING VALVE
ACTUATING PISTON
LINE #1
CYLINDER HEAD
BEARING CAP
CYLINDER HEAD PLUNGER
RETURN LINE TO RESERVOIR
LINE #2
OUTPUT SHAFT AND PINION
MAIN GEAR
ACTUATING PISTON
LINE #2 - TO CYL. HEAD END OF MAIN GEAR
INLET PORT PLUGGED
CYLINDER HEAD
PRESSURE RELIEF CHECK VALVE OIL RELIEVED TO LOW PRESSURE SIDE
BOTH OUTLET PORTS PLUGGED
OIL PASSAGES TO RELIEVE PRESSURE AROUND PINION GEAR
LINE #1 - TO BEARING CAP END OF MAIN GEAR
SECONDARY GEAR
MT-15167

Fig. 39

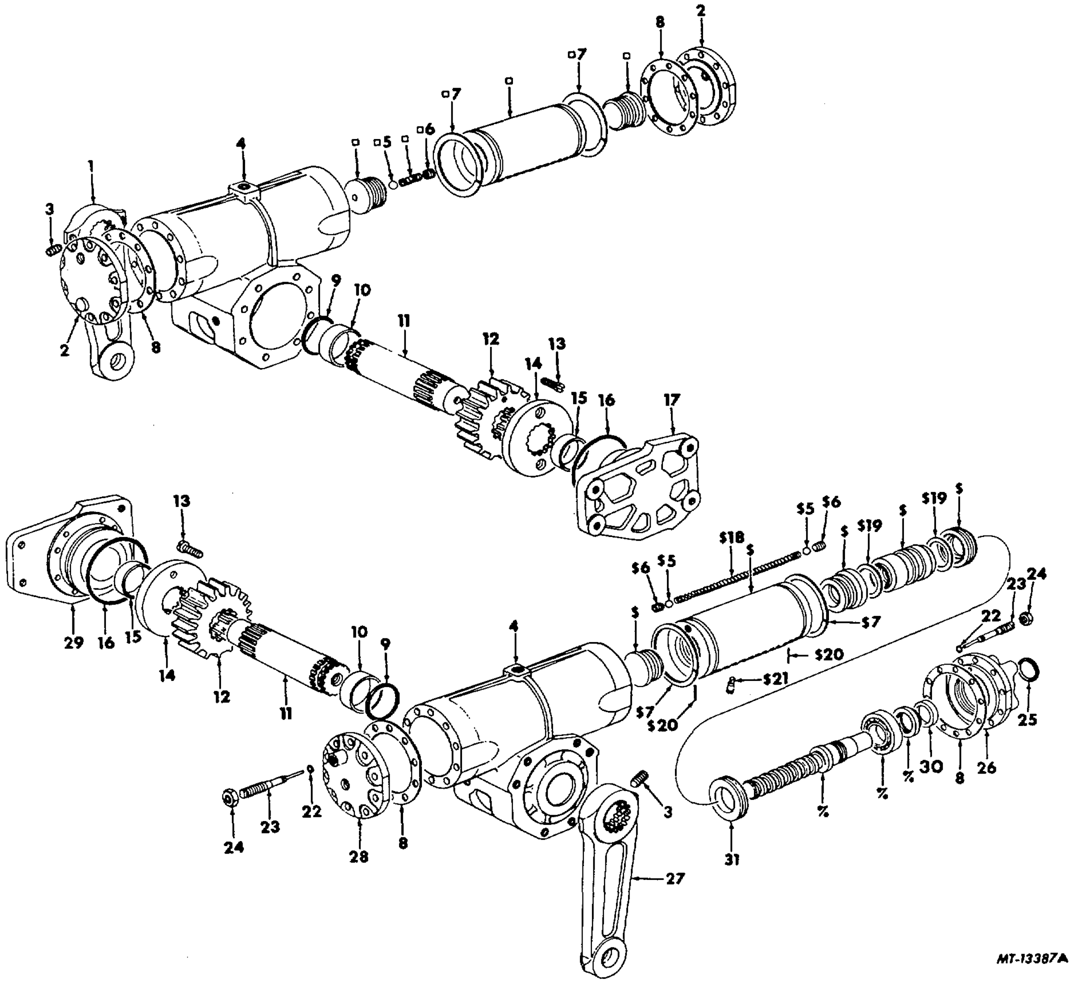


Fig . 42 Exploded View of Steering Gear (Dual System)
(For symbol designation, see Parts Catalog .)
Legend for Fig . 42

Key	Description	Key	Description
1	ARM, Steering Right, Assembly	17	COVER, Right Gear Housing Mounting
2	HEAD, Right Cylinder	18	SPRING, Relief Valve
3	SCREW, Steering Arm Set	19	WASHER, Piston Valve
4	HOUSING with BUSHING, Gear	20	PIN, Valve Locking, 3/32 x 2
5	BALL, Relief Valve	21	PIN, Valve Positioning
6	SEAT, Relief Valve Ball	Z2	O-RING, Plunger Valve
7	RING, Piston	23	PLUNGER, Relief Valve
8	GASKET, Cylinder Head	24	NUT, Hex, 3/8NF
9	RING, Quad	25	SEAL, Housing Cover Outer
10	BUSHING, Housing Inner	26	COVER, with BEARING, Housing
11	SHAFT, Output Gear	27	ARM, Steering Left, Assembly
12	GEAR, Output Shaft	28	HEAD, Left Cylinder
13	BOLT, Hex Socket Head 1/4NF x 5/8	29	COVER, Left Gear Housing Mounting
14	NUT, Output Shaft Mounting	30	SEAL, Housing Cover Inner
15	BUSHING, Housing Outer	31	NUT, Bearing Retaining
16	O-RING, Gear Shaft		

TROUBLE SHOOTING

Power Steering Trouble Shooting

A thorough and orderly trouble shooting procedure will help you diagnose power steering troubles quickly.

Troubles occur and show up in various ways; but with the trouble shooting chart you can eliminate many possibilities quickly, narrow down the cause of trouble, then make the correct repairs promptly.

Trouble shooting procedure should be followed in a three step organized manner:

1. Define the complaint.
2. External inspection.
3. Hydraulic system check.

Cause of Bad Steering Outside of Steering System

1. Soft tires.
2. Loose king pins.
3. Low pressure in one or more tires, particularly rear tires.
4. Swinging load.
5. Improper fifth wheel location.
6. Sheared off spring leaf bolt on steering gear side of truck.
7. Improper front end alignment (caster, camber and toe- in).

TROUBLE SHOOTING CHART

PROBLEM	POSSIBLE CAUSE	REMEDY
1. Oil forcing out of filler cap vent hole in reservoir.r	a. Dirty cartridge in reservoir.	Change oil and cartridge. Replace filter cartridge at short interval if necessary to clean up system
	b. Loose belts.	Tighten belts.
	c. Air in system.	Bleed system and check adjustable stops.
	d. Malfunctioning pump.	Refer to pump servicing instructions.
2. Oil leakage at pump pulley shaft	Worn oil seal	Replace oil seal (change oil and filter, cartridge at more frequent intervals).
3. Oil leakage between reservoir and pump.	Overheating or age..	Replace O-ring between reservoir and pump.
4. Oil leaking at actuating shaft of steering gear.	a. Worn or damaged oil seal.	Replace oil seal.
	b. Worn or damaged actuating shaft.	Replace with actuating shaft assembly.
5. Oil leaking at output shaft of steering gear.	a. Worn or damaged output shaft.	Replace output shaft.
	b. Restricted oil return line.	Check for obstructions and sharp bends in line.
	c. Clogged filter.	Change oil and cartridge. Replace filter cartridge at shorter intervals.
	d. Worn or damaged quad ring.	Replace quad ring.
	e. Worn cover bushing and/or output shaft bushing	Replace bushings.

PROBLEM	POSSIBLE CAUSE	REMEDY
6. Excessive pump pressure-with steering gear in neutral position	Kink in oil return line	Relocate line to remove kink.
7. Erratic steering or no steering at all	a. Insufficient volume of oil being metered by flow divider to steering gear induced by foreign particles on flow divider valve, causing the valve to hang up in the bore.	Polish flow divider valve to remove foreign particles and burrs. Refer to pump servicing instructions.
	b. Flow divider spring takes permanent set because of fatigue, thereby allowing flow divider valve to move easily and reduce oil volume.	Replace flow divider spring. Refer to pump servicing instructions.
	c. Broken bypass spring in flow divider.	Replace with flow divider valve assembly, which includes bypass spring. Refer to pump servicing instructions.
8. Side motion in steering wheel.	Broken jacket bearing in steering column.	Replace jacket bearing.
9. Excessive backlash	a. Worn universal joint.	Replace universal joint
	b. Worn pins and keys, universal joint to actuating shaft and universal joint to steering shaft..	Replace pins and keys
	c. Low oil volume.	Check flow divider and pump speed belt(s).
	d. Pitman arm ball worn “eggshaped.”	Replace pitman arm assembly where riveted or ball only where bolted ball is used.
	e. Improperly adjusted drag link, pitman arm to drag link and steering arm to drag link.	Adjust drag link, drag link to pitman arm and drag link to steering arm.
	f. Loose bracket, frame to bracket or bracket to gear	Remove bracket, clean frame and bracket; check radius of frame making sure bracket is not bearing on radius surface; check bracket for wear from working. Replace bracket and tighten to recommended torque rating according to size and grade of bolts. If necessary, replace bracket with new one.
	g. Worn or damaged actuating valve.	Replace with actuating piston and valve assembly.
	h. Rack or piston worn or damaged.	Replace with actuating piston and valve assembly
	i. Worn or damaged pinion gear on output shaft.	Replace pinion gear.

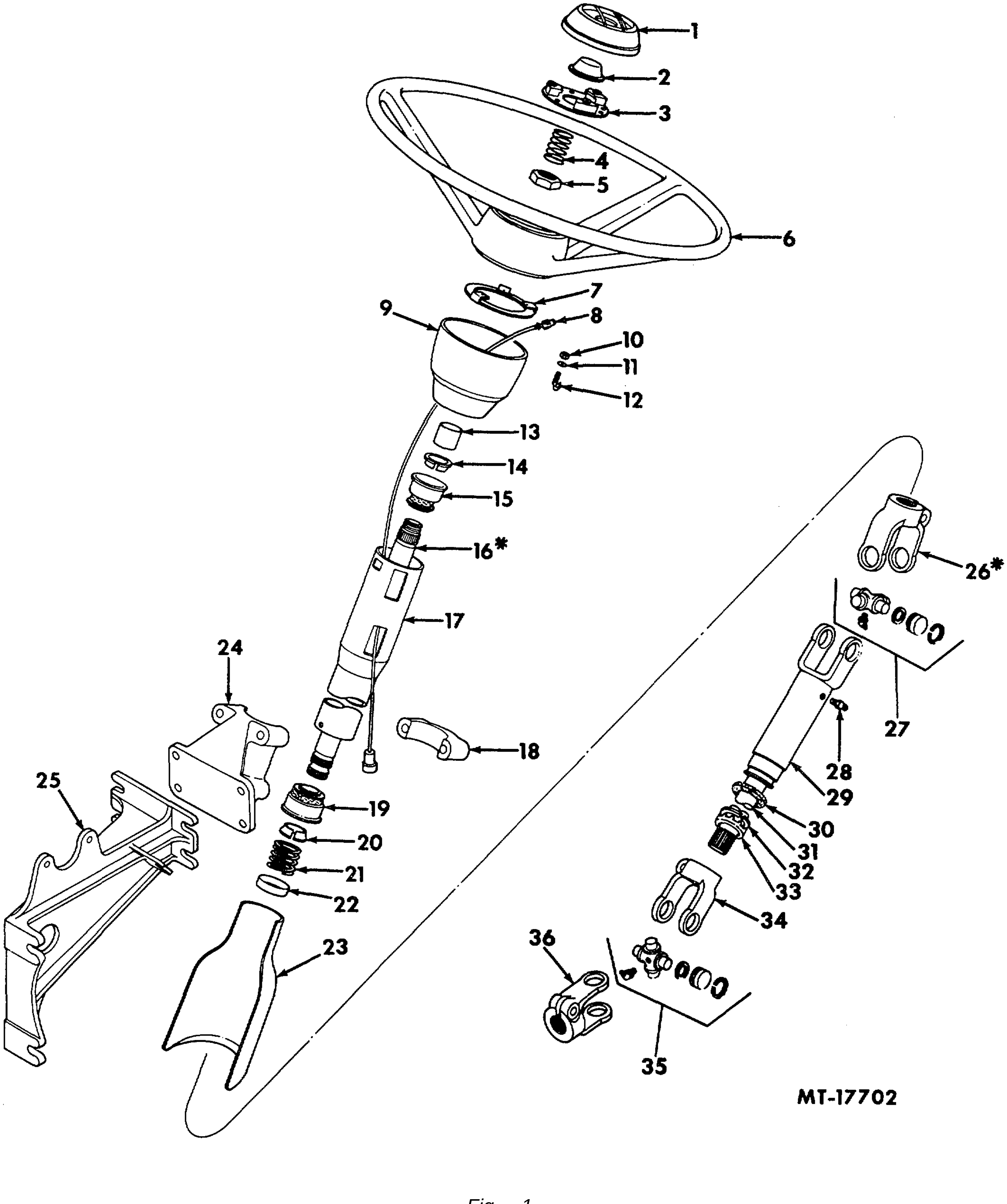
PROBLEM	POSSIBLE CAUSE	REMEDY
10. Wheel steering hard in one direction	Broken reversing springs in steering gear.	Replaces reversing springs
11. Wheel steering hard in one or both directions.	a. Metal or foreign material caught in actuating valve. Actuating valve worn or chipped by dirt.	Remove actuating valve, clean and check parts for damage. If damage is excessive, replace with actuating piston and valve assembly
	b. Bent or damaged king pins and tie rods.	Repair or replace king pins and tie rods. Refer to servicing instructions.
	c. Front end load too great for rated axle capacity.	Lighten load or install larger steering gear.
	d. Fatigued bypass valve spring in pump.	Replace with flow control valve assembly. Refer to pump servicing instructions.
12. Hard steering	a. Loose belts.	Tighten or replace belts
	b. Worn pulley(s) due to belt slippage.	Replace pulley(s) and belts (keep belt tight).
	c. Improper belt	Replace with IH replacement part.
	d. Low oil level in steering system..	Fill oil reservoir as required. See "Lubrication."
	e. Air in system.	Bleed system and check for cause of air.
	f. Caster and camber degree incorrect.	Correct to "Specifications."

TORQUE CHART

Application	Size	Ft. Lbs.
Cylinder Head and Bearing Cap	5/16 - 24NF	20
Cylinder Head and Bearing Cap	3/8 - 24NF	33
Steering Gear Cover (Mounted)	7/16 - 2ONF	53
Steering Gear Cover (Mounted)	1/2 - 20NF	83
Steering Gear Cover (Mounted)	9/16 - 18NF	122
Steering Gear Cover (Mounted)	5/8- 18NF	167
Steering Gear Cover (Mounted)	5/8 - 11NC	152
Steering Gear Cover (Standard)	7/16- 20NF	36
Steering Gear Cover (Standard)	1/2 - 20NF	56
Steering Gear Cover (Standard)	9/16 - 18NF	81
Steering Gear Cover (Standard)	5/8 - 18NF	112
Steering Gear Cover (Standard)	5/8 - 11	100
Pitman Arm Set Screws	5/16 - NC	12
Pitman Arm Retaining Nut	1-1/2 - NF	450
Pitman Arm Retaining Nut	1-3/4 - NF	500

STEERING COLUMN ASSEMBLY

INDEX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MT-17702

Fig . 1

Key	Description	Key	Description
1.	Button, Horn	19.	Bearing, Jacket Tube Lower Assy.
2.	Contact Cup, Horn Button	20.	Seat, Bearing
3.	Plate, Horn Button Contact	21.	Spring, Jacket Tube Bearing
4.	Spring, Horn Button	22.	Cap, Dust
5.	Nut, Steering Wheel Mtg.	23.	Cover, Universal Joint
6.	Wheel, Steering Assy.	24.	Bracket, Steering Column Mtg.
7.	Contact Ring, Horn Button	25.	Brace, Steering Column
8.	Contact Roller w/Cable	26.	*Yoke, Upper End
9.	Flange Steering Column w/Bearing	27.	Universal Joint
10.	Nut, Lock	28.	Fitting Lubrication 1/4 Straight
11.	Washer, Flat	29.	Slip Yoke
12.	Bolt, Clamp	30.	Seal, Slip Yoke
13.	Spacer, Bearing	31.	Shaft, Steering Slip
14.	Seat, Bearing	32.	Washer, Slip Yoke Seal
15.	Bearing, Jacket Tube Upper Assy.	33.	Cap, Dust
16.	*Shaft, Steering	34.	Yoke, Lower End
17.	Tube, Jacket	35.	Universal Joint
18.	Bracket Cap, Steering Column	36.	Yoke, Steering Gear End.

* Parts 16 and 26 welded together on late model chassis.

DESCRIPTION

The steering column assembly provides the vehicle operator control of the steering gear from inside vehicle cab. This manual covers the 21 mm (7/81") diameter shaft, double jointed column used in the Transtar 4200, 4300, and 5000 Paystar series.

The turn signal and in most cases the trailer brake control is mounted to the steering column jacket tube. The only internal accessory not having to do directly with control of the steering gear is the horn assembly.

OPERATION

A steering wheel is connected to the upper steering shaft, which is held by two sets of ball bearings in the steering column jacket tube. The steering shaft is connected to the slip shaft by a universal joint. The lower end of the slip shaft is connected to the steering gear by a second universal joint. The universal joints and slip shaft permit correct alignment and smooth rotation of the steering shaft to steering gear with no binding of the shafts.

STEERING WHEEL REMOVAL

The steering wheel can be removed as follows:

1. Remove the plastic horn button by turning it 28.575 mm (1 1/8") in either direction. The horn button will be released from the rubber retainers on the horn button base plate. The contact cup and spring should also be removed at this time (Fig. 2).

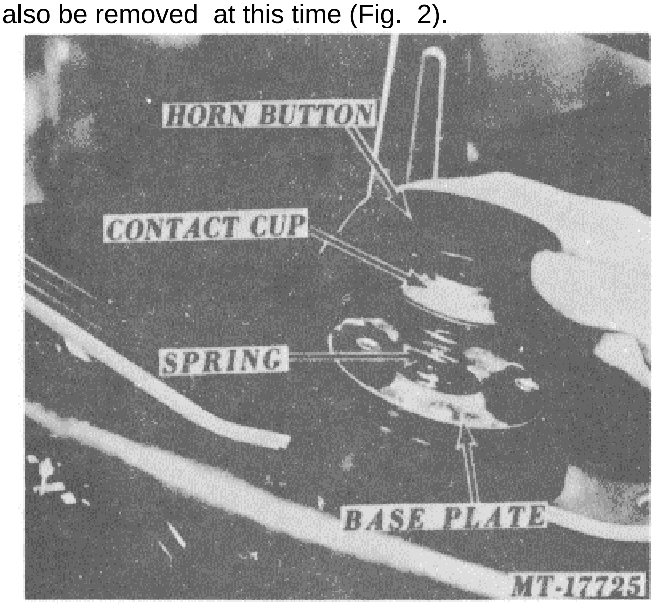


Fig . 2 Plastic Horn Button Removal

2. Remove the horn button base plate by removing three top screws and one "ground" screw.

3. Remove steering wheel nut.

4. Install SE-1821 puller, two drilled and tapped holes are provided in the steering wheel. Remove as shown in Fig. 3.

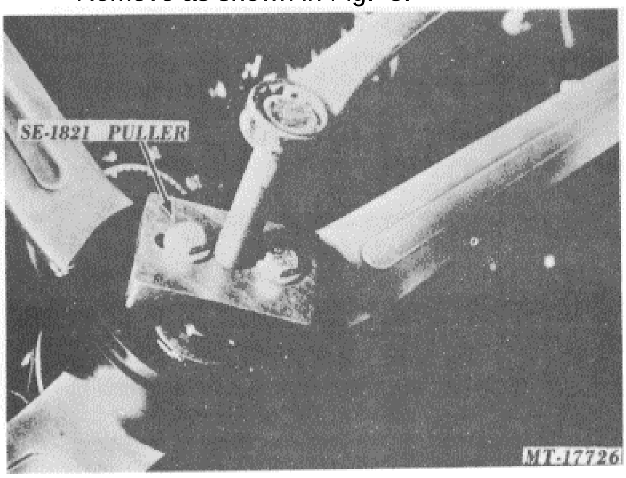


Fig . 3 Steering Wheel Removal Using Puller SE-1821

5. On the reverse side of the steering wheel hub is a horn button contact ring. This contact ring rides on a contact roller and provides a path to ground for horn operation. The contact ring can be removed by removing the (2) mounting screws.

STEERING WHEEL INSTALLATION

1. Install horn button contact ring on reverse side of the steering wheel hub with (2) screws. Lubricate contact ring with IH 251 HEP grease or the equivalent NLGI #2 multi-purpose lithium grease.
2. Check contact roller for freedom of movement in housing (see Fig. 4). Make certain that the spring seat and bearing spacer is in place on the steering shaft.
3. Mount steering wheel on serrated steering drive shaft. Align open serration on top of steering wheel hub with blind serration on steering drive shaft.
4. Rock steering wheel back and forth, use a soft face mallet to seat wheel on steering drive shaft.
5. Install steering wheel nut on steering drive shaft and torque, dry (Fig. 5).
6. Install horn button base plate with (3) tapping screws. Install "grounding" screws.

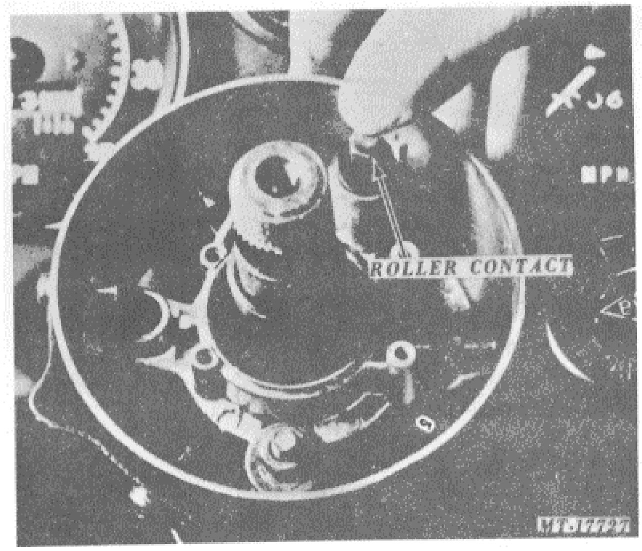


Fig . 4 Checking Contact Roller for Freedom of Movement

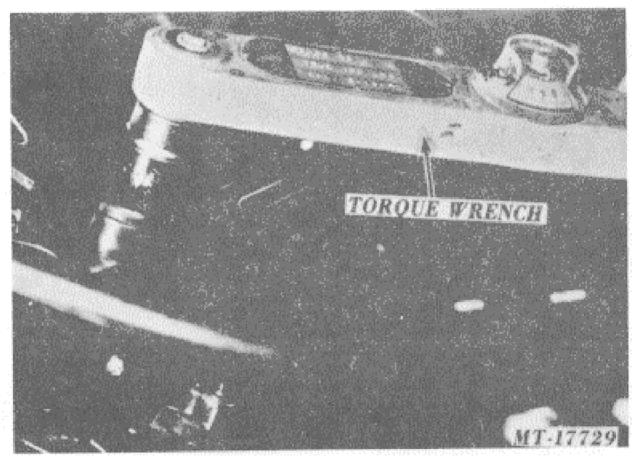


Fig. 5 Torque Steering Wheel Nut

7. Place horn button spring on steering wheel nut and contact cup on spring. Place horn button on contact cup, press down and turn until the rubber keepers on base plate hold the horn button in place.

STEERING COLUMN REMOVAL

For most servicing procedures it will be necessary to remove the steering column. This can be accomplished with the steering wheel in place or removed. Steering column removal can be completed as follows:

1. Open hood.
2. Remove pinch bolt from yoke at end of steering slip shaft. Separate the slip shaft from the yoke.

3. If the steering wheel is removed, it is necessary to replace the steering wheel nut to prevent the steering shaft from sliding out of the steering jacket tube. See index for steering wheel removal.
4. Remove turn signal control from steering column.
5. Remove trailer brake control if mounted on steering column.
6. Disconnect horn wire at the connector.
7. Remove the lower bracket cap, and cover over universal joint from steering column, refer to Fig. 6.
8. Remove upper bracket cap and lift steering column from cab. Be careful not to tear the rubber boot, or break the steering tube locating pin in steering column mounting bracket. When reinstalling steering column the locating pin must align with hole in steering jacket tube.

Fig . 6 Steering Column Removal

STEERING COLUMN INSTALLATION

To install the steering column, reverse removal procedure. Refer to torque chart for correct torque.

STEERING JACKET TUBE BEARINGS REPLACE-MENT

The steering jacket tube bearings are ball bearings. The outer race of the bearing is long with a lip to properly locate it in the steering jacket tube.

The replacement operation will require removal of the steering wheel, turn signal control, and trailer hand brake if mounted on steering column. It will not be necessary to remove the entire steering column assembly. Replacement procedure for the steering jacket tube bearings follows:

1. Remove steering wheel. For procedure refer to steering wheel removal in the index.

2. Remove steering column bracket caps and slide steering jacket tube from steering drive shaft. Do not break the steering jacket tube locating pin in the steering column mounting bracket.

3. Place steering jacket tube in a vise. Use copper jaw covers or insulate vise with a rag. Take care not to deform the steering jacket tube by overtightening the vise.

4. Remove bearing using an inside puller SE-1746 (Fig. 7)

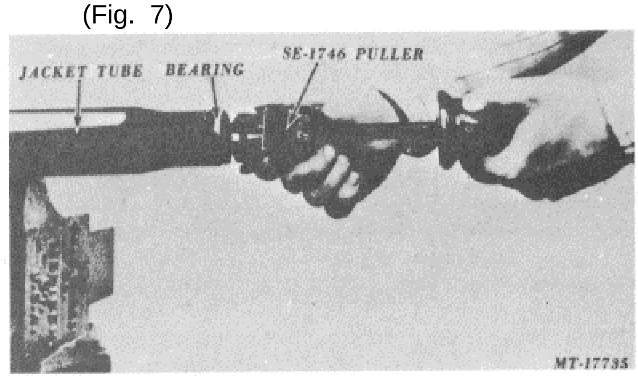


Fig . 7 Remove Steering Jacket Tube Bearings Using Puller SE-1746

5. Pack new bearings with IH 251 HEP grease or the equivalent NLGI #2 multipurpose lithium grease.
6. Install bearings in steering jacket tube. Be careful to start bearing straight and tap gently to avoid damage to the bearing or steering jacket tube.
7. Slide steering jacket tube over steering drive shaft and align with locating pin in steering column mounting bracket. Replace bracket caps and cover over universal joints, torque to value shown in chart.
8. Reinstall turn signal control, trailer hand brake control, steering wheel, and connect horn wiring.

UNIVERSAL JOINT REPLACEMENT

The universal joint at the steering gear may be removed and serviced separately. To service the upper universal joint it is necessary to remove the steering column.

Once the shafts and universal joints are removed from the vehicle the procedure for servicing the universal joint is as follows

NOTE: Be careful not to damage bearing surfaces.

1. Place universal joint in vise as shown in Fig. 8. Remove snap ring fitting in grooves of the spider bearings which locate them on the inside of the yokes. To remove snap rings; place a screwdriver against an end of the snap ring and push.

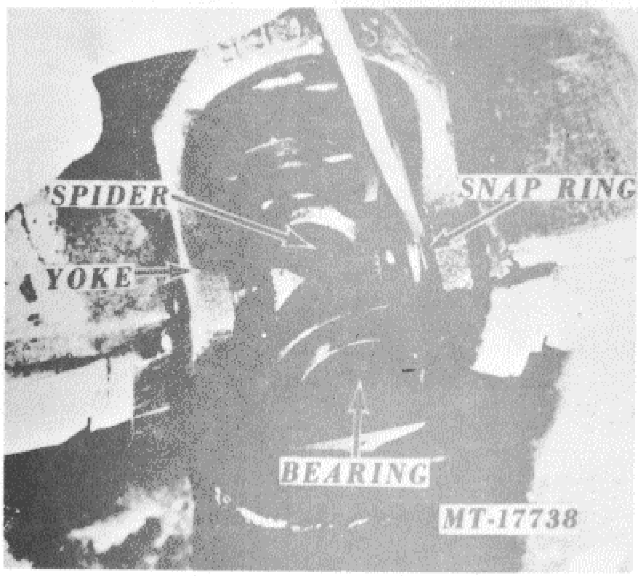


Fig . 8 Snap Ring Removal

2. Place shaft assembly in vise with one yoke resting on the vise and the other yoke suspended with the bearing to be removed facing down (refer to Fig. 9). Tap yoke beside bearing to be removed, bearing should walk out of the yoke.
3. If the bearing does not come completely out, clamp bearing in vise. Use copper jaw covers on vise. Strike the yoke with a soft hammer and drive the yoke away from the bearing as shown in Fig. 10.
4. With the bearings removed, the spider can be easily removed from the yoke.

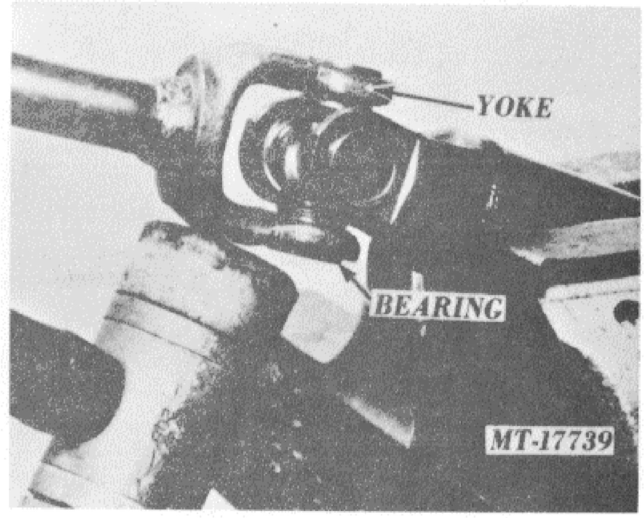


Fig. 9 Bearing Removal, Yoke in Vise

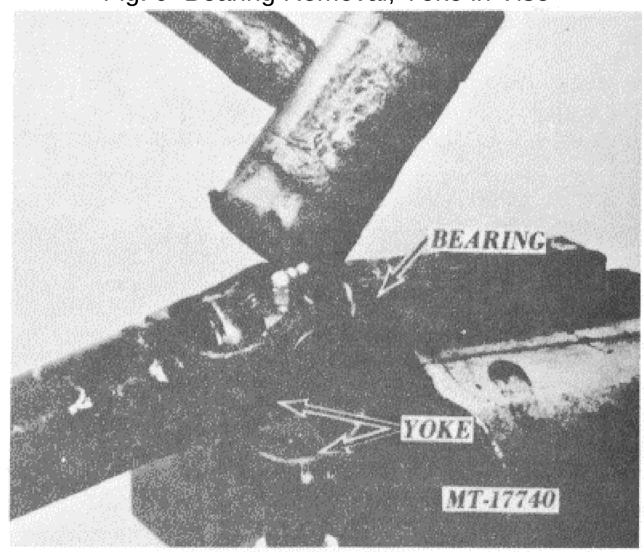


Fig. 10 Bearing Removal (Bearing in Vise Use Copper Jaw Covers on Vise)

UNIVERSAL JOINT REASSEMBLY

1. Make certain parts are clean before assembly.

2. Rest yoke on hard surface. Tap one bearing part way into yoke with a soft hammer (see Fig. 11).

   NOTE: Be certain bearings are started straight in yoke.

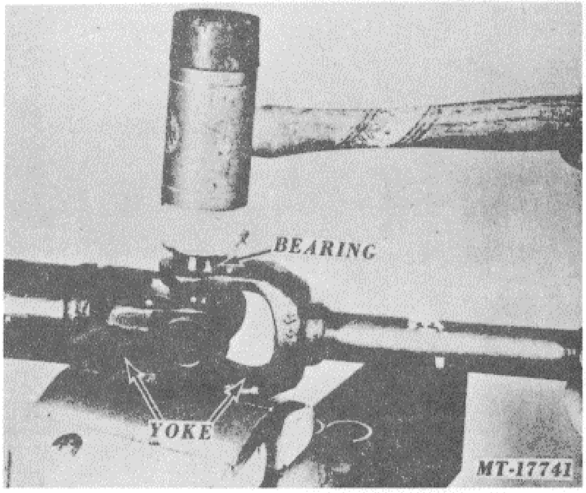


Fig . 11 Start Bearing by Tapping with a Soft Hammer

3. Insert spider through the opposite hole, without bearing, swing it into place and down into the partially installed bearing.
4. Turn assembly over and tap the opposite bearing part way into the yoke. Be certain to start bearing straight in yoke.
5. Place yoke in vise with bearings against jaws of vise. Tighten vise slowly and the bearings will be pressed into the yoke as shown in Fig. 12.

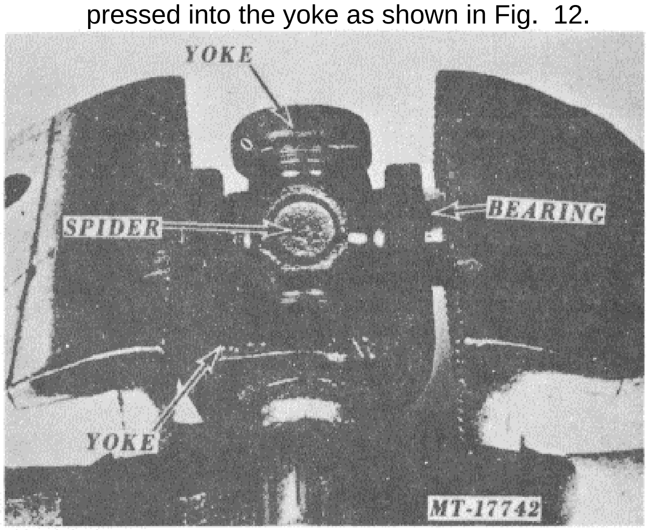


Fig . 12 Pressing Bearing Into Yoke

6. After pressing bearing into yoke the spider may be off center in yoke. This is desirable because it permits installation of snap ring on the side with the most clearance. Refer to Fig. 13 and install snap ring.

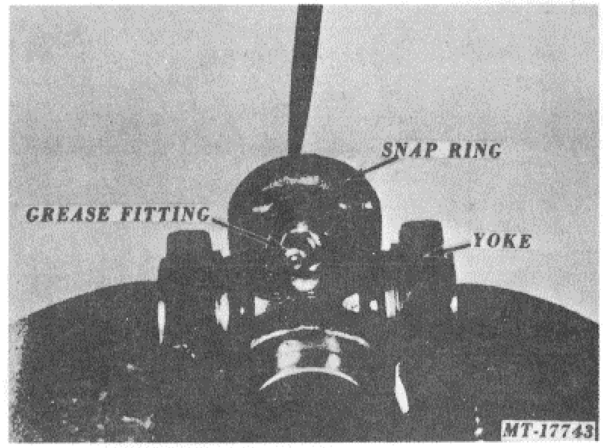


Fig . 13 Snap Ring Installation

7. After the first snap ring is in place turn assembly over. The bearing with snap ring installed should be on the bottom. Rest yoke on vise and strike bearing which is on top, this will seat both bearings. Snap rings should rest against inside milled surface of yoke. Install remaining snap ring.

8. Lubricate universal joint with IH 251 HEP grease or equivalent NLGI #2 multi-purpose lithium grease.

STEERING WHEEL ALIGNMENT

Proper steering wheel-to-steering gear alignment is designed into the steering assembly. Following are a few alignment points to check at assembly or when steering wheel alignment is a problem.

1. The steering wheel has open serrations at the top that align with blind or closed serration on steering shaft. The location of blind serration is marked with either a center punch mark or chisel mark on the end of the steering shaft as shown in Fig. 14.

   NOTE: Do not attempt to adjust steering wheel to straight ahead position by relocating steering wheel to a different serration.

2. Test drive vehicle on a straight and level (no crown) section of road for at least one-quarter mile. Determine if or how far off center the steering wheel is when the vehicle is going straight.

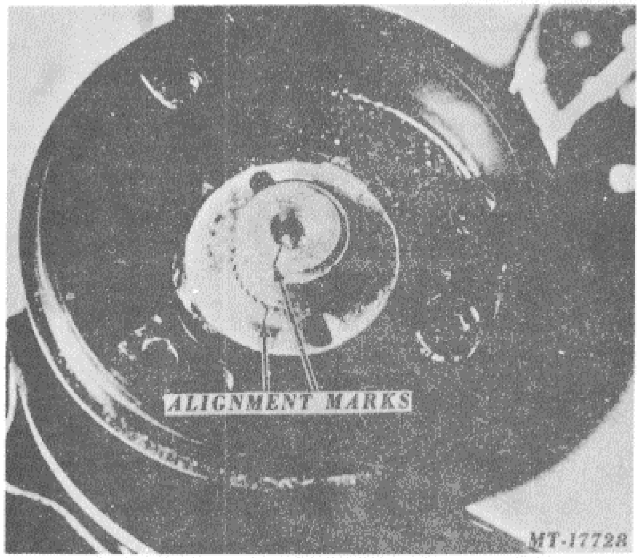


Fig . 14 Steering Wheel Alignment

3. If steering wheel alignment is off return vehicle to work area for further adjustment. Stop vehicle with front road wheels (not steering wheel) straight ahead as indicated by driving test.
4. Disconnect drag link at the steering arm (Pitman Arm).
5. Manual Steering: Turn steering wheel until mark on steering gear output shaft is perpendicular to the input shaft, and the input shaft yoke pinch bolt is at the bottom of the shaft, as shown in Fig. 15.
   Power Steering: Turn steering wheel until mark on steering gear output shaft is perpendicular to the input shaft (Fig. 15). If the steering wheel is off center remove yoke from steering gear input shaft and reinstall on different serrations to align steering wheel.
6. With the road wheels straight ahead and steering gear aligned properly, adjust drag link so it can be connected to the steering arm (Pitman Arm) without altering alignment. Connect drag link to Pitman Arm.
7. Test drive vehicle to assure that proper alignment has been accomplished and that steering is correct.

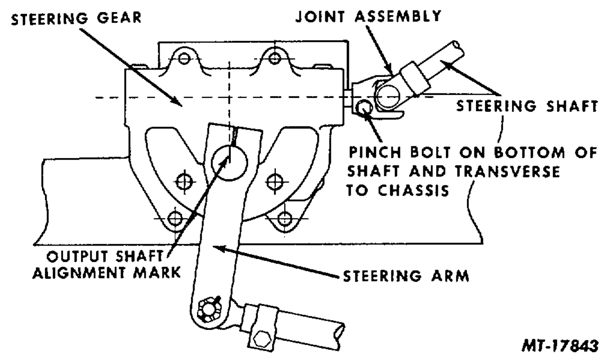


Fig . 15 Steering Gear Alignment

HORN OPERATION AND CIRCUIT

The horn will not operate with the ignition switch in the "OFF" position.

When the ignition switch is in the "ON" or "ACCESSORY" position, current is available at the horn relay. To energize the relay and feed current to the horn, a path to ground must be available. The path to ground is completed through the horn button mechanism in the steering column.

The current path from the horn relay is through a connector and wire that enters the steering column jacket tube, where a spring loaded contact roller rides on the contact ring on the lower side of the steering wheel hub. This 'contact ring is connected to the horn button base plate by a long "ground" screw. When the plastic horn button is depressed, the metal contact cup makes a connection from the base plate through the contact cup support spring, to the steering drive shaft where the path to ground proceeds down the steering shaft through the steering gear to the frame.

LUBRICATION

The steering drive shaft tube bearings and the universal joints should be lubricated at assembly with IH 251 HEP grease or equivalent NLGI #2 multi-purpose lithium grease.

TORQUE CHART

Application	Torque
Steering Wheel Mounting Nut	101-108 N-m (75-80 Ft.lbs.)
Steering Column Bracket Cap	34-38 N-m (25-28 Ft.lbs.)
Steering Yoke Pinch Bolts	47 N-m (35 Ft.lbs.) *

* Insert cotter pin or advance to next slot and insert and spread cotter pin.

Service
Manual

Allison Transmissions

AUTOMATIC MODELS

ALLISON HT 750CRD (A/N 6839074)

IH T 475 PART NO. 515677 C91

1 SEPTEMBER 1975

IMPORTANT SAFETY NOTICE

Proper service and repair is important to the safe, reliable operation of all motor vehicles. The service procedures recommended by Detroit Diesel Allison and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when and as recommended.

It is important to note that some warnings against the use of specific service methods that can damage the vehicle or render it unsafe are stated in this service manual. It is also important to understand these warnings are not exhaustive. Detroit Diesel Allison could not possibly know, evaluate and advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences of each way. Consequently, Detroit Diesel Allison has not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Detroit Diesel Allison must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects.

TABLE OF CONTENTS

Section 2. Continued

Section 3. PREVENT MAINTENANCE

Section 6. REBUILD OF SUBASSEMBLIES

Section 1. GENERAL INFORMATION

1-1. SCOPE OF MANUAL

a. Coverage. This Service Manual describes the operation, maintenance, and overhaul procedures for the HT 750CRD automatic transmission (fig. **1-3 AND 1-4** -). The major components of the transmission are discussed, and the function and operation of the hydraulic system and torque paths are explained. Detailed instructions are provided for disassembly, rebuild and assembly. Wear limits information, par t s inspection procedures, and torque specifications are also included.

b. Illustrations. The text is illustrated with photographs, line drawings, and cross-section views. The overhaul procedures are illustrated mainly by photographs. Line drawings are used to supplement detailed assembly procedures; cross-section views illustrate the torque paths and relationship of assembled parts. Cross-section views, color-coded schematics of the hydraulic system, and all exploded views are presented on foldout pages at the back of the manual.

1-2. SUPPLEMENTARY INFORMATION

Supplementary information will be issued, as required, to cover any improvements which may occur after publication of this manual. Check with your dealer to insure you have the latest information.

1-3. ORDERING PARTS

a. Transmission Nameplate. The nameplate (fig. 1-7) is located on the right-rear side of the transmission. The nameplate displays the transmission serial number, part number (assembly number), and model number. All three of these must be supplied when o r d e r in g replacement parts or requesting service information.

b. Parts Catalog. All replacement parts should be ordered from your dealer. These parts are listed in the current HT 700 Series Parts Catalog (SA 1268). Do not order by illustration item numb e r s used on exploded views in this manual.

1-4. GENERAL DESCRIPTION

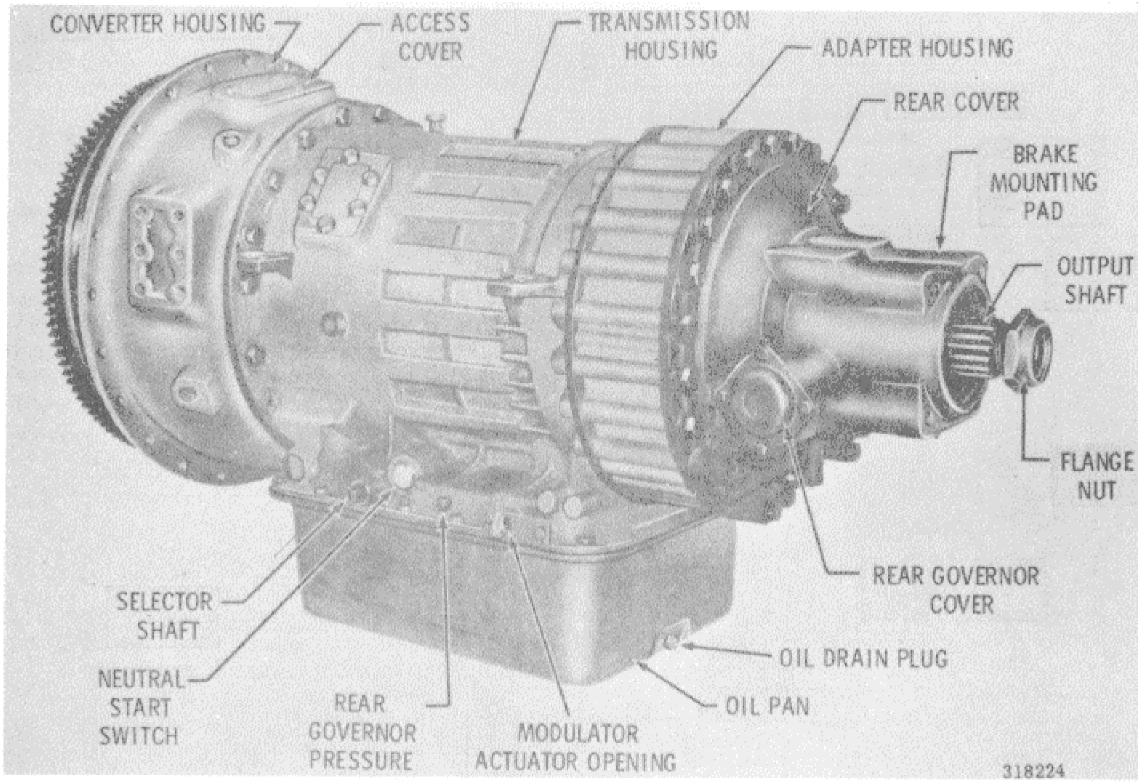
a. Automatic Shifting. Automatic shifting is accomplished in all ranges. **THE DESIGN INCORPORATES FIVE SPEEDS FORWARD AND ONE REVERSE.THE TRANSMISSION WAS DESIGNED FOR OPERATION WITH A DIESEL ENGINE.**

b. Torque Converter. A simple, 3element torque converter (fig **1-4**) transmits power from the engine to the transmission gearing. The torque converter serves as both a fluid coupling and a torque multiplier.

THE TORQUE CONVERTETER USED IN THIS TRANSMISSION HAS A STALL RATIO OF 2.8:1.

c. Lockup Clutch. This clutch automatically locks the turbine element of the torque converter to the flywheel. When the vehicle attains sufficient speed, hydraulic pressure automatically app lie s the lockup clutch. When the lockup clutch is applied, the engine output is directed to the transmission gearing at a 1:1 speed ratio. A decrease in speed automatically releases the lockup clutch.

GENERAL INFORMATION



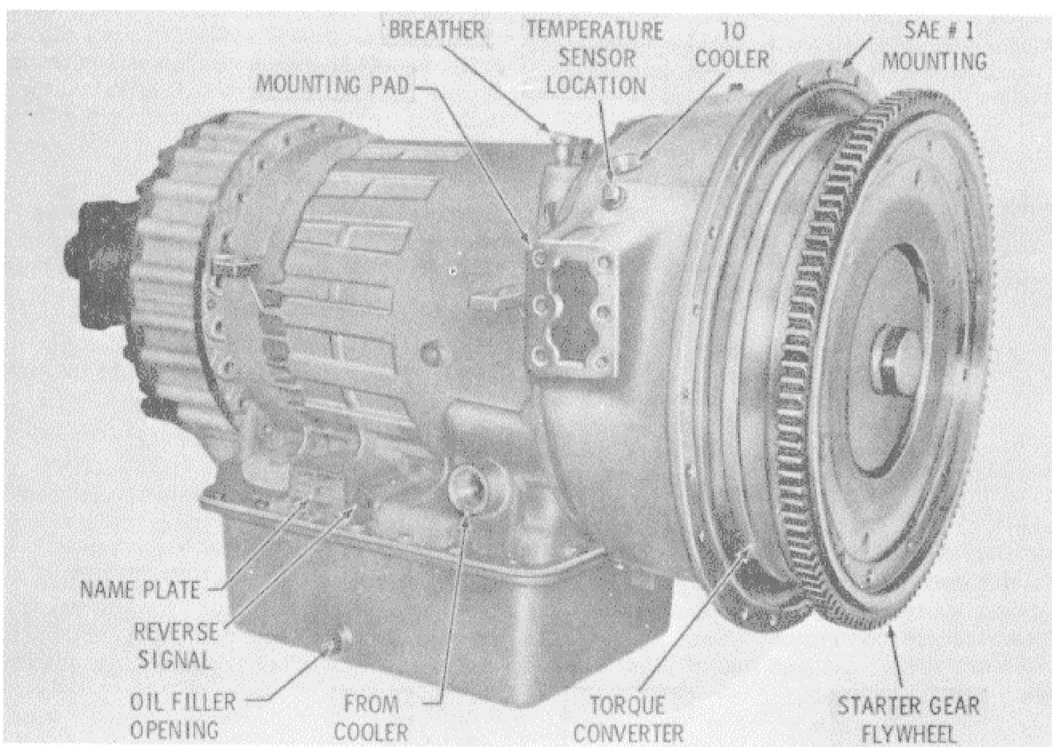


Fig. 1-4. Model HT 750 transmission-right-front view

GENERAL INFORMATION

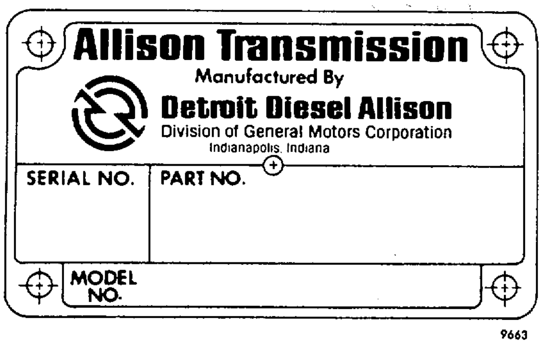


Fig. 1-7 Transmission name plate

e. Power Takeoff Provisions

(1) Transmissions are equipped with provisions for mounting a power takeoff on the front, upper-left side of the transmission housing.

(2) The PTO on the transmission housing i s converter driven.

f. Planetary Gearing, Clutches.

(2) In **THIS** transmission, ratio for five forward speeds and reverse are established by four planetary gear sets. The planetary are controlled by six hydraulic applied clutches. All gearing is in constant mesh.

1-5. OPERATING INSTRUCTIONS

a. Vehicle-Related Controls. For information on controls which are related to the vehicle, refer to the vehicle service manual. Refer also to Drivers Handbook SA 1334.

b. Neutral (N). Place the shift selector at the neutral position before starting the engine. A neutral safety switch (on the transmission or in the selector linkage) prevents starting the engine while the selector lever is not at neutral. Apply the vehicle brakes and shift to neutral any time the engine is to be running while the operator is not at the controls.

c. Forward Drive Ranges

(1) Shifting from neutral. The engine should be at idle speed when any shift from neutral to a drive range is made.

(2) Drive (D). This range is the most commonly used forward range. It includes all forward gears

To drive in this range, simply depress the accelerator. The transmission will start in first (second on HT 750DRD), and automatically upshift at the proper speeds through all gears. Downshifts also will occur automatically, in relation to speed and throttle position.

(3) Drive 4 (4) In this range, the transmission will start in first (second on HT 750DRD), and automatically upshift, at the proper speeds, to the fourth gear.

(4) Drive 3 (3). In this range, the transmission will start in first **AND** automatically upshift, at the proper speeds, to third gear.

(5) Drive 2 (2). In this range, the transmission will start in first **AND** automatically upshift, at the proper speeds, to second gear.

(6) Drive 1 (1). In this range, the transmission will start in first gear. No automatic upshift will occur unless governed speed is exceeded.

HT 700D SERIES

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d. Reverse (R). To move the vehicle backward, idle the engine and shift the selector to the reverse position. Depressing the accelerator will then cause the vehicle to back up.

e. Range Selection. Drive (D) range should be selected for normal load, grade and traffic conditions with an open highway ahead. Drive 3 (3) should be selected for moderate grades and over-the-road operation with restricted speeds. Drive 2 (2) is appropriate for operating in heavy traffic. Drive 1 (1) should be selected when need for speed control requires a hold condition such as descending steep grades where additional engine braking is required, or for operation on rough terrain.

g. Towing. All lubricating and clutch apply oil is provided by an engine-driven pump. Because of t he pump location ahead of the transmission gearing and clutches, the pump cannot be motored by pushing or towing the vehicle. Therefore, anytime that the vehicle must be towed or pushed, the drive line must be disconnected or the driving wheels must be lifted off the ground.

1-6. SPECIFICATIONS AND DATA

The specifications, and data in the chart below provide a quick reference to the major characteristics of the transmission.

GENERAL INFORMATION

Para 1-6

SPECIFICATIONS AND DATA CHART

HT 750CRD

Rating:
- Input torque (net installed) .... 1130 lb ft. (1532 Nm) (max)
- Input speed (max) .... 3000 rpm
- Input horsepower (net installed) .... 400 298 kW (max)

Mounting:
- Engine .... SAE 1 automotive housing
- Vehicle .... Six-hole SAE 2 mounting pad (Earlier models have four-hole SAE 1 mounting pad)
- Drive .... Flex disk

Rotation:
- Input .... Clockwise
- Output (in forward ranges) .... Clockwise

Torque converter:
- Type .... Single-stage, poly-phase, 3 element
- Converter model .... TC 470
- Torque multiplication ratio (at stall) 2.8:1
- Lockup clutch .... Automatic in selected ranges

Gear Data .... Planetary straight-cut spur, constant mesh

Clutches .... Oil cooled, hydraulically actuator, spring released, self-compensating for wear

Sump .... Integral

Oil systems:
- Oil pump (input) .... Engine driven, positive displacement
- Oil pump (scavenge) .... Engine driven, positive displacement, spur gear type.
- Oil filter .... External, Suction screen (in sump)
- Oil capacity (less external circuits) .... 8 US gal (30.3 litres) (approx.)
- Initial fill (as received from factory) .... 6 US gal (22.7 litres) (approx.)
- Refill (oil and filter changed) .... 6 5 US gal (24 6 litres) (approx.)
- Oil type .... Above -30°F (-34°C) hydraulic transmission fluid type ®DEXRON Below -30°F (-34°C), hydraulic transmission fluid type DEXRON -auxiliary preheat required to raise temperature in sump and external circuit.

Oil temperature:	Converter-Out (To Cooler)	Sump
Converter Operation	300°F (149°C)	250°F (121°C)
Lockup Operation	250°F (121°C)	250°F (121°C)

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HT 700D SERIES TRANSMISSIONS

Para 1-6

SPECIFICATIONS AND DATA CHART - Continued

HT 750CRD

Oil pressure:
- Main pressure
  - - Idle 600 RPM .... 90 psi (621 kPa)-min
  - - Stall 1200 RPM .... 140-175 psi (965-1206 kPa)
- Lockup pressure .... Must be within 10 psi (69 kPa) of main pressure
- Lubrication pressure .... 35-45 psi (241-310 kPa)
- Converter-out pressure .... 40-80 psi (276-552 kPa)
- Rear governor pressure .... Refer to table at end of section I

Parking brake provision:
- Type .... 12 x 5 (304.8 x 127.0 mm) (customer supplied)
- Weight .... 50 lbs (22.68 kg)

Drive range and sequences:

- HT 750CRD .... Reverse, neutral, 1-2-3-4-5, 1-2-3-4, 1-2-3, 1-2, 1

Drive range and shift control .... Mechanical (external)

Shifting mechanism .... Hydraulic (internal control)

Shift modulation (upshift and downshift) .... Mechanically actuated (cable, cam, modulator valve)

Neutral start and reverse signal switches .... Supplied by customer

Speedometer drive:
- Type .... Spiral gear
- Drive gear data .... 6-tooth, Rt helix angle
- Driven gear .... Supplied by customer

Dry weight .... HT 750CRD

- Standard unit .... 926 lb (420 kg)

  (housing, rotor, valve body)

Power takeoff mounting (optional)

- Transmission housing, top (40° from vertical) .... Converter driven

GENERAL INFORMATION

Para 1-6

Power takeoff gear backlash .... Refer para 7-20

Output flange .... Supplied by installer

Transmission Ratios (mechanical*)

	Range	Clutches engaged	Ratio
HT 750CRD		Neutral	Low
	First	Forward and low	3.19:1
	Second	Forward and first	1.89:1
	Third	Forward and second	1.55:1
	Fourth	Forward and third	1.24:1
	Fifth	Forward and fourth	1.00:1
	Reverse	Fourth and low	7.97:1

*Overall torque multiplication ratio of transmission (output stalled) is the product of the converter torque multiplication ratio and the mechanical (gear) ratio.

HT 700 SERIES GOVERNOR PRESSURE

Governor	Governor Pressure (psi)	*At rpm
6834473	103-112	1650
6834864	83-91	1650
6836769	59-65	1650

*May be read from engine tachometer during lockup in highest gear.

Section 2. DESCRIPTION AND OPERATION

2-1. SCOPE OF SECTION 2

This section describes the transmission components and explains their functions. Also explained are the hydraulic system and torque paths.

2-3. MOUNTING

a. To Engine. Converter housing 16 (A, foldout 8) is machined to provide an SAE 1 mounting flange. This flange is mated with an SAE 1 bolt circle at the rear of the engine.

b. To Vehicle. An SAE 2 width engine type mounting pad is provided on each side of converter housing 16 (A, foldout 8). Each pad has six 5/8-11 tapped holes. Earlier models provided four 5/8-11 tapped holes on an SAE 1 type mounting pad.

2-4. INPUT DRIVE

A steel laminated flex disk assembly 2 (A, foldout 7) connects the engine crankshaft and transmission flywheel assembly 10. This flywheel serves as the engine flywheel. The inner circumference of the flex plate assembly bolts to an adapter which, in turn, bolts to the engine crankshaft. The plate's outer circumference bolts to flywheel 12. The flywheel is bolted to torque converter pump 22 (B, foldout 7). Starter ring gear 11 (A, foldout 7) is shrunk onto the flywheel.

2-5. TORQUE CONVERTER

a. Description (B, foldout7). The torque converter consists of three elements pump assembly 21, stator 9, and turbine 7. These are vaned elements which are cast aluminum. Pump assembly 21 is the input element and is driven by the engine through the flywheel. Turbine 7 is the output element and is splined to forward clutch and turbine shaft assembly 5 (A, foldout 11). Stator 9 (B, foldout 7) is the reaction (torque multiplying) element. The stator is supported on free-wheel roller race 14 which is splined to a stationary ground sleeve. This stator arrangement provides an over-running clutch which permits the stator to rotate freely in one direction but locks in the opposite direction.

b. Operation

(1) The torque converter assembly is continually filled with oil, which flows through the converter to cool and lubricate it. When the converter is driven by the engine, the pump vanes throw oil against the turbine vanes. The impact of the oil against the turbine vanes tends to rotate the turbine.

(2) The turbine, splined to the turbine shaft, transmits torque to the transmission gearing. At engine idle speed, the impact of oil against the turbine vanes is not great. At high engine speed, the impact is much greater than at idle, and high torque is produced by the turbine.

(3) Oil thrown into the turbine flows to the stator vanes. The stator vanes change

DESCRIPTION AND OPERATION

the direction of oil flow (when the stator is locked against rotation), and directs the oil to the pump in a direction that assists the rotation of the pump. It is the redirection of the oil in a manner to assist the pump that enables the torque converter to multiply input torque.

(4) Greatest torque multiplication occurs when the turbine is stalled and the pump is rotating at its highest speed. Torque multiplication decreases as the turbine rotates and gains speed.

(5) When turbine speed approaches the speed of the pump, oil flowing to the stator begins striking the backs of the stator vanes.

This rotates the stator in the same direction as the turbine and pump. At this point, torque multiplication stops and the converter becomes, in effect, a fluid coupling.

(6) Thus, as explained in (1) through (5), preceding, the torque converter accomplishes three main functions. It acts as a disconnect clutch because little torque is transmitted at engine idle speed. It multiplies torque at low turbine/high pump speed to give greater starting or driving effort when needed. It acts as a fluid coupling to efficiently transmit engine torque to the transmission gearing during drive, other than idle or starting.

2-6. LOCKUP CLUTCH

a. Description (B, foldout 7). The lockup clutch consists mainly of three elements piston 3, clutch plate 4, and back plate 5. These elements are located inside the flywheel. The piston and back plate rotate with the converter pump. The clutch plate is located between the piston and back plate and is splined to the converter turbine.

b. Operation (B, foldout 7). The lockup shift valve directs clutch apply pressure to the lockup clutch piston when sufficient rotational speed is achieved by the forward clutch and turbine shaft assembly. The clutch apply pressure compresses the lockup clutch plate between the piston and back plate, locking all three together. Thus, the converter pump and turbine are locked together, and provide a direct drive from the engine. As rotational speed of the forward clutch and shaft assembly decreases, the lockup shift valve will release the lockup clutch.

2-7. TORQUE CONVERTER HOUSING

Converter housing 16 (A, foldout 8) is machined from cast aluminum. The front of the housing is machined to mate with an SAE 1 engine flywheel housing. The rear of the housing is machined to accept either retarder plate assembly 2 or 19 (A, foldout 10), or front support and valve assembly 1 or 30 (B, foldout 10), and transmission housing 7 (A, foldout 14). The converter housing encloses and supports the torque converter elements and input-driven oil pump assembly 1 (A, foldout 8).

2-9. OIL PUMP ASSEMBLY

a. Description (A, foldout 8). Oil pump assembly 1 consists mainly of three elements drive gear 4, driven gear 7 and pump body 3. The oil pump assembly is

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retained in the converter housing by six bolts. Driven gear 6 is supported in the pump body by gear shafts 5.

b. Operation (A, foldout 8). When the converter pump rotates, its rear hub drives pump drive gear 4. Gear 4 is in mesh with driven gear **ASSEMBLY** 6. Thus, as the gears rotate, oil is drawn into the inlet port and is carried between the pump housing and the gear teeth to the outlet s id e of the pump into the hydraulic system.

2-10. FORWARD SUPPORT AND VALVE ASSEMBLY

The forward support and valve assembly is connected to the rear of the converter housing It provides support for the forward clutch and turbine shaft. Contained within the support assembly are three valves main pressure regulator valve assembly 3 (B, foldout 10), lockup shift valve 8, and converter bypass valve 14.

2-11. FORWARD CLUTCH AND TURBINE SHAFT (A, foldout 11)

a. Function

(2) The forward clutch has multiple functions. When engaged with low clutch, it produces first gear. When engaged with first clutch, second, third or fourth clutches, it produces second, third, fourth or fifth gears, in that sequence.

b. Description

THE MODEL HAS A CLUTCH HOUSING WITH A TURBINE SHAFT ATTACHED

ten clutch plates, a piston, a forward clutch hub and a fourth-clutch driving hub.

(2) The clutch housing contains an oil collector ring attached to its outer diameter and works in conjunction with a pitot tube to produce front governor pressure.

The clutch housing contains the forward clutch piston, positioned inside the housing in its bore, retained by twenty springs, a spring retainer and a snapring.

(3) Five of the clutch plates are internal-splined, while the remaining five are external-tanged. The internal-splined plates are attached to the forward clutch hub. The external-tanged plates are attached to the internal grooves of the forward clutch housing.

c. Operation (A, foldout 11)

(1) Clutch housing and shaft assembly 5 rotate when the converter turbine rotates. Fourth-clutch driving hub 23 also rotates causing the internal-splined plates of the fourth-clutch pack to rotate.

(2) When hydraulic pressure is directed to the front side of piston 13, clutch plates 21 and 22 are compressed together. This locks forward-clutch hub 20 to the forward clutch housing. Since hub 20 is splined to the transmission main shaft, the shaft will rotate with the hub, at input speed.

(3) The simultaneous application of two clutches is necessary to produce one forward or one reverse gear. The forward clutch is applicable only in forward gears (refer to b .(1), (2), above). When the converter turbine rotates, and the forward clutch is applied, the main shaft drives the components of the gear unit which in turn drive the output shaft.

(4) Rotation of the oil (pitot)collector ring directs oil against the front pitot tube any time the converter turbine rotates. Thus, an increase in turbine speed produces a proportional increase in front governor pressure.

DESCRI PTION AND OPERATION

2-12. FOURTH CLUTCH (B, foldout 11)

a. Function

(2) The fourth clutch has a dual function. Engaged with the forward clutch, it produces fifth gear. Engaged with the low clutch, it produces reverse gear.

b. Description. The fourth clutch contain ten clutch plates, a clutch piston housing and a piston. Five plates are internally splined and five are externally tanged. The piston is positioned inside the clutch housing in its bore and retained by twenty piston return springs, a spring retainer and a snapring.

c. Operation (B, foldout 11)
(All models)

(1) Internal-splined clutch plates 4, driven by the fourth-clutch driving hub, rotate any time the input shaft and the forward clutch housing assembly rotates.

(2) When hydraulic pressure is directed to the back side of fourth-clutch piston 9, the piston compresses clutch plates 4 and 5 together. This locks internal-splined plates 4 to external-tanged plates 5, and, in turn, to clutch housing 14.

(3) Since center sun gear and shaft assembly 23 (B, foldout 12 or A and B, foldout 13) is splined to the clutch housing, it will also rotate at input speed.

2-13. SECOND, THIRD CLUTCHES, AND CENTER SUPPORT (A, foldout 12)

a. Function Differs Among Models

(2) The second and third clutches perform only one function. When engaged with forward clutch, the second clutch produces third gear, while the third clutch produces fourth gear.

b. Description (1) The second and third clutches are composed of two identical pistons, twenty-one clutch plates (13 in second clutch; 8 in third clutch) and a center support.

(2) Two pistons 10 and 21 are positioned back-to-back in the bores of center support housing assembly 16. Each piston is retained in its bore by twenty piston return springs 9 or 22, a return spring retainer 8 or 23, four self-locking retainer rings 7 or 24 and snap-rings 5 or 25.

(3) Eight clutch plates are required for the third clutch (four internal-splined and four external-tanged plates). The internal-splined plates are attached to the outside diameter of the fourth clutch housing and are free to rotate. The external-tanged plates are anchored to the transmission housing and cannot rotate.

HT 700D SERIES TRANSMISSIONS

Para 2 -13/2-14

(4) Thirteen clutch plates are required for the second clutch. Six internal-splined plates are attached to the splined area on the outside diameter of the front carrier assembly, and are free to rotate. The seven external-tanged clutch plates a re anchored to the transmission housing and cannot rotate.

(5) The center support assembly is housed in the transmission and located by an anchor bolt. This insures accurate oil passage hole alignment from the valve body to the second and third piston cavities.

c. Operation of Third Clutch (A, foldout 12)

(1) When hydraulic pressure is directed through the oil passages in the center support to the back side of clutch piston 10, clutch plates 3 and 4 are compressed together. This locks the fourth clutch housing to the transmission housing, which prevents the fourth clutch housing and attached components from rotation.
clutch in conjunction with third clutch, a reaction within the planetary gearing will produce a forward rotation to the output shaft.

d. Operation of Second Clutch (A, foldout 12)

(1) When hydraulic pressure is directed through the oil passages in the center support to the front side of clutch piston 21, clutch plates 26 and 27 are compressed together. This locks the front planetary carrier to the transmission housing, which prevents the carrier from rotating.

(2) With the application of the forward clutch in conjunction with the second clutch, a reaction within the planetary gearing will produce a forward rotation to the output shaft.

2-14. FIRST CLUTCH (B, foldout 14)

a. Function

(2) The first clutch has a single function. Engaged with the forward clutch, it produces second gear.

b. Description. The first clutch contain thirteen clutch plates and a piston. Six are internal-splined clutch plates and seven are external-tanged clutch plates. The external-tanged plates are held stationary by the transmission housing, while the internal-splined plates are free to rotate. The piston for each model is positioned in its respective bore and retained there by return springs and a spring retainer.

d. Operation (B, foldout 14)

(1) WHEN THE FIRST CLUTCH IS RELEASED INTERNAL-SPLINED PLATES 2 ARE FREE TO ROTATE. SINCE REAR PLANETARY RING GEAR 4 IS SPLINED TO THE INTERNAL PLATES, IT WILL ALSO ROTATE FREELY.

(2) When hydraulic pressure is directed to the back side of piston 6 (A, foldout 15), the piston compresses clutch plates 1 (B, foldout 14) and 2 together. This locks the rotating internal plates to the stationary external plates preventing ring gear 4 from rotating.

(3) With the application of forward clutch in conjunction with first clutch (refer to a(2), above), a reaction within the planetary gearing will produce a forward rotation at the output shaft.

2-15. LOW CLUTCH (A, foldout 15)

a. Function

(1) Only the five-speed transmissions include the low clutch. Refer to FOLDOUT 2, ITEM 23, FOR ITS LOCATION

(2) The low clutch has a dual function. When engaged with the forward clutch, it produces first gear. When engaged with the fourth clutch, it produces reverse gear.

b. DESCRIPTION. THE LOW CLUTCH :ONTAIN THIRTEEN CLUTCH PLATES AND A

DESCRIPTION AND OPERATION

piston. Six are internal-splined clutch plates and seven are external-tanged clutch plates. The external-tanged plates are held stationary by the adapter housing, while the internal splined plates are free to rotate. The piston for each model is positioned in its respective bore and retained there by 28 piston return springs, the return spring retainer, four retainer rings and a snapring.

c. Operation (A, foldout 15)

(1) When the low clutch is released, internal-splined clutch plates 15 are free to rotate. Since low planetary ring gear 14 is splined to internal plates 15, it will also rotate freely.

(2) When hydraulic pressure is directed to the back side of low piston 6 (A, foldout 15), the piston c o m presses clutch plates 15 and 16 together. This locks rotating internal-splined plate 15 to stationary external-tanged plate 16, preventing ring gear 14 from rotating.

(3) With the application of the forward or fourth clutch in conjunction wit h the low clutch, a reaction within the planetary gearing will produce either forward or reverse rotation, respectively, at the output shaft.

2-17. PLANETARY GEARING

a. Description (A, foldout 13)

(1) The planetary gearing i s composed of a gear unit and main shaft assembly (A, foldout 13), the low planetary carrier assembly 18 (A, foldout 15) and its sun gear and ring gear.

(2) The gear unit and main shaft assembly (A, foldout 13) contains three planetaries called front, center and rear, so designated because of their location i n relation to each other in the gear unit.

(3) Each of the three planetaries has a sun gear and a ring gear, which are interconnected by the main transmission shaft and a connecting drum.

(4) The low planetary gear set is located behind the gear unit and main shaft assembly. Re f e r to figure 2-9. It contains a sun gear, a carrier assembly, and a ring gear. The sun gear is splined to the main shaft, and the rear carrier is splined to the low ring gear, thereby interconnecting the four planetary systems.

(5) This interconnection of the planetary input, reaction, and output elements and connections with the forward and fourth clutches produces five forward speeds and one reverse speed.

b. Operation (A, foldout 13)

(1) The front planetary assembly 5, used in conjunction with the center planetary assembly 16, produces third gear when the forward and second clutches are applied (fig. 2-11).

(2) The center planetary is active in third, fourth, fifth and reverse gears.

(3) The rear planetary carrier assembly 38, is required in second, third, fourth and fifth gears. In second gear, with the application of forward and first clutches, it singularly transmits torque, at a reduction, through the low carrier to the output shaft (fig. 2-10). In third, fourth and fifth gears its only function is in the transmitting of torque through the low carrier to the output shaft.

(4) The low planetary carrier assembly 18 (A, foldout 15), is used in all gears. In first gear, torque is transmitted through the main shaft to low sun gear and then to the low carrier assembly. With the application of the forward and low clutches, the torque is then transmitted by the carrier, at a reduction, to the output shaft. In reverse gear, torque is transmitted through the fourth clutch housing, sun gear shaft assembly 23 (A, foldout 13), center carrier assembly 16 and main shaft assembly 34 to the low sun gear and carrier. With the application of fourth and low clutches, the torque is then transmitted by the carrier, at a reduction, to the output shaft (fig. 2-14).

NOTE

In fifth gear, because both the forward and fourth clutches are engaged, all four planetaries rotate as a unit. This gives direct drive through the transmission.

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Para 2-19/2-23

2-19. SPEEDOMETER DRIVE

a. Description (A, foldout 16)

(1) The speedometer drive consists of drive gear 24 and driven gear bushing 15.

(2) Drive gear 24 is a worm gear with a right hand helix. The gear is concentric with the output shaft and has no key or drive splines. The drive gear is clamped between rotating parts which, in turn, cause the drive gear to rotate.

b. Operation (A, foldout 16). When the transmission output shaft rotates, drive gear 24 rotates. Bushing 15 supports the driven gear (vehicle furnished)within the rear cover. The driven gear rotates clockwise (as viewed at the cable connection in the rear cover) during forward operation.

2-20. GOVERNOR

a. Description(A, foldout 16). Governor assembly 38 is a centrifugal (flyweight) governor which is driven by output shaft 23 or 30. The governor is supported by a bore in rear cover 14 and pin 11, and retained in the rear cover by cover 42.

b. Operation (A, foldout 16). Rotation of the governor causes the governor valve (foldouts 5,) to travel within its bore. When the valve moves leftward, governor pressure rises; when the valve moves rightward governor pressure falls. Thus, governor pressure is proportional to transmission output speed. Governor pressure, in combination with modulator pressure (para 2-26h, below), provides the automatic shifting in the transmission. (Refer also to para 2-26g, i, L k, below, for additional information about automatic shift circuits.)

2-21. CONTROL VALVE ASSEMBLY

a. Description (B, foldout 16). Control valve body assembly 1 includes the various valves, springs and other components which control the selection of ranges, and the automatic shifting of gears. The valve body assembly is bolted to the bottom of the transmission case, which is channeled to direct the flow of oil between the valve body and clutches, and other components.

b. Operation. Refer to paragraph 2-26, below, for operation of the control valve body assembly.

2-22. LOW SHIFT AND TRIMMER VALVES

a. Description (A, foldout 17). Low shift valve body assembly 2 contains a relay valve, a shift valve, springs, pins and an adjusting ring. It is mounted on the bottom of the control valve assembly, and retained by bolt 1. Mounted directly under the low shift valve body, is low-trimmer valve body assembly 18. This body consists of a valve, trimmer and retainer plugs, a spring, a valve stop and a pin. Six bolts (17), extending through both valve bodies and the control valve assembly into the transmission housing, retain the two bodies.

2-24. OIL PAN AND OIL FILTER

a. Description (A, foldout 14)

(1) Oil pan 30 is a pressed steel assembly that provides one opening for attaching a combination oil filter and level gage tube, and another for draining the oil. Earlier models did not provide a separate drain, and oil was drained by loosening the filler tube.

(2) Oil filter 25 is a box-like sheet metal frame with a perforated sheet metal reinforcement covered by a fine-mesh screen across the bottom. Sump oil is drawn through the screen by the oil pump and directed into the hydraulic system. Screw 28 attaches the oil filter to the bottom of the control valve body assembly.

b. Function (A, foldout 14)

(1) Oilpan30 holds the entire oil supply for the transmission and covers the control valve body assemblies and oil filter.

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(2) The oil filter screens all oil entering the hydraulic system.

2-25. REAR COVER (A, foldout 16)

Rear cover 14 is made of cast iron and machined to receive governor assembly 38 and first or low clutch piston 4. The rear cover provides support for output shaft assemblies 19. A parking brake mounting face is also provided on the rear surface. The cover is the rear closure member and is attached to the adapter housing by twenty-four bolts 17 and 36.

2-26. HYDRAULIC SYSTEM

a. System Functions. The hydraulic system generates, directs, and controls the pressure and flow of the hydraulic fluid within the transmission. The hydraulic fluid (transmission oil) is the power transmitting medium in the torque converter. Its velocity drives the converter turbine. Its flow cools and lubricates the transmission and its pressure applies the clutches.

b. System Schematics. A Color-coded foldout illustration of the hydraulic system IS presented at the back of this manual (foldouts 5,). Each illustration represents the system as it would function during neutral operation and with the engine idling.

c. Oil Filter, Pump Circuit
(foldouts 5,)

(1) Oil (blue) is drawn from the sump (transmission oil pan) through a fine-mesh filter screen by the input-driven pump assembly.

(2) The oil (red) is discharged by the input pump through an external filter (when so equipped) and into the bore of the main pressure regulator valve.

(3) F or models equipped with a hydraulic retarder, the oil is discharged from two sections of the input pump. The first section directs oil (red) to the main-pressure regulator valve (item (2), above). The second section directs oil (black and green) to the lubrication circuit, and assists in providing oil to the converter-in circuit.

d. Main-Pressure Circuit
(foldouts 5,)

(1) Main pressure (red) is regulate by the main-pressure regulator valve. Oil from the pump flows into the valve bore, through an internal passage in the valve, to the upper end of the valve. Pressure at the upper end of the valve forces the valve downward against the spring until oil (yellow) flows into the converter-in circuit. When flow from the pump exceeds the circuit requirement, the converter bypass valve opens and allows the excess to escape into the converter-out circuit (orange).

(2) Although main pressure is controlled primarily by the spring force below the regulator valve, it is also affected by the presence of forward regulator pressure. When this pressure is not present at the regulator valve, main pressure is regulated at a higher value.

(3) Main pressure (red) is directed to several points in the hydraulic circuit.

e. Converter, Cooler, Lubrication
Circuit (foldouts 5,)

(1) The converter circuit originates at the main-pressure regulator valve. Converter-in oil (yellow) flows to the torque converter. Oil must flow through the converter continuously to keep it filled and to carry off the heat generated within the converter.

(2) Converter-out oil (orange) leaving the torque converter, is directed to an external cooler (supplied by vehicle or engine manufacturer). When the transmission includes a hydraulic retarder, converter-out oil flows through the retarder control valve

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before going to the cooler. A flow of air or water over or through the cooler removes the heat from the transmission oil.

(3) Lubrication oil (green) is directed through the transmission to components requiring continuous lubrication and cooling. The lubrication oil then drains into the sump. Oil in excess of that required by the lubrication circuit escapes to the sump through the lubrication regulator valve.

f. Selector Valve, Forward Regulator Circuits (foldouts 5,)

(2) **THE SELECTOR VALVE** can be shifted into seven lever positions; (R) reverse, (N) neutral, (D5) drive 5, (D4) drive 4, (D3) drive 3, (D2) drive 2, (D1) drive 1. Attach of these positions, the selector valve establishes the hydraulic circuit for operation in the condition indicated.

NOTE

The quadrant designations listed above are not necessarily the same as those in the vehicle.

(4) drive 1, drive 2, drive 3, drive 4 and drive 5 are forward ranges. Anytime the vehicle moves forward, regardless of what range was selected, it starts in first gear. Shifting is automatic in any of the above ranges, varying with vehicle speed and throttle position.

(6) The forward regulator pressure i s directed from the selector valve to the main-pressure regulator valve when the selector valve is in any position except reverse. In neutral and all forward drive ranges, this regulator pressure assists the pump pressure acting downward upon the main pressure regulator valve. In reverse, the neutral-forward pressure is absent from the main-pressure regulator valve. This allows the valve spring to exert its full force upward against the regulator valve, causing an increase in main pressure. This increase in pressure is necessary for higher clutch pressures, to handle the high torque produced in reverse gear.

g. Rear Governor Circuit

(1) Governor feed is merely main pressure directed to the governor valve. A centrifugal-type g o v e r n o r, driven by the transmission output, controls the position of the governor valve. The position of the governor valve determines the pressure in the governor circuit. When the transmission output is not rotating, governor pressure is negligible. When the transmission output rotates, governor pressure varies with the speed of rotation.

(2) Governor pressure is directed to the shift signal valves and to the governor accumulator valve.

(3) The governor accumulator valve is a spring-loaded valve in a straight bore. The accumulator valve absorbs pressure surges and provides a more uniform governor pressure.

h. Modulator Pressure Circuit foldouts 5,)

(1) The modulator valve produces a regulated, reduced pressure which is derived from main pressure. The valve is moved rightward by a spring at the left end of the valve when the throttle is closed. The valve is moved leftward by the cam and spring action when the throttle is opened. When the spring force at the left of the valve is imbalance with the spring force and modulator pressure at the right end of the valve, modulator pressure is regulated.

(2) When the throttle setting is increased, the upward (or downward) movement of the actuator cam forces the modulator valve toward the left. This leftward movement reduces modulator pressure. When the throttle setting is reduced, the downward movement of the actuator cam allows t he spring at the left end of the valve to return the valve to another regulating position. Because the throttle setting is varied w it h load and engine speed, modulator pressure varies also.

(3) At all the shift signal valves, modulator and governor pressures act on calibrated areas to upshift the valves against

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calibrated springs. Each of the shift valves and springs are calibrated to insure that the valves will shift at the proper time and in proper sequence. At a given governor pressure, an increase in modulator pressure will upshift a signal valve. A decrease in modulator pressure will cause a downshift if governor pressure alone will not hold the valve upward.

(4) A t the trimmer regulator valve, modulator pressure assists in regulating the trimmer regulator pressure against the spring at the top of the valve.

(5) A t the lockup valve, modulator pressure causes lockup to occur at a lower vehicle speed.

i. Trimmer Regulator Valve

(1) The trimmer regulator valve reduces main pressure to a regulated pressure. The regulated pressure i s raised or lowered by change s in modulator pressure (red and green).

(2) Trimmer regulator pressure is directed to the lower side(s) of the trimmer regulator plug(s) to vary the clutch apply pressure pattern of the trimmer valves. A higher modulator pressure (closed throttle) will reduce trimmer regulator pressure. This results in lower initial clutch pressure. Conversely, a lower modulator pressure (open throttle) results in higher regulator pressure and a higher initial clutch pressure.

j. Trimmer Valves

(1) The purpose of the trimmer valves is to avoid shift shock. The valves reduce pressure in the clutch apply circuit during initial clutch application, then gradually returns the pressure to the operating maximum. This applies the clutch gently, and harsh shifts are prevented.

(2) Although each trimmer valve is calibrated for the clutch it serves, all trimmers function in the same manner. Each trimmer includes (from top to bottom) an orificed trimmer valve, trimmer valve plug, trimmer spring and stop pin.

(3) When any clutch (except forward) is applied, apply pressure is sent also to the upper end of the trimmer valve. Initially, the valve and plug are forced downward against the trimmer spring until oil escapes to exhaust. This escape of oil, as long as it continues, reduces clutch apply pressure. However, oil flows through an orifice in the trimmer valve to the cavity between the trimmer valve and plug. Pressure in this cavity forces the plug farther downward, to the stop. The plug stops, but flow through the orifice in the trimmer valve continues. The pressure below the trimmer valve, because it is acting upon a greater diameter than at the upper end, pushes the trimmer valve to the top of the valve bore. This throttles, then stops, the escape of oil to exhaust. When escape of oil is stopped, clutch apply pressure is at maximum value. The plug remains downward, against the stop, until the clutch is released.

(4) When the clutch is released, the trimmer spring pushes the trimmer components to the top of the bore. In this position, the trimmer is reset and ready to repeat the trimming action when its clutch is again engaged.

(5) A trimmer boost accumulator valve is connected to the trimmer regulator pressure circuit. The accumulator will absorb surges in the trimmer regulator pressure and provide a more uniform regulator pressure.

k. Lockup Circuit (Actuated by front governor)

(1) The front governor circuit originates at the front pitot. Rotation of the vaned pitot collector ring directs oil against, and into, the pitot orifice. This produces a pressure in the front governor circuit which varies with the rotational speed of the collector ring. Pressure increases as speed increases. This pressure is directed to the top of the lockup valve.

(2) When front governor pressure (or front governor pressure assisted by modulator pressure) is sufficient to compress the spring at the bottom of the valve, the lockup valve moves downward. In this position, the

valve directs pressure to the lockup clutch piston, which causes the lockup clutch to engage. Main pressure applies the lockup clutch in models not equipped with lockup cutoff valves. When lockup cutoff valves (para2-23) are included, clutch apply pressure from the drive clutch engaged is used to apply the lockup clutch.

m. Priority Valve

(1) The priority valve insures that the control system upstream from the valve will retain sufficient pressure during shifts to perform its automatic functions.

(2) Without the priority valve, the filling of a clutch might require a greater volume of oil (momentarily) than the pump could supply and still maintain the necessary control pressures.

O. Clutch Circuit, Drive Ranges

(1) There are six clutches in the transmission. These are: low clutch; first clutch; second clutch; third clutch; fourth clutch; and forward clutch. The clutches are applied for various conditions as follows:

Condition	Clutch(es) applied
Neutral	Low
First gear	Low and forward
Second gear	First and forward
Third gear	Second and forward
Fourth gear	Third and forward
Fifth gear	Fourth and forward
Reverse gear	Low and fourth

(2) Each of the six clutches has its own circuit. Each clutch except the forward clutch is connected to a relay valve and a trimmer valve. The forward clutch is connected directly to the selector valve and does not connect to a trimmer valve. It does not require connection to a trimmer valve because its application (except in neutral-to first gear on the HT 750CRD and neutral-to second gear on the HT 750DRD) precedes the application of an additional clutch which is trimmed.

(3) The low clutch circuit connects the clutch to the 1-2 relay valve and to the low trimmer valve. In neutral, the 1-2 shift valve connects to the top of the 1-2 relay valve. As long as main pressure is at the top of the 1-2 relay valve, the valve cannot move. Until the 1-2 shift valve is charged by governor pressure, main pressure will continue to hold the 1-2 relay valve down. Therefore hydraulic fluid is directed to only one clutch. Since two clutches are required to move the vehicle and since governor pressure is negligible until the vehicle is moving, neutral is maintained (refer to fig. 2-8).

(4) The low clutch in addition to being applied during neutral operation, is also applied in first and reverse gears. Shifting the selector valve from neutral to drive 5 (D5) position or any other forward drive range (D4, D3, D2, D1) charges the forward clutch circuit and applies the forward clutch. The low clutch remains charged. Hydraulic fluid is directed from the selector valve to the forward clutch. It is also directed through the priority valve to the 2-3 relay valve. The unit is now in first gear. Automatic shifting from first gear, progressively, to higher gears (second, third, fourth, fifth) will occur when vehicle speed increases. The highest gear attainable, in automatic shifts, is determined by the range selected (refer to (7), below).

(5) Shifting the selector valve from neutral to reverse (R) charges the fourth clutch, while the low clutch remains applied. In reverse, fourth clutch (reverse signal) pressure is also directed to the bottom of the 2-3 relay valve. The pressure at this point prevents the relay valve from moving downward during reverse operation.

(6) When the circuits are charged, as described for the shift to drive 5 (D5), above, any forward shift from first to second, second to third, third to fourth, and fourth to fifth can occur automatically. These shifts occur as a result of rear governor pressure. At less than full throttle, modulation will assist governor pressure.

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(7) Movement of the selector valve determines the highest gear which will be normally reached automatically. In drive 5 (D5), automatic 1-2, 2-3, 3-4 and 4-5 shifts can occur. In drive 4 (D4), automatic 1-2, 2-3 and 3-4 shifts can occur. In drive 3 (D3), automatic 1-2 and 2-3 shifts can occur. In drive 1 (D1), no upshift can occur unless overspeed occurs. Automatic downshifts can occur within the selected ranges.

(8) The various drive ranges limit the highest gear attainable by introducing a pressure which prevents rear governor pressure from upshifting the signal valves (unless a governor pressure well above that normally attained is reached). This pressure is a regulated, reduced pressure derived from main pressure at the hold regulator valve.

Main pressure is directed to the hold regulator valve through the hold feed line when the selector valve is at drive 4 (D4), drive 3 (D3), or drive 2 (D2) position. The pressure produced in the hold regulator valve is directed to the 4-5 shift signal valve when the selector valve is at drive 4 (D4). The hold pressure is directed to the 3-4 and 4-5 shift signal valves when the selector valve is at drive 3 (D3) position. With the selector valve in drive 2 (D2) position, the pressure is directed to the 2-3, 3-4 and 4-5 shift valves.

(9) Hold regulator pressure at each shift signal valve will push the upper valve upward, and raise the pressure at which the lower valve will be pushed upward by rear governor pressure. Thus, when hold regulator pressure is present, no upshift can occur at that shift signal valve, except at an elevated speed.

q. Automatic Upshifts

(1) When the transmission is operating in D5 a combination of rear governor pressure and modulator pressure, or rear governor pressure alone, will upshift the transmission to the next gear. At closed, or part throttle, modulator pressure exists and will assist rear governor pressure. At full throttle, there is no modulator pressure. Thus, upshifts occur sooner when the throttle is closed; and is delayed by opening the throttle.

(2) Rear governor pressure is dependent upon the rotational speed of the transmission output. The greater the output (vehicle) speed, the greater is rear governor pressure. When rear governor pressure is sufficient, the first upshift (1-2) will occur.

A FURTHER INCREASE IN REAR GOVERNOR PRESSURE WILL CAUSE A 2-3 UPSHIFT.

A further increase in rear governor pressure (and vehicle speed) will cause a 3-4 upshift. A still further increase in rear governor pressure will cause a ’ 4-5 upshift. Note that each of these upshifts will be either delayed or hastened by the decrease or increase, respectively of modulator pressure.

(3) In other drive ranges, the same upshift sequence occurs until the highest gear attainable in that range selection is reached.

(4) In any automatic upshift, the shift signal valve acts first. This directs a shift pressure to the relay valve. The relay valve shifts, exhausting the applied clutch and applying a clutch for a higher gear.

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r. Automatic Downshifts

(1) Automatic downshifts, like upshifts, are controlled by rear governor and modulator pressures. Downshifts occur in sequence as rear governor pressure and/or modulator pressures decrease. Low modulator pressure (open throttle) will hasten the downshift; high modulator pressure (closed throttle) will delay downshifts

(2) In any automatic downshift, the shift signal valve acts first. This exhausts the shift signal holding the relay valve downward. The relay valve then moves upward, exhausting the applied clutch and applying the clutch for the next lower gear.

s. Downshift and Reverse Inhibiting

(1) Inherent in the system, as a result of valve areas and pressure calibrations, is a means for preventing downshifts at a too high vehicle speed or a reverse shift at an excessive forward speed.

(2) Progressive downshifts occur because the regulated hold pressure is calibrated, along with the valve areas, to shift the signal valves downward against rear governor pressure only when the governor pressure decreases to a value corresponding to a safe downshift speed. Thus, if speed is too great, rear governor pressure is sufficient to hold the shift signal valve upward against hold pressure. As rear governor pressure decreases, the shift signal valves move downward in sequence.

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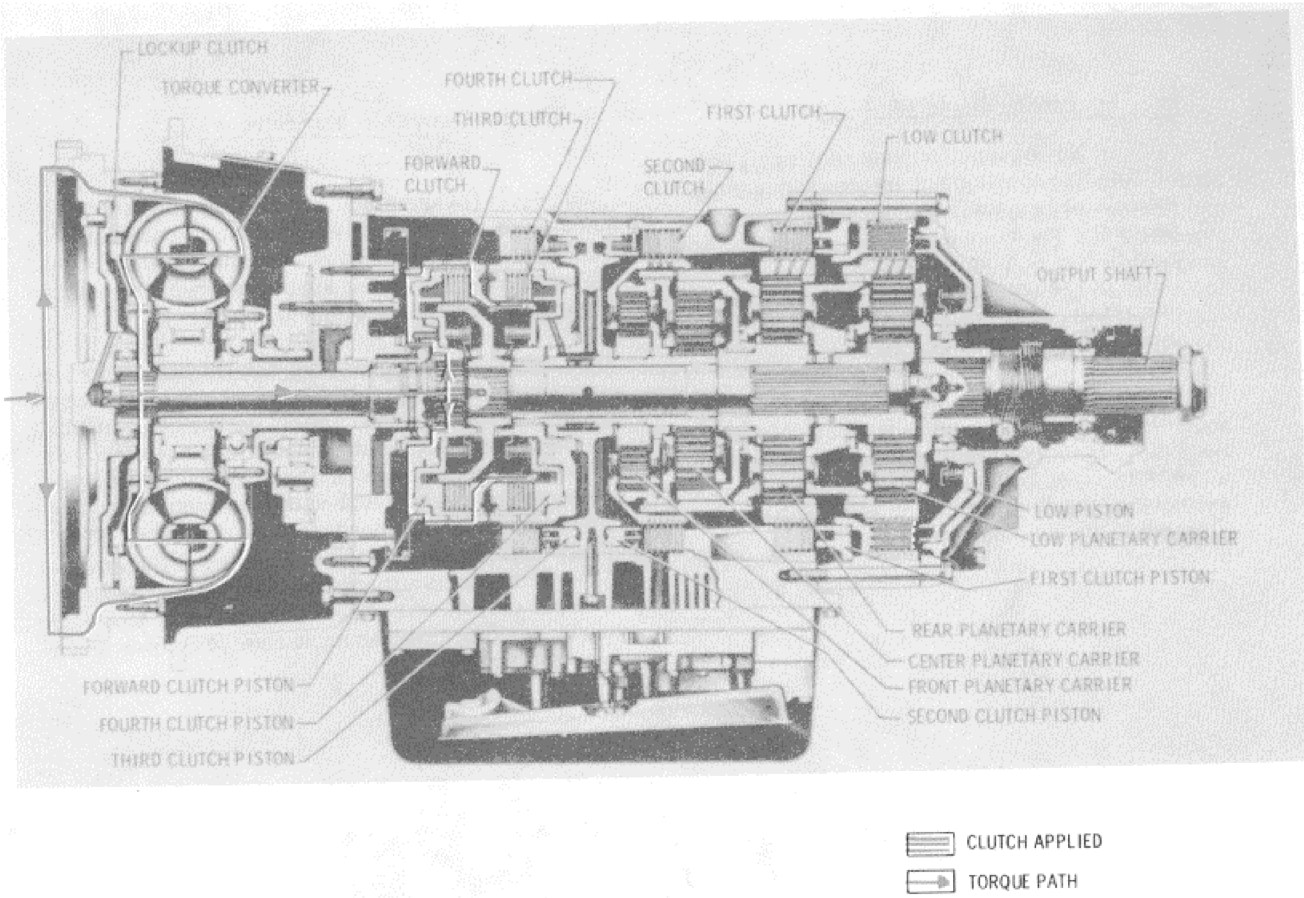

<u>NEUTRAL</u>

Fig. 2-8. Neutral torque path

2-28. TORQUE PATHS THROUGH TRANSMISSION

<u>a</u>. <u>Converter Operation.</u> Power is transmitted hydraulically through the torque converter. The engine drives the converter pump. The pump throws oil against the vanes of the turbine, imparting torque to the converter turbine shaft. From t h e turbine, oil flows between the vanes of the stator, and re-enters the pump where the cycle begins again. When the engine is idling, impact of the oil upon the turbine blades is negligible. When the engine is accelerated, the impact is increased and the torque directed through the turbine shaft can exceed the engine torque (by an amount equal to the torque ratio of the converter). Converter operation is illustrated in first, second, third and reverse operation where it is most likely to occur.

<u>b.</u> <u>Lockup Operation</u>. Power is transmitted mechanically through the lockup clutch. Application of the lockup clutch occurs automatically in selected ranges as a function of governor pressure. When the lockup clutch is applied, the converter elements rotate as a unit at engine speed. This provides a direct drive from the engine to the turbine shaft. Lockup operation is illustrated in fourth and fifth gear operation.

<u>c.</u> <u>Neutral Operation</u> (fig. 2-8). Engine torque is transmitted through the torque converter as described in a, above. The forward clutch is not engaged. Thus the torque is not transmitted beyond the fourth-clutch hub. (Although the low clutch is applied, two clutches must be applied to produce or reverse.) output shaft rotation in either forward

DESCRIPTION AND OPERATION

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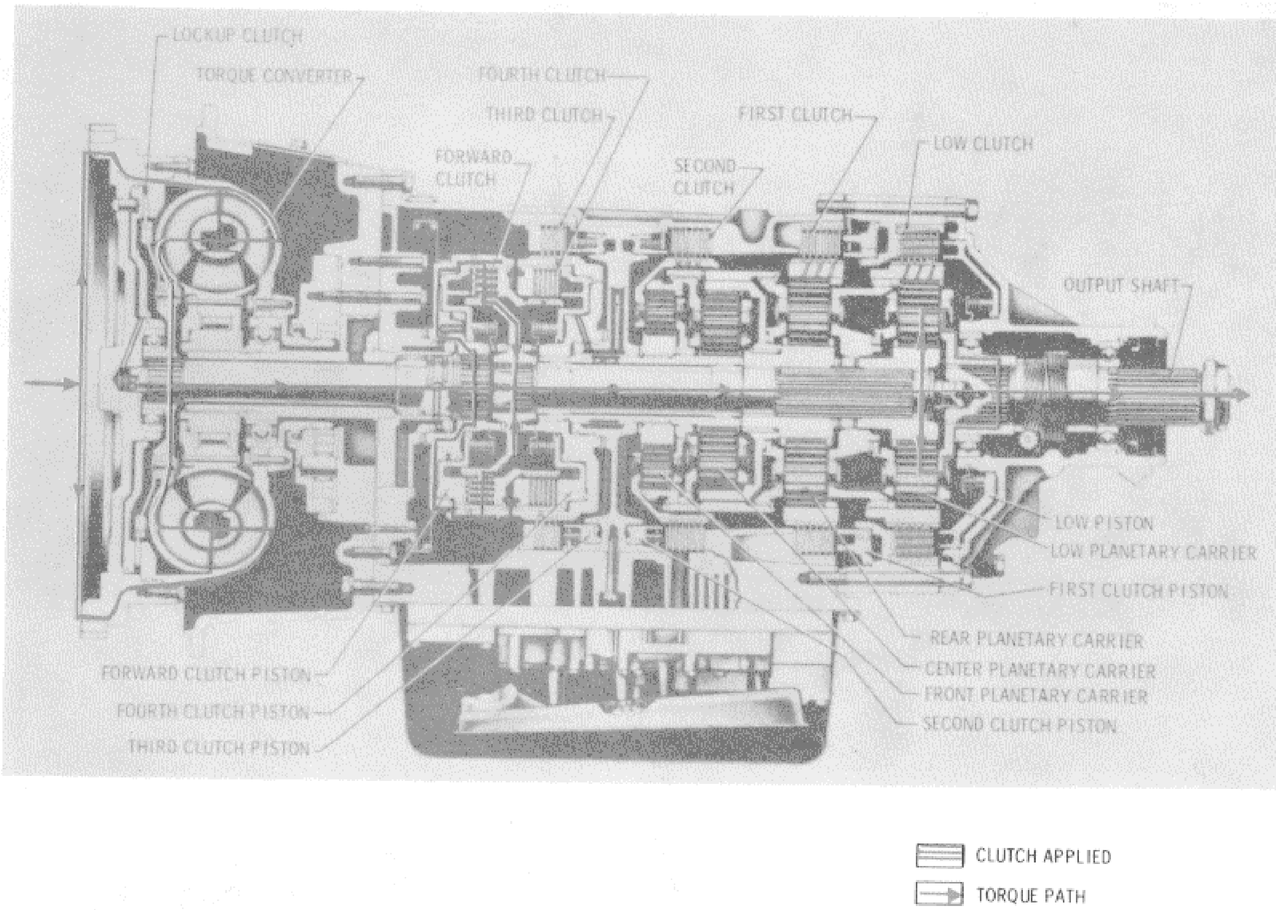

FIRST - GEAR

Fig. 2-9. First-gear

d. First-Gear Operation (fig. 2-9). Engine torque is transmitted through the torque converter as described in a, above. The forward and low clutches are applied. The low clutch application anchors the rear planetary ring gear against rotation. The forward clutch application locks the turbine shaft and transmission main shaft together so that they rotate as a unit. The low sun gear is splined to the main shaft and rotates with it and, in turn, rotates the low planetary pinions. The pinions are part of the low carrier assembly which is splined to the transmission output shaft. With the low ring gear held stationary by the applied low clutch and the low sungear rotating the pinions, the low planetary carrier must rotate within the ring gear and drive the output shaft at a speed reduction of 3. 19:1.

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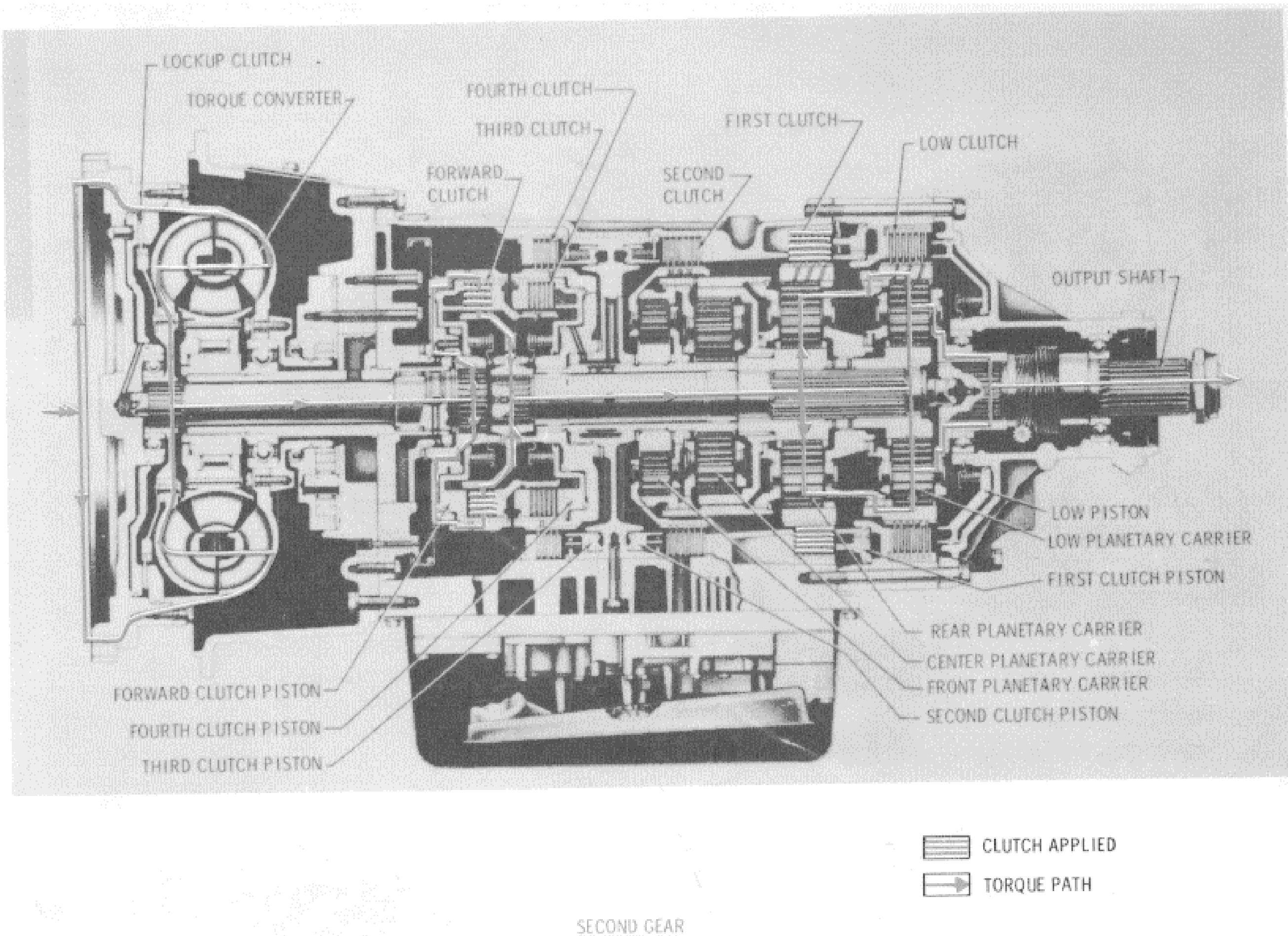

Fig. 2-10. Second-gear torque path

e. Second-Gear Operation (fig. 2-10) Engine torque is transmitted through the torque converter as described in a, above. The forward and first clutches are applied. The firs clutch application anchors the rear planetary ring gear against rotation. The forward clutch application locks the turbine shaft and transmission main shaft together so that they rotate as a unit. The rear sun gear and low sun gear are splined to the main shaft and rotate with it and, in turn, they rotate the rear and low planetary pinions respectively. With the rear planetary ring gear held stationary by the applied first clutch, the rear carrier will rotate i n a clockwise direction. Since the rear carrier hub is splined to the low carrier ring gear, it will also rotate clockwise. Since two members of the low planetary system are driving members (rotating at differing speeds), the third member (carrier) becomes the output member. This, in turn, drives the output shaft at a speed reduction of 1. 89: 1.

DESCRIPTION AND OPERATION

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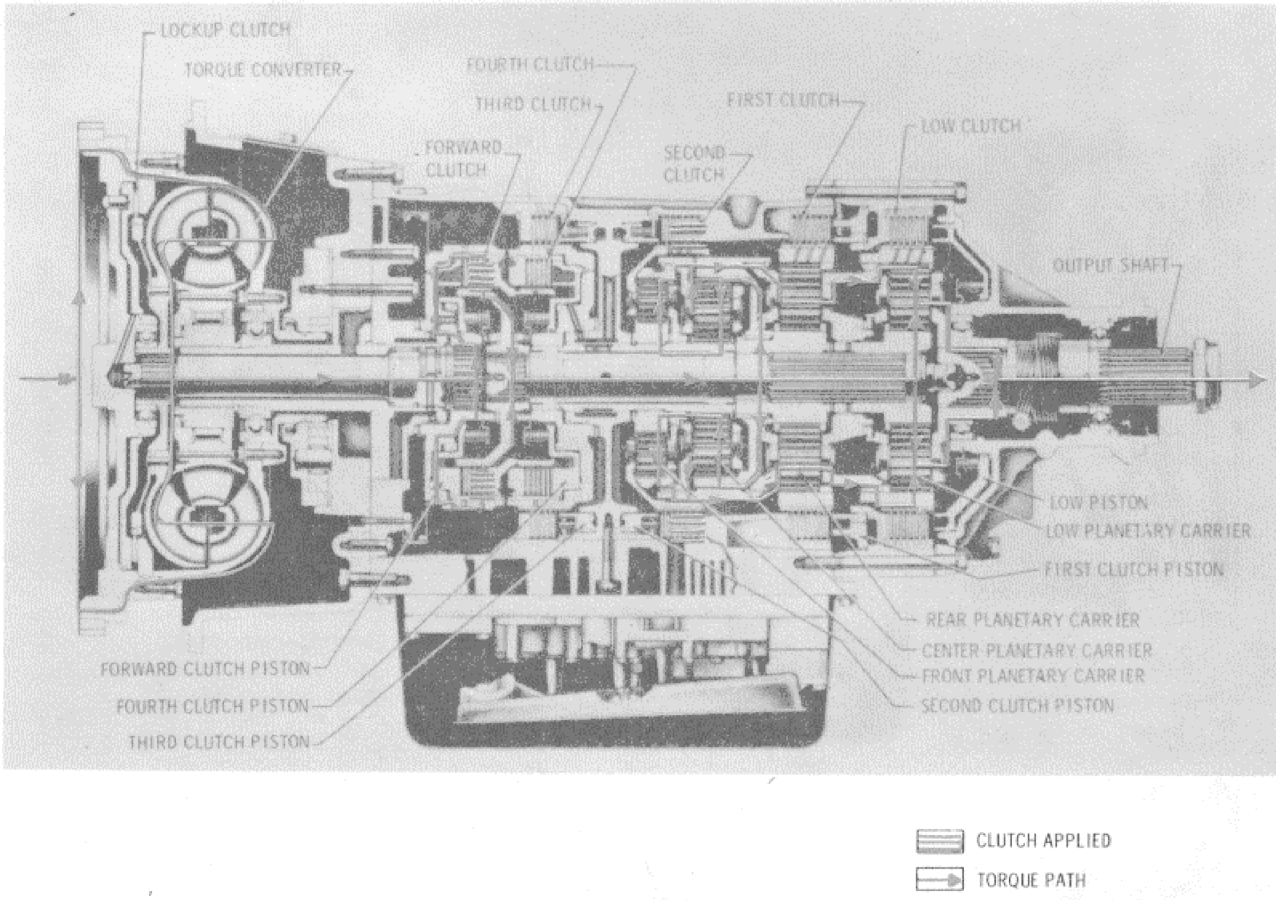

Fig. 2-11. Third-gear torque path

f. Third-Gear Operation(fig. 2-11). Engine torque is transmitted through the torque converter as described in a, above. The forward and the second clutches are applied. The second-clutch application anchors the carrier of the front planetary assembly against rot t ion. The forward-clutch application locks the turbine driven shaft (input shaft) and the main shaft together so they rotate as a unit. The rear sun gear is splined to both the rotating main shaft and the center ring gear and all three parts rotate at input speed. With the carrier of the front planetary carrier assembly anchored against rotation (by second-clutch application), the rotating center ring gear, rotates the center sun gear shaft via the carrier pinions. The center sun gear is integral with the sun gear shaft assembly to which the front sun gear is splined. The rotating front sun gear rotates the front carrier pinions whose carrier is anchored against rotating by the applied second clutch. In turn, the rotating front carrier pinions rotate the front ring gear, which, along with the center carrier, is splined to the rear planetary through the connecting drum. Since the rear carrier hub is splined to the connecting drum on one end and to the low carrier ring gear on the other end, rotation speed of all three components are the same. With the low ring gear driving the low planetary pinions and the low sun gear (which is splined to the rotating main shaft) also driving the low pinions, output shaft rotates at a speed reduction of 1. 55: 1.

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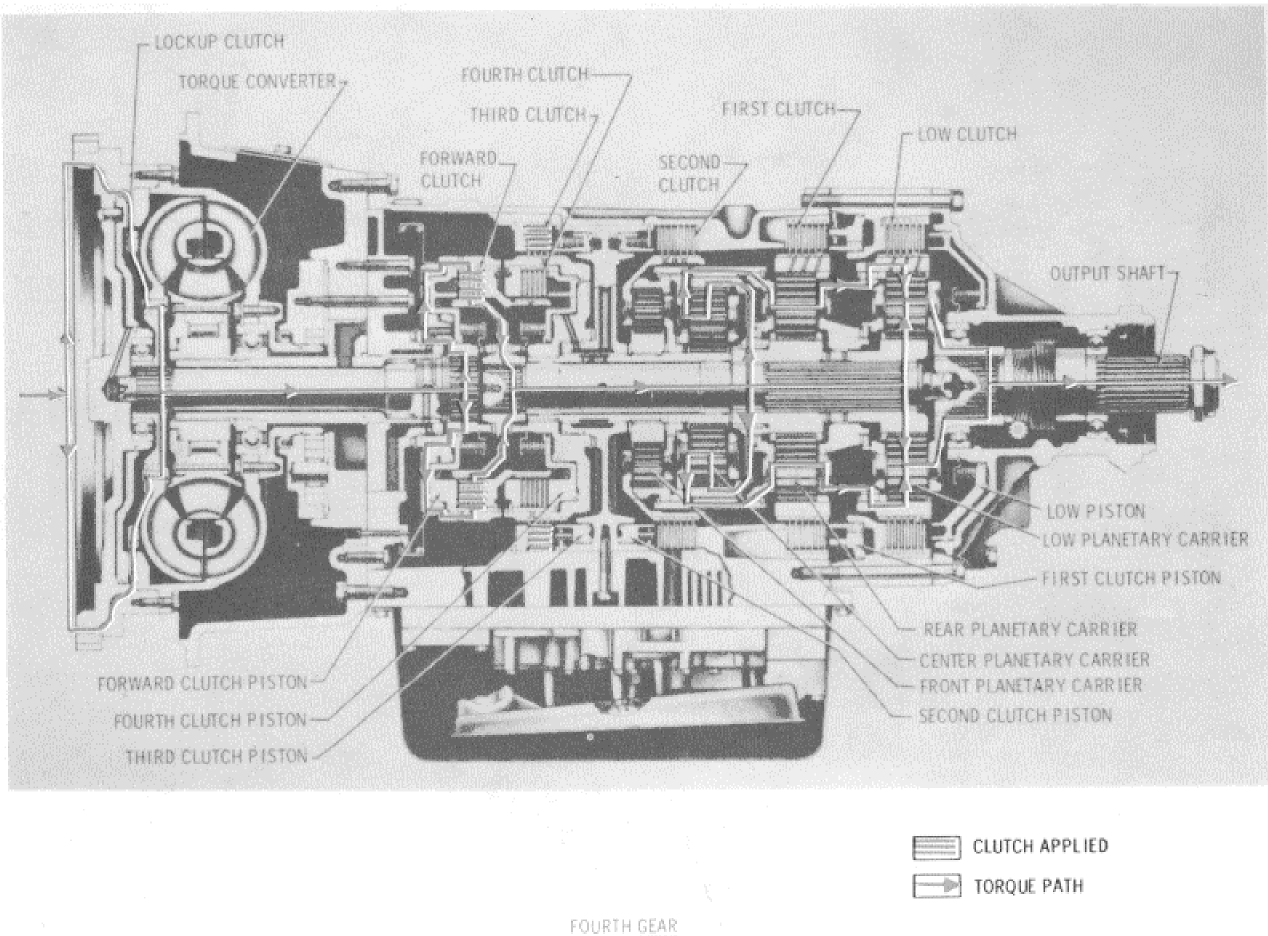

Fig. 2-12. Fourth-gear torque path

g. Fourth-Gear Operation (fig. 2-12). Engine torque is transmitted through the lockup clutch as described in b, above. The forward and the third clutches are applied. The third-clutch application anchors the sun gear shaft via the fourth clutch housing, against rotation which prevents the integral center sun gear from rotating. The forward clutch application locks the turbine shaft and main shaft together so they rotate as a unit. The rear sun gear is splined to both the main shaft and the center ring gear and rotates at inputspeed. With the center sun gear stationary and the center ring gear rotating, the ring gear drives the center planetary carrier pinions. This rotates the center planetary carrier at a speed reduction. This carrier and the rear planetary carrier are splined to the planetary connecting drum. The rear carrier hub on the output side is splined to the low ring gear. When the connecting drum rotates, the rear carrier and the low ring gear rotate at the same speed. This rotation causes the low ring gear to drive the low planetary pinions while the low sun gear, which is splined to the rotating main shaft, also drives the low pinions. The result is a further change of ratio (from that produced in the center planetary). Thus, the output shaft, being splined to the rear carrier, rotates at 1.24:1 reduction.

DESCRIPTION AND OPERATION

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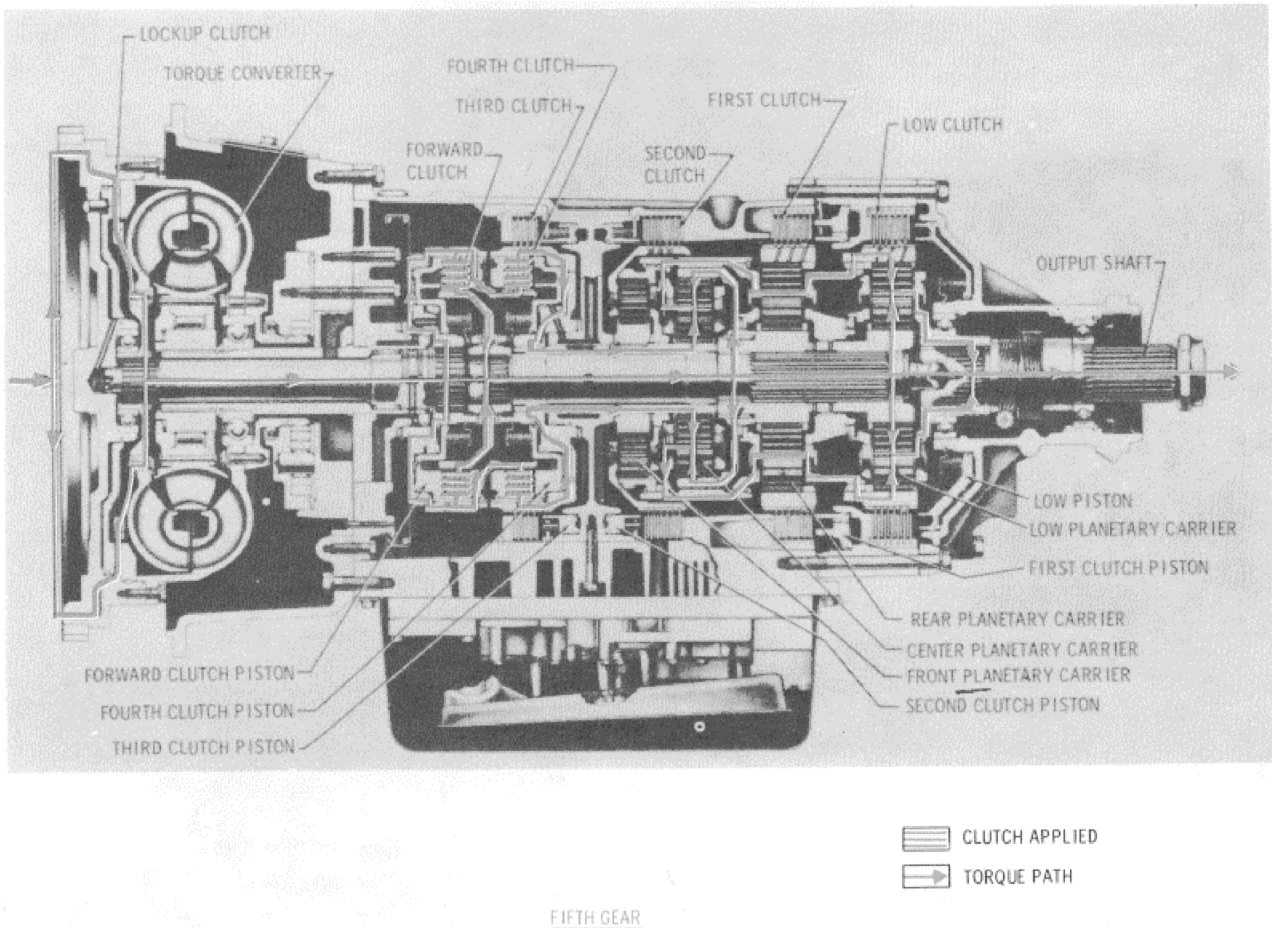

Fig. 2-13. Fifth-gear torque path

h. Fifth-Gear Operation (fig. 2-13). Engine torque is transmitted through the lockup clutch as described in b, above. The forward and fourth clutches are applied. With the clutches applied, the transmission main shaft and' the sun gear shaft are locked together and rotate as a unit at input speed. With the center, rear and low sun gears rotating at the same speed (locked together), and their carriers interconnected to the planetary connecting drum also rotating at the same speed, the transmission output shaft, being splined to the low carrier will produce an output ratio of 1.00:1.

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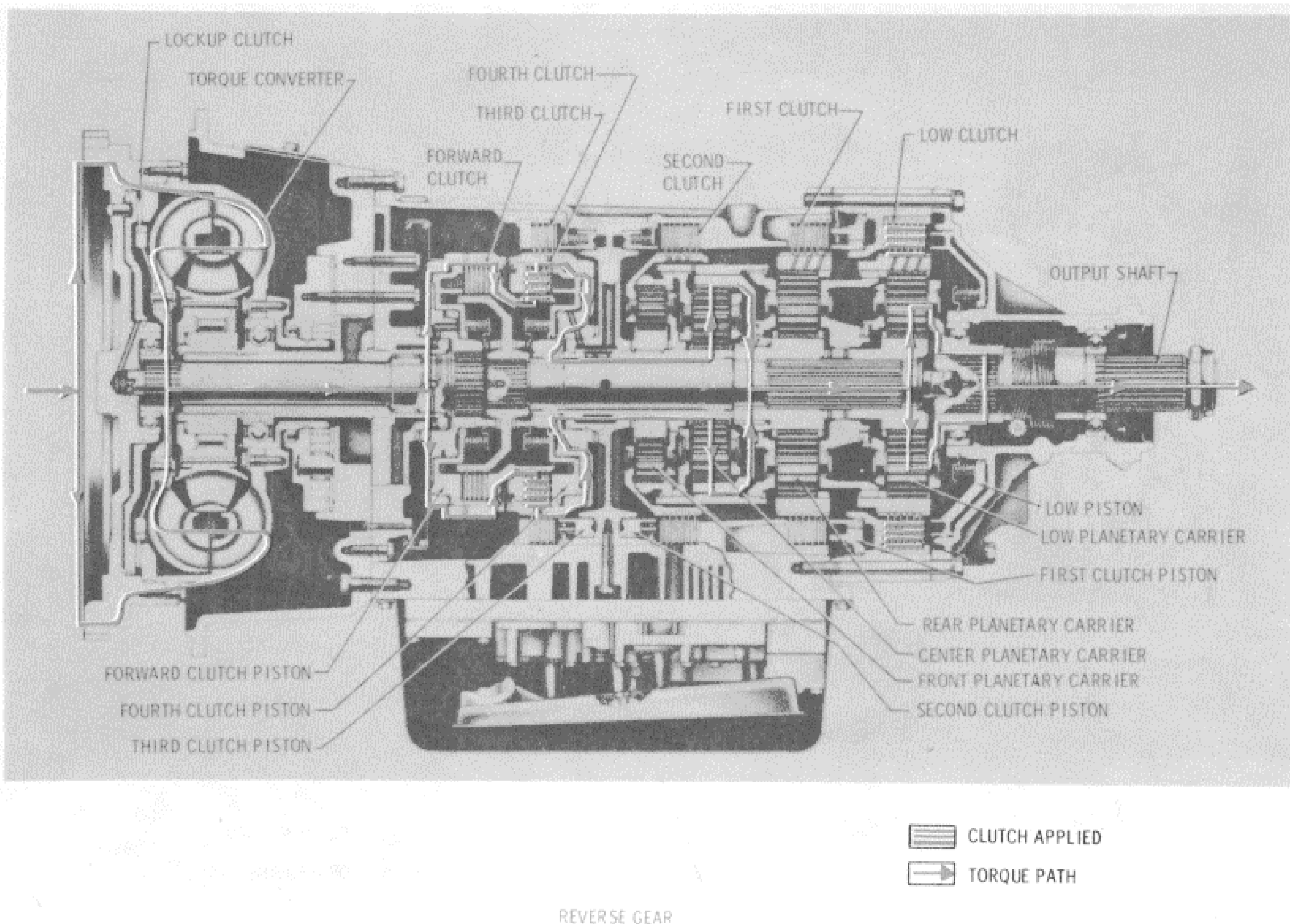

Fig. 2-14. Reverse-gear torque path

i. Reverse-Gear Operation (fig. 2-14). Engine torque is transmitted through the torque converter as described in a, above. Reverse gear is the only gear in which the forward clutch is not engaged. In this gear, the fourth clutch is applied and rotates the sun gear shaft, via the fourth-clutch housing, at input speed. The low clutch is also applied and anchors the low ring gear against rotation. In turn, the low ring gear, rear carrier, center carrier and connecting drum are splined together to form one stationary unit. When he center sun gear rotates, it causes the pinions in the center carrier to rotate in the opposite direction. This rotates the center carrier ring gear in a counterclockwise direction (reverse of input). This reverse rotation is transferred through the main shaft and the low planetary carrier to the output haft. Thus the transmission output shaft rotates in a reverse direction at a speed reduction of 7.97:1.

Section 3. PREVENTIVE MAINTENANCE

3-1. SCOPE OF SECTION 3

This section covers routine and periodical procedures required to maintain the transmission in good operating condition. Included are instructions for inspection, care of the oil system and breather, linkage adjustment, care of external lines, oil filter and oil cooler, stall testing, storage, and checking oil pressures. Troubleshooting information is tabulated at the end of this section.

3-2. INSPECTION AND CARE

The transmission should be kept clean to make inspection easier. Check for loose bolts, loose or leaking oil lines, oil leakage, and condition of control linkage and cables. Check the transmission oil level at the intervals specified in the vehicle operator's manual.

3-3. CHECKING OIL LEVEL

a. Importance of Proper Level. Maintaining the proper oil level is very important. If, during check procedure (d. below), inconsistent dipstick readings occur, look for proper venting of the transmission breather (para 3-9). The transmission oil is used to apply clutches and lubricate and cool the components. If the oil level is too low the result can be poor performance (clutches will not receive adequate oil supply). If the oil level is too high, overheating results from the oil being churned and aerated. Drain any excess oil to restore the proper level; refer to e, below.

b. Foaming and Aerating

(1) Transmission performance will be affected when the oil foams or aerates. The primary causes of aeration are, low oil in the sump, too much oil in the sump, or a defective or missing seal-ring on the intake pipe.

(2) A low oil level (denoted on the dipstick) will not completely envelope the oil filter. Therefore oil and air is drawn by the input pump and is directed to the clutches and converter, causing converter cavitational noises and irregular shifting. The aeration also changes the viscosity and color to a thin milky liquid.

(3) The normal oil level (full mark ,n dipstick) is 1 1/2 inches (38.9 mm) below the oil pan split line. The full mark should not be exceeded.

(4) A defective seal-ring 24 (A, foldout 14) on the filter intake pipe will cause the input pump to draw air into the oil system. Air thus entering the oil will result in the conditions described in (2), above.

c. Protect Fill Pipe. When adding oil or checking oil level, dirt or foreign material must not be allowed to enter the fill pipe. Before removing the dipstick, clean around the end of the fill pipe.

d. Oil Level Check Procedure. Transmission speed and oil temperature significantly affect the oil level. Thus, the speed and temperature must be controlled for an accurate c h e c k. The oil I e v e l should be checked by the following procedure.

(1) Operate the transmission until normal operating temperature (160 to 200°F) is reached.

(2) Shift the transmission through all drive ranges to fill the clutch cavities and oil passages.

(3) With the vehicle positioned on level ground, allow the engine to idle. Shift to neutral and apply the parking brake.

HT 700D SERIES TRANSMI SSIONS

Para 3-4/3-7

(4) Check the oil level on the dipstick at least twice. It should register at the Full mark each time. Inconsistency in registration may be due to pressure buildup in the transmission. Improper venting to atmosphere of the breather (para 3-9) may be a frequent cause of this problem.

CAUTION
The oil level rises as sump temperature increases. Therefore, do not fill above the Add mark before the transmission has reached normal operating temperature.

e. Safe Level. The safe operating level is from the Add mark to the Full mark on the dipstick. Do not operate the vehicle when the oil level is higher or lower than the Full-Add range.

3-4. KEEP OIL CLEAN

Oil must be handled in clean containers, fillers, etc, to prevent foreign material entering the transmission.

CAUTION
Containers or fillers that have been used for any antifreeze solution must not be used for oil that is to be used in the transmission.

Clean around oil filler tube before removing dipstick, and lay dipstick in a c 1 e a n place while filling the transmission. Check the current issue of the HT 700 Series Parts Catalog (SA 1268) for proper replacement oil filter. Keep filters in cartons until ready for installation.

3-5. OIL SPECIFICATIONS

a. Dexron® is the only fluid recommended for the HT 700D series transmission. Type C2 and Type A fluids may be used to fill the transmission or intermixed with Dexron, but only in an emergency, when Dexron is not available.

b. Ambient Temperatures. When the ambient temperature is below -300F (-340C), an auxiliary preheat is required. Raise the sump temperature to above -300F (-340C) before operating the transmission.

3-6. OIL AND OIL FILTER CHANGE INTERVALS

Oil and oil filter change frequency is determined by the transmission application and by the filter equipment installed. The following table is a general guide. More frequent changes may be required when operations are subject to high levels of contamination.

3-7. OIL AND OIL FILTER CHANGE PROCEDURES

a. The transmission should be at operating temperature (160-2000F) (71-930C) when the oil is drained. This will insure quicker and better drainage.

b. On earlier models, remove the fill tube from the oil pan and allow the oil to drain. On later models remove the drain plug from the rear of the oil pan and allow the oil to drain. Check the condition of the oil as described in paragraph 3-8. Suction Screen in Oil Pan

OIL AND OIL FILTER CHANGE INTERVALS

	Oil Change	Suction Screen in Oil Pan		External Oil Filter Element
		When equipped with external filter	When not equipped with external filter	
Coaches	100, 000 miles or 12 months	At first oil change and each 500, 000 miles or overhaul	At each oil change	After first 5, 000 miles and each 50, 000 miles
Trucks (on-highway)	50, 000 miles or 12 months thereafter	At first oil change and each 500, 000 miles or overhaul	At each oil change	After first 5, 000 miles and each 50, 000 miles thereafter
Trucks (off-highway)	25, 000 miles, 800 hours or 6 months	At first oil change and each 500, 000 thereafter miles or overhaul	At each oil change	After first 5, 000 miles and each 25, 000 miles thereafter

c. After draining is completed, remove 23 washer-head screws 33 (A, foldout 14)that retain the oil pan to the transmission housing. Discard pan gasket 29 and clean the pan with mineral spirits or paint thinner.

d. Remove washer-head screw 28 (A, foldout 14) and washer 27, and remove the oil filter (and spacer 26 on later models). Discard the filter.

e. Prior to installing the new filter, install a new seal-ring 24 (A, foldout 14) onto the oil intake pipe (integral with filter). Lubricate the seal-ring with transmission fluid.

f. Install the new oil filter (aligned so that filter does not require twisting), inserting the oil intake pipe into the hole in the bottom of the transmission. Secure the oil filter with a 5/16-18 x 5/8-inch, washer-head screw. Tighten the screw to 10 to 13 pound feet (14 to 18 Nm) torque.

g. Place the oil pan gasket onto the oil pan. Do not use any substance as a gasket retainer.

CAUTION

Do not use gasket-type sealing compounds any place inside the transmission or where they might get washed into the transmission. Also, only oil-soluble greases may be used (except oil pan gasket)for temporarily retaining parts during assembly. Nonsoluble vegetable base cooking compounds or fibrous greases must not be used inside the transmission.

h. Install the oil pan and gasket, carefully guiding them into place. Guard against dirt or foreign material entering the pan. Retain the pan to the housing with four 5/16-18 washer-head screws. Install each screw, by hand, one at a time, into each corner of the pan.

i. Install the remaining 19 washer-head screws by hand, carefully threading each one through the gasket. Bottom all screws before tightening them.

j. Alternately tighten screws 180° apart to 5 pound feet (8 Nm) torque. Repeat the process tightening the screws to 10 to 13 pound feet (14 to 18 Nm) torque.

k. Install the filler tube at the side of the pan. On later models install the oil drain plug at the rear of the pan.

l. Remove the dipstick and pour approximately 26 US quarts (24.6 litres) of transmission fluid into the transmission through the filler tube. Then check the oil level using the procedure described in paragraph 3-3.

3-8. OIL CONTAMINATION

a. Examine at Oil Change. At each oil change, examine the oil which is drained for evidence of dirt or water. A normal amount of condensation will emulsify in the oil during operation of the transmission. However, if there is evidence of water, check the cooler (heat exchanger) for leakage between the water and oil areas. Oil in the water side of the cooler (or vehicle radiator) is another sign of leakage. This, however, may indicate leakage from the engine oil system. Any accumulation of sludge or soft dirt in the sump should be removed.

b. Metal Particles. Metal particles in the oil (except for the minute particles normally trapped in the oil filter) indicate damage has occurred in the transmission. When these particles are found in the sump, the transmission must be disassembled and closely inspected to find the source. Metal contamination will require complete disassembly of the transmission and cleaning of all internal and external circuits, cooler, and all other areas where the particles could lodge.

c. Coolant Leakage. If engine coolant leaks into the transmission oil system, immediate action must be taken to prevent malfunction and possible serious damage. The transmission must be completely disassembled, inspected and cleaned. All traces of the coolant, and varnish deposits resulting from coolant contamination, must be removed. Water and/or coolant contamination will cause rapid deterioration of resin-graphite clutch plates.

HT 700D SERIES TRANSM I S IONS

Para 3-9/3-11

3-9. BREATHER

The breather is located at the top of the transmission housing as shown in figure 3-1 The breather serves to prevent pressure buildup within the transmission. The breather must be kept clean and the passage open. The prevalence of dust and dirt will determine the frequency at which the breather requires cleaning. Always use a wrench of the proper size to remove or replace the breather. Pliers or a pipe wrench will crush or damage the stem and produce metal chips which could enter the transmission.

3-10. LINKAGE

a. Maintain Proper Adjustment. Proper adjustment of the manual selector valve linkage is important as the shift tower detents must correspond exactly to those in the transmission. Periodic inspections should be made for bent or worn parts, loose threaded connections, loose bolts, and accumulation of grease and dirt. All moving joints must be kept clean and well lubricated.

b. Reference to Vehicle Manual. Refer to vehicle manual for specific linkage adjustment procedures. The following general procedures are applicable to most vehicles.

(1) The manual selector lever should move easily and give a crisp detent feel in each position. The linkage should be adjusted so that the stops in the shift tower match the detents in the transmission.

(2) When the linkage is correctly adjusted, the pin which engages the shift lever linkage at the transmission can be moved freely in each range.

CAUTION

Proper installation of the external selector lever is imperative to the function of the transmission. Excessive torque applied to the external selector lever retaining nut may damage the internal selector lever.

(3) To properly install t h e external lever proceed as follows. Rotate the manual selector shaft to a position that is two detent notches from either end of its travel. Install the external lever so that the flat sides of the shaft opening are parallel to the flats on the shaft. Install the nut. While holding the lever against rotation, tighten the nut to 15 to 20 pound feet (21 to 27 Nm) torque.

(4) Clean and lubricate all hydraulic retarder valve linkage. The retarder is applied when the valve moves upward (out of the valve body). Therefore, it is important for normal operation with retarder Off, that the linkage be adjusted so the valve returns to the retracted position. If the linkage causes the retarder to be partially applied, loss of lubrication pressure, overheating, or excessive drag will result and fuel consumption will be excessive. If the valve does not have full travel (1.5 in. [38.1 mm]), maximum performance of the retarder cannot be obtained.

(5) Inspect the linkage for binding, wear, cracks, breaks and defective cotter pins. Replace all defective parts.

3-11. SHIFT SPEED ADJUSTMENTS

NOTE

Transmission shift points cannot be satisfactorily adjusted if the transmission has the wrong governor installed. Check the two-digit code on the head of the governor with the code shown in the current parts catalog (SA 1268) for the governor listed for your trans-mission assembly part number. If the letter "M" follows the two-digit code, the governor is a service replacement assembly. If the "M" is not included, the governor was installed at original factory build.

a. Calibrated On Test Stand Or In Vehicle

(1) Proper timing of shift speed points is necessary for maximum transmission performance. Shifts may be adjusted on the test stand when the transmission is rebuilt or overhauled, or during road testing of the vehicle.

(2) Test stand equipment differs among rebuild or overhaul facilities. Some shops may have equipment to drive and load the transmission, with instrumentation for

observing performance. Other shops may have test stands on which the valve body and governor can be calibrated before installation into the transmission. If test stand equipment is not available, satisfactory calibrations of shift points may be made after road testing of the vehicle.

b. Location of Adjusting Components

(1) Shift speeds are changed by changing the positions of adjusting rings that determine the retaining force of certain valve springs in the valve body. Refer to items 80, 85, 81 and 22 (B, foldout 16) and 15 (A, foldout 17).

(2) A special tool J24314 (item 45, fig. 4-3) is used to depress and rotate the adjusting rings to the proper positions. Clockwise rotation increases spring force and will raise the shift point. Counterclockwise rotation will reduce spring force, and lower the shift point.

NOTE

Each notch of adjustment will alter the shift point as follows.

HT 750CRD
Shift 1-2 - 10 rpm
Shift 2-3 - 10 rpm
Shift 3-4 - 25 rpm
Shift 4-5 - 35 rpm

c. Checks Before Adjusting Shift Points

(1) When calibration is to be made during a road test, or on a test stand that simulates road operation, certain preparations must be made.

(2) Raise the temperature of the transmission fluid in the transmission or test stand to (160° to 220°F [71 to 1040C]).

(3) Check the engine no-load governor setting, and adjust if required, to conform to the transmission's engine speed requirements.

(4) Check the engine for satisfactory performance before making shift point adjustments.

(5) Check the throttle linkage that controls the mechanical modulator valve actuator on the transmission for proper travel, routing and operation.

(6) Check the shift selector linkage for proper range selection.

(7) Provide accurate instrumentation required for observing speeds, temperatures, pressures, etc.

d. Calibration by Road Test Method

NOTE

Before road test, determine the vehicle tachometer error with a test tachometer. Make corrections for error, as required, in subsequent tests.

(1) Check the no-load governed speed of the engine. Adjust the governor, if necessary, to meet the no-load governed speed specified for your particular engine-transmission match (available from vehicle manufacturer).

(2) Note the engine speed and record it. Subtract 100 rpm, and record the remainder as the desired speed for all automatic upshifts except the 1-2 shift This shift must occur at 100 rpm below lockup engagement speed.

(3) If doubt exists regarding when lockup is occurring , install a 0-300 psi (0-2068 kPa) gage at the lockup pressure tap. Duringroad operation in 1-hold observe the first movement of the gage and note rpm. This is first gear lockup engagement speed.

(4) While driving the vehicle in 2-5 range, check the wide open throttle upshift points. These shifts should occur at 100 rpm below engine no-load governed speed. If upshift speed points do not reach those specified, the shiftpoint speed may be raised by adjusting (increasing) the spring load on the 1-2, 2-3, 3-4 or 4-5 shift signal valve. If upshift speeds are above those engine speeds specified, or do not occur at all, the spring load(s) must be reduced. Only the load on springs for the valve (or valves) which do not upshift at the proper speed require adjustment.

Para 3-11/3-13

NOTE

If more than one shift signal valve spring requires adjustment, it may be necessary to adjust the spring compression on the modulator valve one position in the same directionas adjustment for signal valves. If all upshift points are either too high or too low, by approximately the same amount, only the modulator valve should be adjusted.

(5) Refer to Sections 5, 6 and 7 for procedures covering removal and replacement of affected components. Spring charts are at the end of Section 8 immediately preceding foldouts.

e. Alternate Method Using Speedometer Readings

(1) When a tachometer is not available for checking shift points, the vehicle speedometer can be used. Proceed as outlined in (2) through (4) below.

(2) Check and record the road speed of the vehicle at which lockup occurs during operation in 1-hold (refer to (3), above). Also check and record the top speeds that can be attained while operating in 1-2, 2-3 and 3-4.

(3) For checking the shift points, place the selector at 1-5 so that all automatic shifts can occur Drive the vehicle at full throttle from a standing start until the 4-5 upshift occurs. Record the road speed at which each upshift occurs.

(4) Compare the upshift speeds with the speeds recorded in (2), above. The 1-2 shift should occur at approximately two mph below the speed recorded for lockup engagement. All other upshifts should occur approximately two mph below the top speeds recorded in (2), above.

f. Calibration by Test Stand Method

(1) The table below provides detailed information required for adjusting shift points on transmissions matched to engines having governed speeds from 2100 to 2700 rpm.

(2) The actual adjustment procedures are as outlined in d, above. However, the base for checks and adjustments is output shaft speeds instead of engine governed speed. Individual output shaft speed ranges are given for each shift.

3-12. EXTERNAL LINES AND OIL COOLER

a. External Lines

(1) Inspect for loose or leaking connections, worn or damaged hoses, tubing and loose fastenings.

(2) Examine the radiator coolant for traces of transmission oil. This condition indicates a faulty heat exchanger.

b. Oil Cooler. Transmission operation at abnormally high temperatures can cause clogging of the oil cooler as well as transmission failure. It is suggested the oil cooler system be thoroughly cleaned after each major or minor rebuild (para 3-8d). Failure to do so may cause poor performance, overheating and transmission damage. For recommendations for cleaning or flushing the oil cooler, see the vehicle service manual.

3-13. TRANSMISSION STALL TEST

a. Purpose. A stall test may be conduct-d when the power package (engine, transmission combined) is not performing satisfactorily. The purpose of the test is to determine whether the transmission or the engine is the malfunctioning component.

CAUTION

When conducting a converter stall test, the vehicle must be positively prevented from moving. Both the parking and service brakes must be applied and, if necessary, the vehicle should be blocked to prevent movement forward or in reverse. Warn personnel to keep clear of the vehicle and its travel path in the

PREVENTIVE MAINTENANCE

Para 3-13

SHIFT POINT CHECK
HT 750

		2100-2200 RPM						2300-2500 RPM						RPM 2600-2700		1950 RPM		RPM 2100-2200		RPM 2100-2200		RPM 2300-2500		RPM 2600-2700	
		C.T.			F.T.			C.T.			F.T.			C.T.	F.T.	C.T.	F.T.	C.T.	F.T.	C.T.	F.T.	C.T.	F.T.	C.T.	F.T.
RANGE	SHIFT	J	K	L	J	K	L	M	N	O	M	N	O	P	P	T	T	S	S	AE	AE	V	V	U	U
	1C-1L				***	***					***		***												***
	1-2				*	*	430 500				*	450 520	*		520 580		320 380		*		300 400		*		*
	2C-2L				540 600	370 460	900 1010				430 520	960 1110	590 660		1140 1290		825 960				850 960				680 760
	2-3				630 690	630 690	1090 1170				690 750	1200 1280	690 750		1360 1430		1010 1085		570 630		980 1050		635 695		790 850
	3-4				1000 1070	980 1080	1340 1430				1120 1190	1470 1560	1100 1170		1660 1750		1245 1335		900 975		1240 1330		1005 1080		1240 1315
DR5	4-5				1500 1590	1450 1540	1700 1800				1660 1760	1860 1960	1650 1740		2100 2200		1580 1680		1360 1450		1600 1700		1510 1600		1860 1950
	5-4	840 380	1110 650	1270 640				1350 890	1030 770	820 550				1490 900		1070 660		570 400		1010 660		775 495		900 620	
	4-3	630 390	770 490	870 570				950 620	820 610	660 440				1150 570		790 550		465 340		790 530		600 390		670 390	
	3-2	460 310	590 320	680 390				650 420	540 350	570 370				770 530		615 400		400 225		570 370		490 270		570 370	
	2-1	*	*	450 120				*	475 250	*				740 120		380 120		*		300 200		*		*	
	Lockup out	420 MIN	190 MIN	570 320				280 MIN	400 MIN	570 MIN				350 MIN		400 MIN				370 MIN				700 MIN	
DR4	5-4				1850 1520	1850 1520	2110 1610				1910 1560	2140 1760	1910 1560		2400 2160		2080 1610		1850 1520	2050 1730			1910 1565		2160 1820
DR3	4-3				1280 960	1280 960	1660 1290				1330 1060	1710 1420	1330 1060		1960 1730		1610 1290		1290 1000	1600 1340			1330 1060		1590 1240
DR2	3-2				780 620	780 620	1410 1060				810 660	1460 1160	810 650		1690 1320		1360 1060		780 620	1360 1110			805 660		1010 810
DR1	2-1				330 120	330 120	960 620				330 120	1000 710	330 120		1140 830		850 620		330 120	770 590			330 120		350 150

*Manual shift-check for function only.
**HT 750 deep ratio only:
In 1st gear lockup, main pressure to be 145-175 psi
In 2nd gear converter, main pressure to be 145-175 psi
***Check that automatic converter-to-lockup shift occurs

REFERENCE	ENGINE
A, AB, AC	Conventional Diesel Engine
B, E	High-Torque Rise Engine
C, F, R, G	Conventional Diesel — No 1st Lockup
W	Conventional Diesel — Special Lockup Points
D	Conventional Diesel — No 1st Lockup (For 190 H. P. Coach)
J, O, U	Conventional Diesel Engine — Deep Ratio
K, M	High-Torque Rise Engine — Deep Ratio
L, P, N, T	Conventional Diesel Engine — Close Ratio
S, V	Conventional Diesel Engine — Deep Ratio — No Lockup
AE	Conventional Diesel Engine — 3.69 Close Ratio

C.T. — Closed Throttle F.T. — Full Throttle event of brake failure or inadequate blocking. Do not maintain the stalled condition longer than 30 seconds due to rapid heating of the transmission oil. With the transmission in neutral, run the engine at 1200 to 1500 rpm for 2 minutes to cool the oil between tests. Do not allow the converter-out temperature to exceed 3000F (1490C). Keep close check to prevent the engine cooling system from overheating.

b. Procedure

CAUTION

Do not attempt to stall test the transmission in reverse. The extremely high torque produced may damage the transmission and/or the vehicle drive line.

(1) Connect a tachometer of known accuracy to the engine. Stall torque converter by locking the transmission output (putting the transmission in gear) and accelerating the engine to full throttle. Note the maximum rpm the engine will attain. The speed attained is then compared to the speed specified, by the vehicle manufacturer as normal for those conditions. This information (stall speed) may be obtained from your equipment dealer or distributor. An engine speed above or below the specified range may indicate a malfunction in the engine or transmission.

NOTE

Engine power will decrease with an increase in elevation (altitude), the decrease becoming more pronounced at greater elevation. This will result in a lower engine speed under converter-stall conditions.

(2) After making allowances for elevation, a low engine speed may indicate the engine is not delivering full power. Refer to the engine service manual for engine repair information.

(3) If low engine speed persists after the engine is tuned, refer to the troubleshooting procedures and chart in paragraph 3-19 below.

(4) If high engine speed is noted, refer to the troubleshooting chart in paragraph 3-19.

3-14. PRESERVATION AND STORAGE

a. Preservative Method Selection. When transmissions are to be stored or remain inactive for extended periods of time, specific preservative methods a re recommended to prevent rust and corrosion damage. The length of storage will usually determine the preservative method to be used. Various methods are described below.

b. Storage, New Units. New units contain preservative oil when shipped, and can be safely stored for 6 weeks without further treatment.

c. Storage, Month to 6 Weeks

(1) The following procedures will prepare a transmission for a month to 6 weeks storage, depending on the environment.

(2) Drain the oil as described in paragraph 3-7. Re move the transmission oil filter(s).

(3) Install the new filter(s), gasket, oil pan, and fill tube.

(4) Fill the unit to operating level with any commercial preservative oil which meets US Military specifications MIL-L-21260, Grade 1, to latest specifications.

(5) Operate the unit for at least 5 minutes in neutral at 1500 rpm. Shift the transmission slowly through all selector positions to thoroughly distribute the oil. Then, shift to a forward range and stall the transmission output until an oil temperature of 225°F (1070C) is obtained.

CAUTION

Do not allow temperature to exceed 225°F (1070C).

(6) Stop the engine. As soon as the unit is cool enough to touch, seal all opening sand breather with moisture-proof tape.

(7) Coat all exposed (subject to corrosion), unpainted surfaces with a good grade of preservative grease, such as petrolatum (MIL-C-11796) Class 2.

(8) Repeat procedures (5)through (7), above, at monthly intervals for indefinite storage.

d. Storage, 1 Year-Without Oil

(1) Drain oil as described in paragraph 3-7, above.
(2) Seal all openings and breather with moisture-proof tape.
(3) Coat all exposed, unpainted surfaces with a good grade of preservative grease.
(4) If breather can be easily removed, spray 1 ounce (29.5 ml) of Motorstor* (or equivalent) into the housing breather hole, and 1 ounce (29. 5 ml) into the fill tube hole. If the breather cannot be removed, atomize or spray 2 ounces (59 ml) of Motorstor (or equivalent) into the transmission through the fill tube hole.
(5) If additional storage time is required, repeat (3) and (4) above, at yearly intervals.

e. Storage, 1 Year-With Oil

(1) Drain the oil as described in paragraph 3-7, above. Remove the transmission oil filter element(s).
(2) Install the new filter element(s), gasket, oil pan, and fill tube.
(3) Fill the transmission to operating levelwith a 3 percent mixture of Dexron transmission fluid and Motorstor (30 parts Dexron oil to 1 part Motorstor preservative, or equivalent).

*Motorstor is a preservative additive manufactured by the Daubert Chemical Company, Chicago, Illinois. Motorstor (under the designation of "Nucle OIL") is covered by US Military Specifications MIL-L-46002 (ORD) and MIL-I-23310 (WEP).

(4) Operate the unit for approximately 5 minutes in neutral at 1500 rpm. Shift the transmission slowly through all selector positions to thoroughly distribute the oil. Then shift to a forward range and stall the transmission output until an oil temperature of 2250F (1070C) is obtained.

CAUTION
Do not allow temperature to exceed 2250F (1070C).

(5) Stop the engine. As soon as the unit is cool enough to touch, seal all openings and breathers with moisture-proof tape.
(6) Coat all exposed, unpainted surfaces with a good grade of preservative grease.
(7) If additional storage time is required, repeat (3)through (6) above, at yearly intervals, except it is not necessary to drain the transmission each year just add the Motorstor, or equivalent.

f. Restoring Units to Service

(1) If Motorstor, or equivalent, was used in preparing the transmission for storage, use the following procedures to restore the unit to service.
(2) Remove the tape from openings and breather.
(3) Wash off all the external grease with solvent.
(4) Add Dexron automatic transmission fluid to proper level.

NOTE
It is not necessary to drain oil and Motorstor mixture from the transmission.

(5) If Motorstor, or equivalent, was not used in preparing the transmission for storage, use the following procedures to restore the unit to service.

(6) Remove the tape from openings and breathers.

(7) Wash off all the external grease with solvent.

(8) Drain oil as described in paragraph 3-7, above.

(9) Install a new oil filter(s).

(10) Refill transmission with Dexron automatic transmission fluid to proper level.

3-15. CHECKING OIL PRESSURES

Oil pressures may be checked during operation of the transmission to assist in the location of malfunctions. P r e s *s* u r e check points are shown in figure 3-1. Make pressure tests in conjunction with troubleshooting procedures outlined in paragraphs 3-16 through 3-18. Refer to paragraph 1-16.

3-16. TROUBLESHOOTING-BEFORE REMOVAL OR OPERATION

a. Visual Inspection. Do not operate the vehicle prior to completing the procedures described in this paragraph. Inspect for oil leakage. V i s u a l l y inspect a 11 splitlines, plugs, all hose and tube connections at the transmission and cooler. Oil leakage at split-lines may be caused by loose mounting bolts or defective gaskets. Tighten all bolts, plugs, and connections where leakage is found. Check to insure that the modulator control cable and linkage are free.

b. System Knowledge. The engine and transmission must be regarded a s a single package during troubleshooting. A thorough study of the description and operation of the components and hydraulic system will be helpful in determining the cause of trouble.

3-17. TROUBLESHOOTING-BEFORE REMOVAL AND DURING OPERATION

a. Determine Trouble Cause. If inspection (para 3-16a, above) does not reveal the cause of trouble, and the vehicle is operational, further troubleshooting is necessary. Do not remove the transmission from the vehicle until the causes of trouble are checked against the troubleshooting chart (para 3-19, below).

b. Properly Tuned Engine. To make a thorough test of the vehicle-mounted transmission, be sure that the engine is properly tuned and that the oil level in the transmission is correct. (Refer to para 3-3 for checking oil level.)

3-18. TROUBLESHOOTING-AFTER REMOVAL FROM VEHICLE

When the malfunction of a transmission is not ascertained by tests or inspections before removal from the vehicle, the transmission may be mounted in a test stand and checked (if a test stand is available). Particular attention should be given to proper oil level and to correct linkage adjustment in every transmission test.

3-19. TROUBLESHOOTING

The troubleshooting information, below, outlines the possible causes of transmission troubles and their remedies. Capital letters indicate the symptom; numerals following the symptom indicate several p o s i b 1 e causes; corresponding numerals in the right column indicate remedies for the causes.

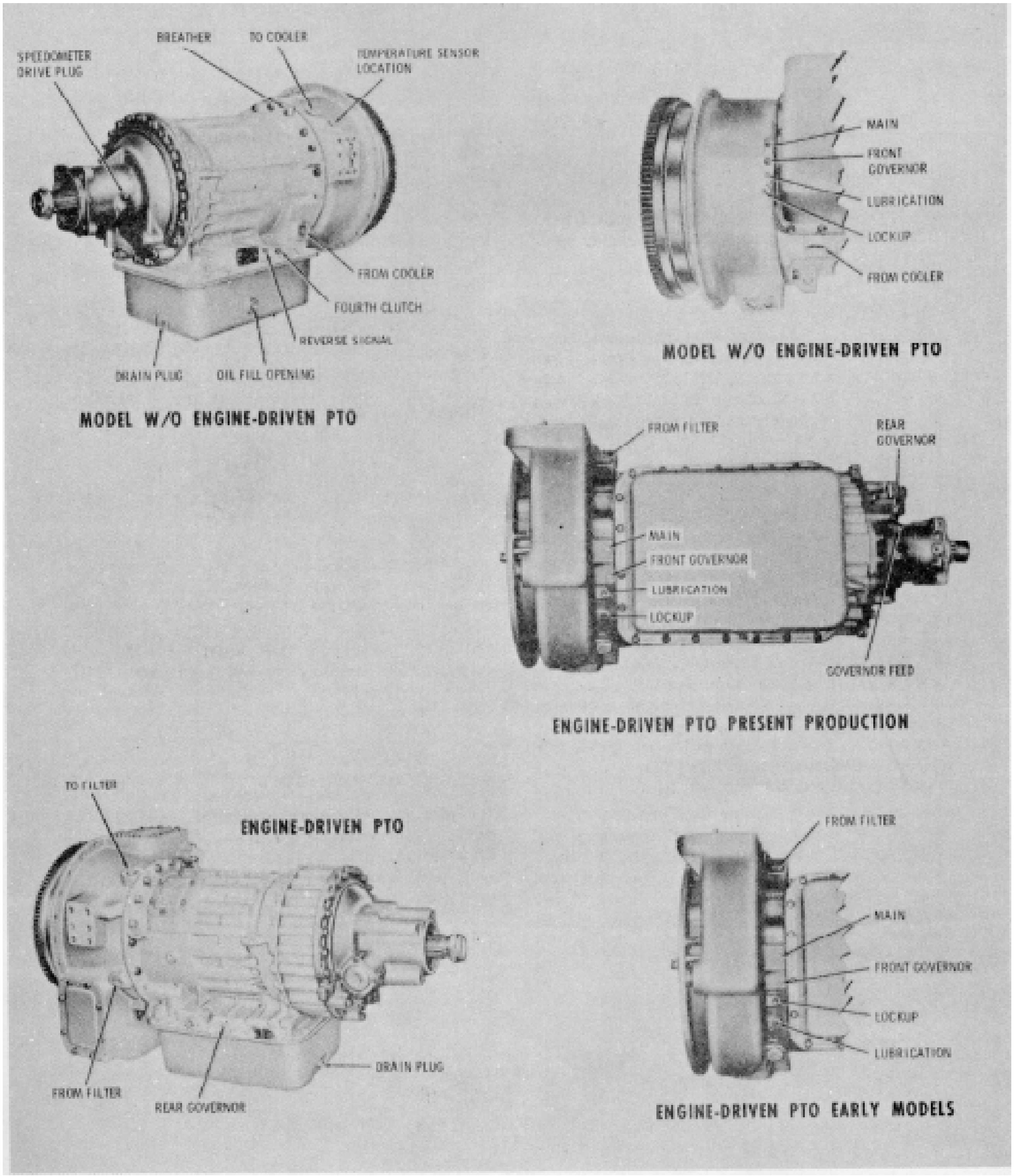

Fig. 3-1. Transmission check points, external connections (c,/o retarder)

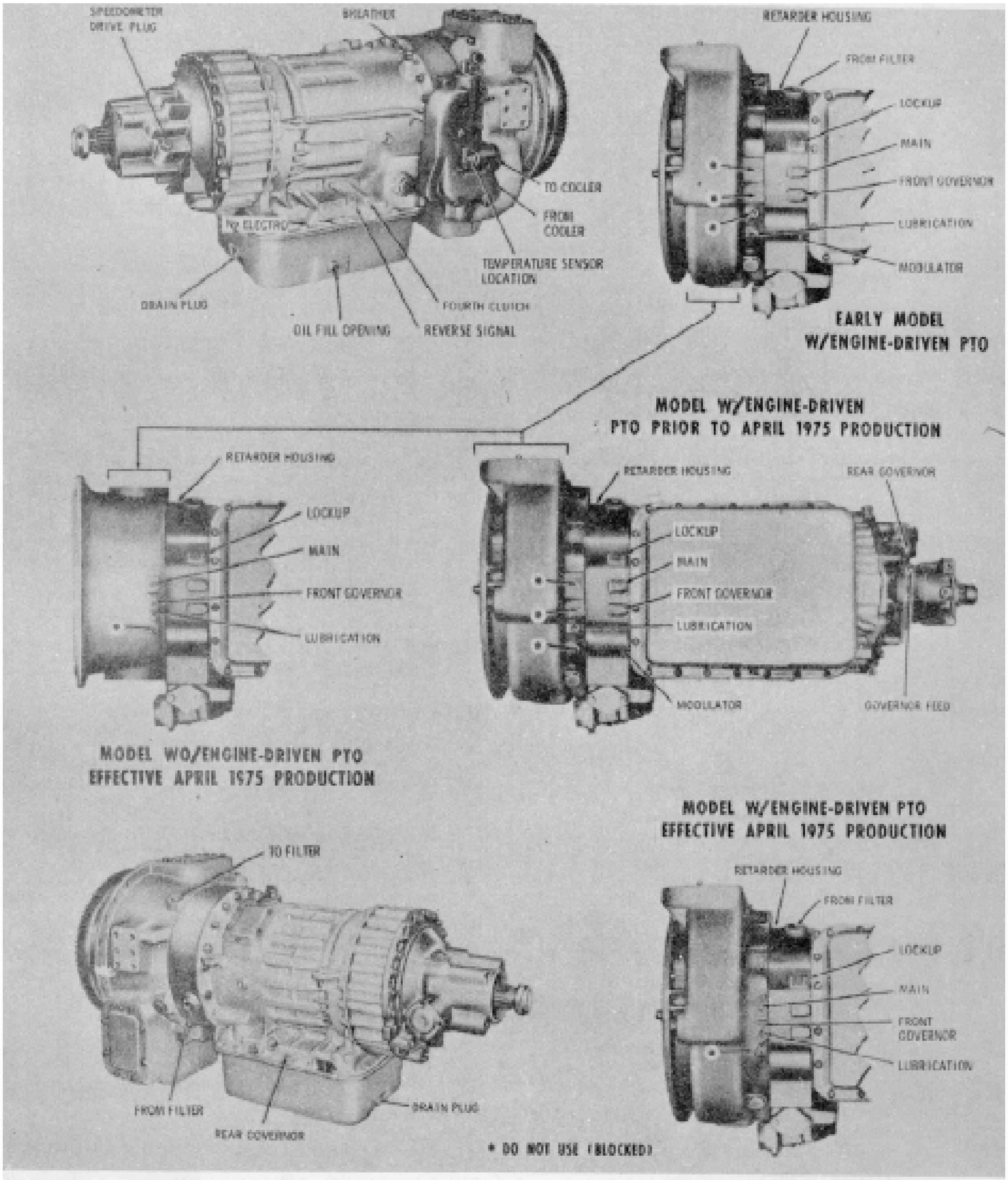

Fig. 3-2 Oil pressure check points (with retarder)

TROUBLESHOOTING CHART

Cause	Remedy
(A) AUTOMATIC SHIFTS OCCUR AT TOO HIGH SPEED	
1. Governor valve stuck	1. Clean or replace governor
2. Shift signal valve spring adjustment too tight	2. Back off spring adjusting ring (para 6-4)
3. Valves sticking	3. Overhaul valve body assembly (para 6-4)
(B) AUTOMATIC SHIFTS OCCUR AT TOO LOW SPEED	
1. Governor valve stuck	1. Clean or replace governor
2. Governor spring weak	2. Replace governor
3. Shift signal valve spring adjustment too loose	3. Tighten spring adjusting ring (para 6-4)
4. Modulator valve stuck	4. Clean or replace modulator valve (para 6-4)
5. Modulator valve spring adjustment too loose	5. Tighten spring adjusting ring (para 6-4)
(C) LOW MAIN PRESSURE IN ALL RANGES	
1. Low oil level	1. Add oil to proper level (para 3-3)
2. Oil filter element clogged	2. Replace filter
3. Sealring at oil intake pipe (filter output) leaking or missing	3. Replace sealring
4. Main-pressure regulator valve spring weak	4. Replace spring
5. Control valve body leakage	5. Replace or rebuild valve body assembly
6. Valves stuck (trimmers, relays, and main-pressure regulator)	6. Overhaul valve body assembly, main-pressure regulator valve
7. Oil pump, worn or damaged	7. Replace or rebuild oil pump
(D) LOW MAIN PRESSURE IN ONE OPERATING RANGE, NORMAL IN OTHER RANGES	
1. Leakage in clutch apply circuits for specific range	1. Replace or rebuild valve body assembly
2. Excessive leakage at clutch piston seals for specific range	2. Overhaul transmission and replace piston seals
(E) EXCESSIVE CREEP IN FIRST AND REVERSE GEARS	
1. Idle throttle setting too high	1. Adjust throttle setting (refer to vehicle manual)

TROUBLESHOOTING CHART - Continued

Cause	Remedy
(F) LOW LUBRICATION PRESSURE	
1. Oil level low	1. Add oil to proper level (para 3-3)
2. Excessive internal oil leakage	2. Check the valve body mounting bolts; lubrication valve seat and spring; low main pressure (refer to C)
3. Cooler lines restricted or leaking	3. Reroute or replace as necessary
4. Lubrication valve spring weak	4. Replace valve spring
(G) OIL LEAKING INTO CONVERTER HOUSING	
1. Converter pump hub seal worn	1. Replace seal
2. Converter pump hub worn at seal area	2. Replace pump hub
3. Engine rear seal worn	3. Refer to engine (or vehicle) service manual
(H) TRANSMISSION OVERHEATING IN ALL RANGES	
1. Oil level low	1. Add oil to proper level (para 3-3)
2. Oil level high	2. Add oil to proper level (para 3-3)
3. Cooler restricted (oil or coolant side)	3. Remove restrictions
(I) NO RESPONSE TO SHIFT LEVER MOVEMENT	
1. Range selector linkage unhooked	1. Hook up linkage (refer to vehicle service manual)
2. Range selector linkage defective or broken	2. Repair or replace linkage (refer to vehicle service manual)
3. Main pressure low	3. Refer to C, above
4. Range selector not engaged at control valve	4. Install or replace parts involved (inside oil pan)
(J) ROUGH SHIFTING	
1. Manual selector linkage out of adjustment	1. Adjust linkage
2. Control valves sticking	2. Replace or rebuild control valve assembly (para 6-4)
3. Modulator valve sticking; spring adjustment too tight	3. Repair or replace valves; back off spring adjustment (para 6-4)
4. Modulator actuator cable kinked or out of adjustment	4. Replace or adjust actuator cable (refer to vehicle service manual)

Cause		Remedy
(K)	DIRTY OIL	
1.	Failure to change oil at proper interval	1. Change oil, install new filter (para 3-7)
2.	Heat excessive	2. Refer to H, above
3.	Clutch failure	3. Overhaul transmission
4.	Damaged oil filter	4. Replace filter (para 3-7)
(L)	OIL LEAKING AT OUTPUT SHAFT	
1.	Oil seal at output flange worn or damaged	1. Replace seal
2.	Flange worn at seal surface	2. Replace flange
(M)	HIGH STALL SPEED (refer to para 3-13)	
1.	Oil level low	1. Add oil to proper level (para 3-3)
2.	Clutch pressure low	2. Refer to D, above
3.	Forward clutch slipping (forward)	3. Rebuild forward clutch (para 6-8)
4.	First clutch slipping	4. Rebuild forward clutch (para 6-18) Rebuild first clutch (para 7-2
5.	Fourth clutch slipping (reverse)	5. Rebuild fourth clutch
6.	Low clutch slipping (5 speed)	6. Rebuild low clutch
(N)	LOW STALL SPEED (refer to para 3-13)	
1.	Engine not performing efficiently (may be due to high altitude)	1. Refer to engine manufacturer’s manual or vehicle service manual
2.	Broken converter parts	2. Replace converter assembly
(O)	CLUTCH SLIPPAGE IN ALL FORWARD GEARS	
1.	Oil level low	1. Add oil to proper level
2.	Clutch (main) pressure low	2. Refer to C, above
3.	Forward clutch slipping	3. Rebuild forward clutch and replace piston sealrings
4.	Sealrings on front support hub worn or broken	4. Replace sealrings

Cause	Remedy
(Q) CLUTCH SLIPPAGE IN FIRST AND REVERSE GEARS ONLY	
1. Low clutch slipping	1. Rebuild clutch and replace piston sealrings
(R) CLUTCH SLIPPAGE IN FIFTH AND REVERSE GEARS ONLY	
1. Fourth clutch slipping	1. Rebuild clutch and replace piston sealrings
(S) CLUTCH SLIPPAGE IN ALL FORWARD GEARS, BUT NO SLIPPAGE IN REVERSE	
1. Forward clutch slipping	1. Rebuild clutch and replace piston sealrings
(W) CLUTCH SLIPPAGE IN FOURTH GEAR ONLY	
1. Third clutch slipping	1. Rebuild clutch and replace piston sealrings
(X) CLUTCH SLIPPAGE IN THIRD GEAR ONLY	
1. Second clutch slipping	1. Rebuild clutch and replace piston sealrings
(Y) CLUTCH SLIPPAGE IN SECOND GEAR ONLY	
1. First clutch slipping	1. Rebuild clutch and replace piston sealrings
(AB) VEHICLE MOVES IN NEUTRAL	
1. Range selector linkage out of adjustment	1. Adjust linkage properly
2. Forward clutch will not release	2. Rebuild forward clutch
3. Fourth clutch will not release	3. Rebuild fourth clutch
(AC) OIL THROWN FROM FILLER TUBE	
1. Dipstick loose	1. Tighten cap; replace if necessary
2. Oil level too high	2. Drain oil to proper level (para 3-3)
3. Breather clogged	3. Clean or replace breather
4. Dipstick gasket worn	4. Replace gasket or dipstick
5. Improper dipstick marking	5. Replace dipstick

Section 4. GENERAL OVERHAUL INFORMATION

4-1. SCOPE OF SECTION 4

This section provides information required before proceeding with overhaul of the transmission. Tools and equipment for overhaul are discussed. Replacement parts and service kit information is provided. The importance of cleanliness and careful handling is stressed. Helpful information on cleaning and inspection is given. General information on the removal and installation of the transmission is given. Torque specifications for bolts and nuts are tabulated. Information on wear limits and spring specifications are referenced.

4-2. TOOLS AND EQUIPMENT

a. Improvised Tools and Equipment.
The rollowing items may be improvised:

- Work table-1500-pound (680 kg) capacity (fig. 4-1)
- Disassembly and assembly stand (fig. 5-1)

b. Special Tools. Special tools are illustrated in figures 4-2, 4-3 and 4-4. They are identified in the tables following the illustrations.

c. Mechanic's Tools, Shop Equipment. The following tools, in addition to the common tools ordinarily required, should be available:

- Snapring pliers
- Micrometer
- A 3-leg lifting sling of 1/2-ton (454kg) capacity with 900 angle attaching plates
- Suitable hoist-1/2-ton (454 kg) capacity
- Container of volatile mineral spirits for cleaning parts

CAUTION C a us t i c cleaning compounds will damage so me transmission parts. Use only mineral spirits.

- A 100-inch pound (11.3 Nm) torque wrench
- A 100-foot pound (136 Nm) torque wrench
- A 1000-foot pound (1356 Nm) torque wrench
- A hot plate or heating equipment (for heating bearings or other interference-fit parts to aid assembly)
- A press for disassembly and assembly of spring-loaded clutches, valves, and interference-fit parts
- Clean shop cloths (do not use waste)
- Boxes, receptacles for parts
- Supply of wood blocks
- Oil-soluble, non-fibrous grease (petrolatum)
- Nonhardening sealer, Permatex No. 2, or equivalent (for plugs, seals, etc.)

4-3. REPLACEMENT PARTS

a. Ordering Information. Refer to the current issue of Parts Catalog SA 1268 for parts information.

b. Parts Normally Replaced. The following parts are normally replaced at each transmission overhaul:

- Gaskets
- Lockstrips
- Washers or snaprings damaged by removal
- Oil seals, piston sealrings

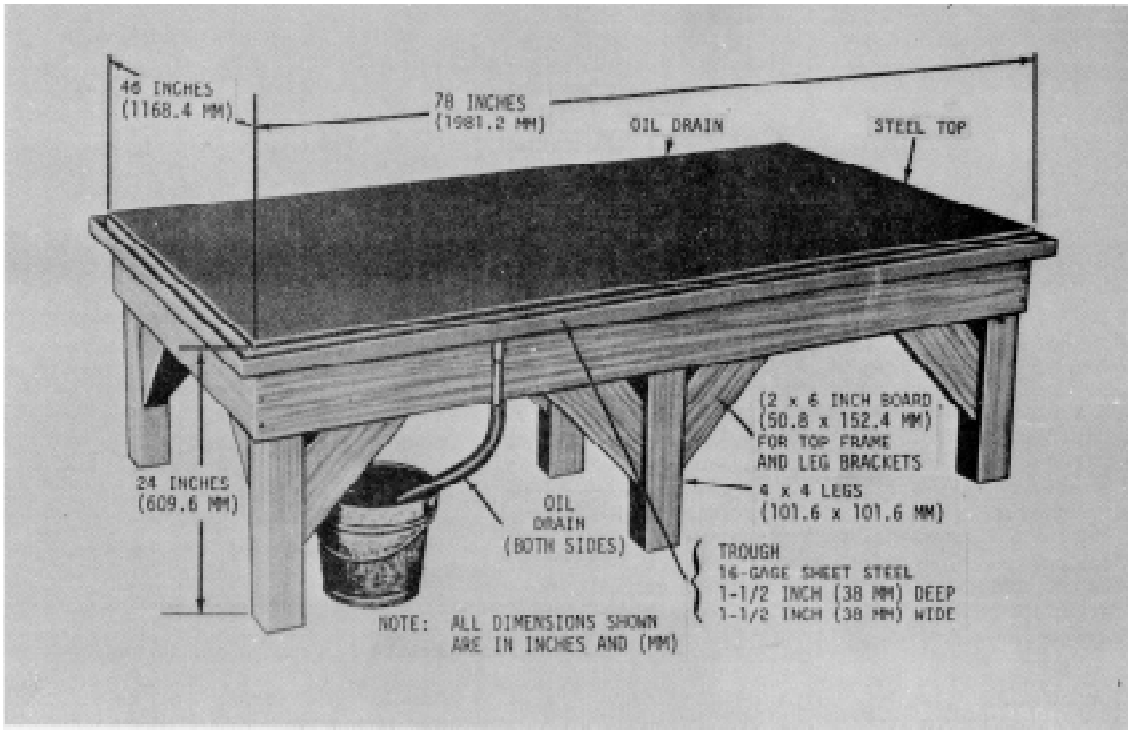

Fig., -1. Work table

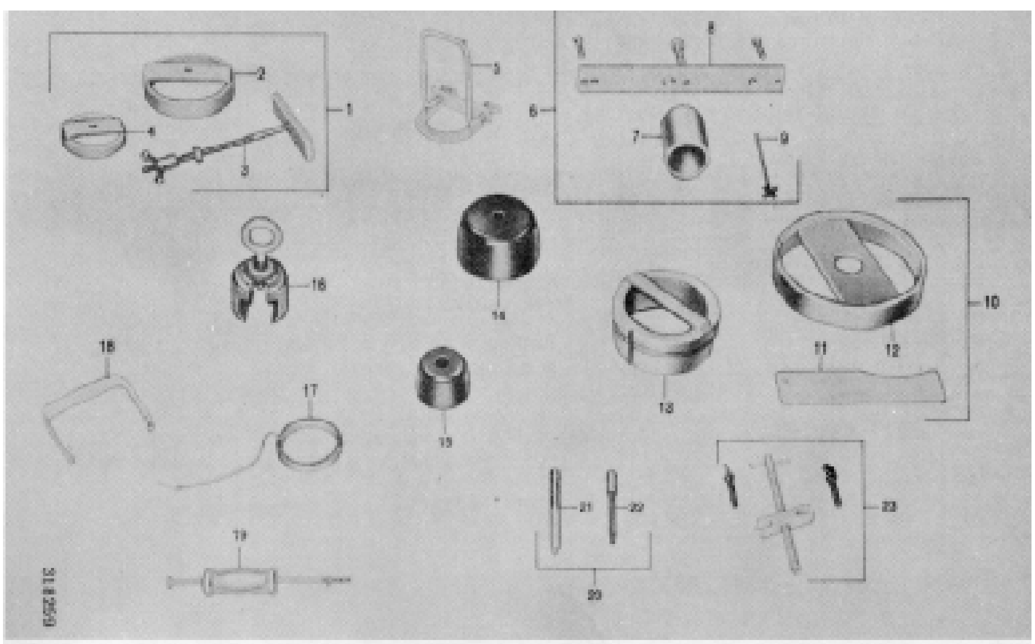

Fig. 4-2 Special tools (1 through 23)

GENERAL OVERHAUL INFORMATION

Para 4-2

SPECIAL TOOLS TABLE (fig. 4-2, 4-3, 4-4)

Fig	Item	Tool No. *	Description	Use illustrated
4-2	1	J24204	Clutch spring compressor set	
	2	J24204-1	Low and first clutch spring compressor	Fig. 6-53
	3	J24204-2	Bar and study assembly	Fig. 6-41, 6-53
	4	J24204-3	Forward and fourth clutch spring compressor	Fig. 6-41
4-2	5	J24195	Center support lifting bracket	Fig. 7-5, 7-17, 7-24, 5-35
4-2	6	J24208	Center support compressor assembly	
	7	J24208-2	Center support compressor sleeve	Fig. 7-6
	8	J24208-3	Center support compressor (bar is also used as gear pack support)	Fig. 7-6, 7-14
	9	J24208-4	Snapring selection gage	Fig. 7-6
4-2	10	J24200	Collector ring installer and staker set	
	11	J24200-1	Collector ring staker	Fig. 6-34
4-3	12	J24200-2	Collector ring installer	Fig. 6-33
4-2	13	J24221	Fourth clutch alinement fixture	Fig. 7-34
4-2	14	J24210	Low and first clutch piston inner seal protector	Fig. 6-57
4-2	15	J24216-01	Forward clutch piston inner seal protector	Fig. 6-36, 6-42
4-2	16	J24196	Main shaft lifting bracket	Fig. 7-14, 7-23
4-2	17	J24218-2	Stator roller holder	Fig. 6-9, 6-11
4-2	18	J24209	Fourth clutch lifting bracket	Fig. 5-32
4-2	19	J6125-1	Slide hammer (used with item 22)	Fig. 6-54
4-2	20	J24205	Bushing replacer set	
	21	J24205-1	Speedometer driven gear bushing installer	Fig. 6-55
	22	J24205-2	Speedometer driven gear bushing remover	Fig. 6-54
4-2	23	J24219	Main pressure regulator and lockup valve spring compressor	Fig. 6-16
4-3	24	J24171-2&4	Slide hammer	Fig. 6-49, 6-50
	25	J24171-1	Dust shield remover	Fig. 6-49, 6-50
4-3	26	J24198	Oil pump oil seal installer (used with J24202-4)	Fig. 6-18
4-3	27	J24202-1	Transmission rear oil seal installer (used with J24202-4)	Fig. 6-60
4-3	28	J24202-4	Driver handle (used with items 26, 27, 59)	Fig. 6-18, 6-60
4-3	30	J24197	Front support needle bearing installer (used with J8092)	Fig. 6-17
4-3	31	J24203	Output shaft bushing installer	Fig. 6-59, 7-54
4-3	32	J26282	Manual shaft oil seal installer	Fig. 6-62
4-3	33	J24217	Main shaft orifice installer	Fig. 6-47
4-3	34	J24369	Orifice plug installer	Fig. 6-58, 6-47

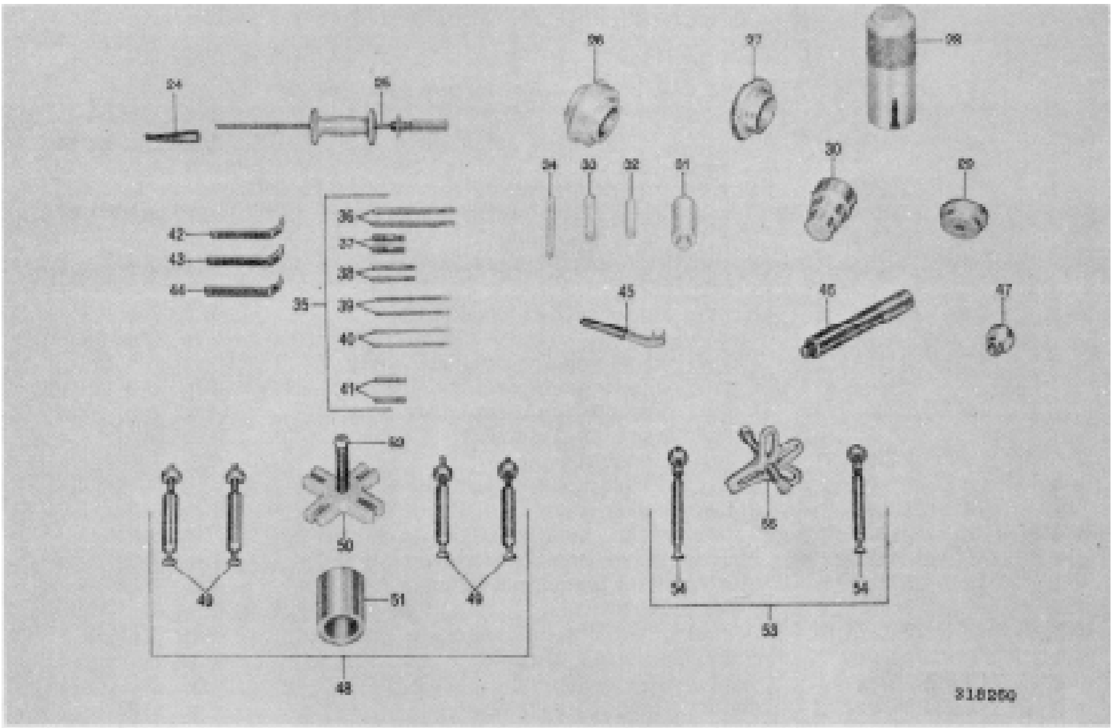

Fig. 4-3 Special tools (24 through 55)

SPECIAL TOOLS TABLE (fig. 4-2, 4-3, 4-4) (cont'd)

Fig	Item	Tool No.*	Description	Use illustrated
4-3	35	J24315	Guide screw set	
	36	J24315-1	Oil pump guide screw 3/8-16 x 6 (2)	Fig. 6-21
	37	J1126-1	Converter housing guide screw 1/2-13 X 2 3/8 (2)	Fig. 7-36
	38	J3387-2	Oil pan guide 5/16-18 x 3 (2)	Fig. 7-51, 7-52
	39	J24315-3	Valve body guide screw 1/4-20 x 5 (2)	Fig. 7-53
	40	J6889-1	Pitot tube guide screw #10-32 x 6 (2)	Fig. 7-36
	41	J24315-2	Flywheel guide screw, 3/8-24 x 2 (2)	
A-3	42	J24192	Clutch pack clearance gage (forward, fourth)	Fig. 6-37, 6-44
	43	J24193	Clutch pack clearance gage (third)	
	44	J24194	Clutch pack clearance gage (first, second, low)	Fig. 7-2, 7-7, 7-10, 7-11
4-3	45	J24314	Valve ring adjusting tool	
4-3	46	J8092	Driver handle (used with items 29, 30, 47, 56)	Fig. 6-17
4-3	48	J25007	Converter pump bearing puller	Fig. 5-20
	49	J25007-2	Leg and nut (4)	Fig. 5-20
	50	J25007-3	Puller body	Fig. 5-20
	51	J25007-4	Sleeve	Fig. 5-20
	52	J8646-2	Puller body screw	

GENERAL OVERHAUL INFORMATION

SPECIAL TOOLS TABLE (fig. 4-2, 4-3, 4-4) (cont'd)

Fig	Item	Tool No.*	Description	Use illustrated
4-3	53		Rear bearing puller assembly (in vehicle) (includes J24420 and J2534)	
	54	J24534	Rear bearing puller legs (2) (used with J24420)	Fig. 7-67
	55	J24420	Rear bearing puller body (used with J24534)	Fig. 7-67
4-4	56	J24368	Rear planetary carrier bushing installer (-used with J8092)	
4-4	57	J24310	Transmission holding fixture	Fig. 7-63
	58	J24453	Lockring installer	Fig. 6-45
	59	J24447	Rear bearing installer (used with J24202-4)	
	60	J24365	Flywheel lifting bracket	Fig. 7-58

* Tools having numbers with "J" prefix may be ordered from Kent-Moore, 1501 South Jackson Street, Jackson, Michigan 49203.

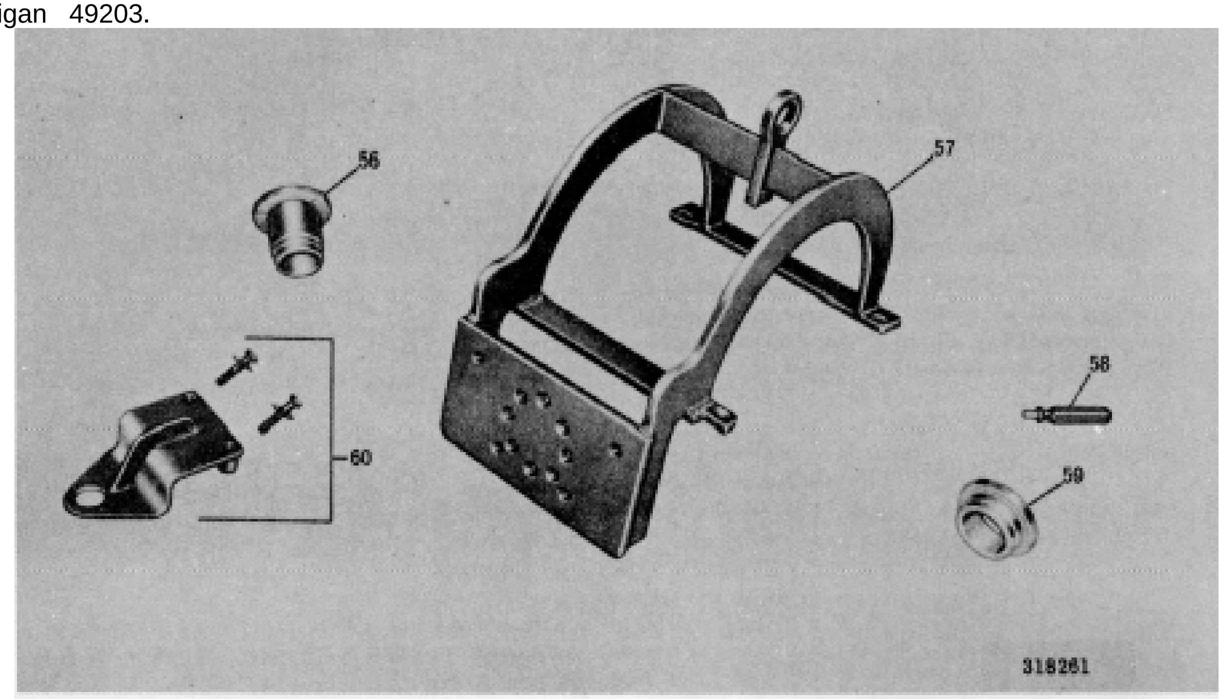

Fig. 4-4 Special (56 through 60)

4-4. CAREFUL HANDULING

During all rebuild procedures, parts and subassemblies must be handled carefully to prevent nicking, scratching and denting. Parts which fit together closely and have proper operating clearance can bind if damaged. Parts which depend upon smooth surfaces for sealing may leak if scratched. This is very important concerning parts of the control valve body assembly (valves, when dry, must move freely by their own weight). Such parts should be carefully handled and protected during removal, cleaning, inspection and installation as well as being kept clean while in containers awaiting installation.

4-5. CLEANING, INSPECTION

a. Dirt Causes Malfunction. All parts must be clean to permit effective inspection. At assembly, it is very important that no dirt or foreign material be allowed to enter the transmission. Even minute part i c 1 e s can cause the malfunction of close-fit parts, such as valves.

b. Cleaning Parts

(1) All the metallic parts of the transmission except bearings and friction-faced clutch plates should be cleaned thoroughly with volatile mineral spirits or by the steam cleaning method. Do not use caustic soda solution for steam cleaning. Use only mineral spirits to clean friction-faced clutch plates.

(2) Parts should be dried with compressed air. Steam-cleaned parts should be oiled immediately after drying.

(3) Clean oil passages by working a piece of soft wire back and forth through the passages and flushing with mineral spirits. Dry the passages with compressed air.

(4) Examine parts, especially oil passages, after cleaning, to make certain they are entirely clean. Reclean them if necessary.

c. Cleaning Bearings

(1) Bearings that have been in service should be thoroughly washed in volatile mineral spirits.

(2) If the bearings a r e particularly dirty or filled with hardened grease, soak them in the spirits before trying to clean them.

(3) Before inspection, oil the bearings with the same type of oil that will be used in the transmission.

Never dry bearings with compressed air. Do not spin bearings while they are not lubricated.

d. Keeping Bearings Clean. Since the presence of dirt or grit in ball bearings is usually responsible for bearing failures, it is important to keep bearings clean during removal and installation. Observance of the following rules will do much to insure maximum bearing life.

(1) Do not remove the wrapper from new bearings until ready to install them.

(2) Do not remove the grease in which new bearings are packed.

(3) Do not lay bearings on a dirty bench; place them on clean, lint-free paper.

(4) If assembly is not to be completed at once, wrap or cover the exposed bearings with clean paper or lint-free cloth to keep out dust.

e. Inspecting Cast Parts, Machined Surfaces.

(1) Inspect bores for wear, scratches, grooves and dirt. Remove scratches and burs with crocus cloth. Remove foreign matter. Replace parts that are deeply scratched or grooved.

(2) Inspect all oil passages for obstructions. If an obstruction is found, remove it with compressed air, or by working a soft wire back and forth through the passage and flushing it out with cleaning solvent.

(3) Inspect mounting faces for nicks, burs, scratches, and foreign matter. Remove

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Para 4-5/4-6

such defects with crocus cloth or a soft stone. If scratches are deep, replace the defective part.

(4) Inspect threaded openings for damaged threads. Chase damaged threads with the correct size used tap (a new tap can cut oversize).
(5) Replace housings or other cast parts that are cracked.
(6) Inspect all machined surfaces for damage that could cause oil leakage or other malfunction of the part. Rework or replace the defective parts.

f. Inspecting Bearings

(1) Inspect bearings for roughness of rotation. Replace a bearing if its rotation is still rough after cleaning and oiling.
(2) Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for excessive wear of rollers or balls. If one of these defects is found, replace the bearing.
(3) Inspect the defective bearing housing and shaft for grooved, burred or galled conditions that would indicate that the bearing had been turning in the bore or on the shaft. If the damage cannot be repaired with crocus cloth, replace the defective part.
(4) When installing a bearing on a shaft, heat the bearing to 2000F (930C) in an oil bath (approximately 30 minutes). Use the proper size installation sleeve and a press to seat the bearing.
(5) If a bearing must be removed or installed without a sleeve, press only on the race which is adjacent to the mounting surface. If a press is not available, seat the bearing with a drift and hammer, driving against the supported race.

g. Inspecting Bushings, Thrust Washers

(1) Inspect bushings for scores, burs, roundness, sharp edges and evidence of overheating. Remove scores with crocus cloth. Remove burs and sharp edges with a scraper

or knife blade. If bushing is out-of-round, deeply scored, or excessively worn, replace it, using the proper size replacer.

CAUTION

When a defective bushing is removed, care should be exercised to prevent damage to the bushing bore.

(2) Inspect thrust washers for distortion, scores, burs, and wear. Replace the thrust washer if it is defective or worn.

h. Inspecting Oil Seals, Gaskets

(1) Inspect sealrings for cuts and hardness. Replace sealrings if these defects are found.
(2) W he n replacing metal-encased, lip-type oil seals, the lip side must be toward the oil to be sealed in (toward the inside of the unit). Use a nonhardening sealing compound on the outside diameter of the seal to help prevent oil leaks. Coat the inside lip of the seal with high-temperature grease to protect the seal during shaft installation and to p r o v i de lubrication during initial operation.
(3) Replace all composition gaskets.
(4) I n s p e c t hook-type sealrings for wear, broken hooks, and distortion.
(5) Installa new hook-type sealring if the ring shows any wear on the outside diameter, or if there is excessive side wear.
(6) The sides of the sealring must be smooth (0. 005-inch (0.13 mm) maximum side wear). The sides of the shaft groove (or the bore) in which the sealring fits should be smooth (50 microinches (1. 27 *u***m)** equivalent) and square with t h e axis of rotation within 0.002 inch (0.05 mm). If the sides of the grooves have to be reworked, install a new sealring.

i. Inspecting Gears

(1) Inspect gears for scuffed, nicked, burred, or broken teeth. If the defect cannot be removed with a soft stone, replace the gear.

(2) Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.

(3) Inspect the thrust face of gears for scores, scratches, and burs. Remove such defects with a soft stone. If scratches and scores cannot be removed with a soft stone, replace the gear.

j. Inspecting Splined Parts. Inspect splined parts f or stripped, twisted, chipped or burred splines. Remove burs with a soft stone. Replace the part if other defects are found. Spline wear is not considered detrimental except where it affects tightness of fit of the splined parts.

k. Inspecting Threaded Parts. Inspect parts for burred or damaged threads. Remove burs with a soft stone or fine file. Replace damaged parts.

l. Inspecting Snaprings. Inspect all snaprings for nicks, distortion, and excessive wear. Replace snapring if any of those defects is found. The snapring must snap tight in its groove for proper functioning.

m. Inspecting Springs. Inspect springs for signs of overheating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any one of these defects is found. Refer to the spring chart at end of Section 8.

n. Inspecting Clutch Plates

(1) Inspect friction-faced steel plates (internal-splined plates) for burs, imbedded metal particles, severely pitted faces, excessive wear, cone, cracks, distortion, and damaged spline teeth. Remove burs, using a soft honing stone. Replace plates which have other defects.

(2) Inspect steel plates (externaltanged plates) for burs, scoring, excessive wear, cone, distortion, imbedded metal, galling, cracks, breaks, and damaged tangs. Remove burs and minor surface irregularities, using a soft-honing stone. Replace plates which have other defects.

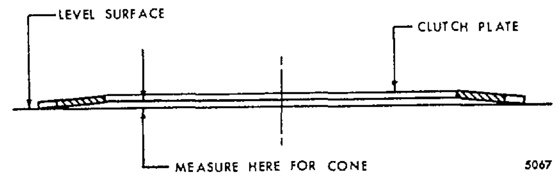

Fig. 1-5 Method of measuring clutch plate cone

(3) The amount of cone in clutch plates is determined by measuring the distance between the inside diameter of the plate and a level surface (fig. 4-5). Discard plates having excessive cone (refer to wear limits, Section 8). When assembling a clutch pack, soak friction-faced clutch plates in transmission fluid for at least 2 minutes and make sure that each plate is installed so that its cone is in the same direction as the cone of the adjacent plates.

o. Inspecting Swaged, Interference-fit Parts. If there is evidence of looseness due to relative motion, the assembly should be replaced.

p. Inspecting Balls in Clutch Housings. Inspect all balls in rotating clutch housings for free movement. Any restriction could prevent the ball from seating during clutch application.

4-6. REMOVING (OR INSTALLING) TRANSMISSION

a. Drain Oil. Drain the oil from the transmission before removal from the vehicle (para 3-7). For better drainage, the transmission should be warm and allowed to drain over night. Since a p p i c a t i o n s will differ, consult the vehicle service manual for s p e c if i c instructions for transmission removal and installation.

b. Check Linkages and Lines. Make sure that all linkages, controls, cooler lines, modulator actuator cable, temperature connection, input and output couplings, and mounting bolts are disconnected before transmission removal (also, oil filler tube and other equipment such as attached parking brake handle, etc). Oil lines should be carefully placed out of the way of damage and all openings covered to keep out dirt.

NOTE

Position jack or hoist sling to coincide with the transmission center of gravity, as follows (measured rearward from front mounting of transmission to engine):

HT 750CRD - 14.50

c. Clean Transmission Clean the exterior of the transmission Steam cleaning should be followed immediately by disassembly, because condensation allowed to remain in the transmission could cause rust.

d. Reconnect at Installation At installation, all items should be reconnected A transmission jack is convenient to raise the transmission into mounting position The transmission should be filled with oil (para 3-3) and road tested after installation.

4-7. WEAR LIMITS

Refer to Section 8 for general and specific information covering p a r t s fits, clearances and wear limits.

4-8. SPRING SPECIFICATIONS

Refer to the spring charts in Section 8 for spring identification and specifications.

4-9. TORQUE SPECIFICATIONS

The torque specifications in the following table apply to all assembly procedures. Refer also to figure 6-74.

TORQUE SPECIFICATIONS

Foldout	Item	Location	Size	Torque lb ft	Torque Nm
A, 7	1	Flex disk to flywheel	1/2-20	96-115	130-156
A, 7	9	Flex disk to hub	1/2-20	96-115	130-156
B, 7	17	Retainer to pump	3/8-24	33-40	45-54
B, 7	29	Pump to flywheel	3/8-24	41-49	56-66
A, 8	10	Cover to pump body	1/4-20	9-11	12-15
A, 8	12	Cover to converter housing	3/8-16	26-32	35-43
A, 8	18	Plug	1/8-27	4-5	5.4-6.8
A, 8	20	Converter housing to main housing	1/2-13	67-80	91-108
A, 8	22	Pitot tube (or block)	10-32	30-48 (in. lb)	3.4-5.4
A, 14	3	Main housing to converter housing	1/2-13	67-80	91-108
A, 14	4	Plug	1/8-27	4-5	5.4-6.8
A, 14	9	Housing to center support	3/8-16	39-46	53-62
A, 14	11	Baffle to transfer plate	1/4-20	8-12	10.9-16
A, 14	13	Transfer plate to housing	1/4-20	8-12	10.9-16
A, 14	14	Transfer plate to housing	1/4-20	8-12	10.9-16
A, 14	16	Transfer plate to housing	1/4-20	8-12	10.9-16
A, 14	17	Valve body to transfer plate	1/4-20	8-12	10.9-16
A, 14	18	Valve body to transfer plate	1/4-20	8-12	10.9-16
A, 14	19	Detent spring to valve body	1/4-20	8-12	10.9-16
A, 14	22	Cover to transfer plate	1/4-20	8-12	10.9-16
A, 14	28	Oil filter to transfer plate	5/16-18	13-16	18-22
A, 14	33	Oil pan to housing	5/16-18	10-13*	14-18
A, 14	35	Detent lever to shaft	3/8-24	15-20	20-27
A, 14	37	Modulator retainer to hsg	5/16-18	10-13	14-18
A, 14	41	Plug	3/4-16	50-60 (in. lb)	5.6-6.8
A, 14	49	Side PTO cover	3/8-16	39-46	53-62
A, 16	9	Plug	1/8-27	4-5	5.4-6.8
A, 16	10	Plug	1/8-27	4-5	5.4-6.8
A, 16	17	Rear cover to hsg	1/2-13	67-80	91-108
A, 16	31	Output flange to shaft	2-16	750-1000	1017-1356
A, 16	36	Rear cover to housing	1/2-13	67-80	91-108
A, 16	43	Cover to housing	5/16-18	10-13*	14-18
A, 17	1	Valve body to transfer plate	1/4-20	9-11	12.2-15
A, 17	17	Valve body to valve body	1/4-20	9-11	12.2-15
B, 10	21	Front support to converter hsg	3/8-16	36-43	49-58
B, 10	22	Front support to converter hsg	3/8-16	36-43	49-58
B, 10	29	Front support to converter hsg	3/8-16	36-43	49-58
B, 16	17	Modulator to transfer plate	1/4-20	9-11	12.2-15
B, 16	44	Cover to valve body	1/4-20	9-11	12.2-15
B, 16	58	Plug	1/8-27	4-5	5.4-6.8
B, 16	64	Valve stop bolt	3/8-16	36-43	49-58

*5 lb ft (6. 8 Nm) minimum after gasket sets

Section 5. DISASSEMBLY OF TRANSMISSION Para5-1/5-2
INTO SUBASSEMBLIES

5-1. SCOPE OF SECTION 5

This section covers the disassembly of the transmission It is arranged in a continuous sequence to facilitate assembly Certain illustrations will not always illustrate the model being dis- ,., assembled, but when the operation is identical the illustration may be referenced and will correctly illustrate the procedure.

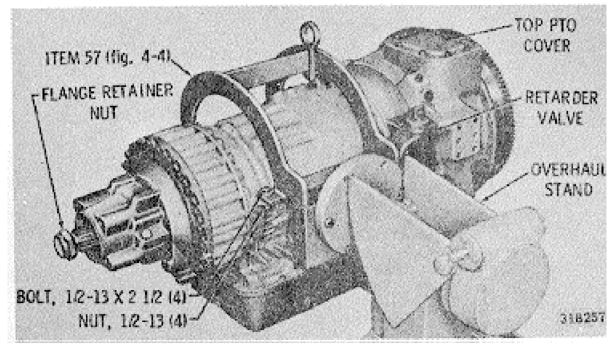

Fig. 5-1. Installing transmission overhaul stand

5-2. REMOVING EXTERNAL X COMPONENTS

a. Mounting Transmission In Overhaul Stand

(1) Overhaul stands, and mounting of the transmission therein, will vary. Figure 5-1 shows the transmission installed in a typical overhaul stand.

(2) Before installing the lifting bracket onto the transmission, remove any bolts which cannot be removed due to obstruction by the bracket.

<u>b.</u> <u>Removing</u> <u>External</u> <u>Components</u>

(1) Remove the self-locking nut from the output shaft (fig. 5-1). Remove the flange.

(2) On models having a two-bolt top cover on the converter housing, remove two bolts 12 (A, foldout 8), two washers 13, cover 14 and gasket 15.
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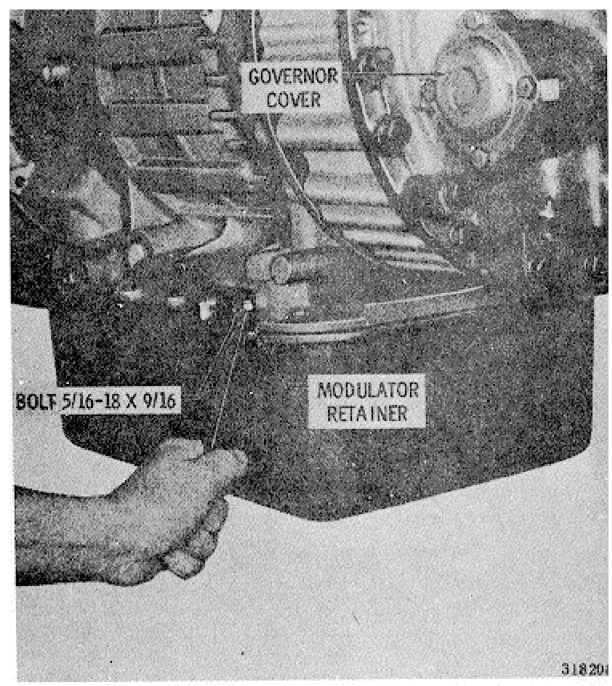


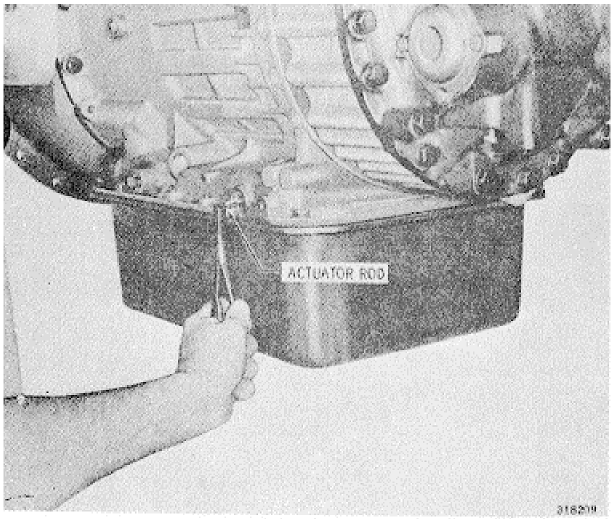


Fig. 5-3. Removing modulator actuator rod

(5) Remove the four bolts that retain the governor cover and gasket (fig. 5-2). Remove the cover and gasket.

(6) Carefully remove the governor by rotating it clockwise while removing it.

(7) Remove the bolt that retains the modulator retainer (fig. 5-2). Remove the retainer. 0 n earlier models, remove the modulator actuator rod (fig. 5-3).

5-3. REMOVING FLYWHEEL, LOCKUP CLUTCH

a. Flywheel Bolts

(1) With the transmission in a horizontal position, place a suitable container beneath the flywheel to retain any excess oil which may drain during removal of the flywheel.

(2) Remove twenty-nine of thirty bolts and washers that retain the converter flywheel to the converter pump (fig. 5-4).

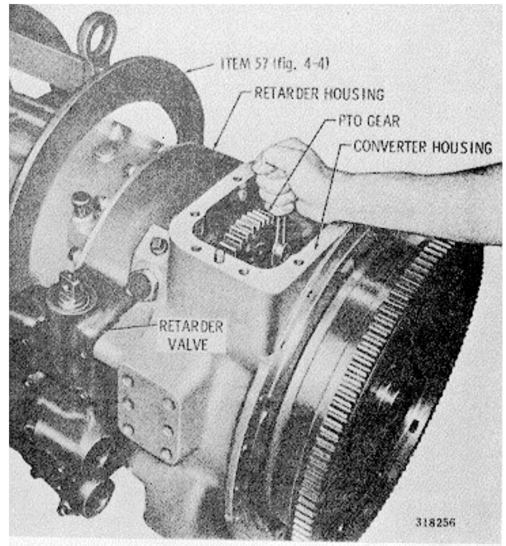


Figure. 5-4. Removing flywheel bolts

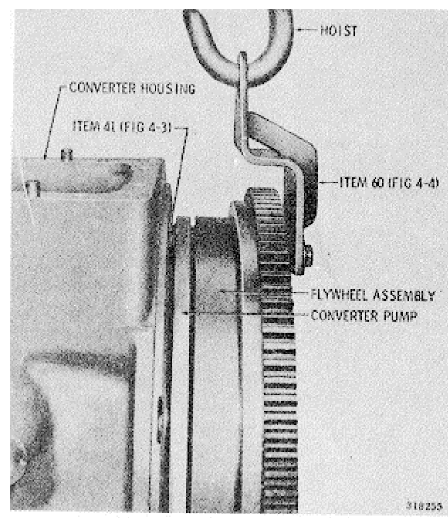


Fig. 5-5. Lifting tool installed on flywheel

b. Flywheel and Attached Parts

(1) Install lifting tool 60 (fig. 4-4) onto the flywheel (fig. 5-5).

(2) Attach a hoist to the lifting tool. Support the weight of the flywheel during removal of the remaining bolt and washer.

DISASSEMBLY

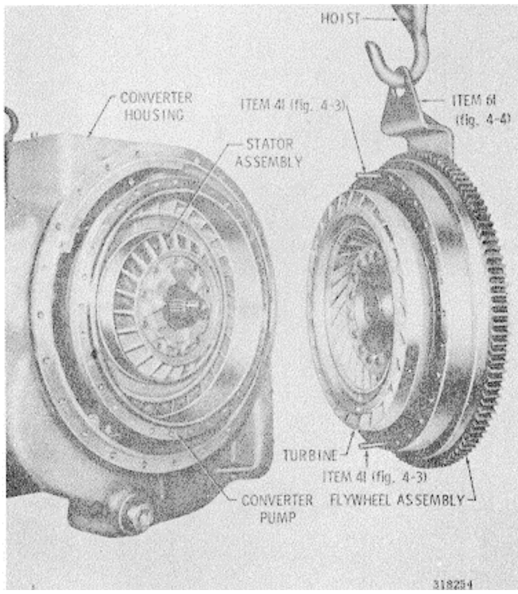


Fig. 5-6. *Remoting flywheel and turbine*

(3) Remove the flywheel and attached parts from the converter housing (fig. 5-6). The guide bolts shown are not required for removal.

NOTE

If the turbine remains with the flywheel as shown in figure 5-6, care should be taken to prevent the turbine from falling.

(4) Refer to paragraph 6-3 for rebuild of flywheel assembly.

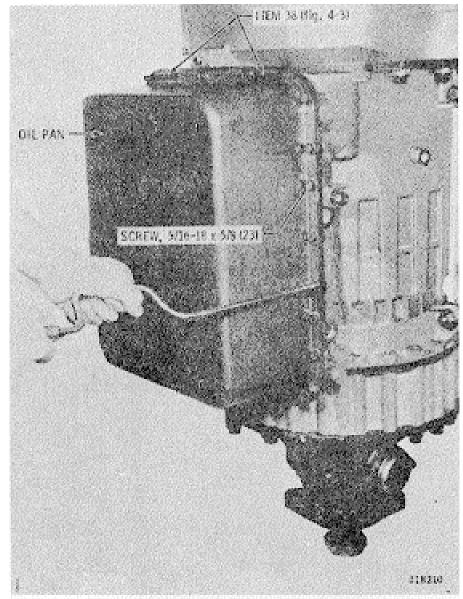


Fig. 5-7. Removing oil pan screws

5-5. REMOVING OIL PAN, FILTER, VALVE BODIES (HT 750)

a. Oil Pan, Filter

(1) Rotate the transmission to a vertical position, front end (converter housing) upward.

(2) Remove two pan screws (fig. 5-7) and install two 5/16-18 guide bolts 30 (fig. 4-3).

(3) Remove the remaining twenty-one pan screws. Remove the oil pan and gasket. Remove the guide bolts.

(4) Remove the screwthat retains the oil filter to the valve body (fig. 5-10). Re

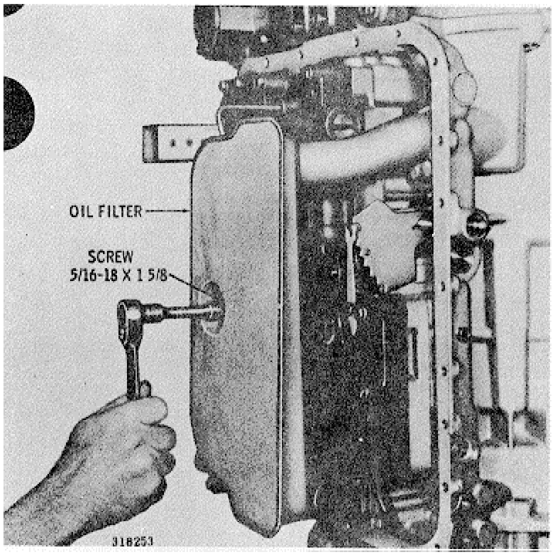


Fig. 5-11. Removing oil filter

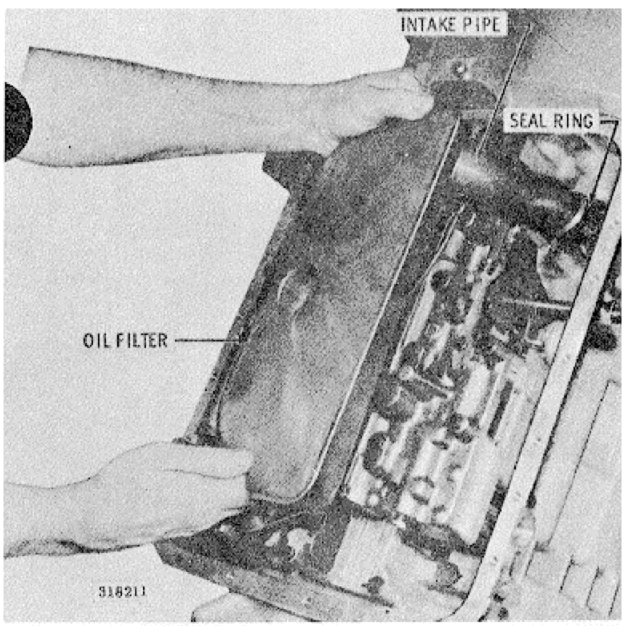


Fig. 5-11. Removing oil filter

move the oil filter (fig. 5-11), sealring, and the oil filter spacer.

b. Valve Bodies

(1) Remove the signal tube (fig. 5-12).

(2) Remove bolts A and B (fig. 5-13). Install two 1/4-20 guide bolts 39 (fig. 4-3) into positions A and Bo

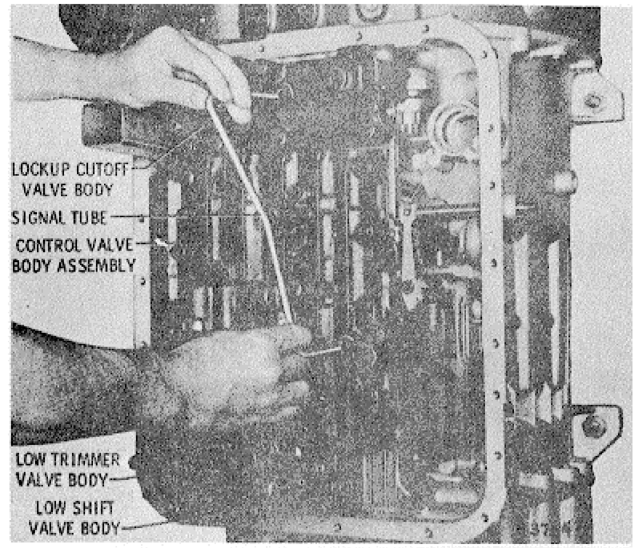


Fig. 5-12. Removing signal tube

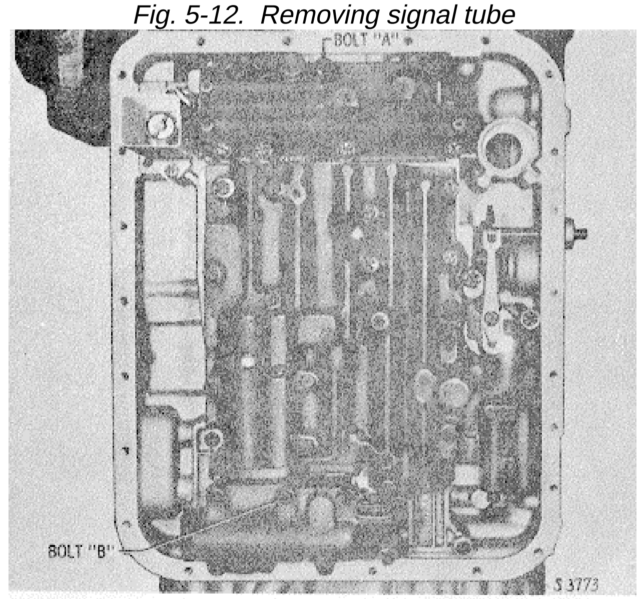


Fig. 5-13. Valve body assembly

(3) Remove the five bolts remaining in the low trimmer valve body (fig. 5-14). Remove the low trimmer valve body.

(4) Remove the one remaining bolt iin the low shift valve body. Remove the low shift valve body.

(5) Refer to paragraphs 6-5 and 6-6 for rebuild of the low trimmer and shiftvalve bodies.

(6) Remove the seven remaining bolts that retain the cover plate, Remove the cover plate.

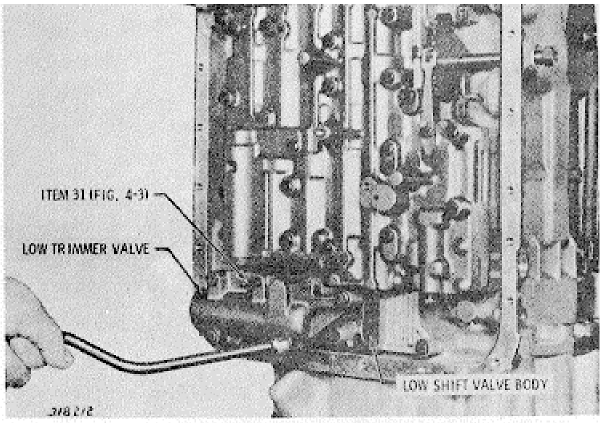


Fig. 5-14. Removing trimmer valve body

(7) Remove eighteen bolts from the control valve (fig. 5-16). Remove one selector lever detent retainer bolt. Do not remove the bolt (0. 725-long) that retains the selector valve.

(8) Remove the four bolts, two washers and baffle that retain the oil transfer plate (fig. 5-16).

(9) Remove the controlvalve body assembly, separator plate and transfer plate as a unit (fig. 5-17). Refer to paragraph 6-4 for rebuild of the control valve body assembly.

5-6. REMOVING TORQUE CONVERTER AND PTO COMPONENTS

a. Converter Stator, Pump

(1) Holding the stator assembly, lock the stator and the freewheel roller race together by rotating the stator in a counterclockwise direction. (Refer to figure 5-6.)

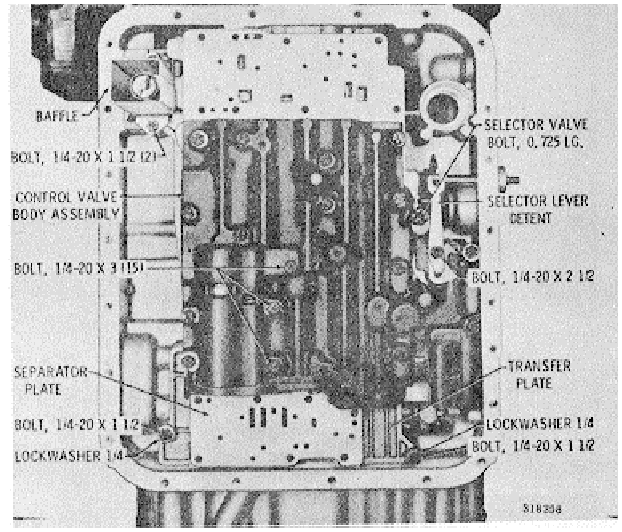


Fig. 5-16 Control valve body bolt locations

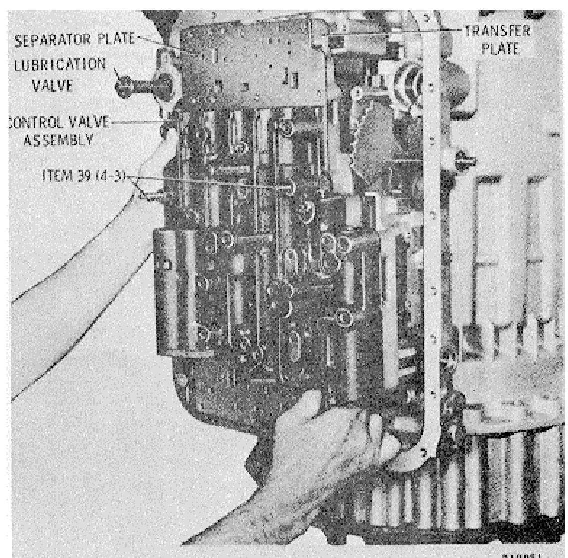


Fig. 5-17 Removing control valve assembly

DISASSEMBLY

Para 5-6

(2) Carefully lift the stator assembly from the turbine shaft. Refer to paragraph 6-8 for rebuild of the stator assembly.

(3) Remove the snapring and splined spacer from the converter ground sleeve (fig..5-18).

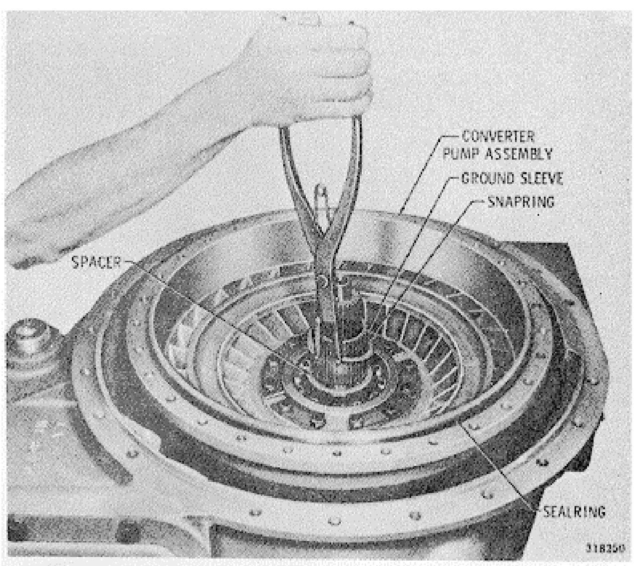
(4) Remove the converter pump from the converter housing (fig. 5-19) After S/N 2082, remove the converter pump (fig. 5-20), using tool J25007, as follows.

(5) Using figure 5-20 as a guide, place puller sleeve 51 (fig. 4-3) onto the converter ground sleeve.

(6) Insert the feet of leg and nut assemblies 49 (fig. 4-3) between the balls of the bearing assembly, spacing them 90 apart

(7) Rotate the legs to make the feet bear against both the inner and outer bearing race grooves. Install puller head 50 onto the legs, tightening the nuts evenly.

(8) Install center screw 52 and tighten I it by hand until it is centered on sleeve 51. Hold the pump assembly, and tighten the center screw until the pump assembly will lift off the ground sleeve. Refer to paragraph 6-9 for rebuild of the pump assembly



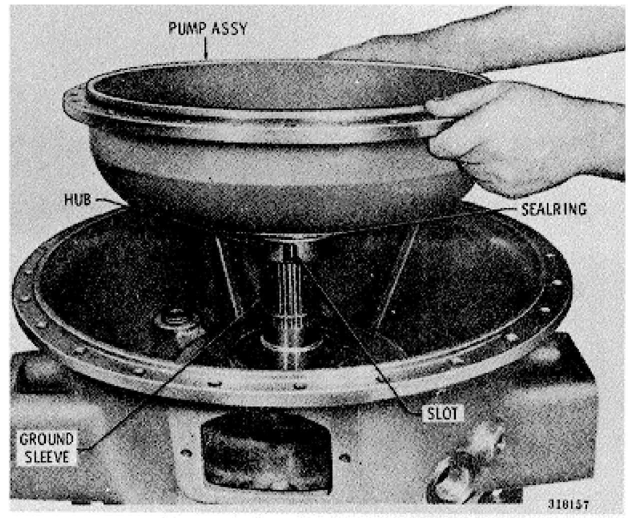


Fig. 5-19 Removing torque converter pump

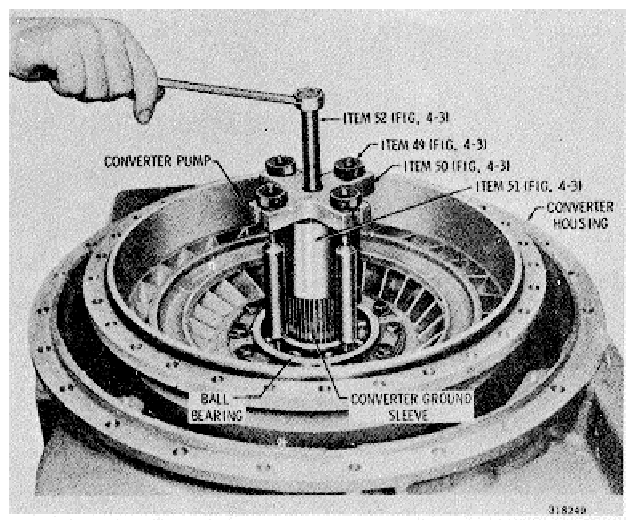


Fig. 5-20 Removing torque converter pump using special tool

HT 700D SERIES TRANSMISSION

5-7. REMOVING CONVERTER HOUSING a. Housing with 2-Bolt Top Cover (no retarder)

(1) From inside the converter housing, remove the two screws and washers that retain the pitot tube or (fig. 5-25).

(2) Remove seven bolts and washers from the inside of the converter housing (fig.5-25).

(3) Remove nine bolts and washers retaining the converter housing to the transmission housing. Two bolts were removed before the installation of the lifting bracket. Refer to figure 5-1.

(4) Remove the converter housing from the transmission housing with the lifting sling and place it on the work table (fig. 5-26).

(5) Refer to paragraph 6-9 for rebuild of the converter housing assembly.

(6) Remove the pitot tube or steel block (fig. 5-26). freed in item (1), above.

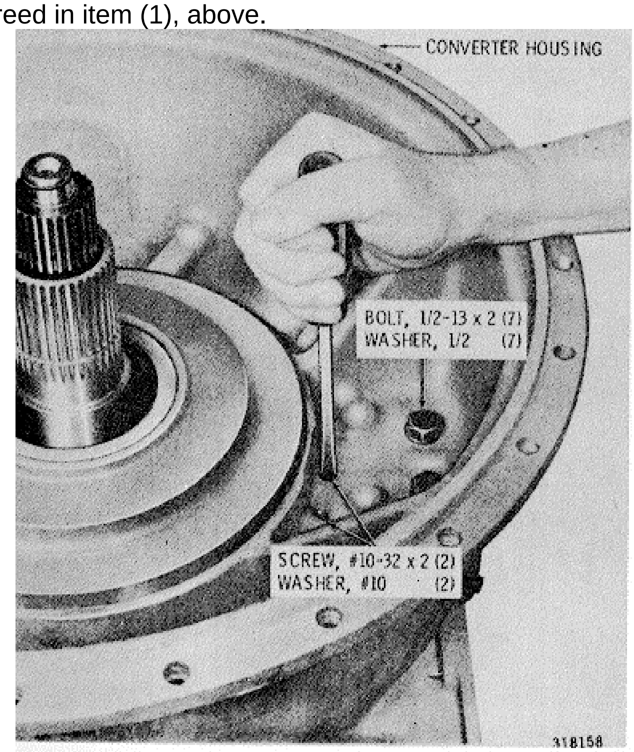


Fig. 5-25 Removing pitot tube or block screws

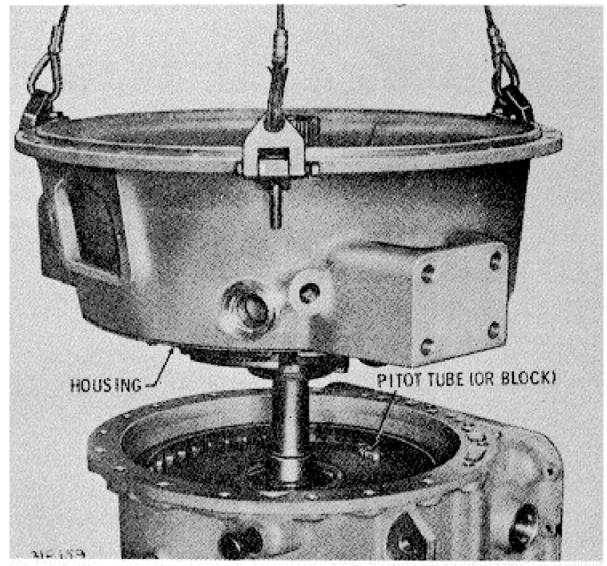


Fig. 5-26 Removing torque converter housing

5-9. REMOVING FORWARD, FOURTH, THIRD CLUTCHES

a. Forward, Fourth Clutches

(1) If the pitot tube (fig. 5-30) was not removed from the oil collector ring, remove it.

(2) Grasp the turbine shaft (fig. 5-31) and lift out the forward clutch and turbine shaft assembly.

CAUTION

Do not let weight rest on the governor oil collector.

(3) During removal of the forward clutch assembly, do not lose the needle bearing 18 (A, foldout 11) or race 19, if they adhere to the forward clutch hub.

DISASSEMBLY

Para5-9

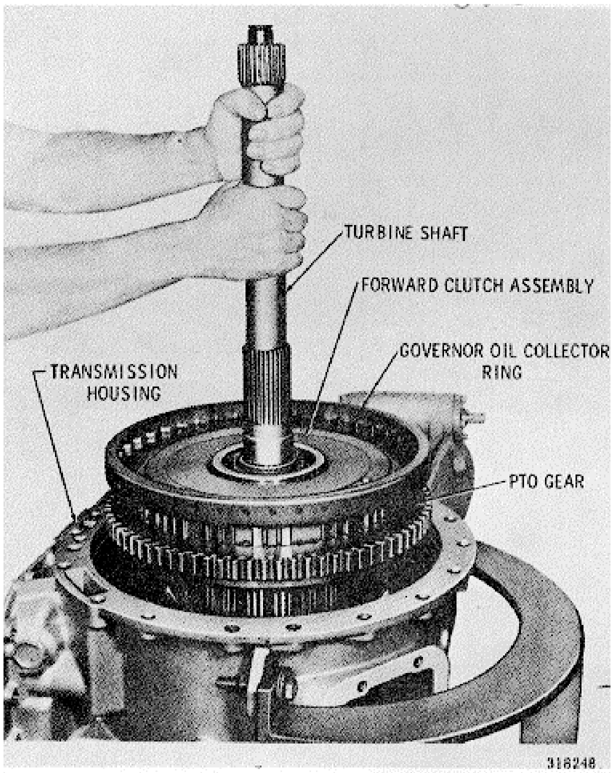


Fig. 5-31 Removing forward clutch assembly

(4) Refer to paragraph 6-18 for rebuild of the forward clutch and turbine shaft a assembly.

(5) Place the hooked legs of lifting tool 18 (fig. 4-2) under the edges of the fourth clutch spring retainer (fig. 5-32).

NOTE

Keep both front and rear bearing races with the clutch assembly during rebuild.

(6) Refer to paragraph 6-18 for rebuild of the fourth-clutch assembly.

b. <u>Third</u> <u>Clutch</u>

(1) Remove the snapring (fig. 5-32) that retains the third-clutch back plate. Re move the back plate. *Fig. 5-33 Center support anchor bolt*

(2) Remove eight third-clutch plates.

NOTE

Tie the third-clutch plates together, and identify the pack. Identification is required at assembly.

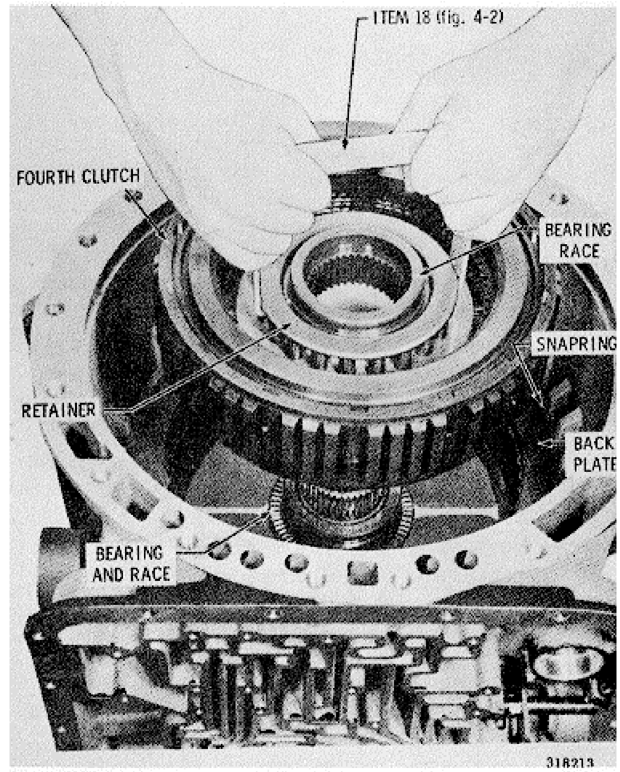


Fig. 5-32 Removing fourth-clutch assembly

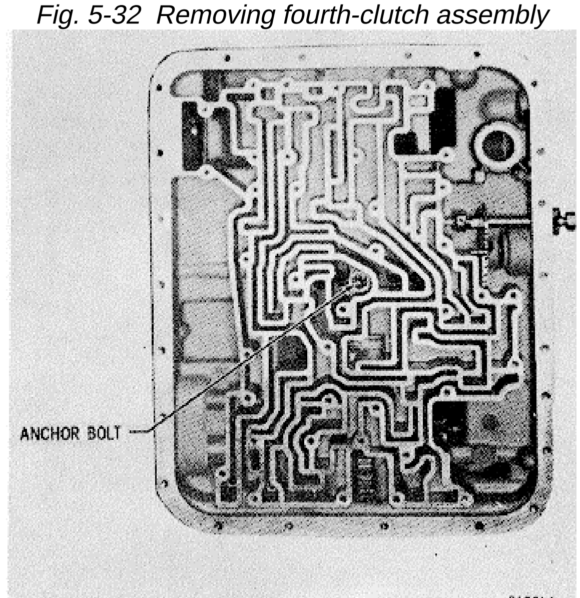


Fig. 5-33 Center support anchor bolt

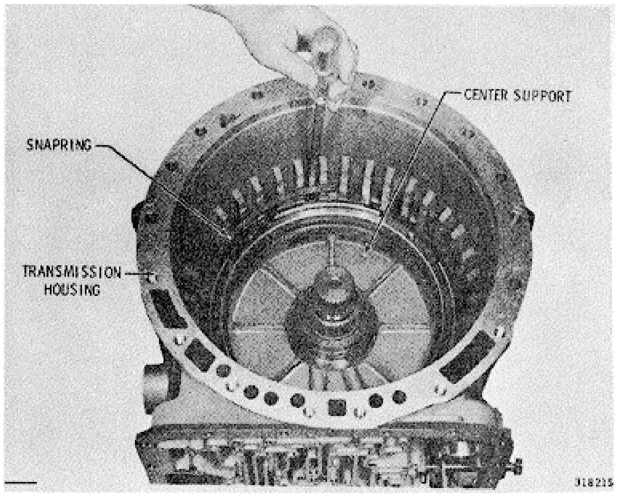


Fig. 5-37 Removing second-clutch snapring

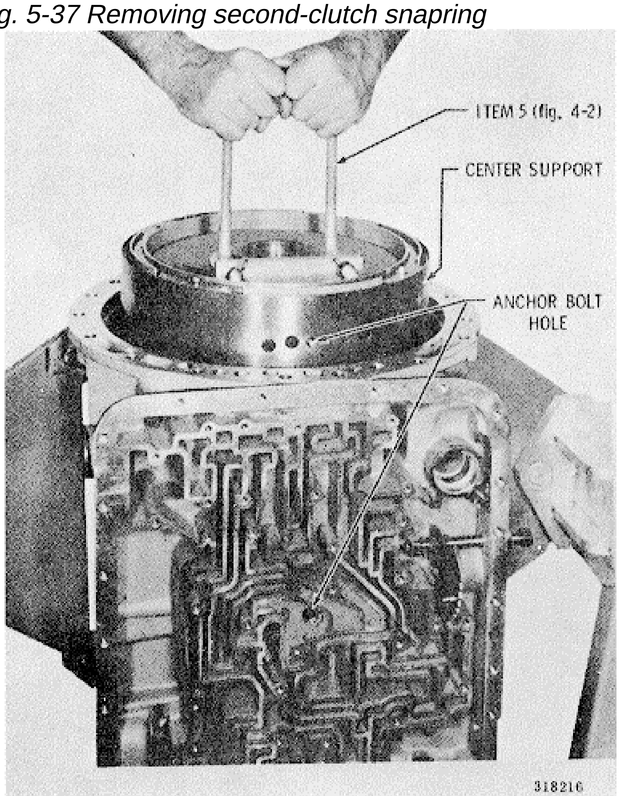


Fig. 5-3-4 Removing center support snapring

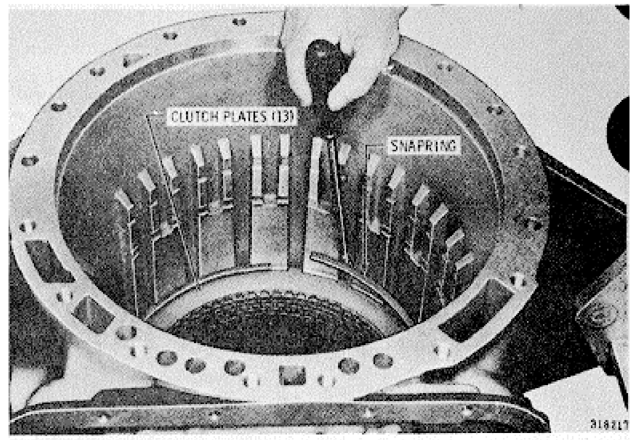


Fig. 5-37 Removing second-clutch snapring

5-12. REMOVING REAR COMPONENTS

a. <u>Rear Cover</u>

(1) Invert the transmission housing, rear cover upward. Remove the twenty-four bolts and washers that retain the rear cover and the adapter housing to the transmission

(2) Attach a hoist to the lifting bracket (fastened to output shaft) and carefully separate the rear cover from the adapter housing (fig. 5-41). Remove the rear cover gasket.

(3) Refer to paragraph 6-22 for rebuild of the rear cover assembly.

b. <u>Low Planetary and Clutch</u>

(1) Remove the low planetary carrier assembly (fig. 5-42).

NOTE

Because the bearing fit on the carrier hub may not be tight, do not attempt to carry the planetary carrier by the bearing.

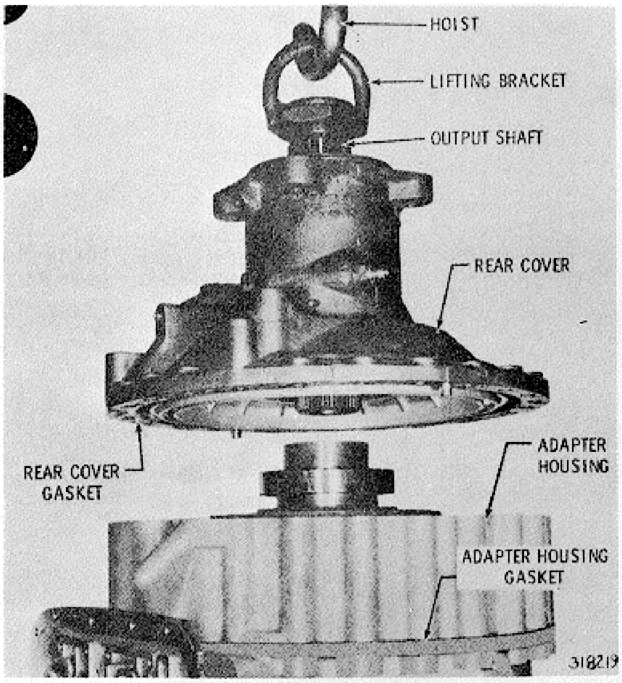


Fig. 5-41 Removing rear cover

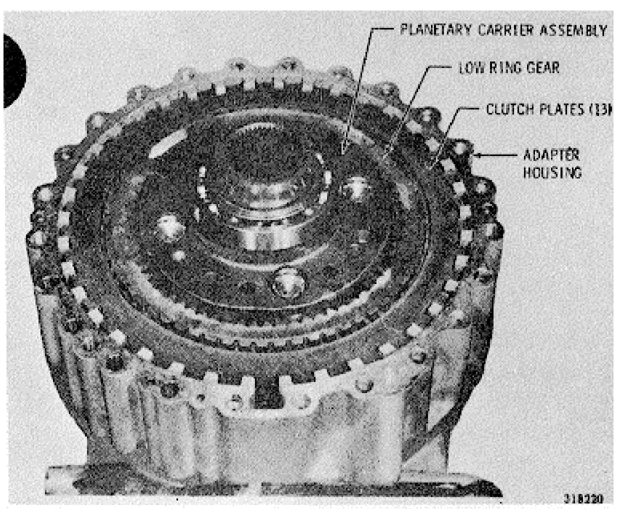


Fig. 5-42. Low planetary carrier, ring gear and clutch

(2) Refer to paragraph 6-24 for rebuild of low planetary carrier assembly.

(3) Remove the low ring gear with two clutch plates (fig. 5-42).

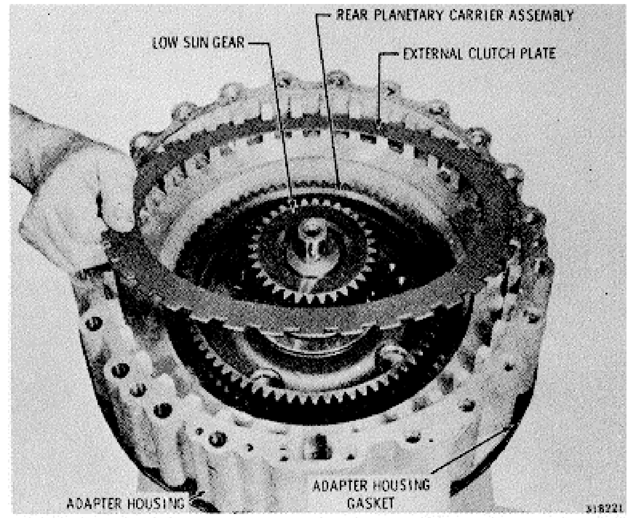


Fig. 5-43. Removing low clutch plates.

(4) Remove the remaining eleven clutch plates (fig. 5-43).

NOTE

Tie the low-clutch plates together, and identify the pack. Identification is required at assembly.

(5) Remove the adapter housing and the adapter housing gasket (fig. 5-43).

(6) Refer to paragraph 6-25 for rebuild of the adapter housing assembly.

c. First Clutch and Ring Gear

(1) Remove one internal-splined and one external-tanged clutch plate (fig. 5-44).

(2) Remove the ring gear (fig. 5-44).

(3) Remove the remaining eleven clutch plates (fig. 5-44).

NOTE

Tie the first-clutch plates together, and identify the pack. Identification is required at assembly.

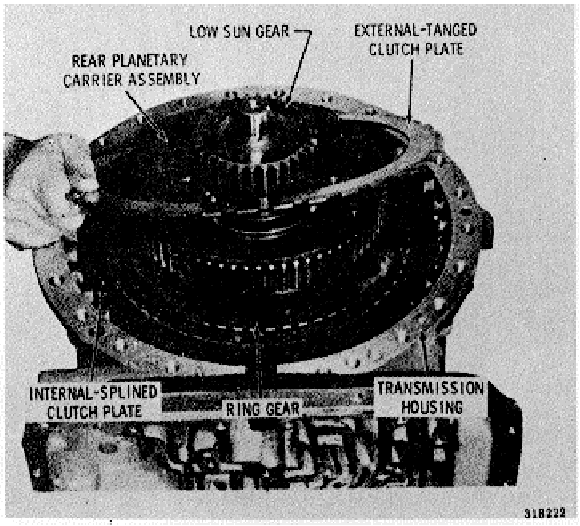


Fig. 5.44. Removing first clutch plates .

5-13. REMOVING CENTER SUPPORT, GEAR UNIT, SECOND CLUTCH.

a. Supporting Gear Unit

(1) With the output end of the transmission upward, install the adapter housing (less piston) and gasket.

(2) Place center support compressor bar 8 (fig. 4-2) across the rear of the adapter housing so that the center hole in the bar will engage the mainshaft (fig. 5-45).

(3) Install two bolts to retain the tool and the adapter housing to the transmission housing.

b. Removing Components

(1) Invert the transmission housing, converter end upward. Remove the center support anchor bolt and washer (figure 5-33).

(2) Remove the snapring that retains the center support assembly (fig. 5-34). This is a selective thickness snapring.

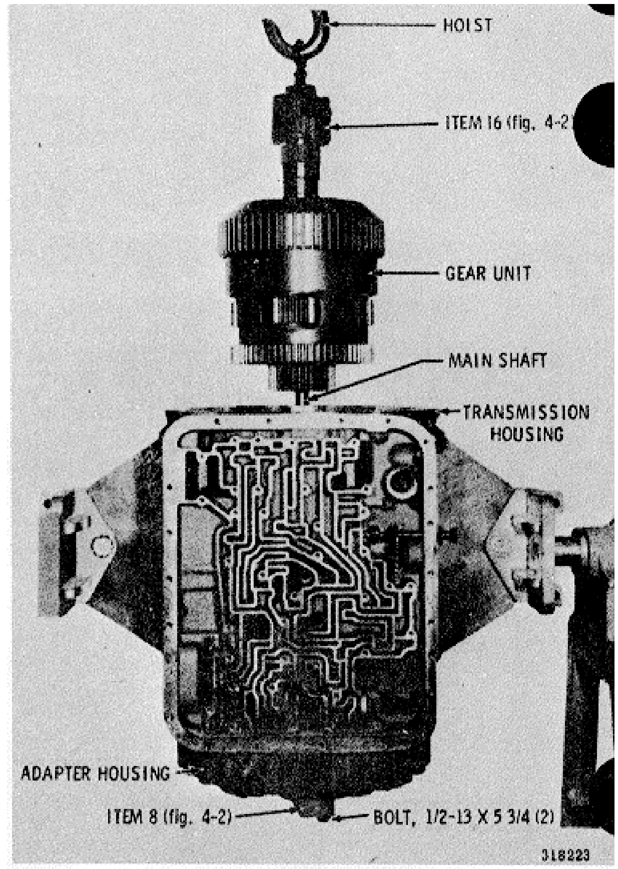


Fig. 5-45. Removing gear unit assembly

(3) Install center support lifting bracket 5 (fig. 4-2) into the recess between the step-joint sealrings on the center support hub (fig. 5-35).

(4) Lift carefully, straight upward, on the lifting bracket to remove the center support assembly.

CAUTION

The center support is fitted to the transmission case with very little clearance. It may bind in the case if the case is cold. Heat the case slightly, if necessary. Do not use a torch to heat the case. A heat lamp, or a current of warm air, is sufficient. If the support assembly starts upward and then binds, tap it downward and lift again.

(5) Refer to paragraph 6-19 for rebuild of the center support assembly.

(6) Attach lifting bracket 16 (fig. 4-2) to the main shaft of the gear unit assembly (fig. 5-45).

(7) Attach a hoist to the lifting bracket eyebolt and remove the gear unit and shaft assembly from the transmission housing (fig. 5-45).

(8) Refer to paragraph 6-26 for rebuild of the gear unit and shaft assembly.

(9) Remove the snapring that retains the second-clutch plates (fig. 5-37). Remove the 13 second-clutch plates.

NOTE

Tie the second-clutch plates together, and identify the pack. Identification is required at assembly.

(10) Remove the two bolts retaining the tool 8 (fig. 4-2), adapter housing and gasket to the transmission housing (fig. 5-45). Remove the tool, housing and gasket.

(11) Refer to paragraph 6-23 for rebuild of the transmission housing.

Section 6. INSPECTION AND REBUILD OF SUBASSEMBLIES

6-1. SCOPE OF SECTION 6

This section describes the disassembly and assembly of subassemblies that were removed in Section 5. For rebuild procedures, refer to the exploded views (foldouts 7 through 17) located at the end of this manual. Reference is also made to line drawings and photographs in this section.

6-2. GENERAL INFORMATION FOR SUBASSEMBLY REBUILD

a. Tools, Parts, Methods. Refer to paragraphs 4-2, 4-3 and 4-4.

b. Cleaning, Inspection. Refer to paragraph 4-5 for cleaning and inspection procedures.

c. Torque Specifications. The specific torque value for each threaded fastener is stated at each assembly step. Torque values are also presented in paragraph 4-9.

d. Wear Limits, Spring Data. Refer to Section 8 for wear limits and spring data.

e. Plugs and Fittings. Prior to installation, apply a small amount of nonhardening sealant (or Teflon tape) into the threads of each plug. Tighten the plugs sufficiently to prevent leakage.

f. Clutch Pack Procedure. Soak the friction-faced clutch plates in transmission fluid for a minimum of 2 minutes prior to assembly.

6-3. FLYWHEEL, LOCKUP CLUTCH, CONVERTER TURBINE

a. Disassembly (foldout 7)

(1) Position the flywheel assembly, front downward, on the work table (fig. 6-1).

(2) Using two large screwdrivers or (prybars) cushioned to prevent scratching(components)pry the torque converter turbine free of the flywheel and lockup clutch (fig. 6-1).

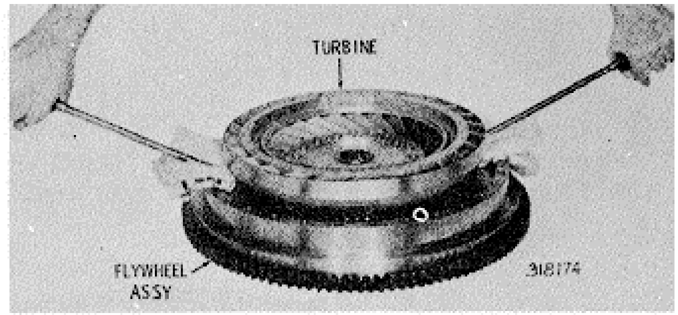


Fig. 6-1. Removing converter turbine 6 from flywheel.

(3) Remove ball bearing 6 (B, foldout 7) from torque converter turbine 7, if parts replacement is necessary.

(4) Re move the lockup clutch back plate from the flywheel (fig. 6-2). Remove the key from the recess in the flywheel bore.

(5) Remove the lockup clutch plate (fig. 6-2).

(6) Remove the lockup clutch piston (fig. 6-3). Remove the sealring from the piston outer groove.

(7) Remove the sealring from the inner hub of the flywheel (fig. 6-3).

(8) If replacement is necessary, remove the starter ring gear from the flywheel after noting whether the gear chamfers are toward the front or rear of the flywheel.

(9) If the sealring surface of the flywheel bore is worn beyond 1. 007 inches diameter, rework the bore and install a sleeve (P/N 6881519) as shown in figure 6-4.

(10) Cool the sleeve in dry ice for at least thirty minutes before installing. Proper alinement during installation is necessary to prevent damaging the bore and sleeve.

(11) Press the sleeve flush with surface X (fig. 6-4). Be sure the internal chamfer is toward the rear side of the flywheel.

NOTE

Refer to paragraph 6-2, above.

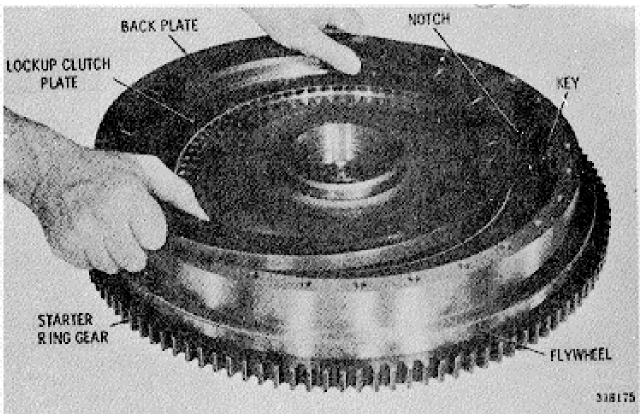


Fig. 6.2. Removing (or installing) lockup clutch back plate .

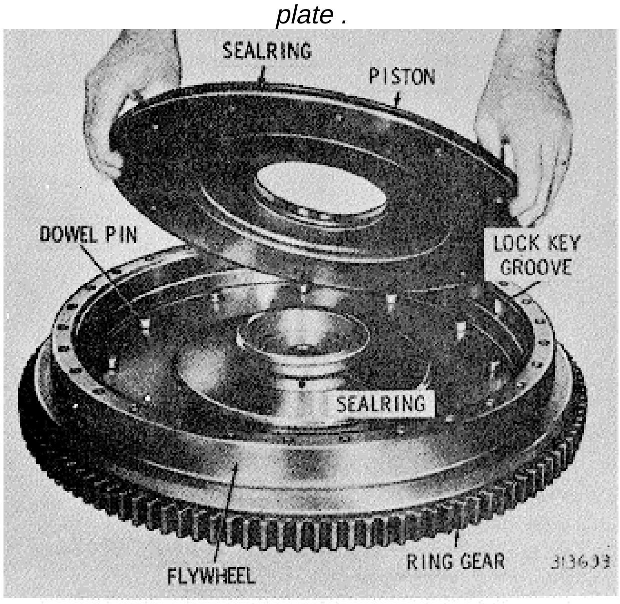


Fig. 6.3. Installing lockup clutch piston.

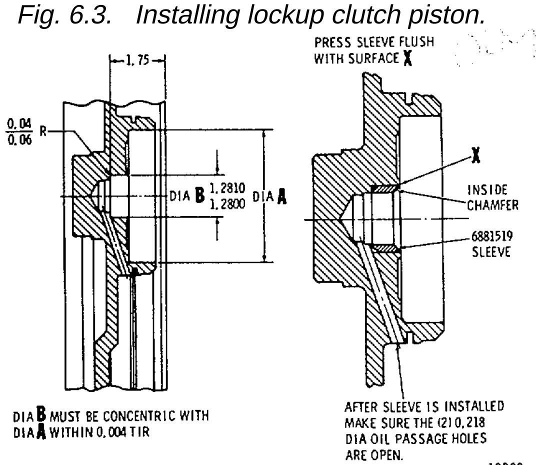


Fig. 6-4. Rework of flywheel-cross section view.

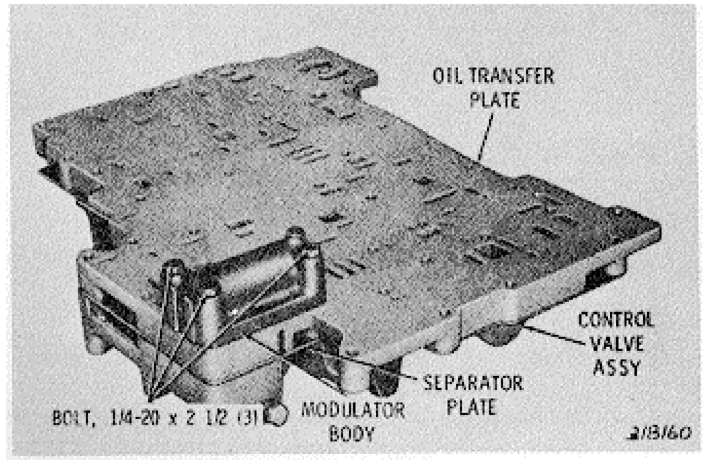


Fig. 6-5. Components of control valve assembly

b. <u>Assembly</u>

(1) If the starter ring gear was removed, install a new gear, as follows.

(2) Install the starter ring gear after heating it uniformly to 4000F (2040C) maximum temperature. Be sure the chamfers of the teeth are facing the proper direction for starter pinion engagement. The ring gear must seat firmly against the shoulder on the flywheel.

(3) Lay the flywheel on the assembly table, with the cavity side upward, and install the sealring onto the hub (fig. 6-3).

(4) Install a sealring on the outside diameter of the lockup clutch piston and lubricate both sealrings.

(5) Place a pencil mark on the edge of the lockup clutch piston opposite a dowel pin hole. Also place a pencil mark in the flywheel bore, opposite a dowel pin.

(6) Install the lockup clutch piston into the flywheel, alining the pencil marks, to engage the recesses in the piston with the dowel pins (fig. 6-3). Be certain the dowel pins are engaged.

(7) Install the lock key in the lock key groove of the flywheel (fig. 6-2). Use oil soluble grease to retain it.

(8) Install the lockup clutch plate (fig. 6-2)

(9) Install the lockup clutch back plate, flat side first, engaging the notch in the plate with the key in the flywheel (fig. 6-2).

CONTROL VALVE ASSEMBLY P/N	BALL LOCATION *						
	1	2	3	4	5	6	7
6839713.			x	x	x		x

* Use ball P/N 6880187 (5/16 dia. - Color Code "Red") in No. 5 location (if indicated in column by "x"). All other locations (if indicated in column by "x") use ball P/N 6830319 (1/4 dia.).

Note: If control valve assembly number is not listed above, contact Detroit Diesel Allison Service Department.

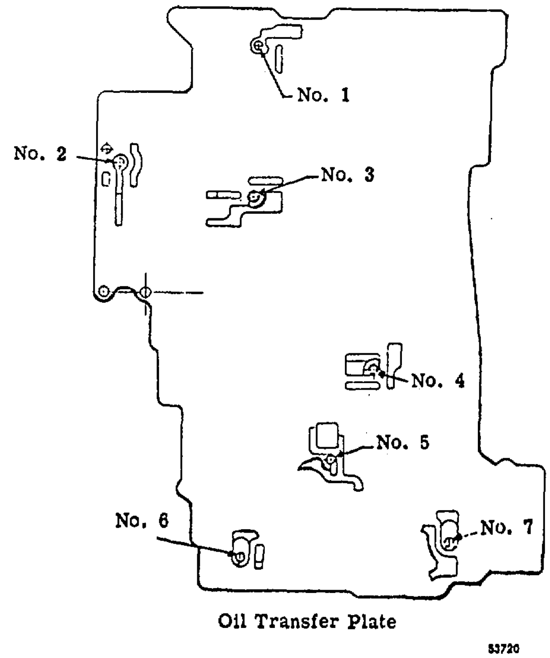


Fig. 6-6. Ball locations for contro

(10) If ball bearing 6 (B, foldout 7) was removed, press it onto the hub of turbine 7.

(11) Carefully center the lockup clutch plate in the flywheel. Install the torque converter turbine, engaging its hub splines with the internal splines of the lockup clutch plate. Seat the ball bearing in its bore.

6-4. CONTROL VALVE BODY ASSEMBLY

CAUTION

The valve body assembly contains a number of springs, some of which are similar and can be mistakenly interchanged. Also, springs vary in valve bodies used on different models. If springs are not reinstalled in the same locations from which removed, the calibration of valve body functions will be lost. For these reasons, it is recommended that each spring, at removal, be tagged with its item number in B, foldout 16. This will simplify correct reassembly of the valve body components.

a. Disassembly (B, foldout 16)

(1) If not removed previously, remove manual selector valve 72. Stop bolt 62 must be removed before valve 72 can be removed.

(2) Position the valve assembly, modulator upward (fig. 6-5). Remove three bolts that retain the modulator valve body, while holding the oil transfer plate and separator plate together.

(3) Lift off the modulator valve body and set it aside, while retaining a grasp on the oil transfer and separator plates.

(4) Invert the oil transfer and separator plates while holding them firmly together. Lay them on the work table.

(5) Lift the separator plate off the oil transfer plate. Compare check ball locations in the transfer plate to those in the chart (shown in fig. 6-6), Make a sketch or list that will identify the ball sizes and locations (for reassembly). Remove the balls.

(6) Remove the lubrication pressure regulator valve from the oil transfer plate as

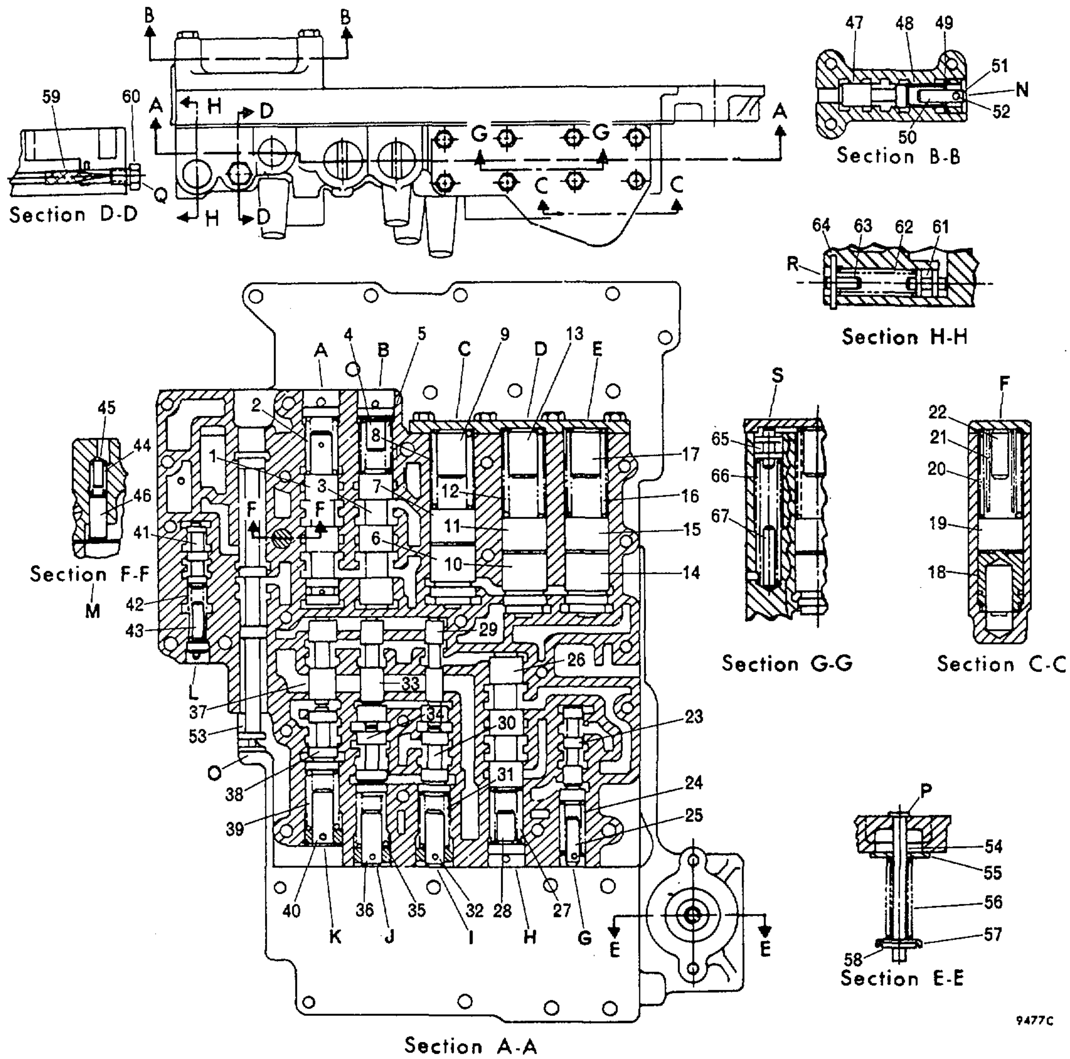


Fig. 6-7. Control valve assembly - with components installed.

follows. Compress cup washer 4 (B, foldout 16) and remove pin 5. Release washer 4 and remove it. Remove spring 3 and valve 2. Remove lubrication valve pin 6 from the oil transfer plate.

NOTE

Before the modulator valve is disassembled (in (7), below), the grooves in adjusting ring 22 in which retainer pin 16 seats must be marked to insure correct reassembly. Adjusting ring 22 also must be identified for installation into the same bore from which removed.

(7) Disassemble the modulator valve body, removed in (3), above. Press adjusting ring 22 inward and remove retainer pin 16. Release the adjusting ring and remove it. Remove valve stop 21, washer 20, spring 19, and valve 18.

(8) Remove priority valve 46 (fig. 6-7) spring 44, and valve stop 45 from the control valve assembly.

(9) Position valve body 24 (B, foldout 16), flat side downward, on the work table. Remove plug 58 and screen assembly 59.

LEGEND FOR FIGURE 6-7.

A.
2-3 RELAY VALVE BORE
1 -- Relay valve
*2 -- Spring

B.
3-4 RELAY VALVE BORE
3 -- Relay valve
4 -- Valve stop
*5 -- Spring

C. FOURTH-CLUTCH TRIMMER VALVE BORE
6 -- Fourth-clutch trimmer valve
7 -- Trimmer plug
*8 -- Spring
9 -- Valve stop

D. SECOND-CLUTCH TRIMMER VALVE BORE
10 -- Second-clutch trimmer valve
11 -- Trimmer plug
*12 -- Spring
13 -- Valve stop

E. THIRD-CLUTCH TRIMMER VALVE BORE
14 -- Third-clutch trimmer valve
15 -- Trimmer plug
*16 -- Spring
17 -- Valve stop

F. FIRST-CLUTCH TRIMMER VALVE BORE
18 -- First-clutch trimmer valve
19 -- Trimmer plug
*20 -- Spring -- outer
*21 -- Spring -- inner
22 -- Valve stop

G. TRIMMER REGULATOR VALVE BORE
23 -- Trimmer regulator valve
*24 -- Spring
25 -- Valve stop

H.
4-5 RELAY VALVE BORE
26 -- Relay valve
*27 -- Spring
28 -- Valve stop

I.
4-5 SHIFT VALVE BORE
29 -- Shift signal valve
30 -- Shift modulator valve
*31 -- Spring
32 -- Valve stop

J.
3-4 SHIFT VALVE BORE
33 -- Shift signal valve
34 -- Signal modulator valve
*35 -- Spring
36 -- Valve stop

K.
2-3 SHIFT VALVE BORE
37 -- Shift signal valve
38 -- Signal modulator valve
*39- Spring
40- Valve stop

L. HOLD REGULATOR VALVE BORE
41 -- Hold regulator valve
*42 -- Spring
43 -- Valve stop

M. PRIORITY VALVE BORE
*44 -- Spring
45 -- Valve stop
46 -- Priority valve

N. MODULATOR VALVE BORE
47 -- Modulator valve
*48- Spring
49 -- Spring washer
50 -- Adjusting ring
51 -- Valve stop
52 -- Retainer pin

0. MANUAL SELECTOR VALVE BORE
53 -- Manual selector valve

P. LUBRICATION PRESSURE REGULATOR VALVE BORE
54 -- Valve guide pin
55 -- Lubrication valve
*56 -- Spring
57 -- Washer
58 -- Retainer pin

Q. GOVERNOR SCREEN
59 -- Screen
60 -- Pipe plug

R. GOVERNOR ACCUMULATOR
61 -- Accumulator valve
*62 -- Accumulator spring
63 -- Accumulator stop
64 -- Accumulator pin

S. TRIMMER BOOST ACCUMULATOR
*65 -- Trim boost accum. spring
66 -- Trim boost accum. stop
67 -- Trim boost accum. valve

* Before installing, refer to spring chart (Section 8) for positive identification.

(10) Remove eight bolts 44while holding trimmer cover 43 against spring pressure. Relieve pressure and remove cover 41.

(11) Remove springs 27 and 28, valve stop 29, trimmer plug 26, and trimmer valve 25.

(12) Remove springs 32 and 33, stop 34, plug 31, and valve 30.

(13) Remove springs 37 and 38, stop 39, plug 36, and valve 35.

(14) Remove valve 42, spring 41 and stop 40.

(15) Remove springs 47 and 48, stop 49, plug 46 and valve 45.

NOTE

In operations (16) through (24), below, the components i n each bore are spring-loaded, and must be restrained while removing the retainer pins. Also, before removing retainer pins in operations (20), (21) and (22), the adjusting rings must be marked, and each identified with its bore, so they can be reassembled into the same bores and at the same positions in the bores.

(16) Remove retainer pin 50, valve stop 54, spring 53, and valve 52.

NOTE

In earlier models, valve stop 54 consisted of two separate pieces.

(17) Remove retainer pin 51, spring spacer 57, spring 56, and valve 55.

(18) Remove retainer pin 63, spring 61, stop 62 and valve 60.

(19) Remove retainer pin 72, valve plug 71, spring 69, valve stop 70, and valve 68.

(20) Remove retainer pin 75, adjusting ring 80, spring 78, valve stop 79, and valves 77 and 76.

(21) Remove retainer pin 86, adjusting ring 85, spring 83, valve stop 84, and valves 82 and 81.

(22) Remove retainer pin 92, adjusting ring 91, spring 89, valve stop 90, and valves 88 and 87.

(23) Remove retainer pin 96, valve stop 95, spring 94, and valve 93.

NOTE

In earlier models, valve stop 95 consisted of two separate pieces.

(24) Remove retainer pin 100, spring 98, valve stop 99, and valve 97.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (B, foldout 16)

NOTE

Check the position of all valve assembly components, the configuration of all valves and plugs, and the identification of all springs before installation. Refer to figure 6-7 for position and configuration of components. Refer to the spring chart in Section 8 for identification of springs.

(1) Install components into bores A and B (fig. 6-7), in the sequence indicated by numbers 1 through 5.

NOTE

All valves must move by their own weight (dry) when installed.

(2) Install spring spacer 57 and valve stop 54 (B, foldout 16) into bores A and B (fig. 6-7). Depress the springs and install retainer pins 51 and 50 (B, foldout 16) to retain spacer 57 and valve stop 54.

NOTE

In earlier models, valve stop 54 consisted of two separate pieces.

(3) Install components into bores C, D and E (fig. 6-7), in the sequence indicated by numbers 6 through 17.

(4) Install components into bore F, in the sequence indicated by numbers 18 through 22.

(5) Install components into bore S (fig. 6-7), in sequence indicated by numbers 65, 66 and 67.

(6) Install trimmer cover 43 (B, foldout 16). Compress the springs, and retain the cover with eight 1/4-20 x 5/8-inch bolts.

44. Tighten the bolts to 9 to 11 pound feet (12 to 15 Nm) torque.

(7) Install the components into bore G (fig. 6-7), in the sequence indicated by numbers 23, 24 and 25. Install pin 100 (B, foldout 16) to retain stop 25 (fig. 6-7).

(8) Install the components into bore H (fig. 6-7), in the sequence indicated by numbers 26, 27 and 28.

(9) Install valve stop 95 (B, foldout 16). Compress the spring, and install retainer pin 96 into valve body 24 to retain valve stop 95.

NOTE

In earlier models valve stop 95 consisted of two separate pieces.

(10) Install the components into bore I (fig. 6-7), in the sequence indicated by numbers 29 through 32. Aline the pin hole in valve stop 32 with the pin holes in the valve body.

(11) Install adjusting ring 91 (B, foldout 16), flat side first and at same position as before removal. Compress the spring, and install retainer pin 92 into the valve body to retain adjusting ring 91 and valve stop 99. Be sure that pin 92 seats in the same grooves in ring 91 it was seated in prior to removal.

(12) Install the components into bore J (fig. 6-7), in the sequence indicated by numbers 33 through 36.

(13) Install adjusting ring 85 (B, foldout 16), flat side first and at the same position as before removal. Compress the spring, and install retainer pin 86 into the valve body to retain adjusting ring 85 and valve stop 84. Be sure that the retainer pin is seated in the same grooves in the adjusting ring as before removal.

(14) Install the components into bore K (fig. 6-7), in the sequence indicated by numbers 37 through 40.

(15) Install adjusting ring 80 (B, foldout 16), flat side first and at the same position as before removal. Compress the spring, and install retainer pin 75 into the valve body to retain adjusting ring 80 and valve stop 79. Be sure that the retainer pin is seated in the same grooves in the adjusting ring as before removal.

(16) Install the components into bore L (fig. 6-7), in the sequence indicated by numbers 41, 42 and 43.

(17) Install valve plug 71 (B, foldout 16). Compress the spring, and install retainer pin 72 into the valve body to retain valve plug 71.

(18) Install components into bore M (fig. 6-6), in the sequence indicated by numbers 44, 45 and 46.

(19) Install components into bore N (fig. 6-7) of the modulator valve body, in the sequence indicated by numbers 47 through 52. Adjusting ring 50 must be installed flat side first and at the same position as before removal. Retainer pin 52 must pass through the hole in valve stop 51, and seat in the same grooves in adjusting ring 50 as before removal.

(20) Install the components into bore R (fig. 6-7) in proper sequence. Install valve 61, spring 62, stop 63 and retainer pin 64. Aline stop 63 and the valve body for correct retainer pin installation.

(21) Install governor screen assembly 59 (fig. 6-7), open end first, into bore Q. Retain the screen assembly with plug 60, tightened to 50 to 60 inch pounds (5. 6 to 6.8 Nm) torque.

(22) Install components into bore P (fig. 6-7) of the oil transfer plate, in the sequence indicated by numbers 54 through 58.

(23) Position the oil transfer plate, channeled side upward, on the work table.

(24) Using the chart in figure 6-6 as a guide, install the correct number of check valve balls in their proper positions. Retain each ball with a small quantity of oil soluble grease.

NOTE

Failure to retain the balls with oil soluble grease may result in balls being accidentally misplaced during subsequent assembly steps.

(25) Lay separator plate 23 (B, foldout 16)onto the oil transfer plate so that their bolt holes aline. Grasp the two plates together, invert them, and position them on the assembled control valve body so that priority valve 67 is compressed against spring 66 and into valve body 24.

NOTE

Use extreme care that the separator plate and oil transfer plate do not separate. A slight separation could dislocate the check valve balls and cause malfunction of the transmission.

(26) Install the assembled modulator valve onto the oil transfer plate as shown in figure 6-5. Install three 1/4-20 x 2 1/2-inch bolts to retain the modulator body, oil transfer plate, separator plate and control valve assembly as a unit. Do not tighten the bolts at this time.

(27) Aline the bolt holes in the control valve assembly with those in the separator plate and oil transfer plate. When all bolt holes are alined, tighten the bolts installed in (26), above, to 9 to 11 pound feet (12 to 15 Nm) torque.

(28) Install manual selector valve 53 (fig. 6-7) into bore O of the control valve body.

(29) Valve 53 must be positioned so that its flat side is upward (when assembly is positioned as in fig. 6-8).

(30) Install stop bolt 64 (B, foldout 16) into control valve assembly. The flat end of the bolt must aline with the flat side of the selector valve (fig. 6-8). Tighten the stop bolt to 36 to 43 pound feet (49 to 58 Nm) torque.

NOTE

Refer to paragraph 3-11 for adjustment of shift speed points.

(31) To prevent dust or dirt from contaminating the valve assembly, place it in a plastic bag until ready for installation onto the transmission.

6-5. LOW TRIMMER VALVE BODY ASSEMBLY

a. Disassembly (A, foldout 17)

(1) Press inward on retainer plug 26, and remove retainer pin 20.

(2) Release pressure, and remove plug 26, springs 23and 24, valve stop 25, plug 22 and valve 21.

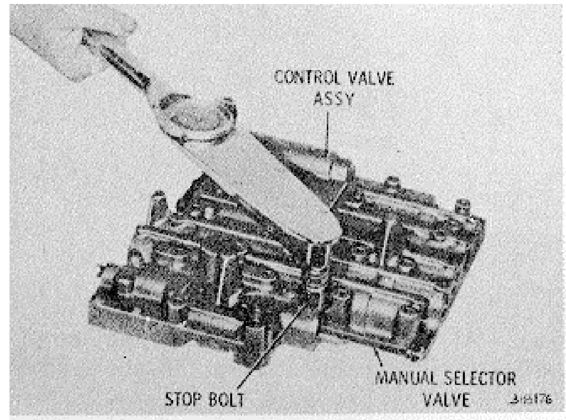


Fig. 6-8 Tightening selector valve stop bolt .

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 17)

(1) Install low clutch trimmer valve 21, recessed end first, into valve body 19.

NOTE

Valves, when installed dry, should move by their own weight.

(2) Install trimmer plug 22.

(3) Install springs 23 and 24, valve stop 25, and retainer plug 26.

(4) Compress springs 23 and 24, and install retainer pin 20 to secure plug 26.

6-6. LOW SHIFT VALVE BODY ASSEMBLY

a. Disassembly (A, foldout 17)

(1) While holding inward against valve stop 9, remove retainer pin 5.

NOTE

In earlier models, valve stop 9 consisted of two separate pieces.

(2) Release spring pressure, and remove valve stop 9, spring 8, and relay valve 7.

NOTE

Mark adjusting ring 15 and valve body 3 so that ring 15 can be reinstalled at the same position as before removal.

(3) While holding inward against adjusting ring 15, remove retainer pin 6. Relieve the spring pressure.

(4) Remove adjusting ring 15, washer 14, valve stop 13, spring 12, and valve ll.

(5) Remove retainer pin 4 and plug valve 16.

NOTE
Refer to paragraph 6-2, above.

b. Assembly (A, foldout 17)

(1) Install, plug valve 16, and retainer pin 4.

NOTE

Valves, when installed dry, should move by their own weight.

(2) Install valve 11 into valve body 3.

(3) Install spring 12, valve stop 13, washer 14, and adjusting ring 15. Aline the hole in valve stop 13 with the pin hole in valve body 3. Position adjusting ring 15 as before removal.

(4) Press inward against adjusting ring 15 until retainer pin 6 can be installed.

(5) Install relay valve 7, spring 8, valve stop 9.

NOTE

In earlier models, valve stop 9 consisted of two separate pieces.

(6) Press inward against valve stop 9, and install retainer pin 5.

6-8. TORQUE CONVERTER STATOR ASSEMBLY

a. Disassembly (B, foldout 7)

(1) Rotate stator freewheel roller race 14 in a clockwise direction so the race may be removed.

(2) Remove race 14, thrust bearing 13, thrust bearing race 12, ten stator rollers 11 and ten freewheel roller springs 10 from stator 9.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (B, foldout 7)

(1) Place stator 9 on the work table, rear upward, and install thrust bearing race 12 into the stator.

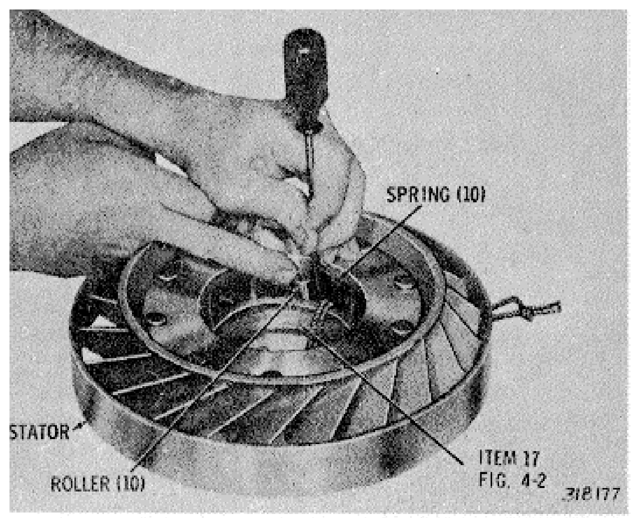


Fig. 6-9. Installing stator freewheel roller

(2) Coat the pockets of stator 9, stator springs 10 and rollers 11 with oil-soluble grease.

(3) Install stator roller holder 17 (fig. 4-2) into the stator against the thrust bearing race installed in (1), above (fig. 6-9).

(4) Install ten freewheel roller springs into the stator cam pockets. The springs must be positioned as shown in figure 6-10 (5) Install ten freewheel rollers (fig. 6-9).

(6) Install the thrust bearing onto the freewheel roller race (fig. 6-11).

(7) Start the freewheel roller race the roller holder (fig. 6-11). Rotate the race clockwise to install it.

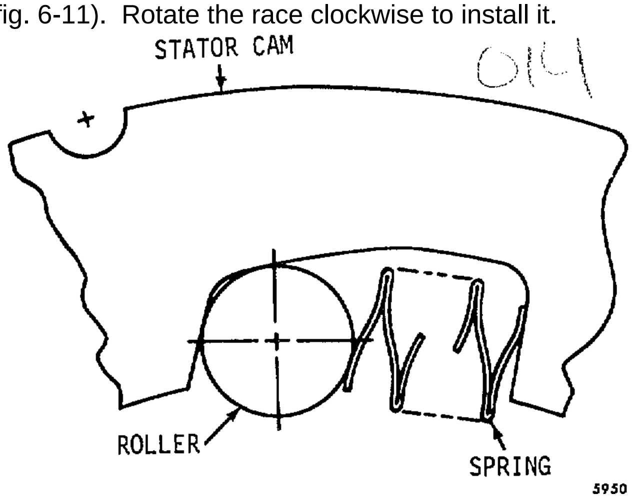


Fig. 6-10. Spring and roller in stator cam.

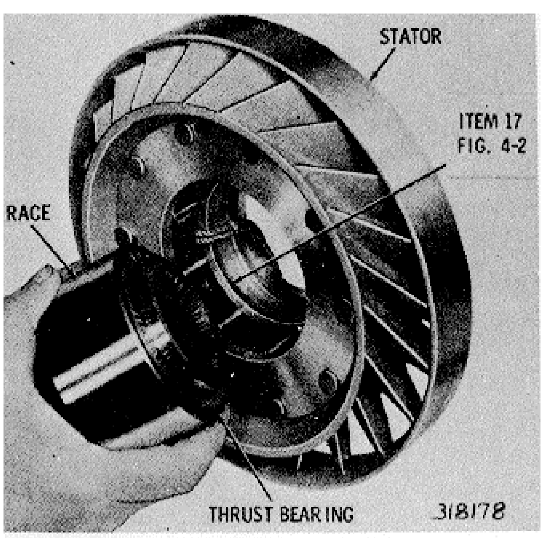


Fig. 6-11. Installing freewheel roller race.

(8) Remove the roller holder by pulling on the thong attached to it. Push the roller race inward (rotating clockwise) until the thrust bearing seats.

(9) Rotate the freewheel roller race counterclockwise to lock it in place. Place the stator assembly, roller race upward until ready for installation. Cover or wrap the assembly to keep out dust and dirt.

6-9. TORQUE CONVERTER PUMP ASSEMBLY

a. Disassembly (B, foldout 7)

(1) Flatten the corners of the lockstrips, and remove twelve bolts from the converter pump (fig. 6-12).

(2) Remove the bearing retainers. Remove pump hub 27 (B, foldout 7), pump hub gasket 26, and sealring 28 from hub 27.

(4) If necessary for parts replacement, remove bearing 25 or 31. Remove sealring 20 from the converter pump.

(5) Replacement of any converter balance weights 23, requires re-balancing of the converter pump.

NOTE

Refer to paragraph 6-2, above.

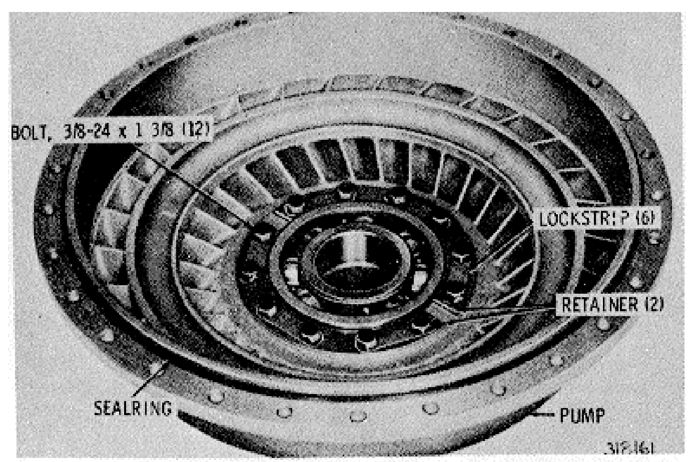


Fig. 6.12. Torque converter pump components.

b. Assembly (B, foldout 7)

(1) If bearing 25 was removed, install a new bearing, ungrooved end first, into pump hub 27. Install gasket 26.

(2) Install a 3/8-24 headless guide bolt into converter pump hub 27 or gear 32. Install sealring 20 onto the outside diameter of converter pump assembly 21.

(3) Install converter pump hub 27 onto the converter pump. Remove the guide bolt. Install two bearing retainers 19 and retain them with twelve 3/8-24 x 1 1/4-inch bolts (pump hub 27) and six new lockstrips. Tighten the bolts to 33 to 40 pound feet (45 to 54 Nm) torque. Bend one lockstrip corner against each bolt head (fig. 6-12).

6-10. CONVERTER HOUSING WITH 2-BOLT TOP COVER, FRONT SUPPORT, OIL PUMP.

a. Disassembly

(1) Place the converter housing front downward (fig. 6-13). Remove two sealrings, needle bearing and race from the front support hub.

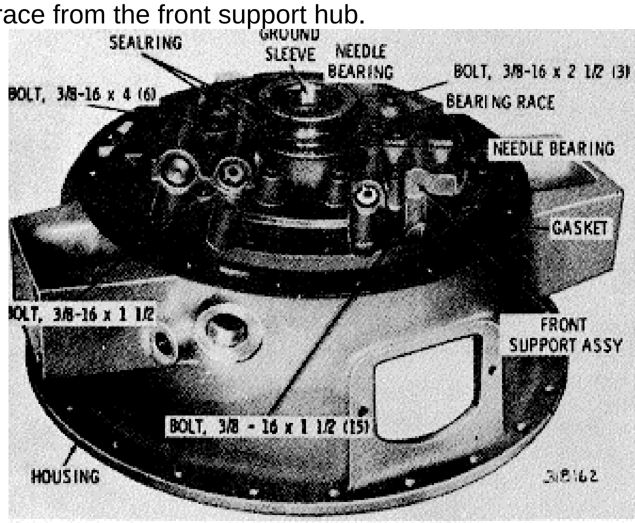


Fig. 6.13 Converter housing components (2.bolt cover, no retarder).

(2) Place a wood 2 x 4 (51 x 102 mm) through the converter housing access opening, about 14 inches (356 mm) into the housing (fig. 6-14). Remove four of the six bolts retaining the oil pump assembly. Loosen the remaining two bolts, leaving about four turns of thread engaged.

(3) Press on the wood 2 x 4 (51 x 102 mm), and tap alternately on the two loose bolts (fig. 6-14). This will dislodge the oil pump. Remove the bolts, and allow the pump to drop onto the wood support. Remove the pump assembly. Remove the sealring (if present) from the outer circumference of the pump.

(4) Remove the screw retaining the oil pump cover (fig. 6-15). Remove the cover, sealring, drive gear, and driven gear assembly.

(5) Remove the roller bearing from the driven gear, and the oil seal from the pump assembly. Remove the sealring (if present) from the outer circumference of the pump.

(6) Using the spring compressor (item 23, fig. 4-2)depress the main pressure regulator valve spring (fig. 6-16). Remove the snapring.

NOTE

The spring compressor may be used whether the front support assembly is attached to or removed from the torque converter housing.

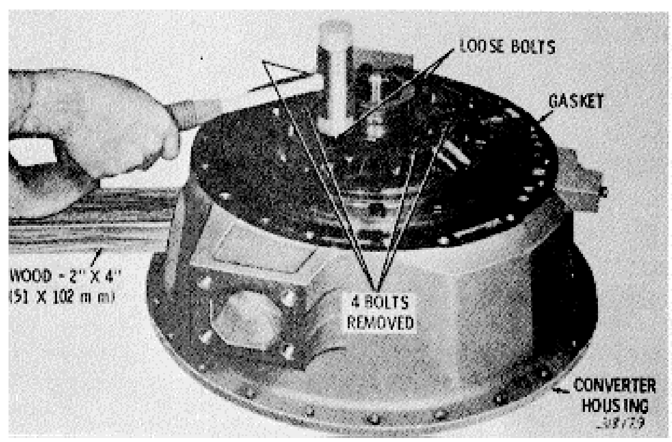


Fig. 6.14. Supporting oil pump during removal.

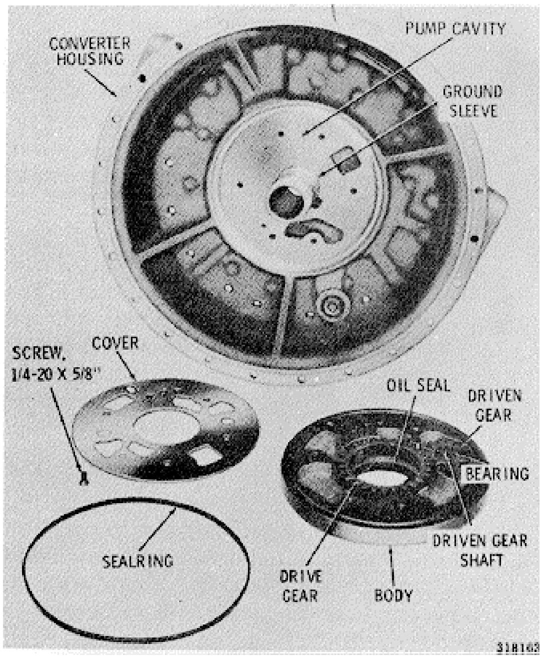


Fig. 6-15. Oil pump and torque converter housing .

(7) Remove the spring compressor, and remove washer 6 (B, foldout 10), valve stop 5, spring 4, and main pressure regulator valve 3.

(8) Using the spring compressor, remove snapring 12, washer 11, valve stop 10, spring 9, and lockup shift valve 8.

(9) The spring compressor is not required for the remaining valve components. Push inward against valve support assembly 16, and remove snapring 19. Remove support assembly 16, seat 15, converter bypass valve 14, and spring 13.

(10) Remove the 19 bolts remaining in the front support assembly (fig. 6-13). Lift off the front support assembly and gasket.

(11) If replacement is necessary, remove the needle bearing from the bore of the support hub (fig. 6-16).

(12) If parts replacement is necessary, remove test plugs 18 (A, foldout 8) from housing 16.

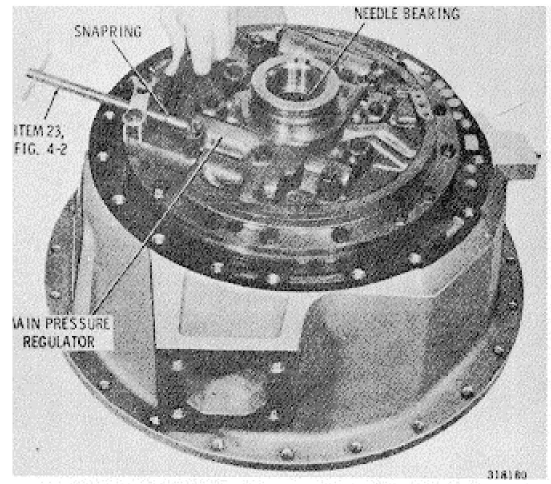


Fig. 6-16. Removing (or installing) main pressure regulator snapring.

(13) Do not remove the ground sleeve (fig. 6-15) from the front support. If there is evidence of movement, or damage, replace front support and ground sleeve assembly 2 (B, foldout 10).

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 8).

(1) If the needle bearing was removed from the front support (fig. 6-17), install a new bearing. Installer 30 (fig. 4-3) may be used with handle 46 for driving the bearing, or without the handle when press-installing the bearing.

NOTE

When no installer is available, the depth of installation must be measured. Proper depth, from rear of hub to rear of bearing is 1.26 to 1.28 inches (32-32.5 mm)

(2) Install the main-pressure regulator and lockup shift valves, as described in (3) through (6), below. Install the converter regulator valve, as described in (7) through (9), below.

(3) Install main-pressure regulator valve 3, small end first, into the bore indicated in B, foldout 10. Be sure the valve will move freely of its own weight in its bore.

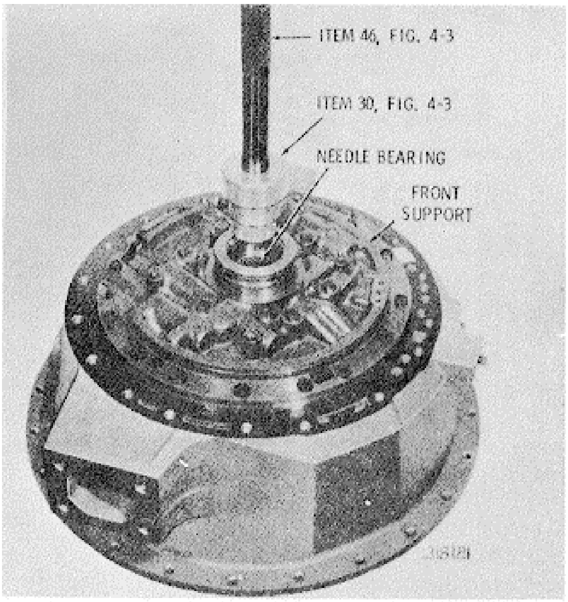


Fig. 6-17. Tool for installing front support needle bearing.

(4) Install spring 4 and valve stop 5. Place washer 6 on spring 4 and compress the spring into the valve bore until the snapring groove is clear (fig. 6-16). Install snapring 7.

(5) Install lockup shift valve 8, small end first, into the bore indicated in B, foldout 10. Be sure the valve will move freely of its own weight in its bore.

(6) Install spring 9 and valve stop 10. Place washer 11 on spring 9 and compress the spring into the valve bore until the snapring groove is clear (use spring compressor). Install snapring 12.

(7) Install spring 13 into the converter regulator valve bore indicated in B, foldout 10. Install converter bypass valve 14 and valve seat 15. Spring compressor is not required for this spring.

(8) Install support assembly 16 and snapring 19 into the valve bore.

(9) Place converter housing 16 (A, foldout 8) on the work table, front side down.

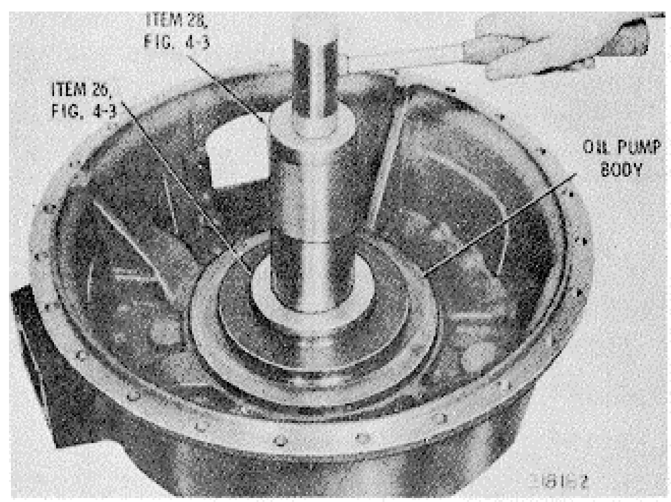
(10) Place front support gasket 17 onto the converter housing. Aline holes in the gasket with those in the converter housing.

(11) Install front support assembly I (B, foldout 10) onto converter housing 16 (B, foldout 8).

(12) Install three 3/8-16 x 2 1/2-inch bolts into the front support (fig. 6-13). Tighten the bolts to 36 to 43 pound feet (49 to 58 Nm) torque.

(13) Install one 3/8-16 x 1 1/2-inch bolt into the hole between the two valve bores that are closer to each other (fig. 6-13). Tighten it to 36 to 43 pound feet (49 to 58 Nm) torque.

(14) Install fifteen 3/8-16x 11/2-inch bolts into the outer bolt circle of the front support (fig. 6-13). Tighten the bolts to 36 to 43 pound feet (49 to 58 Nm) torque.



Para 6-10

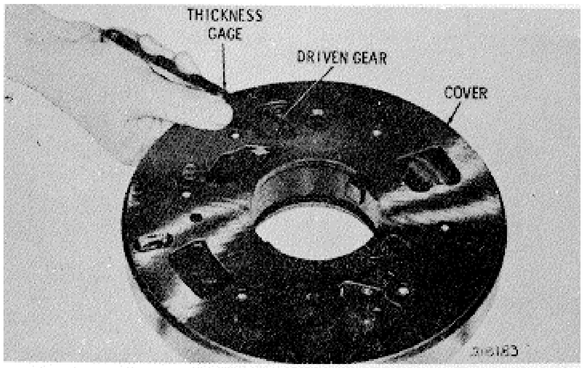


Fig. 6-19 Checking oil pump driven gear end clearance

(15) Install the bearing race, flat side first, onto the front support hub (fig. 6-13).Install the needle bearing onto the race.

NOTE

Grease both the race and bearing, before installing, with sufficient oil-soluble grease to retain them.

(16) If the oil seal was removed from the oil pump body, install a new seal (fig. 6-18). Use seal installer 27 and driver handle 28 (fig. 4-3) for driving or pressing the seal. The lip of the seal must face inward (toward rear of transmission). If no installer is available, press the seal lightly until it is flush with the front of the housing.

NOTE

The installer 27, (fig. 4-3) can be used with the transmission assembled except for the flywheel and torque converter.

(17) If the needle bearing (fig. 6-15) was removed from the oil pump driven gear, install a new bearing. Center it in the gear.

(18) Install the driven gear and the drive gear into the oil pump body (fig. 6-15).

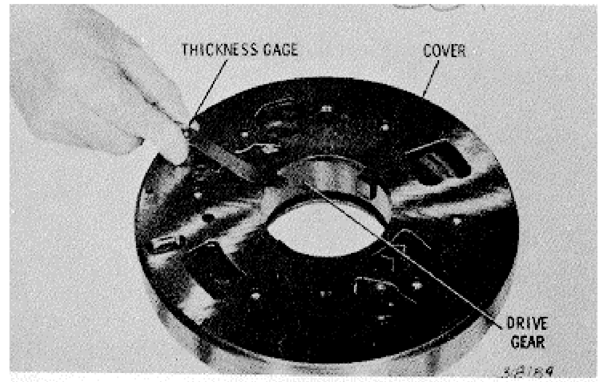


Fig. 6-20 Checking oil pump drive gear end clearance

(19) Install the cover, and retain it with the 1/4-20 x 5/8-inch flat-head screw (fig. 6-15).

(20) Check the oil pump driven gear end clearance as shown in figure 6-19. Check the oil pump drive gear clearance as shown in figure 6-20. The gear end clearance should not exceed 0. 006 inch (0.15 mm).

(21) Install the sealring around the cover outer circumference (fig. 6-21). Install two 3/8-16 guide screws into the pump at the locations shown.

(22) Lubricate the seal ring (if used) and oil pump cavity in the housing (fig. 6-21).

Install the pump assembly, guiding the screws through the holes indicated.

(23) While holding the pump assembly in place, install six 3/8-16 x 4-inch bolts to retain it (remove guide screws to install last two bolts). Tighten the bolts to 36 to 43 pound feet (49 to 58 Nm) torque.

(24) Lubricate the two step-joint seal rings with oil-soluble g r e a s e, and install them into the grooves in the front support hub (fig. 6-13).

(25) If removed, install plugs 18 (A, foldout 8). Use nonhardening sealer on the plug threads, and tighten them to 50 to 60 inch-pounds (5. 64 to 6.78 Nm) torque.

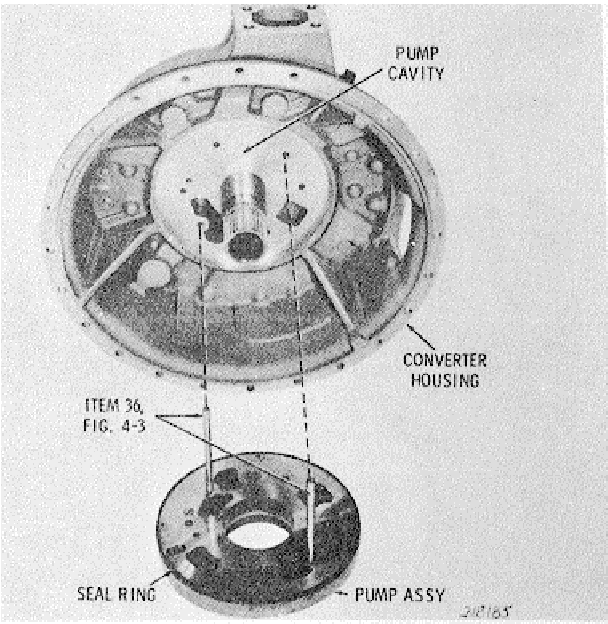


Fig. 6-21 Installation position of oil pump assembly (housing with 2-bolt cover)

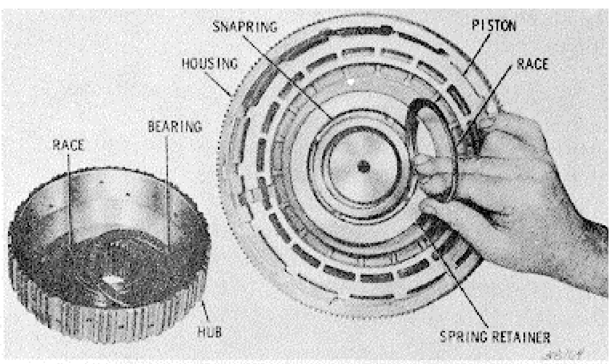


Fig. 6-29 Forward clutch components

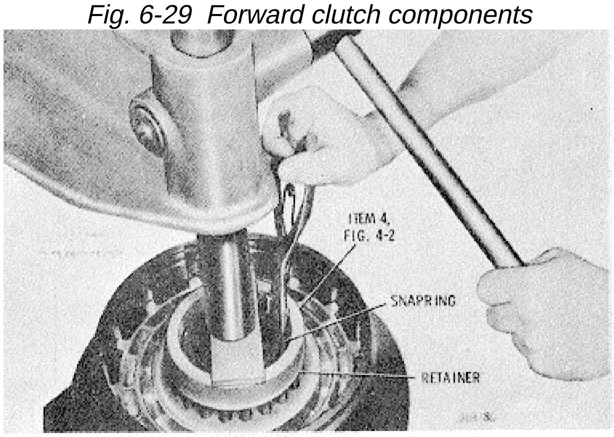


Figure 6-30 Removing (or installing) forward clutch spring retainer snapping

6-17. FORWARD CLUTCH AND TURBINE SHAFT

a. Disassembly (A, foldout 11)

(1) Remove hook-type sealring 1 from the front of the turbine shaft.

(2) Remove bearing race 2 from the hub of forward clutch housing assembly 3.

(3) Remove two hook-type sealrings 4 from the turbine shaft.

(4) Position forward clutch assembly 3 on a work table, turbine shaft down.

(5) Remove bearing race 25and bearing 26 from forward clutch hub 20.

(6) Remove snapring 24 and fourth-clutch driving hub 23.

(7) Remove five each of clutch plates 21 and 22.

(8) Re move forward clutch hub 20.

(9) Remove bearing race 19 and needle bearing 18 from the inner hub of the forward clutch hub (fig. 6-29).

(10) Remove bearing race 17 from the inner hub of the forward clutch housing (fig. 6-29).

(11) Using spring compressor 4 (fig. *Fig. 6.29)* 4-2), compress the spring retainer. Remove the snapring (fig. 6-30).

(12) Carefully remove pressure from at the spring retainer. Remove the spring retainer.

HT 700D SERIES TRANSMISSIONS

Para 6-17

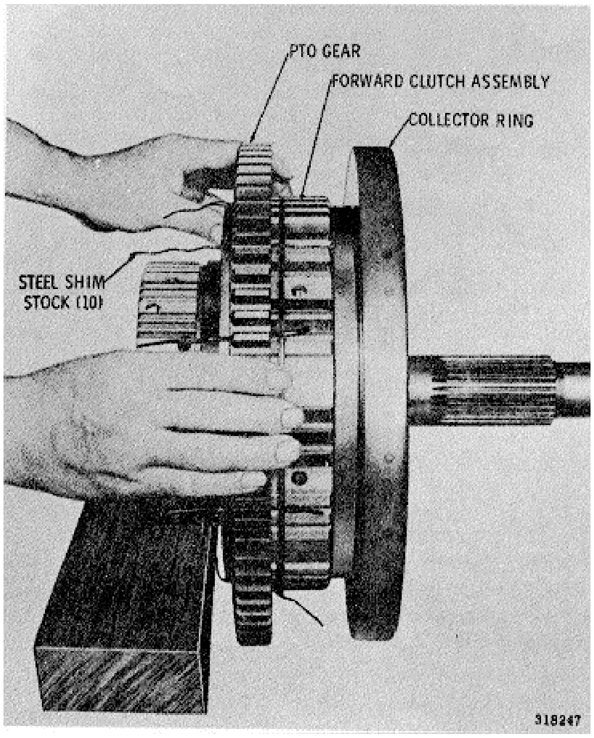


Fig. 6-31 Removing PTO gear from forward clutch

(13) Remove twenty piston return springs 14 (A, foldout 11).

(14) Remove forward clutch piston 13 and sealrings 10, 11 and 12. If the piston is replaced, be sure the identification (A, B or C) for the new piston is identical to that of the piston replaced.

(15) Remove the PTO gear by compressing the snapring, located within the gear, sufficiently to allow the gear to slip easily from the clutch housing.

(16) To compress the snapring, insert 10 pieces of 3/32 x 0.020 x 3-inch (2.38 x 0. 50x 76. 2-mm) steel shim stock between the snapring and the PTO gear (fig. 6-31). To accomplish this, locate the snapring gap, and at the cutout nearest the gap, press the snapring into the groove in the housing. Slip a piece of shim stock between the snapring and the inner ends of the splines of the PTO gear. Repeat the operation at the other side of the snapring gap.

(17) Then, working at each opening (missing spline) to compress the snapring, insert the remaining pieces of shim stock at approximately 3-inch (76.2 mm) increments. Push the gear from the housing. Remove the

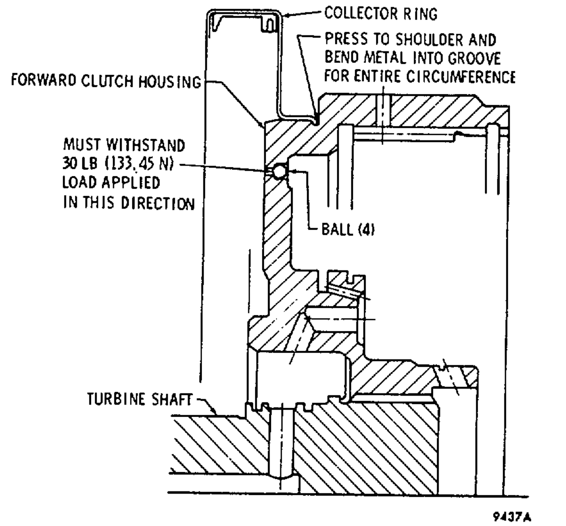


Fig. 6-32 Forward clutch housing-partial cross-section view

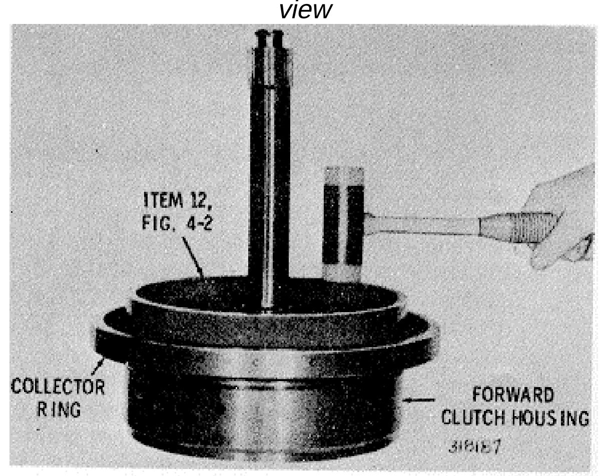


Fig. 6-33 Installing pivot collector ring

snapring. If the gear does not slip easily, check for a break in the light that can be seen between the gear and housing; work to depress the snapring in that area.

(18) Unless replacement is necessary, do not remove collector ring 6. If damage has occurred, support the inner circumference of the ring and press the forward housing and input shaft assembly free.

(19) Do not remove balls 7 from the forward clutch housing unless replacement is necessary.

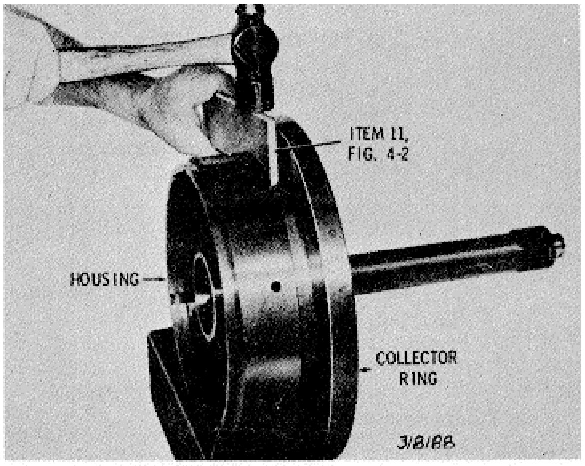


Fig. 6-34 Staking pivot collector ring to forward clutch housing

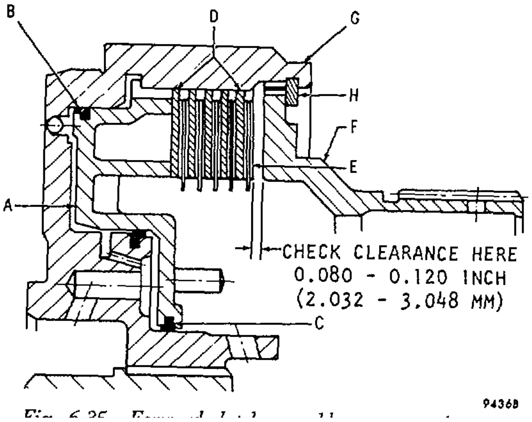


Fig. 6-35 Forward clutch assembly –cross section

NOTE
Refer to paragraph 6-2, above.

b. Assembly (A, foldout 11)

(1) If collector ring 6 was removed, replace it with a new ring. Apply Loctite Retaining Compound 40 to the joint and install the ring (fig. 6-33)Use installer 12 (fig. 4-2)to drive the collector ring onto the clutch housing (fig. 6-33)Use light hammer blows, and work around the entire installer circumference.

(2) Using staking tool 11 (fig. 4-2), bend the edge of the ring into the groove in the clutch housing (fig. 6-34)Check the four steel balls in the housing (fig. 6-32)They must be free to move, unobstructed, and securely staked.

(3) Position the forward clutch housing and shaft assembly 5 (A, foldout 11), turbine shaft down, on a work table.

(4) Grease and install sealring 12 into the sealring groove in the forward clutch housing. Be sure the lip of the seal faces upward (rearward) (fig. 6-35).

CAUTION
If sealring 12 is installed incorrectly, rough shifts in forward gears will occur.

(5) A clutch plate running clearance check is essential before completing the assembly rebuild. Items (6) through (13), below, explain the procedure. Items (14) through (20), below, complete the rebuild of the subassembly.

NOTE
If the forward clutch housing is replaced, selection of a proper piston (A, B or C) is imperative before sealring installation. If the forward clutch housing is not replaced and a new piston is required, make sure the identification letter stamped on the new piston is identical to that on the old piston.

(6) Usingfigure6-35as a guide, place forward piston A on the work table with the return spring bosses up. Grease and install lip-type sealring B and C, lips of the seals facing downward.

(7) Install piston A into forward clutch housing G. Make sure the lips of sealrings B and C are facing the bottom of the piston cavity. Install seal protector 15 (fig. 4-2) onto the clutch housing hub before installing the piston (fig. 6-36).

(8) Beginning with an external-tangled plate, alternately install five external-tangled plates D (fig. 6-35) and five internal-splined plates **E** into forward clutch housing G.

(9) Install fourth-clutch driving hub F into housing G.

(10) Install snapring H.

Para 6-17

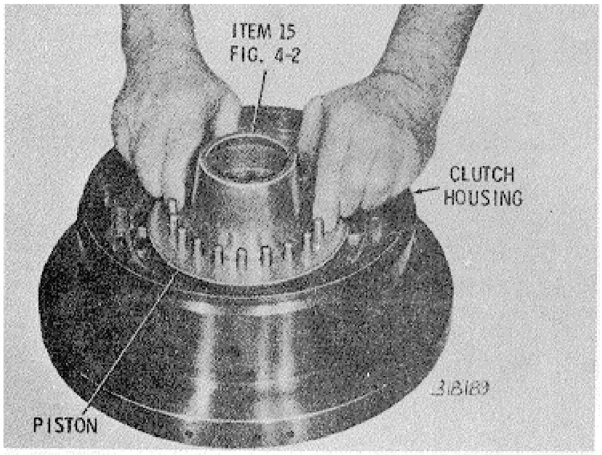


Fig. 6-36 Installing forward clutch piston

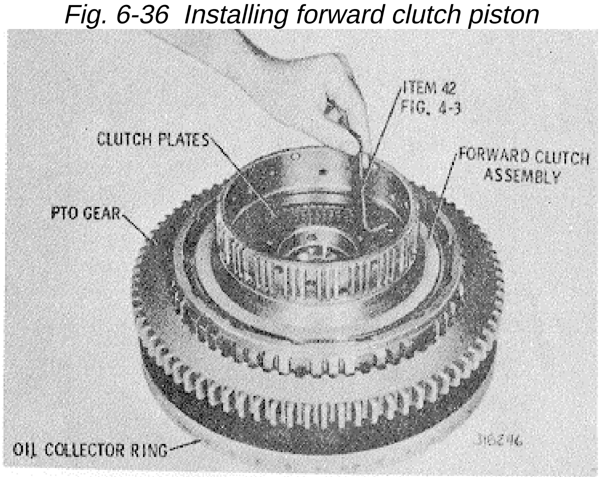


Fig. 6-37 Checking forward clutch plate running clearance

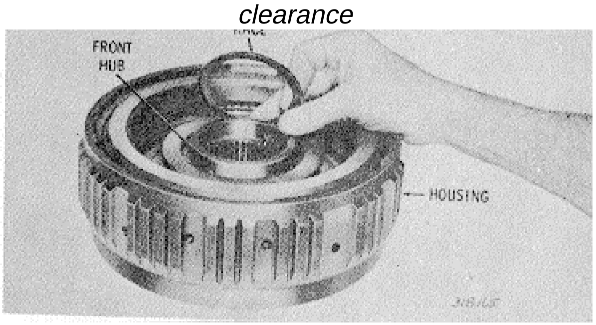


Fig. 6-38 Removing (or installing) fourth clutch front bearing race

(11) While holding hub F firmly against snapring H, measure. the clutch clearance with gage 42 (fig. 4-3) at the location shown CLUTCH in figure 6-35. When clearance is satisfactory, the thinner step of the gage will enter between the driving hub and clutch plates; the thicker step will not (fig. 6-37). The prescribed clearance is 0.080 to 0. 120 inch (2.03 to 3.05 mm). Any clearance measurement within this range is satisfactory, but the nearer to 0.080 inch that can be attained, the longer the clutch will maintain satisfactory clearance.

(12) If the clutch running clearance is not within the specified limits, remove snapring H, fourth-clutch driving hub F and clutch plates D and E. Replace clutch plates, as required, to obtain the desired running clearance. Refer to wear limits in Section 8, to determine the plate thickness.

(13) Repeat items (9), (10) and (11), above. When the clutch running clearance is within the specified limits of 0. 080 to 0. 120 (2.03 to 3.05 mm), remove snapring H and hub F.

(14) Install 20 piston return springs 14 (A, foldout 11) onto the spring guide bosses of piston 13. Place spring retainer 15 on top of the 20 springs, recessed side (outer lip) of the retainer facing down.

(15) Compress spring retainer 15 until the snapring groove on the clutch housing hub is exposed (fig. 6-30). Install the snapring.

(16) Grease (with oil-soluble grease) and install the thrust bearing race onto the retainer hub of forward clutch housing (fig. A

(17) Grease (with oil-soluble grease) and install the bearing race and needle bearing onto the inner hub of the forward clutch hub). (fig. 6-29).
Install the forward clutch hub, outer splines first, into the forward clutch housing (fig. 6-29).

(19) Install the fourth- clutch driving hub 23 (A, foldout 11) and retain it with snapring 24.

(20) Place the forward clutch housing on a work table, turbine shaft upward. Install PTO gear snapring 8 (A, foldout 11) on

to the forward-clutch housing. Install the PTO gear, chamfered end of internal splines first, from the rear of the clutch housing. Slide the gear onto the housing until the snapring engages its mating groove in the gear.

(21) Grease and install two hook-type sealrings 4 (A, foldout 11). Install hook-type sealring 1 on the front of the turbine shaft. Install thrust bearing race 2, cupped side first, onto the front of the forward clutch housing.

(22) Grease (with oil-soluble grease) and install bearing race 25, flat side first, and needle bearing 26 onto the rear of forward clutch hub 20.

6-18. FOURTH CLUTCH ASSEMBLY

a. Disassembly (B, foldout 11)

(1) Remove the bearing race from the front hub of the fourth-clutch housing (fig. 6-38).

(2) Remove the bearing race from the rear hub of the fourth-clutch housing (fig. 6-39).

(3) Place the fourth-clutch assembly, snapring up, on the work table.

(4) Remove the large snapring and the back plate (fig. 6-40).

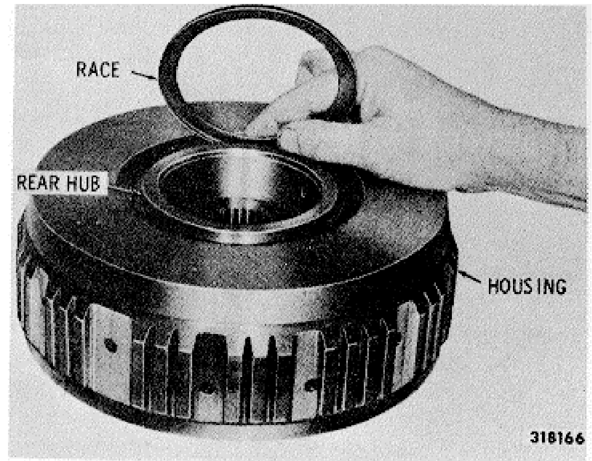


Fig. 6-39 Removing (or installing) fourth clutch rear bearing race

(5) Remove five external-tangled clutch plates and five internal-splined clutch plates.

(6) Using items 3 and 4 (fig. 4-2), compress the spring retainer until it is clear of the snapring (fig. 6-41). Remove the snapring.

(7) Carefully release the pressure from the spring retainer. Remove the retainer and 20 piston return springs.

(8) Remove the piston from the clutch housing (fig. 6-41).

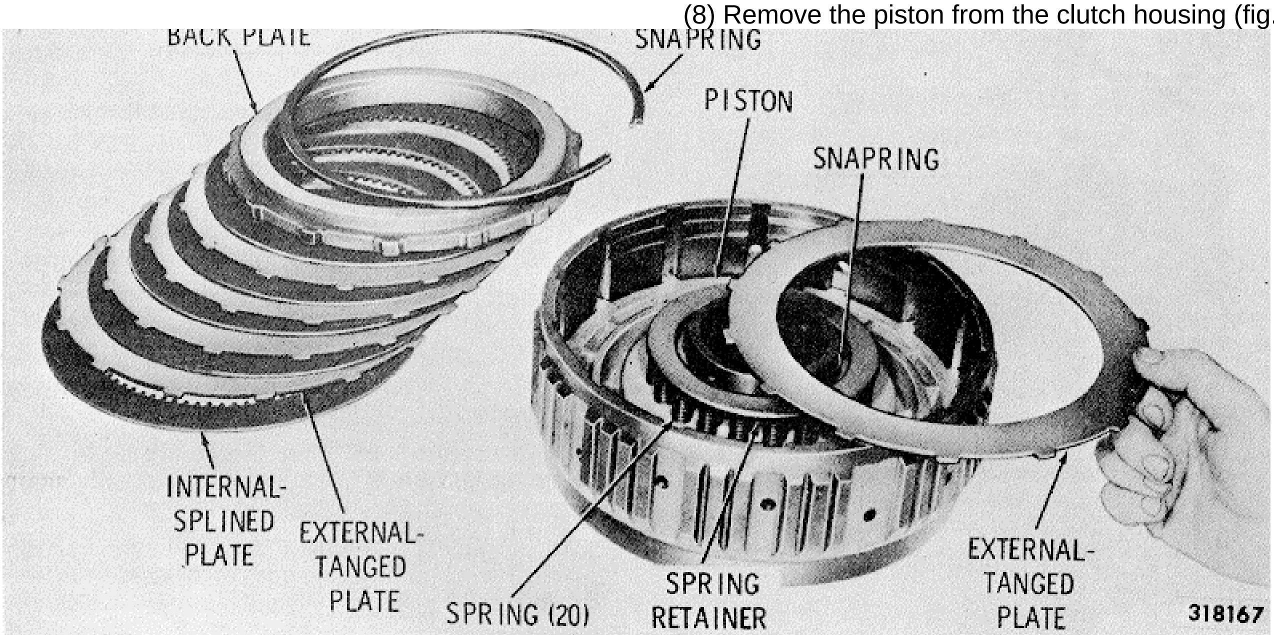


Fig. 6-40 Removing (or installing) fourth clutch plates

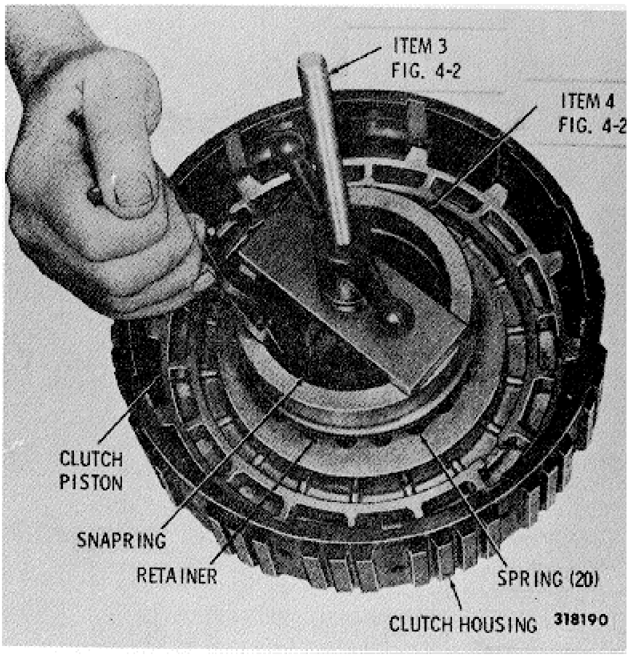


Fig. 6-41 Removing (or installing) fourth clutch spring retainer snapring

(9) Remove sealrings 10 (B, foldout 11) and 11.

(10) Check balls 13, as outlined in paragraph 6-17b(2), above.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (B, foldout 11)

(1) Place fourth-clutch housing assembly 12 (B, foldout 11) on the work table, flat (rear) side downward.

(2) Grease (oil-soluble grease) and install sealring 11 into the clutch housing. Be sure the lip of the sealring is facing the bottom of the piston cavity.

(3) Place fourth-clutch piston 9 on the work table, spring bosses side up. Grease and install sealring 10, lip downward, into the groove on the outside circumference of the piston. A sealring for the inside groove in piston 9 is not required. Install the piston into the clutch housing, using inner seal protector 13 (fig. 4-2) to center and guide the piston, although no seal contacts the tool (fig. 6-42).

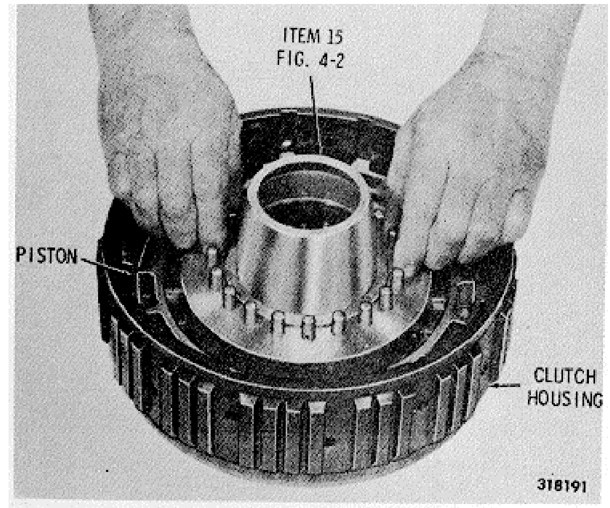


Fig. 6-12 Installing fourth clutch piston

NOTE

If the forward clutch housing is replaced, selection of a proper piston (A, B or C) is imperative before sealring installation. If the forward clutch housing is not replaced and a new piston is required, make sure the identification letter stamped on the new piston is identical to that on the old piston.

(4) A clutch plate running clearance check is essential before completing the assembly. Items (5) through (7), below, explain the procedure. Items (8) through (12), below, complete the rebuild of the assembly.

(5) Beginning with an external-tangled plate, alternately install five external-tangled plates and five internal-splined plates into the fourth-clutch housing (fig. 6-40).

(6) Install the back plate and snapring (fig. 6-30).

(7) Hold the back plate firmly against the snapring. Insert gage 42 (fig. 4-3) and check the clearance at the location shown in figure 6-43. When clearance is satisfactory, the thinner step of the gage will enter between the back plate and clutch plates; the thicker

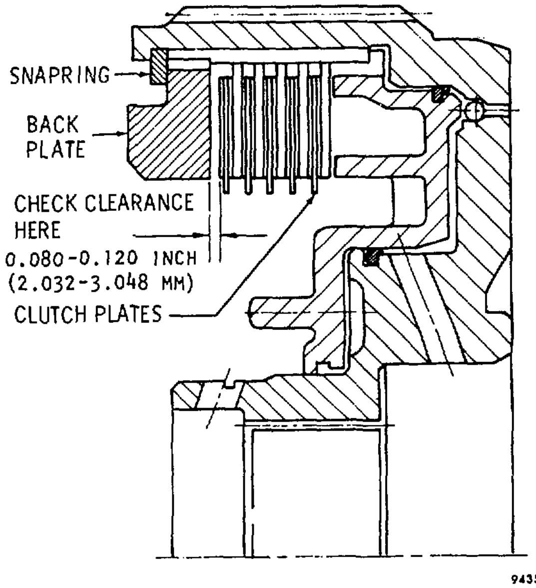


Fig. 6-13 Fourth clutch assembly-cross-section view

step will not (fig. 6-44). The prescribed clearance is 0. 080 to 0.120 inch(2.03 to 3.05 mm). Any clearance measurement within this range is satisfactory, but the nearer to 0. 080 inch that can be attained, the longer the clutch will maintain satisfactory clearance.

(8) Install 20 piston release springs, one each on the 20 cast bosses on the fourth clutch piston (fig. 6-40).

(9) Install the spring retainer, recessed side (outer lip) down, on the 20 piston return springs (fig. 6-40).

(10) Compress the spring retainer until the snapring groove on the clutch hub is clear (fig. 6-41). Install the snapring.

(11) Grease (with oil-soluble grease) and install the bearing race onto the rear hub of the fourth-clutch housing (fig. 6-39).

(12) Grease (with oil-soluble grease) and install the bearing race onto the front hub of the fourth-clutch housing assembly (fig. 6-38).

6-19. CENTER SUPPORT ASSEMBLY

a. Disassembly (A, foldout 12)

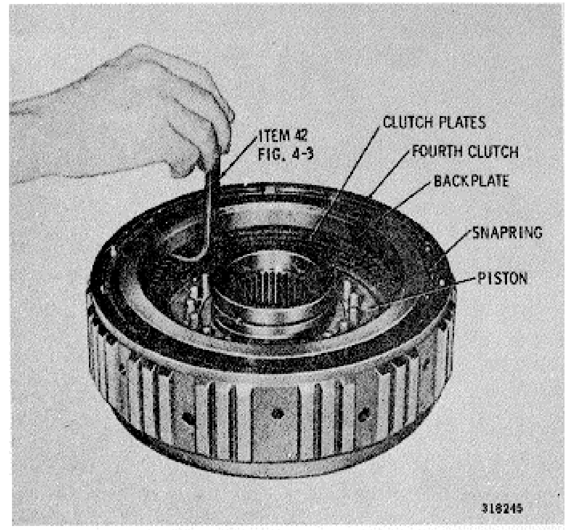


Fig. 6-4. Checking fourth clutch running clearance

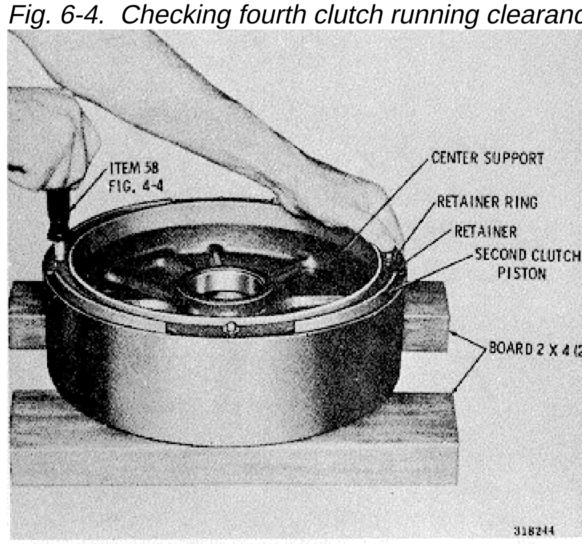


Fig. 6-45 Installing retainer rings onto second clutch piston

(1) Place center support housing assembly 16 (A, foldout 12), vertically (upright), on the work table.

(2) Remove pistons 10 and 21with attached parts.

(3) Remove the inner and outer sealrings from each piston. If replacement is necessary, disassemble the two piston assemblies. Cut the

retainer rings to prevent damaging the piston projections. Remove four retainer rings, a retainer, and twenty springs from each piston.

(5) Remove two step-joint sealrings 13 (A, foldout 12) from the hub of support housing 18.

(6) Remove thrust bearing race 15 and needle bearing 14.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 12)

(1) Temporarily place piston 10 in the front piston cavity of center support housing 18. Install springs 9 into the pockets of the piston. Aline spring retainer 8 on the four ejector pin bosses of the piston. Compress the springs by forcing the retainer into the recess at the outer edge of the center support w hen the retainer rings are installed (fig. 6-45). Install a new self-locking retainer ring 7 on the ejector pins of each piston, using installer 58 (fig. 4-4). Remove the piston from the center support.

(2) Repeat the procedures in (1), above, to assemble items 21 through 24 (A, foldout 12) into the rear cavity of support housing 18.

NOTE

If the pistons are not forced to the bottom of their cavities during installation of self-locking retainer rings 7 and 24, proper clutch clearance cannot be established.

(3) Grease (with oil-soluble grease) and install inner sealrings 11 and 20, and outer sealrings 12 and 19 onto pistons 10 and 21. The lips of all sealrings must be toward the piston cavities of the center support.

(4) Inspect the piston cavities in center support housing 18 for any obstruction or foreign material. Install piston 21 into the rear of the center support. Be sure the lips of both the inner and outer sealrings face the bottom of the piston cavity. Leave the assembled third clutch piston (10) out of the center support until final installation of the center support assembly in Section 7.

(5) Lubricate needle roller bearing 14 and bearing race 15 with oil-soluble grease. Install the race, flat side first, onto the front hub of the center support. To facilitate assembly, keep the race square with the support housing hub during installation. Forcing may damage the race. Install the needle roller bearing onto the race.

(6) Carefully install two step-joint sealrings 13 into the sealring grooves of the support housing hub. Retain them with oil-soluble grease.

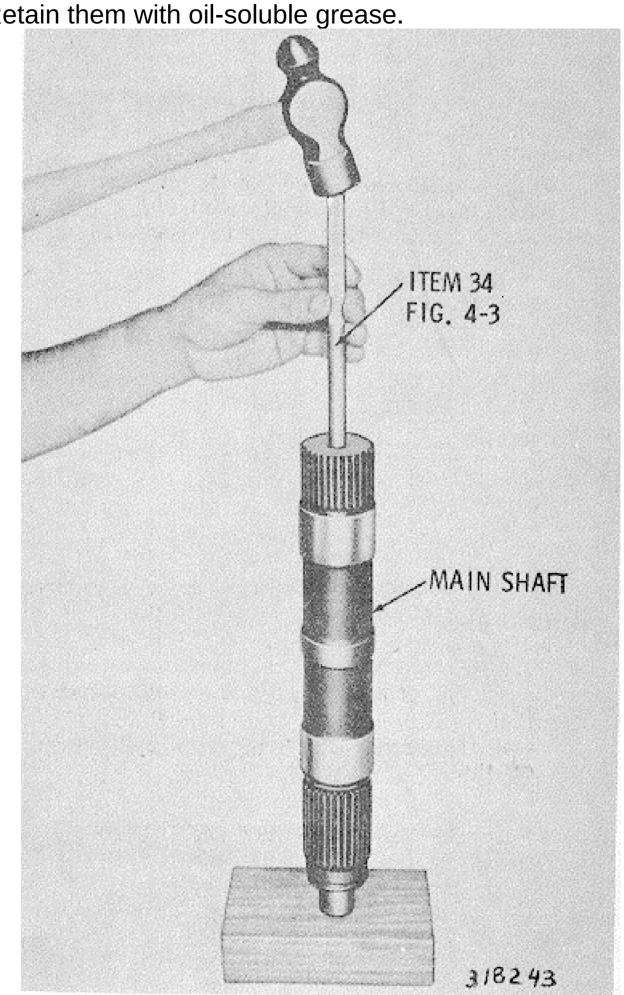


Fig. 6-17 Installing orifice plug into main shaft

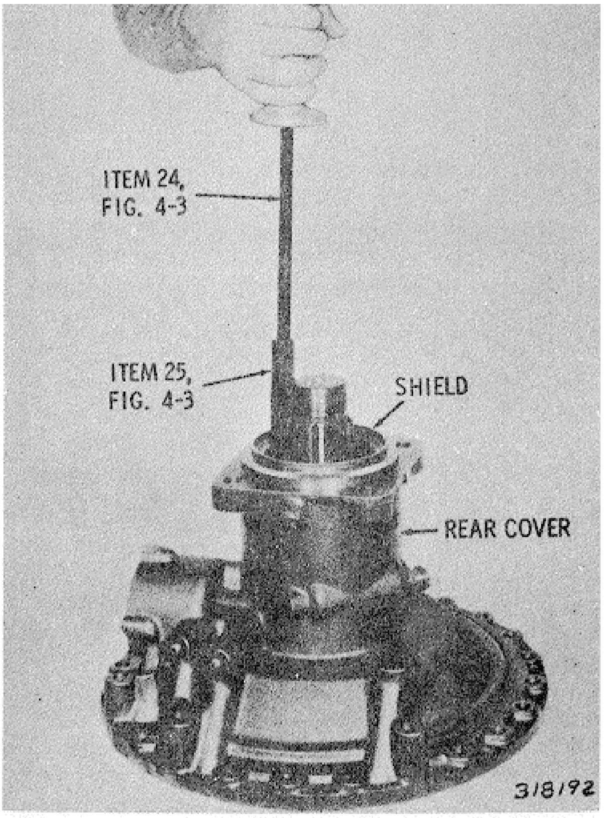


Fig. 6-49 Removing dust shield from rear cover

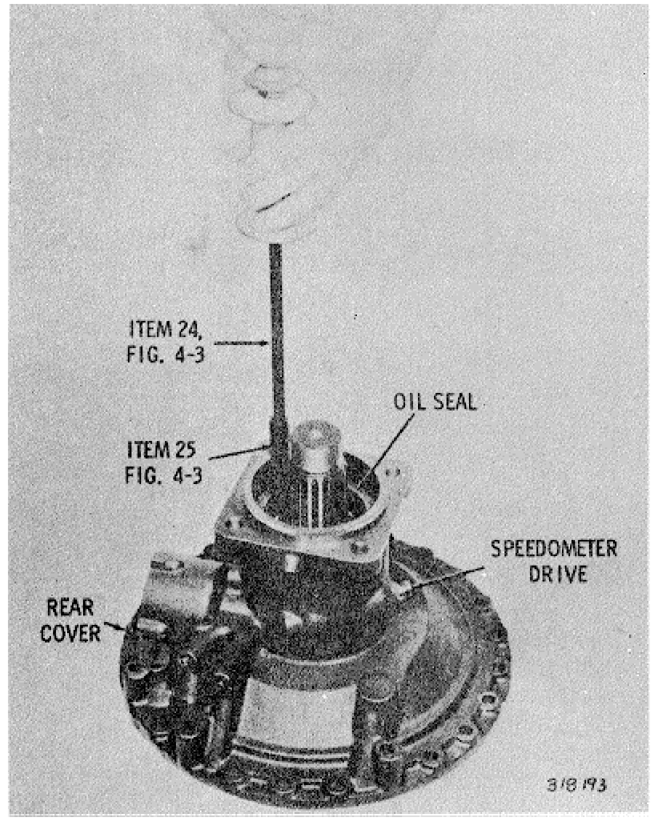


Fig. 6-50 Removing output shaft rear oil seal

6-22. REAR COVER ASSEMBLY

a. Disassembly (A, foldout 16)

(1) Using remover 24 (fig. 4-3), remove the dust shield from the rear cover (fig. 6-49).

(2) Using remover 24 (fig. 4-3), remove the output shaft oil seal from the rear cover (fig. 6-50).

(3) Re move the speedometer drive components from the rear cover (fig. 6-50).

(4) Remove the snapring that retains the rear output shaft bearing (fig. 6-51).

(5) Remove the rear output shaft, and its attached parts, from the rear cover (fig. 6-52).

(6)

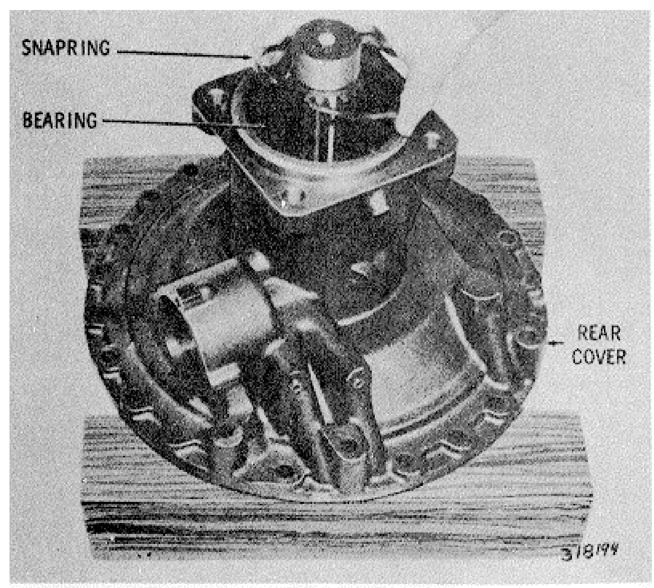


Fig. 6-51 Removing (or installing) output shaft bearing snapring

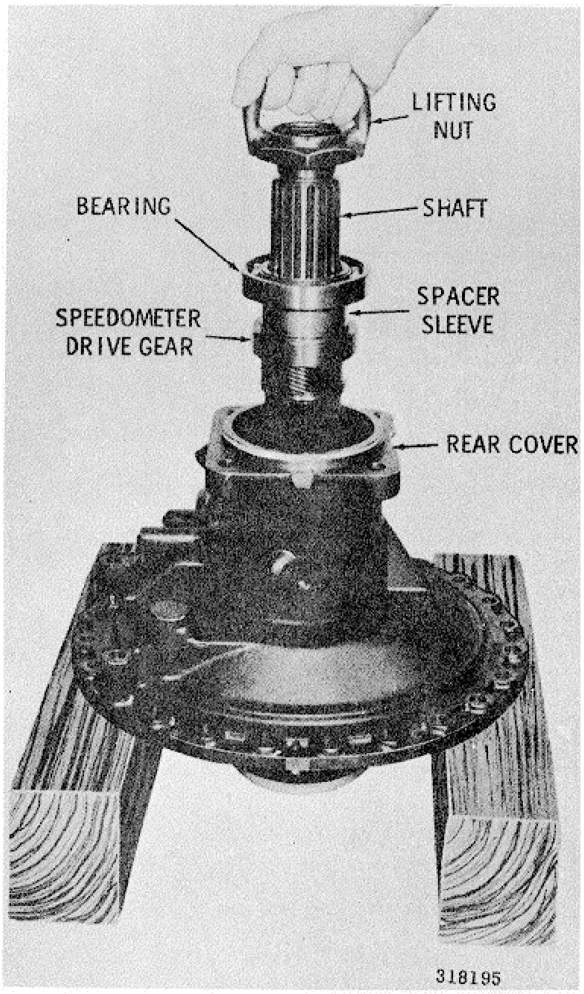


Fig. 6-52. Removing (or Installing) output shaft

(6) Support the front of the speedometer drive gear, and press the output shaft from the gear, spacer sleeve and bearing (Fig. 6-52).

(7) If orifice plug 20 (A, foldout 16) or bushing 22 requires replacement remove either or both as required.

(8) Using compressor components 2 and 3 (Fig. 4-2), compress the spring retainer and springs (Fig. 6-53). Remove the snapring, and remove the compressor.

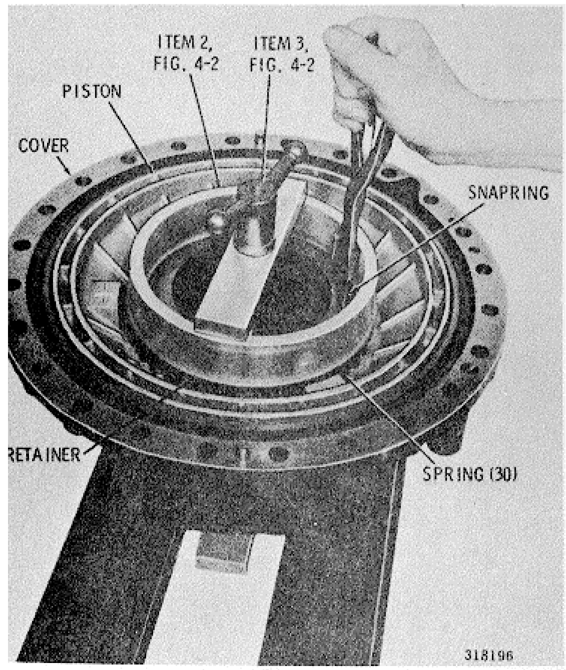


Fig.6-53. Removing (or iInstalling) snap ring that retains piston in rear cover

(9) Remove the spring retainer and30 springs (Fig. 6-53).

(10) Remove the clutch piston (fig 6-53). Remove the inner and outer sealrings from the piston.

(11) If the speedometer driven gear bushing requires replacement, remove it. Thread remover 22 (Fig. 4-2).into the bushing (Fig. 6-54). Attach slide hammer 19 (fig.4-2) to remover 22 and remove the bushing.

(12) Remove any remaining parts (dowel pins, snapring, governor support pin, plugs) that require replacement, from the rear cover (Fig. 6-54).

NOTE

Refer to paragraph 6-2, above.

b. <u>Assembly</u> (A, foldout 16)

(1) If removed, replace the dowelpins in the mounting face of the rear cover (fig.6-55). The dowel pins project 0. 360 to 0.400 inch (9.15 to 10.16 mm) above the face of the cover.

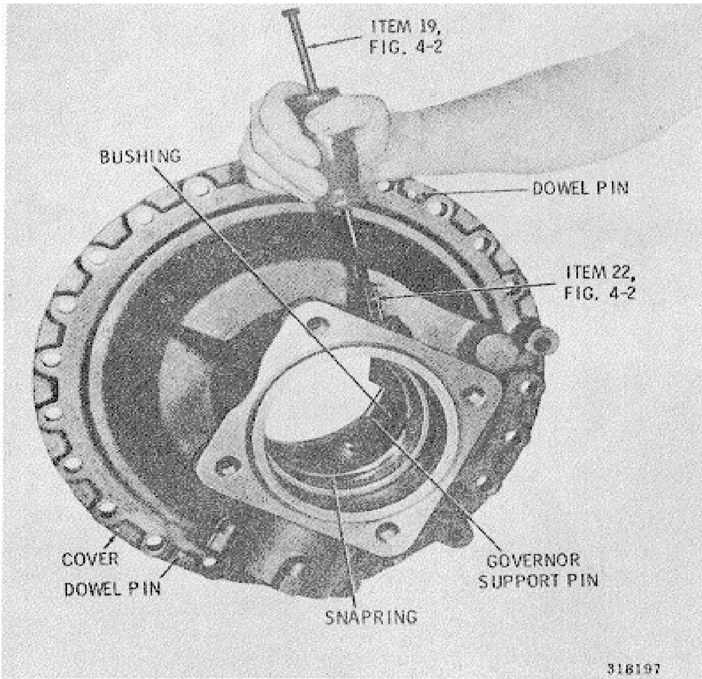


Fig. 6-54. Removing speedometer driven gear bushing

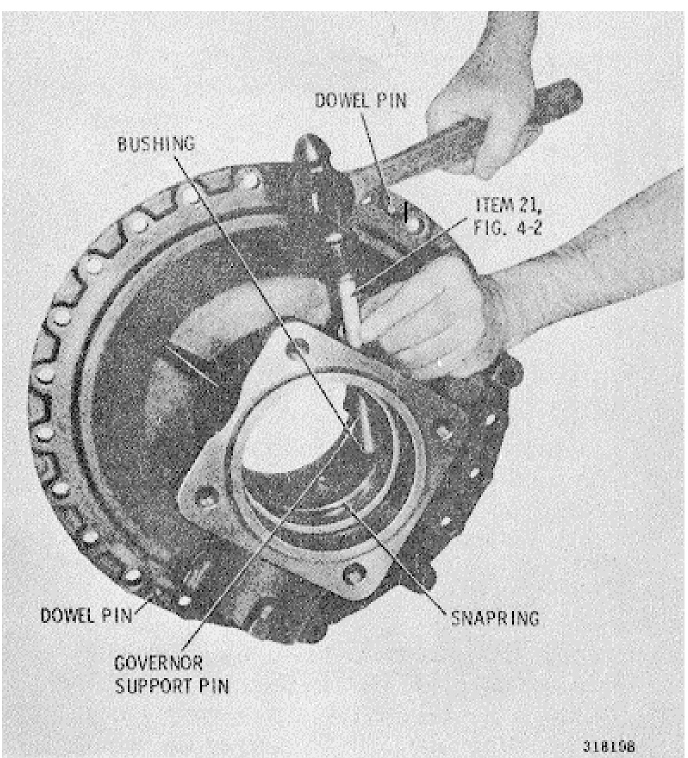


Fig. 6-55. Installing speedometer driven gear bushing.

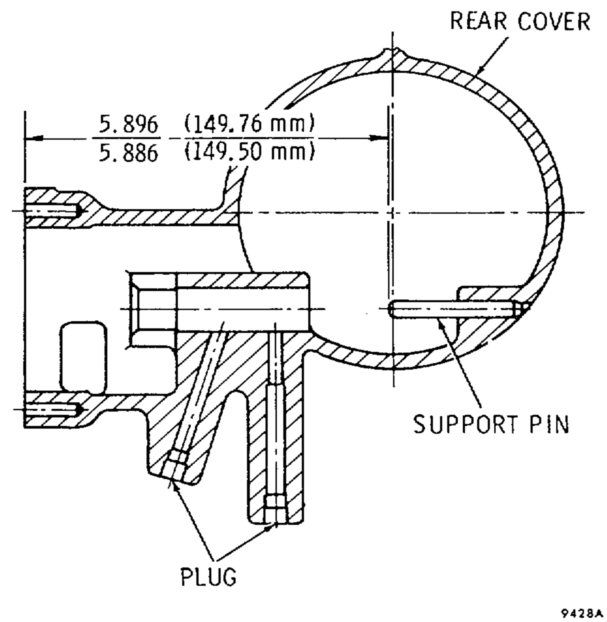


Fig. 6-56. Governor support pin location

(2) If removed, install the bearing front snapring into the rear cover (Fig. 6-55) Install plugs, if removed, into the rear cover.

(3) If removed, install the governor support pin to the dimension shown in figure 6-56. Accuracy of location and concentricity with the governor bore is of the utmost importance when installing the pin.

(4) If removed, install a new speedometer driven gear bushing (Fig. 6-55). Use installer 21 (Fig. 4-2) to seat the bushing in the rear cover.

(5) Lubricate sealrings 5 and 6 (A, foldout 16) with transmission fluid, and install them into the grooves of piston 4. The lip of each sealring must face the rear of the piston (toward piston cavity in rear cover).

(6) Using inner seal protector 12 (fig.4-2), carefully install the piston into the rear cover (Fig. 6-57). Use extreme care to prevent the lip of either seal folding back over itself. If installation is difficult, remove the piston and check the seal and cover bore before again attempting installation.

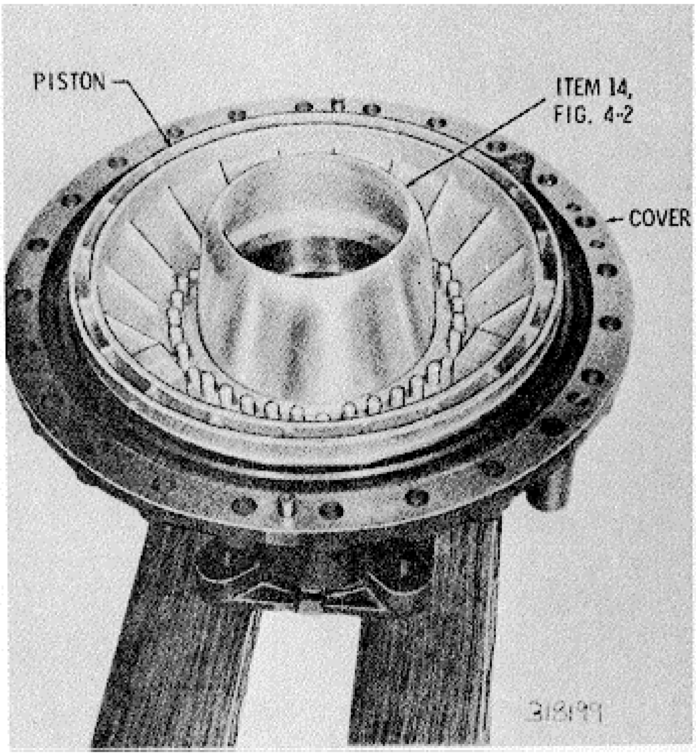


Fig. 6-57. Installing piston into rear cover

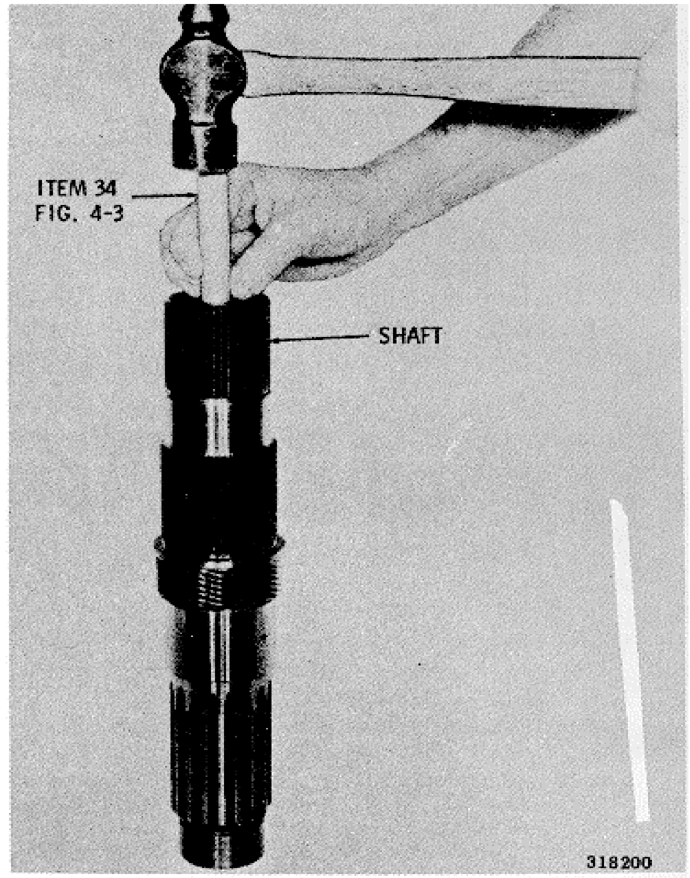


Fig. 6-58 Installing output shaft orifice plug

Figure 6-58. Installing output shaft orifice plug.

(7) Remove the seal protector. Install 30 springs (Fig. 6-53). Install the spring retainer, cupped side first, onto the springs.

(8) Using compressor components 2 and 3 (Fig. 4-2), compress the retainer and springs (Fig. 6-53). Install the snapring, and remove the compressor.

(9) If the orifice plug was removed f r o m the output shaft, install a new plug, orificed side first (Fig. 6-58). Use installer 34 (Fig. 4-3) to properly position the plug in the shaft. In each model, the plug must clear the chamfer at the front of the plug bore in the output shaft.

(10) If the bushing was removed from the front of the output shaft, install a new bushing (Fig. 6-59).
Locate the bushing in the shaft with installer 31 (Fig. 4-3). The bushing is 0. 145 to 0. 165 inch (3. 68 to 4.19 mm) from the front of the shaft.

(11) Press the speedometer drive gear, spacer sleeve, and bearing onto the rear output shaft (Fig. 6-52). Install the assembled shaft.
Fig. 6-58 Installing output shaft orifice plug

(12) On assemblies before S/N 5660, install the bevelled snapring (bevel toward rear of transmission) as shown inf igure 6-51 On later transmissions, the snapring is not bevelled. Be certain that the proper snapring is used to match the groove in the housing. Be sure the snapring is expanded fully into the groove.

(13) Coat the outer circumference of the output shaft oil seal with nonhardening sealer. Install the oil seal, spring-loaded lip first. Use installer 26 and driver handle 28 (Fig. 4-3) to locate the rear of the seal 0. 60 to 0.70 inch (15. 2 to 17.8 mm) in front of the parking brake mounting surface plane (fig.
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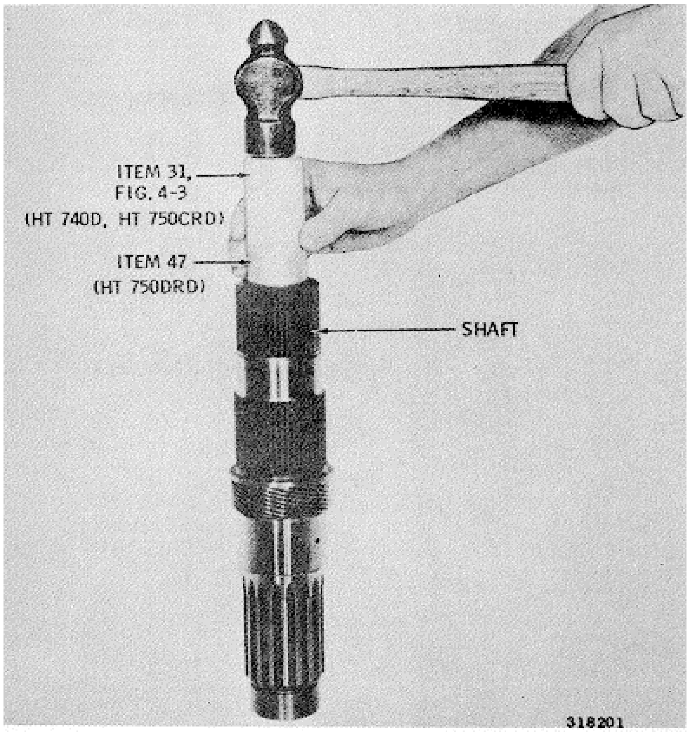
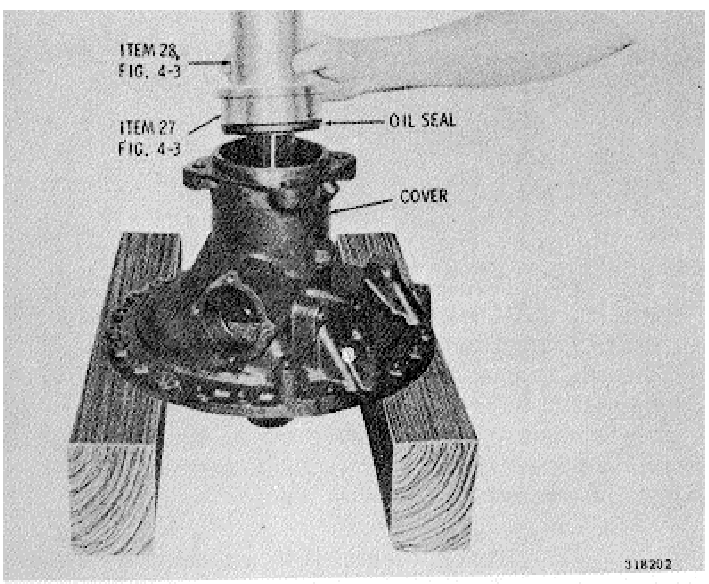


Fig. 6-59. Installing output shaft bushing



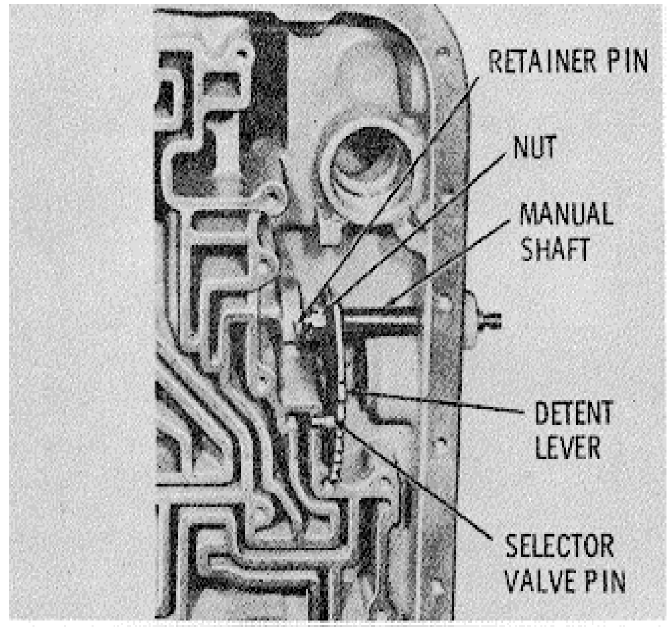


Fig. 6-61. Manual shaft components

(14) Coat the outer circumference of dust shield 32 (A, foldout 16) with nonhardening sealer. Install the shield, flat side first, into the rear cover. The rear edge of the shield must be flush with, to 0.040 inch (1. 01 mm) below, the rear surface of the cover.

(15) If available, install the output flange after coating the oil sealinner circumference with high-temperature grease.

Tighten the flange retaining nut 31 (A, foldout 16) to750 to 1000 pound feet (1017 to 1356 Nm) torque.

(16) Install the speedometer drive components (Fig. 6-50).

6-23. TRANSMISSION HOUSING

a. Disassembly (A, foldout 14)

(1) To remove the manual detent lever, use the following procedure. Remove the retainer pin and locknut (Fig. 6-61).

(2) Hold the detent lever in one hand and remove the manual shaft by carefully pulling the shaft through the oil seal in the housing. Remove the detent lever.

CAUTION

If the shaft is burred or rough, smooth it with crocus cloth or a honing stone, before removal, to avoid scratching the housing bore.

(3) Remove oil seal 42 (A, foldout 14) from the transmission housing.

4) If replacement of breather 1 is necessary, remove it from the housing.

(5) Inspect neutral safety switch plug 41, washer 40, and reverse signal plug 4 for damage. If damaged, replace with new parts.

(6) If it is necessary to replace nameplate 6, remove one drive screw 5.

NOTE

All replacement parts ordered refer to the information both nameplate Therefore it is imperative that the new nameplate be stamped with identical information.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 14)

(1) Coat the inside diameter of oil seal 42 (A, foldout 14) with a seal lubricant, and the outside diameter with a nonhardening sealant. Install the oil seal, lip first, into the transmission housing (Fig. 6-62). Use installer 32 (Fig. 4-3) to properly locate the seal in the housing. The seal must clear the chamfer in the housing bore.

(2) Hold detent lever 34 (A, foldout 14) so that the selector valve pin extends toward the inside of the housing (Fig. 6-61).Slide the manual shaft through the opening in the housing, oil seal, and slot in the detent lever. Install the locknut and retainer pin. Tighten the locknut to 15 to 20 pound feet (20 to 27 Nm) torque.

(3) If breather 1 (A, foldout 14) was removed, install the breather.

(4) If removed, install nameplate 6 and drive screw 5 (refer to a(6), and note, above).

6-24. LOW PLANETARY CARRIER ASSEMBLY

NOTE

Disassemble the planetary assembly only if there is evidence of undue wear or damage. Failure of one pinion requires replacement of the entire set, because the pinions are selectively matched.

a. Disassembly (A, foldout 15) (1) Using a 31/32-inch drill, centered accurately, drill into one end of each pinion pin 20 until the swaged end is sufficiently weakened.

CAUTION

Do not drill into metal of carrier 19.

(2) Place carrier assembly 18 in a press, and press four pins 20 from carrier 19, shearing the drilled ends of pins 20.

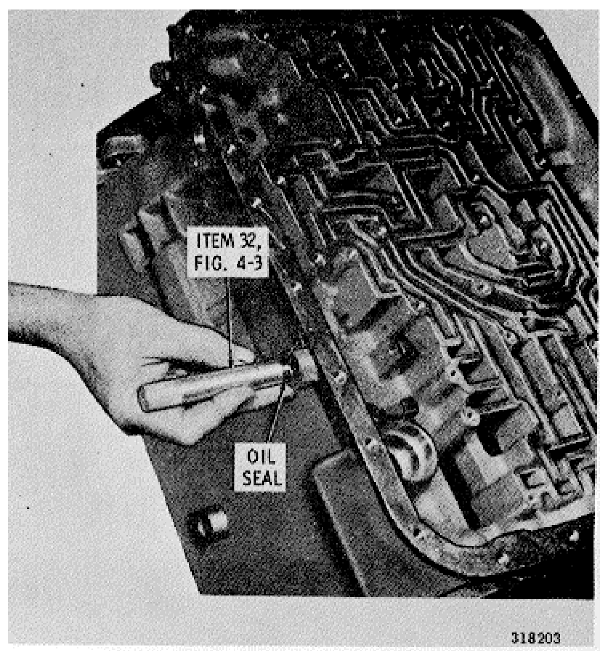


Fig. 6-62. Installing manual shaft oil seal

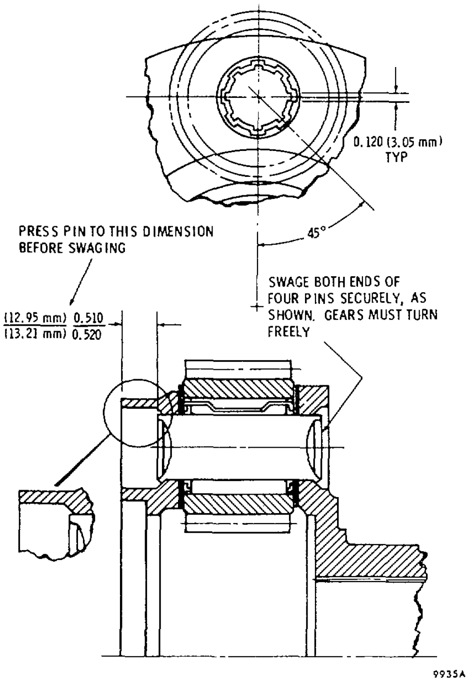


Fig. 6-63. Components of low planetary carrier assembly

(3) Remove as a unit, each of the four pinion groups consisting of pinions 23, thrust washers 21 and 24, and needle roller bearings 22. Remove bearings from pinion bores.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 15)

NOTE

To facilitate assembly, it is permissible to freeze pinion pin 20 or heat carrier 19 before pinion pin installation.

(1) Install bearings 22 into the bore of each pinion 23. Place a steel thrust washer 24 (first), and a bronze washer 21 (last) onto each face of pinions 23.

(2) Position carrier 19 in a press, and place a pinion group (as assembled in (1), above) into the carrier. Aline the parts of the pinion group with the pinion pin holes in the carrier.

(3) Install pinion pin 20 and press it through the carrier and pinion group to the dimension shown in figure 6-63.

NOTE

Pins must be a tight, to moderately tight, press fit (when parts are at normal temperatures).

(4) Install the remaining pinion groups and pins in the manner described above.

(5) Support each pinion pin on an 0. 812-inch (20. 62 mm) (approx) anvil. Using a suitable punch, swage the pin firmly against the carrier to form the pattern shown in figure 6-63. After swaging, each pinion must rotate freely with 0. 008 to 0. 031 inch (0. 203 to 0. 787 mm) end play.

6-25. ADAPTER HOUSING ASSEMBLY

a. Disassembly (A, foldout 15)

(1) Position the assembly, piston assembly upward. Lift out the piston assembly (includes items 3 through 8).

(2) Remove the inner and outer sealrings from the piston (Fig. 6-64).

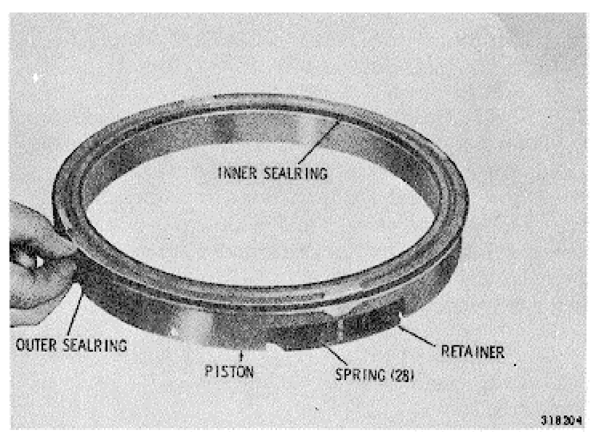


Fig. 6-64. Removing (or installing) first clutch piston seal ring

(3) Turn the piston assembly over, and cut the our retainer rings while depressing the retainer (Fig. 6-65).

NOTE
Any method of removal except cutting may damage the risers on the piston. Damage will lessen the holding power of retainer rings installed thereafter.

(4) Remove the spring retainer and 28 springs from the piston (Fig. 6-55).

(5) If replacement is necessary, remove dowel pins 11 and 12, and orifice plug 13 (A, foldout 15) from adapter housing 10.

NOTE
Refer to paragraph 6-2, above.

b. Assembly (A, foldout 15)

(1) If removed, install new dowelpins 11 and 12 into housing 10. They must project 0. 360 to 0.400 (9.15 to 10.16 mm) above the front face of the adapter housing. Install orifice plug 13 (if removed) flush with, or to 0. 060 inch below the front face of the housing.

(2) Place piston 6 in the piston cavity of housing 10. Be sure it is firmly bottomed in the cavity.

(3) Install 28 springs 5 into their recesses in the piston. Install retainer 4, so that its offset tangs are upward, onto the piston and springs.

(4) Using installer 58 (Fig. 4-4), install four retainer rings 3 (A, foldout 15).Press each ring into place until the adjacent retainer tang bottoms in the counterbore of the adapter housing.

CAUTION
Failure to install the retainer rings properly can result in transmission damage or malfunction. If installed too far onto the risers, proper clutch clearance cannot be obtained .If not installed far enough, the retainers may fall off.

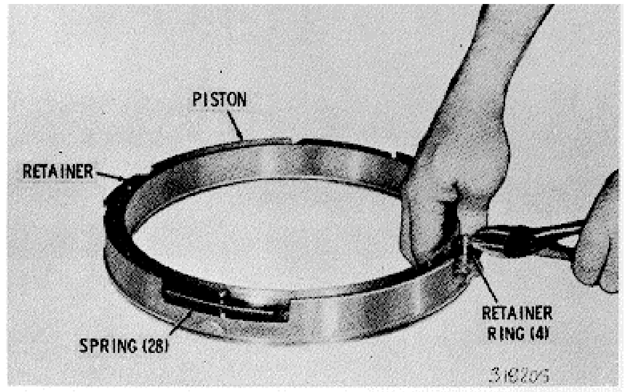


Fig. 6.65. Removing retainer rings from first clutch piston

(5) When all four retainer rings are properly installed, remove the piston assembly from the adapter housing.

(6) Lubricate sealrings 7 and 8 with transmission fluid. Install the sealrings, with the lip of each sealring facing rearward, away from the spring side of the piston (Fig. 6-64).

(7) Do not install the piston assembly into the adapter housing until the housing is installed, as outlined in Section 7, for gear unit installation.

6-26. GEAR UNIT AND MAIN SHAFT ASSEMBLY

a. Disassembly (A, foldout 13)

(1) Remove thrust washer 1 (fig.6-66) from sun gear 2. Remove sun gear 2 and thrust washer 3.

(2) Remove front planetary carrier assembly 4, and thrust washer 5. Refer to paragraph 6-30 for rebuild of the carrier assembly.

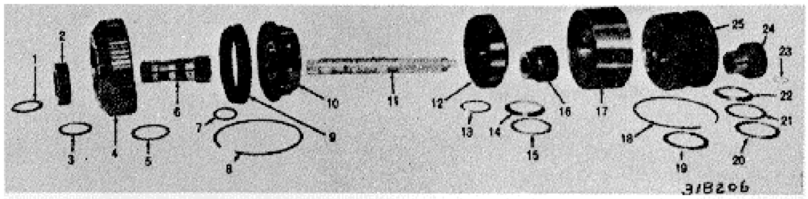


Fig. 6-66. Components of gear unit and main shaft assembly (HT750CRD)

(3) Remove sun gear and shaft assembly 6, and thrust washer 7. If the bushings in gear and shaft assembly 6 require replacement, replace entire shaft assembly 6.

(4) Remove snapring 8 and ring gear 9 from the front of planetary connecting drum 17.

(5) Lift out center planetary carrier assembly 10. Refer to paragraph 6-31 for rebuild of the carrier assembly.

(6) Remove snapring 23. Remove low sun gear 24.

(7) Remove bearing race 20, bearing 21, and bearing race 22.

(8) Remove main shaft 11. Remove center planetary ring gear 12 and its attached parts (items 13, 14, 15, 16, 19).

(9) Remove snapring 13. Lift gear 12 from gear 16. Remove race 14, bearing 15, and race 19.

(10) Remove snapring 18, and lift rear planetary carrier assembly 25 from drum 17. Refer to paragraph 6-34 for rebuild of carrier assembly.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 13)

(1) If the bushings were unserviceable or removed from sun gear and shaft assembly 6 (Fig. 6-66), replace the entire shaft assembly.

(2) If orifice plug 36 (A, foldout 13) was removed from shaft 35, install a new plug. If orifice plug 35 (B, foldout 12) was removed from main shaft 36, install a new plug. Be sure the plug is pressed deep enough into the bore to clear the chamfer of the shaft. Use installer 34 (Fig. 4-3) to position the orifice plug properly (Fig. 6-47).

(3) Position planetary connecting drum 17 (Fig. 6-66), front (longer internal splines) downward. Install r ear planetary carrier assembly 25, larger carrier bore first, into drum 17. Retain the carrier with snapring 18.

(4) Install bearing race 14, flat side first, onto the rear of center planetary ring gear 12. Retain it with oil-soluble grease. Install needle roller bearing 15 onto race 14.Retain it with oil-soluble grease.

(5) Install thick, flat bearing race 19 onto bearing 15. Retain it with oil-soluble grease.

(6) Install rear planetary sun gear 16 into the rear of center planetary ring gear 12. Retain it with snapring 13.

(7) Install main shaft 11, smaller end first, through the parts (12, 13, 14, 15, 16, 19) assembled above. Install shaft 11 and its assembled parts into drum 17 until bearing race 19 seats in the front counterbore of rear planetary carrier assembly 25.

(8) Install bearing race 22, flat side first, onto the rear hub of rear planetary carrier assembly 25. Retain it with oil-soluble grease. Install bearing 21, and thick,

flat race 20 onto bearing 21, retaining each with oil-soluble grease.

(9) At the rear of carrier assembly 25, install low sun gear 24, extended hub first, over the rear end of shaft 11. Retain it with snapring 23.

(10) Position the assembly, front upward, and support the rear of carrier assembly 25.

(11) Install center planetary carrier assembly 10, outer splines upward, into drum 17. Install front planetary ring gear 9, outer splines first, into drum 17. Retain gear 9 with snapring 8.

(12) Install thrust washer 7 onto shaft 11. Install sun gear and shaft assembly 6, larger diameter first, onto shaft 11.

(13) Install thrust washer 5 onto the rear hub of front planetary carrier assembly 4. Install carrier assembly 4 so that thrust washer 5 seats on the front of center planetary carrier assembly 10.

(14) Install thrust washer 3, sun gear 2, and thrust washer 1 into the front of front planetary carrier assembly 4.

6-29. FLEX DISK ASSEMBLY

a. Disassembly (A, foldout 7)

(1) If flex disk assembly 2 has not been removed from the engine crankshaft, remove it.

(2) Remove twelve self-locking bolts 9 and separate plate 8, flex disks 6 and 7, and hub assembly 3.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 7)

(1) Install flex disk6 onto hub assembly 3, alining the dowel pin hole in the disk with pin 5. Washers attached to disk 6 must face toward hub assembly 3.

(2) Install flex disks 7 in the same manner.

(3) Install plate 8, alining the plate with dowel pin 5.

(4) Install twelve self-locking, 1/2-20 x 3/4-inch bolts 9 through plate 8, disks 6 and 7, and into hub assembly 3. Tighten the bolts to 96 to 115 pound feet (130 to 156 Nm) torque.

(5) Install flex disk assembly 2 onto the engine crankshaft. Refer to the vehicle service manual for bolt torque-value.

6-30. FRONT PLANETARY CARRIER ASSEMBLY

NOTE

Refer to paragraph 6-26 for removal from gear unit. Disassemble the planetary only if there is evidence of undue wear or damage. Failure of one pinion requires replacement of the entire set because the pinions are selectively matched.

a. Disassembly (A foldout 13)

(1) Using a 5/8-inch drill, centered accurately, drill into one end of each pinion pin 12, until the swaged end is sufficiently weakened.

CAUTION

Do not drill into metal of carrier assembly 6.

(2) Place carrier assembly 5 on a press bed. Support the carrier in a manner such that no stress will be placed on the swaged pins (smaller diameter) that do not retain the pinions. Press six pinion pins 12 from carrier assembly 5, shearing the drilled ends of pins 12.

(3) Remove as a unit, each of the six pinion groups consisting of pinions 10, thrust washers 8 and 11, and needle roller bearing 9. Remove the bearings from the pinion bores.

(4) Inspect carrier assembly 6 for relative movement bet w e e n the remaining parts. If looseness is detected, replace the assembly.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A,foldoutl3)

NOTE

To facilitate assembly, it is permissible to freeze pinion pin 12 or heat carrier 6 before pinion installation.

(2) Install a needle roller bearing 9 (A, foldout 13) into the bore of each pinion 10. Place a steel thrust washer 11(first) and a bronze thrust washer 8 (second) onto each face of pinion 10.

(3) Place the carrier assembly in a press. Support the carrier in such a manner that no stress will be placed on the swaged pins when the pinion pins are installed. Place a pinion group (as assembled in (2), above) into the carrier.

(4) Carefully aline the parts of the pinion group with the pinion pin holes in the carrier assembly, and install pinion pin 12 (A foldout 13). Press the pinion pin through the carrier and pinion group to the dimension shown in figure 6-68.

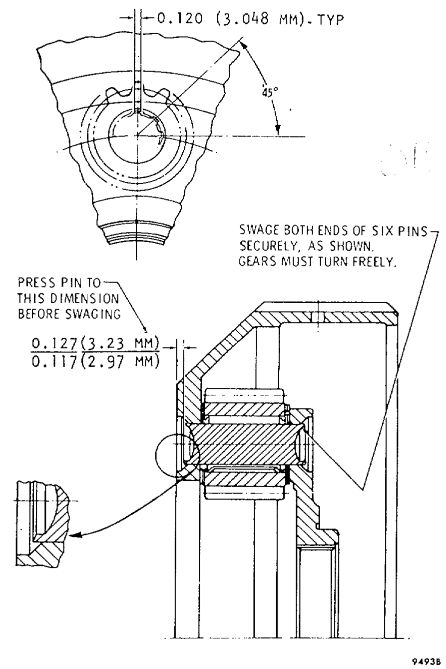


Fig. 6-68. Components of front planetary carrier assembly

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NOTE

Pins must be a tight, to moderately tight, press fit (when parts are at normal temperatures).

(5) Install the remaining pinion groups and pins in the manner described above.

(6) Support each pinion pin on a 1/2inch (12. 7 mm) (approx.) anvil. Using a suitable punch, swage the pins firmly against the carrier to form the pattern shown in figure 6-68. Pinions must rotate freely after swaging.

6-31. CENTER PLANETARY CARRIER ASSEMBLY

NOTE

Refer to paragraph 6-26 for removal from gear unit. Disassemble the planetary assembly only if there is evidence of undue wear or damage. Failure of one pinion requires replacement of the entire set because the pinions are selectively matched.

a. Disassembly (A foldout 13)

(1) Using a31/32-inch drill, centered accurately, drill into one end of each pinion pin 17 until the swaged end is sufficiently weakened.

CAUTION

Do not drill into metal of carrier 18.

(2) Place carrier assembly 16 in a press, and press four pins 17 from carrier 18, shearing the drilled ends of pins 17.

(3) Remove as a unit, each of the four pinion groups consisting of pinions 20, thrust washers 19 and 22, and needle roller bearings 21. Remove bearings from pinion bores.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A foldout 13)

NOTE

To facilitate assembly, it is permissible to freeze pinion pin 17 or heat carrier 18 before pinion pin installation.

(1) Install two bearings 21 into the bore of each pinion 20. Place a steel thrust washer 22 (first) and a bronze thrust washer 19 (second) onto each face of pinions 20.

(2) Position carrier 18 in a press, and place a pinion group (as assembled in (1), above) into the carrier. Align the parts of the pinion group with the pinion pin holes in the carrier.

(3) Install pinion pin 17 and press it through the carrier and pinion group to the dimension shown in figure 6-69.

NOTE

Pins must be a tight, to moderately tight, press fit (when parts a r e at normal temperatures).

(4) Install the remaining pinion groups and pins in the manner described above.

(5) Support each pinion pin on an 0.812-inch (20.62 mm) (approx.) anvil. Using a suitable punch, swage the pin firmly against the carrier to form the pattern shown in figure 6-69. After swaging, each pinion must rotate freely.

INSPECTION AND REBUILD

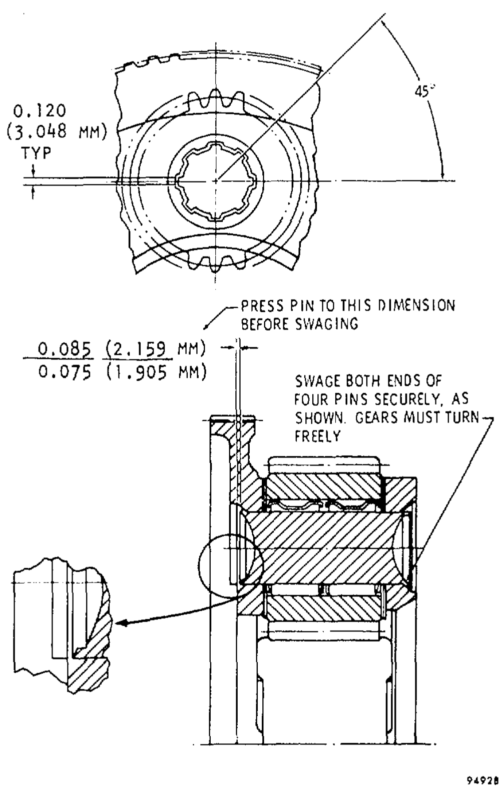

Fig. 6.69 Components of center planetary carrier assembly

6-34. REAR PLANETARY CARRIER ASSEMBLY

NOTE

Disassemble the planetary assembly only if there is evidence of undue wear or damage. Failure of one pinion requires the replacement of the entire set, because the pinions are selectively matched.

a. Disassembly (A, foldout 13)

(1) If carrier 40 or bushing 41 is damaged or otherwise unserviceable, replace with a carrier and bushing assembly. Field replacement of the bushing alone is not recommended.

(2) Using a31/32-inch drill, centered accurately, drill into one end of each pinion pin 46 until the swaged end is sufficiently weakened.

CAUTION

Do not drill into metal of carrier 40.

(3) Place carrier assembly 38 in a press, and press four pins 46 from carrier 40, shearing the drilled ends of pins 46.

(4) Remove, as a unit, each of the four pinion groups consisting of pinions 43, thrust washers 42 and 45, and needle roller bearings 44.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (A, foldout 13)

NOTE

To facilitate assembly, it is permissible to freeze pinion pin 46 or heat carrier 40 before pinion pin installation.

(1) Install a needle roller bearing 44 into the bore of each pinion 43. Place a steel thrust washer 45 (first) and a bronze thrust washer 42 (second) onto each face of pinions 43.

(2) Position carrier 40, front downward (bushing bore upward), in a press. Place a pinion group (as assembled in (1), above) into the carrier. Align the pinion group with the pinion pin bore in the carrier.

(3) Install a pinion pin 46, and press it through the carrier and pinion group, to the dimension shown in figure 6-72.

NOTE

Pins must be a tight, to moderately tight, press fit (when parts are at normal temperatures).

(4) Install the remaining pinion groups and pins in the manner described above.

(5) Support each pinion pin on a.0. 812inch (20. 62 mm) (approx.) anvil. Using a suitable punch, swage the ends of each pinion pin firmly against the carrier, to form the pattern shown in figure 6-72. After swaging, each pinion must rotate freely, with 0. 008 to 0. 031inch (0. 20 to 0.78 mm) end play.

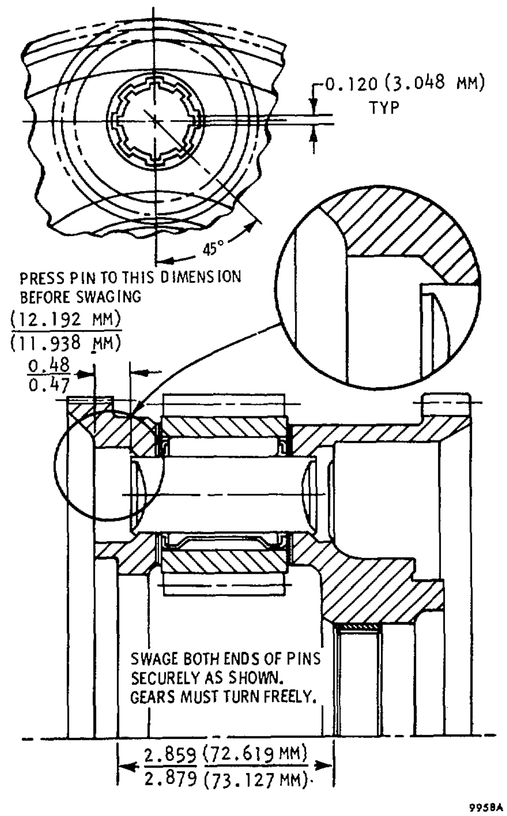

Fig. 6-72. Components of rear planetary carrier assembly 771

6-35. GOVERNOR INSPECTION

a. Inspect the governor to determine that its function has not been impaired. If dirt or other foreign materials are present, clean the governor in mineral spirits then check the governor as explained in c, below. If the governor function is still impaired, disassemble the governor as explained in b, below.

b. Remove pins 'A' shown in figure 6-73 and carefully remove the governor weights and springs. Slide the governor valve out of its housing and after cleaning the valve and housing, check for wear. If wear is evident, replace the governor, otherwise assemble the governor by reversing the disassembly procedure above. Be sure the governor valve is installed as shown in figure 6-73. New pins must be used at reassembly. These pins, with instructions, are available in kit form. See your HT 700 Series parts catalog SA 1268 for detail part number.

c. Hold the governor assembly drive gear upward, as shown in figure 6-73. Hold one weight outward against its stop. Check the opening at the governor feed port. This is the distance the governor valve land clears the bottom side of the port. Repeat this check while holding the other weight outward against the stop. The minimum opening should be 0.020 inch (0.51 mm). If the opening is less, replace the governor.

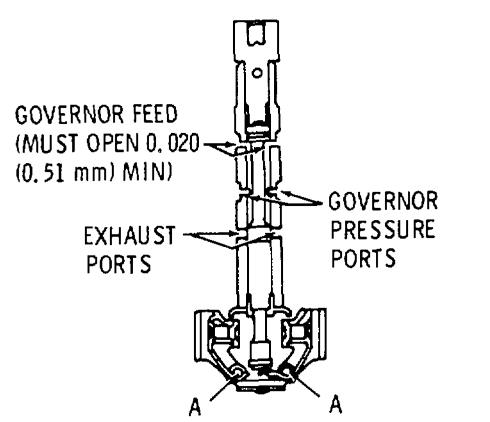

Fig. 6-73. Governor assembly-showing port openings

INSPECTION AND REBUILD

Para 6-36

6-36.TORQUE SPECIFICATIONS

A complete listing of torque specifications are in a table in paragraph 4-9. Figure 6-74 illustrates a majority of the fasteners and the torque recommendations for each.

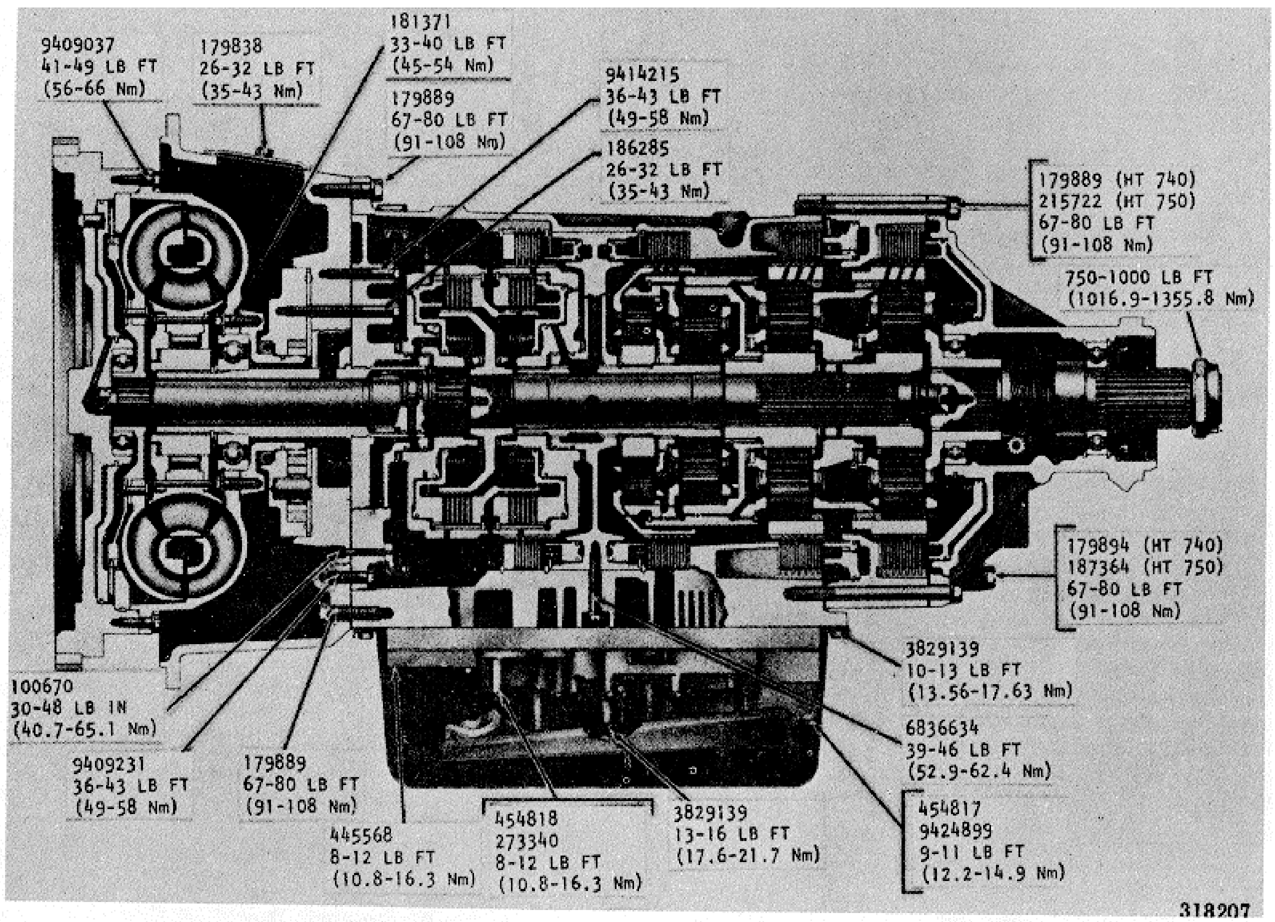

Fig. 6.74. Torque requirements for threaded fasteners

Section 7. ASSEMBLY OF TRANSMISSION FROM SUBASSEMBLIES

7-1. SCOPE OF SECTION 7

This section covers the assembly of the transmission. It is arranged in a continuous sequence to facilitate assembly. Certain illustrations will not always illustrate the model being assembled, but, when the operation is identical, the illustration may be referenced and will correctly illustrate the procedure.

7-2. CLUTCH CLEARANCES

a. Preparation Procedure. Preparations are required to establish the proper running clearance for each clutch pack. Follow the procedures in b, below.

b. Determine Plate Thickness

(1) Determine the original thickness of each external-tanged plate with a micrometer. Because the tangs of the clutch plate are not subject to face wear, the micrometer reading at a tang will be the original thickness. Note that each clutch pack must contain one thick plate next to the piston, and a basic number of thick and thin plates. The combination of thick and thin plates are selected to meet the prescribed clearance with the clutch released. Install all thick plates toward the piston end of the pack.

(2) Determine the wear on both internal and external plates (refer to wear limits in Section 8). Replace worn plates. Note that the thicknesses of external-tanged plates in the low, first, second, and third clutches in earlier models may be different from the thicknesses of corresponding plates in later models. Wear limits started in Section 8 are for plates presently supplied.

(3) If it is necessary to replace an external-tanged plate, be sure the plate thickness is identical to the original equipment. Refer to b(l) and (2), above. Keep the clutch plates separated; do not mix the plates of one clutch with the plates of another.

(4) Clearance for the third clutch is established during assembly. Clearances for the forward and fourth clutches are established during rebuild of those subassemblies in Section 60

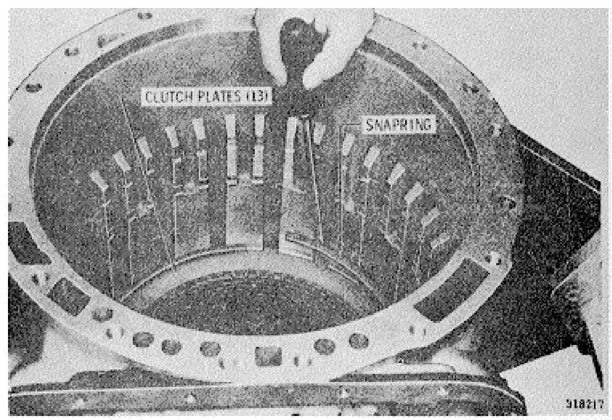

Fig. 7-3. Installing second clutch, external-tangled plate

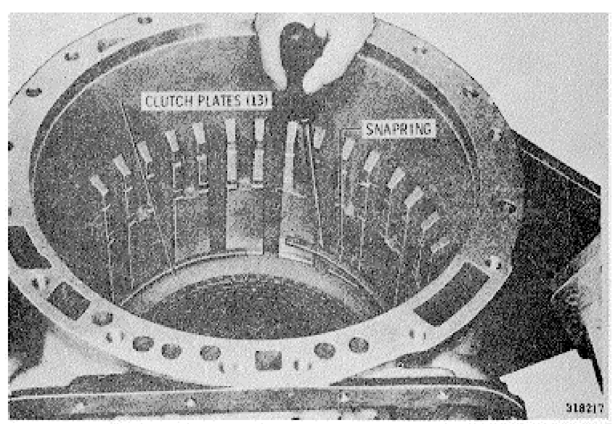

Fig. 7-4. Installing second clutch snapring

ASSEMBLY

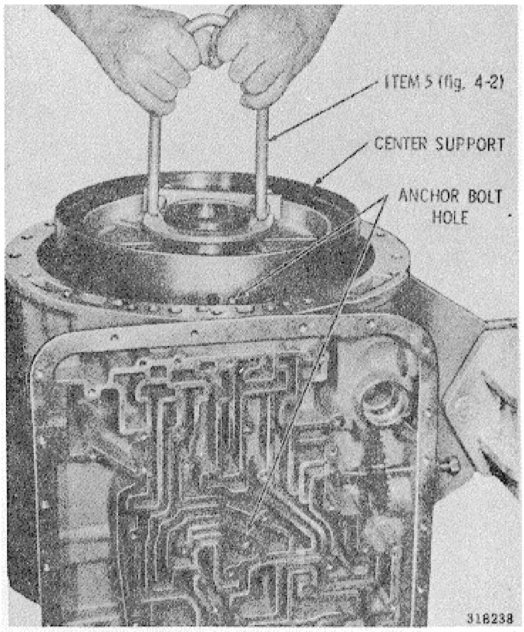

Fig. 7-5. Installing center support assembly

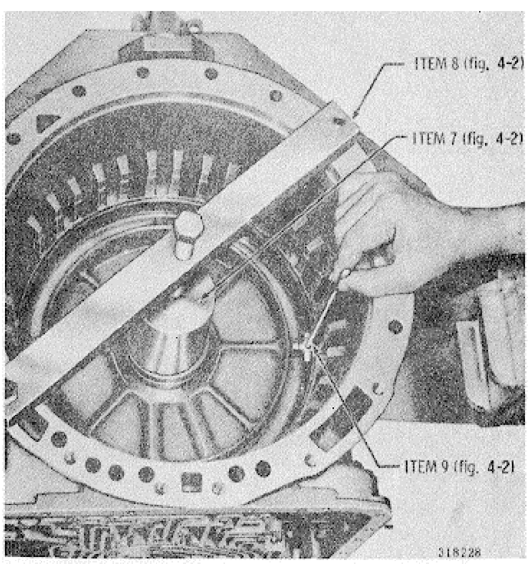

Fig. 7-6. Checking selective snapring clearance

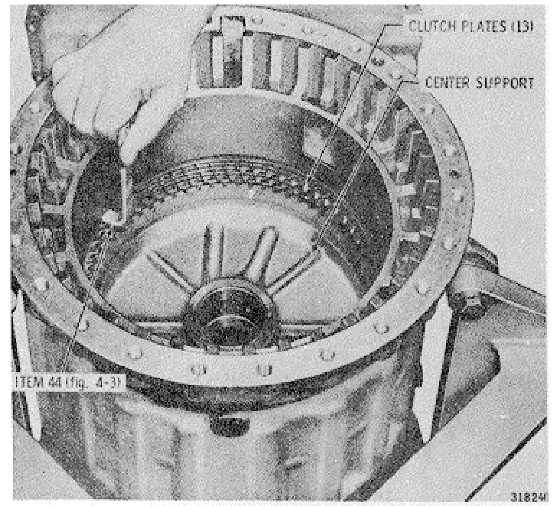

Fig. 7-7. Checking second clutch plate clearance

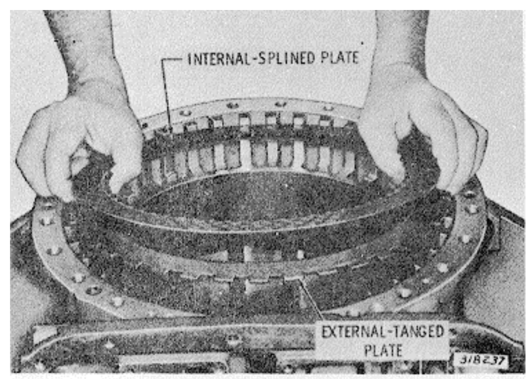

Fig. 7-8. Installing first clutch plates

7-4. ESTABLISHING CLUTCH CLEARANCES, SELECTING CENTER SUPPORT SNAPRING

a. Low and First Clutch Clearances

(1) Place the transmission housing in a vertical position, rear end upward (Fig. 7-8).

(2) Beginning with an external-tanged clutch plate, alternately installs even external-tanged, and six internal-splined first clutch plates (Fig. 7-8).

(3) Install the adapter housing assembly (as assembled in para 6-25) and gasket.

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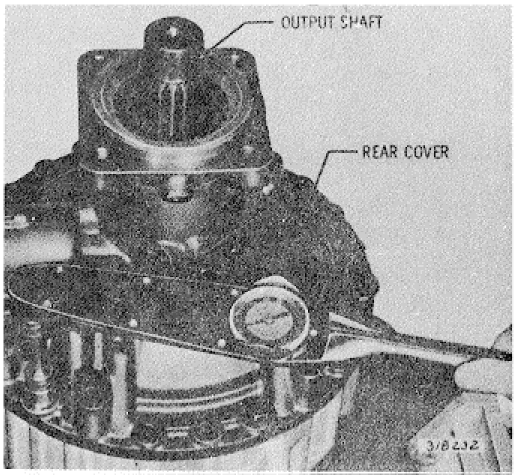

Fig. 7-9. Installing rear cover assembly

(4) Beginning with an external-tanged clutch plate, alternately install seven external-tanged and six internal-splined low clutch plates (refer to Fig. 7-19).

(5) Install the rear cover assembly (as assembled in para 6-22) and gasket onto the rear of the transmission housing and secure it with six 1/2-13 bolts and flatwashers, evenly spaced (Fig. 7-9). Tighten the bolts to approximately 30 pound feet (41 Nm) torque.

(6) Invert the transmission, front end upward. Using gage 44 (Fig. 4-3), check the clearance between the low clutch plates (fig. 7-10). It is recommended the gage be placed between the adapter housing wall and the first steelplate. The prescribed running clearance is 0.095 to 0.145 inch (2. 41 to 3.68 mm) Any dimension within 0.095 to 0.145 inch (2.41 to 3.68 mm) is satisfactory. However, the closer the clearance is to 0.095 inch, the longer the interval between clutch plate replacements will be. Clearance must not be less than 0.095 inch. Replace worn clutch plates with new plates to establish the desired clearance. Recheck the clearance as described above.

(7) Using gage 44 (Fig. 4-3), check the clearance between the first clutch plates (Fig. 7-11). It is recommended the gage be placed between the transmission housing and the first steel plate. The prescribed running clearance is 0.095 to 0.145 inch (2.41

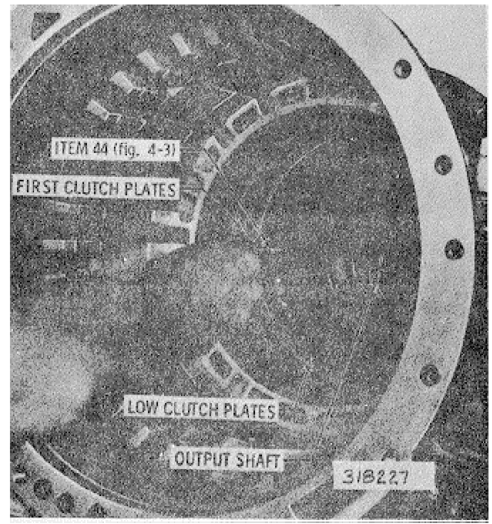

Fig. 7.10. Checking low clutch clearance

to 3.68 mm). Any dimension within 0.095 to 0.145 inch (2. 41 to 3.68 mm) is satisfactory. However, the closer the clearance is to 0.095 inch, the longer the interval between clutch plate replacements will be. Clearance must not be less than 0.095 inch. Replace worn clutch plates with new plates to establish the desired clearance. Recheck the clearance as described above.

<u>b</u>. <u>Selecting Center Support Slapring</u>

(1) Install thirteen second clutch plate s, beginning with an external-tanged plate. Alternately install seven external tanged plates and six internal-splined plates (Fig. 7-3).

(2) Install the clutch plate retaining snapring (Fig. 7-4). Be sure the snapring gap is at the top of the transmission housing.

(3) Remove the third-clutch piston from the center support assembly (if not previously removed). Install bracket 5 (Fig. 4-2) into the recess between the step-joint sealrings on the center, support hub (Fig. 7-5).

(4) Install the center support into the transmission housing (Fig. 7-5). Be sure the

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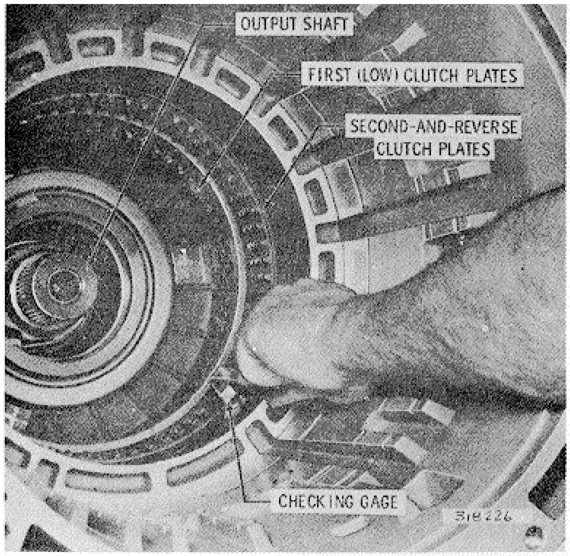

Fig. 7-11. Checking first clutch clearance

tapped hole in the support is aligned with the anchor bolt hole in the bottom of the housing.

(5) Remove lifting bracket 5 (Fig. 4-2) from the center support, Install the special 3/8-16 x 2 1/4-inch anchor bolt into the support through the anchor bolt hole in the bottom of the housing (Fig. 7-5). Tighten the bolt finger tight.

(6) Place compressor sleeve 7 (Fig. 4-2) on the hub of the center support. Place compressor 8 (Fig. 4-2) across the transmission housing Retain the compressor bar with two bolts (Fig. 7-6)

(7) Compress the center support with a force of 5 pound feet (6. 78 Nm) torque. Use gage 9 (Fig. 4-2) to determine the width of the snapring opening while the support is loaded (Fig. 7-6). The lugs of the gage are color coded to match the snapring colors. Select one of the snaprings listed below. Select the thickest snapring that can be put into the groove.

Snapring color code	Snapring thickness
Blue	0.148-0.150 in. (3.76-3.81 mm)
Yellow	0.152-0.154 in. (3.86-3.91 mm)
Green	0.155-0.157 in. (3.94-3.99 mm)
Red	0.158-0.160 in. (4.01-4.06 mm)

(8) Install the snapring to retain the center support (selected in b(7), above). Be sure the snapring gap is at the top of the transmission housing.

(9) Remove compressor 8 (Fig. 4-2) and sleeve 7.

c. Second Clutch Clearance

(1) Invert the transmission housing, rear cover side up.

(2) Remove the six bolts and washers that temporarily retained the rear cover to the transmission housing. Remove the rear cover and gasket. (Refer to figure 7-9.)

(3) Remove the thirteen low clutch plates from the adapter housing. (Refer to figure 7-21.) Since these plates are preset for the low clutch running clearance, they should be maintained in a package form so they cannot be intermixed with other plates.

(4) Remove the adapter housing and gasket from the transmission housing. (Refer to figure 7-28.)

(5) Remove the thirteen first clutch plates from the transmission housing. These plates are now preset for proper clearance and should be maintained as a package for final installation.

(6) Using gage 44 (Fig. 4-3), check the second-clutch plate clearance (Fig. 7-7). It is recommended the gage be placed between the transmission housing and the first steel plate. The prescribed running clearance is 0.095 to 0.145 inch (2.41 to 3.68 mm). Any dimension within .095 to 0. 145 inch is satisfactory. However, the closer the clearance is to 0.095 inch, the longer the interval between clutch plate replacements will be. Clearance must not be less than 0.095 inch. Replace worn plates with new plates to establish the desired clearance. Recheck the clearance as described above.

NOTE

Leave the second clutch and the center support in the transmission housing until the housing is again positioned front end upward. Begin assembly of Model HT 750CRD at paragraph 7-6.

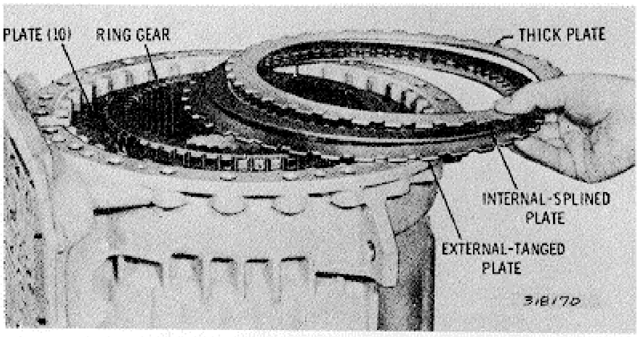

Fig. 7-12. Installing first clutch plates

7-6. INSTALLING FIRST CLUTCH, GEAR UNIT, SECOND CLUTCH, CENTER SUPPORT

a. First Clutch, Rear Planetary Ring Gear

(1) Place the rear planetary ring gear, short splines (rear) downward, on a bench. Install ten of the plates from the clutch pack removed in 7-4c(5), above, as follows. Lay aside the first three plates from the piston end of the pack (refer to para 7-2b). Starting with the fourth plate in the pack (internal splined), alternately install five internal splined and five external tanged plates onto the ring gear.

(2) Align the external tangs of the plate pack. Carefully invert the ring gear and plate pack, and install the assembled parts into the rear of the transmission housing.

(3) Install the three remaining plates of the pack (external-tanged, internal-splined, external-tanged sequence).

NOTE
Last plate installed must be a thick plate.

(4) Place the adapter housing with piston (front) downward onto the transmission housing.

(5) Install compressor bar 8 (Fig. 4-2) onto the adapter housing. Retain it with two 1/2-13 x 5 3/4-inch bolts (Fig. 7-14).

(6) Position the transmission with the front end upward.

(7) Remove the center support snapring and anchor bolt. Attach bracket 5 (Fig. 4-2) to the center support, and remove the support assembly (Fig. 7-5).

(8) Remove the snapring and the second clutch plates (Fig. 7-4). These plates are now preset for proper clearance and should be retained as a pack for final installation.

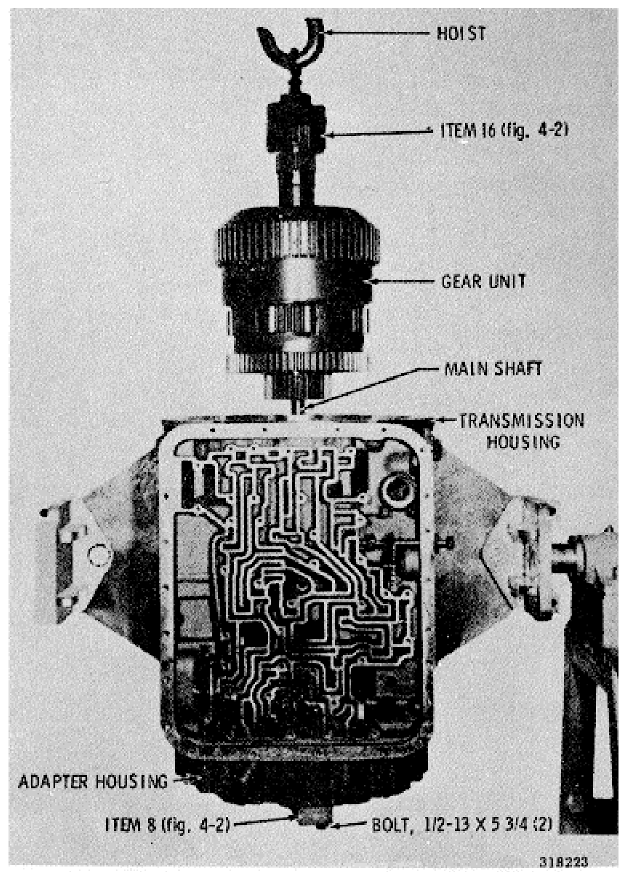

Fig. 7-14. Installing gear unit assembly

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Para 7-6

b. Gear Unit, Second Clutch, Center Support

(1) Attach lifting bracket 16 (Fig. 4-2) to the assembled gear unit (Fig. 7-14). Lower the gear unit carefully, aligning the pinions of the rear planetary to mesh with the rear planetary ring gear.

(2) Install the second clutch plate pack removed in a(8) above. The thinner external tanged plates should all be toward the rear of the transmission housing (refer to para7-2b). Begin with an external-tanged plate (Fig. 7i5) and alternately install seven external-tanged and six internal-splined plates.

(3) Install the snapring that retains the second clutch pack (Fig. 7-16).

(4) Install the third clutch piston assembly into the center support. The lips of the sealrings must be toward the cavity in the

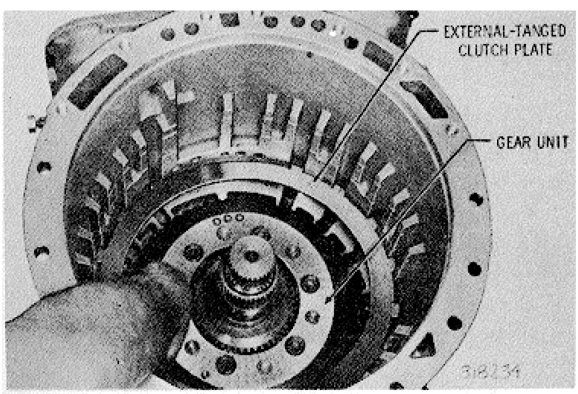

Fig. 7-15. Installing second clutch plate

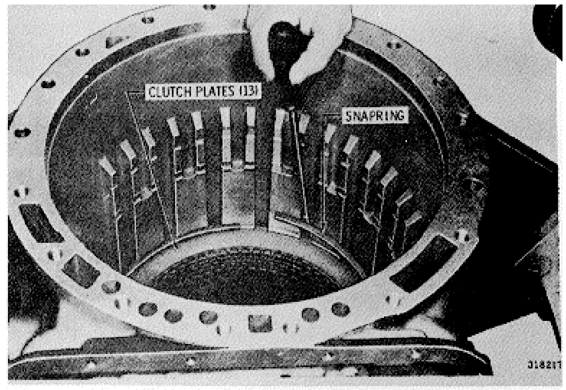

Fig. 7-16. Installing second clutch snapring

center support. Using lifting bracket 5 (Fig. 4-2), install the center support assembly, aligning its tapped hole with the anchor bolt hole in the transmission housing (Fig. 7-17).

(5) Install the special 3/8-16 x 3-inch (2 1/4-inch in earlier models) anchor bolt and plain washer, finger-tight. Remove the lifting bracket.

(6) Install the snapring, selected in paragraph 7-4b(7), that retains the center support assembly (Fig. 7-25). The gap of the snapring should be toward the top of the transmission.

(7) Position the transmission rear upward, and remove the two bolts and compressor bar from the adapter housing.

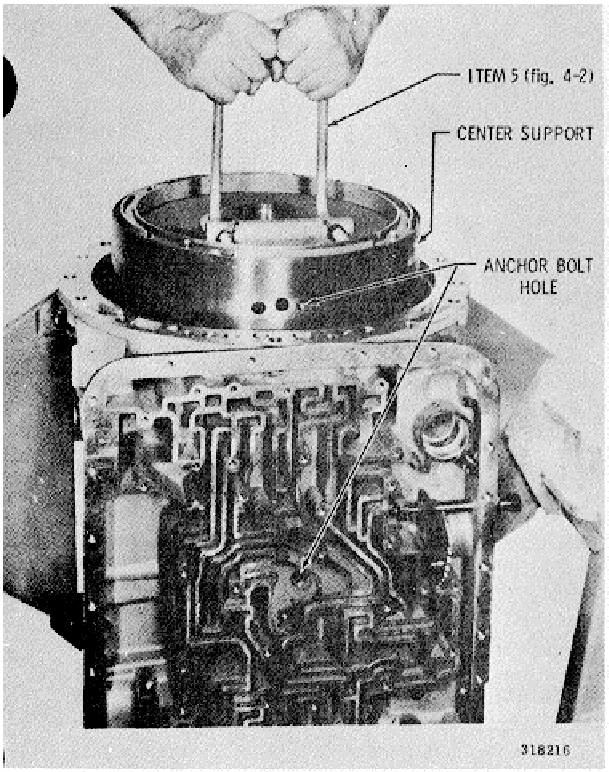

Fig. 7-17. Installing center support

7-7. INSTALLING REAR COMPONENTS

a. Adapter Housing, Low Clutch, Low Ring Gear

(1) Place the low ring gear, flat side (rear) downward on a bench. Install ten plates of the low clutch pack removed in paragraph 7-4c(3), as follows. Lay aside the first three plates from the piston end of the pack. The plates laid aside should include two thick external tanged plates (refer to paragraph7-2b). Beginning with the fourth plate in the pack (internal-splined), alternately install five internal-splined and five external-tanged plates onto the ring gear.

(2) Remove the adapter housing from the transmission housing, being careful to not drop the first clutch piston.

(3) Place the adapter housing, with piston upward, over the assembled low ring gear and clutch plates.

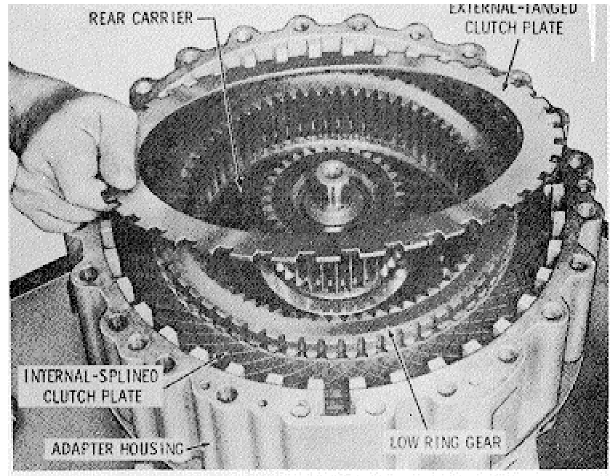

Fig. 7-18. Installing low clutch plates and ring gear

(4) Install the adapter housing gasket onto the adapter housing, aligning the holes in the gasket with those in the housing, Retain the gasket with oil-soluble grease.

(5) Grasp the assembled adapter housing, ring gear and clutch plates, invert the assembly and install it onto the rear of the transmission housing as follows.

(6) Align the adapter housing dowel pins with proper holes in the transmission housing. Lower the adapter housing until the internal teeth of the low ring gear begin to mesh with splines on the rear planetary carrier hub. Support the adapter housing while meshing the low ring gear by tapping with a soft mallet. When mesh is complete, seat the adapter housing.

(7) Install the three remaining low clutch plates.(laid aside in (1), above). Install the plates in external-tang, internal spline, external-tang sequence (fig. 7-18).

b. Low Planetary, Rear Cover Assembly

(1) Install the low planetary carrier by carefully aligning the teeth of the four pinions with those of the low ring gear (fig. 7-19).

CAUTION

Do not lift the low carrier by the ball bearing. The bearing may be loose, permitting the assembly to drop.

ASSEMBLY

Para 7-7

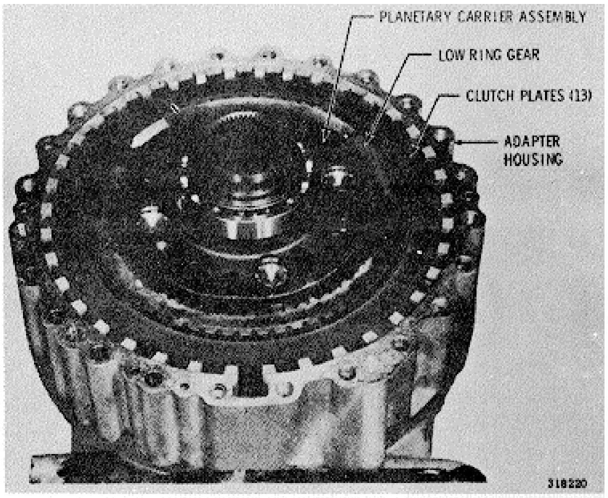

Fig. 7-19. Low planetary carrier, ring gear and clutch

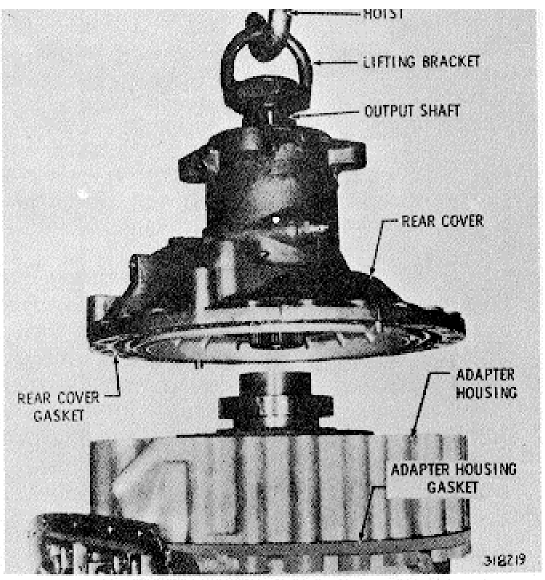

Fig. 7 .20. Installing rear housing

(2) Place the rear cover gasket onto the rear cover. Retain the gasket with oil soluble grease (fig. 7-20). Be sure the holes in the gasket are aliened with those in the adapter housing.

(3) Attach a lifting bracket to the output shaft (fig. 7-20). Using a hoist, guide the cover onto the adapter housing. Since the two dowel pins in the cover are of different size, simplification of installation is achieved.

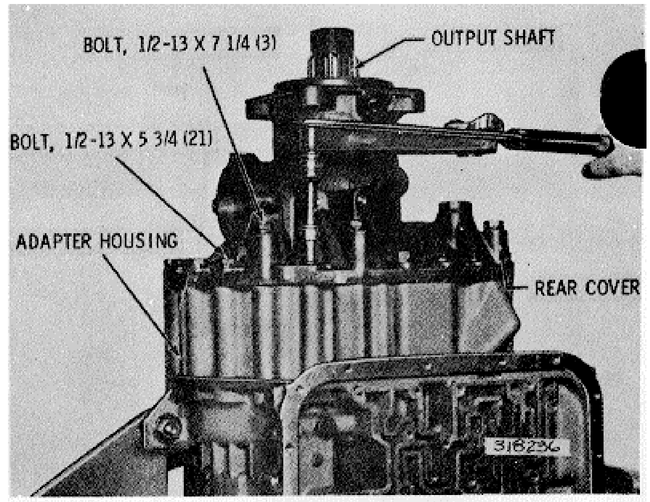

Fig. 7.21. Installing rear cover bolts

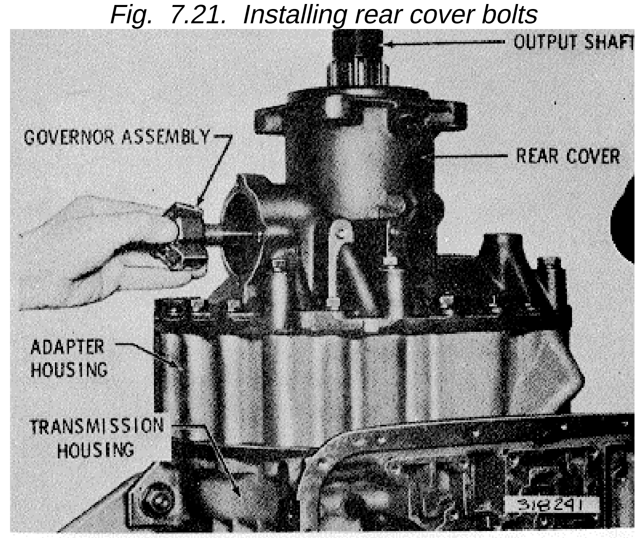

Fig. 7-22. Installing governor assembly

(4) Install twenty-one 1/2-13 x 5 3/4inch bolts and three 1/2 -13 x 7 1/4-inch bolts, and washers, to retain the rear cover (fig. 7-21). Tighten the bolts to 67 to 80 pound feet (90 to 108 Nm) torque.

(5) Install the governor assembly into the rear cover by rotating it counterclockwise (fig. 7-22).

(6) Install the governor cover gasket and cover, and retain them with four 5/1618 x 9/16-inch bolts. Tighten the bolts to 10 to 13 pound feet (14 to 17 Nm) torque.

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Para 7-11

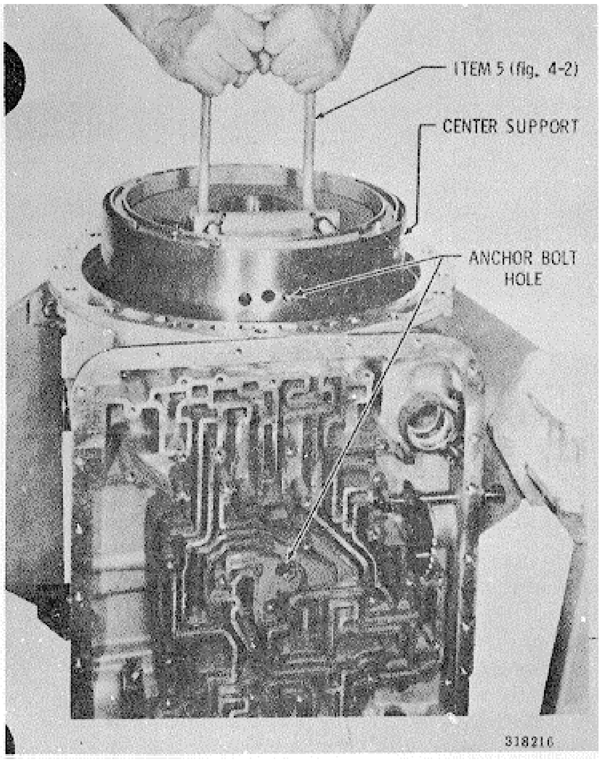

Fig. 7-24. Installing center support

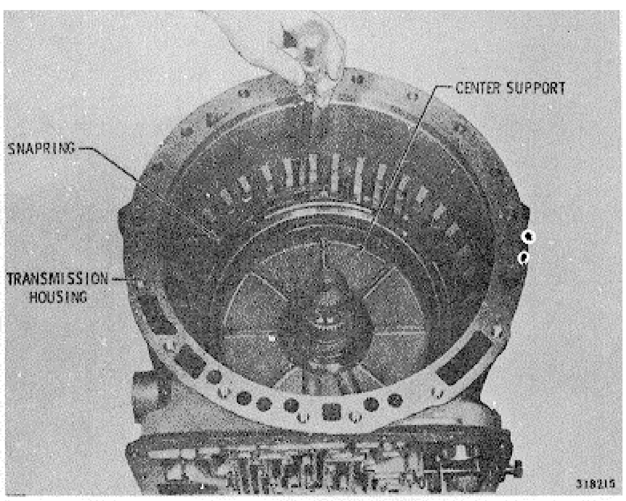

Fig. 7-25. Installing center support snapring

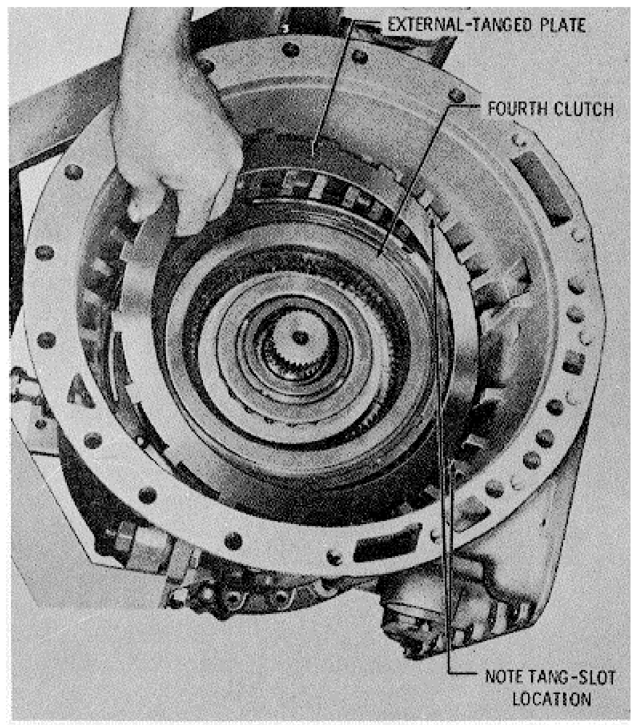

Fig. 7.32. Installing third clutch plates

ASSEMBLY

7-11. INSTALLING FOURTH, THIRD, FORWARD CLUTCHES

a. Fourth Clutch, Third Clutch

(1) Prior to the installation of the fourth-clutch assembly, be sure the bearing races at both the front and back are in place. If not, refer to figures 6-25 and 6-26. Check also that the step-joint sealrings, bearing and race are in place on the center support (fig. 5-21).

(2) Place lifting bracket 18 (fig. 4-2) under the spring retainer of the fourth-clutch assembly (refer to fig. 5-32). Carefully lower the fourth clutch into the transmission. Engage the internal splines with splines on the center sun gear shaft.

(3) Be sure the bearing race at the top (front) of the clutch is in place. If not, lubricate it with oil-soluble grease and install.

(4) Install 8 third-clutch plates (fig. 7-32), beginning with a thick external-tanged plate and alternately installing 4 external tanged plates and 4 internal-splined plates. (Refer to para 7-2b(l), above.).

CAUTION

Be sure the clutch plate next to the piston is a thick plate.

(5) Install the back plate. To insure proper tang to housing slot alignment, use figure 7-32 as a guide.

(6) Install the third-clutch snapring (fig. 7-33). Be sure the gap of the snapring is at the top of the transmission housing.

(7) Check the third clutch running clearance by inserting gage 43 (fig. 4-3) between the snapring and the back plate of the third clutch (fig. 7-33). The clearance should be 0. 060to 0. 120-inch (1. 52 to 3.05 mm). Any dimension between 0.060 to 0.120 inch is satisfactory. However, the closer the clearance is to 0. 060 inch, the longer the interval between clutch plate replacements will be. Replace worn plates with new plates to establish the desired clearance. If the assembly is satisfactory, continue assembly with b, below. Clearance must not be less than 0. 060 inch.

(8) If the clearance is not satisfactory, remove the fourth clutch assembly and replace plates in the third clutch as required to obtain a satisfactory clearance. Refer to paragraph 7-2. Reinstall the fourth clutch assembly and reassemble the third clutch when the clearance is satisfactory.

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ASSEMBLY

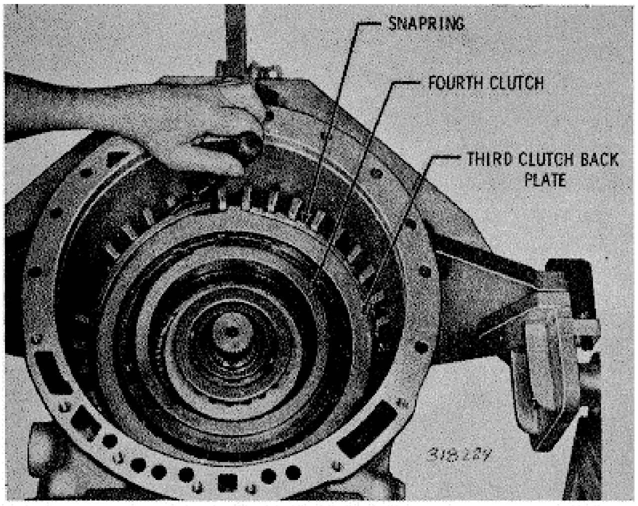

Fig. 7.33. Installing third clutch snapring

b. Forward Clutch

(1) Prior to the installation of the forward clutch assembly, make sure the thrust bearing race and thrust bearing have been installed at the rear of the clutch assembly. Use oil-soluble grease to hold the race and bearing in place during installation of the clutch assembly.

(2) Install alignment fixture 13 (fig. 4-2). Engage the fourth-clutch plates by applying air pressure to the fourth-clutch piston (fig. 7-34). If all plates do not engage tool 13 (fig. 4-2), the fixture will rise slightly when air pressure is applied.

(3) Hold air pressure in the clutch and remove the fixture. Continue holding air pressure, and install the forward clutch assembly (with race and bearing) (fig. 7-35).

(4) Release the air pressure when the forward clutch is fully seated (forward clutch will fall slightly when air is released if the clutch is not fully seated).

(5) Make sure the thrust bearing race on the front of the forward clutch assembly is installed (fig. 7-36). If not, apply oil-soluble grease to the race and install it.

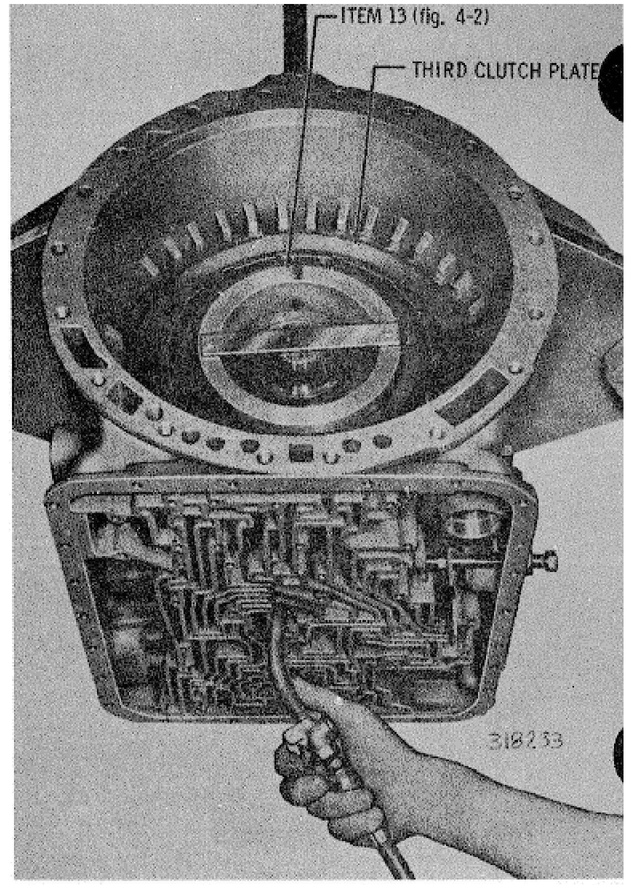

Fig. 7-3,4. Applying air pressure to fourth clutch piston

7-12. INSTALLING TORQUE CONVERTER HOUSING

a. Housing With 2-Bolt Top Cover

(1) Place the converter housing assembly (as assembled in para 6-10) on the work table, so that both the front and rear are accessible.

(2) sure that the thrust race, needle bearing, and two sealrings have been installed at the rear of the converter housing (fig. 6-13)

HT 700D SERIES TRANSMISSION

Para 7-12

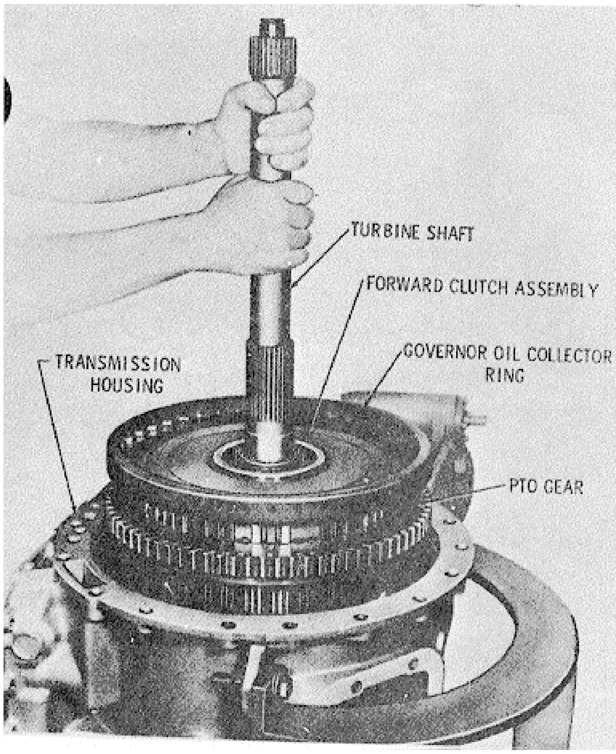

Fig. 7-35. Installing forward clutch assembly

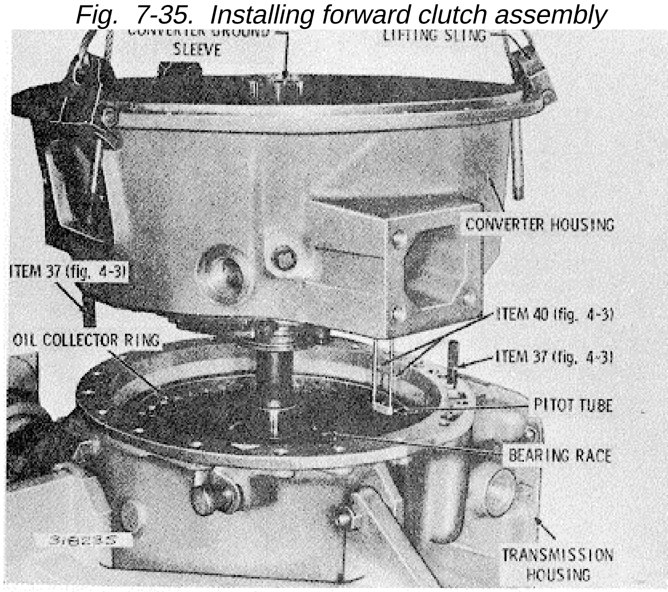

Fig. 7-36. Installing converter housing assembly

(3) Attach a lifting sling to the converter housing (fig. 7-36). Raise the converter housing assembly above the transmission.

(4) Install two 1/2-13 x 2 3/8-inch guide screws 37 (fig. 4-3). One in the converter housing and one in the transmission housing (fig. 7-36).

(5) Install two #10-32 x 6-inch guide screws 40 (fig. 4-3) into the pitot tube. Exit port of pitot tube must face toward guide bolts (fig. 7-36). Install the pitot tube and guide bolts so that the guide bolts enter the screw holes in the converter housing, and entrance port of pitot tube faces outward (toward pitot collector ring) (fig. 7-36).

(6) Install the converter housing onto the transmission housing, using care to avoid damage to the pitot tube and the collector ring (fig. 7-36).

(7) Install seven 1/2-13 x 2-inch bolts and washers at the inside of the converter housing (fig. 7-37). Tighten the bolts 67 to 80 pound feet (90 to 108 Nm) torque.

(8) Install the pitot tube screws and washers as each guide bolt is removed (fig. 7-38). Tighten the screws to 30 to 48 inch pounds (3. 4 to 5.4 Nm) torque.

(9) Install nine 1/2-13 x 2-inch bolts and washers through the transmission housing into the converter housing (fig. 7-37). The two remaining bolts and washers cannot be

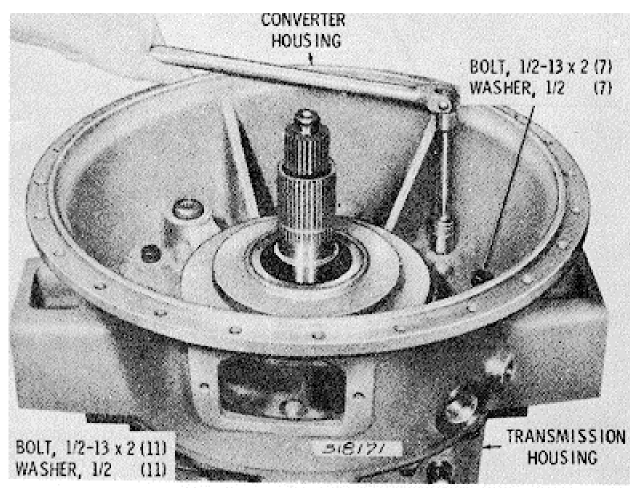

Fig. 7-37. Installing converter housing bolts

ASSEMBLY

installed until the mounting bracket is removed. Tighten the bolts to 67 to 80 pound feet (90 to 108 Nm) torque.

(10) Tighten the center support anchor bolt to 39 to 46 pound feet (53 to 62 Nm) torque (fig. 7-39).

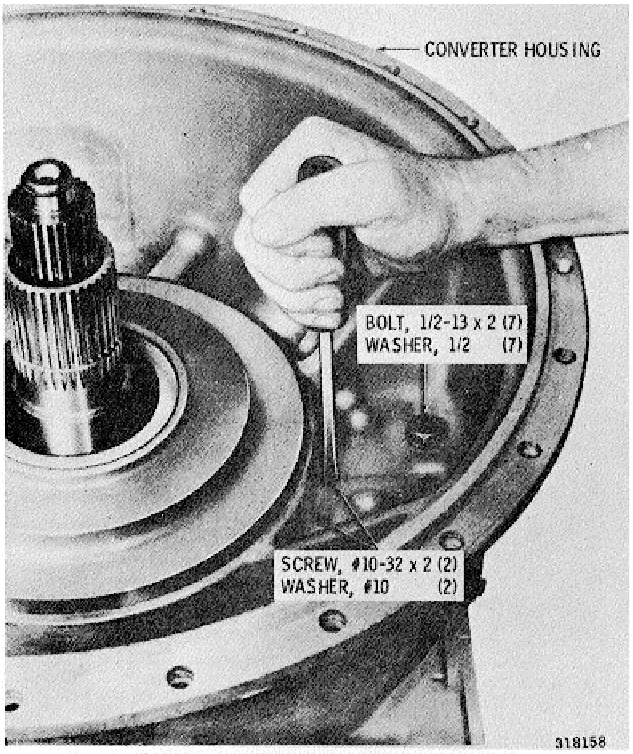

Fig. 7-38 insulating pilot tube screw

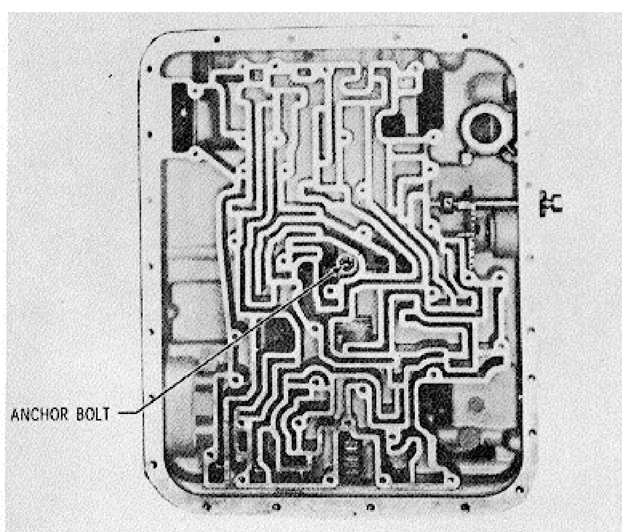

Fig. 7-39 Center support anchor bolt

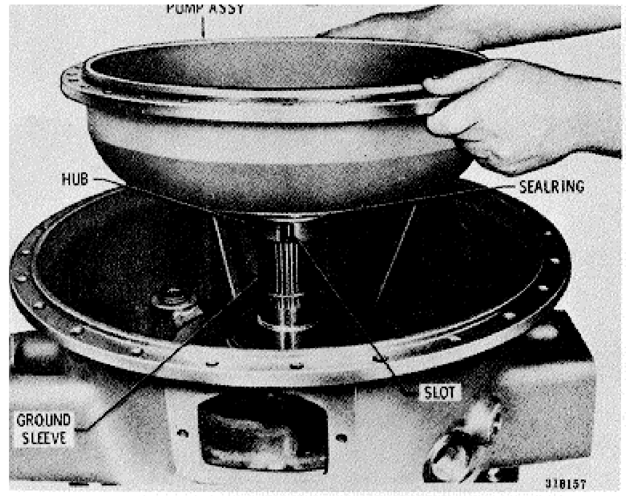

Fig. 7-46 Installing torque converter pump assembly

7-15. INSTALLING TORQUE CONVERTER PUMP, STATOR ASSEMBLIES

a. Pump Assembly

(1) Install the torque converter pump assembly, as rebuilt in paragraph 6-9, onto the ground sleeve (fig. 7-46). Check the sealring on the hub.

NOTE
After transmission S/N 2081, the pump bearing is a press fit on the ground sleeve. It may be necessary to heat the hub and bearing area of the pump assembly to 300°F (149°C) with heated oil before installation.

(2) Align the slot in the pump hub with tangs in the oil pump drive gear as the pump is being installed (fig. 7-46).

(3) Install the splined washer and snapring to retain the pump assembly (fig. 7-47).

(4) Install the sealring near the outer bolt holes of the pump (fig. 7-47).

b. Stator Assembly

(1) Install the freewheel roller race and stator assembly, as rebuilt in paragraph 6-8.

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Para 7-15/7-16

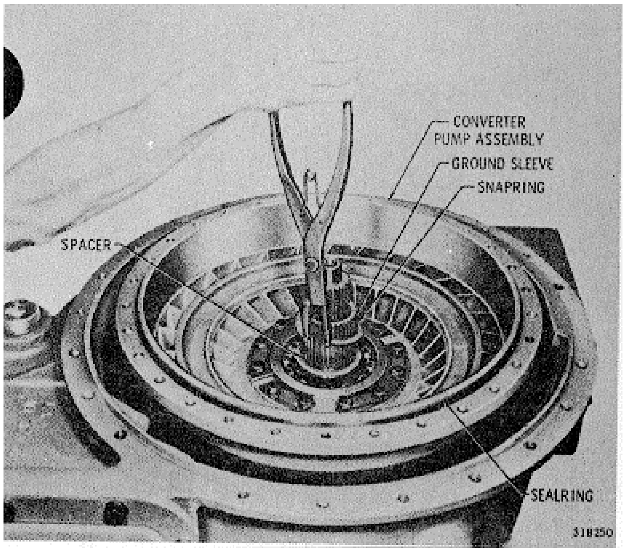


Fig. 7-47 Installing snapring onto the converter ground sleeve

(2) Rotate the stator clockwise to check for freedom of rotation. The stator should lock if counterclockwise rotation is attempted.

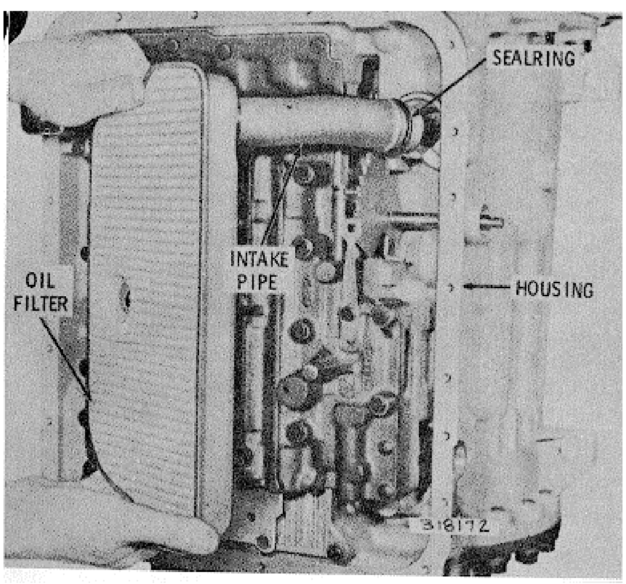


Fig. 7-50 Installing oil filter

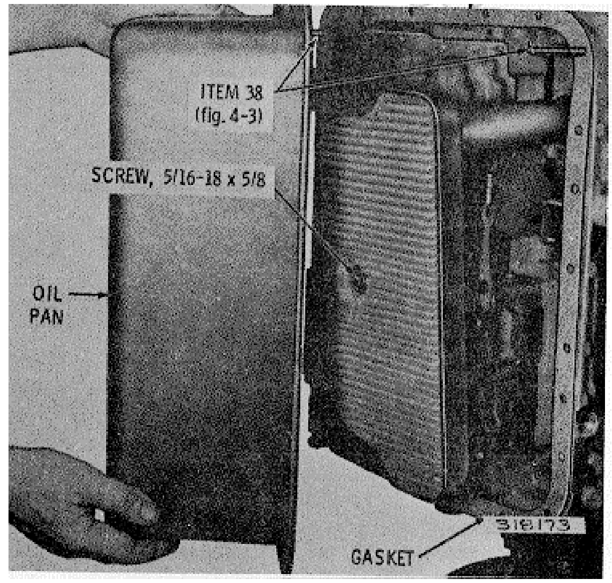


Fig. 7.51 Installing oil pan

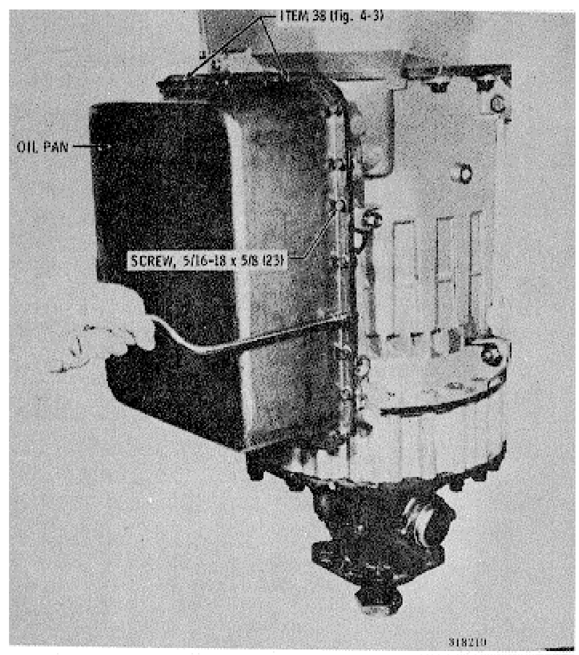


Fig. 7-52 Installing oil pan screws

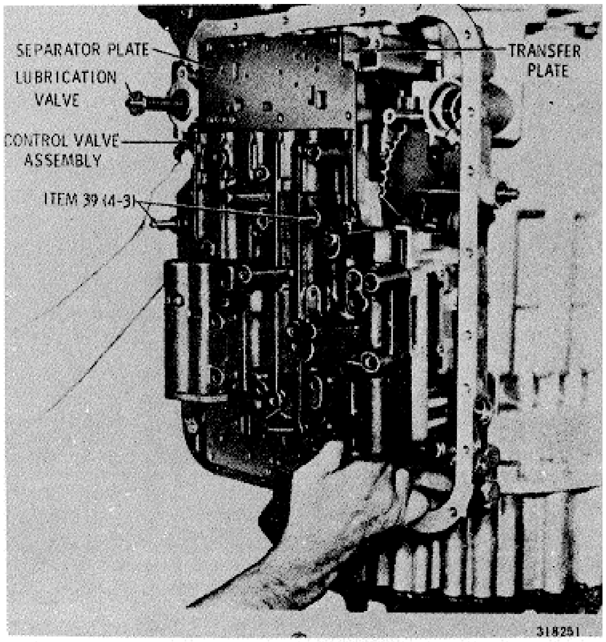


Fig. 7.53 Installing control valve body

7-17. INSTALLING VALVE BODIES, FILTER, OIL PAN

a. Valve Bodies

(1) Install two guide screws 39 (fig. 4-3) into opposite holes in the bottom of the transmission housing (fig. 7-53).

(2) Install the control valve assembly (as assembled in para 6-4), using the guide screws as support, onto the transmission. The groove in the selector valve must engage the pin on the detent lever.

(3) Install the lubrication check valve baffle and retain it with two 1/4-20 x 1 1/2inch bolts marked A (fig. 7-54).

(4) Install two 1/4-20 x 1 1/2-inch bolts B and two 1/4-inch washers through the oil transfer plate and into the transmission housing (fig. 7-54). Bolts A and B retain the oil transfer plate, separator plate and control valve assembly to the transmission housing.

(5) Install fifteen 1/4-20 x 3-inch bolts "C" through the valve body assembly and into

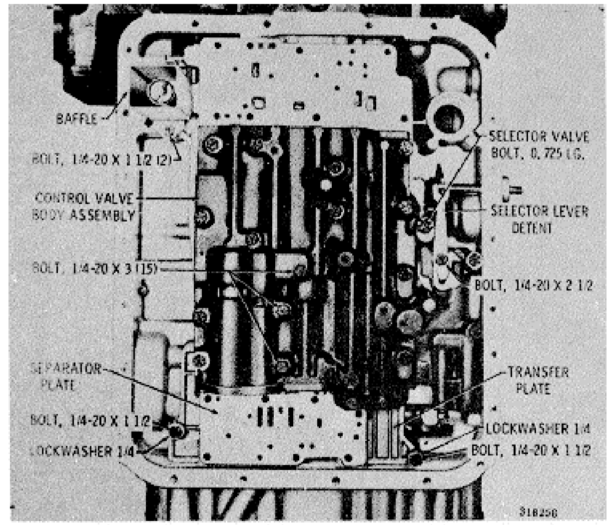


Fig. 7-54 Control valve body bolt locations

the housing (fig. 7-54). Earlier models use seventeen 3-inch bolts, two of which were replaced by two 3 1/2-inch bolts at the lower "D" positions in later models. Install three 1/4-20 x 3 1/2-inch bolts "D" (earlier models use only one at the top "D" position). Install the selector detent and retain it with a 1/420 x 2 1/2-inch bolt "E".

NOTE

Some transmissions use cover plate 21 (A, foldout 14), retained by eight 1/4-20 x 2-inch bolts 22, instead of the lockup shift valve body assembly. Tighten all of the bolts to 8 to 12 pound feet (11 to 16 N.m) torque.

(7) Install the low shift valve body onto the lower guide screw (fig.7-56). Retain the body with one 1/4-20 x 2 3/4-inch bolt.

(8) Install the low trimmer valve (fig. 7-56). Install five of six 1/4-20 x 4-inch bolts to retain the trimmer valve. Remove the guide screw and install the remaining 4-inch bolt.

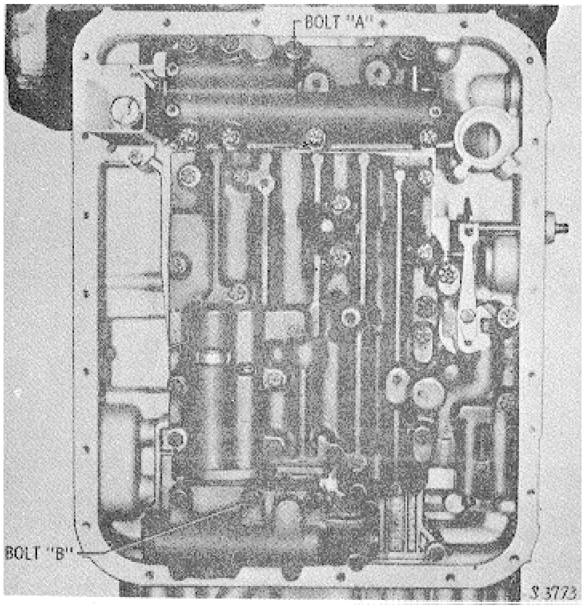


Fig. 7-56 Valve body assemblies (HT750)

(9) Hold the detent in alinement over the detent lever while the 2 1/2-inch bolt is tightened to 8 to 12 pound feet (11 to 16 Nm) torque. Tighten all (38) of the bolts to 8 to 12 pound feet (11 to 16 Nm) torque.

(10) Install the signal tube (fig. 7-57).

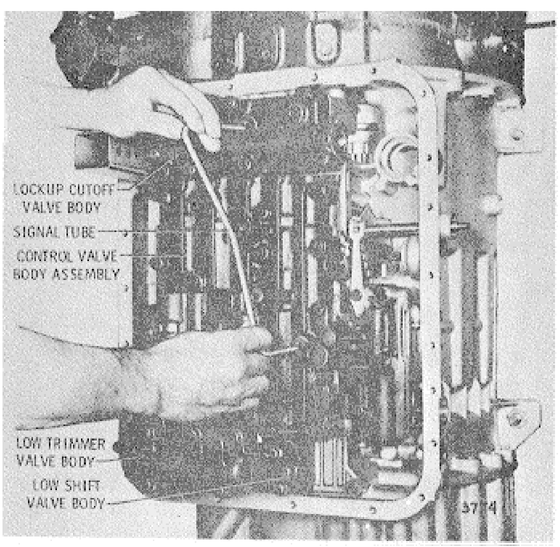


Fig. 7-57 Installing signal tube (HT750)

b. Oil Filter, Oil Pan

(1) Install the sealring onto the oil intake pipe (fig. 7-50). Lubricate the sealring with oil-soluble grease.

(2) Install the oil filter making sure the intake pipe fits snugly into the housing (fig. 7-50). Do not twist the oil filter during installation push straight inward.

(3) Retain the oil filter with one 5/16-18 x 5/8-inch, washer headscrew and a spacer between the filter and valve body (fig. 7-51). Tighten the screw to 10 to 13 pound feet (14 to 18 N.m) torque.

(4) Install two 5/16-18 x 3-inch guide screws 38 (fig. 4-3) into the transmission housing (fig. 7-51).

(5) Install a new oil pan gasket over the guide screws. Aline all holes in the gasket with those in the housing (fig. 7-51).

NOTE

Do not apply grease or any type of sealer to the oil pan gasket except in the area outside the bead on the oil pan flange.

(6) Install 'the oil pan (fig. 7-51). Install twenty-three 5/16-18 x 5/8-inch, washerhead screws (fig. 7-52). Tighten the screws evenly to 10 to 13 pound feet (14 to 18 N.m) torque.

7-18. INSTALLING FLYWHEEL, LOCKUP CLUTCH, TORQUE CONVERTER TURBINE

a. Aline Flywheel for Installation

(1) Position the transmission horizontally (fig. 7-58).

(2) Place the flywheel assembly (as assembled in para 6-3) on a work table, ring

ASSEMBLY

Para 7-18

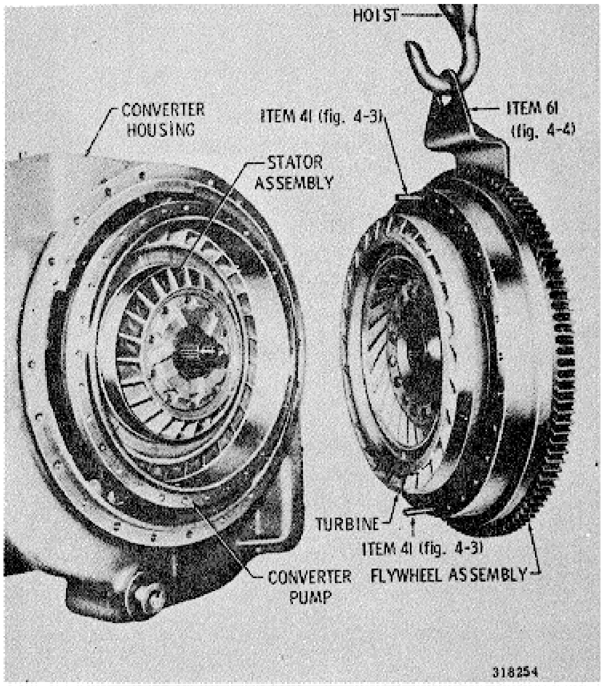


Fig. 7-58 Installing flywheel and turbine

gear side down. Install one 3/8-24 x 2-inch guide screw 41 (fig. 4-3) into one of the flywheel mounting holes (fig. 7-58).

(3) Carefully lift the flywheel to a vertical position and attach a lifting bracket 60 (fig. 4-4) opposite the guide screw. Retain the bracket with 1/2-20 bolts.

(4) Attach a hoist to the lifting bracket. Aline the flywheel assembly with the transmission (fig. 7-58).

b. Installation

(1) Push flywheel assembly straight onto the transmission, alining guide screw 41 (fig. 4-3) through one bolt hole in the converter pump. Engage turbine splines with the forward clutch shaft splines (fig. 7-59).

(2) Using the access hole at the top of the converter housing install one 3/8-24 x 1 1/4-inch bolt and one 3/8 flat washer through the converter housing into the flywheel assembly (fig. 7-60).

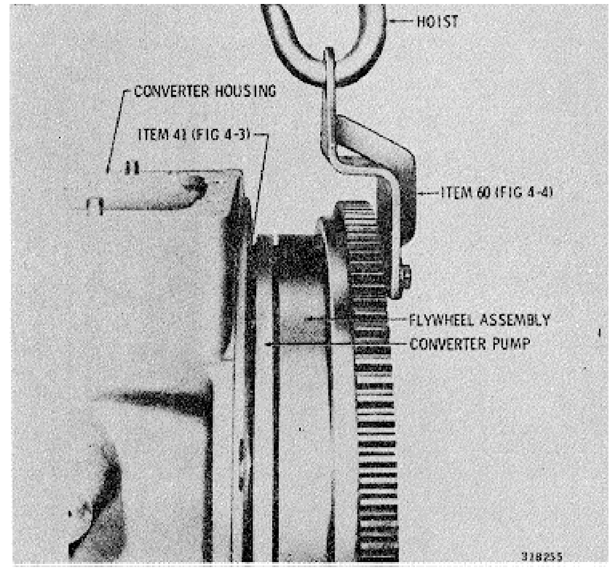


Fig. 7-60 Installing flywheel on the converter pump

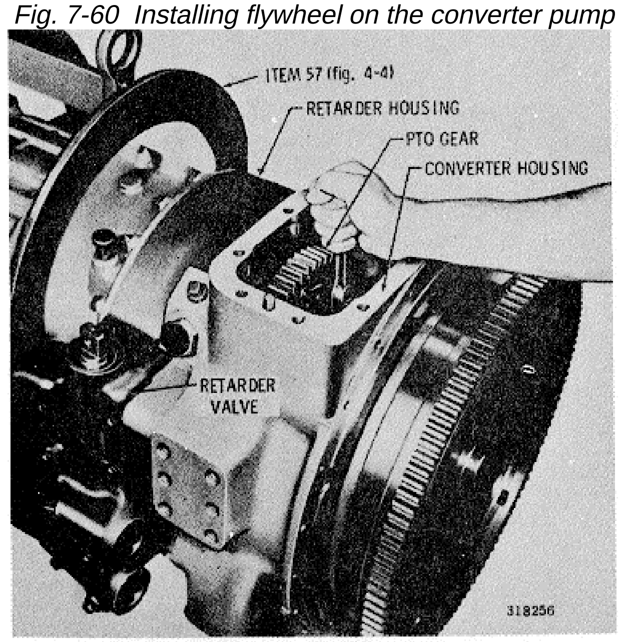


Fig. 7-60 Installing flywheel retaining bolts

(3) Release the hoist and remove the lifting bracket.

(4) Install the remaining 29 bolts and flat washers (fig. 7-60). Prior to installing the last bolt and washer, remove guide screw 41 (fig. 4-3).

(5) Tighten the bolts to 41 to 49pound feet (56 to 66 Nm) torque.

HT 700D SER IES TRANSMISSION

Para 7-19

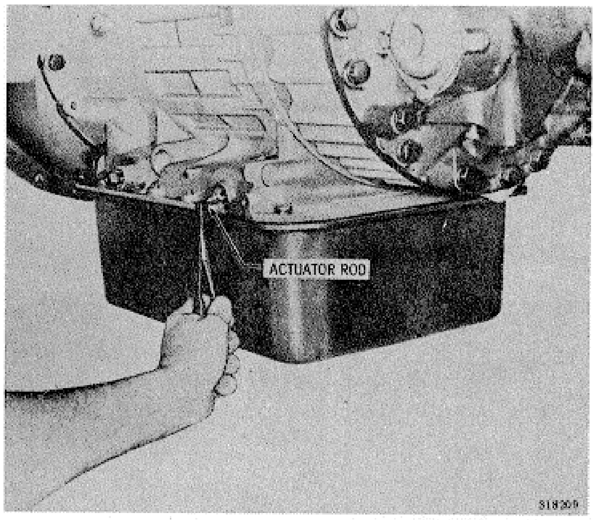


Fig. 7-61 Installing modulator actuator rod

7-19. INSTALLING EXTERNAL COMPONENTS

a. External Components

(1) Install the modulator pressure valve actuator rod (fig. 7-61).

(2) Install the modulator valve retainer and secure it with one 5/16-18 x 9/16inch bolt (fig. 7-62). Do not tighten the bolt at this time (modulator actuator will be installed when the transmission goes into the vehicle).

(3) Install items 1 through 4 (A, foldout 9). Tighten the bolts to 26 to 32 pound feet (35 to 43 Nm) torque.

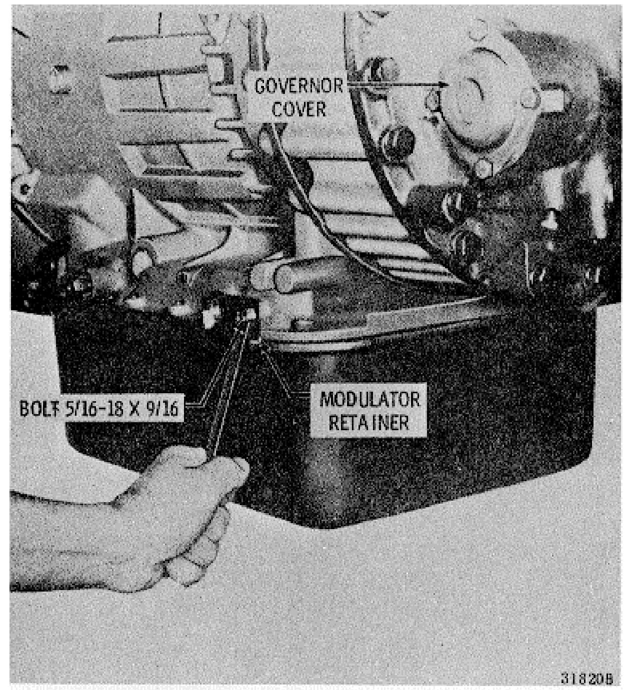


Fig. 7-62 Installing modulator actuator retainer

b. Removing from Overhaul Stand

(1) Attach a hoist to the holding fixture that is secured to the transmission (fig. 7-63).

(2) Remove all fasteners that retain the holding fixture and the transmission to the overhaul stand. Remove the transmission and fixture from the overhaul stand.

(3) Remove the four bolts and nuts that retain the holding fixture to the transmission. Remove the fixture.

(4) Install any nuts, bolts or washers that may have been blocked by the transmission holding fixture (fig. 7-63). Tighten the nuts to 83 to 100 pound feet (113 to 135 Nm) torque; tighten the bolts to 67 to 80 pound feet (90 to 108 Nm) torque.

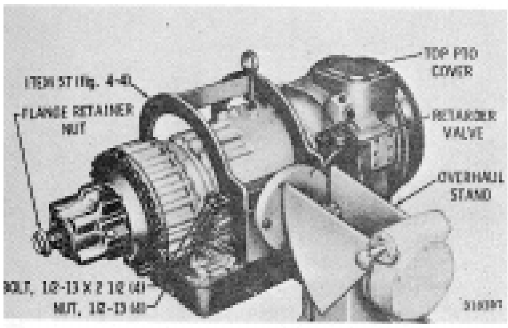


Fig. 7-63 Removing transmission from overhaul stand

7-20. REPLACING OUTPUT SHAFT SEAL, BEARING, SPEEDOMETER DRIVE GEAR (in vehicle)

a. Removal

(1) Remove the vehicle drive shaft from the transmission output flange. Remove the speedometer driven gear from the transmission rear cover. Remove the output flange.

(2) Remove the dust shield, oil seal and rear bearing snapring (refer to para 6-22a).

(3) Using puller assembly 53 (fig. 4-3), remove the rear bearing. The legs of the puller assembly are designed to be locked between the inner and outer ball races of the bearing assembly. The bearing is pulled by tightening the puller screw against the rear of the output shaft.

(4) Remove the spacer and speedometer drive gear.

b. Installation

(1) Install the speedometer drive gear, and spacer and bearing. Use installer 59 (fig. 4-3) and driver handle 28 to seat the bearing.

(2) Install the bearing snapring, oil seal and dust shield (refer to para 6-22b).

(3) Install the rear output flange and tighten the nut to 750 to 1000 pound feet (1017 to 1357 Nm) torque.

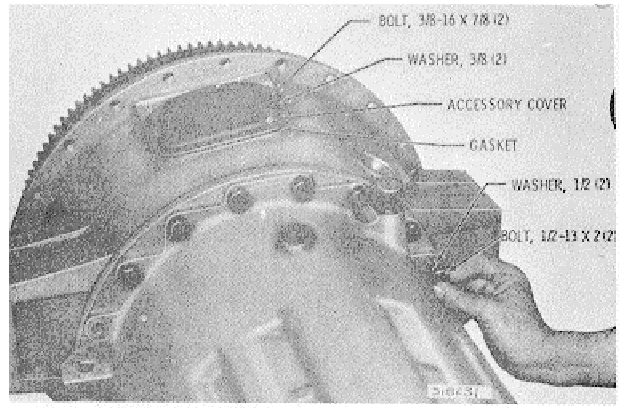


Fig. 7-64 Installing converter housing retainer bolt

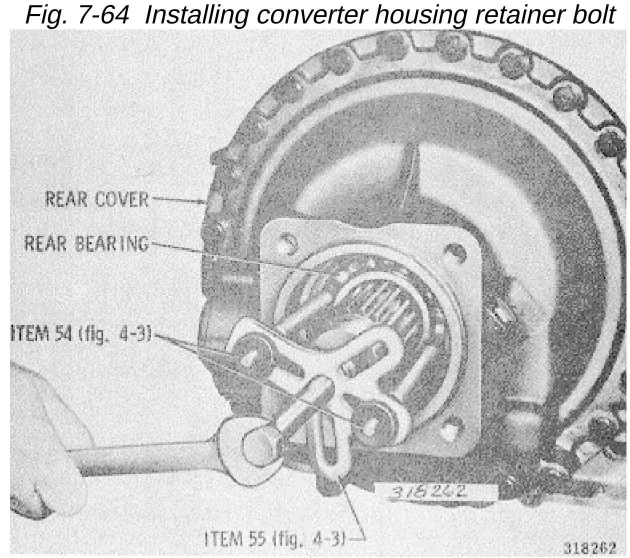


Fig. 7-65 Removing rear bearing

(4) Install the speedometer driven gear into the transmission rear cover. Connect the speedometer drive cable.

(5) Install the vehicle drive shaft (refer to vehicle service manual).

7-21. CHECKING SHIFT POINTS

Refer to paragraph 3-11 for procedures covering checking and adjusting shift point speeds.

7-22. POWER TAKEOFF COMPONENTS

a. Existing Installation

(1) Unless space limitations prevent, install the PTO components before the transmission is installed in the vehicle.

(2) Use the proper shims or gaskets to establish satisfactory gear backlash(0.006 to 0.012 inch).

CAUTION

Cork or other soft gasket material cannot be used to mount the PTO. Use only the shims or gaskets recommended by the PTO manufacturer.

(3) Connect the lubrication line (if used).

b. New Installation

(1) Contact Detroit Diesel Allison Division for approval of planned installation, or for recommendations.

(2) Speeds, type of duty, power requirements, and other factors must be considered when adding a PTO to a transmission. If the job requirements of the PTO cannot be fully met by the transmission, the installation will not be satisfactory. Also, the transmission could be damaged.

(3) Follow all of the recommendations in a, above.

(4) If a lubrication source is required, the return line from cooler-to-transmission may be tapped. Provide a 0.032 inch restriction in the lubrication circuit (usually already provided in PTO assembly).

Section 8. WEAR LIMITS AND SPRING DATA

8-1. SCOPE OF SECTION 8

This section tabulates wear limits and spring data.

8-2. WEAR LIMITS DATA

a. Maximum Variations. Wear limits information in this section shows the maximum wear at which components are expected to function satisfactorily.

b. Cleaning, Inspection. Parts must be clean to permit effective inspection for wear or damage. Refer to Section 4, above.

c. Bearings, Bearing Journals, Bores. The application of bearings to any product is based on the recommendations of the bearing manufacturer and, therefore, no diametral dimensional deviation should be permitted in the bearing or mated parts. Bearings should be carefully checked for signs of distress before reinstalling in the transmission.

d. Gears. Gears should be inspected for load pattern and signs of distress. Any distress indicates a possible future failure, and the reuse of such gears should be the decision of the individual customer, based on experience. Backlash cannot be used to establish critical wear of a gear. The backlash tolerances are of such nature that a gear usually pits, scuffs, scores, or galls long before the gear wear becomes critical.

e. Splines. Unless severe, spline wear is not considered detrimental except where it affects tightness of an assembly such as drive line flanges. Here, again, backlash cannot be used to establish critical wear because both mating parts must be concentrically located to obtain accurate measurement of backlash.

f. Hook-type Sealrings. Sides of the sealring should be smooth (maximum wear 0.005 inch (0.13 mm)). The sides of the groove into which the sealrings fit should be smooth (50 microinch (1. 27 iLm) equivalent), and square with the axis of rotation within 0.002 inch (0. 05 mm). A new sealring should be installed if grooves are reworked, or if there is wear on the sealring outside diameter.

g. Oil Seals. Seals should be replaced if they show signs of excessive hardening, sc o ring, cracking or other indications of deterioration. See Section 4.

8-3. SPRING DATA

Springs must be clean to permit effective inspection. Springs should be replaced if there are signs of overheating, wear due to rubbing adjacent parts, or permanent set. Discard springs which do not meet the loadheight specifications in the spring chart.

8-4. WEAR LIMITS CHART

The chart which follows lists the wear limits data and is referenced to the exploded views (foldouts 7 through 17) in the back of this manual.

8-5. SPRING CHART

Inspection criteria (load vs height) and identification characteristics o f the springs are presented in the spring chart following the wear limits chart. The spring data are keyed to the exploded views (foldouts 7 through 17) in the back of this manual.

NOTE

Where more than one spring part number is listed for the same location, refer to the HT 700 Series Parts Catalog to determine which spring is used in your specific assembly number.

HT 700D SERIES TRANSMISSION

Para 8-4

WEAR LIMITS AND SPRING DATA

Illustration	Description	Part No	Wear Limit Inch	(mm)
B, foldout 7	TORQUE CONVERTER AND LOCKUP CLUTCH			
3	Piston - face wear	6774881	0.010	(0.25)
*4	Plate - thickness	6833972	0.190	(4.83)
5	Back plate - face wear	6834969	0.010	(0.25)
9	Stator assembly (TC 470):	6772462		
	roller thrust washer - thickness		0.022	(0.56)
	front thrust washer - inside diameter		4.016	(102.01)
	front thrust washer - thickness		0.460	(11.68)
	rear thrust washer - inside diameter		4.018	(102.06)
12	Thrust bearing race - thickness	9417722	0.029	(0.74)
14	Roller race - outside diameter	6772293	3.998	(101.55)
A, foldout 8	OIL PUMP ASSEMBLY			
3, 4, 9	Body, gear, and cover:	6839665 or 6834738 6771084 6834739 or 6838844		
	Gear 4 end clearance between body 3 and cover 9		0.006	(0.15)
3, 6, 9	Body, gear and cover:	6839965 or 6834738 6834979 6834739 or 6838844		
	Gear 6 end clearance between body 3 and cover 9		0.006	(0.15)

WEAR LIMITS AND SPRING DATA

Para 8-4

Illustration	Description	Part No	Wear Limit Inch	(mm)
A, foldout 11	FORWARD CLUTCH			
21	External-tanged clutch plate:	6834679		
	Thickness		0.0993	(2.52)
	Cone		0.010	(0.25)
*22	Internal-splined clutch plate - thickness	6835687	0.090	(2.29)
23	Fourth-clutch driving hub:	6835605		
	Friction face thickness		0.390	(9.91)
	Forward clutch running clearance (refer to para 6-18)			
B, foldout 11	FOURTH-CLUTCH ASSEMBLY			
3	Clutch back plate - thickness	6834685	0.390	(9.91)
*4	Internal-splined clutch plate - thickness	6835687	0.090	(2.29)
5	External-tanged clutch plate:	6834679		
	Thickness		0.0993	(2.52)
	Cone		0.010	(0.25)
	Fourth-clutch running clearance (refer to para 6-19)			

WEAR LIMITS AND SPRING DATA

Para 8-4

Illustration	Description	Part No	Wear Limit Inch	(mm)
A, foldout 12	THIRD CLUTCH, CENTER SUPPORT, SECOND CLUTCH			
2	Third-clutch back plate - thickness	6834319	0.490	(12.45)
*3, 26	Internal-splined clutch plate - thickness	6835748	0.1347	(3.42)
4, 27	External-tanged clutch plate:	6834488		
	Thickness		0.0993	(2.52)
	Cone		0.013	(0.33)
	External-tanged clutch plate:	6834720		
	Thickness		0.1161	(2.95)
	Cone		0.013	(0.33)
17	Center support bushing - clearance on sun gear shaft 25 (A, foldout 13) or 25 (B, foldout 13)	6834605	0.0065	(0.17)
	Third-clutch running clearance (refer to para 7-11)			
A, foldout 13	GEAR UNIT AND MAIN SHAFT ASSEMBLY			
2	Thrust washer - thickness	6834548	0.085	(2.16)
4	Thrust washer - thickness	6835320	0.085	(2.16)
7	Front carrier bushing - clearance on sun gear shaft 23	6835322	0.0072	(0.183)
13	Thrust washer - thickness	6835321	0.085	(2.16)
24, 26	Sun gear shaft bushing - clearance on main shaft 36 (A, foldout 13)	6835323	0.0064	(0.163)
25	Sun gear shaft - clearance in support bushing 17 (A, foldout 12)	6835185	0.0065	(0.165)
	Sun gear shaft - clearance in carrier bushing 7 (B, foldout 13)		0.0072	(0.183)
27	Thrust washer - thickness	6835173	0.085	(2.16)

WEAR LIMITS AND SPRING DATA

Para 8-4

Illustration	Description	Part No	Wear Limit Inch	(mm)
B, foldout 14	FIRST CLUTCH			
1	External-tanged clutch plate:	6834680		
	Thickness		0.0993	(2.52)
	Cone		0.013	(0.33)
	External-tanged clutch plate:	6834766		
	Thickness		0.1161	(2.95)
	Cone		0.013	(0.33)
*2	Internal-splined clutch plate - thickness	6835748	0.1347	(3.42)
A, foldout 15	LOW CLUTCH PLATES			
*15	Internal-splined clutch plate -thickness	6835748	0.1347	(3.42)
*15	Internal-splined clutch plate -thickness	6834487	0.1347	(3.42)
16	External-tanged clutch plate:	6834680		
	Thickness		0.0993	(2.52)
	Cone		0.013	(0.33)
16	External-tanged clutch plate:	6834766		
	Thickness		0.1161	(2.95)
	Cone		0.013	(0.33)
	Low clutch running clearance (refer to para 7-4)			
A, foldout 16	REAR COVER, OUTPUT SHAFT AND GOVERNOR			
8	Rear cover - clearance of governor bore to governor	6835689 6836769	0.004	(0.10)
22,	Output shaft bushing - clearance on main shaft 34 (A, foldout 13),	8623075 or 6836272	0.004	(0.10)

*Minimum depth of oil grooves - 0.008 inch (0.20 mm).

WEAR LIMITS AND SPRING DATA

Para 8-5

SPRING CHART

Foldout	Ref	Spring	Part No.	No. coils	Diameter of wire Inches	Diameter of wire Millimetres	Outside diameter Inches	Outside diameter Millimetres	Free length Inches	Free length Millimetres	Length Inches	Length Millimetres	Under force Pounds	Under force Newtons
B,7	10	Stator freewheel roller	6775852	(Not a coil-type spring)					0.81	20.57	0.384	9.75	0.36 to 0.66	1.60 to 2.94
B,8	49	Lubrication valve	6837882	8.5	0.053/0.055	1.35/1.40	0.713	18.11	1.738	44.15	0.808	20.52	5.02 to 6.14	22.38 to 27.31
A,9	12	Lubrication valve	6837882	8.5	0.053/0.055	1.35/1.40	0.713	18.11	1.738	44.15	0.808	20.52	5.02 to 6.14	22.38 to 27.31
B,10	4	Main regulator valve	6839209	19	0.127/0.130	3.23/3.30	0.830	21.08	3.943	100.15	2.643	67.13	82.4 to 86.6	366.53 to 385.22
B,10	9	Lockup shift valve	6838089	17	0.090/0.093	2.29/2.36	0.746	18.95	3.040	77.22	1.80	45.72	29 to 31	129 to 138
			6838090	16	0.0785/0.0815	2.01/2.08	0.723	18.36	2.661	67.59	1.80	45.72	13.44 to 14.36	59.78 to 63.87
			6838520	16	0.079/0.082	2.01/2.08	0.720	18.29	2.930	74.42	1.800	45.72	17.60 to 18.80	78.29 to 83.63
			6839268	16	0.0785/0.0815	2.01/2.08	0.723	18.36	3.33	84.58	1.80	45.72	23.8 to 25.4	105.86 to 112.98
			6839419	16	0.0785/0.0815	2.01/2.08	0.723	18.36	3.22	81.79	1.80	45.72	22.1 to 23.5	98.30 to 104.53
			6880166	17	0.090/0.093	2.29/2.36	0.746	18.95	3.505	89.02	1.80	45.72	39.6 to 42.6	176.14 to 189.48
B,10	13	Converter bypass valve	6769252	14	0.079/0.082	2.01/2.08	0.690	17.53	2.650	67.31	1.460	37.08	24.5 to 26.9	108.98 to 119.66
A,11	14	Fwd clutch release	6836138	10.2	0.061/0.063	1.55/1.60	0.439	11.15	1.250	31.75	0.880	22.35	17.9 to 18.9	79.63 to 84.07
B,11	8	Fourth clutch release	6836138	10.2	0.061/0.063	1.55/1.60	0.439	11.15	1.250	31.75	0.880	22.35	17.9 to 18.9	79.63 to 84.07
A,12	9	Third clutch piston return	6831656	11.5	0.041	1.04	0.385	9.78	1.290	32.77	0.816	20.73	4.3 to 5.7	19.13 to 25.35
A,12	22	Second clutch piston return	6831656	11.5	0.041	1.04	0.385	9.78	1.290	32.77	0.816	20.73	4.3 to 5.7	19.13 to 25.35
A,15	5	First clutch piston	6831656	11.5	0.041	1.04	0.385	9.78	1.290	32.77	0.816	20.73	4.3 to 5.7	19.13 to 25.35
B,15	5	First clutch piston	6831656	11.5	0.041	1.04	0.385	9.78	1.290	32.77	0.816	20.73	4.3 to 5.7	19.13 to 25.35
A,16	3	Low or first clutch piston	6836138	10.2	0.061/0.063	1.55/1.60	0.439	11.15	1.250	31.75	0.880	22.35	17.9 to 18.9	79.63 to 84.07
			6880418	9.5	0.0705/0.0735	1.79/1.87	0.500	12.7	1.31	33.27	0.90	22.86	26.05 to 27.85	115.87 to 123.88
B,16	3	Check valve	6836693	19	0.090/0.093	2.29/2.36	0.535	13.59	2.480	62.99	1.970	50.04	32.25 to 37.05	143.46 to 164.81
B,16	19	Modulator valve	6833934	10	0.053/0.055	1.35/1.40	0.490	12.45	1.470	37.34	0.800	20.32	11.9 to 13.1	52.93 to 58.27
			6833950	18	0.0635/0.0615	1.61/1.56	0.635	16.13	3.42	86.87	1.940	49.28	10.55 to 11.75	46.93 to 52.26
			6838077	10	0.053/0.055	1.35/1.40	0.490	12.45	1.150	29.21	0.800	20.32	6.26 to 6.90	27.85 to 30.69
			6838519	10	0.053/0.055	1.35/1.40	0.490	12.45	1.266	32.16	0.800	20.32	7.39 to 9.03	32.87 to 40.17
			6880980	10	0.053/0.055	1.35/1.40	0.490	12.45	1.36	34.54	0.80	20.32	9.88 to 10.92	43.95 to 48.57
B,16	27	Third clutch trimmer valve (inner)	6880274	9.6	0.090/0.093	2.29/2.36	0.690	17.53	1.690	42.93	1.100	27.94	32.6 to 39.8	145 to 177.03
B,16	28	Third clutch trimmer valve (outer)	6833938	12.5	0.079/0.081	2.01/2.06	0.940	23.88	2.960	75.18	1.100	27.94	15.95 to 17.65	70.95 to 78.51
			6839271	10	0.101/0.104	2.57/2.64	0.940	23.88	2.560	65.02	1.100	27.94	47 to 52	209.06 to 231.30
			6880045	10	0.097/0.100	2.46/2.54	0.940	23.88	2.181	55.40	1.940	49.28	6.20 to 7.40	27.58 to 32.92
B,16	32	First clutch trimmer valve (inner)	6880274	9.6	0.090/0.093	2.29/2.36	0.690	17.53	1.690	42.93	1.100	27.94	32.6 to 39.8	145 to 177.03
B,16	33	First clutch trimmer valve (outer)	6833938	12.5	0.079/0.081	2.01/2.06	0.940	23.88	2.960	75.18	1.100	27.94	15.95 to 17.65	70.95 to 78.51
			6835730	10	0.097/0.100	2.46/2.54	0.940	23.88	2.181	55.40	1.940	49.28	6.2 to 7.4	27.58 to 32.92
			6837693	8.5	0.111/0.114	2.82/2.90	0.940	23.88	1.970	50.04	1.940	49.28	0.8 to 2.8	3.56 to 12.45
			6839026	7	0.090/0.093	2.29/2.36	0.930	23.62	1.85	46.99	1.10	27.94	23.5 to 27.5	104.53 to 122.32
B,16	37	Second clutch trimmer valve (inner)	6880274	9.6	0.090/0.093	2.29/2.36	0.690	17.53	1.690	42.93	1.100	27.94	32.6 to 39.8	145 to 177.03
B,16	38	Second clutch trimmer valve (outer)	6833945	8	0.090/0.093	2.29/2.36	0.930	23.62	2.300	58.42	1.940	49.28	9.4 to 11.4	41.81 to 50.71
			6839271	10	0.101/0.104	2.57/2.64	0.940	23.88	2.560	65.02	1.100	27.94	47 to 52	209.06 to 231.30
			6880045	10	0.097/0.100	2.46/2.54	0.940	23.88	2.181	55.40	1.940	49.28	6.20 to 7.40	27.58 to 32.92
B,16	41	Trimmer boost accumulator	6838989	20	0.062/0.064	1.57/1.63	0.564	14.33	2.765	70.23	1.490	37.85	11.6 to 12.8	51.60 to 56.93
B,16	47	Fourth clutch trimmer valve (inner)	6880118	8.5	0.0895/0.0935	2.27/2.37	0.690	17.53	1.45	36.83	1.10	27.94	21.7 to 25.3	96.52 to 112.53
B,16	48	Fourth clutch trimmer valve (outer)	6833940	8.5	0.119/0.122	3.02/3.10	0.950	24.13	2.380	60.45	1.940	49.28	29 to 35	128.99 to 155.68
			6833945	8	0.090/0.093	2.29/2.36	0.930	23.62	2.300	58.42	1.940	49.28	9.4 to 11.4	41.81 to 50.71
			6880045	10	0.097/0.100	2.46/2.54	0.940	23.88	2.181	55.40	1.940	49.28	6.20 to 7.40	27.58 to 32.92
B,16	53	1-3 relay valve	6832462	11	0.071/0.073	1.80/1.85	0.690	17.53	2.180	55.37	1.200	30.48	16.2 to 19.8	72.06 to 88.07
B,16	56	1-2 relay valve	6834528	11	0.071/0.074	1.80/1.88	0.680	17.27	1.520	38.61	1.100	27.94	7.2 to 8.8	32.03 to 39.14
B,16	61	Governor accumulator valve	6838988	10	0.050/0.052	1.27/1.32	0.564	14.33	1.835	46.61	0.700	17.78	9.6 to 10.6	42.70 to 47.15
B,16	66	Priority valve	6835729	11	0.053/0.055	1.35/1.40	0.384	9.75	1.169	29.69	0.940	23.88	8.6 to 8.7	38.25 to 38.70
B,16	69	Hold regulator valve	6836783	11	0.040/0.042	1.02/1.07	0.400	10.16	1.697	43.10	1.150	29.21	5.29 to 5.51	23.53 to 24.51
			6836784	13	0.040/0.042	1.02/1.07	0.400	10.16	1.898	48.21	1.150	29.21	5.93 to 6.17	26.38 to 27.44
			6836785	14	0.040/0.042	1.02/1.07	0.400	10.16	2.008	51.00	1.150	29.21	6.22 to 6.48	27.67 to 28.82
			6836867	11	0.040/0.042	1.02/1.07	0.400	10.16	1.592	40.44	1.150	29.21	4.26 to 4.44	18.95 to 19.75
			6836917	11	0.040/0.042	1.02/1.07	0.400	10.16	1.592	40.44	1.150	29.21	4.26 to 4.44	18.95 to 19.75
			6836977	16	0.046/0.048	1.17/1.22	0.400	10.16	1.846	46.89	1.150	29.21	7.79 to 8.11	34.69 to 36.07
			6837539	11	0.040/0.042	1.02/1.07	0.400	10.16	1.715	43.56	1.150	29.21	5.44 to 5.66	24.20 to 25.18
			6837540	11	0.041/0.042	1.04/1.07	0.400	10.16	1.745	44.32	1.150	29.21	5.73 to 5.97	25.49 to 26.55
			6838088	17.7	0.047/0.049	1.19/1.24	0.409	10.39	1.684	42.77	1.150	29.21	5.14 to 5.36	22.86 to 23.84
			6838368	15	0.048/0.050	1.22/1.27	0.409	10.39	1.920	48.77	1.150	29.21	10.25 to 10.75	45.59 to 47.82
			6880319	15	0.048/0.050	1.22/1.27	0.409	10.39	1.880	47.75	1.150	29.21	9.75 to 10.25	43.37 to 45.59
			6880320	17	0.048/0.050	1.22/1.27	0.409	10.39	1.930	49.02	1.150	29.21	9.0 to 9.6	40.03 to 42.70
			6838367	15	0.048/0.050	1.22/1.27	0.409	10.39	1.790	45.47	1.150	29.21	8.55 to 9.05	38.03 to 40.25
			6835733	11	0.040/0.042	1.02/1.07	0.400	10.16	1.771	44.98	1.150	29.21	5.85 to 6.45	26.02 to 28.69

HT 700D SERIES TRANSMISSIONS

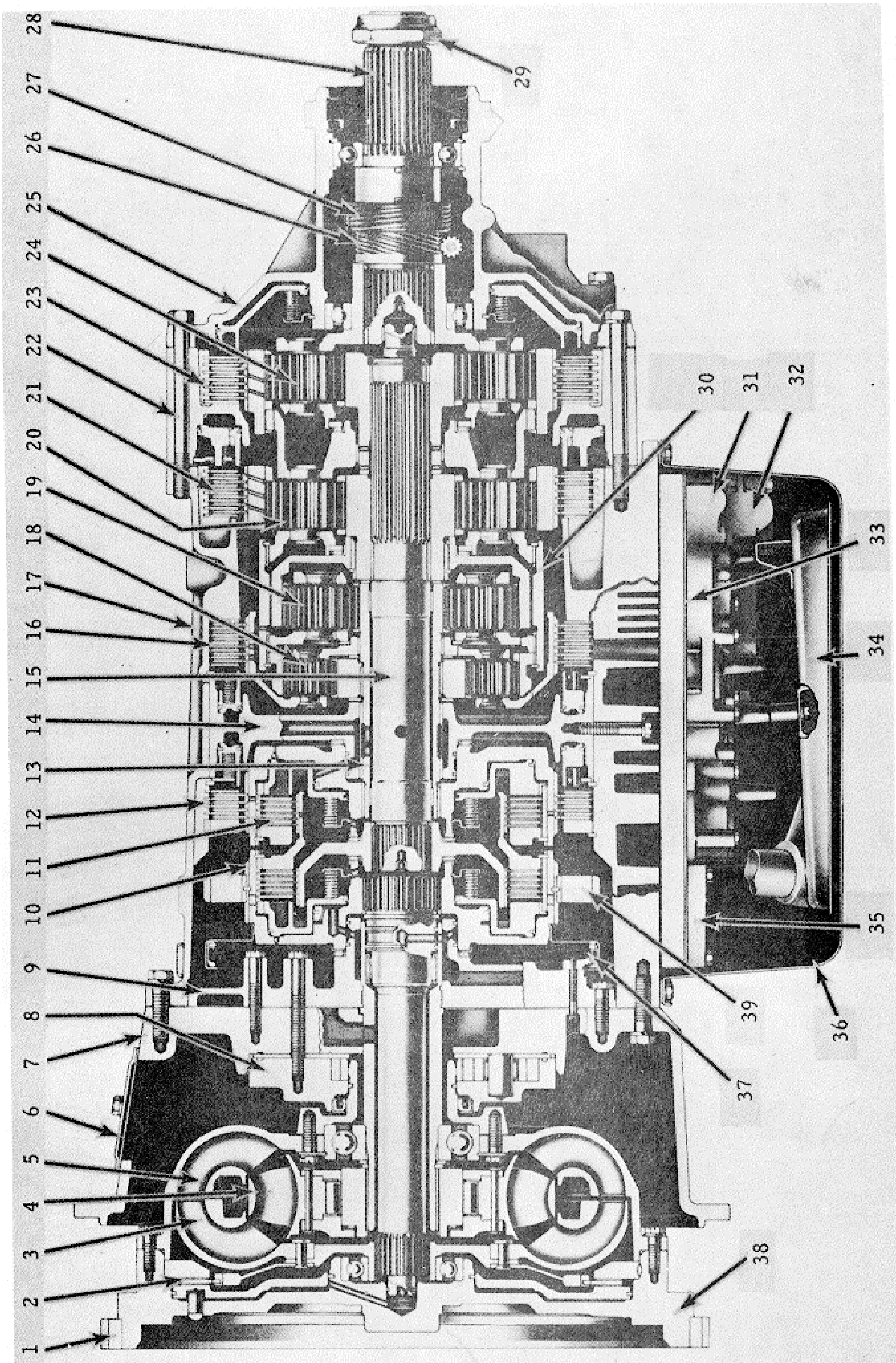
Para 8-5

SPRING CHART (Cont'd)

Foldout	Ref	Spring	Part No.	No. coils	Diameter of wire Inches	Diameter of wire Millimetres	Outside diameter Inches	Outside diameter Millimetres	Free length Inches	Free length Millimetres	Length Inches	Length Millimetres	Under force Pounds	Under force Newtons
B,16	78	1-2 shift valve	6833935	9	0.053/0.055	1.35/1.40	0.640	16.26	2.170	55.12	1.150	29.21	8.6 to 9.1	38.25 to 40.48
			6833941	13.5	0.061/0.063	1.55/1.60	0.640	16.26	2.150	54.61	1.150	29.21	9.35 to 9.85	41.59 to 43.81
			6834576	12	0.053/0.055	1.35/1.40	0.640	16.26	2.390	60.71	1.150	29.21	7.18 to 7.68	31.94 to 34.16
			6834903	12	0.053/0.055	1.35/1.40	0.640	16.26	2.217	56.31	1.150	29.21	6.1 to 6.7	27.13 to 29.80
			6835309	12	0.053/0.055	1.35/1.40	0.640	16.26	2.317	58.85	1.150	29.21	6.75 to 7.25	30.02 to 32.25
			6835310	13	0.058/0.060	1.47/1.52	0.640	16.26	2.510	63.75	1.150	29.21	10.75 to 11.25	47.82 to 50.04
			6837454	9	0.055/0.057	1.40/1.45	0.640	16.26	1.985	50.42	1.150	29.21	8.22 to 8.72	36.56 to 38.79
			6838356	14	0.061/0.063	1.55/1.60	0.640	16.26	2.430	61.72	1.150	29.21	11.45 to 11.95	50.93 to 53.15
			6838357	14	0.0615/0.0635	1.56/1.61	0.640	16.26	2.525	64.14	1.150	29.21	12.25 to 12.75	54.49 to 56.71
			6838358	14	0.061/0.063	1.55/1.60	0.640	16.26	2.570	65.28	1.150	29.21	12.74 to 13.26	56.67 to 58.98
			6838366	14	0.061/0.063	1.55/1.60	0.640	16.26	2.665	67.69	1.150	29.21	13.45 to 13.85	59.83 to 61.60
			6880991	12	0.053/0.055	1.35/1.40	0.640	16.26	2.75	69.85	1.150	29.21	9.25 to 9.95	41.14 to 44.26
			6880993	12	0.053/0.055	1.35/1.40	0.640	16.26	2.98	75.69	1.150	29.21	10.60 to 11.40	47.15 to 50.71
			6881060	12	0.053/0.055	1.35/1.40	0.640	16.26	2.62	66.55	1.150	29.21	8.50 to 9.10	37.81 to 40.48
			6881061	12	0.053/0.055	1.35/1.40	0.640	16.26	2.55	64.77	1.150	29.21	8.10 to 8.70	36.03 to 38.70
B,16	83	2-3 shift valve	6833935	9	0.053/0.055	1.35/1.40	0.640	16.26	2.170	55.12	1.150	29.21	8.6 to 9.1	38.25 to 40.48
			6834902	13	0.058/0.060	1.47/1.52	0.640	16.26	2.410	61.21	1.150	29.21	9.95 to 10.45	44.26 to 46.48
			6835310	13	0.058/0.060	1.47/1.52	0.640	16.26	2.510	63.75	1.150	29.21	10.75 to 11.25	47.82 to 50.04
			6838356	14	0.061/0.063	1.55/1.60	0.640	16.26	2.430	61.72	1.150	29.21	11.45 to 11.95	50.93 to 53.15
			6838357	14	0.0615/0.0635	1.56/1.61	0.640	16.26	2.525	64.14	1.150	29.21	12.25 to 12.75	54.49 to 56.71
			6838358	14	0.061/0.063	1.55/1.60	0.640	16.26	2.570	65.28	1.150	29.21	12.74 to 13.26	56.67 to 58.98
			6880991	12	0.053/0.055	1.35/1.40	0.640	16.26	2.75	69.85	1.150	29.21	9.25 to 9.95	41.14 to 44.26
			6880992	12	0.053/0.055	1.35/1.40	0.640	16.26	2.85	72.39	1.150	29.21	9.85 to 11.55	43.81 to 51.37
			6880993	12	0.053/0.055	1.35/1.40	0.640	16.26	2.98	75.69	1.150	29.21	10.60 to 11.40	47.15 to 50.71
			6881060	12	0.053/0.055	1.35/1.40	0.640	16.26	2.62	66.55	1.150	29.21	8.50 to 9.10	37.81 to 40.48
B,16	89	3-4 shift valve	6833935	9	0.053/0.055	1.35/1.40	0.640	16.26	2.170	55.12	1.150	29.21	8.6 to 9.1	38.25 to 40.48
			6833941	13.5	0.061/0.063	1.55/1.60	0.640	16.26	2.150	54.61	1.150	29.21	9.35 to 9.85	41.59 to 43.81
			6833942	12	0.053/0.055	1.35/1.40	0.640	16.26	2.500	63.50	1.150	29.21	7.85 to 8.35	34.92 to 37.14
			6834902	13	0.058/0.060	1.47/1.52	0.640	16.26	2.410	61.21	1.150	29.21	9.95 to 10.45	44.26 to 46.48
			6835310	13	0.058/0.060	1.47/1.52	0.640	16.26	2.510	63.75	1.150	29.21	10.75 to 11.25	47.82 to 50.04
			6837454	9	0.055/0.057	1.40/1.45	0.640	16.26	1.985	50.42	1.150	29.21	8.22 to 8.72	36.56 to 38.79
			6838356	14	0.061/0.063	1.55/1.60	0.640	16.26	2.430	61.72	1.150	29.21	11.45 to 11.95	50.93 to 53.15
			6880991	12	0.053/0.055	1.35/1.40	0.640	16.26	2.75	69.85	1.150	29.21	9.25 to 9.95	41.14 to 44.26
			6880992	12	0.053/0.055	1.35/1.40	0.640	16.26	2.85	72.39	1.150	29.21	9.85 to 11.55	43.81 to 51.37
			6880993	12	0.053/0.055	1.35/1.40	0.640	16.26	2.98	75.69	1.150	29.21	10.60 to 11.40	47.15 to 50.71
			6881060	12	0.053/0.055	1.35/1.40	0.640	16.26	2.62	66.59	1.150	29.21	8.50 to 9.10	37.81 to 40.48
			6881061	12	0.053/0.055	1.35/1.40	0.640	16.26	2.55	64.77	1.150	29.21	8.10 to 8.70	36.03 to 38.70
B,16	94	3-4 relay valve	6832462	11	0.071/0.073	1.80/1.85	0.690	17.53	2.180	55.37	1.200	30.48	16.2 to 19.8	72.06 to 88.07
B,16	99	Trimmer regulator valve	6770763	14	0.040/0.042	1.02/1.07	0.480	12.19	1.780	45.21	0.780	19.81	3.8 to 4.2	16.90 to 18.68
			6834527	14	0.046/0.048	1.17/1.22	0.500	12.70	1.87	47.50	1.14	28.96	4.25 to 4.75	18.90 to 21.13
			6880186	12	0.040/0.042	1.02/1.07	0.452	11.48	1.370	34.80	0.890	22.61	2.52 to 2.69	11.21 to 11.97
			6880246	13	0.040/0.042	1.02/1.07	0.452	11.48	1.810	45.97	0.890	22.61	4.25 to 4.75	18.90 to 21.13
A,17	8	Low shift valve	6768544	14	0.053/0.055	1.35/1.40	0.560	14.22	1.990	50.55	0.840	21.34	8.1 to 9.9	36.03 to 44.04
A,17	13	Low shift signal valve	6838285	8	0.040/0.042	1.02/1.07	0.501	12.73	1.095	27.81	0.690	17.53	2.57 to 3.13	11.43 to 13.92
			6838340	12	0.037/0.039	0.94/0.99	0.450	11.43	2.075	52.71	1.090	25.69	4.0 to 4.5	17.79 to 20.02
			6880154	11	0.040/0.042	1.02/1.07	0.450	11.43	1.882	47.80	1.090	27.69	4.55 to 4.95	20.24 to 22.02
			6880155	12	0.037/0.039	0.94/0.99	0.450	11.43	1.800	45.72	1.090	27.69	2.9 to 3.2	12.90 to 14.23
A,17	24	Low trimmer valve	6833938	12.5	0.079/0.081	2.01/2.06	0.940	23.88	2.960	75.18	1.100	27.94	15.95 to 17.65	70.95 to 78.51
			6833940	8.5	0.119/0.122	3.02/3.10	0.950	24.13	2.380	60.45	1.940	49.28	29 to 35	128.99 to 155.68
			6833945	8	0.090/0.093	2.29/2.36	0.930	23.62	2.300	58.42	1.940	49.28	9.4 to 11.4	41.81 to 50.71
A,17	25	Low trimmer valve	6839102	8.5	0.090/0.093	2.29/2.36	0.720	18.29	1.700	43.18	1.100	27.94	32.6 to 39.8	145 to 177.03
B,17	16	Retarder control valve	6838531	8	0.103/0.107	2.62/2.72	1.600	40.64	3.98	101.09	2.82	71.63	8.95 to 10.93	39.81 to 48.62

LEGEND - FOLDOUT 2

1 - Starter ring gear
2 - Lockup clutch
3 - Torque converter turbine
4 - Torque converter stator
5 - Torque converter pump
6 - Accessory cover
7 - Torque converter housing
8 - Transmission input pump
9 - Forward support and valve assembly
10 - Forward clutch assembly
11 - Fourth clutch assembly
12 - Third clutch
13 - Sun gear and shaft assembly
14 - Center support housing assembly
15 - Main shaft assembly
16 - Second clutch
17 - Transmission housing
18 - Front planetary carrier assembly
19 - Center planetary carrier assembly
20 - Rear planetary carrier assembly
21 - First clutch
22 - Adapter housing assembly
23 - Low clutch
24 - Low carrier assembly
25 - Rear cover assembly
26 - Governor drive gear
27 - Speedometer drive gear
28 - Output shaft
29 - Output flange retaining nut
30 - Gear unit connecting drum
31 - Low shift valve assembly
32 - Low trimmer valve assembly
33 - Control valve assembly
34 - Oil filter
35 - Cover plate
36 - Oil pan
37 - Pilot tube
38 - Flywheel
39 - PTO drive gear

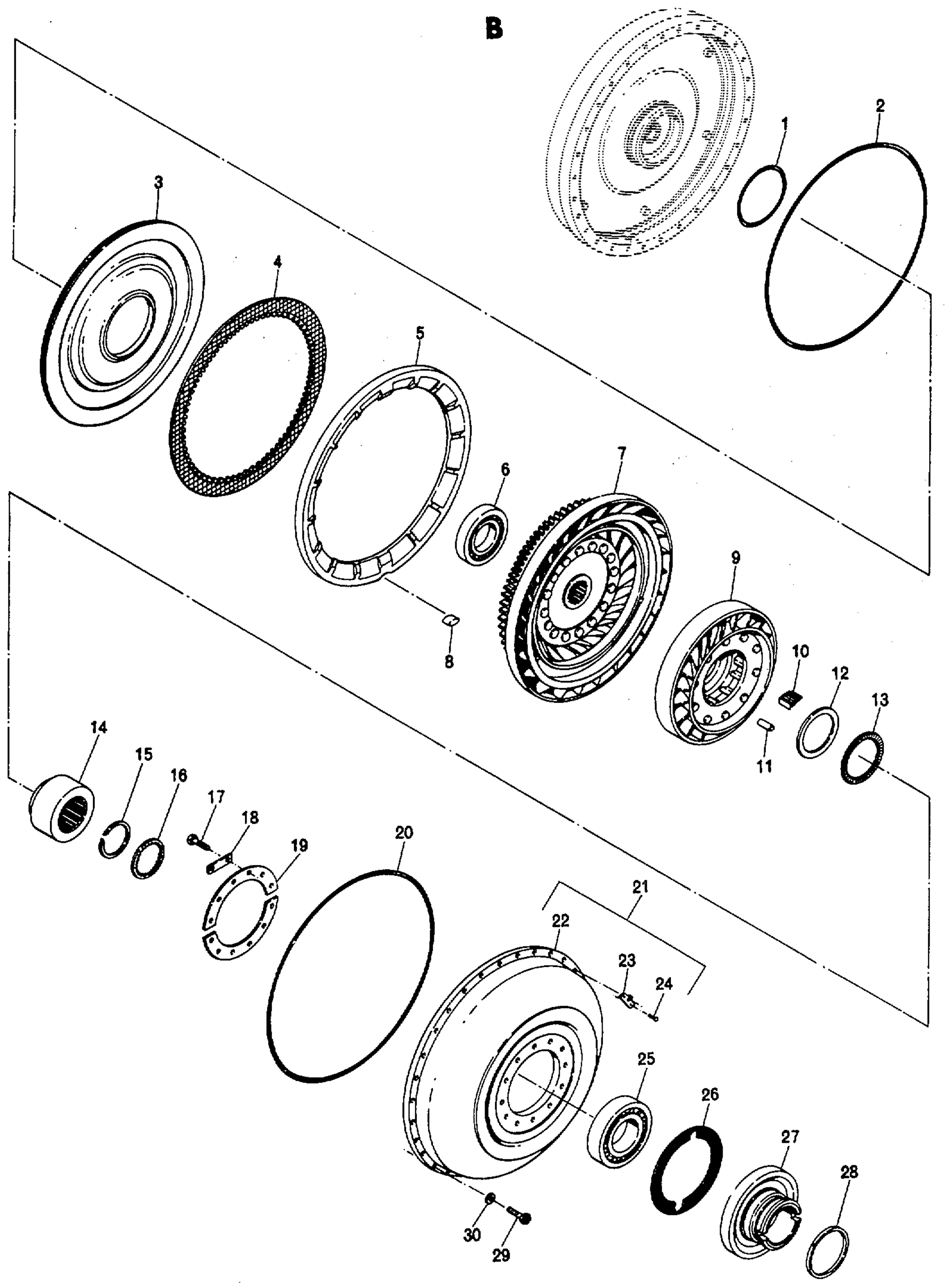


FOLDOUT 2. MODEL HT 750CRD TRANSMISSION—CROSS SECTION VIEW

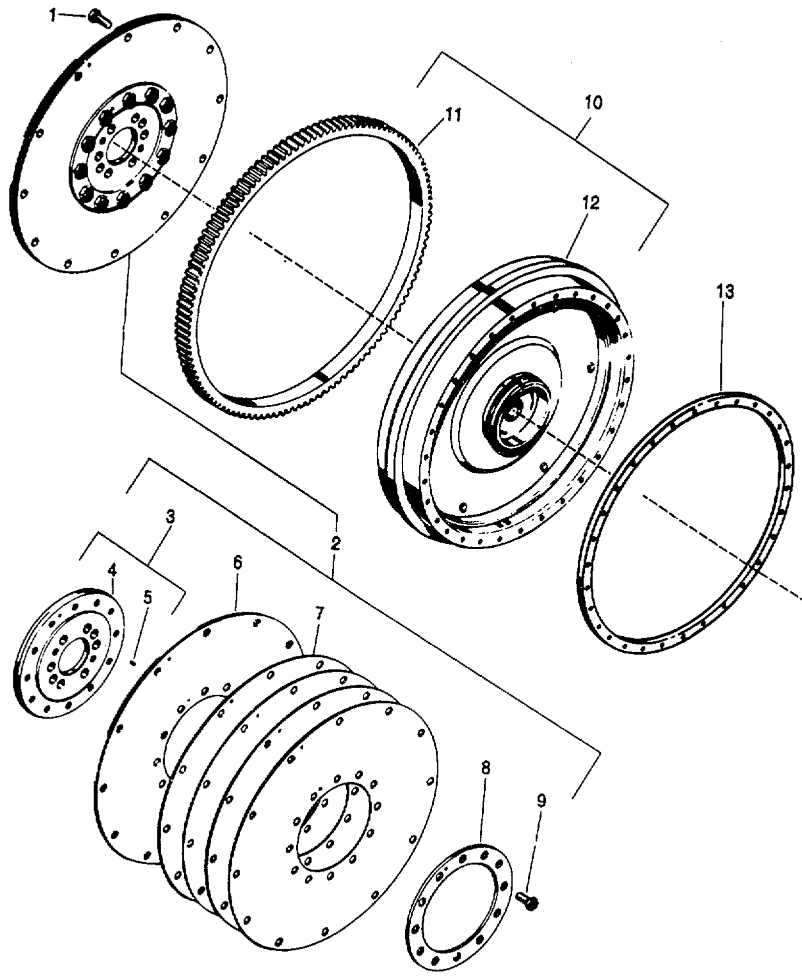
Foldout 5 is deleted.

LEGEND FOR B, FOLD OUT 7.

1 - Sealring
2 - Sealring
3 - Lockup clutch piston
4 - Lockup clutch plate
5 - Lockup clutch back plate
6 - Ball bearing
7 - Torque converter turbine
8 - Key
9 - Torque converter stator
10 - Stator freewheel roller spring (10)
11 - Stator freewheel roller (10)
12 - Thrust bearing race
13 - Thrust bearing
14 - Stator freewheel roller race
15 - External snapring
16 - Converter pump spacer
17 - Bolt, 3/8-24 x 1 1/4 (12)
18 - Lockstrip (6)
19 - Bearing retainer (2)
20 - Sealring
21 - Torque converter pump assembly
22 - Torque converter pump
23 - Balance weight (ar)
24 - Balance weight screw (ar)
25 - Ball bearing
26 - Converter pump hub gasket
27 - Converter pump hub
28 - Hook-type sealring
29 - Self-locking bolt, 3/8-24 x 1 1/4 (30)
30 - Washer (30)



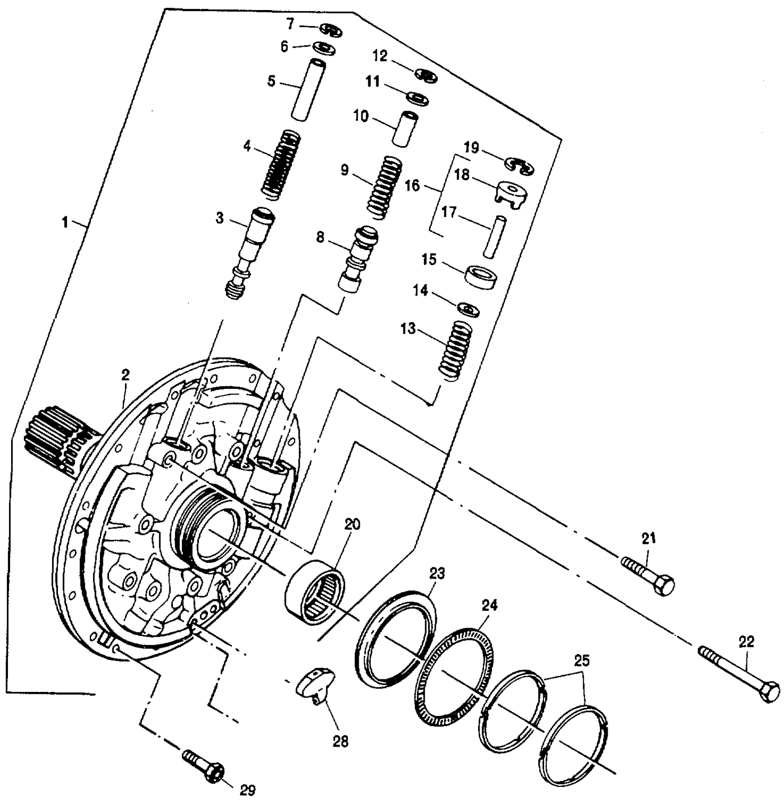
B, foldout 7. Lockup clutch and torque converter-exploded view



A

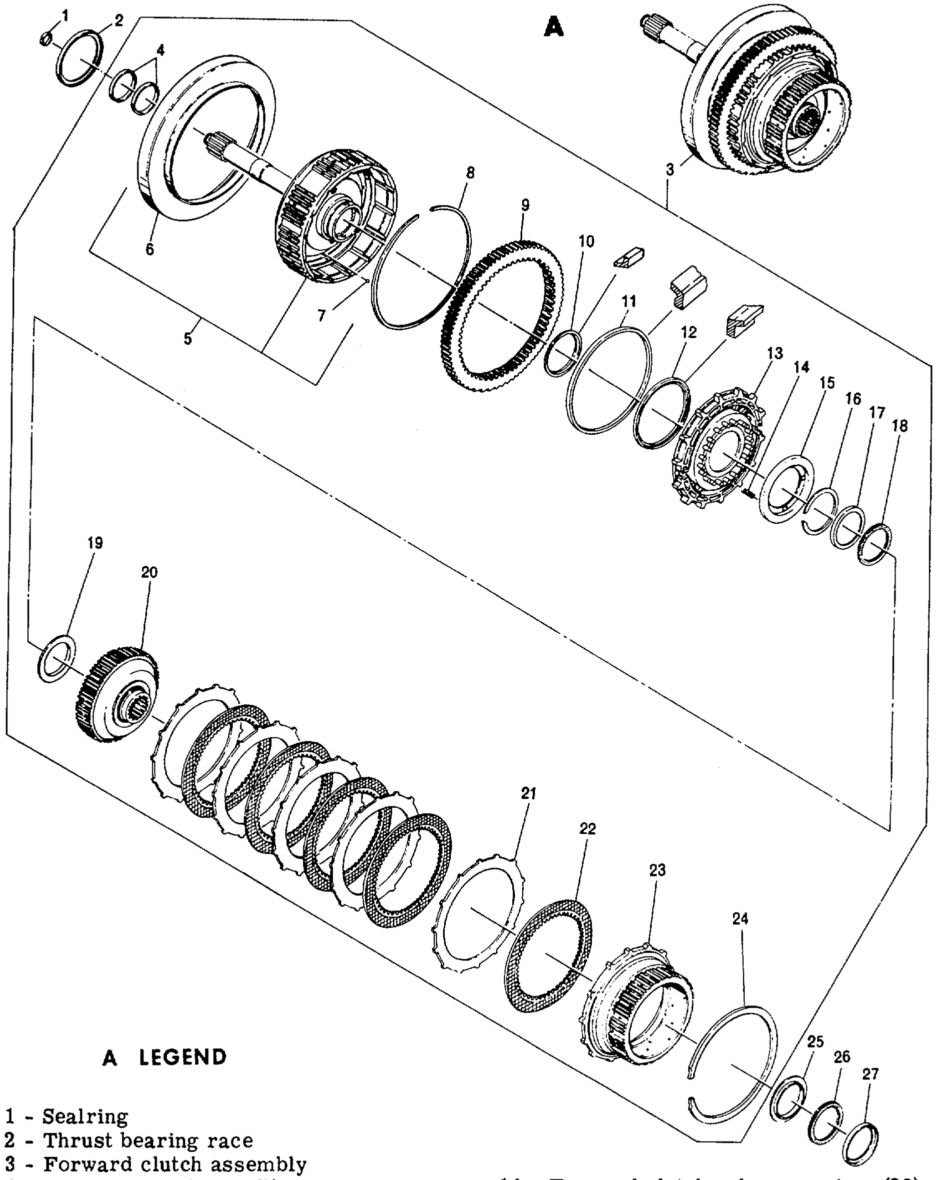
1 - Self-locking bolt, 1/2-20 x 1 (12)
2 - Flex disk assembly
3 - Flex disk hub assembly
4 - Hub
5 - Dowel pin
6 - Flex disk
7 - Flex disk (4)
8 - Flex disk plate
9 - Self-locking bolt, 1/2-20 x 3/4 (12)
10 - Flywheel assembly
11 - Starter ring gear
12 - Flywheel
13 - Converter housing adapter

A, foldout 7. Flex disc and flywheel assemblies-exploded view



1 - Front support and valve assembly
2 - Front support and ground sleeve asseml
3 - Main pressure regulator valve
4 - Main regulator valve spring
5 - Valve stop
6 - Retainer washer
7 - Internal snapring
8 - Lockup shift valve
9 - Valve spring
10 - Valve stop
11 - Retainer washer
12 - Internal snapring
13 - Valve spring
14 - Converter bypass valve
15 - Valve seat
16 - Valve support assembly
17 - Valve guide
18 - Valve support
19 - Snapring
20 - Roller bearing assembly
21 - Bolt, 3/8-16 x 2 1/2 (3)
22 - Bolt, 3/8-16 x 4 (6)
23 - Thrust bearing race
24 - Roller bearing assembly
25 - Step joint sealring
28 - Front pitot tube
29 - Bolt, 3/8-16 x 1 1/2 (16)

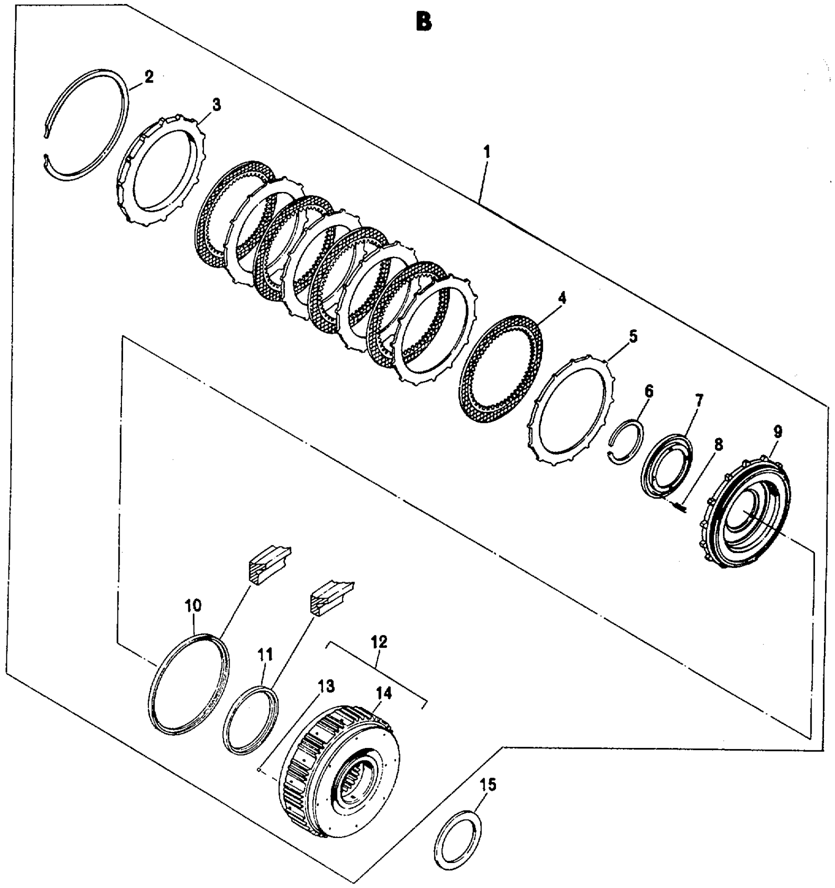
B, foldout 10. Front support and valve assembly-exploded view



A LEGEND

1 - Sealring
2 - Thrust bearing race
3 - Forward clutch assembly
4 - Hook type sealring (2)
5 - Forward clutch housing and input shaft assembly
6 - Pitot collector ring
7 - Ball, 3/16 (4)
8 - Internal snapring
9 - PTO gear
10 - Piston inner sealring
11 - Piston outer sealring
12 - Clutch housing sealring
13 - Forward clutch piston (marked):
A . . . . 1.110—1.120 THK.
B . . . . 1.137—1.147 THK.
C . . . . 1.164—1.174 THK.
14 - Forward clutch release spring (20)
15 - Spring retainer
16 - External snapring
17 - Thrust Bearing race
18 - Roller bearing assembly
19 - Thrust bearing race
20 - Forward clutch hub
21 - External-tanged clutch plate (5)
22 - Internal-splined plate (5)
23 - Fourth-clutch driving hub
24 - Internal snapring
25 - Thrust bearing race
26 - Roller bearing assembly
27 - Thrust bearing race

A, foldout 11. Forward clutch assembly-exploded view



B LEGEND

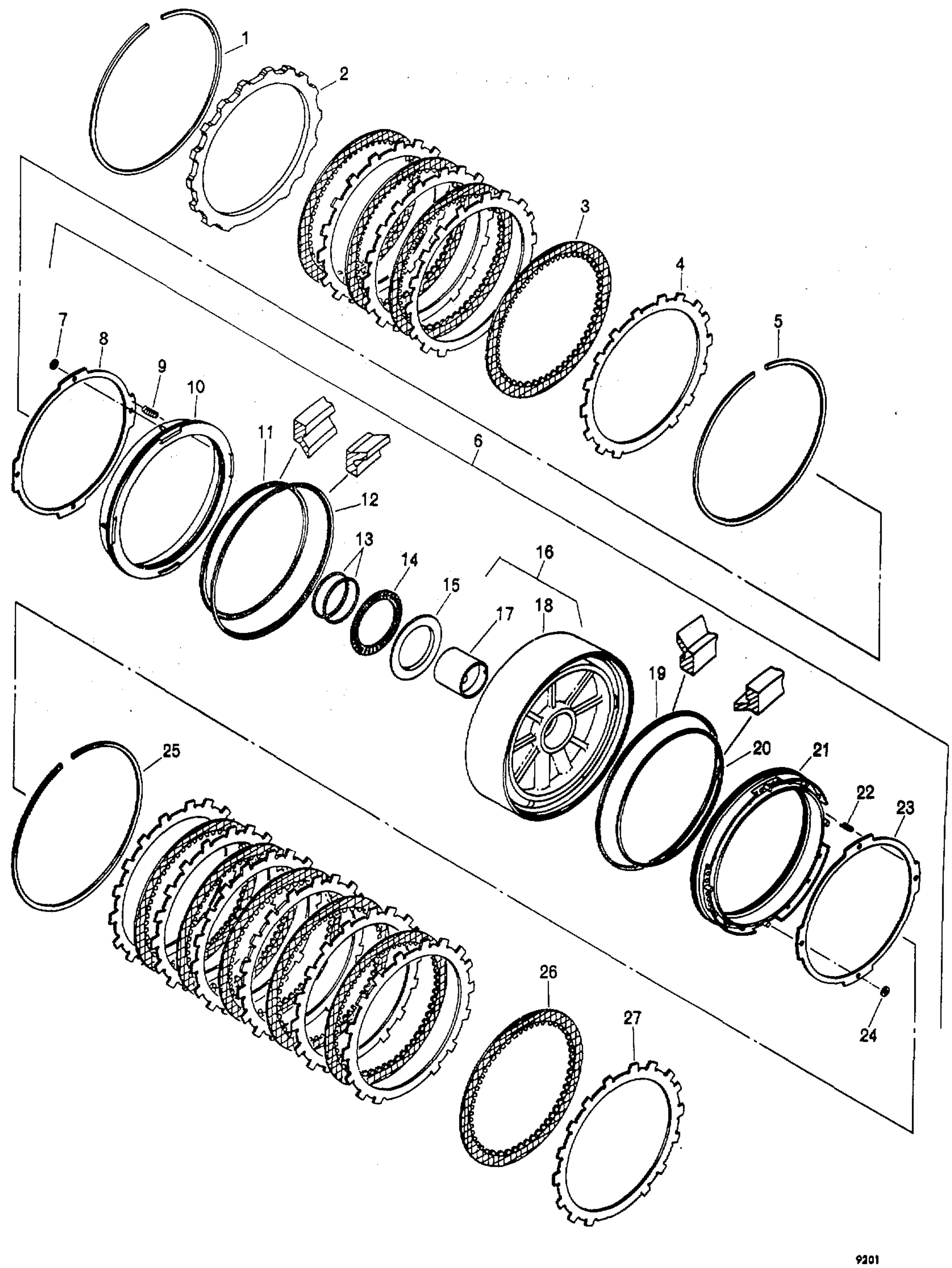
1 - Fourth-clutch assembly
2 - Snapring
3 - Clutch back plate
4 - Internal-splined plate (5)
5 - External-tanged plate (5)
6 - Snapring
7 - Spring retainer
8 - Clutch release spring (20)
9 - Fourth-clutch piston (marked):
  A . . . . 1.110—1.120 thk
  B . . . . 1.137—1.147 thk
  C . . . . 1.164—1.174 thk
10 - Piston outer sealring
11 - Piston inner sealring
12 - Fourth-clutch housing assembly
13 - Ball, 3/16 (4)
14 - Fourth-clutch housing
15 - Thrust bearing race

B, foldout 11. Fourth-clutch assembly-exploded view

LEGEND A FOLDOUT 12

A

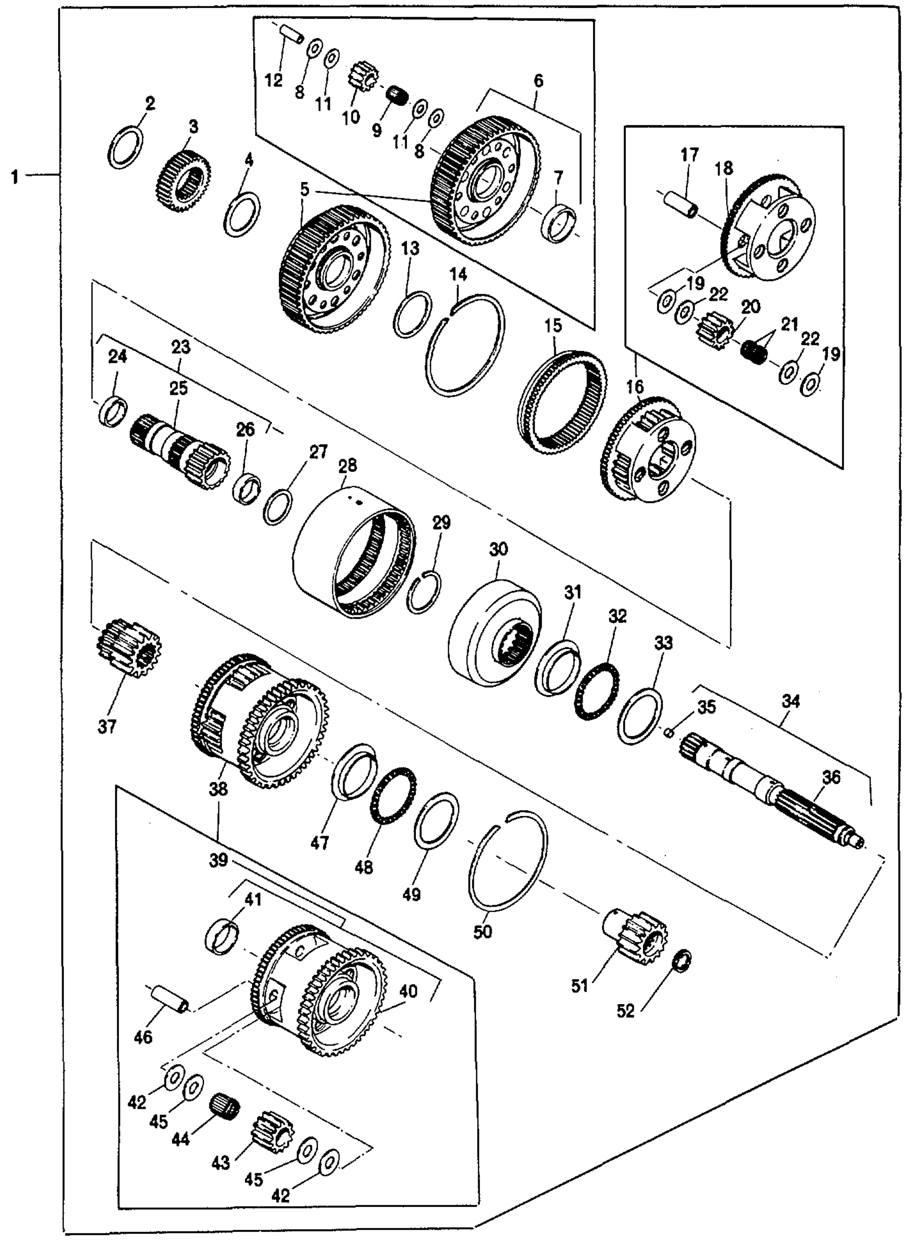
1 - Snapring
2 - Third-clutch back plate
3 - Internal-splined clutch plate (4)
4 - External-tanged clutch plate (4):
    0.0993--0. 1063 thk (Red) (ar)
    0.1161-0.1231 thk (Green) (ar)
5 - Snapring (1):
    0.148 (3.76 mm) - 0.150 (3.81 mm)
    0.152 (3. 86 mm) - 0. 154 (3.91 mm)
    0.155 (3. 94 mm) - 0. 157 (3.99 mm)
    0.158 (4. 01 mm) - 0. 160 (4.06 mm)
6 - Center support assembly
7 - Self-locking retainer ring (4)
8 - Spring retainer
9 - Piston release spring (20)
10 - Third-clutch piston
11 - Piston inner sealring
12 - Piston outer sealring
13 - Step-joint sealring (2)
14 - Needle roller bearing
15 - Thrust bearing race
16 - Center support housing assembly
17 - Bushing
18 - Center support housing
19 - Piston outer sealring
20 - Piston inner sealring
21 - Second-clutch piston
22 - Piston release spring (20)
23 - Spring retainer
24 - Self-locking retainer ring (4)
25 - Snapring
26 - Internal-splined clutch plate (6)
27 - External-tanged clutch plate (7):
    0.0993-0.1063 thk (Red) (ar)
    0.1161-0.1231 thk (Green) (ar)



A, foldout 12. Third-clutch, center support, and second clutch-exploded view

LEGEND FOR A, FOLDOUT 13

1 - Gear unit and main shaft assembly
2 - Thrust washer
3 - Front planetary sun gear
4 - Thrust washer
5 - Front planetary carrier assembly
6 - Flange and carrier assembly
7 - Sleeve bushing
8 - Bronze thrust washer (12)
9 - Needle roller bearing (6)
10 - Pinion (6)
11 - Steel thrust washer (12)
12 - Pinion pin (6)
13 - Thrust washer
14 - Internal snapring
15 - Front planetary ring gear
16 - Center planetary carrier assembly
17 - Pinion pin (4)
18 - Center planetary carrier
19 - Bronze thrust washer (8)
20 - Pinion (4)
21 - Needle roller bearing (8)
22 - Steel thrust washer (8)
23 - Center sun gear and shaft assembly
24 - Split sleeve bushing
25 - Center sun gear shaft
26 - Split sleeve bushing
27 - Thrust washer
28 - Planetary connecting drum
29- External snapring
30 - Center planetary ring gear
31 - Thrust race
32 - Needle roller bearing
33 - Thrust race
34 - Main shaft assembly
35 - Orifice plug
36 - Main shaft
37 - Rear planetary sun gear
38 - Rear planetary carrier assembly
39 - Rear carrier and bushing assembly
40 - Rear carrier
41 - Sleeve bushing
42 - Bronze thrust washer (8)
43- Pinion (4)
44 - Needle roller bearing (4)
45 - Steel thrust washer (8)
46 - Pinion pin (4)
47 - Thrust race
48 - Needle roller bearing
49 - Thrust race
50- Internal snapring
51 - Low planetary sun gear
52 - Snapring

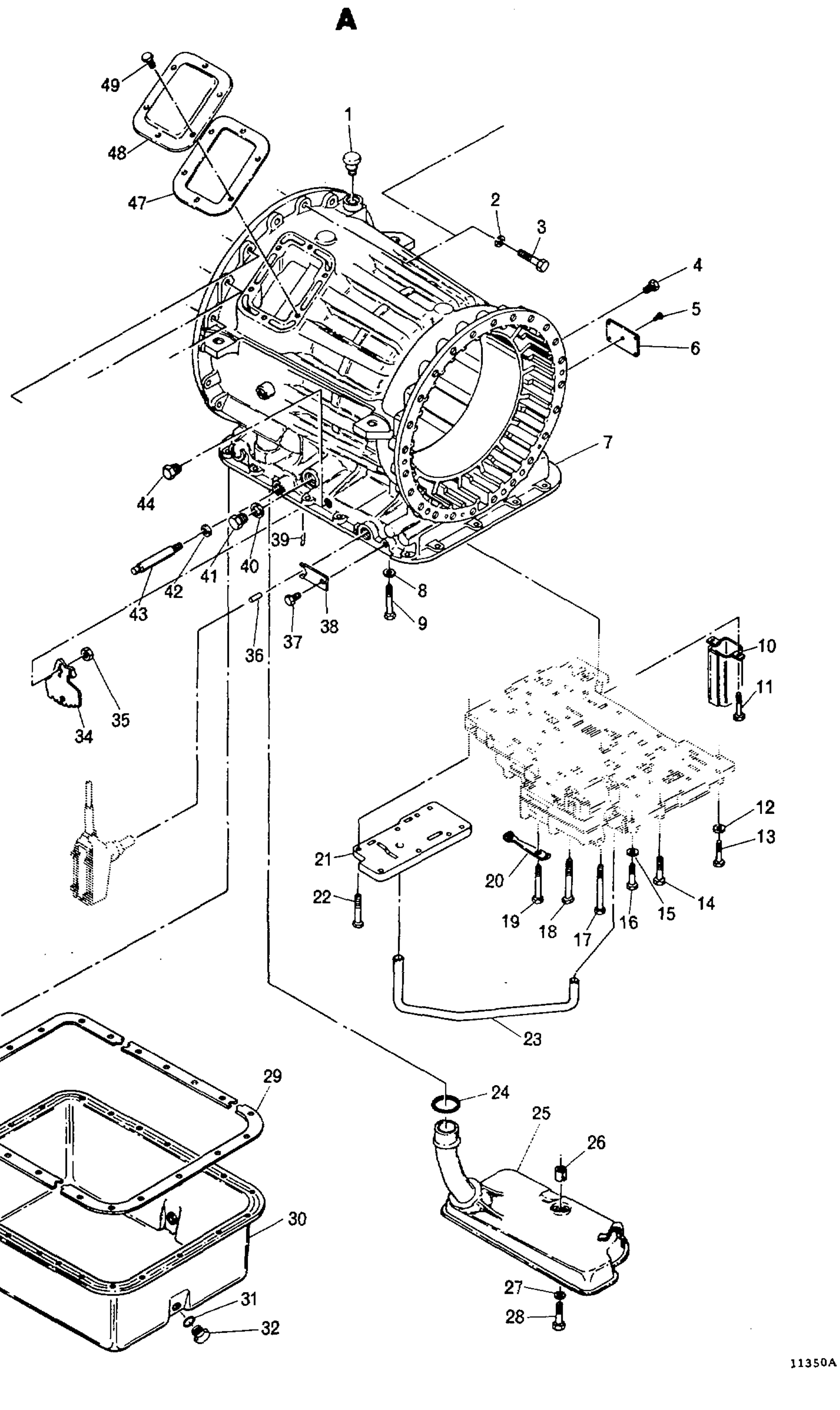


A, foldout 13. Gear unit and main shaft assembly exploded view

LEGEND A, FOLDOUT 14

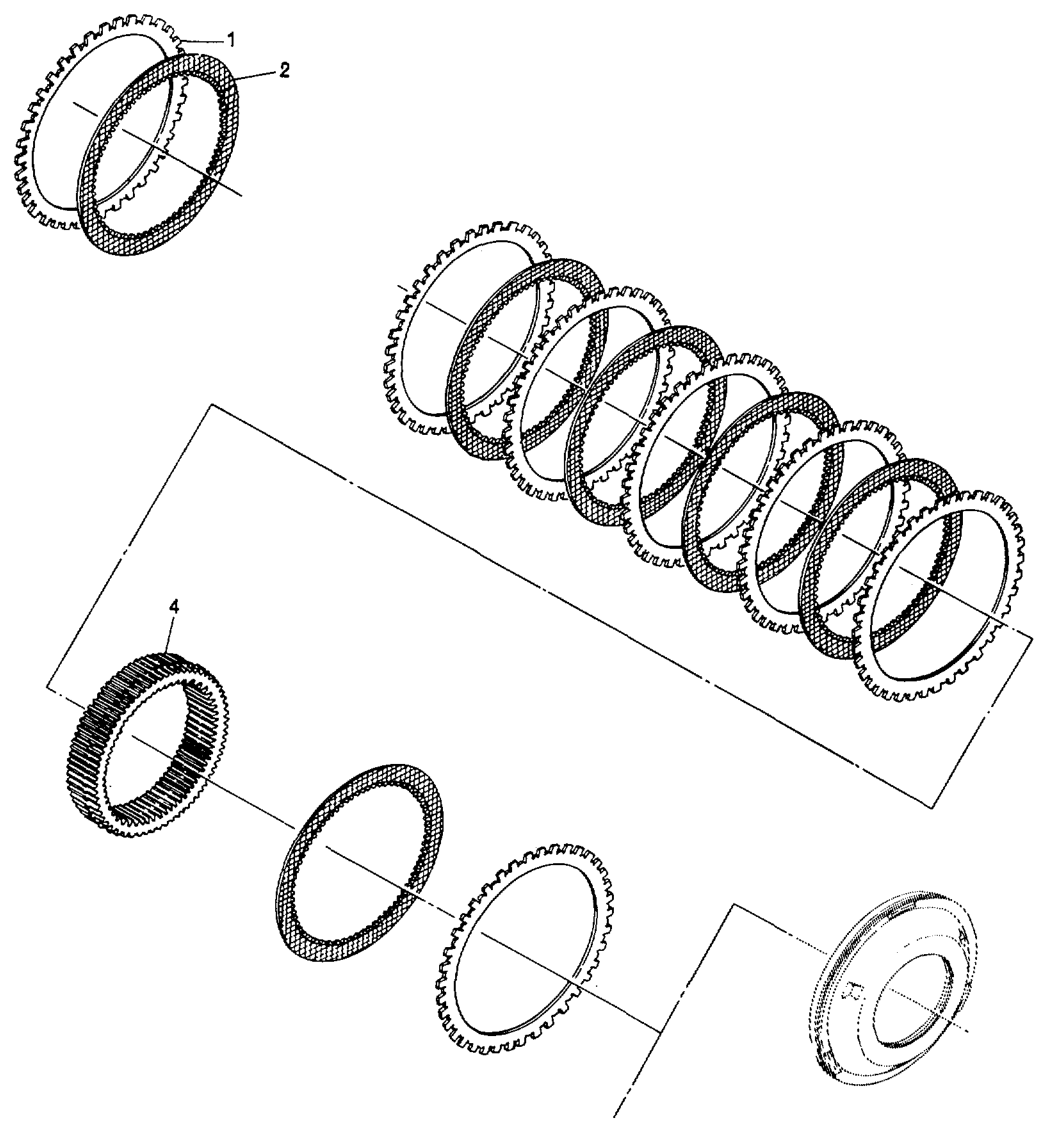
1 - Transmission breather
2 - Lockwasher, 1/2 (11)
3 - Bolt, 1/2-13 x 2 (11)
4 - Pipe plug, 1/8
5 - Drive screw
6 - Name plate
7 - Transmission housing
8 - Plain washer, 3/8
9 - Bolt, 3/8-16 x 3
10 - Oil baffle
11 - Bolt, 1/4-20 x 1 1/2 (2)
12 - Plain washer, 1/4
13 - Bolt, 1/4-20 x 1 1/2
14 - Bolt, 1/4-20 x 1 1/2 (7)
15 - Plain washer, 1/4
16 - Bolt, 1/4-20 x 1 1/2
17 - Bolt, 1/4-20 x 3 1/2 (3)
18 - Bolt, 1/4-20 x 3 (15)
19 - Bolt, 1/4-20 x 2 1/2
20 - Detent roller and spring assembly
21 - Cover plate
22 - Bolt, 1/4-20 x 2 (8)
23 - Tube, 3, 4, 5 Signal (HT 750)
24 - Sealring
25 - Oil filter
26 - Oil filter spacer
27 - Plain washer, 5/16
28 - Bolt, 5/16-18 x 1 5/8
29 - Oil pan gasket
30 - Oil pan
31 - Drain plug washer
32 - Drain plug
33 - Washer head screw, 5/16-18 x 5/8 (23)
34 - Inside detent lever assembly
35- Locknut, 3/8
36 - Modulator valve actuator pin
37 - Bolt, 5/16-18 x 9/16
38 - Modulator-to-housing retainer
39 - Shaft retainer pin
40 - Washer
41 - Pipe plug, 3/4
42 - Shaft seal
43 - Manual selector shaft
44 - Pipe plug, 1/8

47 - PTO cover gasket
48 - PTO cover
49 - Bolt, 3/8-16 x 3/4 (6)



A, foldout 14. Transmission housing, oil filter and oil pan-exploded view

B



B

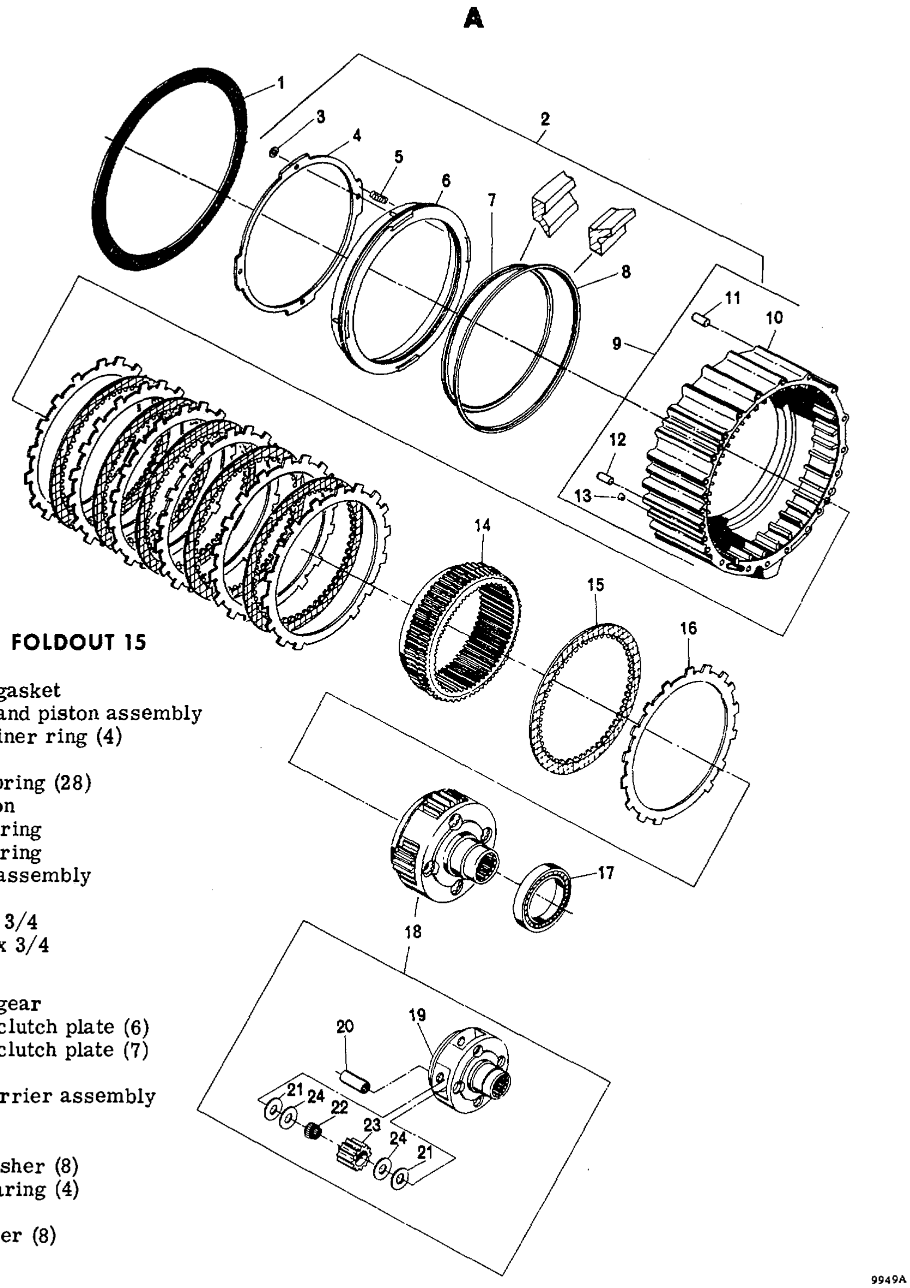
LEGEND

1 - External-tanged clutch plate (7):
0.0955 (2.43 mm)-0.1025 (2.60 mm) thk (ar)
0.1161 (2.95 mm)-0.1231 (3.13 mm) thk (ar)

2 - Internal-splined clutch plate (6)

9863A

B, foldout 14. First clutch--exploded view



LEGEND FOR A, FOLDOUT 15

1 - Adapter housing gasket
2 - Adapter housing and piston assembly
3 - Self-locking retainer ring (4)
4 - Spring retainer
5 - Piston release spring (28)
6 - First clutch piston
7 - Piston inner sealring
8 - Piston outer sealring
9 - Adapter housing assembly
10 - Adapter housing
11 - Dowel pin, 3/8 x 3/4
12 - Dowel pin, 7/16 x 3/4
13 - Orifice plug
14 - Low-clutch ring gear
15 - Internal-splined clutch plate (6)
16 - External-tanged clutch plate (7)
17 - Ball bearing
18 - Low planetary carrier assembly
19 - Low carrier
20 - Pinion pin
21 - Bronze thrust washer (8)
22 - Needle roller bearing (4)
23 - Pinion (4)
24 - Steel thrust washer (8)

—exploded view

A, foldout 15. Adapter housing, low-clutch plates and low carrier

LEGEND A, FOR FOLDOUT 16

1 - External snapring
2 - Spring retainer
3 - Piston release spring (30)
4 - Low-clutch piston

5 - Piston outer sealring
6 - Piston inner sealring
7 - Rear cover gasket
8 - Rear cover assembly
9 - Plug, 1/8 NPTF
10 - Plug, 1/8 NPTF
11 - Governor support pin
12 - Dowel pin, 3/8 x 3/4
13 - Dowel pin, 7/16 x 3/4
14 - Rear cover
15 - Speedometer driven gear bushing
16 - Lockwasher, 1/2 (21)
17 - Bolt, 1/2-13 x 5 3/4 (21)

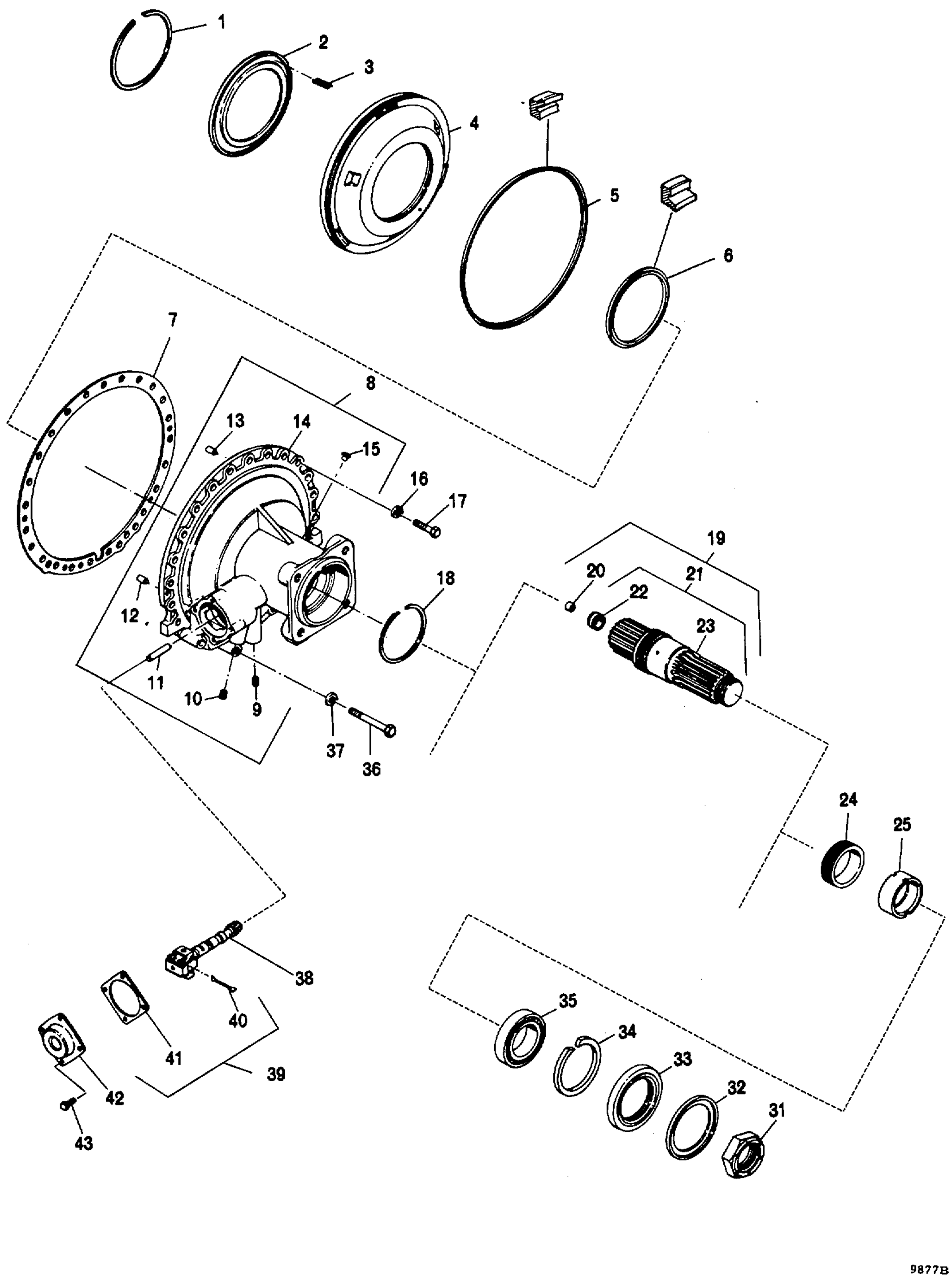
18 - Internal snapring (use before SN 5660)
19 - Output shaft assembly

20 - Orifice plug
21 - Output shaft and bushing assembly

22 - Bushing
23 - Output shaft
24 - Speedometer drive gear
25 - Spacer sleeve

31 - Self-locking nut 2-16
32 - Dust shield
33 - Lip type oil seal
34 - Internal snapring
35 - Ball bearing
36 - Bolt, 1/2-13 x 7 1/4 (3)

37 - Lockwasher, 1/2 (3)
38 - Governor assembly
39 - Governor pin and gasket assembly
40 - Governor pin (2)
41 - Gasket
42 - Governor cover
43 - Bolt, 5/16-18 x 9/16 (4)



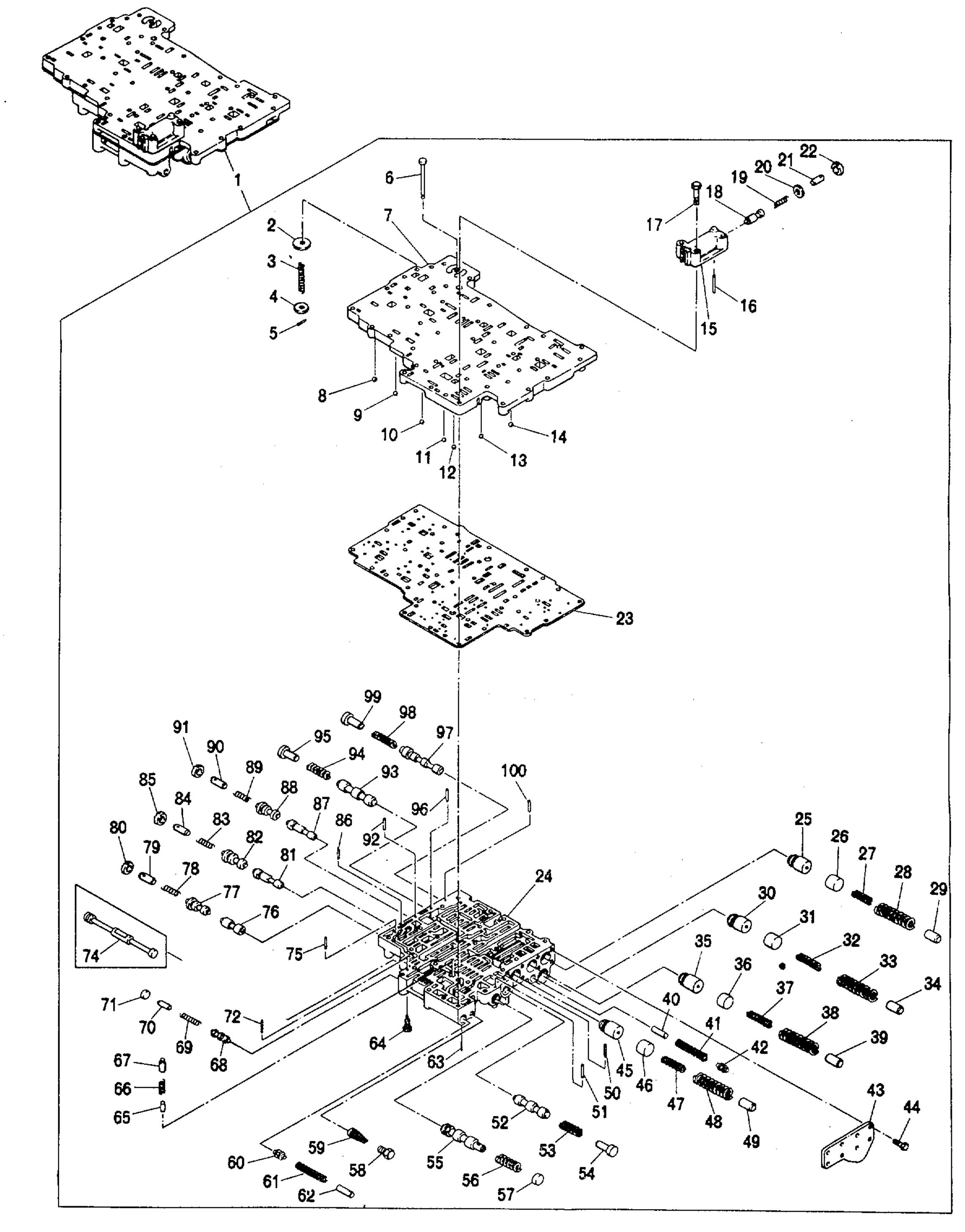
A, foldout 16. First and low piston, rear cover, output shaft and governor-exploded view

LEGEND B, FOR FOLDOUT 16

1 - Control valve assembly
2 - Lubrication valve
3 - Check valve spring
4 - Spring cup washer
5 - Spring pin
6 - Check valve pin
7 - Oil transfer plate
8 - Ball, 1/4 dia.
9 - Ball, 5/16 dia.
10 - Ball, 1/4 dia.
11 - Ball, 1/4 dia.
12 - Ball, 1/4 dia.
13 - Ball, 1/4 dia.
14 - Ball, 1/4 dia.
15 - Modulator pressure valve body
16 - Retainer pin
17 - Bolt, 1/4-20 x 2 1/2 (3)
18 - Modulator valve
19 - Modulator valve spring
20 - Retainer washer
21 - Valve stop
22 - Spring adjusting ring
23 - Separator plate
24 - Control valve body
25 - Third clutch trimmer valve
26 - Trimmer plug
27 - Trimmer valve secondary spring
28 - Trimmer valve primary spring
29 - Third clutch trimmer valve stop
30 - First and reverse clutch trimmer valve
31 - Trimmer plug
32 - Trimmer valve secondary spring
33 - Trimmer valve primary spring
34 - First clutch trimmer valve stop
35 - Second clutch trimmer valve
36 - Trimmer plug
37 - Trimmer valve secondary spring
38 - Trimmer valve primary spring
39 - Second clutch trimmer valve stop
40 - Trimmer boost accumulator stop
41 - Trimmer boost accumulator valve spring
42 - Trimmer boost accumulator valve
43 - Trimmer valve cover
44 - Bolt, 1/4-20 x 5/8 (8)
45 - Fourth clutch trimmer valve
46 - Trimmer plug
47 - Trimmer valve secondary spring
48 - Trimmer valve primary spring
49 - Fourth clutch trimmer valve stop
50 - Retainer pin
51 - Retainer pin
52 - (3-4) relay valve
53 - Relay valve spring
54 - (3-4) relay valve stop
55 - (2-3) relay valve
56 - Relay valve spring
57 - Valve spring spacer
58 - Pipe plug, 1/8
59 - Governor screen assembly
60 - Governor accumulator valve
61 - Governor accumulator valve spring
62 - Governor accumulator valve stop
63 - Retainer pin
64 - Special bolt assembly
65 - Priority valve stop
66 - Priority valve spring
67 - Priority valve
68 - Hold regulator valve
69 - Hold regulator valve spring
70 - Hold regulator valve stop
71 - Hold regulator valve plug
72 - Retainer pin

74 - Manual selector valve
75 - Retainer pin
76 - (2-3) shift valve
77 - (2-3) modulator valve
78 - (2-3) shift valve spring
79 - (2-3) shift valve stop
80 - Spring adjusting ring
81 - (3-4) shift valve
82 - (3-4) modulator. valve
83 - (3-4) shift valve spring
84 - (3-4) shift valve stop
85 - Spring adjusting ring
86 - Retainer pin
87 - (4-5) shift valve
88 - (4-5) modulator valve
89 - (4-5) shift valve spring
90 - (4-5) shift valve stop
91 - Spring adjusting ring
92 - Retainer pin
93 - (4-5) relay valve
94 - Relay valve spring
95 - (4-5) relay valve stop
96 - Retainer pin
97 - Trimmer regulator valve
98 - Trimmer regulator valve spring
99 - Trimmer regulator valve stop
100 - Retainer pin

B

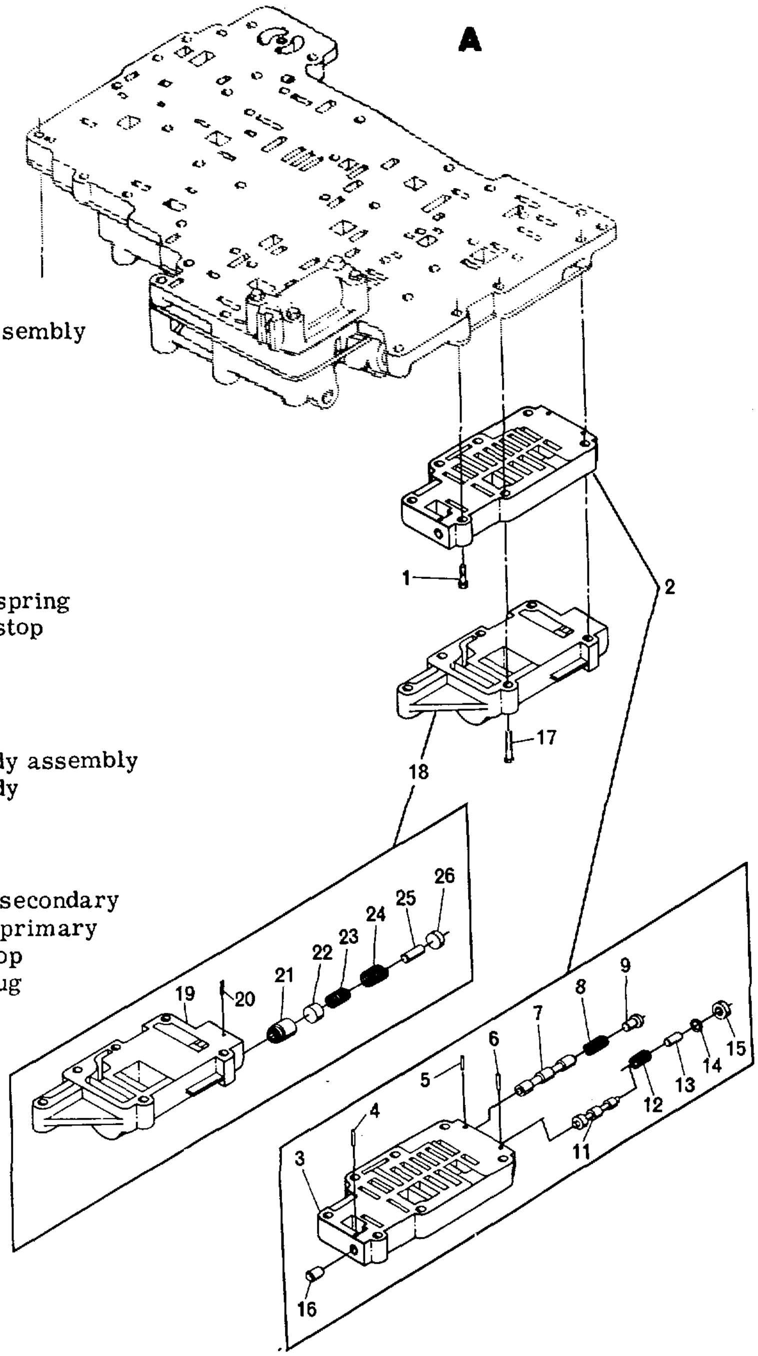


B, foldout 16. Control valve assembly-exploded view

A LEGEND

1 - Bolt, 1/4-20 x 2 3/4
2 - Low shift valve body assembly
3 - Low shift valve body
4 - Retainer pin
5 - Retainer pin
6 - Retainer pin
7 - Relay valve
8 - Relay valve spring
9 - Relay valve stop

11 - Low shift signal valve
12 - Low shift signal valve spring
13 - Low shift signal valve stop
14 - Washer
15 - Spring adjusting ring
16 - Plug valve
17 - Bolt, 1/4-20 x 4 (6)
18 - Low trimmer valve body assembly
19 - Low trimmer valve body
20 - Retainer pin
21 - Low trimmer valve
22 - Low trimmer plug
23 - Low trimmer spring, secondary
24 - Low trimmer spring, primary
25 - Low trimmer valve stop
26 - Low trimmer valve plug



A, foldout 17. Lockup cutoff, low shift and low trimnmer valve body assemblies-exploded view

TRANSMISSION - AUXILIARY

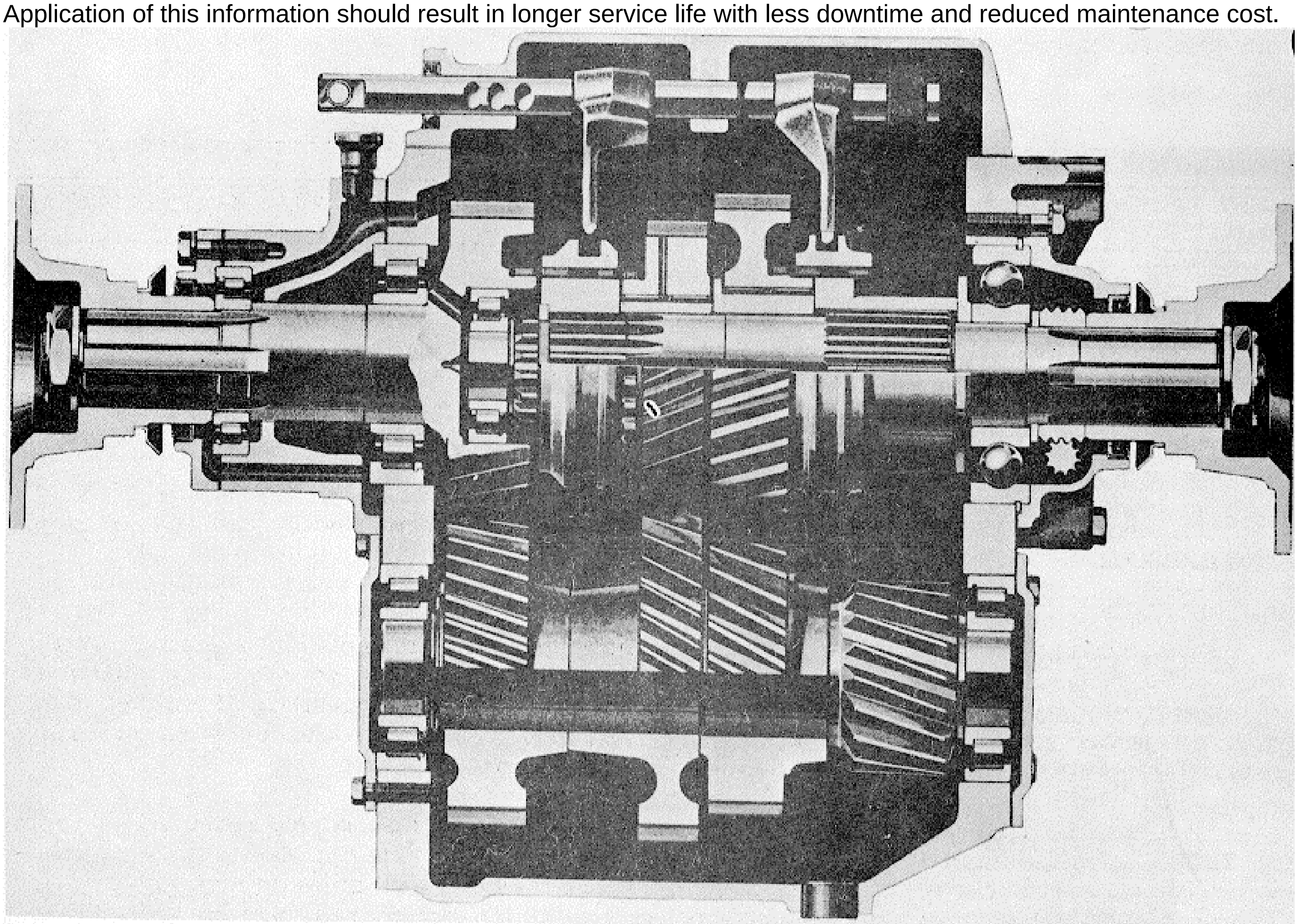
IH CODE NO. 13538

INDEX

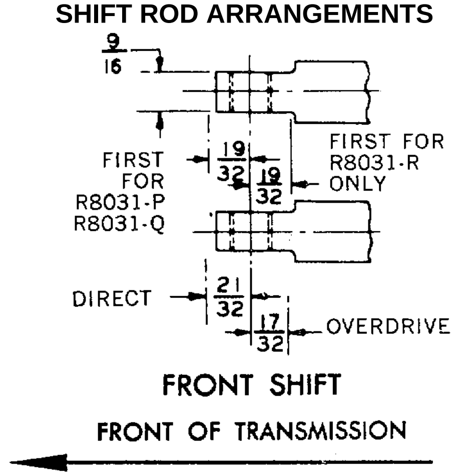
INTRODUCTION

This maintenance manual covers details of the SPI'ER R8000 Series 3-Speed Auxiliary Transmissions.

The information is written for the professional service man and, therefore, excludes much elementary information. Application of this information should result in longer service life with less downtime and reduced maintenance cost.



SHIFT ROD ARRANGEMENTS



SPICER TRANSMISSION LUBRICATION

GENERAL INFORMATION

The R8000 auxiliary transmission is designed to utilize splash lubrication for all internal bearings, bushings, shafts and gears.

To insure proper lubrication and operating temperatures in these units it is most important that the proper lubricants be used and that correct oil levels be maintained.

RECOMMENDED LUBRICANTS

TEMPERATURE	GRADE	TYPE
ABOVE 0°F **BELOW 0°F**	**SAE 30, 40, or 50** **SAE 30**	**HEAVY DUTY ENGINE OIL MEETING SPEC MIL-L-2104B OR MIL-L-45199 SERIES 3**
ABOVE 0°F **BELOW 0°F**	**SAE 90** **SAE 80**	**STRAIGHT MINERAL GEAR OIL**

Do NOT USE EXTREME PRESSURE ADDITIVES, such as found in multi-purpose or rear axle type lubricants. These additives are not required in Spicer transmissions, and may, in some cases, create transmission problems. Multi-purpose oils, as a group, have relatively poor oxidation stability, a high rate of sludge formation and a greater tendency to react on, or corrode, the steel and bronze parts.

Capacity: 12 pints at 0° installation capacity will vary with, and is dependent on, angle of installation.

OIL CHANGES

We recommend an initial oil change and flush after the transmission is placed in *actual* service. This change should be made any time following 1000 miles, but *never to exceed 4000 miles,* of over-the-road service. In off-highway use, the change should be made after 24 and before 100 hours of service have elapsed. There are many factors that influence the following oil change periods and we have not specified a definite mileage interval.

In general, it is suggested that a drain and flush period be scheduled every 20,000 miles for normal over-the-highway operations. Off-the-highway usually requires oil change every 30 days. The oil level in the transmission should be checked every 2,000 miles on-highway, or every 24 hours in off-highway operation. The correct oil level in *all* Spicer transmissions is established by the filler plug opening.

REFILL First, remove all dirt around the filler plug. Then refill with new oil of a grade recommended for the existing season and prevailing service. Fill to the bottom of the level testing plug positioned on the side of the transmission.

OVERFILLING

Do not overfill the transmission. Overfilling usually results in oil breakdown due to excessive heat and aeration from the churning action of the gears. Early breakdown of the oil will result in heavy varnish and sludge deposits that plug up oil ports and build up on splines and bearings. Overflow of oil usually escapes onto parking brakes causing additional trouble.

CAUTION

Do not tow vehicles equipped with Spicer transmissions at high speeds or for long distances without first pulling the axles or disconnecting the drive shaft. Lubrication of the internal gear train is inadequate when the vehicle is towed.

AUXILIARY TRANSMISSION ASSEMBLY

REMOVE AND REINSTALL

Remove

1. Disconnect shift linkage, speedometer cable and propeller shafts at input, and output shaft flanges.
2. Support auxiliary transmission with a unit lift.
3. Disconnect auxiliary transmission front trunnion support; then disconnect transmission rear support.
4. Remove auxiliary transmission using the unit lift.

Reinstall

1. Position the auxiliary transmission under the vehicle using a unit lift. Then raise the transmission aligning the transmission in relation to its location.
2. Connect the auxiliary transmission front trunnion support and rear support.
3. Remove the unit lift.
4. Connect the propeller shafts at input and output shaft flanges. Then connect shift linkage and speedometer cable.

SHIFTER HOUSING FRONT CONTROL

DISASSEMBLY:

1. Shift auxiliary into neutral. Remove retaining cap screws (K-2) and lock washers (K-5). Separate cover (R-2) from case (G-1) and gasket (K-I) and lift straight up.

2. Remove plug (R-7) from poppet ball hole and tip shifter housing to remove poppet spring (R-6), poppet plunger (R-5) and poppet ball (R-4) from housing.

3. Place shifter housing in a vise so that shift forks are facing out and end of shift rods (R-11 and R-8) are pointing to the right.

4. Remove screw (R-14) in shift forks (R-9 and R-12). Remove screw (R-14) from shift fork (R-12) and use brass drift to tap shift rod free of underdrive shift fork (R-12). If models 8031-P or Q are being worked on remove stop sleeve (R-13) behind fork (R-12). If model R8031-R is being worked on remove long stop sleeve (R-13) in front of fork (R-12).

5. Remove screw (R-14) from direct and overdrive shift fork (R-9). Use brass drift to tap shift rod forward and free of fork. Use *caution* as shift rod is pulled free of front boss to prevent loss of interlock (R-10) and poppet ball (R-4). Use magnet or tip shifter housing over to remove poppet plunger (R-5) and spring (R-6) from cross bore in front boss of shifter housing.

6. If shift rod oil seals (R-3) are to be replaced then remove from housing at this time. Remove old gaskets from sealing surface and clean housing for inspection prior to reassembly.

7. Clean and inspect all shifter housing parts for wear or damage before reassembly.

ASSEMBLY

FRONT CONTROL:

1. To reassemble shifter housing it may be placed on edge in a vise with inside of housing facing out and shift rod oil seal openings to the right. Or, if desired, housing may be placed upside down on a bench.

2. Check fit of shift rods (R-8 and R-11) in shift forks (R-9 and R-12) as well as in their proper position in housing to make sure the parts assemble properly and slide freely. Remove shift rods and apply a light coat of grease to all bores in housing and to the rods as they are assembled in the housing.

3. If shift rod oil seals (R-3) were removed, use a light coat of gasket cement on O.D. of seals and use 12 " tubing or proper tools to press seals into housing.

4. Assemble shift rod poppet spring (R-6), poppet plunger (R-5) and poppet ball (R-4) into lower end of interlock and poppet cross hole in front boss of shifter housing. Use poppet assembly tool to preload poppet, ball and spring during assembly of shift rod.

5. Select the shortest shift rod (direct and overdrive speed shift rod R-8) and enter it through the lower oil seal (R-3) and into bore of housing. Position shift rod so that three poppet notches are down and will align with poppet ball.

6. Tap shift rod (R-8) through first boss to dislodge poppet assembly tool. Slide shift rod through bore and with long hub of shift fork to the left. Assemble direct and overdrive shift fork (R-9) to rod.

7. Locate shift fork (R-9) in its proper position and secure to shift rod with screw (R-14). Torque screw to 40 50 lbs. ft.

8. Locate direct and overdrive shift rod in its neutral position and drop interlock (R-10) into interlock and poppet cross hole of front boss. Make sure interlock seats in neutral notch of shift rod (R-8).

9. Select longest shift rod (underdrive rod R-11) and enter through upper oil seal (R-3) and through front boss of shifter housing. Position shift rod so that two poppet notches are up.

10. Slide shift rod into housing. With long hub of shift fork to the right, assemble underdrive shift fork (R-12) to rod. If reassembling cover for R8031-P or Q model, assemble stop sleeve (R-13) in back of fork (R-12). If reassembling cover for R8031-R assemble long stop sleeve (R-13) on shift rod before assembling fork (R-12) on rod.

11. Pass shift rod through rear boss and locate shift fork in its proper position on rod. Secure fork to rod with screw (R-14) torque to 40-50 lbs. ft.

12. Assemble poppet ball (R-4), poppet plunger (R-5) and poppet spring (R-6) through threaded hole on top outside of shifter housing. Secure with poppet hole plug (R-7).

13. Use large screwdriver and move underdrive shift fork out of neutral position. If interlocks are in place and operative then direct and overdrive shift fork (R-9) will be locked in the neutral position.

14. Return underdrive rod to neutral. Check shifting of both shift rods in and out of neutral to make sure they travel freely and completely into all shift positions. Shift rod back into neutral position.

SHIFTER HOUSING -FRONT CONTROL

NOTE

Poppet spring (R-6) used in front control is not the same as spring (R-66) used in side control.

Spring (R-6) is Spicer Part 71-72-1 Spec's. 38#. Plus or Minus 2 lbs. at 1.00 inch-free length 1-7/32".

Spring (E-66) is Spicer Part 82-72-2 Spec's. 38# Plus or Minus 2 lbs. at 1-13/64 inch-free length 1-31/64".

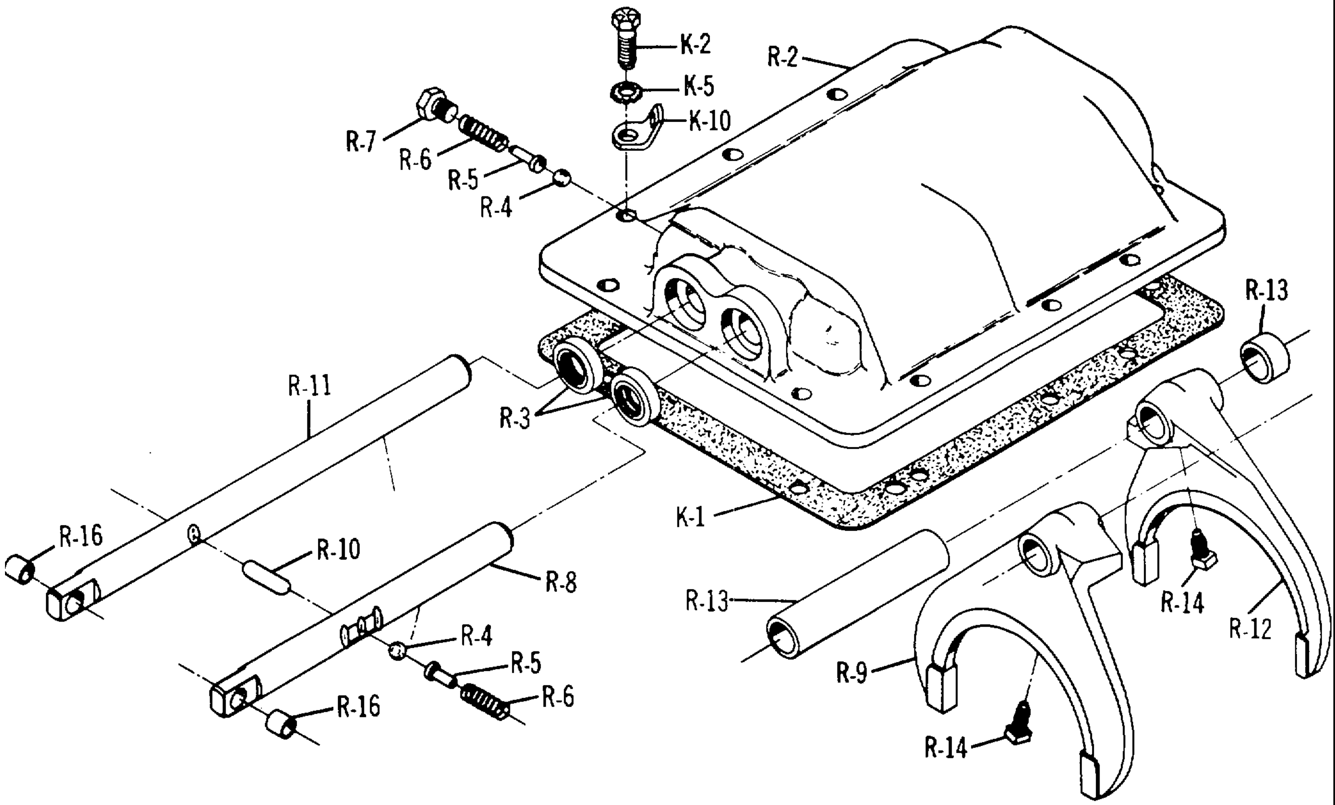


Fig. 1

INSTALLATION OF SHIFTER HOUSING ON CASE:

1. Use light coat of cement and assemble shift cover gasket (K-1) to auxiliary case.

2. Place both clutch gear collars in neutral position.

3. Check to determine that shifter housing is in neutral and set shifter housing assembly down into position on case. Make sure both shift forks are in their proper place on corresponding shift collars.

4. Secure shifter housing to main case with cap screws (K-2), lock washers (K-5).

5. Use large screwdriver or small pry bar and check movement of each shift rod to make sure auxiliary will shift readily and completely into each gear position.

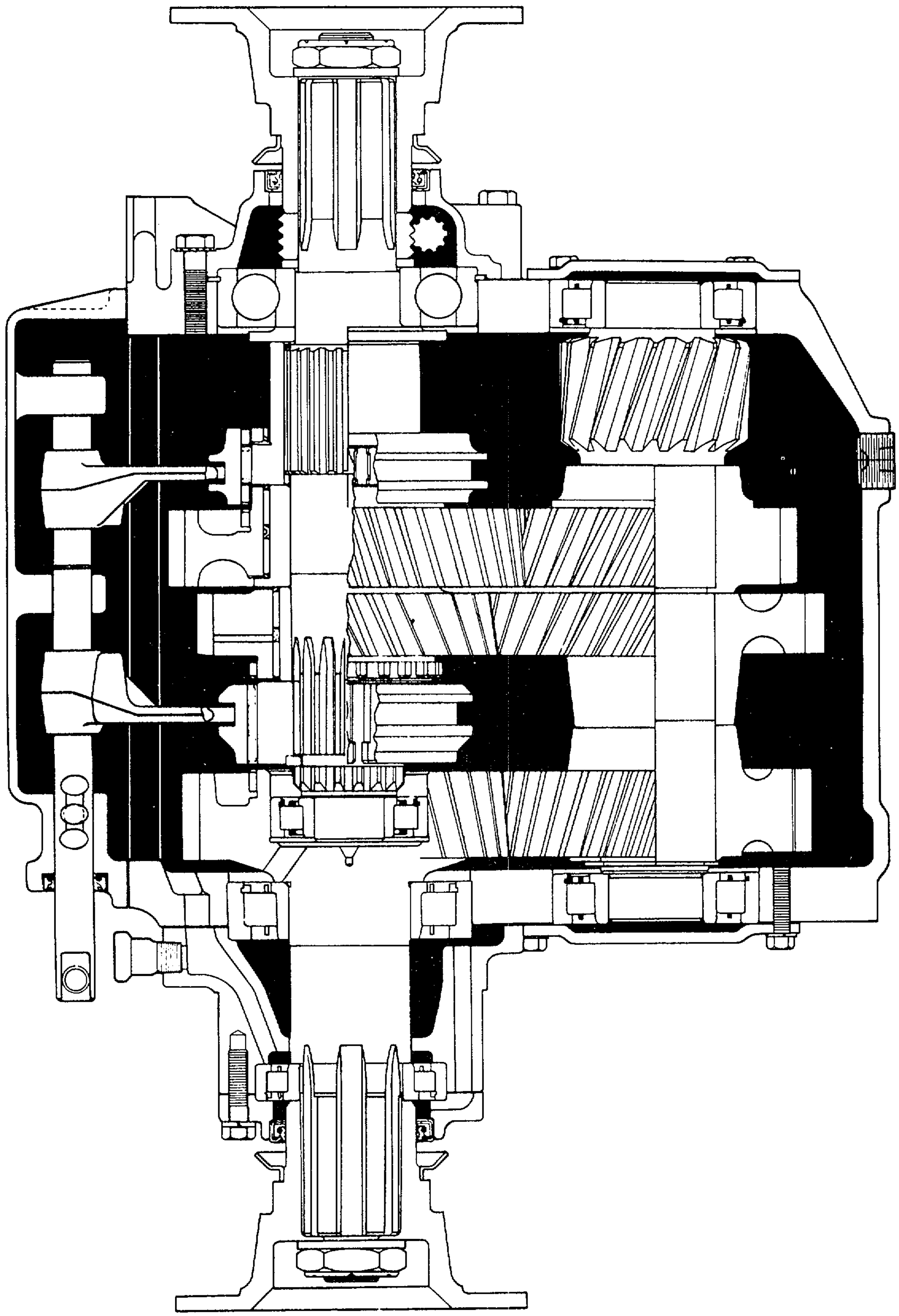


Fig. 4

MAINSHAFT REMOVAL & DISASSEMBLY:

1. Lock auxiliary transmission in two gears by engaging underdrive clutch collar (B-16) with mainshaft gear (B-18) and direct and overdrive clutch collar (B-6) with overdrive gear (B-7).

2. Use 2Y " socket to remove drive gear and mainshaft companion flange or end yoke nuts (A-5 and B-28) and flat washers (A-4 and B-27).

3. Use puller or equivalent and remove main drive gear and mainshaft rear companion flanges or end yokes (A-2 and B-25).

4. Remove front transmission hanger (if used) from drive gear bearing cap (F-7).

5. Remove cap screws (F-4), lock washers (F-6) and separate front bearing cap (F-1) from main drive gear bearing cap (F-7). Remove bearing cap gasket (F-3). Remove front bearing cap oil seal (F-2).

6. Remove cap screws (F-9), lock washers (F-10) from drive gear bearing cap (F-7). Use pull screws on bearing cap (F-7) to separate cap and bearing (A-7) from drive gear (A-1).

7. After drive gear bearing cap (F-7) has been removed, tap bearing (A-7) free of bearing cap by tapping on outer race of bearing from inside of bearing cap.

8. Remove retaining cap screws (H-6 and J-3) with copper washers (H-10 and J-4) from mainshaft and countershaft rear bearing caps (H-2 and J-1). Separate bearing caps from gaskets and case. Check and remove speedometer bushing (H-3) if it is to be replaced by removing mounting parts (H-21 through H-25).

9. Remove speedometer drive gear (or spacer if used) (B-24) and bearing thrust washer (B-23) from rear of mainshaft.

10. To remove mainshaft rear bearing, slide main drive gear (A-1) and bearing (A-9) as far forward as possible. Tap mainshaft (B-1) forward to start rear bearing off mainshaft and expose retaining lock ring (B-2) by using tubular driver against splined shoulder to rear of shaft.

Caution: Do not drive against threaded section at end of shaft. Tap shaft forward until mainshaft clutch gear (B-5) bottoms against drive gear (A-1).

11. Use screw driver lip in groove of retaining ring to remove from groove of mainshaft, or use two screw driver ends on the ends of ring. Push on end and allow ring to fall in bottom of case.

12. Use two pry bars to slide mainshaft and gear assembly (B-1 through B-22) toward rear of case as far as possible. This should slide mainshaft rear bearing (B-22) out of case far enough to use a puller that clamps on the snap ring of the bearing. Remove rear bearing (B-22) and thrust washer (B-21) from mainshaft.

13. Pull mainshaft out through rear bearing bore, lifting the parts from the mainshaft and out the top opening of case as they pull free:

A. Inner race of drive gear pocket bearing (A-10). This is a two piece bearing. The inner race will usually stay with the mainshaft, however, the inner race is a slip fit on the mainshaft and may come off with the drive gear.

B. Direct and overdrive clutch gear and collar (B-5 and B-6).

C. Overdrive gear (B-7) with sleeve (B-10), needle bearings (B-8), and spacer (B-9).

D. Underdrive gear (B-12) with remaining caged-or loose needles (B-14), for models R8031-P and Q. Model R8031-R unit (B-12A) gear will be located next to back of case. This gear is a deep reduction gear 2.40:1 ratio.

E. Shift collar (B-16).

14. Loose or caged needle roller bearings (B-8) are also used with mainshaft overdrive gear (B-7). If these bearings are to be reused then use caution to prevent loss of needles as gear (B-7) is removed from sleeve (B-10).

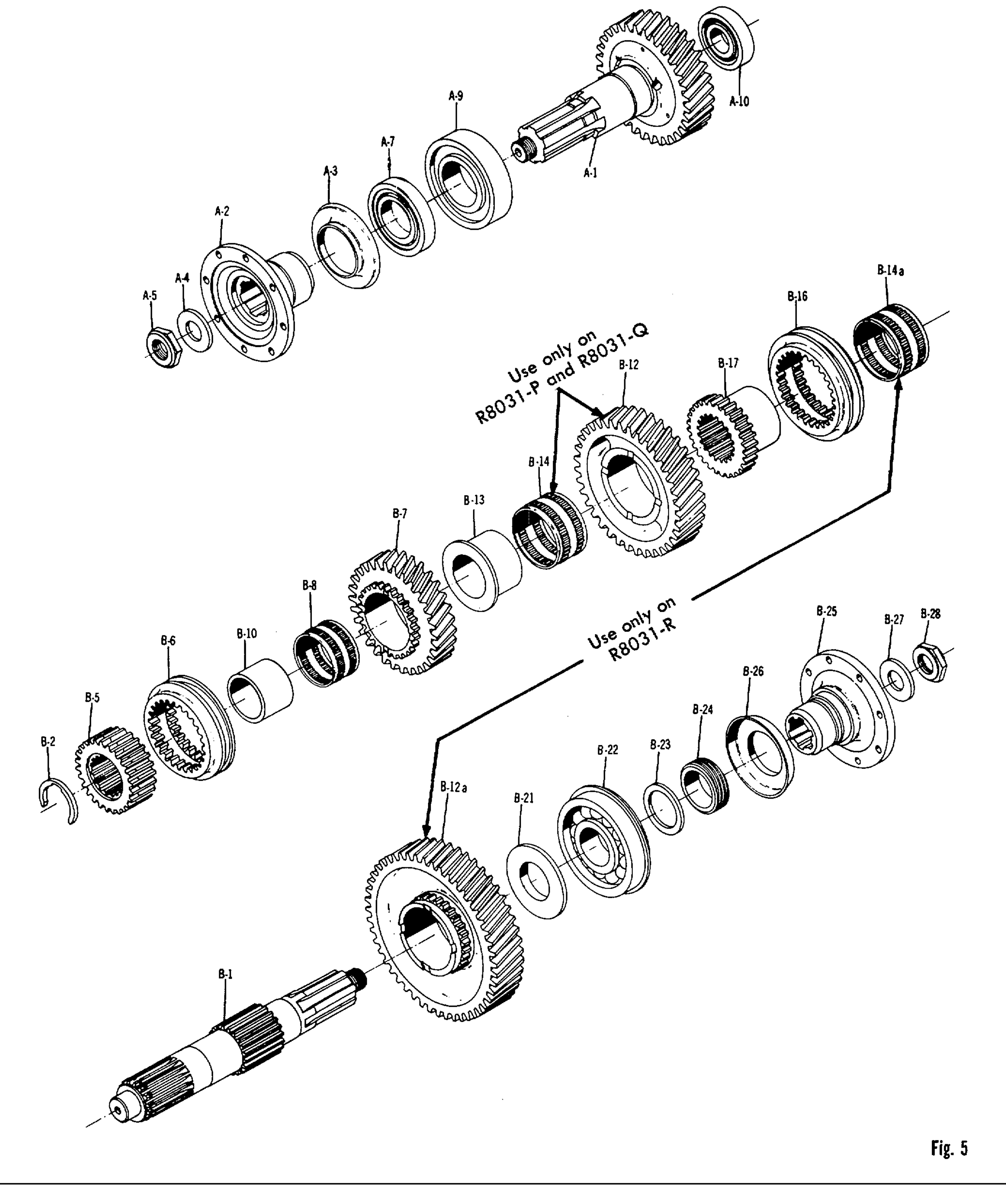
15. Slide drive gear (A-1) rearward and lift out through top opening of case. Remove inner race of bearing (A-9) from drive gear.

16. Use soft hammer and tap outer race of drive gear roller bearing (A-9) out of front bearing bore of case.

17. Remove pocket bearing (A-10) from drive gear (A-1).

COUNTERSHAFT DISASSEMBLY

1. With pry bar on front face of gear (C-6), force countershaft assembly rearward to clear front bearing (C-2) of which the outer race will remain in case bore. Rear bearing (C-14) will be pushed out of case remaining on the countershaft.


A-10
A-9
A-7
A-3
A-2
A-1
A-4
A-5
B-14a
B-16
B-17
Use only on
R8031-P and R8031-Q
B-12
B-14
B-13
B-7
B-8
B-10
B-6
B-5
B-2
Use only on
R8031-R
B-25
B-27
B-28
B-26
B-24
B-23
B-22
B-21
B-12 a
B-1
Fig. 5

2. Remove outer race of rear bearing (C-14).

3. Lift countershaft assembly out top of case.

4. Remove front bearing outer race (C-2) by tapping out with soft hammer from inside of case.

5. Remove snap ring (C-3) from shaft. Using an Arbor Press, press countershaft out of gears (one at a time) by supporting each gear with parallel bars as close to hub of gear as possible. In succession, remove drive gear (C-6) and overdrive gear (C-8), under drive gear (C-12).

6. Remove three exposed Woodruff keys (C-7, C-9 and C-13) for models R8031-P and Q keys (C-7) and (C-9) for model R8031-R. NOTE : On model R8031-R a snap ring (C-3) secures gear (C-8) to shaft.

COUNTERSHAFT REASSEMBLY IMPORTANT

All countershaft gears should fit tight on the countershaft. An interference fit of .0015" to .003" is built into new parts; it presents a field assembly problem.

If heat is used to expand countershaft gear bores, boiling water, hot oil or steam are usually satisfactory. DO NOT EXCEED 250" F. Do not use hot plates or acetylene torches or any method that will turn the steel blue or straw color and damage the heat treated gears.

If heat is not used, it is advisable to coat the gear bores with white lead to reduce galling or seizing of parts.

NOTE

When in doubt about which end of the gear hub to assemble on the shaft first, look for the chamfered end of the bore in gear. This end assembles first.

If Woodruff keys or keyways were mutilated or burred during disassembly, clean up with a file before reassembling. This will help prevent metal chips from getting between gear hub faces.

1. For models R8031-P and Q assemble Woodruff key (C-13) to countershaft (C-1). Seat key securely and redress with file if necessary.

2. In a suitable Arbor press, support underdrive gear (C-12) on hub, with long hub and chamfer up. Place countershaft (C-1) into position, align key with keyway and press into gear until shoulder on countershaft seats firmly against gear.

3. Assemble Woodruff keys (C-7 and C-9) to countershaft (C-1). Seat keys securely and redress with file if necessary.

4. Again, in arbor press, support under hub of overdrive gear (C-8) with long hub down and chamfer up, place countershaft into position, align key with keyway and press into gear until seated against gear (C-12).

5. In a similar manner, support countershaft drive gear (C-6), with long hub and chamfer up. Press countershaft sub-assembly into gear until seated against overdrive gear (C-8). Secure with snap ring (C-3).

NOTE

Separable bearings will be found as the front and rear countershaft bearing (C-14) and (C-2). When separable bearings are used, press on the inner race with flange seated against shoulder of countershaft. Outer race snap ring, must face toward gears when installed. To prevent auxiliary countershaft bearing preload at assembly, front and rear bearing outer rings must protrude .020 outside of case bore, before bearing caps are assembled and secured.

INSTALLATION OF COUNTERSHAFT

1. Lower countershaft sub-assembly into case with rear end of shaft and hub of underdrive gear (C-12) out rear bearing bore. Lower front of countershaft into its position to front bearing outer race bore. Assemble outer race of rear bearing (C-14) and (C-2).

2. Use light coat of gasket cement and assemble countershaft front and rear bearing cap gaskets (J-2) (F-21) to bearing caps (J-i) (F-20). Apply gasket cement to case side of gaskets and apply to case front and rear bearing caps.

3. Dip retaining cap screws (J-3) (F-22) in sealer and assemble to case with lock washers (J-4) (F-23). Torque cap screws to 25 32 lbs. ft.

MAINSHAFT ASSEMBLY AND INSTALLATION PARTIAL INSTALLATION OF MAIN DRIVE GEAR

The diameter of the main drive gears used in the R8000 Series auxiliaries are larger than the main drive gear bearing bore in the case. This necessitates a partial assembly of the drive gear in the case prior to installation of the mainshaft assembly.

NOTE

Assemble auxiliary drive gear bearing (A-9) with outer race snap ring toward gear teeth to prevent bearings from operating with thrust load against snap ring.

1. Position inner race of drive gear roller bearing (A-9) under arbor press with flanged end of inner race up. Support inner bearing race and press drive gear (A-1) into bearing. Be sure flanged end of inner race bottoms against front face of drive gear.

2. Position drive gear pocket bearing (A-10) in drive gear (A-1) and press into place.

NOTE

Drive gear pocket bearing (A-10) is made in two pieces. Be sure pocket bearing is assembled with flanged end of inner race up or so it will be toward mainshaft.

3. Use soft hammer and tap outer race and roller assembly of drive gear bearing (A-9) into front bearing bore of case. Seat bearing tight against counterbore of case.
4. Lower front end of drive gear (A-1) through top opening of case and slide it forward into drive gear roller bearing assembly (A-9).
5. Check to make sure inner race of drive gear pocket bearing (A-10) is in place in drive gear counterbore.

MAINSHAFT ASSEMBLY:

Prior to assembly check the following parts for slip fits, to insure free and easy assembly of the mainshaft inside the case.

(a) Spline fit of direct and overdrive clutch gear (B-5) with clutch collar (B-6) and fit of internal splines on (B-5) with mainshaft splines.

(b) Slip or loose fit of overdrive gear sleeve (B-10) on mainshaft ground diameter.

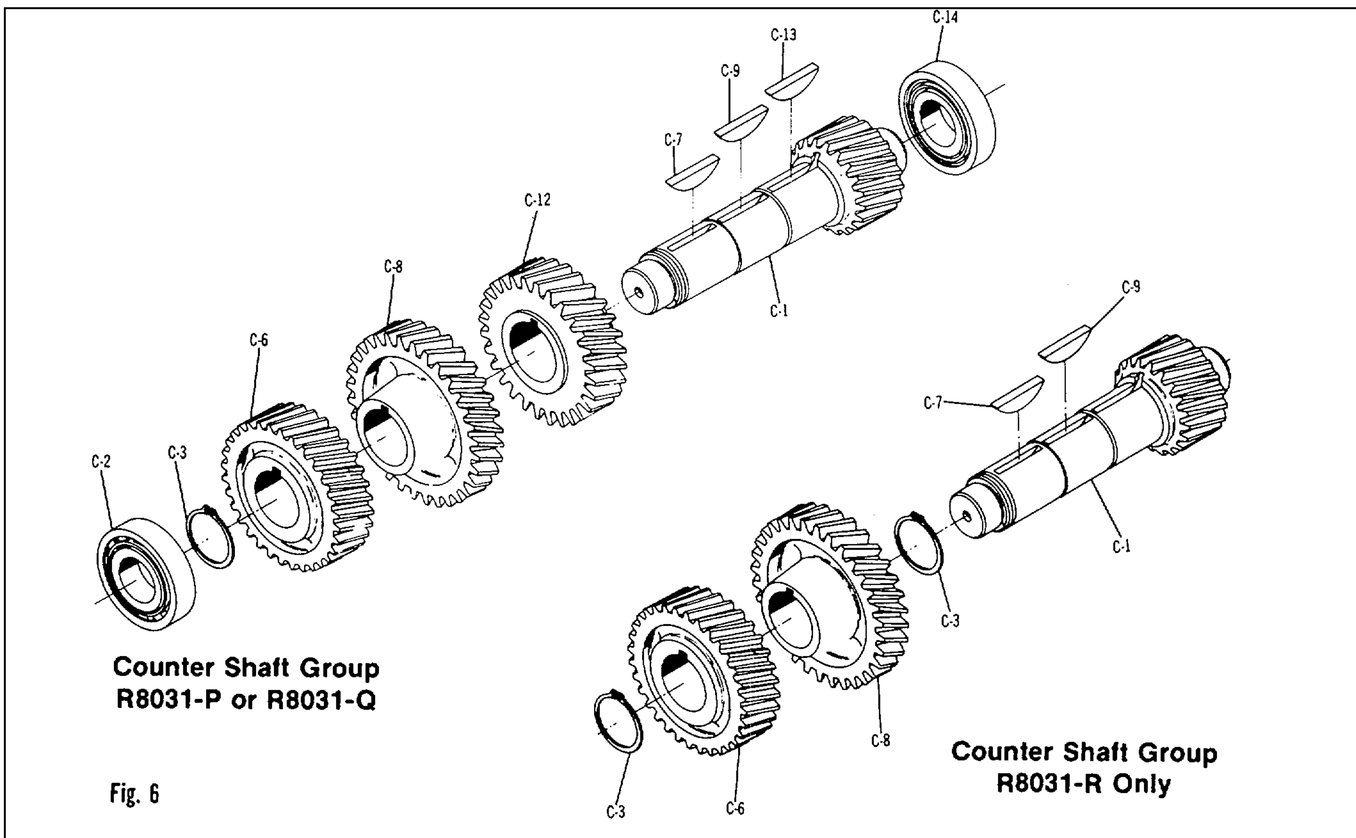
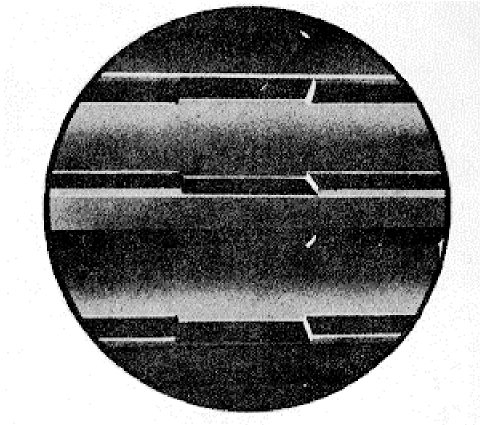


Fig. 6

CAUTION

The splines of many Spicer clutching gears, main shafts, etc., are equipped with a machined relief called c "hopping guard". With the clutch gear in the engaged position, the mating gear is free to slip into this notch, preventing the two gears from "walking out of gear" under load.

(See enlarged view.) This is not a worn or chipped gear! Do not grind it down or discard the gear.



A. Loose or caged needle roller bearings are used to carry the overdrive, underdrive and lo-lo gears (B-7, B-12 & B-12a) on the mainshaft of the R8000 Series auxiliaries.

B. The individual gears, with sleeve and needle roller bearing sub-assemblies must be positioned in the case and the mainshaft assembled through the rear bearing retainer bore.

C. Due to variations in tolerances and to provide better bearing lubrication, Dana engineers recommend that loose needle bearings should not completely encircle the shaft. Space for approximately one needle should be left unfilled on all Dana/Spicer needle bearing applications. This will aid in preventing seizures by allowing easier oil entry and free movement of the needle bearings.

D. To reassemble loose needle roller bearings (B-8 and B-14) the following steps are suggested. However, if it is more convenient to assemble needle bearings to inside of gears, rather than outside of sleeves, the method is applicable.

If new parts are being installed, always check the following to insure free and easy assembly and installation of mainshaft:

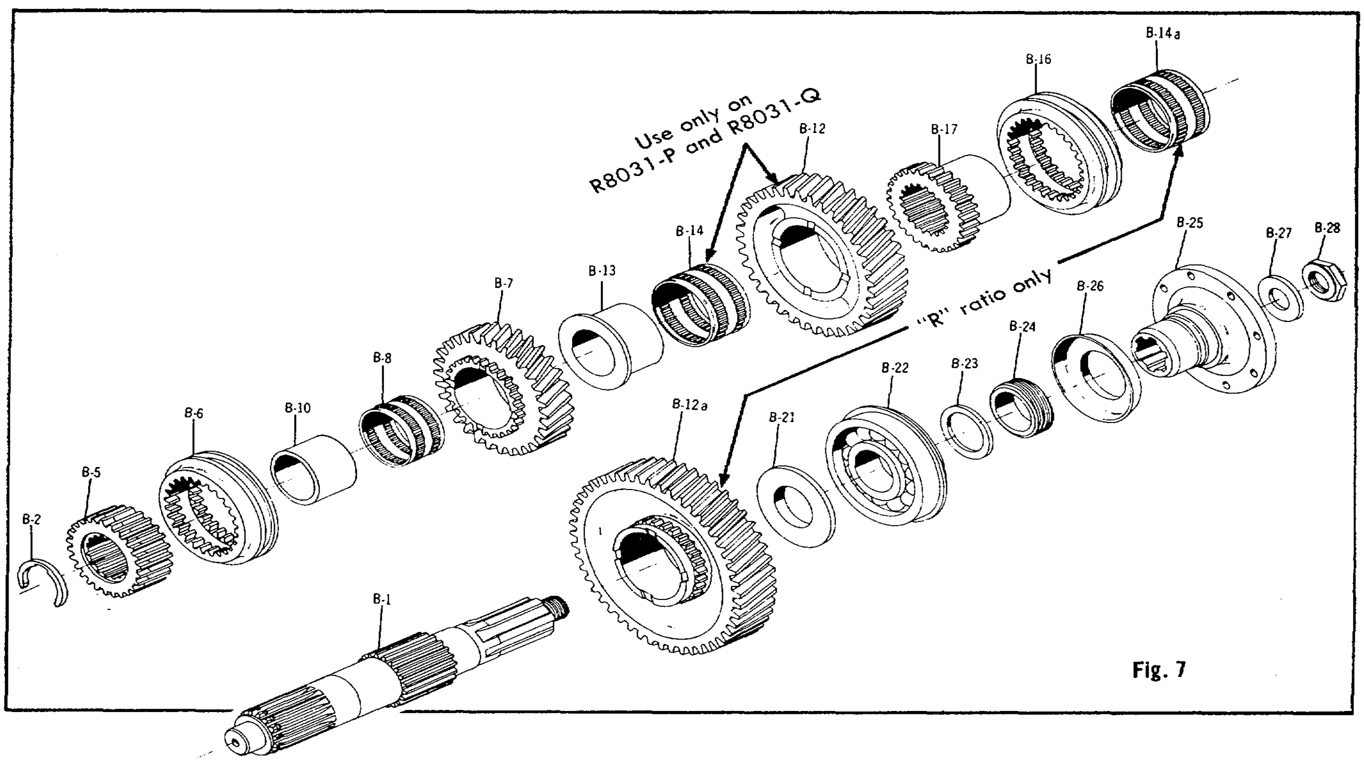


Fig. 7

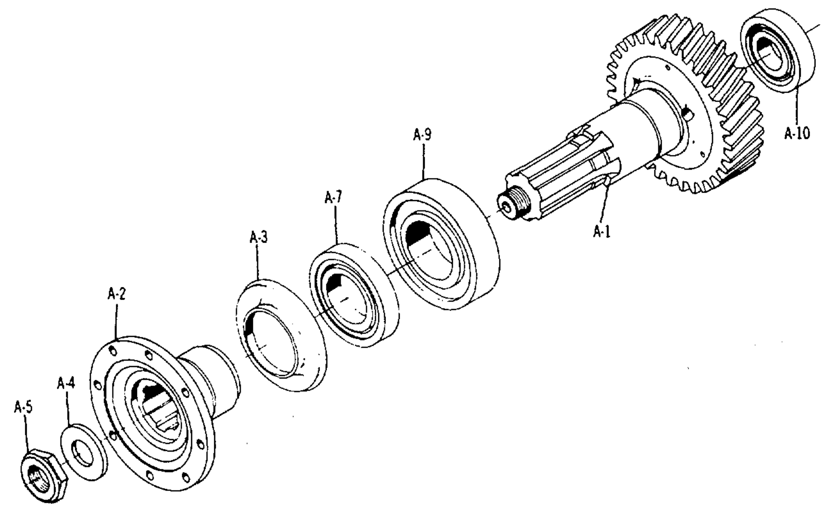


Fig. 8

a. Spline fit of lo-lo and underdrive clutch gear (B-17).
b. Spline fit of direct and overdrive clutch gear (B-5).
c. Underdrive gear sleeve (B-13).
d. Overdrive gear sleeve (B-10).

Spline and sleeve must be a free fit with mainshaft.

1. For model R8031-R only, place lo-lo and underdrive clutch gear (B-17) on bench with flange down. Apply a light coat of grease, approximately 1" wide, to the ground area above the flange. Assemble one row of 72 needle roller bearings, (B-19) to clutch gear. Assemble spacer (B-20). Apply light coat of grease and assemble the second row of 72 needle roller bearings or complete caged needle bearing.

CAUTION
Do not plug oil holes in gears with grease.

2. Assemble lo-lo gear (B-12a) to clutch gear (B-17) by placing (B-12a) clutch teeth toward flanged end of (B-17). Slide over needles and spacer. Place gear and sleeve assembly aside.

3. For models R8031-P and Q, in a similar manner, coat underdrive gear sleeve (B-13) on thrust face and ground surface with grease and apply two rows of 72 needle bearings (B-14) with spacer (B-15) between.

4. Assemble underdrive gear (B-12) to sleeve and bearings with clutch teeth of gear away from flanged end. Place gear and sleeve assembly aside.

5. Place overdrive gear sleeve (B-10) on flat plate and coat lower 1" with light grease. Assemble one row of 62 needle roller bearings (B-8) to sleeve, add spacer (B-9) and in a like manner, assemble the second row of 62 needle roller bearings.

6. Assemble overdrive gear (B-7) to sleeve and bearings with clutch teeth of gear up. Place assembly aside.

INSTALLATION OF MAINSHAFT:

The diameter of the main drive gears used in the R8000 Series auxiliaries are larger than the main drive gear bearing bore in the case. This necessitates assembly of the drive gear in the case prior to installation of the mainshaft.

NOTE
Drive gear pocket bearing (A-10) is made in two pieces. Be sure pocket bearing is assembled with flanged end of inner race up or toward mainshaft.

1. For model R8031-R only, position lo-lo gear and sleeve assembly (B-17 thru B-20) in rear of case with clutch teeth toward front of case. Mesh with countershaft gear (C-1). Assemble lo-lo and underdrive clutch collar (B-16) to lo-lo gear with extended hub toward gear (B-18).

2. For model R8031-P and Q, place underdrive gear and sleeve assembly (B-12 thru B-15) in case with clutching teeth of gear toward lo-lo gear (B-17) and mesh with countershaft gear (C-10). Move clutch collar (B-16) into engagement with underdrive gear (B-12) to hold alignment.

3. Coat thrust faces and splines of main shaft with light grease. Enter pilot bearing end of main shaft through rear bearing bore until main shaft has passed through underdrive gear sleeve (B-13) approximately 1".

4. Place overdrive gear and sleeve assembly (B-7 thru B-10) in case with clutch teeth forward or away from underdrive gear (B-12). Slide main shaft forward through bore of sleeve (B-10).

NOTE

Check to make sure inner race of drive gear pocket bearing (A-10) is in place in drive gear counterbore.

5. Assemble direct and overdrive clutch collar (B-6) to clutch gear (B-5). Extended hub of clutch collar assembles toward front as does lock ring counterbore in end of clutch gear (B-5). Position gear and collar in case and assemble to main shaft spline.

6. Place a 1/2" thick soft block (aluminum or brass) between main drive gear (A-1) and direct and overdrive clutch gear (B-5). Tap mainshaft forward until the lock ring groove in splines at front of mainshaft extend beyond face of clutch gear (B-5).

7. Assemble lo-lo gear thrust washer (B-21) on rear of mainshaft with flat surface of washer toward lo-lo gear (B-18) or clutch gear (B-17).

8. Position mainshaft rear bearing (B-22) onto mainshaft with external snap ring away from case. Use pinch bar to lift mainshaft into position to align outer race of bearing with rear case bore. Tap rear bearing onto mainshaft and into rear case bore. If bearing taps into position easily, then seat snap ring of bearing against case and proceed to step 11.

9. If mainshaft rear bearing (B-22) does not tap into position readily then remove 2" block between drive gear (A-1) and clutch gear (B-5). Assemble lock ring (B-2) to groove in mainshaft.

10. Use short length of 2Y " I.D. tubing with flange washer and nut (B-27 and B-28) to pull mainshaft back into its proper position and against rear mainshaft bearing. Make sure ring is centered and seated inside of clutch gear (B-5) counterbore during mainshaft positioning.

11. Remove puller tool or tubing from rear of mainshaft and assemble rear bearing washer (B-23) and speedometer gear or spacer washer (B-24) to mainshaft and seat against rear bearing (B-22).

12. If mainshaft rear bearing cap oil seal (H-3) was removed, then replace. Use gasket cement on O.D. of seal and use seal installation tool to press into place. If required, assemble new speedometer gear bushing (H-2) in cap. Lubricate with engine oil and assemble speedometer driven gear (H-21) and sleeve (H-22) to cap. Check speedometer driven gear to make sure it rotates freely and has .005-.008 end play.

13. Apply gasket cement to mainshaft rear bearing cap gasket (H-4) and install on rear bearing cap. Align the oil passage ports.

14. Apply gasket cement to other side of gasket and assemble bearing cap and gasket to rear of case. Dip cap screws (H-5) in gasket cement and assemble to case with copper washers (H-7). Torque cap screws 60 80 lbs. ft. then lockwire. Assemble dirt flinger on hub of yoke or flange if removed.

15. Assemble end yoke or flange (B-25) to mainshaft with pusher tool. Do not drive yoke or flange onto shaft without provisions to block mainshaft overdrive gear (B-7) against front of case with hardwood block. Be sure lock ring (B-2) is in proper location.

CAUTION

If necessary to drive flanges or end yokes onto mainshaft spline, take care not to damage flange pilot surfaces or bearing diameters in yokes. Use tubing and drive on hubs only.

16. Assemble flat washer (B-27) and nut (B-28) to mainshaft. Lock unit in two gears and torque to 500 550 lbs. ft.

17. Shift clutch collars back into neutral and make sure all shafts turn free.

18. Apply gasket cement to drive gear bearing cap gasket (F-8) and install on drive gear bearing cap (F-7). Align the oil passage ports.

19. Apply gasket cement to other side of gasket and assemble drive gear bearing cap to front of case. Make sure bearing cap is piloted on drive gear roller bearing (A-9).

20. Dip cap screws (F-9) in gasket cement and assemble to case with lock washers (F-10). Tighten and torque drive gear bearing cap retaining cap screws, 60 80 lbs. ft.

21. Position outer roller bearing (A-7) with flange of inner race facing drive gear splines, also outer race snap ring toward splines on shaft of main drive gear (A-1). Use tubing and drive on inner race of bearing. Seat bearing tight against shoulder in bearing cap.

22. If used, assemble new lip seal (F-2) to front bearing cap (F-l). Apply gasket cement to front bearing cap cover gasket (F-3) and install on bearing cap cover (F-l). Line up oil drain hole.

23. Apply gasket cement to other side of gasket and assemble bearing cap cover to front of drive gear bearing cap (F-7).

24. Locate and secure front bearing cap cover (F-l) to drive gear bearing cap (F-7) with cap screws (F-4) and lock washers (F-6). Torque cap screws fo 40 50 lbs. ft.

25. Place front transmission hanger over front bearing cap and assemble end yoke or flange with dirt flinger on hub of yoke or flange (A-2). Assemble drive gear with pusher tool. Observe the same caution and procedure used in step 15.

26. Assemble flat washer (A-4) and nut (A-5) to end of main drive gear. Lock auxiliary in two gears and torque drive gear nut to 500 550 lbs. ft.

27. Shift clutch collars (B-6 and B-16) back into neutral and rotate drive gear to make sure all shafts turn free.

28. Use pressure type oil can to force lubricant down the oil holes and end slots of all floating gears on the mainshaft to flush out the grease and insure initial lubrication of over-running gears and bearings. Use regular auxiliary lubricant

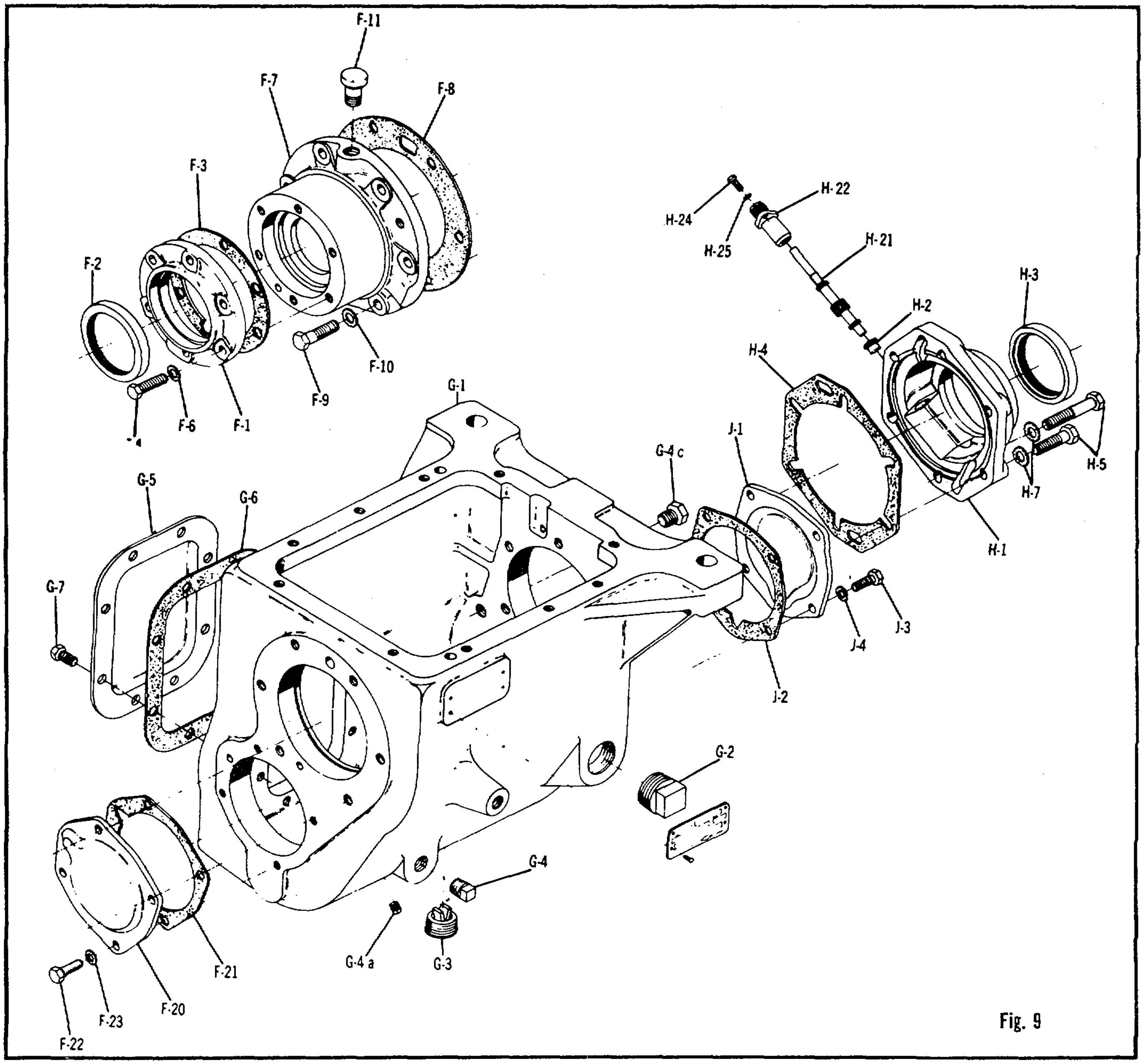


Fig. 9

IMPORTANT PROCEDURE

When locating and correcting unit power or auxiliary transmission troubles, a systematic procedure should be followed.

Road test whenever possible. Mechanics usually get second or third hand reports of trouble experienced with the unit and these reports do not always accurately describe the actual conditions. Sometimes symptoms seem to indicate trouble in the auxiliary; while, actually the trouble may be caused by the axle, propeller shaft, universal joints, engine or clutch. This is especially true of complaints on noise. Therefore, before removing transmission or related components to locate trouble, always road test to check possibility that trouble may exist in other closely associated units. If the mechanic can drive, road testing will be more effective; however, just riding with the driver can be very informative.

Check Functioning Prior to Disassembly:

If remote controls are used, a careful check of the remote and connecting linkage to auxiliary must be made. The remote units and linkage must be in good working order if the auxiliary is expected to shift satisfactorily.

Many times the answer to the trouble is apparent when the unit is inspected prior to disassembly, but this evidence is often lost when the parts are separated. If possible, check the unit prior to disassembly. Bear in mind that a careful inspection of the unit should be made as each disassembly step is performed.

Inspect Thoroughly During Disassembly:

It is poor practice to disassemble a unit as quickly as possible without bothering to examine the parts as they come down. It happens many times that a mechanic has completely disassembled a unit and failed to find the cause of the trouble because he did not bother to examine the parts as they came apart. After the auxiliary is disassembled, check the lubricant for breakdown and foreign particles which often reveal sources of trouble that are overlooked during the disassembly.

Repair or Replace Defective Parts:

Many times the parts or critical adjustments that have caused the trouble are not replaced or corrected because the mechanic will only inspect and replace parts that have failed completely. All pieces should be accurately examined because the broken parts are often just the result and not the cause of the trouble. All parts that are broken or worn and no longer meet specifications should be replaced. On large units, like an auxiliary, it is suggested that a mechanic replace parts that are worn to the extent that they do not have a long service life remaining. This avoids another teardown on the unit in the near future. It is also good practice to make the changes or modifications recommended to bring the auxiliary up to date and increase the service life of the unit.

Driver Training:

One of the major causes of bearing and gear failures in the auxiliary unit is poor driving habits.

Driver should be taught to always use the lo speed or reductions available in the auxiliary unit and keep the front box in the higher ratios not vice versa.

Worn and pitted gears, as well as worn and pitted bearings are usually caused by excessive use of the auxiliary overdrive gears with the mainbox in lower gear ratios.

Broken teeth in the auxiliary unit are usually caused by drivers trying to start their vehicles with the auxiliary unit in the high ratio while the big reduction is made in the front box. Frogging or quick release of clutch gives a jump start also noted for breaking teeth.

Noisy Operation:

Noise is usually very elusive and generally not the fault of the auxiliary; therefore, mechanics should road test to determine if the driver's complaint of noise is actually in the auxiliary. Remember that auxiliary units act as sounding boxes and in numerous instances, drivers have insisted that the noise was in the auxiliary; however, investigations revealed the noise to be caused by one of the following conditions:

(a) Fan out of balance or blades were bent.
(b) Defective vibration dampers.
(c) Crankshafts out of balance.
(d) Flywheels out of balance.
(e) Flywheels mounting bolts loose.
(f) Engine rough at idle producing rattle in gear train.
(g) Clutch assembly out of balance.
(h) Engine mounts loose or broken.
(i) P.T.O. gear not fully engaged or housing not properly shimmed.
(j) Universal joints worn out.
(k) Propeller shafts out of balance.
(l) Universal joint angles out of plane or at excessive angle.
(m) Center bearings in drive line dry, not mounted properly, etc.
(n) Wheels out of balance.
(o) Tire treads humming or vibrating at certain speeds.
(p) Air leaks on suction side of induction system specially with turbo-chargers.

Mechanics should try to locate and eliminate noise by means other than auxiliary removal, or overhaul. However, if the noise appears to be in the auxiliary try to break it down into the following classifications. If possible, determine what position the gear shift lever is in when the noise occurs. If the noise is evident in only one gear position, the cause of the noise is generally traceable to the gears in operation.

(a) Growl and humming or, more serious, a grinding noise. These noises are caused by worn, chipped, rough or cracked gears. As gears continue to wear, the grinding noise will be noticeable, particularly in the gear position that throws the greatest load on the worn gear.

(b) Hissing or, more serious, a thumping or bumping-type noise. Hissing noises can be caused by bad bearings. As bearings wear and retainers start to break up, etc., the noise could change to a thumping or-bumping.

(c) Metallic rattles within the auxiliary usually result from a variety of conditions. Engine torsional vibrations are transmitted to the transmission through the clutch, which may be amplified and transmitted to the auxiliary through the connecting propeller shaft. In heavy duty equipment, clutch discs with vibration dampers are not used, so a rattle, particularly in neutral, is common with diesel equipment. In general, engine speeds should be 600 RPM or above to eliminate objectionable rattles and vibration during the idle. *Always leave the main box in neutral and the auxiliary unit in gear when idling.* A defective or faulty injector would cause a rough or lower idle speed and a rattle in the auxiliary. Rattle could also be caused by excessive backlash in P.T.O. unit mounting.

(d) Improper lubricants or lack of lubricant can produce noises. Auxiliaries with low oil levels sometimes run hotter than normal, as there is insufficient lubricant to cool and cover the gears.

(e) Squealing, particularly when the auxiliary is operating at higher speeds, could be caused by one of the free running gears seizing on the thrust face or fluted diameter temporarily and then letting go. In general, a mild seizure will clear itself up and the auxiliary will continue to operate very satisfactorily without this defect being known. See .(g) below:

(f) Gear seizure at high speed, usually accompanied with loud squealing noise. This type of seizure is readily apparent to the driver, since the truck will suddenly slow down as if the brakes were being applied. If the truck continues to move ahead, even though the gear shift lever is placed in neutral, it would indicate the floating gear on the mainshaft had seized. Depressing the clutch should interrupt the driving torque. The seized gear could be checked quite readily by depressing the clutch and checking the action with the gear shift lever progressively in all shift positions. If releasing the clutch tends to kill the engine, then this gear position has not seized. In other words, the auxiliary would be in two gears at the same time. By a process of elimination, the gear at fault can be readily identified. See (g) below: (g) Vibration: Gear seizures on thrust faces or fluted diameters are usually caused by vibrations in the power train-this could be engine, propeller shafts, joint angles rear axle, differentials, etc.

Improved highways permit sustained high speeds. The fact that engines and entire power trains can now cruise at higher R.P.M. can introduce vibration frequencies, that were not critical in the past. At slower speeds these items would get by or only pass through critical periods while accelerating or decelerating through the gears.

In the past, drive line vibrations such as bent tubes, joints out of phase or alignment, bad angles due to short couples, clutches out of balance, gears and shafts in auxiliaries out of balance, were fairly obvious. These items will become more critical in vehicles running at sustained high speeds.

Critical vibrations associated with higher speeds are not the old thumping or bumping type, but are high frequency vibrations which sting or tingle the soles of your feet, tickle the end of your fingers, etc. This type of vibration will cause gear seizures, bearing failure due to retainer rivet failures, promote brinelling, fretting, corrosion, etc.

(h) Gear whine is usually caused by lack of backlash between mating gears-improper shimming of P.T.O. units is the big offender here.

Noise in Neutral

Possible Causes:

(a) Misalignment.
(b) Worn, or scored countershaft bearings.
(c) Worn drive gear bearings.
(d) Sprung, or worn countershaft.
(e) Excessive backlash in gears.
(f) Worn mainshaft pocket bearing.
(g) Scuffed gear tooth contact surface.
(h) Insufficient lubrication.
(i) Use of incorrect grade of lubricant.

Noise in Gear

Possible Causes:

(a) Worn, or rough mainshaft rear bearing.
(b) Rough, chipped, or tapered sliding gear teeth.
(c) Noisy speedometer gears.
(d) Excessive end play of mainshaft gears.
(e) Refer to conditions listed under Noise in Neutral.

Oil Leaks

Possible Causes:

(a) Oil level too high.
(b) Wrong lubricant in unit.
(c) Non-shielded bearing used at front or rear bearing cap. (Where applicable.)
(d) Seals (if used) defective or omitted from bearing cap, wrong type seal used, etc.
(f) Transmission breather omitted, plugged internally, etc.
(g) Capscrews loose, omitted or missing from remote control, shifter housing, bearing caps, P.T.O. or covers, etc.
(h) Welch "seal" plugs loose or missing entirely from machined openings in shifter housing or case.
(i) Oil drain-back openings in bearing caps or case plugged with varnish, dirt, covered with gasket material, etc.
(j) Broken gaskets, gaskets shifted or squeezed out of position, pieces still under bearing caps, clutch housing, P.T.O. and covers, etc.
(k) Cracks or holes in castings.
(L) Drain plug loose.
(m) Also possibility that oil leakage could be from engine.

Walking or Jumping Out of Gear:

For clarification we would like to separate walking out of gear and jumping out of gear into two distinct groups.

Walking out of gear is usually associated with power applications or coasting on long smooth grades, i.e., when power is applied the shift lever moves into the neutral position. Occasionally it may be impossible to hold the shift lever in gear by hand.
Sometimes this condition may also be noted when coasting down a long relatively smooth grade or power is being applied on the coast side of the gear.

Dana/Spicer transmissions and auxiliaries are provided with "hopping guards" for most gear positions. Therefore, if the units are walking out of gear it could be caused by:

(a) Interference or resistance in the shift mechanism preventing full engagement of the sliding clutch gear or (b) If the gear has been shifted completely into position some other malfunction which could move the gear or the shaft itself out of its proper location.

(c) On new or rebuilt units the wrong parts or old defective parts may have been used; thereby rendering the hopping-guard feature useless. High mileage units may start walking out of gear due to the general deterioration or rounding of clutch teeth due to numerous slip-outs or partial engagements due to conditions listed below.

(d) Walkout on coast side could be caused by lack of hopping guard feature for this particular gear position. If remote controls are used, the mechanic must satisfy himself that the remote units are satisfactory and that auxiliary is actually at fault. A number of items that would prevent full engagement of gears are:

(a) Improperly positioned forward remote control which limits full travel forward and backward from the remote neutral position.

(b) Improper length shift rods or linkage that limits travel of forward remote from neutral position.

(c) Loose ball cranks, sloppy ball and socket joints.

(d) Shift rods, cables, etc., too spongy, flexible, or not secured properly at both ends.

(e) Worn or loose auxiliary mounts if remote unit is mounted to frame.

(f) Forward remote mount too flimsy, loose on frame, etc.

(g) Set screws loose at remote control joints or on shift forks inside remote or even inside auxiliary unit.

(h) Shift fork pads or groove in sliding gear or collar worn excessively.

(i) Worn taper on gear clutch teeth.

(j) Auxiliary out of alignment either vertically or horizontally.

Jumping Out of Gear:

Jumping out of gear is usually associated with slip-out reports experienced when crossing railroad tracks traveling rough roads, etc.

A few items which could move the gear or shaft out of proper position, particularly on rough roads are:

(a) Use of long and heavy shift lever extensions.
(b) Shift rod poppet springs broken.
(c) Shift rod poppet notches worn.
(d) Shift rod bent or sprung out of line.
(e) Shift fork pads not square with shift rod bore.
(f) Excessive end-play in drive gear, mainshaft or countershaft caused by worn bearings, retainers, etc.
(g) Thrust washers or faces worn excessively, missing, etc.

Hard Shifting:

An improperly operating clutch will interfere with the proper shifting of gears in any auxiliary. It is important that the hydraulic, air or similar release mechanism (if used), also be in proper working order. If the mechanic is sure that a full and complete clutch release is being made, the following could be a few of the possible causes for hard shifting complaints.

(a) No lubricant in remote control units. Forward remote is isolated and is often overlooked. However, many remote controls used on transmissions and auxiliaries require separate lubrication.

(b) No lubricant in (or grease fittings on) U-joints or swivels of remote controls.

(c) Lack of lubricant or wrong lubricant used, causing buildup of sticky varnish and sludge deposits on splines of shaft and gears.

(d) Badly *worn or* bent *shift* rods.

(e) Improper adjustment of shifter linkage.

(f) Sliding clutch gears tight on splines of shaft.

(g) Clutch teeth burred over, chipped or badly mutilated due to improper shifting.

(h) Binding or interference of shift lever with other objects or rods inside the cab or near the remote control island.

(i) Driver not familiar with proper shifting procedure for this transmission. Also includes proper shifting as used with 2-speed axle, auxiliary, etc.

(j) Drive gear pocket bearing seized, rough, or dragging.

(k) Gear seizure on thrust face or bearing diameter.

Sticking in Gear:

(a) Clutch not releasing-also check remote units such as hydraulic or air assist, etc. *Note:* On some units employing a full air control for clutch release, air pressure of approximately 60 lbs. or more must be secured before clutch can be released. *Do not leave these vehicle & parked in gear.*

(b) Sliding clutch gears tight on splines.

(c) Chips wedged between or under splines of shaft and gear.

(d) Improper adjustment, excessive wear or lost motion in shifter linkage.

Bearing Failures:

The service life of most *transmissions* either main or auxiliaries is governed by the life of the bearings. Majority of bearing failures can be attributed to vibration and dirt. Some of the more prominent reasons for unit removal with bearing failures are:

(a) Worn out due to dirt
(b) Fatigue of raceways or balls.
(c) Wrong type or grade of lubricant.
(d) Lack of lubricant.
(e) Vibrations-breakup of retainer and brinnelling of races-fretting corrosion.
(f) Bearings tied-up due to chips in bearings.
(g) Bearings set-up too tight or too loose.
(h) Improper assembly-brinnelling bearing.
(j) Improper fit of shafts or bore.
(k) Acid etch of bearings due to water in lube.
(1) Overloading of vehicle. Overload from engine or engine too large for transmissions used.

Dirt:

More than 90% of all ball bearing failures are caused by dirt which is always abrasive. Dirt may enter the bearings during assembly of the units or be carried into the bearing by the lubricant while in service. Dirt may enter through seals, breather or even dirty containers used for addition or change of lubricant.

Softer material such as dirt, dust, etc., usually forms abrasive paste or lapping compounds within the bearings themselves since the unit pressure between the balls and raceways makes a perfect pulverizer. The rolling motion tends to entrap and old the abrasives. As the balls and raceways wear, the bearings become noisy. The lapping action tends to increase rapidly as the fine steel from the balls and rollway adds to the lapping material.

Hard, coarse material such as chips, etc., may enter the bearings during assembly from hammers, drifts, power chisels, etc., or be manufactured within the unit during service from raking teeth, etc. These chips produce small indentation in balls and races. Jamming of these hard particles between balls and races may cause the inner race to turn on shaft, or the outer race to turn in the housing.

Fatigue:

All bearings are subject to fatigue and must be replaced eventually. Your own operating experience will dictate mileage replacement of bearings showing only normal wear.

Corrosion:

Water, acid and corrosive materials formed by deterioration of lubricant, will produce reddish-brown coating and small etched holes over outer and exposed surfaces of race. Corrosive oxides also act as lapping agent.

Brinelling caused by improper assembly or removal usually hammering with off-center blows. Use drivers, preferably under an arbor, or pullers.

Shaft Fits:

Excessive looseness under load is very objectionable because it produces a creeping or slipping of the inner ring on the rotating shaft. This causes the surface metal of shafts to scrub or wear off.

Bearing fits on rotating shafts are usually specified as tight. When play or looseness, even .001", exists between the bearing and shaft, there is a very powerful force tending to rotate the inner race on the shaft; this force is caused by the looseness or lost motion between the parts and disappears when no looseness exists.

Removal of Bearings:

It is far more difficult to remove bearings from a shaft than to put them on. In most cases it is necessary to remove the bearing by pulling on the outer-race which can damage the balls or races. Since such damage is seldom visible, it does not become known until after complete reassembly. It is good P.M. to replace most ball bearings during the overhaul period. If a bearing is not going to be replaced, avoid removal during low mileage rebuild.

Interchangeability:

All ball bearings (whether manufactured here or abroad) are interchangeable in regard to-standardized dimensions, tolerances and fits. However, for a given shaft size there are standard bearings for light, medium, and heavy-duty service.

Numbers and symbols stamped on inner and outer races of bearings designate size and type.

Numbering systems of different bearing manufacturers, however, have not been standardized.

Consult interchangeable tables and use proper bearings for replacement parts.

WHEELS, DRUMS, RIMS AND TIRES

CHAPTER I (WHEELS)

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CHAPTER II (BRAKE DRUMS)

CHAPTER III (RIMS AND TIRES)

CHAPTER III (Continued)

CHAPTER IV

CHAPTER I

WHEELS

GENERAL

The information presented herein covers factory installed wheels and hubs for medium and heavy duty vehicles. Many types of wheels are available and they vary in size, types (disc or cast) and materials (steel or aluminum). Fundamentally, they are the same in that all wheels (or hubs for disc wheels) are mounted to the axles on tapered roller bearings.

SAFETY PRECAUTIONS

Always deflate tires completely before removing locks or side rings.

Always inspect and clean all parts before assembly.

Always inflate tires in safety cage.

Always use a "clip-on" air chuck with remote valve to inflate tires.

Never mix parts of different types or size.

Never use cracked, bent or badly rusted parts.

Never reinflate flat tire on vehicle--use the spare.

Never add air until certain each side or lock ring is fully seated.

WHEEL BEARING ADJUSTMENT

Satisfactory wheel operation and long bearing life depends on correct wheel bearing installation, lubrication and adjustment. The following will help you perform these required services for wheels and hubs.

FRONT WHEEL BEARINGS

Wheels or hubs, bearing cups, nuts, locks, hub caps, shafts and spindles are to be free from any foreign matter. Bearing cones must be properly packed with specified lubricant if wheels are grease packed (see LUBRICATION, Section CTS-2412).

If wheel bearings are oil lubricated dip bearing cones in lubricant to provide proper starting lubrication. Outer surface of bearing cone and matching surface of cup may be coated with lubricant to promote cone-to-cup adhesion and facilitate assembly.

After wheel (or hub) and bearings are assembled in place on the spindle, tighten the wheel bearing adjusting nut to 69 N.m (50 ft lbs) while rotating the wheel. Then back off the nut 1/4 turn. If the lock or cotter key can be installed at this position, do so; if not, tighten to the nearest locking position and insert new key or lock. Bent type lockwasher is to have one tab bent over the adjusting nut. For axles that have double nut type lock, tighten jam nut to 136 203 N.m (100 150 ft lbs) and bend one tab of the lockwasher over the jam nut (Fig. 1). These procedures are intended to result in zero to .25 mm (.010") end play with no preload.

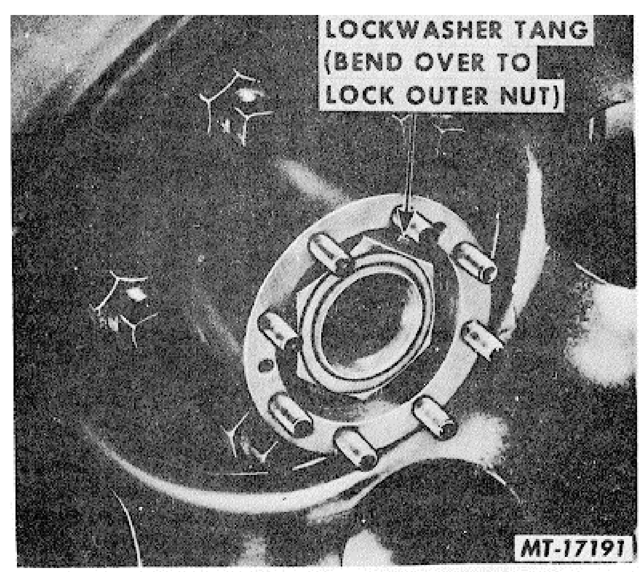
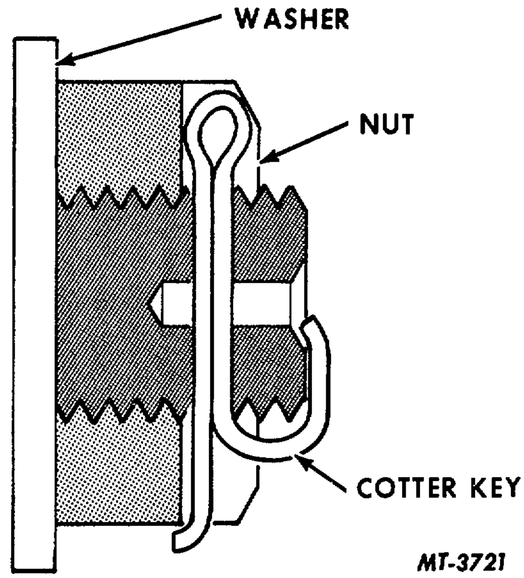


Fig. 1

NOTE: The cotter key should be inserted with the long tang toward the end of the spindle. Bend long tang of cotter key over end of spindle. Clip remaining tang leaving just enough stock to bend down against side of nut. A correctly installed cotter key should have the appearance as shown in Figure 2.



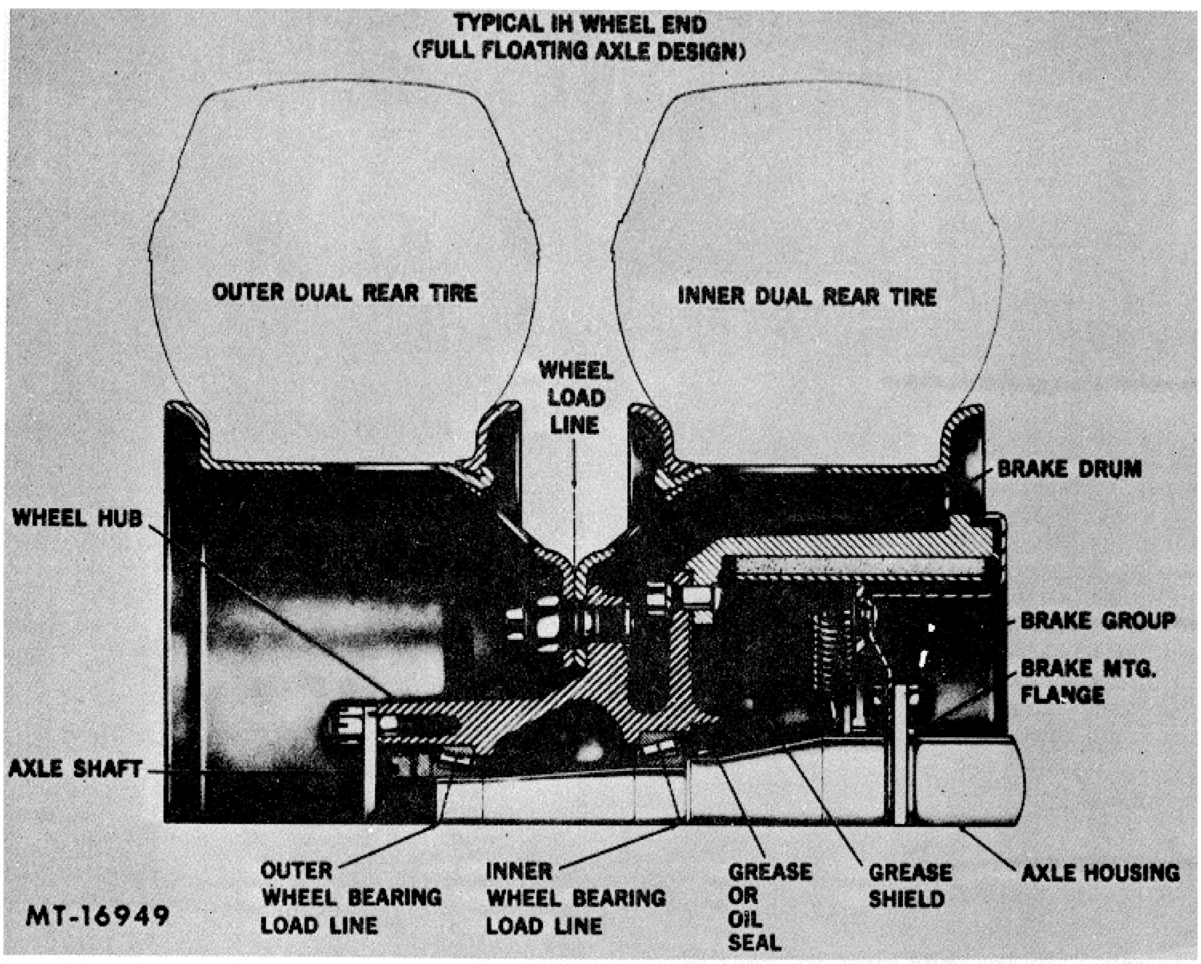


Fig. 3 Heavy Duty

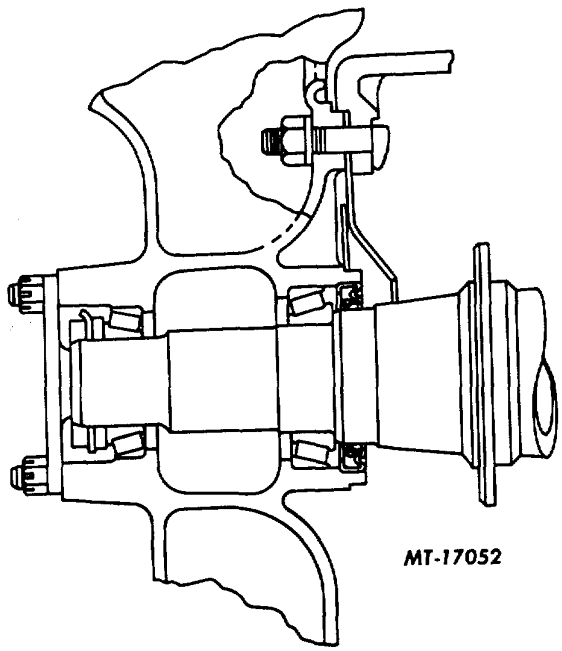


Fig. 4. Medium Duty

REAR WHEEL BEARINGS

Full Floating axle wheel bearings (Fig. 3 and Fig. 4) are adjusted by an adjusting (inner) nut on end of axle. Install adjusting nut and rotate wheel while tightening to be sure bearings are properly seated.

> NOTE : 68.0 N.m (50 ft lbs) torque on adjusting nut is considered sufficient to seat bearings.

Back off adjusting nut 1/4 turn and install lockwasher and jam nut. Tighten jam nut to 203 N.m (150 ft lbs) torque and bend over lockwasher tang to secure nut. Assemblies which use doweled adjusting nut and pierced wheel bearing nut lock require 271 407 N.m (200 300 ft lbs) torque on outer lock nut.

OIL SEALS (OIL LUBRICATED WHEEL BEARINGS)

Various precautions are necessary when oil seals are installed in wheels and also when wheels with oil seals are installed on axles. To insure factory performance from oil seals, the following information has been prepared to guide and assist in proper installation.

Due to the various types of front and rear axle hub seal installations, check axle ring and hub seal position at time of disassembly to assure proper reassembly of new seal and axle ring (wiper).

OIL SEALS WITH AXLE RING (WIPER)

<u>Axle Ring (Wiper) Installation</u>

1. Thoroughly clean all parts: axle tube or spindle, bearings, nuts and inside of wheel hub.

2. Remove burrs from axle tube or spindle shoulder. Shoulder must be smooth.

3. Apply a thin coat of Permatex No. 2 to inside perimeter of axle ring.

4. Place axle ring on axle tube or spindle using an installing tool (Fig. 5).

   NOTE : A suitable installing tool can be made locally by obtaining a piece of standard 8.9 cm (3-1/2") inside diameter tubing approximately 25.4 cm (10") long.

Weld a used close fitting bearing cone or large washer to one end and similarly close opposite end with a plate. This will enable tool to pilot squarely onto axle tube and permit driving force to be centered over the complete ring. The same type of tool can be used for both front and rear axles.

The care with which the axle ring is installed cannot be over-emphasized. Damage to this ring will result in shortened seal life.

5. Tap on end of axle tool driving axle ring firmly on shoulder until axle tool contacts shoulder. Remove excess Permatex.

6. Check position of axle ring to make sure edge of ring is parallel with shoulder.

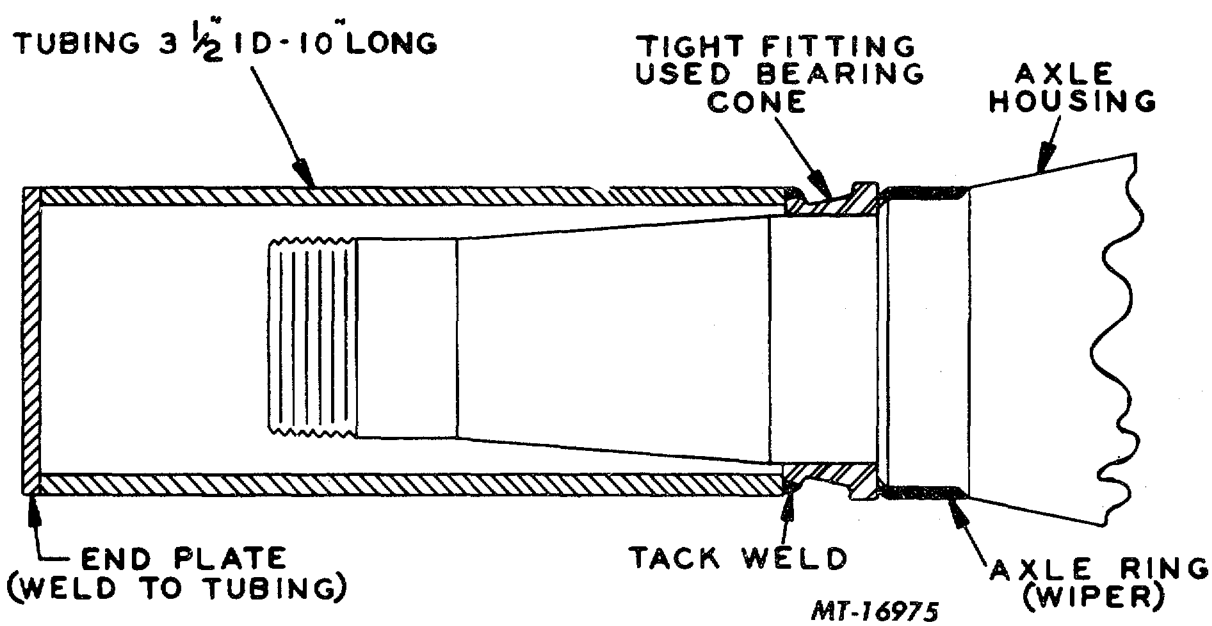


Fig. 5

OIL SEAL INSTALLATION (OIL SEAL WITH AXLE RING)

1. Remove burrs from inside back edge of hub. Hub must be smooth and free from burrs that will scratch the hub seal.
2. Apply a thin coat of Permatex No. 2 around the outside perimeter of hub seal. Permatex coating must be very light yet cover press fit area. Remember that Permatex is abrasive and should never be allowed to contact lip of leather seal nor contaminate oil.
3. Lay wheel flat with brake drum up. Place inner wheel bearing into bearing cup and place hub seal into starting position on hub.
4. Install hub seal using SE-1904 Installer Set (Fig. 6). Select the size disc which will apply force to outer edge of hub seal and prevent seal from becoming distorted or damaged.
5. Drive hub seal into hub until it bottoms in hub bore. Do not continue to drive after seal is once seated as this will distort or damage the seal. After removal of seal installer tool, clean off excess Permatex (for proper installation, note Fig. 7).

UNITIZED OIL SEAL (AXLE RING NOT REQUIRED)

Unitized oil seals do not require axle rings (wipers) and minimize wear on the axle spindle as follows. The outer shell of the seal being pressure fit in the wheel hub rotates with the wheel around the sealing element which is pressure fit on the axle spindle. With the unitized seal when replacement is made, the worn surface created by the sealing lip is also replaced.

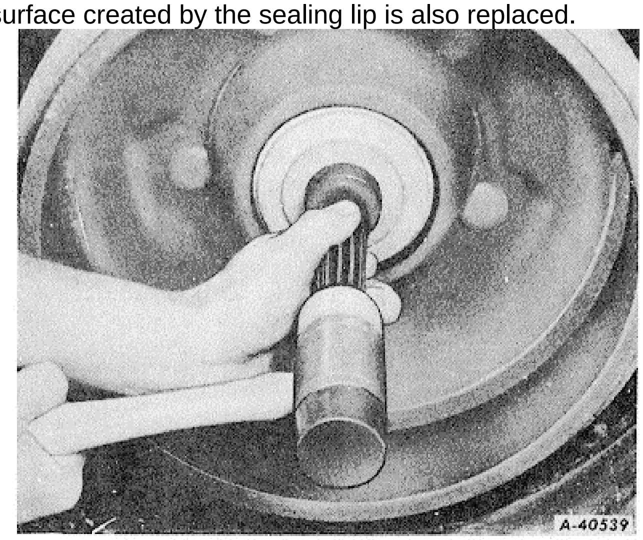


Fig. 6

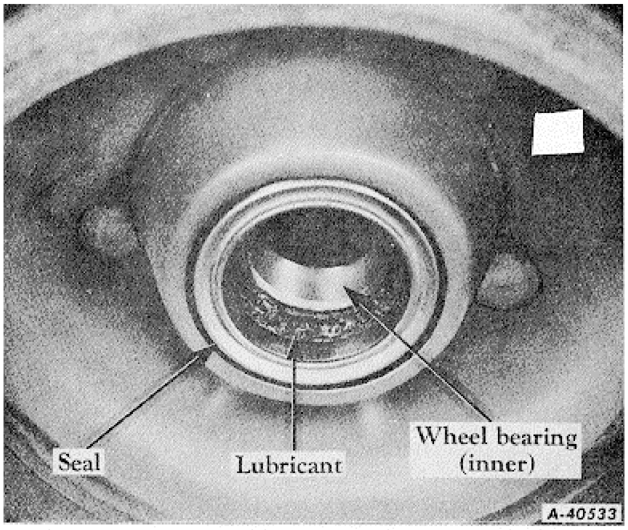


Fig. 7

Unitized Seal Installation

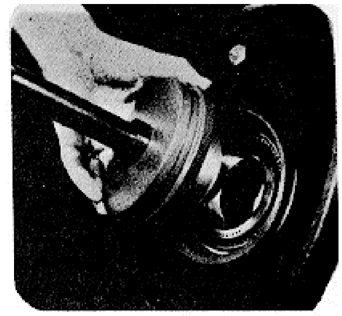
1. If wheel is being changed to a unitized seal from another type of seal, remove wear sleeve backing plates or axle rings as they are no longer required. Note the order of parts at disassembly to assure proper reassembly.

2. Thoroughly clean all parts and remove all burrs from spindle and hub bore. Inspect and replace all parts as warranted.

3. To install unitized seal in wheel, seat outer face of seal in the recess of tool adapter SE-2524 (Fig. 8). Insert centering plug of tool in bore of inner bearing cone (Fig. 9). Using the centering plug prevents cocking of the seal in wheel bore. Bore-tite coating on seal fills in minor imperfections in the wheel bore.

MT-17000

Fig. 8



MT-17001

Fig. 8

4. Hold tool handle firmly and strike until sound of impact changes when seal is seated (Fig. 10).

NOTE:
Seal must be reseated any time wheel is removed.

A good check of proper seal installation is to move the synthetic sealing member with your fingers after installation in wheel hub. There should be a slight in and out movement possible.

MT-17002

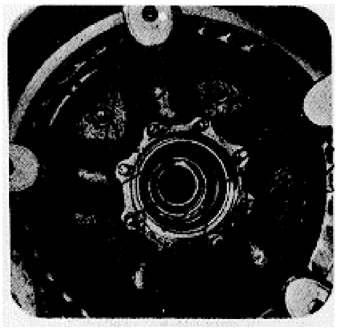
Fig. 10

MOUNTING WHEEL ON SPINDLE INSTRUCTIONS (With Oil Lubricated Bearings)

1. To insure good starting lubrication fill wheel cavity between the bearings with lubricant.

   Front Axle: Fill wheel cavity with engine oil or rear axle lubricant (see LUBRICATION, Section CTS-2412).

   Rear Axle: Fill with same gear lubricant as used in the axle differential.



MT-I7003

Fig. 11

2. Using a wheel dolly place wheel on spindle; care must be taken not to damage the seal, especially on the leading edge of the spindle or axle (Fig. 11).

INITIAL LUBRICATION OF WHEEL BEARINGS

Transparent Hub Cap (Front Axle)

Add oil through filler plug hole in hub cap allowing time for oil to seep through the bearings and seek a level on initial fill. When properly filled oil should be on or 9.5 mm (3/8") above the oil level mark on the hub cap window. Use engine oil or gear oil for front wheels (see LUBRICATION, Section CTS2412).

Hub Cap Without Window (Front Axle)

Add .71 liter (1-1/2 pints) of matching differential lubricant or enough lubricant to touch the bottom surface of the wheel spindle outside diameter of each front wheel. For initial fill, pipe tap hole should be at 12 o'clock position. Add oil through pipe tap hole in axle shafts. Fill until oil runs out of filler hole when positioned at 4 to 5 or 7 to 8 o'clock positions [approximately .71 liter (1-1/2 pints)].

TRACTOR DRIVE WHEELS (Rear Axle) Dip bearing cones in lubricant.

Before installing outer cone fill the wheel cavity between bearings with the same oil to be used in differential. This will assure bearing and spindle lubrication until lubrication creeps through the outer bearing.

NOTE : The differential must not be over-filled. A periodic check is to be made for proper lubricant level.

On tractor drive wheels, apply Loctite gasket eliminator (sealant) material No. 504 to back of axle flange and install axle (Fig. 12).

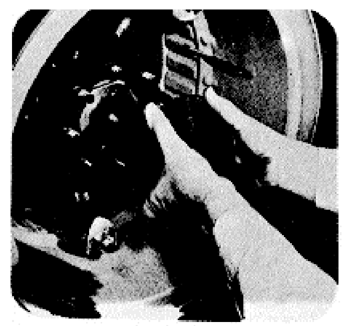


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Fig. 12

CHAPTER II
BRAKE DRUMS

INSPECTION

The friction surface of brake drums must be smooth, true and concentric whether for air or hydraulic brakes. Make certain with a visual check that drums are not barrel shaped, bellmouthed, scored or eccentric. A barrel shaped drum (Fig. 1) results from overheating. If this barrel shaped condition is not corrected, the braking surface is reduced and uneven lining wear results.

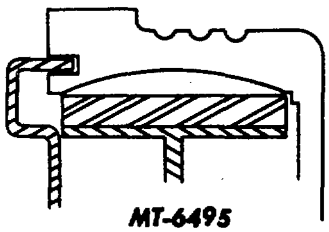


Fig. 1

Extreme pressure which over a period of time will create a bellmouthed drum is shown in Fig. 2. Brake linings on a bellmouthed brake drum will make contact only on the inner surface of the drum. In addition to cutting the braking surface to a minimum, it will also cause uneven and rapid wear.

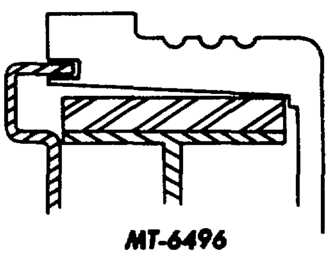


Fig. 2

Scored drums are the result of worn linings to the point where the drum-to-shoe contact is made or an accumulation of small steel particles imbed themselves in the brake lining (Fig. 3). The steel particles form a tough scale which is sometimes harder than the drum. As a result deep grooves are formed in friction surface of drum.

Brake drum scoring never improves but continually gests worse until both lining and brake drum are useless. Attempting to reline brakes without turning scored

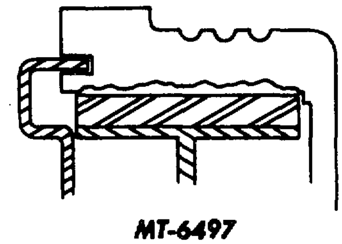


Fig. 3

brake drum surface will quickly destroy new lining and make effective braking impossible.

Brake lining in an eccentric or out of-round drum cannot make full contact with the drum resulting in rapid or uneven lining wear and could even cause brakes to seize or chatter. Maximum allowable out-of-round or eccentricity should be .10 mm (.004").

If inspection shows that any of the preceding conditions exist, brake drum should be either turned or replaced. To assure a balanced braking system, always install turned or new brake drums in pairs on each axle.

Any time a new brake drum is to be installed on a vehicle, the runout should be checked as follows. Place the new brake drum with hub and wheel assembled in lathe making certain drum is centered.

Mount Dial Indicator SE-1848 on lathe and check runout about 12.7 mm (.5") in from end of drum as shown in Fig. 4. Runout must not exceed .38 mm (.015").

NOTE: Before assembling drum, hub and wheel, all parts must be clean and free of foreign matter.

If runout exceeds .38mm (.015") remove drum from hub, rotate drum 180° and reinstall on hub. Check runout again; if runout still exceeds .38mm (.015"), remove drum from hub and rotate drum 1/4 turn. Reinstall drum on hub and recheck runout.

REFINISHING BRAKE DRUM

On brake drums manufactured after January 1, 1971, the maximum diameter to which drum can be worn is stamped or cast into drum. Drum should be discarded if worn beyond this limit. Minor scores on brake drum can be removed with fine emery cloth or steel wool, but always clean

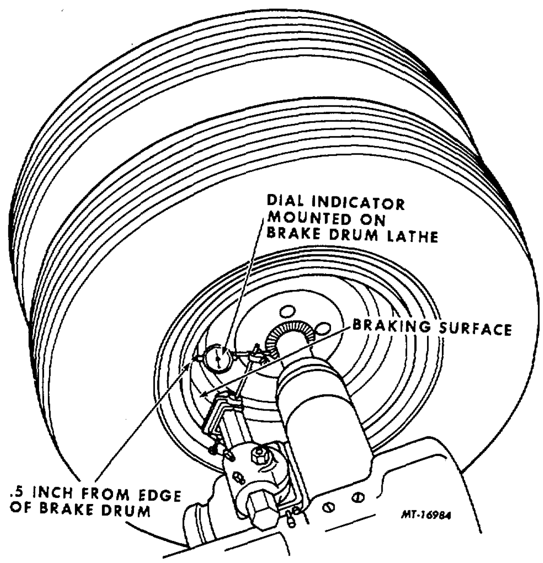


Fig. 4

emery or steel wool particles from drum after this operation. More heavily damaged or out-of-round drums should be ground or turned on brake drum lathe.

If depth of scoring, bellmouth or barrel shaping exceeds .13 mm (.005"), measured with micrometer across part or all of brake surface, drum should be refinished. Reboring limits (see drum) must not be exceeded and no heat checks, cracks or bluing is evident.

Use a micrometer also to check for an out-of-round drum. Make check by measuring drum brake surface diameter at various points, 450 apart around circumference. Eccentricity (out-of-round) should not exceed .38 mm (.015") on diameter.

For older brake drums which do not show a maximum diameter the drum must be discarded when diameter is 3.05mm (.120") over original diameter.

Remember that each time brake drums are turned, less metal remains to absorb the heat developed by braking action. Brake drums containing less metal will operate at a higher temperature. As a result, brake fade, slow recovery and erratic wear will be more noticeable. Also, extremely high temperatures shorten lining life and cause heat checks and cracks (Fig. 5) form on inner surface of drums. These conditions will become progressively worse until finally drums fail.

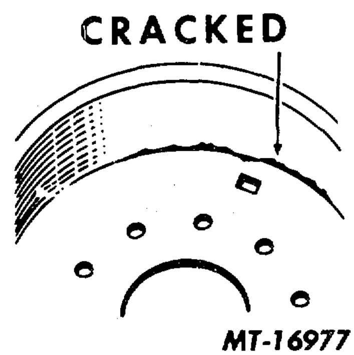


Fig. 5

To recondition a brake drum in a lathe (Fig. 6), the drum must be mounted so that it is centered. Use proper size cone to provide accurate centering. Turn drum, taking only light cuts and remove just enough material to clean up drum. Then grind the finished surface if grinder is available or use emery cloth on a straight piece of wood and polish the drum friction surface.

NOTE: Brake drums that are otherwise in good condition can be turned in a lathe. However, it must be remembered that recommended rebore limit for brake drums over 35.6 cm (14") in diameter must not be increased more than 2.03mm (.080") diameter (total cut) and discarded at 3.05 mm (.120") over normal diameter.

Brake drums should be cleaned thoroughly with a steam cleaner or hot water. Do not use a solvent which leaves an oily residue. If inspection shows the drums may be used without remachining, rub friction surface with fine emery cloth or sandpaper to remove any foreign deposits. If drum has been reconditioned, clean friction surface with fine emery cloth or sandpaper and wash. Next examine very carefully to see that no metal chips remain in drum.

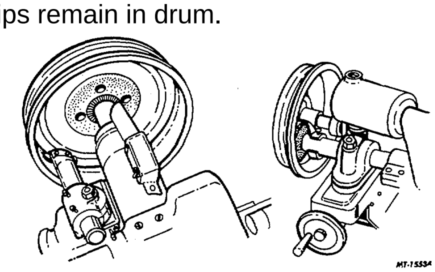


Fig. 6

CHAPTER III
RIMS AND TIRES

GENERAL

Since there are many different kinds of rims and tires for trucks, the methods of servicing them also vary. Most types, however, have been in use for many years, and for that reason the instructions covered here will pertain chiefly to the newest or tubeless types. Some of the most common types of rim and tire combinations are given in the following illustrations

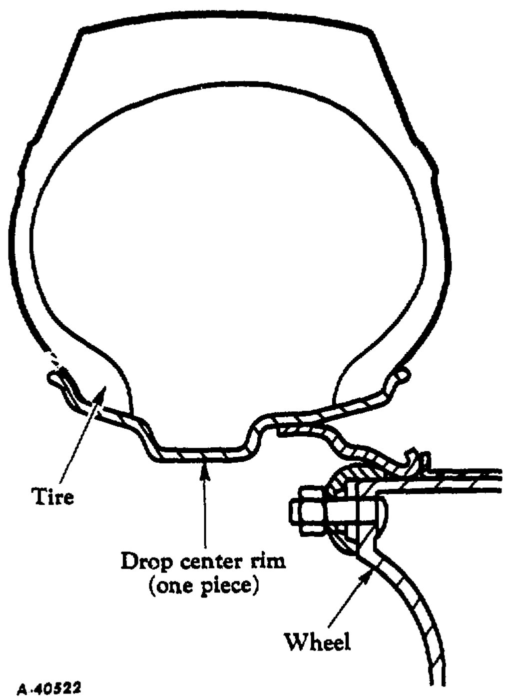


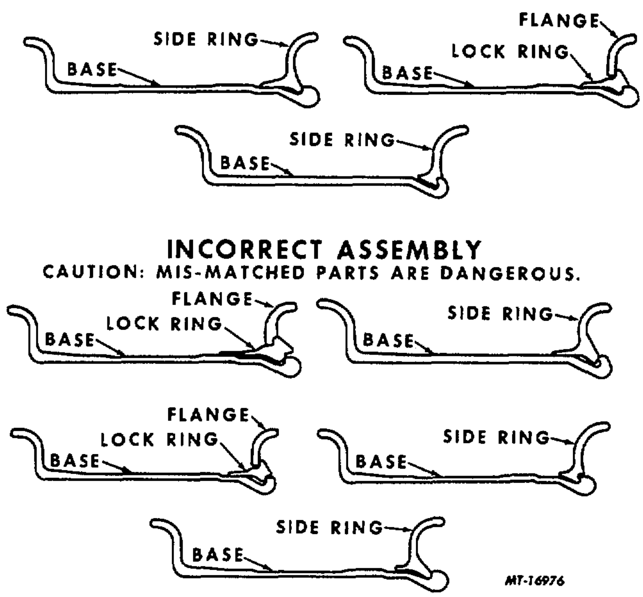
Fig. 2 Drop Center Type Disc Wheel (Tubeless)

Multiple Piece Rims

On multiple piece rims if it is determined during periodic inspection or during tire changes, that a part is defective it must be replaced.

Caution must be observed when selecting the proper replacement part, an incorrect fit is dangerous. (See Incorrect Assembly Fig, 5). The side ring, locking ring and base must all fit correctly as illustrated in Figure 5 under Correct Assembly.

MULTIPLE PIECE WHEEL ASSEMBLIES
CORRECT ASSEMBLY



<u>Wheel Studs and Mounting Nuts</u>

Maintaining wheel stud and mounting nut tightness does much to insure safe and satisfactory wheel operation. Loose wheel mounting can cause vibration, shimmy, tire wear, stud breakage, worn studs, mounting nuts (Fig. 6) and worn or elongated stud holes (Fig. 7). Parts with these characteristics must be replaced. Always keep wheel stud nuts tightened to specified torque.

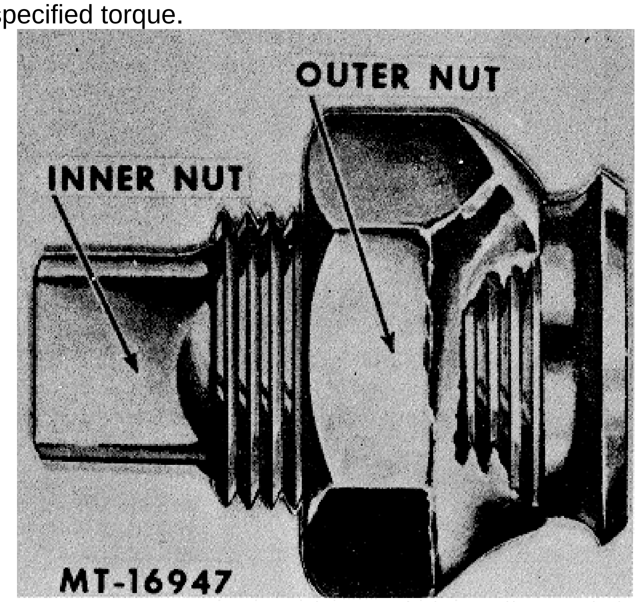


Fig. 6

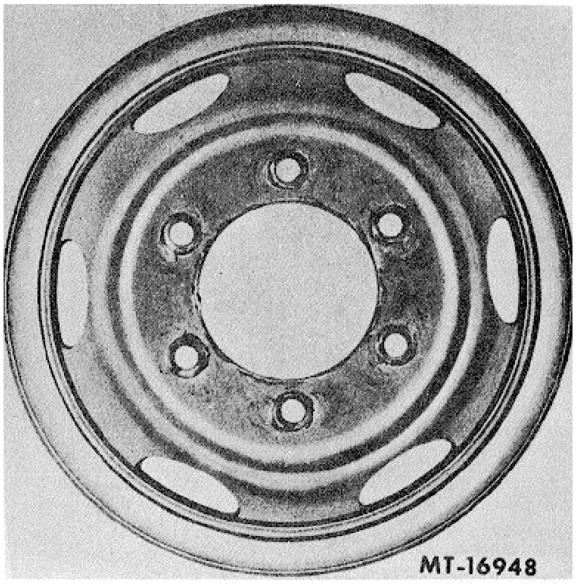


Fig. 7

NOTE: Rust streaks (Fig. 8) from stud holes is a good indication that mounting nuts are not tightened to the specified torque.

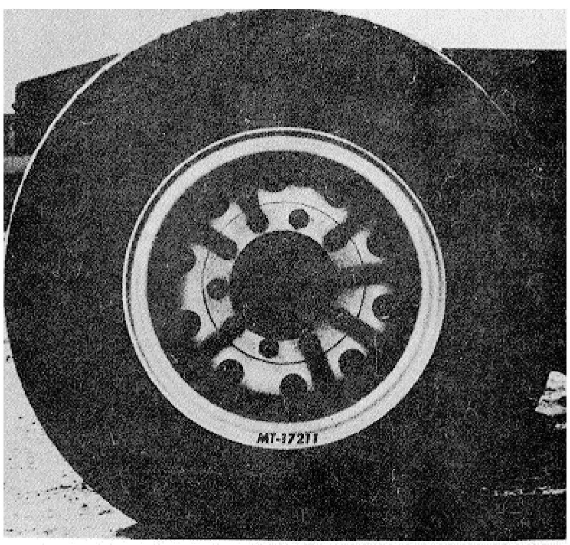


Fig. 8

DISC WHEELS

On disc wheels, which have rims integral with the wheel itself, the important thing to note is that the wheel stud nuts must be kept tight. This means they should be inspected and tightened at regular intervals. When checking the mounting studs and nuts on dual disc wheels, (Fig. 9) the outer nut should be backed off before attempting to tighten the inner nut. Try all cap nuts after the first trip or any wheel change. Properly installed they should remain tight indefinitely. On cast wheels which have rims that are demountable with the tire, the rim clamp nuts should also be kept tight. Rim and tire to wheel alignment should be checked frequently to make sure the tire is running true. Left-hand thread nuts can be identified by the small groove machined around the flats. Lefthand studs can be identified by the letter "L" stamped on the head. Use left-hand nuts on the left side of the truck.

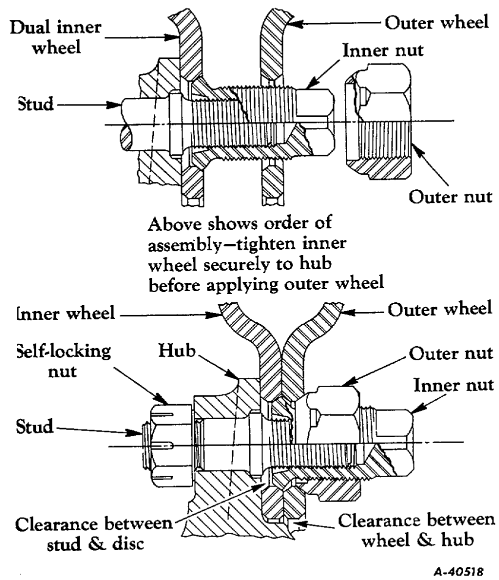


Fig. 9

NOTE: Before mounting wheel assemblies on vehicle make sure all parts are clean and free from foreign matter. Excess paint on wheel stud hole perimeters can permit wheel mounting nuts to loosen with use.

RIM TIGHTENING AND ALIGNMENT

When installing demountable rims, be certain stud threads are clean to permit correct torquing of nuts. NOTE: Do not use any type of lubrication on threads except when installing aluminum wheels.

With rims in position (valve stem 180 degrees apart) successively tighten opposite nuts to assure drawing wheel (or wheels) in evenly. This procedure will also minimize wheel misalignment. See "TORQUE CHART" for correct torque values.

After rim has been properly torqued, it should be checked for alignment. This can be accomplished by rotating wheel with a piece of chalk attached to a steady, firm surface and placed to just barely clear outside surface of tire bead seat. This procedure will point out the "high spot". Keep in mind, however, that a "high spot" does not necessarily mean that lug nuts have been unevenly tightened. This condition or misalignment can also result from a bent wheel.

WHEEL AND TIRE BALANCING

Front wheel and tire assemblies must be balanced to prevent wheel vibrating and bounce. While the correct front wheel alignment is necessary for easy steering and maximum tire life, the cause of unstable steering can be frequently traced to improper balance of front wheels. When this condition exists, the wheel assembly should be properly balanced.

A vulcanized or retreaded tire, or a tire that has a boot in it, may cause an unbalanced condition that cannot be corrected by balancing. In such cases the tire should be replaced before attempting to balance the assembly.

Static Balancing

A wheel out of balance statically has a tendency to bounce up and down resulting in rapid tire wear in round or oblong spots.

Static balancing is performed while wheel is stationary by attaching weights to rim flange to offset an opposite heavy point.

Static balancing may be sufficient in some instances where vehicle is operated only at slow speeds, however, dynamic balancing (in motion) balances the wheel and tire assembly statically as well as dynamically, thereby eliminating vibrations and wheel bounce at both low and high speeds. NOTE: A wheel may be perfectly balanced statically (not in motion) but may still vibrate *and* bounce at high *speed* rotation because of its being out of balance dynamically.

Dynamic Balancing

Dynamic balancing is complete wheel balancing of which static balancing is only a part.

Dynamic balancing (in motion) takes into consideration the distribution of weight to be added to the wheel. This is accomplished by rapidly rotating (normal truck operating speed) the wheel and tire assembly either on the vehicle or with the wheel assembly removed and placed on a dynamic balancing machine. This determines heavy point on wheel.

When the amount of weight required to offset a heavy part in a wheel assembly is known, it is sometimes necessary to attach one-half of the weight to the outside rim flange and the remaining half to the inside rim flange.

With the weight properly distributed on the wheel assembly, the wheel should be in balance both statically and dynamically and should rotate free of vibration and bounce at normal truck operating *speeds.*

TIRE CARE

Proper tire inflation, tire loads, and road speeds are important determining factors governing tire mileage, and also affect steering ease and maneuverability. How much these three factors affect tire wear is illustrated in the paragraphs which follow.

INFLATION

Tire pressures should be checked at regular and frequent intervals and the pressures maintained to specifications. Use an accurate tire pressure gauge and check when tires are cool. The chart (Fig. 10) illustrates the loss in tire mileage caused by underinflation. It will be noted that a tire underinflated only 20% will produce only 70% normal mileage.

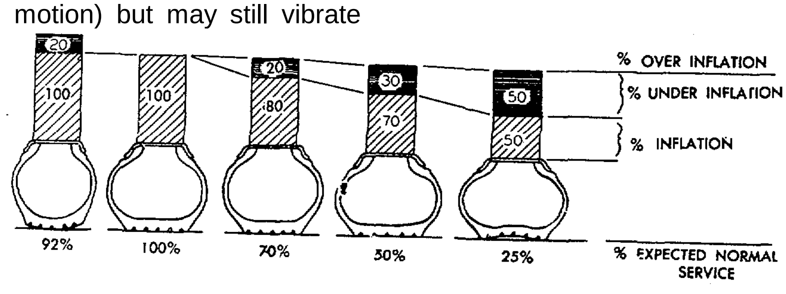


Fig. 10 Inflation vs. Mileage

Overinflation is also costly because a tire which is 20% overinflated will produce only 92% normal tire mileage.

"Bleeding" of air from hot tires should never be practiced. The pressure will be reduced but an increase in temperature will result as soon as driving continues.

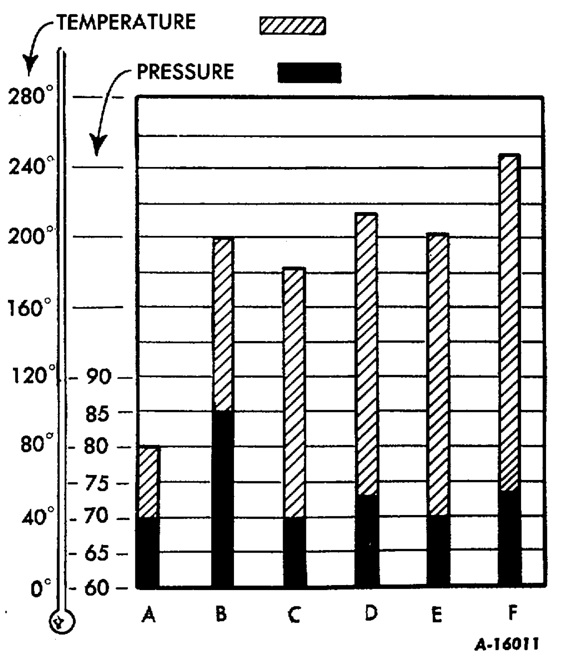


Fig. 11 Chart Showing Effects of Bleeding

The chart (Fig. 11) illustrates a condition where a tire was started cool with a pressure of 70 pounds and at a temperature of 26.7 degrees C (80 degrees F).

A - Initial conditions.

B - After 225 km (140 miles) of driving the pressure had increased to 85 pounds and temperature 93.3 degrees C (200 degrees F).

C - The pressure was then "bled" to 70 pounds and an additional drive made of 225 km (140 miles). Note the temperature.

D - The pressure had increased to 73 pounds while the temperature increased to approximately 104.4 degrees C (220 degrees F).

E - Again "bleeding" was resorted to. Note the temperature.

F - After 322 km (200 miles), the tire failed from a temperature of over 121.1 degrees C (250 degrees F).

LOADS

Loading tires beyond their rated capacity is expensive because tire mileages are rapidly decreased with overloads. The following chart (Fig. 12) illustrates how an overload of only 20% will result in tire mileage being only 70% of normal.

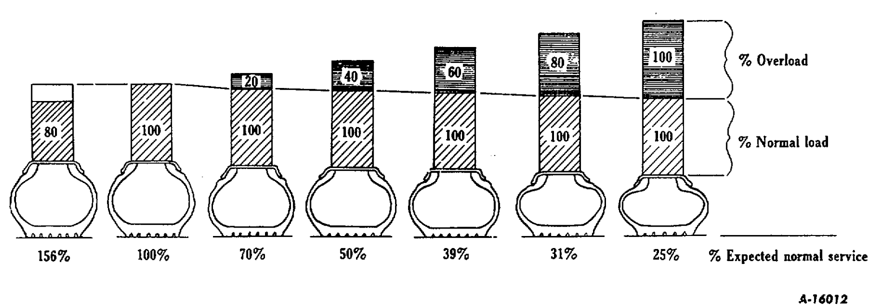


Fig. 12 Overload vs. Mileage

SPEEDS

Excessive speed is definitely one of the most important factors in loss of tire mileage. The chart (Fig. 13) illustrates how an increase in speed from 40 to 50 mph results in 18% loss in mileage. An increase of speed from 40 to 60 mph results in a 33% mileage loss.

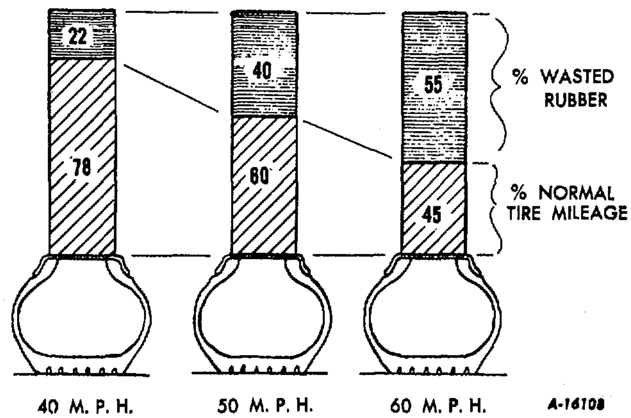


Fig. 13 Speed vs. Mileage

TIRE MATCHING (Dual Tires)

Use care in matching dual tires. Tires which differ more than 1/4" in diameter or 3/4" in circumference should not be mounted on the same dual wheel. Should it become necessary to mount two tires of unequal size on the same dual wheel, place the larger or less worn tire on the outside.

TIRE MATCHING (Tandem Drive Axles)

When mounting tires on tendem drive axles, follow the same instructions as specified for dual tires. However, never install the (four largest tires on one driving axle and the four smallest on the other. This method of tire mounting will cause high lubricant temperatures which may lead to premature axle failures.

TIRE REPAIR

Methods for repairing tires will vary slightly with each manufacturer and it is recommended that the tire manufacturers' procedures be followed if possible. However, the procedure outlined here applies in general to most tires whether they are light duty or heavy duty. Patching will usually be satisfactory for all injuries up to 3/16" diameter. Larger injuries should be handled by spot or section repair methods. The first four steps given here apply to both the hot and cold patch methods.

NOTE: Some tire repair methods for simple punctures do not require the dismounting of tire from rim. These methods should be regarded as temporary fixes since there is a good chance of ply separation and ultimate tire failure can result when puncture plug is installed from the outside.

1. Remove tire and wheel assembly and inflate the tire to the recommended pressure. Locate the leak and mark with a crayon. It may be necessary to immerse the tire in water or apply a coat of soapsuds to the tire to locate the leak. Demount the tire. Probe the injury with an awl (Fig. 14) to remove the puncturing object and foreign material.

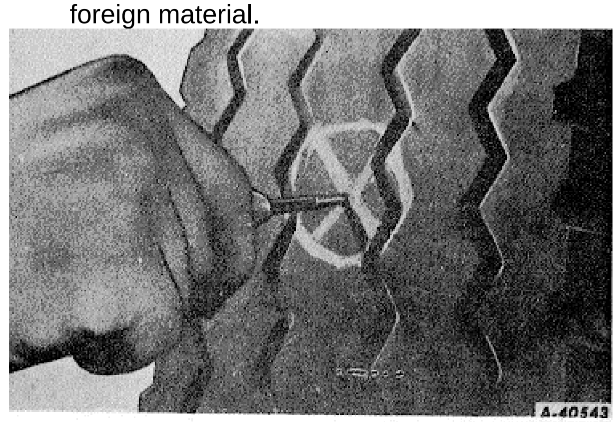


Fig. 14

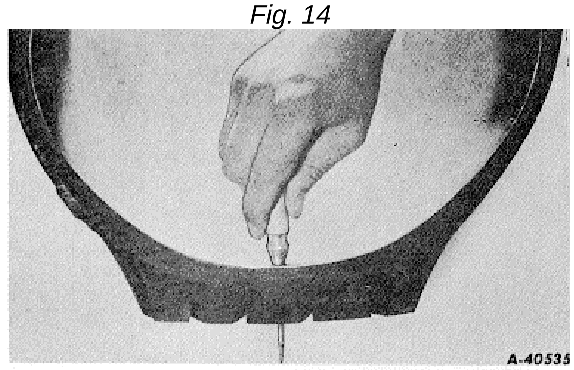


Fig. 15

2. Thoroughly clean the inside of the tire around the injury with rubber solvent and allow to dry. As a safety precaution, solvent vapors should be blown out of the tire with compressed air. Solvent is not needed

to clean an injury if a power buffer equipped with a fine wire brush is used. Care must be taken not to buff through the innerliner. Clean the awl needle and dip in self-vulcanizing fluid and from the inside of the tire, force the needle through the puncture until the point extends beyond the tread (Fig, 15).

3. Remove the detachable handle from the needle. Cut a 3.175 mm (1/8") strip of filler rubber and place it into the hole of the needle with the end of the rubber strip extending beyond the needle. Pull needle through the tire with a pliers (Fig. 16). Filler rubber will remain in puncture. Using an awl, pack excess rubber flush with inside of tire.

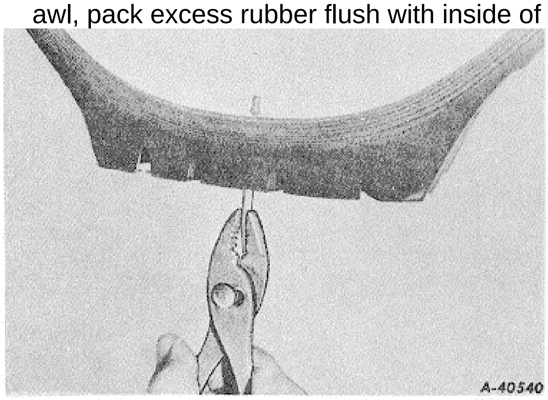


Fig. 16

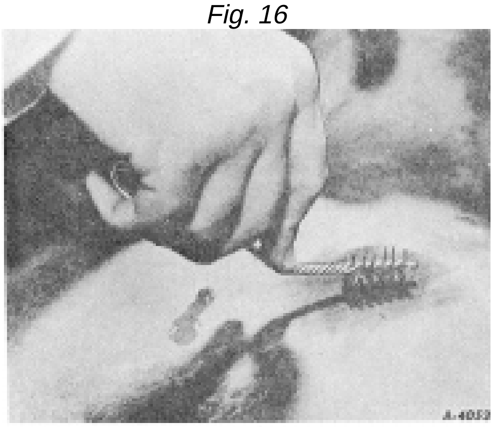


Fig. 17

4. With a wire brush (Fig. 17) or a power buffer, thoroughly roughen an area about the injury slightly larger than patch and within previously cleaned surface area. Remove all traces of lubricant, foreign material, etc. Do not use more solvent after buffing.

<u>The next three steps apply only to the hot patch method.</u>

5. Remove backing from patch and carefully center it over injury. Place a clamp over patch and tighten clamp only finger tight (Fig. 18).
6. Ignite patch and allow it to cool for at least 15 minutes or until cool to the touch. Carefully remove metal pan and ashes remaining in tire.
7. Remount tire. Inflate to recommended operating pressure. Then check to make sure injury is sealed.

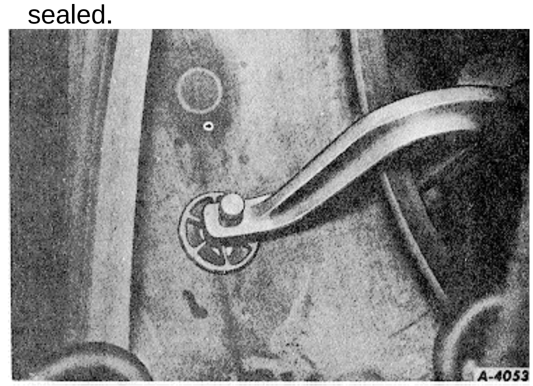


Fig. 18

<u>The next three steps apply only to the cold patch method.</u>

8. Apply self-vulcanizing cement over buffed area and allow it to dry for a minimum of five minutes. This time factor is important.
9. Remove backing from patch base and place patch over injury. Press down firmly, especially at the edges, for good adhesion (and easy removal of paper cover)(Fig. 19).
10. Remount tire. Inflate to the recommended operating pressure. Then check to make sure injury is sealed.

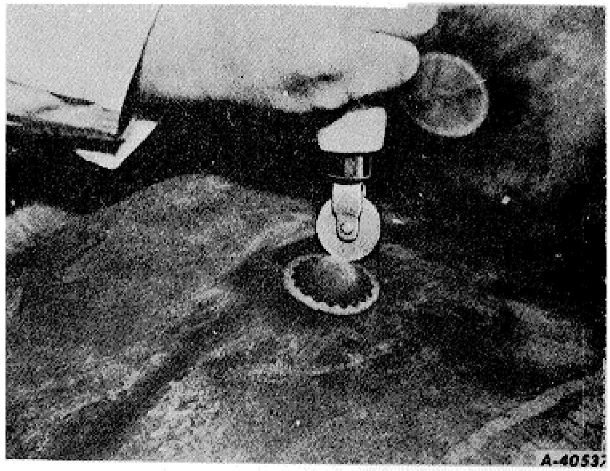


Fig. 19

MOUNTING AND DISMOUNTING TIRES

General

The following instructions were prepared as an aid for mounting and dismounting tires on different types of wheels. All standard safety precautions should be observed.

CAUTION: Before mounting radial tires make certain that heavy duty rims or approved rims for these tires are being used. It may be necessary to contact your wheel and rim distributor to determine if rims are approved for radial tires.

MOUNTING NUTS (Disc Wheels)

Where standard automotive type disc wheels have been used in the past, both left and right hand threads will be found at the wheel mounting studs and nuts. Common practice has been to use left-hand threads at the left-hand wheels and right-hand threads at the right side of the vehicle. This was done to assure keeping wheel mounting nuts tight.

With the improvement in design of both wheel bolt holes and mounting bolts or nuts the left-hand threaded parts are no longer used and right-hand threaded parts are used at all wheels. To prevent loosening of wheel bolts or nuts, cup-shaped depressions are formed in wheel disc at the bolt holes so that when mating cup-shaped nut or bolt is tightened, elastic pressure against the nut or bolt together with thread friction prevents loosening in service. For this reason wheel mounting bolts, nuts and wheel bolt hole surface must not be lubricated.

It is good practice to tighten wheel nuts daily during the first 500 miles of service on new vehicles and anytime wheels have been removed. Regular inspection periods should be established to assure keeping nuts tightened.

ONE PIECE DROP CENTER HEAVY DUTY TUBELESS TIRES (7.00-20 and Up)

The mounting or demounting of heavy duty tubeless truck tires is accomplished in much the same manner as light duty or passenger-car type tubeless tires. Consequently, same precautions for protecting the sealing edges of the tire beads and rims should be observed. Rims used are all of the one-piece drop-center type whether they are integral with wheel (disc type) or demountable (cast type). Because heavier tires are less flexible, it is suggested that the special tubeless truck tire tools, which are available, be obtained.

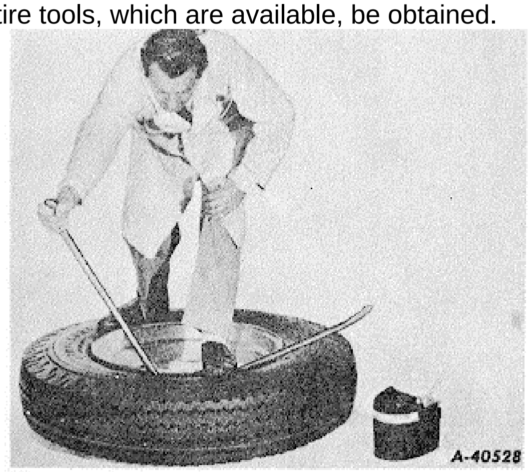


Fig. 30

<u>Dismounting Instructions</u>

1. Remove the valve core to completely deflate tire. With tire lying flat on the floor, loosen beads from rim seats by walking around on tire with heels at points close to rim. With wide side of rim down, lubricate top bead thoroughly. Insert spoon ends of both tire irons between rim and tire bead at points about 10" apart. While standing on tire, pull end of tire iron to the opposite side of rim so as to pry tire bead up and out of rim (Fig. 30).
2. Hold tool in position with one foot and pull second tool toward center of rim (Fig. 31). Progressively work bead off rim in this manner, taking additional bites as necessary.

Fig. 31

3. Stand assembly in a vertical position and lubricate second bead. At top of assembly, insert straight end of tool between bead and back flange of rim at about 45 degree angle (Fig. 32).

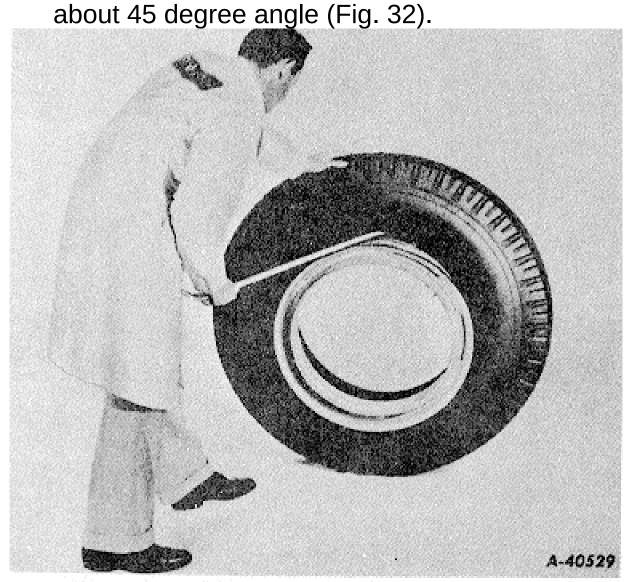


Fig. 32

4. Turn tool so it is perpendicular to rim and pry off second bead (Fig. 33).

Fig. 33

Mounting Instructions

1. Inspect the rim to insure that bead seats are clean and smooth. Then place rim on the floor with wide side down and lubricate first bead of tire and upper bead seat of rim (Fig. 34).

Fig. 34

2. Push the first bead into well of rim and onto rim as far as possible. Using straight end of tool (with stop resting on rim flange), take small bites to work remaining section of first bead onto rim (Fig. 35).

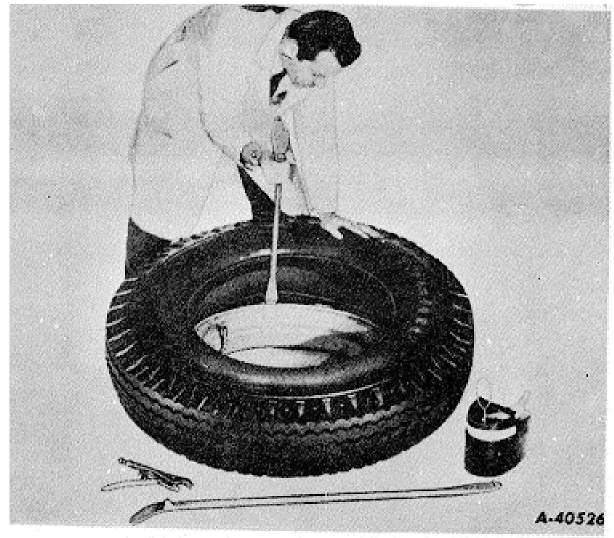


Fig. 35

3. Hold the second bead in the well by standing on tire. When necessary, push a section of the bead into rim well and anchor with a vise-grip pliers by pinching the plier onto the rim flange (snub side toward tire). Using spoon end of the tire iron with stop toward rim, work progressively around the bead, using small bites until bead slips over flange onto the rim base. If necessary, insert a second tire iron and lubricate the last 15.3 cm (6") of bead before completing mounting (Fig,. 36).

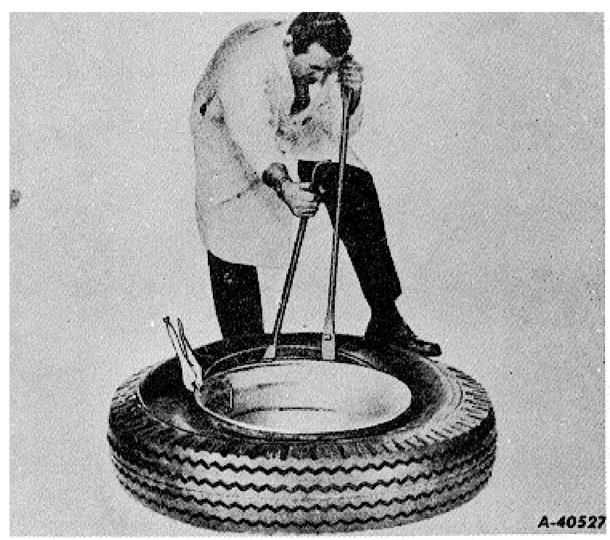


Fig. 36

4. Check valve to be certain that hex nut at the base is tight; also check valve core to make sure that no air loss can occur. Stand tire in a vertical position and inflate to recommended air pressure.

THREE-PIECE FLAT BASE

Dismounting:

1. Remove valve core and completely deflate the tire or both tires if working on duals before removing the tire and rim assembly from the truck. Remove tire assembly from truck and place on floor with the side-ring up. Insert tapered end of rim tool into depression in lock ring, or between rings, and press down on side ring to free bead. Continue around tire until the bead is completely rings, freed from the bead seat (Fig. 43).

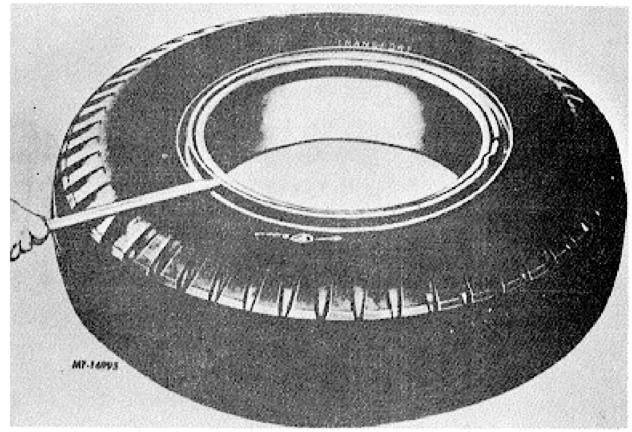


Fig. 43

2. Insert rim tool into removing notch, near split in the ring and push downward to remove lock-ring from rim gutter, A second rim tool may be helpful to aid in removal (Fig. 44).

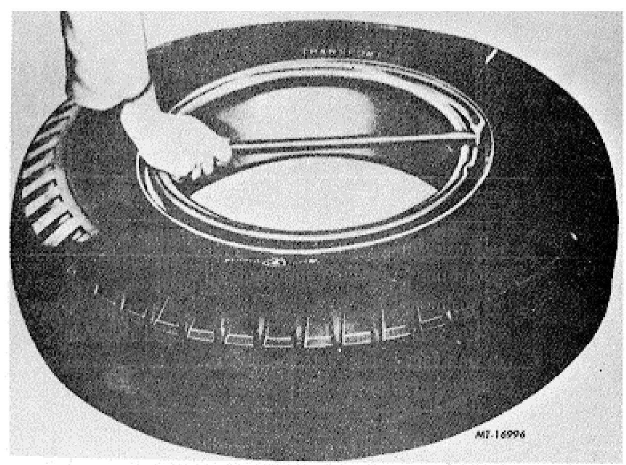


Fig. 44

3. Insert rim tool between lock-ring and sidering. Press down to pry ring up and continue around rim until lock-ring is free (Fig. 45). Remove lock and side-rings from rim. Turn assembly over, unseat second tire bead, stand tire up and remove rim base

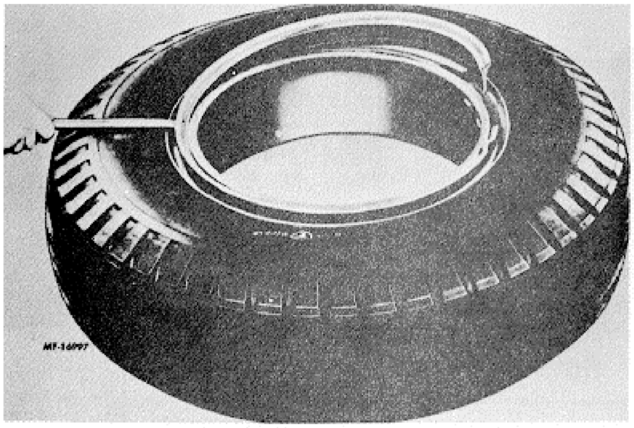


Fig. 45

Mounting:

1. Insert tube and flap into tire and partially inflate to round out tube. Apply approved rubber lubricant to inside and outside surfaces of both beads and also to the portion of tube and flap that appears between bead say rim flat on floor with valve slot up. Align valve with rim valve, place tire on rim and insert valve through valve slot.

2. Place side-ring on bead of tire. Insert tapered end of lock-ring between side-ring and rim base (Fig. 46).

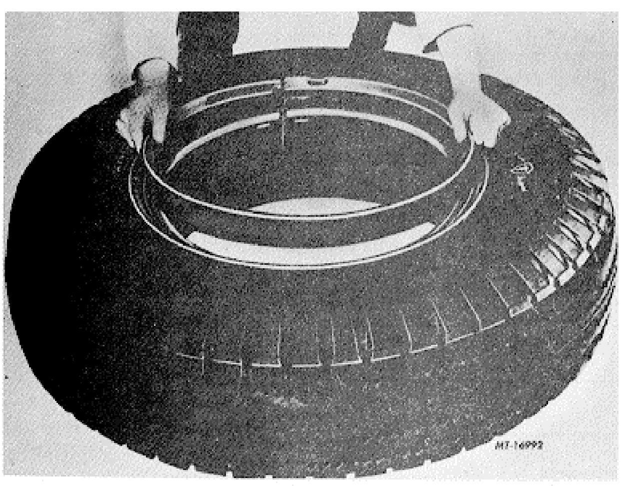


Fig. 46

3. Fasten lock-ring by holding at one end of split with foot and hammering end of ring into place with rim mallet (Fig. 47).

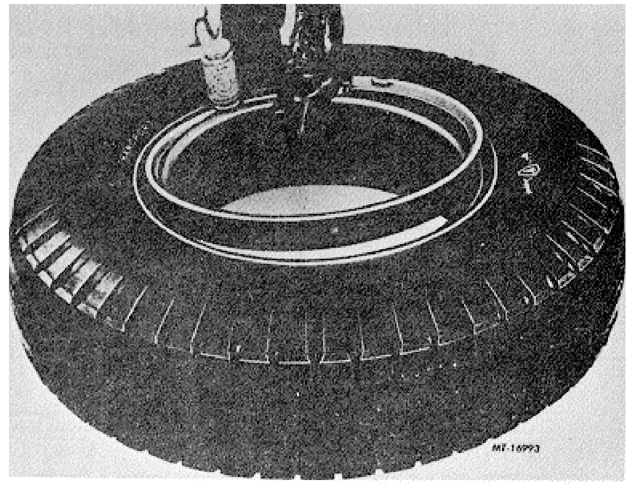


Fig. 47

4. Continue hammering around rim while holding ring with foot until entire ring is seated (Fig. 48).

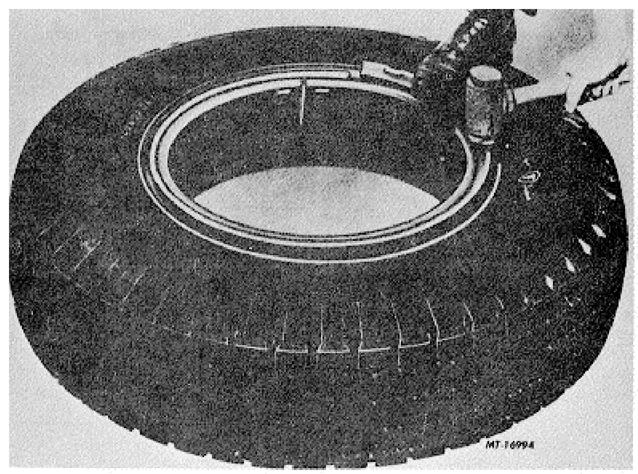


Fig. 48

5. Place tire assembly into safety cage and inflate to a maximum of 10 psi using extension hose with gauge and clip-on chuck. Inspect beads, side-ring and lock-ring for proper seating. Completely deflate tire to prevent tube from buckling. Reinflate to recommended pressure.

LOAD AND INFLATION CHART

WIDE BASE TIRES FOR TRUCKS, BUSSES, TRAILERS AND
MULTIPURPOSE PASSENGER VEHICLES USED IN HIGHWAY SERVICE
(Bias and Radial Ply Tubeless)

TIRES USED AS SINGLES

Tire Identification		Tire Load Limits at Various Inflation Pressures							
Size	Load Range	45	50	55	60	65	70	75	80
16.5 x 22.5	H	6590	7010	7410	7790	8170	8540	8890	9230

TIRES USED AS DUALS

Tire Identification		Tire Load Limits at Various Inflation Pressures							
Size	Load Range		55	60	65	70	75	80	
12.00 x 20	G		4930	5190	5440	5680	5910	6140	

NOTE: For sustained high speed driving over 60 mph, cold inflation pressures must be increased 10 psi above those specified by the table for the load being carried (but not to exceed 100 psi). Where the 10 psi pressure adjustment for sustained high speed is limited by the maximum of 100 psi, speed must be limited to 60 mph. (COLD INFLATION PRESSURES MUST NEVER EXCEED 100 PSI.)

CONVERSION OF PLY RATING TO
LOAD RANGE DESIGNATION

Load Range	Replaces Ply Rating
A	2
B	4
C	6
D	8
E	10
F	12
G	14
H	16
J	18
L	20
M	22
N	24

CHAPTER IV

TORQUE CHART

DISC WHEELS

Size		Torque N.m	Torque Ft Lbs
1-1/8"	Standard Hex Cap Nut Mounting:		
1-1/2"	Across Flats	610 - 678	450 - 500
	Heavy Duty Hex Cap Nut Mounting:		
1-3/4"	Across Flats	882 - 949	650 - 700
15/16"	Heavy Duty Square Cap Nut Mounting:		
1-5/16"	Across Flats	1017 - 1221	750 - 900
1-5/16"	Heavy Duty Cap Nut Mounting:		
1-3/4"	Across Flats	1017 - 1221	750 - 900

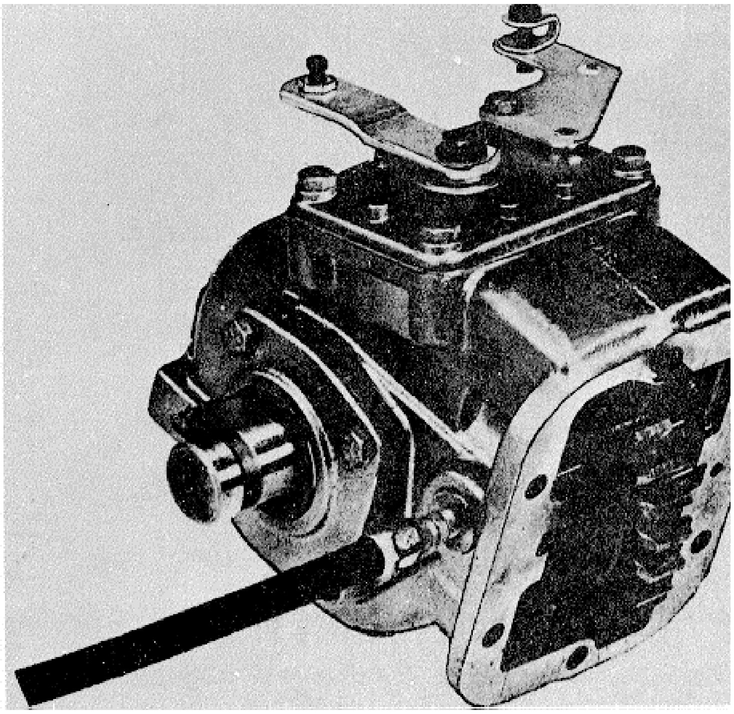
DRY THREADS - NO LUBRICATION

Where excessive corrosion exists, a light coat of lubricant on first three threads of stud on bolt is permitted. Keep lubricant away from cap nut ball faces or ball seats of disc wheels and rim clamps of cast wheels.

MISCELLANEOUS

CONTENTS

SIDE MOUNTED
POWER TAKE-OFFS
SAE SIX HOLE



SINGLE SPEED - TWO
Basic Model 26...For Heavy Duty Operation

26 Series P.T.O.'s are designed for heavy duty applications.

These units are designed with heavy duty tapered roller bearings.

Standard features of these units include 1'4" round output shaft and ten foot cable control. Lever control shift is available as an option.

Various assembly arrangements are available to enable flexibility of output shaft location.

This unit features interchangeable Pump Mounting Flanges which may be adapted to a wide range of direct mounting hydraulic pumps.

NOTE

The pump weight should not exceed 40 lbs.
Torque Rating ....250 lbs. ft.

Horsepower Rating for Intermittent Service at
500 RPM of Output Shaft..................24
1000 RPM of Output Shaft 48

Approximate Weight ....28 lbs.

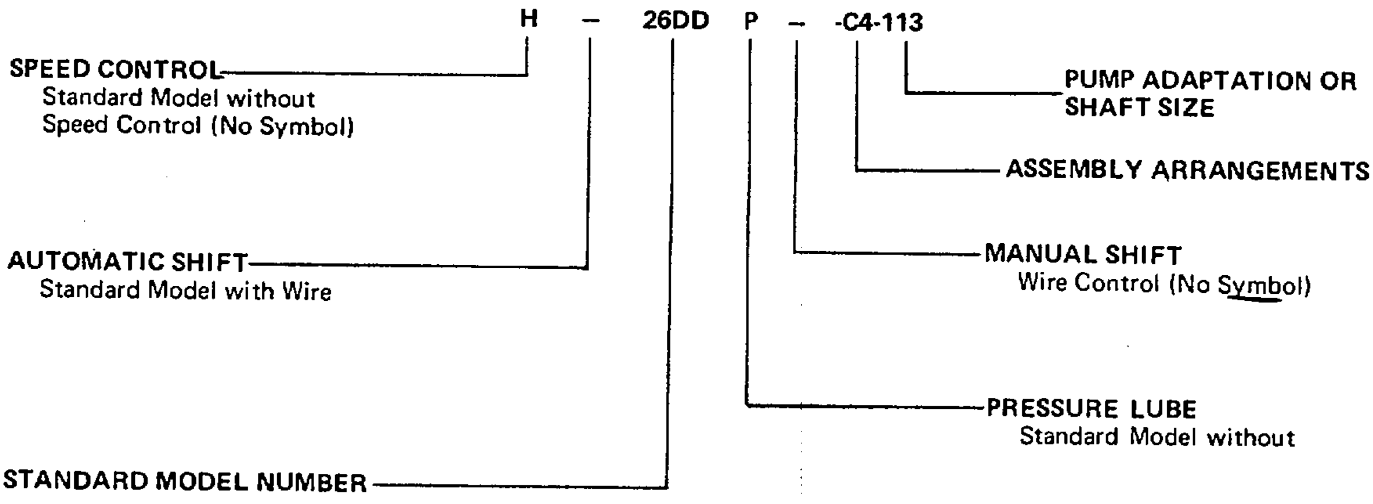
The PTO is located on the top left side of the automatic transmission.

REMOVE AND REINSTALL

To remove the PTO remove the cab floor mat and transmission floor cover. Disconnect oil supply line and shift control. Then remove the six mounting bolts securing power-take-off to the automatic transmission.

The power-take-off is installed by reversing the removal procedure. When installing the PTO select proper mounting gaskets to obtain .006" to .012" backlash.

MODEL NUMBER CONSTRUCTION
26DD SERIES EXTRA HEAVY DUTY P.T.O.



This is to advise of a modification precaution when installing or removing the lubrication valve adapter to provide lubrication for PTO assemblies. Reports of lubrication valves missing on failed PTO equipped transmissions has prompted the following recommendations.

It appears that customers are removing the lubrication valve adapter to facilitate drilling and tapping the cooler return oil line fitting for providing lubrication to the PTO unit. During removal of this adapter, the lubrication valve can easily "pop out" and be lost. Reassembly without the lubrication valve in place allows transmission lubrication oil to by-pass to sump thus resulting in transmission failure.

As illustrated in Figure 1, it is permissible to provide PTO unit lubrication through a .032 orifice line from the cooler oil line. However, it should be emphasized that drilling and tapping be accomplished without removing the lubrication valve adapter from the transmission. If necessary to remove adapter, be sure a lube valve and spring are included on reassembly.

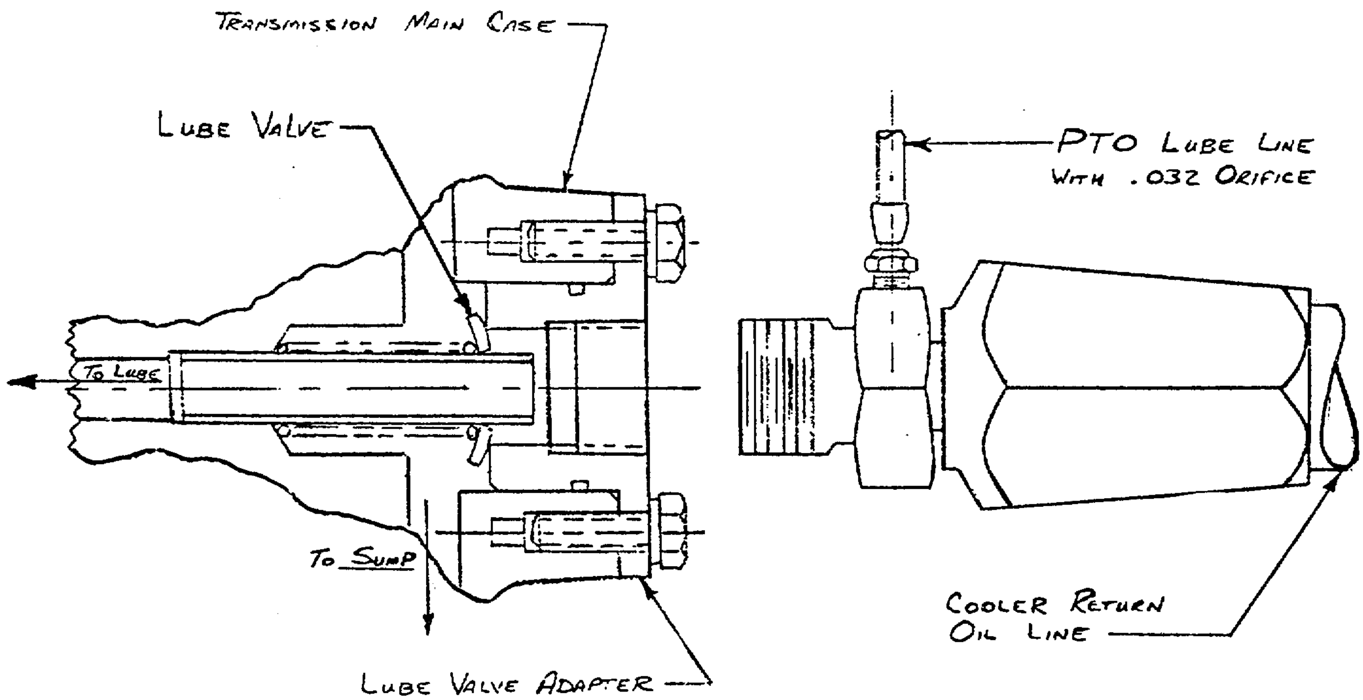
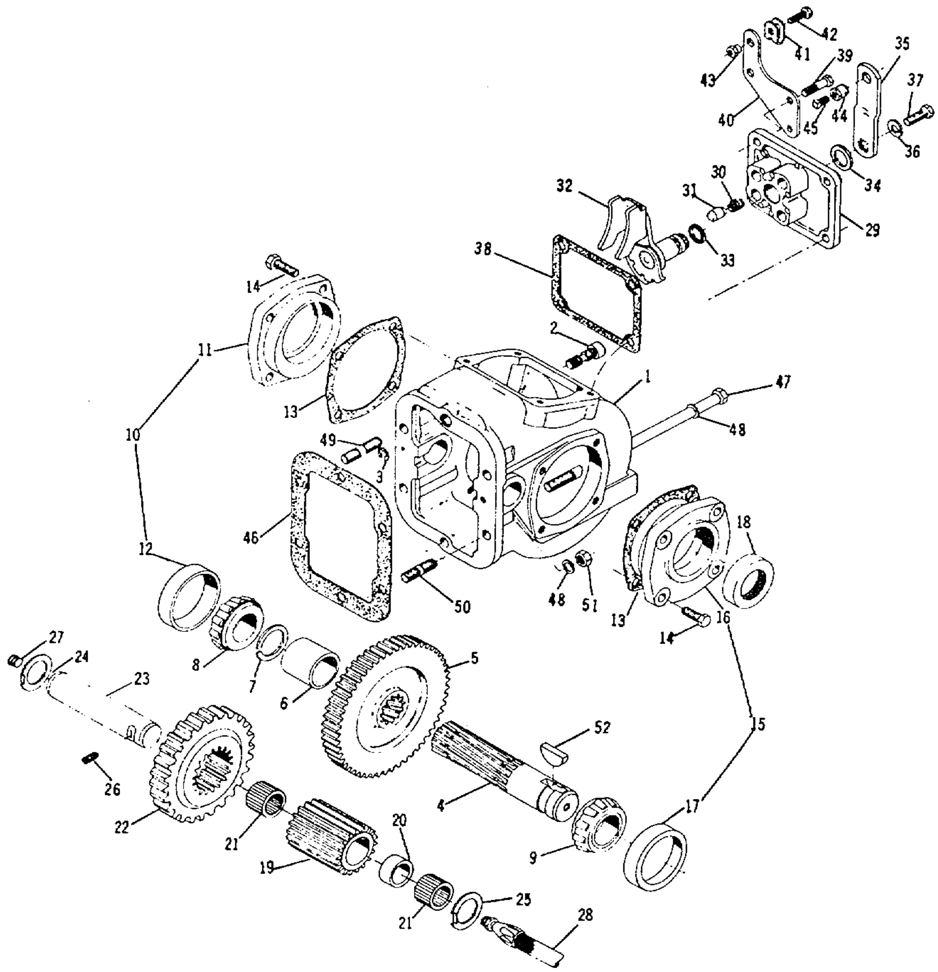


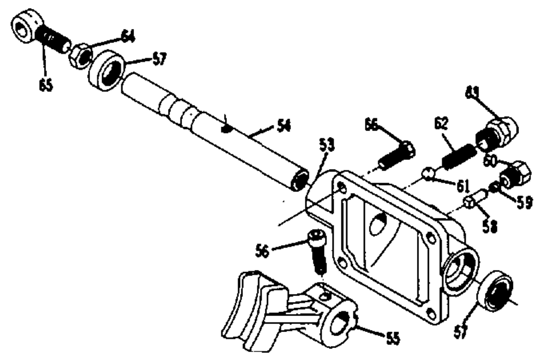
Fig. 1. PTO Lubrication Adaptation



	P.T.O	COMMON PARTS LIST FOR	26DD Series
Item	**Part Number**	**Description**	**Quantity**
	P.T.O	ASSEMBLY - Complete	1
1	1-P-281	CASE, p.t.o.	1
2	378766	SCREW, socket head cap (special)	1
3	378767	RING, retaining	1
4	A3-P-202	SHAFT, std p.t.o. output 1-1/4" Rd- 5/16" Key 500007-29	1
5	2-P-461	GEAR, output	1
6	4-P-45	SPACER, output gear	1
7	378391	RING, output shaft locking	1
8	550532	CONE, output shaft bearing - Closed End	1
9	55039’1	CONE, output shaft bearing - Open End	1
10	328274X	BEARING CAP ASSEMBLY - Closed End	1
11	N.S.S	CAP, bearing	1
12	550221	CUP, bearing	1
13	22-P-24-1	GASKET, bearing cap(.010" Thick)	AR

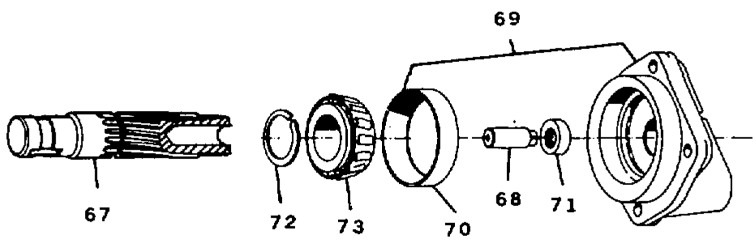
Item	Part Number	Description	Quantity
14	▲ 378430-10	SCREW, bearing cap .... (5/16"-x 1)	8
15	A328273X	BEARING CAP ASSEMBLY - Open End	1
16	N.S.S	CAP, bearing	1
17	550221	CUP, bearing	1
18	28-P-52	SEAL, output shaft oil	1
19	5-P-487	GEAR, driving	1
20	14-P-50	SPACER, needle roller	1
21	550886	NEEDLE ROLLER - Caged	2
22	5-P-486	GEAR, input sliding	1
23	*9-P-55	SHAFT, idler std	1
24	31-P-58	WASHE R, thrust .... (2" 0.0.)	1
25	31-P-47	WASHE R, thrust .... (1-1/2" 0)	1
26	378452-7	SCREW, input shaft set .... (1/4"-20x 1/2")	1
27	500132-3	PLUG, pipe .... (1/8"-27 N.P.T.)	1
28	■ 328075X	HOSE, Shipped Loose (Pressure Lube Only)	
	328149X	SHIFTER ASSY., Wire Control - (Assy Arngmnts C5) }	1
29	34-P-17	COVER, shifter	1
30	37-P-20	SPRING, poppet	1
31	63-P-6	PIN, poppet	1
32 {	328151X	SHIFTER PLATE SUB-ASSY- (Assy Arngmnts C5) }	1
33	28-P-49	O-RING, shifter post	1
34	378004	WASHE R, flat .... (" 0.D.)	1
35	51-P-22	LEVER, shift .... (4")	1
36	378003	WASHER, lock .... (5/16")	1
37	500409-6	SCREW, hex head cap .... (5/16"-24 x 5/8")	1
38	35-P-8	GASKET, shifter cover	1
39	378430-10	SCREW, eslock'hex head cap .... (5/16"-18 x 1")	4
		PARTS SHIPPED LOOSE	
	328346-10X	WIRE CONTROL ASSEMBLY - Wire & Knob	1
	328380X	WIRE CONTROL MOUNTING PARTS	1
40	50-P-17	BRACKET, wire control	1
41	50-P-19	BRACKET, swivel	1
42	500396-8	SCREW, hex head cap .... (1/4"-20 x 3/4")	1
43	378326	NUT, special hex .... (1/4"-20)	1
44	378019	PIN, pivot	1
45	500568-4	SCREW, square head set .... (1/4"-20 x 1/2")	1
46	35-P-9-1	GASKET mounting .... (.010"" Thirk)	AR
	328170-97X	KIT, p.t.o mounting	1
47	378041-10	SCREW, hex head cap .... (3/8"-16 x 8-1/4")	1
48	378018	GASKET, copper bolt	5
49	378478-12	STUD .... (3/8"-16 & 3/8"24 x 1-5/8")	2
50	378478-10	STUD .... (3/8"-16 & 3/8"-24 x 1-1/2")	2
51	500371-3	NUT, hex .... (3/8"-24)	4
52 {	500007-29	KEY woodruff (5/16") - Fo?-3-P-202 or 3-P-340 Shafts }	1

▲ For Hydraulic Pump Shaft & Flange,
N.S.S - Not Sold Separately.
AR - As Required.
* For Optional Pressure Lubrication Kit,
■ Included with Pressure Lube Kit 328663X



Item	Part Number	Description	Quantity
	328312X	SHIFTER COVER ASSEMBLY - Lever Control	1
53	34-P-26	COVER, shifter	1
54	11-P-76	SHAFT, shifter	1
55	32-P-85	FORK, shifter	1
56	378447-6	SCREW, hex socket cap	1
57	28-P-56	SEAL, oil	2
58	45-P-6	PIN, guide	1
59	378468	PLUG, felt	1
60	38-P4	HOLDER, hex guide screw	1
61	378002	BALL, shifter	1
62	37-P-14	SPRING, shifter	1
63	378554	CAP, poppet	1
64	5003814	NUT, hex jam	1
65	36-P-10	BOLT, eye	1
66	378430-8	SCREW, hex head eslock (5/1"-18 x 3/4")	4

GOVERNOR DRIVE



Item	Part Number	Description	Quantity
		KIT, governor drive	
	328060X	D RIVE SHAFT & SPINNER ASSY- Governor Drive	1
67	3-P-270	SHAFT, drive	1
68	378178	SPINNER	1
69	328588X	BEARING CAP ASSEMBLY	1
70	550221	CUP, bearing	1
71	28-P-53	SEAL, oil	1
72	378391	RING, locking	1
73	550532	CONE, bearing	1

Governor Drive Kit consists of parts shown plus gaskets, 22-P-24-1 & 22-P-24-2.

HYCO

SERVICE INSTRUCTIONS FOR THE C10000 SERIES TELESCOPIC CYLINDERS

CYLINDER SERVICE REMOVAL

To remove cylinder, raise body, block with safety props, remove top and bottom pins. In as much as cylinder weighs approximately 450 lbs., it is suggested that chain block be used to remove same from mounting.

1. Packing.

   a. Unlike our cylinders in the past, the packing on the C10000 series cylinder is nonadjustable; therefore, the head nuts are bottomed against the threaded end of the tube. Disregard all past instructions concerning readjustment of the head nuts.

   b. The packing set consists of one bottom bushing, one bottom adapter, four vee rings and one top bushing which also serves as the top adapter. The two lips formed by the "V" shape of each vee ring face the fluid pressure and contact the inner and outer surfaces to be sealed. Lip interference (the flare built into the vee rings) preloads the packing and automatically prevents any leakage. Each vee ring in the packing set functions as a separate seal.

   c. Installing new packing.

   1. Be sure packing cavity is clean and free of any small pieces of old packing.

      2. Unlike our instructions in the past, the B10038 series packing must be installed as a complete set rather than each component separately.

      3. Lubricate the pack set with an oil film or grease and position it at the packing cavity. Turn the head nut upside down placing the wiper flange against the top bushing and tap it with a plastic mallet. Make certain that each vee ring slides into the packing cavity.

      4 Place the wiper on the top of the packing then install the head nut.

      5 Reinstall the head nuts, securing them against the top edge of each tube.

      6 Reinstall plunger end in last plunger and tighten set screw. If cylinder is designed without set screw, use a small amount of Locktite, Type CVV, before installing plunger end in tube.

      7 Tighten lock screw in head nut.

2 Completely disassembling telescopic cylinder.

   a When it is necessary to replace a damaged plunger tube assembly in the field, the telescopic cylinder should be completely disassembled. This will allow all plunger tube assemblies to be cleaned and inspected for wear and/or damage.

b. It is highly recommended that the telescopic cylinder be returned to HYCO, Inc, for complete overhaul.

c. Disassembly Begin by removing the threaded pin eye at the top of the cylinder, all head nuts and packing. NOTE: On most cylinders, the pin eye is secured to the tube by a set screw set against the top edge of the tube. Remove set screw before disassembling.

d. Remove the retainer ring from the outer casing by forcing the edge of the retainer ring out of its groove and pulling it upward.

e. Once the retainer ring is removed pull the cluster of remaining tubes from the outercasing.

f. The remaining plungers can be removed through the bottom of the cylinder thus the retainer rings on the balance of the plungers need not be removed from their grooves.

g. Reassemble cylinder in reverse of disassembly, reinstall retainer ring in cylinder tube, and install packing as is outlined under paragraph one.

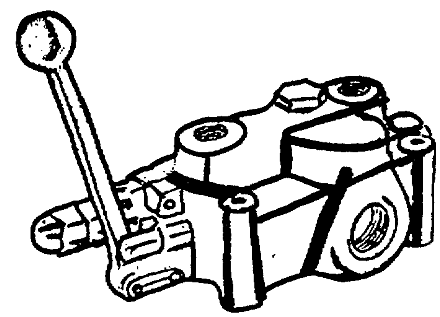
h. Replace all head nuts and the pin eye.

i. Install nylon slug and set screw to lock head nuts in place. Reinstate set screw in pin eye if applicable, If cylinder is designed without set screw, put a small amount of Locktite, Type CVV, before installing it in the tube.

NOTE Inspection of the head nuts will determine if a cylinder is old style or C10000 series cylinder. On the C10000 series cylinder, the head nut will be 2" long and they will completely nestle together when the cylinder is closed. On the old style cylinder, the head nuts are 1 1/2" long and when cylinder is closed, there is approximately 3/8" clearance between each nut.

MODEL WP
40-GPM
DIRECTIONAL CONTROL VALVE
(PARALLEL CIRCUIT)

- *Fully Balanced - Self Centering Spools*
- *Built-in "High Lift" Ball-Spring Cartridge Type Relief Valve with Hardened Seat*
- *Pilot Operated Relief Valve - (Optional)*
- *Tripod Mounting Feet*
- *Load Checks on Each Spool*
- *Accurately Feathered Spools for Fine Metering Action*
- *Hardened and Chrome Plated Spools*
- *Optional 180° Handle Position*
- *SAE Straight Threads "Inlet", "Outlet" and "Cylinder Ports" (Optional)*
- *High Pressure Carry-over (Power Beyond) (Optional)*



MODEL WP (1 SPOOL) 3 WAY

SPECIFICATIONS
Capacity.........................Up to 40 GPM (W/Pilot Operated Relief
Up to 38 GPM (W/Standard Ball-Spring Relief
Maximum Pressure .... 2000 PSI’
*(2500 PSI W/Pilot-Operated Relief and Heavy Spool Centering Spring)

NOTE :Unless otherwise specified on order, unit relief valve will be factory set at 1000 PSI @ 24 GPM.
Shipping Weight
1-Spool .... 35lbs.

NO LOAD DROP WITH INDIVIDUAL LOAD CHECKS ON EACH SPOOL

With individual check valves for each spool, there is no momentary reversal of the cylinder, nor can the load drop as the spool is shifted. Loads may be accurately positioned with the check valve assuring positive control. Also, these valves prevent back filling from one cylinder to another when two spools are operated simultaneously.

PORT SIZES

Standard - Cylinder (Work) Parts...3/4"-14 NPTF
End Inlet...1"-11 Y NPTF
End Outlet...1 1/4"-1 1/2" NPTF

SPOOLS

The standard valve spools, 3-way have the Open Center spool design. This allows the oil to pass through Open Center to the return line when the spool is in the neutral position. A 3-way spool is used to control a single-acting cylinder or motor having one direction of rotation

PRESSURE DROP THRU WP VALVES

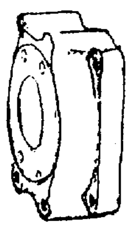
GPM	Press. Drop Thru "Open-Center" (PSI)	SPOOL #1 (Press. Drop PSI) Flow "In" via Valve (Inlet) & "Out" via Cyl. Port		Flow "Out via Valve (Outlet) & "In" via Cyl. Port										MAXIMUM TOTAL PRESS. DROP THRU TWO OF THE VALVE WORKING PORTS.
		A	B	A	B	A	B	A	B	A	B	A	B	(Pressure
		(W)	(X)	(Y)	(Z)	(W)	(X)	(Y)	(Z)	(W)	(X)	(Y)	(Z)	Drop – PSI)
MODEL WP-4														
20	7	40	33	6	5									45
25	13	59	51	12	110									69
30	16	76	68	17	12									88
35	20	105	92	22	15									120
40	28	149	131	33	27									176

NOTES:
1. Cylinder Port "A" – Port Closest to Handle End of Valve.
   Cylinder Port "B" – Port Closest to Bonnet End of Valve.
2. Inlet 1" NPTF, Outlet 1¼" NPTF = Cylinder Ports ¾"
3. Test Run using Hydraulic Oil – DTE Light, 150SSU @ 100° F.
4. Back Pressure thru connecting hoses & fittings has been deducted from total readings.
5. In order to get total pressure drop thru a complete power cycle of valve, add readings in column (W) & (Z) or (X) & (Y) depending on which route oil will flow for the particular application under consideration.

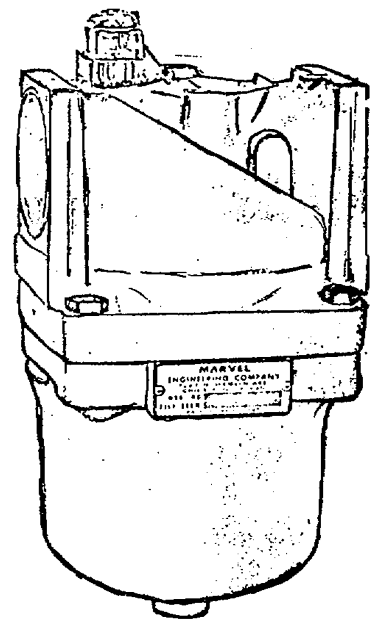
PUMP SERVICE REMOVAL

To remove pump, remove bolts holding pump to pump mounting bracket.

Marvel "12-IN-1" Hydraulic Filters for Suction, Return, and Low Pressure Lines



1¼"



PATENT APPLIED FOR

Now-with these new filters-you can actually create your desired ports anytime without having to buy and attach port step down bushings. And since you can do so much with just one filter, even a modest supply of filters and port adapters can cover your long-term needs with greatly multiplied savings and convenience, Here's how and why..

- The 3 filter sizes 12 port options for each size (interchangeable with each other on all 3 sizes) enable you to select and port size , type , and flow rates desireddo it yourself in minutes right in your own plant.
- You eliminate the repititious paperwork, time waste, and waiting for delivery of ordinary filters that have to be ordered individually with different port sizes and types for different applications.
- Not chance of being stuck with filters you can't use, you can always change ports right on the spot.
- With so many options on one filter, you can cover your needs with a much smaller stock, thus saving on investment, inventory, and space.
- Since one "quantity" order fulfills needs formerly requiring many individual orders (for I or 2 filters at a time), you save -from quantity discounts and lower shipping costs.
- No more costly discarding of entire filter because of port thread damage (such as cross-threading and over tightening damage). Merely replace port adapter.
- Easier, Safer Piping-symmetrical l bolting of port adapters to filter head permits 360(adapter rotation (in 90increments) in either direction to achieve precise directional positioning of elbows, "Ts", etc. without danger of over tightening.
- No need to disturb piping when removing and replacing filter (for example, for one with different by-pass, element length, or degree of filtration). Merely remove port adapter screws

Marveline-TB

SERIES

Housing Nos. 265161- thru 270324-

350 psi Maximum for General Service
1,400 psi Minimum Burst at 70° F.

For Hydraulic Oils, Coolants, Lubricants, Water Glycol, and Phosphate Ester Base Fluids — UP TO 150 GPM

The new "TB" Series represents another Marvel big-value offering to the machine tool and mobile equipment field. To the unique advantages shown on page 879, add these outstanding quality features.

- Extra large By-Pass Valve eliminates danger of pump cavitation from clogged system and from heavy, stiff oil of "cold start" conditions.
- Patented *Marvelflo sloping head design reduces pressure drop by channeling oil directly around the element.
- Available with (optional) patented MarvelMag Magnetic Shield and (optional) Colorgage Indicator that assure greatly enhanced filtering efficiency and longer element life.
- Wide choice of By-Pass settings and filtering media.
- Minimum weight—with cast aluminum head and housing that provide smooth, corrosion-resistant surfaces.
- Ideal for confined areas—only 2⅝" clearance needed for service-removal of housing and element (using ordinary wrench).
- Built to high quality Marvel specifications.

SIMPLIFIED ORDERING

You can order the "TB" Series Filter in the conventional manner—with desired ports pre-assembled on filter—and order a supply of the Port Adapters with the filter or separately, when and as needed. Or you can order the basic filter or filters (without port adapters attached) along with a supply of Port Adapters of your choice.

In ordering in the conventional manner, the complete Filter Model No. consists of the following:

(a) Housing No. for fluid to be filtered. Select from Table 1, Col. 4 or 6.
(b) By-Pass No., from Table II.
(c) Filter Element No. for fluid selected, from Table I, Col. 5 or 7.
(d) Filter Element Media No. for desired degree of filtration, Table III.

Example: A "TB" Filter, 1½" SAE Flange Ports for Hydraulic Oil, Standard (7.25" Long) Element, 200 Mesh, and 25 psi By-Pass is specified by:

(a) (b) (c) (d)
Filter No. 265244-2500-576366-1120

To specify above filter with MarvelMag Magnets, simply change dash in Element-Media combined number to "M", making it: "576366M1120". To specify filter with integral Colorgage Indicator, see next page.

o order basic filters (without port adapters attached), simply hange last three digits of Housing No. to three zeros. Example: Housing No. 265244-etc. becomes "265000-" etc.

Order Port Adapters (2 per filter) from Table IV, according to port size and type. 4 mounting screws and seal supplied with each Port Adapter. The same screws fit all types and sizes of Adapters.

To order Replacement Elements only, simply specify Element Number only. To order Replacement Element pleated for Magnets but less the Magnets, simply change the "M" in Magnetic Element Number to "MN", making it, in above example, "576366-[illegible]

Table I—Marveline "TB" Housing & Filter Element Numbers

	GROUP A HYDRAULIC OILS, COOLANTS, LUBRICANTS & WATER GLYCOL					GROUP B PHOSPHATE ESTER BASE FLUIDS	
	(1) NPTF	(2) SAE ST. TH'D	(3) SAE FLANGE	(4) HOUSING NUMBERS	(5) FILTER ELEMENT NUMBERS	(6) HOUSING NUMBERS	(7) FILTER ELEMENT NUMBERS
7.25" LENGTH (Standard) ELEMENT	1 1/4-11 1/2			265201	576366		

Table II—By-Pass Options

By-Pass, ADD 2500 to Housing No.
By-Pass, " 1500 "
By-Pass, " 1000 "
8 psi By-Pass, " 0800 "
5 psi By-Pass, " 0500 "
3 psi By-Pass, " 0300 "
No By-Pass, " 0000 "

Table III—Filter Element Media Numbers

Number	Nom. Micron	Filter Element Media
5125	25	25 Micron Paper

**Mesh reinforcement recommended for shock return lines, for pressure installations where by-pass valve does not open, or for momentary reverse flow pressure applications.

TABLE IV—PORT ADAPTER PART NUMBERS

PART NUMBER	NPTF PIPE	SAE ST. TH'D.	SAE 4-BOLT
265201-16DC	1¼-11½		

880

DUMP BODY COMPONENTS

CYLINDER REMOVAL

With body in down position remove retaining plate on inside of body and remove top cylinder pin. With a crane or some other lifting device pick up or raise body as high as possible. Prop body well in raised position using extra caution and sufficient supports. Remove cotter pin and bottom base pin. Before removing bottom base pin, it is suggested that a chain, etc. be installed on top of cylinder and a crane be used to lift cylinder from mounting. With chain secure and pin removed, cylinder is now ready to lift out of base.

PUMP REMOVAL

Close valve on bottom of oil tank using oil pans to catch excess oil that will drain from hoses, Remove hoses from pump and plug if necessary to reduce oil loss, Pump is held in position on mounting bracket with 4 mounting bolts. Remove bolts. Pump can be removed by hand for service or replacement.

OIL TANK REMOVAL

It is suggested that oil be drained from tank. Loosen straps and remove tank from frame. -Two men or a lifting device should be used as tank weighs approximately 75 lbs,.

BODY REMOVAL

To remove body from truck, remove cylinder in manner described above. Using overhead crane, lift front of body. Remove rear hinge bar and with the use of another lifting device lift rear of body clear of hinges. Truck may hen be removed from under body.

GATE REMOVAL

Use overhead crane or lifting device, fasten chain sling on top of gate brackets welded on top inside corners, Loosen handle at left front corner of body. Remove top gate pins, then lift gate clear of body. To reinstall, use above method, installing top pins first and allowing gate to settle into bottom hooks.

BODY STOP CABLE

To adjust body stop cable, raise body to the full extent of cylinder stroke.

CAUTION Cylinder must not be extended full stroke under pressure for any length of time.

When cylinder is fully extended stop Pump and PTO, lower body 6". Block body in raised position and adjust cable so there is a snug fit. Recheck in the following manner: lower body and raise body making sure that stop cable pulls valve lever to neutral position before reaching full stroke of cylinder.

Under no condition must cylinder be allowed to extend to full stroke with pressure against it.

NOTES

By Order of the Secretary of the Army:

E. C. MEYER
General United States Army
Chief of Staff

Official

J. C. PENNINGTON
Major General, United States Army
The Adjutant General

Distribution:

To be distributed in accordance with DA Form 12-25B, Organizational maintenance requirements for Dump Trucks.

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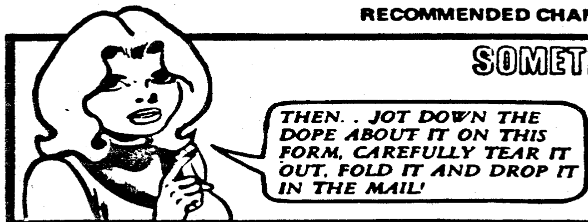
TEAR ALONG PERFORATED LINE

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS



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