# TM 5-3805-237-35

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

## DS, GS AND DEPOT MAINTENANCE MANUAL

## GRADER, ROAD, MOTORIZED DIESEL ENGINE DRIVEN FSN 3805-931-7881



HEADQUARTERS, DEPARTMENT OF THE ARMY

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TECHNICAL MANUAL
No. 5-3805-237-35

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *31 July 1967*

# DS, GS and Depot Maintenance Manual
# GRADER, ROAD, MOTORIZED
# DIESEL ENGINE DRIVEN
# (FSN 3805-931-7881)

# CHAPTER 1

# INTRODUCTION

## Section I. GENERAL

### 1-1. Scope

*a.* These instructions are published for use of direct and general support and depot maintenance personnel maintaining the Letourneau-Westinghouse Model 440HA Motor Grader. They provide information on the maintenance of the equipment which is beyond the scope of the tools, equipment, personnel, or supplies normally available to the using organizations.

*b.* DA Form 2028 (Recommended Changes to DA Publications) will be used for reporting discrepancies and recommendations for improving this equipment publication. This form will be completed by the individual using the manual and forwarded directly to Commanding General, U. S. Army Mobility Equipment Command, ATTN: AMSME-MPD, 4300 Goodfellow Blvd., St. Louis, Mo. 63120.

*c.* Report all equipment improvement recommendations as prescribed by TM 38-750.

### 1-2. Record and Report Forms

For record and report forms applicable to direct and general support and depot maintenance, refer to TM 38-750.

*Note.* Applicable forms, excluding Standard Form 46 (United States Government Motor Vehicle Operator's Identification Card) which is carried by the operator, shall be kept in a canvas bag mounted on the equipment.

## Section II. DESCRIPTION AND TABULATED DATA

### 1-3. Description

A general description of the motor grader, the location and description of identification and instruction plates, and information on the differences in models are contained in the Operator and Organizational Maintenance Manual. Direct and general support and depot repair and maintenance instructions are described in appropriate sections of this manual.

### 1-4. Tabulated Data

*a. General.* This paragraph contains all overhaul data pertinent to direct and general support and depot maintenance personnel. A wiring diagram (fig. 1-1) is included.

*b. Nut and Bolt Torque Data.*

*Note.* The following listing shows major nuts and bolt torques for the motor grader and engine. The torques are all listed in ft-lb (foot-pounds).

(1) *Transmission and final drive.*

| | |
|---|---|
| Drive gear assembly mounting bolts. | 275 ft-lb |
| Lower transmission mounting bolts. | 190 ft-lb |
| Intermediate plate mounting bolts. | 190 ft-lb |
| Lower transmission upper shaft nut. | 550-575 ft-lb |
| Lower transmission lower shaft nut. | 550-575 ft-lb |
| Parking brake drum mounting nuts. | 65 ft-lb |
| Pinion and bevel gear bearing cage screws. | 275 ft-lb |
| Lower shaft bearing cap | 65 ft-lb |
| Upper transmission upper shaft lock nut. | 550-575 ft-lb |
| Upper transmission lower shaft lock nut. | 300-325 ft-lb |

(2) *Tandem drives*

| | |
|---|---|
| Brake anchor pin lock nut | 400-440 ft-lb |
| Wheel mounting nuts | 600-650 ft-lb |
| Cover nuts | 25-30 ft-lb |

(3) *Lift Housings*

| | |
|---|---|
| Worm gear housing stud | 100-110 ft-lb |
| Worm gear housing mounting nuts. | 135-145 ft-lb |
| Thrust bearing lock nut | 250-260 ft-lb |

(4) *Lateral shift housing*

| | |
|---|---|
| Housing screws | 60-70 ft-lb |
| Housing studs | 25-35 ft-lb |
| Thrust bearing lock nut | 250-260 ft-lb |
| Pinion thrust lock nut | 130-140 ft-lb |

(5) *Scarifier lift housing*

| | |
|---|---|
| Reduction gear housing studs | 100-110 ft-lb |
| Reduction gear housing mounting nuts. | 135-145 ft-lb |

(6) *Scarifier block*

| | |
|---|---|
| Lift ball nut | 1,400-1,500 ft-lb |

(7) *Lateral shift link*

| | |
|---|---|
| Clamping bolts | 65-75 ft-lb |

(8) *Service brakes*

| | |
|---|---|
| Brake pedal shaft bearing clamp screws | 25-35 ft-lb |

(9) *Hydraulic system*

| | |
|---|---|
| Hydraulic pump cover screws | 65-75 ft-lb |
| Power steering housing cover: | |
| 1/2-inch screws | 50-55 ft-lb |
| 5/16-inch screws | 11-14 ft-lb |
| Moldboard control valve mounting nuts. | 45-55 ft-lb |

(10) *Front lean wheel housing*

| | |
|---|---|
| Special bolts | 230-250 ft-lb |

(11) *Engine*

| | |
|---|---|
| Accessory drive bolts to balance gears. | 45-50 ft-lb |
| Air inlet housing to blower bolt. | 16-20 ft-lb |
| Balance weight cover screws | 25-30 ft-lb |
| Balance weight to timing gear bolt. | 25-30 ft-lb |
| Balance weight to hub bolt | 25-30 ft-lb |
| Blower drive gear | 55-65 ft-lb |
| Blower drive gear hub bolts and nuts. | 25-30 ft-lb |
| Blower drive gear hub nut | 50-60 ft-lb |
| Blower drive coupling to gear hub bolt. | 20-25 ft-lb |
| Blower rotor gear hub bolt | 25-30 ft-lb |
| Cam and balance ends bearing bolt. | 35-40 ft-lb |
| Cam and balance shaft nuts | 300-325 ft-lb |
| Cam follower guide bolt | 12-15 ft-lb |
| Connecting rod nuts | 65-75 ft-lb |
| Control shaft bracket bolt | 10-12 ft-lb |
| Crankshaft end bolt | 180-200 ft-lb |
| Cylinder head nuts | 165-175 ft-lb |
| Engine lifter bracket to cylinder head bolts. | 55-60 ft-lb |
| Exhaust manifold outlet flange nuts. | 20-25 ft-lb |
| Exhaust muffler nuts | 30-35 ft-lb |
| Flywheel housing nuts | 25-30 ft-lb |
| Flywheel housing nuts (1/2-13) | 90-100 ft-lb |
| Flywheel bolts | 150-160 ft-lb |
| Front cover bolt | 80-90 ft-lb |
| Front cover (crankshaft) | 25-30 ft-lb |
| Hand hole cover screws | 10-15 ft-lb |
| Idler gear and dummy hub screws. | 80-90 ft-lb |
| Injector clamp nut | 20-25 ft-lb |
| Main bearing nuts (5/8-11) | 180-190 ft-lb |
| Main bearing nuts (5/8-18) | 155-185 ft-lb |
| Rocker shaft bolt | 90-100 ft-lb |
| Water manifold nuts | 25-30 ft-lb |

Standard bolt and nut torques:

| | |
|---|---|
| 1/4-20 | 7-9 ft-lb |
| 1/4-28 | 8-10 ft-lb |
| 5/16-18 | 13-17 ft-lb |
| 5/16-24 | 15-19 ft-lb |
| 3/8-16 | 30-35 ft-lb |
| 3/8-24 | 35-39 ft-lb |
| 7/16-14 | 46-50 ft-lb |
| 7/16-20 | 57-61 ft-lb |
| 1/2-13 | 71-65 ft-lb |
| 1/2-20 | 83-93 ft-lb |
| 9/16-12 | 90-100 ft-lb |
| 9/16-18 | 107-117 ft-lb |
| 5/8-11 | 137-147 ft-lb |
| 5/8-18 | 168-178 ft-lb |
| 3/4-10 | 240-250 ft-lb |
| 3/4-16 | 290-300 ft-lb |
| 7/8-9 | 410-420 ft-lb |
| 7/8-14 | 475-485 ft-lb |
| 1-8 | 580-590 ft-lb |
| 1-14 | 585-595 ft-lb |

Engine stud torques:

| | |
|---|---|
| Injector clamp stud | 10-25 ft-lb |
| Water manifold stud | 10-25 ft-lb |
| Exhaust muffler stud | 15-30 ft-lb |
| Cylinder head stud (4.3125 to 4.4375 high). | 35-75 ft-lb |
| Main bearing stud (3.9687 to 4.0312 high). | 35-75 ft-lb |

*c. Repair and Replacement Standards.* Table 1-1 lists manufacturer's sizes, tolerances, desired clearances, and maximum wear and clearances.

*d. Schematic Wiring Diagram.* Figure 1-1 shows the schematic wiring diagram for this motor grader.

*Table 1-1. Repair and Replacement Standards*

| Component | Manufacturer's dimensions and tolerances in inches — Minimum | Manufacturer's dimensions and tolerances in inches — Maximum | Desired clearance — Minimum | Desired clearance — Maximum | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| ENGINE: | | | | | |
| Cylinder block | | | | | |
| Bore diameter | 4.6265 | 4.6275 | ------ | ------ | 0.0005 |
| Out-of-round | ------ | 0.0010 | ------ | ------ | 0.0030 |
| Taper | ------ | 0.0010 | ------ | ------ | 0.0020 |
| Counterbore | | | | | |
| Diameter | 5.0460 | 5.0485 | | | |
| Depth | 0.4785 | 0.4795 | | | |
| Clinder liners | | | | | |
| Outside diameter | 4.6250 | 4.6260 | | | |
| Inside diameter | 4.2495 | 4.2505 | | | |
| Flange diameter | 4.776 | 4.766 | | | |
| Clearance w/bore | ------ | ------ | 0.0005 | 0.0025 | 0.0030 |
| Out-of-round, id | ------ | 0.0010 | ------ | ------ | 0.0020 |
| Taper, id | ------ | 0.0010 | ------ | ------ | 0.0020 |
| Depth of flange below block | 0.0465 | 0.0500 | ------ | ------ | 0.0500 |
| Crankshaft | | | | | |
| Diameter of journals (main bearing) | 3.4990 | 3.5000 | | | |
| Diameter of journals (connecting rod) | 2.7490 | 2.7500 | | | |
| Journal out-of-round | ------ | 0.00025 | ------ | ------ | 0.0030 |
| Journal taper | ------ | 0.0005 | ------ | ------ | 0.0030 |
| Runout-total indicator reading (mounted #1 and #5 journals). | | | | | |
| At #2 and #4 journals | ------ | 0.0020 | ------ | ------ | 0.0020 |
| At #3 journal | ------ | 0.0040 | ------ | ------ | 0.0040 |
| Thrust washer | | | | | |
| Thickness | 0.1205 | 0.1220 | | | |
| End play | 0.0040 | 0.0110 | ------ | ------ | 0.0180 |
| Main bearings | | | | | |
| Inside diameter | 3.5020 | 3.5040 | | | |
| Bearing to journal clearance | ------ | ------ | 0.0014 | 0.0044 | 0.0060 |
| Bearing thickness 90° from parting line | 0.1545 | 0.1550 | ------ | ------ | 0.1530 |
| Pistons | | | | | |
| Diameter | | | | | |
| At top | 4.2190 | 4.2220 | | | |
| At ring lands | 4.2350 | 4.2380 | | | |
| At skirt | 4.2433 | 4.2455 | | | |
| Clearance | | | | | |
| Top of skirt | 0.0040 | 0.0072 | ------ | ------ | 0.0090 |
| Bottom of skirt | 0.0040 | 0.0072 | ------ | ------ | 0.0090 |
| Out-of-round | ------ | 0.0005 | | | |
| Taper | ------ | 0.0005 | | | |
| Ring groove width | | | | | |
| Upper compression ring | 0.1340 | 0.1360 | | | |
| 2nd compression ring | 0.1320 | 0.1340 | | | |
| 3rd and 4th compression rings | 0.1300 | 0.1320 | | | |
| Oil ring | 0.1875 | 0.1895 | | | |

Table 1-1. *Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| ENGINE: (cont'd) | | | | | |
| Piston ring bushing | | | | | |
| Outside diameter | 1.5025 | 1.5030 | | | |
| Inside diameter | 1.7540 | 1.7555 | | | |
| Piston pins | | | | | |
| Diameter | 1,4996 | 1.5000 | | | |
| Pin-to-piston bushing clearance | ------ | ------ | 0.0025 | 0.0034 | 0.0100 |
| Pin-to-rod bushing clearance | ------ | ------ | 0.0015 | 0.0024 | 0.0100 |
| Pin-to-retainer end clearance | ------ | ------ | 0.0160 | 0.0640 | 0.0640 |
| Piston rings | | | | | |
| Compression rings gap | | | | | |
| Chrome rings | 0.025 | 0.0400 | ------ | ------ | 0.0500 |
| Standard rings | 0.025 | 0.0350 | ------ | ------ | 0.0450 |
| Ring-to-groove clearance | | | | | |
| Top (No. 1) | ------ | ------ | 0.0100 | 0.0125 | 0.0220 |
| No. 2 | ------ | ------ | 0.0080 | 0.0105 | 0.0150 |
| No. 3 and No. 4 | ------ | ------ | 0.0060 | 0.0085 | 0.0130 |
| Oil rings gap | 0.0100 | 0.0200 | ------ | ------ | 0.0400 |
| Ring-to-groove clearance | ------ | ------ | 0.0015 | 0.0055 | 0.0080 |
| Connecting rods | | | | | |
| Length-center to center | 10.1240 | 10.1260 | | | |
| Lower bore diameter | 3.0620 | 3.0630 | | | |
| Upper bore diameter | 1.7490 | 1.7510 | | | |
| Upper bushing diameter | 1.5015 | 1.5020 | | | |
| Normal rod end thrust | 0.0060 | 0.0120 | | | |
| Connecting rod bearings | | | | | |
| Inside diameter | 2.7520 | 2.7540 | | | |
| Clearance | ------ | ------ | 0.0014 | 0.0044 | 0.006 |
| Thickness—90° from parting line | 0.1545 | 0.1550 | ------ | ------ | 0.1530 |
| Blower drive gear | | | | | |
| Backlash | 0.0030 | 0.0080 | ------ | ------ | 0.0080 |
| Gear-to-hub fit | 0.0050T | 0.0010L | | | |
| Blower drive gear support | | | | | |
| Bushing inside diameter | 1.6260 | 1.6250 | | | |
| Bushing-to-hub clearance | 0.0010 | 0.0025 | | | |
| Support fit in end plate | 0.0005T | 0.0025L | | | |
| Blower drive gear hub | | | | | |
| Outside diameter | 1.6240 | 1.6250 | | | |
| Hub-to-bushing clearance | 0.0010 | 0.0025 | | | |
| Hub-to-cam clearance | 0.0020 | 0.0070 | | | |
| End thrust | 0.0050 | 0.0080 | | | |
| Idler gear | | | | | |
| Backlash | ------ | ------ | 0.0030 | 0.0080 | 0.0080 |
| Inside diameter | 1.1860 | 1.1870 | | | |
| Gear fit to shaft | 0.0000L | 0.0015T | | | |
| Camshaft | | | | | |
| Diameter at bearings | | | | | |
| Front and rear | 1.4975 | 1.4970 | | | |
| Center and intermediate | 1.4985 | 1.4980 | | | |
| Runout at center bearing (when mounted on end bearings). | ------ | 0.0020 | | | |
| End thrust | 0.0040 | 0.0110 | | | |
| Thrust washer thickness | 0.1200 | 0.1220 | ------ | ------ | 0.0180 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| ENGINE: (cont'd) | | | | | |
| Camshaft (cont'd) | | | | | |
| Camshaft and balancer shaft bearings | | | | | |
| Inside diameter | | | | | |
| Front and rear | 1.5000 | 1.5010 | | | |
| Center and intermediate | 1.5010 | 1.5030 | | | |
| Clearance-bearings to shaft | | | | | |
| Front and rear | ------ | ------ | 0.0015 | 0.0030 | 0.0060 |
| Center and intermediate | ------ | ------ | 0.0025 | 0.0050 | 0.0080 |
| Outside diameter | | | | | |
| Front and rear | 2.1880 | 2.1885 | | | |
| Intermediate | 2.1840 | 2.1860 | | | |
| Diameter of block bore | 2.1875 | 2.1885 | | | |
| Clearance-bearings to block | | | | | |
| Front and rear | 0.0010T | 0.0005L | | | |
| Intermediate | 0.0015L | 0.0045T | | | |
| Balancer shaft | | | | | |
| Outside diameter | 1.4970 | 1.4975 | | | |
| Clearance-shaft to bearings | ------ | ------ | 0.0025 | 0.0050 | 0.0080 |
| End thrust | 0.0040 | 0.0110 | ------ | ------ | 0.0180 |
| Thrust washer thickness | 0.1200 | 0.1220 | | | |
| Cylinder head | | | | | |
| Cam follower bore | 1.0620 | 1.0630 | | | |
| Exhaust valve seat insert counterbore | | | | | |
| Diameter | 1.6260 | 1.6270 | | | |
| Depth | 0.3750 | 0.3800 | | | |
| Valve seat inserts | | | | | |
| Exhaust valve seat angle | 30° | 30° | ------ | ------ | 30° |
| Exhaust valve seat width | 0.0625 | 0.9375 | ------ | ------ | 0.9375 |
| Valve seat runout | ------ | 0.0020 | ------ | ------ | 0.0020 |
| Diameter of seat counterbore in head | 1.6260 | 1.6270 | | | |
| Depth of seat counterbore in head | 0.3750 | 0.3800 | | | |
| Valve head to cylinder head | 0.0050 below | 0.0170 above | ------ | ------ | 0.0400 below |
| Exhaust valves | | | | | |
| Diameter of head | 1.5690 | 1.5590 | | | |
| Stem diameter | 0.3415 | 0.3425 | | | |
| Valve clearance (hot) | ------ | ------ | 0.0090 | 0.0090 | 0.0090 |
| Valve guides | | | | | |
| Height above cylinder head | 1.5937 | 1.5937 | | | |
| Inside diameter | 0.3445 | 0.3445 | | | |
| Clearance-stem to guide | ------ | ------ | 0.0020 | 0.0040 | 0.0050 |
| Rocker arms and shafts | | | | | |
| Shaft diameter | 0.8735 | 0.8740 | | | |
| Bushing inside diameter | 0.8750 | 0.8760 | | | |
| Clearance-shaft to bushing | ------ | ------ | 0.0010 | 0.0025 | |
| Rocker arm outer bushing inside diameter | 0.5640 | 0.5650 | | | |
| Rocker arm inner bushing outside diameter | 0.5620 | 0.5625 | | | |
| Clearance-outer to inner bushing | 0.0015 | 0.0030 | | | |
| Rocker arm inner bushing inside diameter | 0.4375 | 0.4385 | | | |
| Push rod clevis pin outside diameter | 0.4380 | 0.4385 | | | |
| Clearance-pin to bushing | ------ | ------ | 0.0010T | 0.0005L | |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| ENGINE: (cont'd) | | | | | |
| Rocker arms, and shafts (cont'd) | | | | | |
| Push rod clevis pin inside diameter | 0.4370 | 0.4385 | | | |
| Clearance-pin to clevis | ------ | ------ | 0.0015T | 0.005L | |
| End play-clevis to rocker arm | 0.0070 | 0.0130 | | | |
| Cam followers | | | | | |
| Diameter | 1.0600 | 1.0610 | | | |
| Bore diameter in head | 0.0620 | 0.0630 | | | |
| Clearance-follower to head | ------ | ------ | 0.0010 | 0.0030 | |
| Width of roller slot | 0.5635 | 0.5640 | | | |
| Roller pin hole diameter | 0.4362 | 0.4370 | | | |
| Cam follower rollers and pins | | | | | |
| Roller outside diameter | 0.9050 | 0.9070 | | | |
| Roller bushing inside diameter | 0.4385 | 0.4390 | | | |
| Roller pin outside diameter | 0.4375 | 0.4377 | | | |
| Clearance-pin to bushing | ------ | ------ | 0.0008 | 0.0015 | |
| Bushing to roller fit | ------ | ------ | 0.0025 | 0.0040 | |
| End play-follower in roller | 0.0145 | 0.0180 | | | |
| TRANSMISSION: | | | | | |
| Coupling flange, outside diameter | 1.2460 | 1.2490 | ------ | ------ | 0.0100 |
| Split bushing, universal joint, inside diameter | 1.2510 | 1.2555 | ------ | ------ | 0.0100 |
| Spacer, casting, Inside diameter | 3.2520 | 3.2560 | ------ | ------ | 0.0025 |
| Collar, oil seal drive shaft | | | | | |
| Outside diameter | 3.2450 | 3.2455 | ------ | ------ | 0.0025 |
| Inside diameter | 2.7554 | 2.7574 | | | |
| Collar, oil seal, drive shaft | | | | | |
| Outside diameter | 3.1200 | 3.1300 | ------ | ------ | 0.0025 |
| Inside diameter | 1.9686 | 1.9696 | | | |
| Spacer, bearing output shaft, lower transmission | | | | | |
| Outside diameter | 2.8700 | 2.8800 | ------ | ------ | 0.0025 |
| Inside diameter | 1.9970 | 1.9980 | | | |
| Collar, shifter, lower transmission, backlash | 0.0020 | 0.0040 | ------ | ------ | 0.0080 |
| Gear, shifter, lower transmission | | | | | |
| Inside diameter | 3.3000 | 3.3150 | | | |
| Backlash | 0.0010 | 0.0030 | ------ | ------ | 0.0080 |
| Spacer, lower transmission | | | | | |
| Thickness | 0.4040 | 0.4080 | ------ | ------ | 0.0025 |
| Gear, shifter, lower transmission | | | | | |
| Backlash | 0.0010 | 0.0020 | ------ | ------ | 0.0080 |
| Gear, shifter, lower transmission | | | | | |
| Inside diameter | 5.8000 | 5.8100 | ------ | ------ | 0.0080 |
| Backlash | 0.0020 | 0.0040 | ------ | ------ | 0.0080 |
| Gear, drive lower transmission | | | | | |
| Backlash | 0.0040 | 0.0080 | ------ | ------ | 0.0150 |
| Spacer, drive gear lower transmission | | | | | |
| Thickness | 0.4800 | 0.4840 | ------ | ------ | 0.0100 |
| Gear, driven, lower transmission | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0150 |
| Gear, drive, lower transmission | | | | | |
| Backlash | 0.0040 | 0.0080 | ------ | ------ | 0.0150 |
| Spacer, shifter gears, lower transmission | | | | | |
| Thickness | 0.5020 | 0.5040 | ------ | ------ | 0.0050 |
| Ring, setting, final drive | | | | | |
| Thickness | 0.6230 | 0.6270 | ------ | ------ | 0.0050 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| TRANSMISSION: (cont'd) | | | | | |
| Gear bevel, final drive | | | | | |
| Backlash | 0.0030 | 0.0090 | ------ | ------ | 0.0200 |
| Ball, shifter lever | | | | | |
| Spherical dia. | 2.7900 | 2.6200 | ------ | ------ | 0.0100 |
| Gear, lower shaft, lower transmission | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0200 |
| Gear, upper shaft driven, high, upper transmission | | | | | |
| Backlash | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Gear, lower shaft driven, high, upper transmission | | | | | |
| Backlash | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Gear, upper shaft driven, low, upper transmission | | | | | |
| Backlash | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Gear, lower shaft driven, low, upper transmission | | | | | |
| Backlash | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Gear, lower shaft driven, reverse, upper transmission | | | | | |
| Backlash | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Gear, idler, reverse, upper transmission | 0.0088 | 0.0159 | ------ | ------ | 0.0200 |
| Spacer upper shaft driver gear | | | | | |
| Thickness | 0.1555 | 0.1585 | ------ | ------ | 0.0100 |
| Washer, gear | | | | | |
| Thickness | 0.1555 | 0.1585 | ------ | ------ | 0.0100 |
| Gear, shifter, upper transmission | | | | | |
| Backlash | 0.0010 | 0.0030 | ------ | ------ | 0.0080 |
| Spacer, reverse idler gear, upper transmission | | | | | |
| Thickness | 0.2500 | 0.2535 | ------ | ------ | 0.0080 |
| Shaft, idler gear | | | | | |
| Outside diameter | 1.7487 | 1.7495 | ------ | ------ | 0.0100 |
| Washer, reverse gears | | | | | |
| Thickness | 0.2600 | 0.2700 | ------ | ------ | 0.0080 |
| Spacer, shifter gear and bearing | | | | | |
| Thickness | 0.3750 | 0.3750 | ------ | ------ | 0.0025 |
| Gear, driver, upper shaft, reverse, upper transmission | | | | | |
| Backlash | 0.00801 | 0.01468 | ------ | ------ | 0.0080 |
| Gear, driven, lower transmission | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0200 |
| Gear, driver, lower transmission | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0200 |
| Fork, shifter, upper front | 0.4225 | 0.4275 | ------ | ------ | 0.0050 |
| Fork, shifter, upper rear width of fork | 0.4225 | 0.4275 | ------ | ------ | 0.0050 |
| Gear, bevel | | | | | |
| Backlash | 0.0117 | 0.0184 | ------ | ------ | 0.0200 |
| Gear, Pinion Shaft | | | | | |
| Backlash | 0.0117 | 0.0184 | ------ | ------ | 0.0200 |
| Drum, parking brake | | | | | |
| Inside diameter | 11.999 | 12.005 | ------ | ------ | 0.040 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| FINAL DRIVE: | | | | | |
| Bushing, axle outer carrier | | | | | |
| Inside diameter | 6.862 | 6.872 | ------ | ------ | 0.020 |
| Bushing, axle inner carrier | | | | | |
| Inside diameter | 5.411 | 5.420 | ------ | ------ | 0.020 |
| FRONT AXLE: | | | | | |
| Bushing, lower spindle fork | | | | | |
| Inside diameter | 1.8750 | 1.8770 | ------ | ------ | 0.0080 |
| Bushing, upper spindle fork | 1.3745 | 1.3765 | ------ | ------ | 0.0080 |
| Spacer, wheel bearing | | | | | |
| Inside diameter | 2.5020 | 2.5080 | ------ | ------ | 0.0050 |
| Bearing, lower spindle fork | | | | | |
| Inside diameter | 2.3120 | 3.2140 | ------ | ------ | 0.0050 |
| Bushing, spindle | | | | | |
| Inside diameter | 1.9985 | 2.0005 | ------ | ------ | 0.0050 |
| Bushing, drag link | | | | | |
| Inside diameter | 0.9950 | 0.9970 | ------ | ------ | 0.0050 |
| Block, swivel drag link | | | | | |
| Inside diameter | 1.1920 | 1.1940 | ------ | ------ | 0.0050 |
| Bushing, bronze, front lean wheel housing | | | | | |
| Inside diameter | 2.3770 | 2.3825 | ------ | ------ | 0.0100 |
| Bushing, bronze, front lean wheel housing cover | | | | | |
| Inside diameter | 1.8770 | 1.8815 | ------ | ------ | 0.0100 |
| Bearing, worm, thrust, lean wheel housing | | | | | |
| Inside diameter | 1.1875 | 1.1895 | ------ | ------ | 0.0050 |
| Bearing, thrust, worm shaft, front lean wheel housing | | | | | |
| Thickness | 0.5000 | 0.5010 | ------ | ------ | 0.0050 |
| Bushing, bolster pin, front axle | | | | | |
| Inside diameter | 2.0050 | 2.0090 | ------ | ------ | 0.0100 |
| Pin, vibrating bar to spindle | | | | | |
| Outside diameter | 1.2480 | 1.2500 | ------ | ------ | 0.0050 |
| Pin, vibrating bar to axle | | | | | |
| Outside diameter | 1.7460 | 1.7500 | ------ | ------ | 0.0100 |
| Tie rod end ball | | | | | |
| Spherical diameter | 2.8790 | 2.8830 | ------ | ------ | 0.0080 |
| Pinion, front lean wheel housing, with rack | | | | | |
| Backlash | 0.0020 | 0.0020 | ------ | ------ | 0.0080 |
| Ball, steering socket | | | | | |
| Spherical diameter | 3.6905 | 3.6945 | ------ | ------ | 0.0100 |
| WHEELS AND BRAKES: | | | | | |
| Drum, brake | | | | | |
| Inside diameter | 17.250 | 17.260 | ------ | ------ | 0.040 |
| DRAWBAR AND CIRCLE: | | | | | |
| Cap, socket, lateral shift link | | | | | |
| Sperical radius | 1.4395 | 1.4415 | ------ | ------ | 0.0200 |
| Shaft, reverse and gear | | | | | |
| Outside diameter | 2.4980 | 2.5000 | ------ | ------ | 0.0100 |
| Bushing, bronze, gear shaft | | | | | |
| Inside diameter | 2.5020 | 2.5075 | ------ | ------ | 0.0100 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches Minimum | Manufacturer's dimensions and tolerances in inches Maximum | Desired clearance Minimum | Desired clearance Maximum | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| DRAWBAR AND CIRCLE: (cont'd) | | | | | |
| Bushing, bronze, worm shaft | | | | | |
| Inside diameter | 1.5050 | 1.7520 | ------ | ------ | 0.0100 |
| Bushing, worm | | | | | |
| Inside diameter | 1.6805 | 1.7055 | ------ | ------ | 0.0100 |
| Bushing, worm thrust | | | | | |
| Inside diameter | 1.6805 | 1.7005 | ------ | ------ | 0.0100 |
| Shaft, worm gear, splined | | | | | |
| Outside diameter | 1.5000 | 1.5020 | ------ | ------ | 0.0100 |
| Bushing, bronze transfer housing gear shaft | 1.5010 | 1.5055 | ------ | ------ | 0.0100 |
| Gear, w/shaft transfer | | | | | |
| Outside diameter | 1.4960 | 1.4980 | ------ | ------ | 0.0200 |
| Backlash | 0.0100 | 0.0150 | | | |
| Clearance, gear thrust fact to bushing | 0.0600 | 0.0600 | | | |
| Gear, w/shaft, transfer drive | | | | | |
| Outside diameter | 1.4960 | 1.4980 | ------ | ------ | 0.0200 |
| Backlash | 0.0100 | 0.0150 | | | |
| Clearance, gear thrust face to bushing | 0.0600 | 0.0600 | | | |
| Cap, socket, lift link | | | | | |
| Spherical radius | 1.4405 | 1.4505 | ------ | ------ | 0.0100 |
| SCARIFIER: | | | | | |
| Bushing, bronze, pinion shaft, housing | | | | | |
| Inside diameter | 1.0010 | 1.0055 | ------ | ------ | 0.0100 |
| Bushing, bronze, pinion shaft, housing cover | | | | | |
| Inside diameter | 1.0010 | 1.0055 | ------ | ------ | 0.0100 |
| Shaft, w/pinion, reduction gear housing | | | | | |
| Outside diameter | 0.998 | 1.0000 | ------ | ------ | 0.0050 |
| Backlash | 0.0030 | 0.0100 | ------ | ------ | 0.0100 |
| Gear, spur, reduction housing | | | | | |
| Backlash | 0.0030 | 0.0100 | ------ | ------ | 0.0100 |
| Bushing, bronze, worm shaft | | | | | |
| Inside diameter | 1.5020 | 1.5040 | ------ | ------ | 0.0050 |
| Bearing, worm thrust | | | | | |
| Outside diameter | 3.4815 | 3.4835 | ------ | ------ | 0.010 |
| Groove diameter | 3.1150 | 3.1260 | ------ | ------ | 0.0050 |
| Inside diameter | 1.6855 | 1.6915 | ------ | ------ | 0.0050 |
| Shaft, worm gear | 1.5000 | 1.5020 | ------ | ------ | 0.0050 |
| Bushing, bronze, scarifier shaft | | | | | |
| Inside diameter | 3.4990 | 3.5045 | ------ | ------ | 0.0100 |
| Shaft, scarifier lift housing | | | | | |
| Outside diameter | 3.4950 | 3.4970 | ------ | ------ | 0.020 |
| Arm, lift, ball | | | | | |
| Spherical diameter | 2.8690 | 2.8740 | ------ | ------ | 0.0200 |
| Cap, lift link, upper | | | | | |
| Spherical radius | 1.4405 | 1.4505 | ------ | ------ | 0.0200 |
| Cap, lift link, lower | | | | | |
| Spherical radius | 1.1592 | 1.1692 | ------ | ------ | 0.0200 |
| POWER CONTROL BOX: | | | | | |
| Cap, lever | | | | | |
| Spherical diameter | 1.7510 | 1.7550 | ------ | ------ | 0.0100 |
| Clearance-lever cap and seal cap | 0.0050 | 0.0620 | ------ | ------ | 0.0100 |
| Ball, lever | | | | | |
| Spherical diameter | 1.7480 | 1.7520 | ------ | ------ | 0.0100 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| POWER CONTROL BOX: (cont'd) | | | | | |
| Seat, lever ball | | | | | |
| Spherical radius | 0.8755 | 0.8775 | ------ | ------ | 0.0100 |
| Ball, fulcrum | | | | | |
| Spherical diameter | 1.7450 | 1.7500 | ------ | ------ | 0.0100 |
| Lever, power box | | | | | |
| Spherical diameter | 0.6130 | 0.6230 | | | |
| Race, outer, outlet bevel gear shaft bearings | | | | | |
| Inside diameter | 1.6240 | 1.6250 | ------ | ------ | 0.0080 |
| Washer, thrust, bevel gear shaft | | | | | |
| Thickness | 0.1230 | 0.1250 | ------ | ------ | 0.0050 |
| Washers thrust, clutch shaft | | | | | |
| Thickness | 0.1230 | 0.1250 | ------ | ------ | 0.0050 |
| Ring, spacer, bevel gear shaft | | | | | |
| Thickness | 0.2490 | 0.2510 | ------ | ------ | 0.0050 |
| Seat ball | | | | | |
| Gear, power box clutch | | | | | |
| Backlash | 0.0100 | 0.0150 | ------ | ------ | 0.0200 |
| Clutch, power box | | | | | |
| Backlash | 0.3070 | 0.3150 | ------ | ------ | 0.0200 |
| Rail, shifter | | | | | |
| Outside diameter | 0.7470 | 0.7500 | ------ | ------ | 0.0080 |
| Fork, shifter power box | | | | | |
| Free play | 0.0050 | 0.0100 | ------ | ------ | 0.0150 |
| Gear, spiral bevel, vertical drive | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0200 |
| Gear, spiral pinion, vertical drive | | | | | |
| Backlash | 0.0050 | 0.0090 | ------ | ------ | 0.0200 |
| Shaft, outlet | | | | | |
| Outside diameter | 0.9990 | 0.9900 | ------ | ------ | 0.0150 |
| Gear, bevel, drive, power box front | | | | | |
| Backlash | 0.0050 | 0.0075 | ------ | ------ | 0.0200 |
| Gear, bevel drive power box rear | | | | | |
| Backlash | 0.0040 | 0.0075 | ------ | ------ | 0.0200 |
| Drum brake | | | | | |
| Outside diameter | 3.1050 | 3.1090 | ------ | ------ | 0.0150 |
| LIFT GEAR HOUSING: | | | | | |
| Bearing, worm shaft, | | | | | |
| Inside diameter | 1.5006 | 1.5035 | ------ | ------ | 0.0080 |
| Cap, bearing, worm shaft | | | | | |
| Inside diameter | 1.8270 | 1.8290 | ------ | ------ | 0.0080 |
| Shaft, worm | | | | | |
| Outside diameter | 1.5000 | 1.5020 | ------ | ------ | 0.0080 |
| Gear, spiral | | | | | |
| Pitch diameter | 5.2810 | 5.2860 | ------ | ------ | 0.0100 |
| Bushing, bronze lift shaft | | | | | |
| Inside diameter | 3.0010 | 3.0010 | ------ | ------ | 0.0100 |
| Shaft, lift | | | | | |
| Outside diameter | 2.4980 | 2.5000 | ------ | ------ | 0.0100 |
| Bushing, bronze, housing cover | | | | | |
| Inside diameter | 2.5020 | 2.5075 | ------ | ------ | 0.0150 |
| Bushing, reduction housing | | | | | |
| Inside diameter | 1.5050 | 1.5050 | ------ | ------ | 0.0100 |

*Table 1-1. Repair and Replacement Standards*—Continued

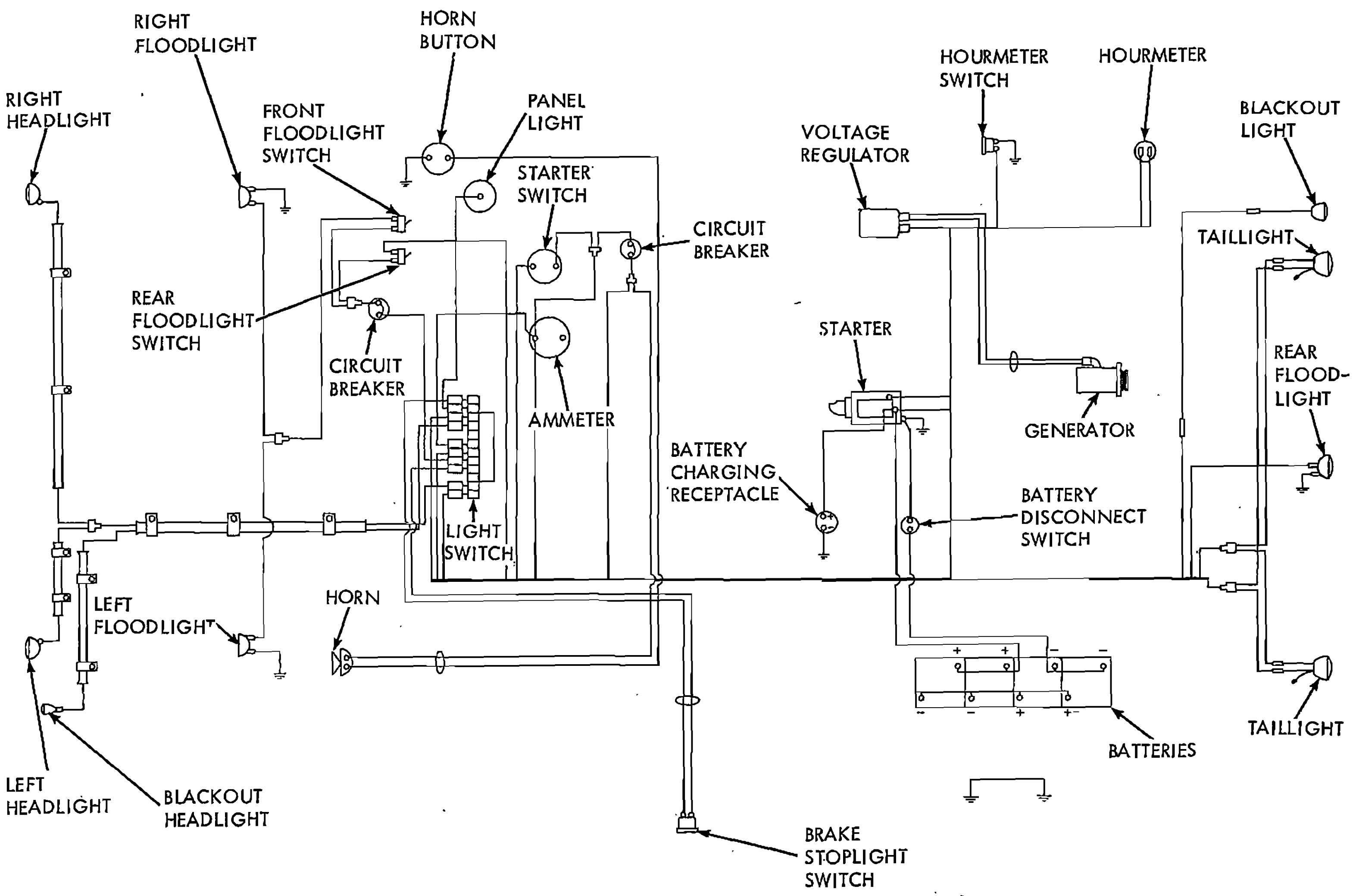
| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| LIFT GEAR HOUSING: (cont'd) | | | | | |
| Bearing, thrust reduction housing worm shaft | | | | | |
| Inside diameter | 1.1240 | 1.1260 | ------ | ------ | 0.0100 |
| Bushing, thrust bearing | | | | | |
| Inside diameter | 1.0010 | 1.0055 | ------ | ------ | 0.0100 |
| Bearing, thrust, lift housing worm shaft | | | | | |
| Inside diameter | 1.6895 | 1.6915 | ------ | ------ | 0.0100 |
| Bushing, thrust bearing | | | | | |
| Inside diameter | 1.5040 | 1.5085 | ------ | ------ | 0.0100 |
| Arm, lifting | | | | | |
| Spherical diameter | 2.8710 | 2.8770 | ------ | ------ | 0.0150 |
| LATERAL SHIFT HOUSING: | | | | | |
| Bushing, bronze, shift housing | | | | | |
| Inside diameter | 3.4490 | 3.5045 | ------ | ------ | 0.0150 |
| Shaft, lateral shift | | | | | |
| Outside diameter | 2.4980 | 2.5020 | ------ | ------ | 0.0100 |
| Gear, lateral shift | | | | | |
| Pitch diameter | 12.0000 | 12.0000 | | | |
| Bushing, bronze, reduction housing thrust bearing | | | | | |
| Inside diameter | 1.0010 | 1.0055 | ------ | ------ | 0.0100 |
| Bearing, thrust reduction housing | 1.1240 | 1.1260 | ------ | ------ | 0.0100 |
| Bushing, bronze, lateral shift housing thrust bearing | | | | | |
| Inside diameter | 1.5040 | 1.5085 | ------ | ------ | 0.0100 |
| Bearing, thrust, lateral shift housing | | | | | |
| Inside diameter | 1.6895 | 1.6915 | ------ | ------ | 0.0100 |
| Bearing, thrust worm lateral shift housing | | | | | |
| Inside diameter | 1.5035 | 1.5050 | ------ | ------ | 0.0100 |
| Cap bearing reduction housing | | | | | |
| Inside diameter | 1.8270 | 1.8290 | ------ | ------ | 0.0080 |
| Bushing, bronze, lateral shift housing cover | | | | | |
| Inside diameter | 2.5020 | 2.5075 | ------ | ------ | 0.010 |
| Arm, lateral shift | | | | | |
| Spherical diameter | 2.8710 | 2.8770 | ------ | ------ | 0.0150 |
| FRAME GROUP: | | | | | |
| Pin, bolster | | | | | |
| Outside diameter | 1.9960 | 2.0000 | ------ | ------ | 0.0080 |
| Cap, bearing, drawbar | | | | | |
| Spherical radius | 2.2535 | 2.2552 | ------ | ------ | 0.0250 |
| Ball, drawbar | | | | | |
| Spherical diameter | 4.4950 | 4.5000 | ------ | ------ | 0.0250 |
| Cap, axle | | | | | |
| Inside diameter | 1.4395 | 1.4415 | ------ | ------ | 0.0080 |
| CLUTCH: | | | | | |
| Spring length | 3.3125 | | | | |
| Spring test | 2.1250 | | | | |
| Spring-pounds pressure | 130 | 140 | | | |
| Pedal free travel | 2.0000 | 2.0000 | | | |
| Drum, brake | | | | | |
| Outside diameter | 6.120 | 6.130 | ------ | ------ | 0.040 |
| Bushing, clutch operating shaft | | | | | |
| Inside diameter | 1.3795 | 1.376 | ------ | ------ | 0.0100 |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| CLUTCH: (cond's) | | | | | |
| Pressure plate, clutch | | | | | |
| Overall thickness | | | | | Replace if worn or grooved |
| Disk, clutch | | | | | |
| Overall thickness | .469 | .479 | ------ | ------ | 0.010 |
| HYDRAULIC PUMP: | | | | | |
| Gear, driven | | | | | |
| Backlash | 0.0030 | 0.0060 | ------ | ------ | 0.0100 |
| Cover, wear plate | | | | | |
| Thickness | 0.116 | 0.118 | ------ | ------ | 0.113 |
| Gear housing bore | | | | | |
| Inside diameter | | | | | Replace if worn or grooved |
| Valve plunger to housing | | | | | |
| Clearance | | | | | Replace if worn or grooved |
| HYDRAULIC SYSTEM: | | | | | |
| Rotary portion to valve body clearance | 2.3730 | 2.3740 | ------ | ------ | 0.018 |
| Piston rod | | | | | |
| Outside diameter | 1.997 | 2.000 | ------ | ------ | .0005 |
| Bushing | | | | | |
| Inside diameter | 2.002 | 2.005 | ------ | ------ | .0003 |
| POWER STEERING: | | | | | |
| Bushing, output shaft | | | | | |
| Inside diameter | 2.0010 | 2.0055 | ------ | ------ | 0.0050 |
| Bearing, self-alineing, output shaft | | | | | |
| Inside diameter | 2.8710 | 2.8740 | ------ | ------ | 0.0150 |
| Cap, bearing | | | | | |
| Spherical radius | 1.4365 | 1.4415 | ------ | ------ | 0.0200 |
| Bearing, power steering housing | | | | | |
| Inside diameter | 2.2375 | 2.2380 | ------ | ------ | 0.0100 |
| Ring, quad, housing | | | | | |
| Inside diameter | 2.3490 | 2.3690 | ------ | ------ | 0.0200 |
| STARTER: | | | | | |
| Brush length | 0.7500 | 0.7600 | ------ | ------ | 0.3750 |
| Brush spring tension | 2.25 lb | 2.50 lb | | | |
| Commutator end thrust washer | | | | | |
| Thickness | 0.0570 | 0.0670 | | | |
| Drive end spacer | | | | | |
| Thickness | 0.1800 | 0.1960 | | | |
| Armature end play | ------ | ------ | ------ | ------ | 0.0700 |
| Lever shaft | | | | | |
| Diameter | 0.4980 | 0.5000 | | | |
| Bore | 0.5100 | 0.5120 | | | |
| Fit in shift lever | 0.0100L | 0.0140L | | | |
| Solenoid spring | | | | | |
| Free length | 2.7920 | 2.7920 | | | |
| Solid length | 0.6510 | 0.6510 | | | |
| Load at 1.56 inches length | 13.50 lb | 14.50 lb | | | |
| Commutator end plate sleeve bearing | | | | | |
| Inside diameter | 0.6860 | 0.6880 | | | |
| Outside diameter | 0.8800 | 0.8820 | | | |
| Fit in end plate | 0.0050T | 0.0080T | | | |

*Table 1-1. Repair and Replacement Standards*—Continued

| Component | Manufacturer's dimensions and tolerances in inches | | Desired clearance | | Maximum allowable wear and clearance |
|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | |
| STARTER: (cont'd) | | | | | |
| Lever housing sleeve bearing | | | | | |
| Inside diameter | 0.8335 | 0.8355 | | | |
| Outside diameter | 0.9630 | 0.9650 | | | |
| Fit in housing | 0.0095L | 0.0130L | | | |
| Drive housing sleeve bearing | | | | | |
| Inside diameter | 0.6240 | 0.6260 | | | |
| Outside diameter | 0.7550 | 0.7570 | | | |
| Fit in housing | 0.0050T | 0.0080T | | | |
| Armature shaft | | | | | |
| Diameter at commutator end | 0.6835 | 0.6845 | | | |
| Diameter at drive end | 0.8225 | 0.8240 | | | |
| Fit of shaft in commutator end plate bearing | 0.0015L | 0.0045L | | | |
| Fit of shaft in drive housing bearing | 0.0010L | 0.0040L | | | |
| Fit of shaft in lever housing bearing | 0.0095L | 0.0130L | | | |
| Commutator end plate bore | 0.8740 | 0.8750 | | | |
| Lever housing bore | 0.9570 | 0.9580 | | | |
| Drive housing bore | 0.7490 | 0.7570 | | | |
| Commutator | | | | | |
| Diameter | 2.3080 | 2.3180 | | | |
| Turned diameter | 2.1930 | | | | |
| Eccentricity (total indicator reading) | ------ | ------ | ------ | ------ | 0.0200 |




MEC 3805-237-35/1-1

*Figure 1-1. Wiring diagram.*

# CHAPTER 2

# GENERAL MAINTENANCE INSTRUCTIONS

## Section I. SPECIAL TOOLS AND EQUIPMENT

### 2-1. Special Tools and Equipment

The special tools and equipment supplied by the manufacturer to perform direct and general support and depot maintenance on the motor grader are listed in Table 2-1. References and illustrations indicating the use of these tools are listed in the table. No special equipment is required by direct and general support and depot maintenance personnel for performing maintenance on the motor grader.

*Table 2-1. Special Tools*

| Item | FSN or Part No. | Reference | | Use |
|---|---|---|---|---|
| | | Figure | Paragraph | |
| Lifter, injector | (35311) 724695 | 2-1 | 12-17 | Lifting injectors from head |

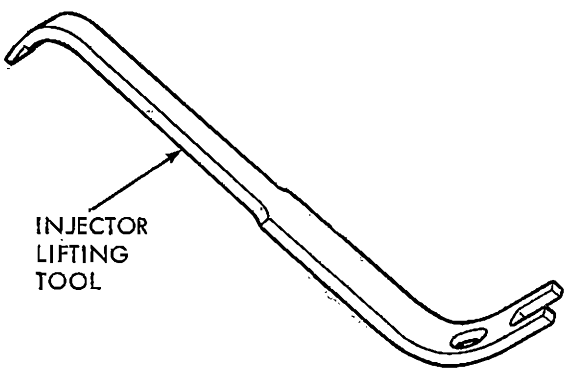



*Figure 2-1. Injector lifting tool.*

### 2-2. Specially Designed Tools and Equipment

The specially designed tools and equipment illustrated in figure 2-2 and listed in Table 2-2 are for direct and general support and depot maintenance performing major overhaul work on the motor grader. Tools and equipment listed in Table 2-2 are not available for issue, but must be fabricated by qualified direct and general support and depot maintenance personnel.

*Table 2-2. Specially Designed Tools and Equipment*

| Item | Reference | | Use |
|---|---|---|---|
| | Figure | Paragraph | |
| Retaining ring tool | 2-2 | 3-13<br>3-16 | Install bearing retaining rings on transmission shaft. |

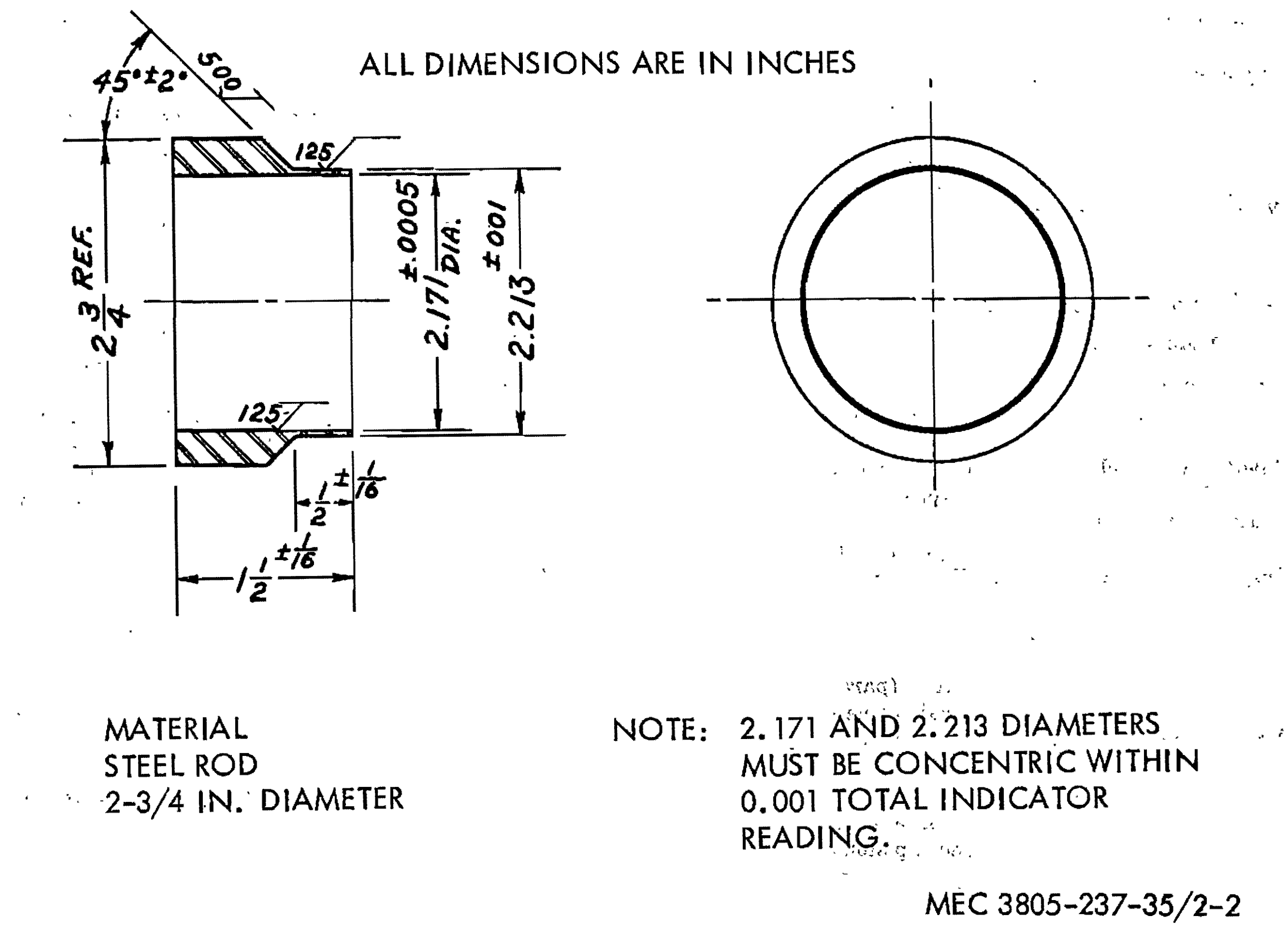



*Figure 2-2. Transmission bearing retaining ring tool.*

## Section II. TROUBLESHOOTING

### 2-3. General

This section provides information useful in diagnosing and correcting unsatisfactory operation or failure of the motor grader or any of its components. Each trouble symptom stated is followed by a list of probable causes. The possible remedy recommended is described opposite the probable cause.

### 2-4. Engine Fails to Start

| Probable cause | Possible remedy |
|---|---|
| Low starting rpm | Defective starter. Replace starter (TM 5-3805-237-12). |
| | Improper oil viscosity. Change oil to proper grade. |
| | Internal seizure. Check engine and repair. |

### 2-5. Engine Misses or Operates Erratically

| Probable cause | Possible remedy |
|---|---|
| Engine timing not adjusted properly | Adjust timing. (para 12-37). |
| Blower not supplying sufficient air | Check blower and repair (para 12-6). |

| Probable cause | Possible remedy |
|---|---|
| Fuel system not operating properly | Check fuel system and repair (para 12-13). |
| Injectors defective | Repair or replace injectors (para 12-17). |
| Low compression | Check for faulty valves and repair or replace valves (para 12-33). |
| Worn or broken piston rings | Repair or replace piston rings (para 12-43). |

## 2-6. Engine Lacks Power

| Probable cause | Possible remedy |
|---|---|
| Improper adjustment and timing | Adjust and time engine (para 12-37). |
| Insufficient fuel | Check fuel system and repair (para 12-13). |
| Lack of sufficient air | Check and repair blower (para 12-6). |
| Improper detonation | Check for oil in air stream (para 12-6), faulty injectors (para 12-17), and low coolant temperature (para 12-9). Repair as necessary. |
| Valve guide worn | Replace valve guide (para 12-33). |
| Valve springs weak or broken | Replace valve springs (para 12-33). |
| Low cylinder compression | Check pistons and rings and repair (para 12-43). |

## 2-7. Engine Overspeeds

| Probable cause | Possible remedy |
|---|---|
| Governor not adjusted properly | Adjust governor (para 12-51). |
| Fuel system not operating properly | Check and repair fuel systems (para 12-13). |
| Oil in air system | Check air system and blower and repair (para 12-3). |
| Fuel injectors not operating properly | Check injectors and repair (para 12-17). |

## 2-8. Engine Will not Idle Properly

| Probable cause | Possible remedy |
|---|---|
| Defective fuel injectors | Repair or replace injectors (para 12-17). |
| Injectors not properly timed | Time injectors (para 12-17). |
| Governor not adjusted properly | Adjust governor (para 12-51). |

## 2-9. Engine Exhaust Smokes Excessively

| Probable cause | Possible remedy |
|---|---|
| Engine running to cold for proper combustion | Check thermostat and replace (Refer to TM 5-3805-237-12). |
| Defective fuel injectors or gaskets | Repair injectors or replace gaskets (para 12-17). |
| Contaminated fuel or water in fuel | Service fuel filters (Refer to TM 5-3805-237-12). |
| Low compression | Check compression and repair engine as necssary to correct. |
| One or more cylinders not firing | Check fuel and air systems and repair engine as necessary to correct. |
| Worn or stuck piston rings or worn cylinder sleeves | Repair or replace pistons or rings (para 12-43). |
| Worn valves or valve guides | Repair or replace guides or valves (para 12-33). |
| Reduced manifold pressure | Check and replace manifold gaskets if necessary (para 12-8). |

## 2-10. Engine Knocks or is Noisy

| Probable cause | Possible remedy |
|---|---|
| Loose piston pin or pins | Repair or replace piston pins (para 12-43). |
| Worn cylinder liner or piston | Replace worn liners (para 12-46) or worn pistons (para 12-43). |
| Worn main bearings | Replace bearings as necessary (para 12-40). |
| Connecting rod bearings worn | Repair or replace worn connecting rod bearings (para 12-40). |
| Broken piston ring | Replace broken ring (para 12-40). |
| Excessive valve clearance | Adjust valve clearance (para 12-48). |
| Defective or worn valve rocker arm assembly | Replace rocker arm assembly (para 12-31). |

| Probable cause | Possible remedy |
|---|---|
| Bent valve push rod | Replace push rod (para 12-34). |
| Defective valve tappet | Replace tappet (para 12-33). |
| Worn crankshaft and camshaft gears | Replace worn gears (para 12-40). |
| Defective starter, generator, or water pump | Replace defective parts (Refer to TM 5-3805-237-12). |
| Defective blower or blower parts | Repair or replace blower (para 12-6). |

## 2-11. Excessive Oil Consumption

| Probable cause | Possible remedy |
|---|---|
| Leakage in oil system | Check oil filter and tubes for leaks and correct. |
| Gaskets or oil seals leak | Replace defective gaskets or oil seals (para 12-21). |
| Oil cooler core leaking | Check and repair oil cooler (para 12-23). |
| Oil control piston rings broken | Replace rings (para 12-43). |
| Piston pin retainer loose | Repair or replace piston pin retainer (para 12-43). |
| Crankcase liners, pistons, or oil rings scored | Repair or replace scored parts. |

## 2-12. Abnormal Engine Coolant Temperatures

| Probable cause | Possible remedy |
|---|---|
| Defective radiator | Replace radiator (Refer to TM 5-3805-237-12). |
| Poor coolant circulation | Check cooling system and correct (para 12-9). |
| Defective thermostat | Replace thermostat (Refer to TM 5-3805-237-12). |
| Defective water pump | Replace water pump (Refer to TM 5-3805-237-12). |

## 2-13. Low Oil Pressure

*Note.* Make oil pressure checks with engine at operating temperature. Coolant temperature gage should read 160° to 185°F.

| Probable cause | Possible remedy |
|---|---|
| Incorrect oil viscosity | Check lubrication order and fill with correct oil. |
| Oil filter clogged | Clean filter and change element (Refer to TM 5-3805-237-12). |
| Oil cooler clogged or valves defective | Repair or replace oil cooler (para 12-23). |
| Defective oil pressure gage or clogged lines | Clean lines or replace gage (Refer to TM 5-3805-237-12). |
| Defective oil pump | Repair or replace oil pump (para 12-25). |

## 2-14. Grader Will Not go in Motion

| Probable cause | Possible remedy |
|---|---|
| Parking brake will not release | Repair or replace parking brake (para 3-5). |
| Clutch will not engage | Check clutch pedal and clutch operation and repair or replace clutch (para 10-8). |
| Transmission inoperative | Repair or replace transmission (para 3-15). |

## 2-15. Grader Goes In Motion but does not Operate Smoothly

| Probable cause | Possible remedy |
|---|---|
| Clutch not engaging properly | Clutch pedal and linkage not properly adjusted (Refer to TM 5-3805-237-12). |
| Clutch worn or defective | Repair or replace clutch (para 10-9). |
| Defective drive shaft | Repair or replace drive shaft (Refer to TM 5-3805-237-12). |
| Defective transmission | Repair or replace transmission (para 3-15). |
| Defective final drive | Repair or replace final drive (para 4-12). |
| Defective tandem drive chain or drive | Repair or replace tandem drive (para 4-5). |

## 2-16. Grader does not Steer Properly

| Probable cause | Possible remedy |
|---|---|
| Defective steering gear | Repair or replace steering gear (para 7-19). |
| Defective hydraulic pump | Repair or replace hydraulic pump. (para 7-12). |
| Defective steering arm or tie rods | Replace steering arm or tie rods (Refer to TM 5-3805-237-12). |

| Probable cause | Possible remedy |
|---|---|
| Improper toe-in, caster or camber adjustment | Adjust caster, camber, and toe-in (Refer to TM 5-3805-237-12). |
| Defective front lean wheel gear | Repair or replace front lean wheel gear (para 5-35). |

## 2-17. Wheel Brakes do not Operate Properly

| Probable cause | Possible remedy |
|---|---|
| Brakes not properly adjusted | Adjust brakes (Refer to TM 5-3805-237-12). |
| Brake master cylinder defective | Repair or replace master cylinder (para 8-8). |
| Wheel brakes defective | Repair or replace wheel brakes (para 8-6). |

## 2-18. Parking Brake does not Hold Grader

| Probable cause | Possible remedy |
|---|---|
| Brake lever bent or jammed | Repair or replace brake lever (para 3-5). |
| Brake lining worn | Replace brake lining (para 3-6). |
| Brake drum or shoes damaged | Repair or replace parking brake drum or shoes (para 3-6). |

## 2-19. Anti-Coast Brakes do not Function Properly

| Probable cause | Possible remedy |
|---|---|
| Brake lining worn | Replace brake linings (para 6-3). |
| Brake damaged or defective | Repair or replace anti-coast brake (para 6-3). |

## 2-20. Tandem Drive Inoperative

| Probable cause | Possible remedy |
|---|---|
| Worn or broken chains or sprockets | Repair or replace chains and sprockets as necessary (para 4-5). |
| Broken drive axle | Replace drive axle (para 4-10). |

## 2-21. Moldboard does not Lift or Lower

| Probable cause | Possible remedy |
|---|---|
| Defective clutch | Repair or replace power control box (para 6-3). |
| Defective lift gear assembly | Repair or replace lift gear assembly (para 5-7). |

## 2-22. Moldboard does not Circle Properly

| Probable cause | Possible remedy |
|---|---|
| Circle binding | Check cause and repair or replace circle (para 9-6). |
| Defective circle drive pinion | Repair or replace drive pinion (para 5-21). |
| Defective circle reverse gear assembly | Repair or replace circle reverse gear assembly. (para 5-21). |
| Defective circle reverse transfer gear | Repair or replace transfer gear (para 5-21). |

## 2-23. Moldboard does not Shift Properly

| Probable cause | Possible remedy |
|---|---|
| Defective power control box | Repair or replace power control box (para 6-3). |
| Defective lateral shift gear assembly | Repair or replace lateral shift gear assembly (para 5-28). |

## 2-24. Moldboard does not Slide Properly

| Probable cause | Possible remedy |
|---|---|
| Defective hydraulic system | Repair or replace hydraulic system as necessary (para 7-23). |
| Defective moldboard cylinder | Repair or replace moldboard cylinder (para 7-23). |
| Moldboard slides damaged | Repair or replace slides (para 9-4). |
| Defective rotary valve | Repair or replace rotary valve (para 7-22). |

## 2-25. Scarifier does not Lift or Lower

| Probable cause | Possible remedy |
|---|---|
| Defective power control box | Repair or replace power control box (para 6-3). |

| Probable cause | Possible remedy |
|---|---|
| Defective scarifier lift gear assembly | Repair or replace scarifier left gear assembly (para 5-14). |

## 2-26. Clutch Brake does not Function Properly

| Probable cause | Possible remedy |
|---|---|
| Defective clutch brake | Repair or replace clutch brake (para 10-6). |
| Defective clutch assembly | Repair or replace clutch assembly (para 10-8). |
| Defective clutch and brake linkage | Repair or replace linkage (para 10-5). |

## 2-27. Electrical System does not Function Properly

| Probable cause | Possible remedy |
|---|---|
| Defective generator | Repair or replace generator (para 11-4). |
| Defective voltage regulator | Repair or replace voltage regulator (para 11-6). |
| Defective switches, circuit breakers, or other components | Replace defective components as necessary. |

## 2-28. Hydraulic System does not Function Properly

| Probable cause | Possible remedy |
|---|---|
| Defective hydraulic pump | Repair or replace hydraulic pump (para 7-12). |
| Defective drive from power control box | Repair or replace power control box (para 6-3). |

# Section III. REMOVAL AND INSTALLATION OF MAJOR COMPONENTS

## 2-29. General

*a.* Information in this section includes removal and installation of the entire drive unit, engine, clutch, power control box, and the gear assemblies.

*b.* The drive unit of the motor grader consists of the four rear wheels, tandem assemblies, final drive, transmission, clutch and engine. By disconnecting portions of the motor grader, the entire unit can be separated from the remainder of the grader for ease of access and maintenance.

*c.* After separation of the drive unit, the transmission can be removed. The clutch assembly can be removed from the engine.

*d.* The power control box and gear assemblies can be removed from the grader without interference from other components.

*e.* The transmission, final drive, and tandems will be removed and repaired in separate chapters.

## 2-30. Drive Unit

*a. Preparation.*

(1) Refer to TM 5-3805-237-12 to start engine and operate motor grader.

(2) Rotate moldboard to center line of frame and at an angle of 90° to frame.

(3) Lower moldboard to ground. Continue operating moldboard lift levers to raise front wheels of grader 10 to 12 inches above the ground.

(4) Refer to TM 5-3805-237-12 and remove the following components from the unit.

(*a*) Muffler
(*b*) Engine hood
(*c*) Radiator
(*d*) Shifter levers

(5) Refer to figure 2-3 and disconnect components prior to removing drive unit from motor grader.

(6) When rear axle caps are removed, front wheels of grader will lower to ground

*b. Removal.*

(1) Using four men, two at each front tandem wheel, roll drive unit towards rear of grader approximately one foot.

*Note.* Move drive unit carefully to clear frame with shifter housing.

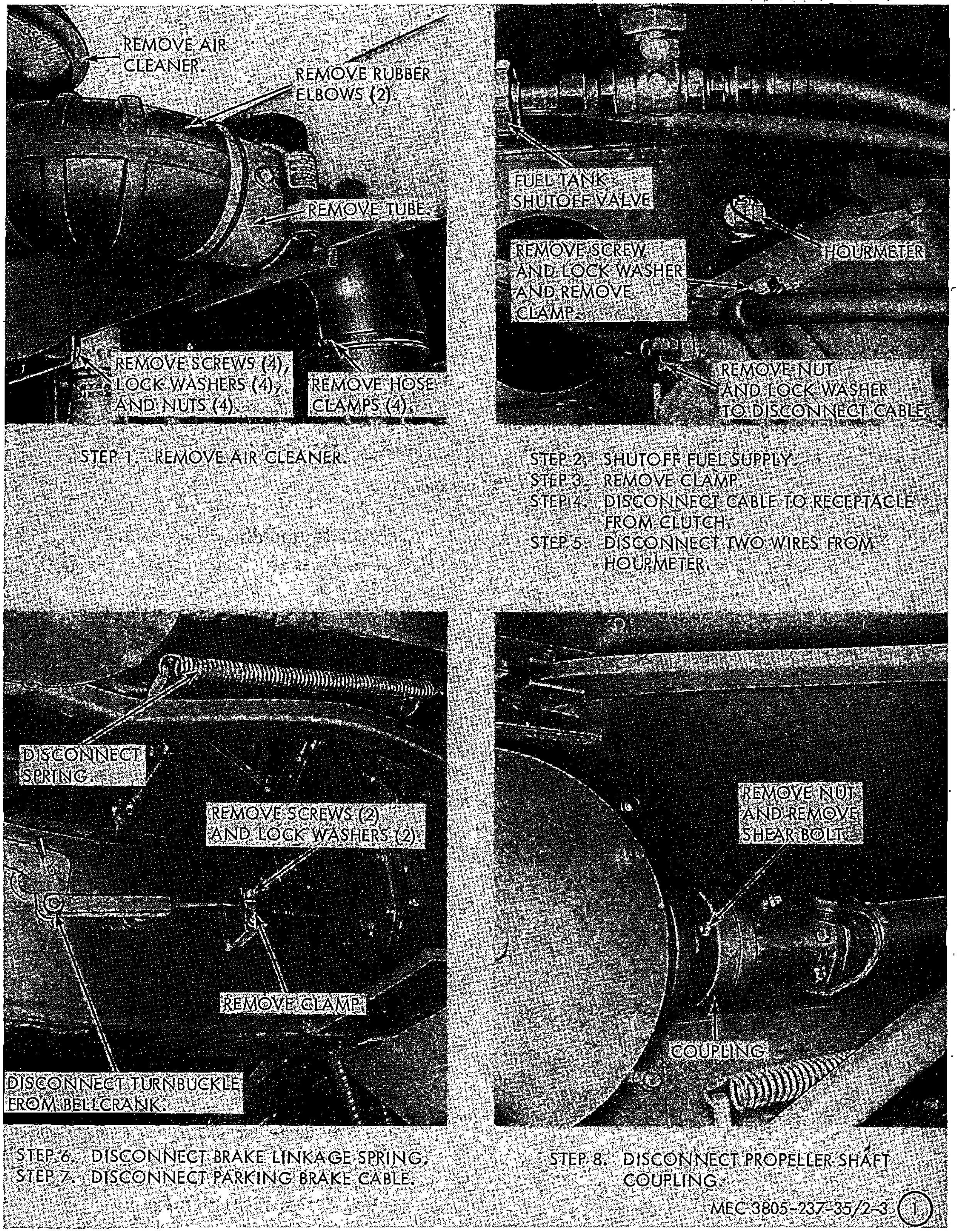
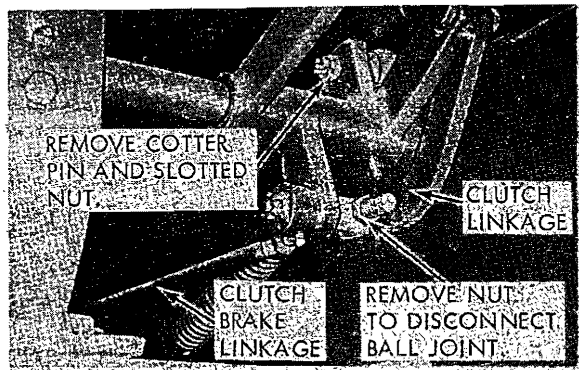
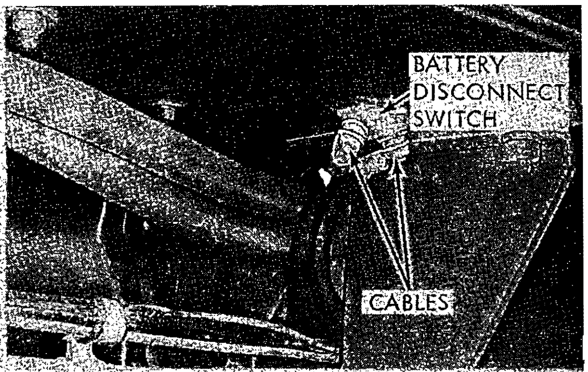


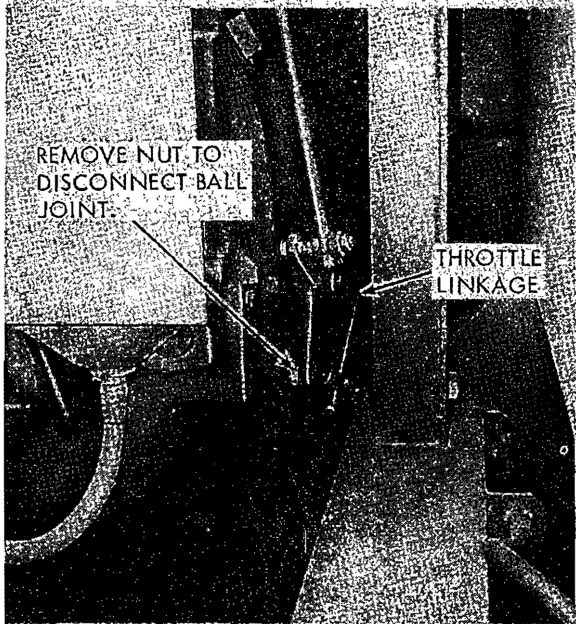

*Figure 2-3 (1). Drive unit removal and installation.*



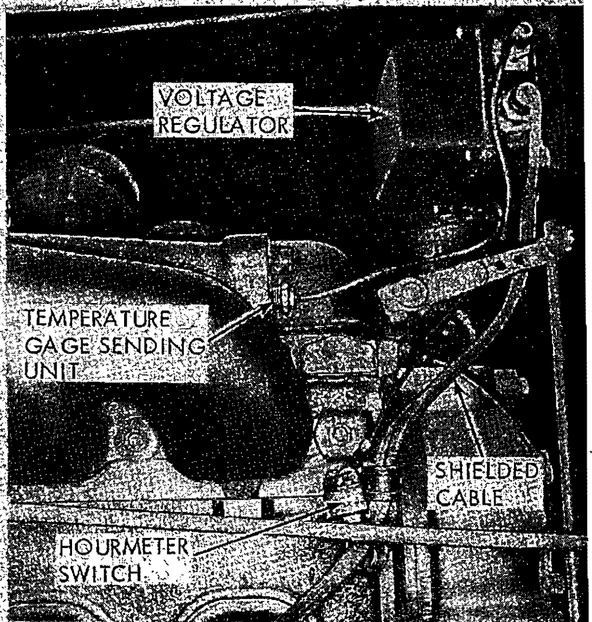

STEP 9. DISCONNECT CLUTCH BRAKE LINKAGE.
STEP 10. DISCONNECT CLUTCH LINKAGE.




STEP 11. DISCONNECT CABLES FROM BATTERY DISCONNECT SWITCH.




STEP 12. DISCONNECT THROTTLE LINKAGE FROM BELLCRANK ON FLYWHEEL HOUSING.




STEP 13. REMOVE TEMPERATURE GAGE SENDING UNIT.
STEP 14. DISCONNECT WIRES FROM HOURMETER SWITCH.
STEP 15. DISCONNECT SHIELDED CABLE FROM VOLTAGE REGULATOR.
NOTE: DO NOT PULL ON CABLE OR TWIST BRAIDED SHIELDING. GENTLY WORK CABLE FROM SIDE TO SIDE TO FREE RUBBER SEAL. DO NOT USE SHARP METAL TOOLS TO INSTALL RUBBER SEALS.

MEC 3805-237-35/2-3 (2)

*Figure 2-3 (2)*—Continued

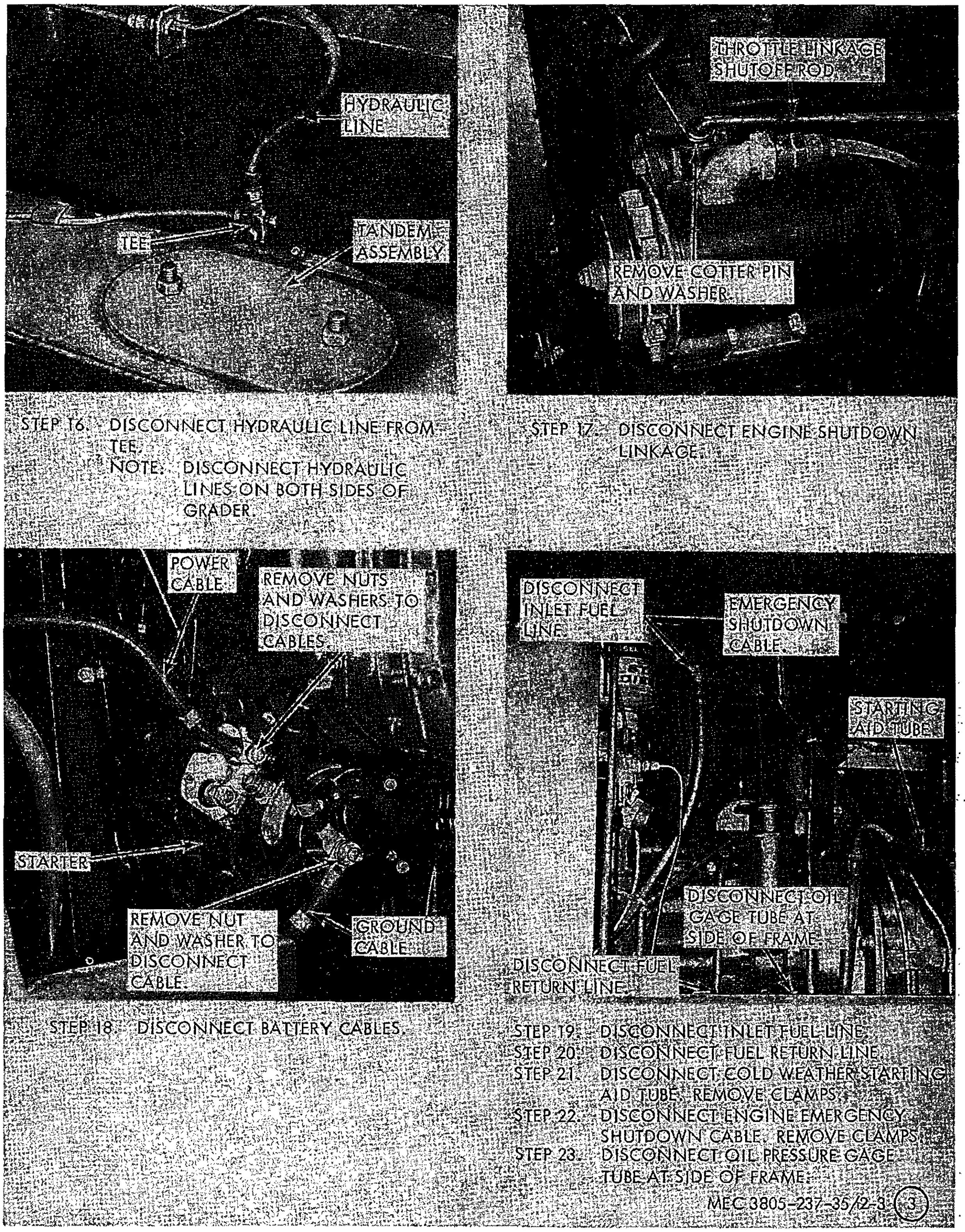
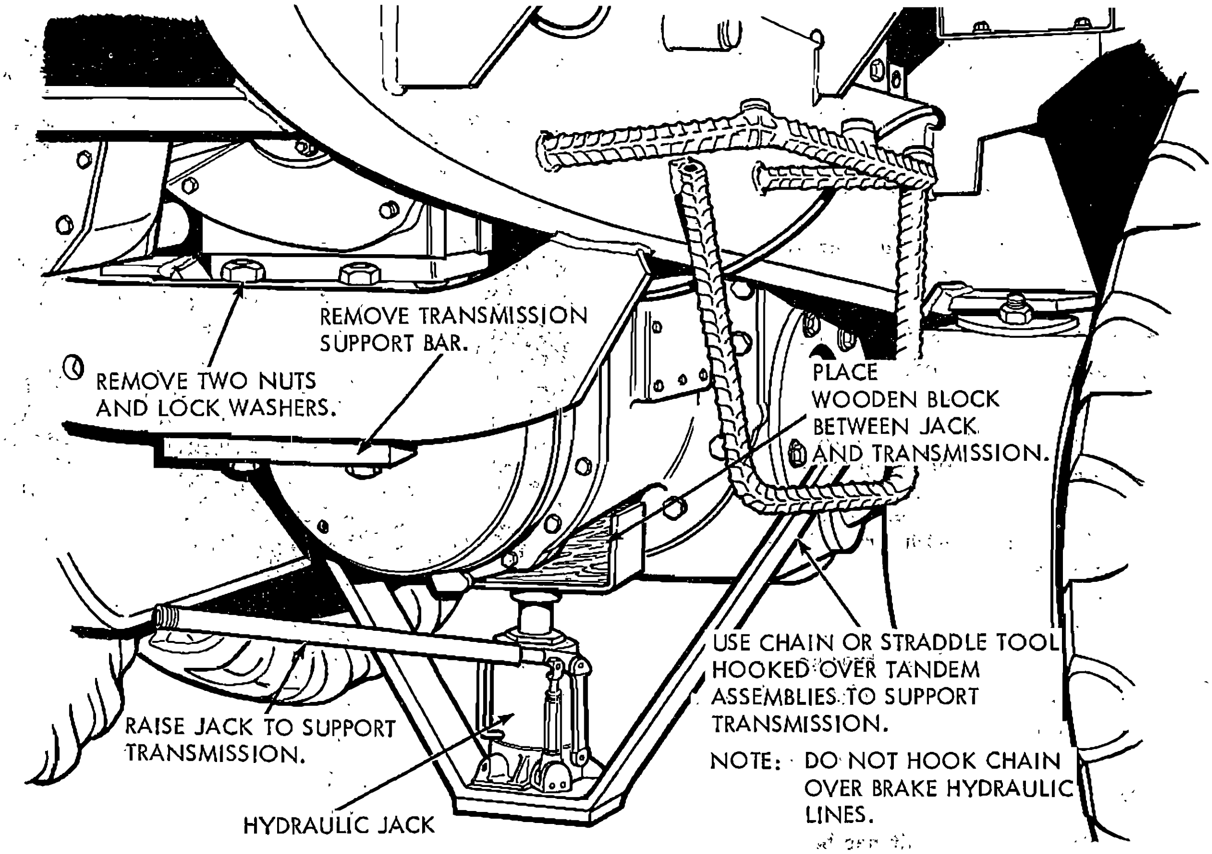
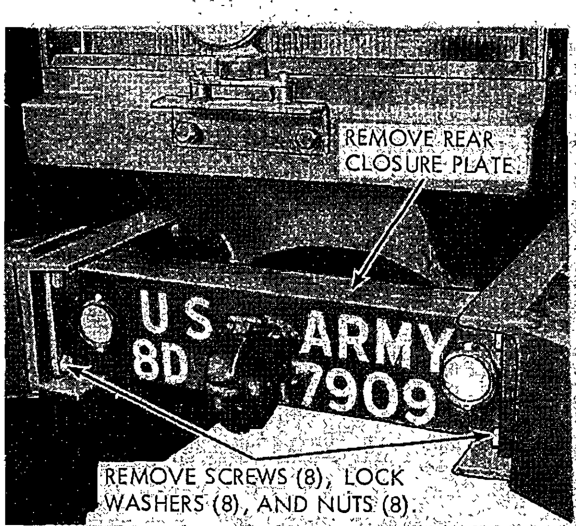


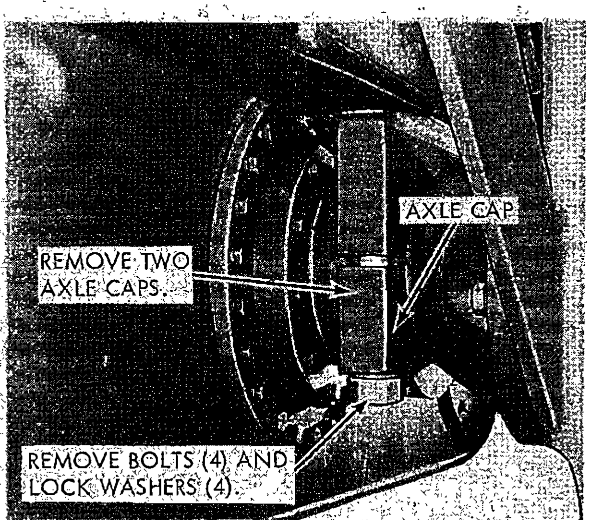

*Figure 2-3 (3)*—Continued




STEP 24. SUPPORT TRANSMISSION AND REMOVE TRANSMISSION SUPPORT BAR.




STEP 25. REMOVE REAR CLOSURE PLATE.




STEP 26. REMOVE REAR AXLE CAPS.

MEC 3805-237-35/2-3 (4)

*Figure 2-3 (4)*—Continued

(2) Check all disconnect points (fig. 2-3) to be certain drive unit is free to be removed.

(3) After checking, continue to roll drive unit from motor grader frame.

*Note.* It may be necessary to raise jack under transmission and shift drive unit to clear lifting eyes on rear of frame with rear axle and tandems.

c. *Installation.*

(1) Aline drive unit between two rear frame extensions.

(2) Roll drive unit back into place between frame extensions until unit is in place on motor grader.

*Note.* When installing drive unit, raise and support clutch brake linkage to clear cross bar on frame.

(3) Refer to figure 2-3 and complete installation of drive unit.

(4) When installing, transmission support bar, tighten bolts until a clearance of 1/16 inch exists between support bar and transmission support and frame.

*Note.* If drive unit has been removed and new resilient mounts have been installed (fig. 2-4), clearance should be 1/8 inch at both points.

(5) Install rear axle caps as shown in figure 2-5. Tighten bolts evenly until metal-to-metal contact between cap and frame is made at front of axle. Gap between caps must be to rear of axle.

## 2-31. Engine

a. *Removal.* The engine can be removed after removal of the drive unit as described in paragraph 2-30. Removal can also be accomplished without removing the complete drive unit. Remove engine as described below.

(1) Refer to figure 2-3 and disconnect all points shown except steps 6 and 7. Disconnect propeller shaft, step 8. Remove five capscrews and lockwashers from retainer at opposite end of shaft and pull retainer and shaft end from transmission. Com-

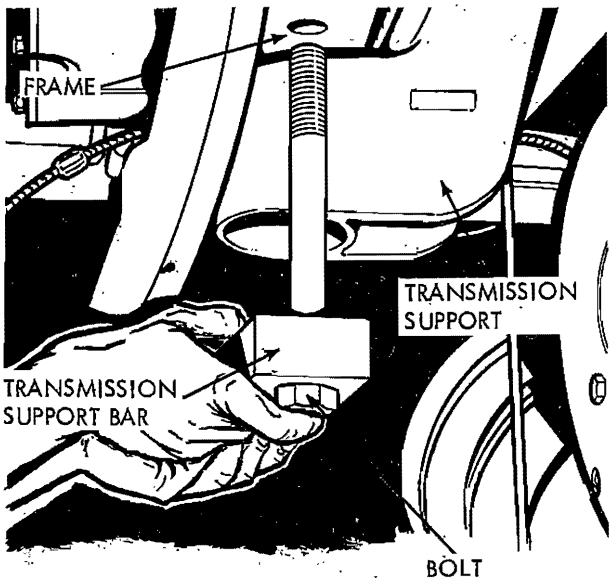



*Figure 2-4. Installing transmission support bar.*

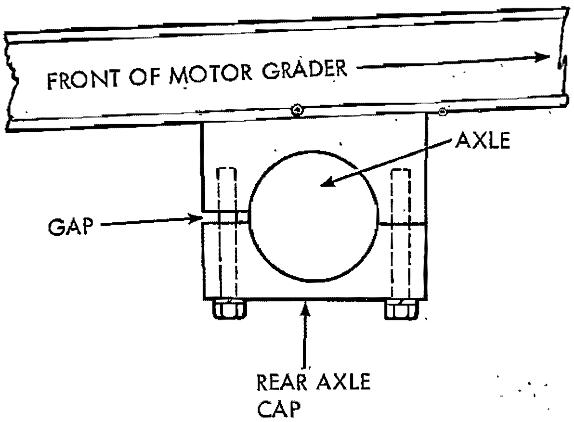



*Figure 2-5. Installing rear axle caps.*

plete step 16, and steps 24 through 26.

*Caution:* **Power take off shaft must be clear of clutch before attempting engine removal.**

(2) Using a suitable hoist connected to engine lifting brackets, raise engine to ease strain on engine mounts.

(3) Refer to figure 2-6 and disconnect engine for removal. Lift engine with hoist to remove from motor grader.

*Note.* When lifting engine from motor grader, raise radiator end of engine higher than clutch end to provide clearance at frame.

*b. Installation.*

(1) Using a suitable hoist connected to the engine lifting brackets, install the engine and clutch in the motor grader.

(2) Guide the universal joint at rear of clutch to engage splines on transmission stub shaft. Splines marked before removal must be alined.

*Note.* Incorrect alinement of splines will cause excessive vibration in drive train.

(3) Refer to figure 2-6 and install engine on mounts. Insert mounting bolts in both front and rear mounts but do not tighten.

(4) Tighten rear engine mounts to leave clearance between upper and lower bonded rubber washers and engine mount as shown in figure 2-7.

(5) After tightening rear engine mounts, tighten front engine mount bolts to compress resilient mounts as shown in figure 2-8.

(6) Refer to figure 2-3 and connect engine to motor grader.

## 2-32. Clutch Assembly

*a. Removal.* The clutch assembly is enclosed by the clutch housing and is removed from the grader with the engine.

(1) Refer to paragraph 2-31 and remove the engine and clutch from the motor grader.

(2) Refer to figure 2-9 and remove the clutch housing and clutch brake from the engine.

(3) Refer to figure 2-10 and remove clutch assembly.

*b. Installation.*

(1) Refer to figure 2-10 and install the clutch assembly.

(2) Refer to figure 2-9 and install the clutch housing.

(3) Refer to paragraph 2-31 and install the engine and clutch on the motor grader.

## 2-33. Moldboard Lift Gear Assemblies

*a. General.* Two moldboard lift gear assemblies are incorporated on the motor grader. The lift assemblies are mounted on large steel mars on either side of the main frame. A lifting arm from each gear assembly is connected to a lift link for raising or lowering the moldboard circle. Removal of the assemblies is identical except for a few items which are indicated on the legend for figure 2-11.

*Note.* Parentheses (R H only) and (L H only) following a part on legend denotes right or left hand lift gear assembly.

*b. Removal.*

(1) Remove the moldboard lift gear assembly in the numerical sequence as illustrated on figure 2-11.

*Note.* After removing light brackets install screws and washers in housing.

(2) To disengage control shaft universal joint (32) from gear assembly, loosen screw in universal joint and slide control shaft from gear assembly shaft.

(3) Before removing large U bolt (36) and two screws (35), attach a chain and suitable hoist to gear assembly. After removing attaching parts, lift gear assembly from frame.

*c. Installation.* Install moldboard lift gear assembly in reverse of numerical sequence as illustrated on figure 2-11.

## 2-34. Scarifier Lift Gear Assembly

*a. General.* The scarifier lift gear assembly is mounted on two plates which are attached to the front end of the frame assembly. Two lift arms, attached to the gear assembly, raise and lower the scarifier assembly.

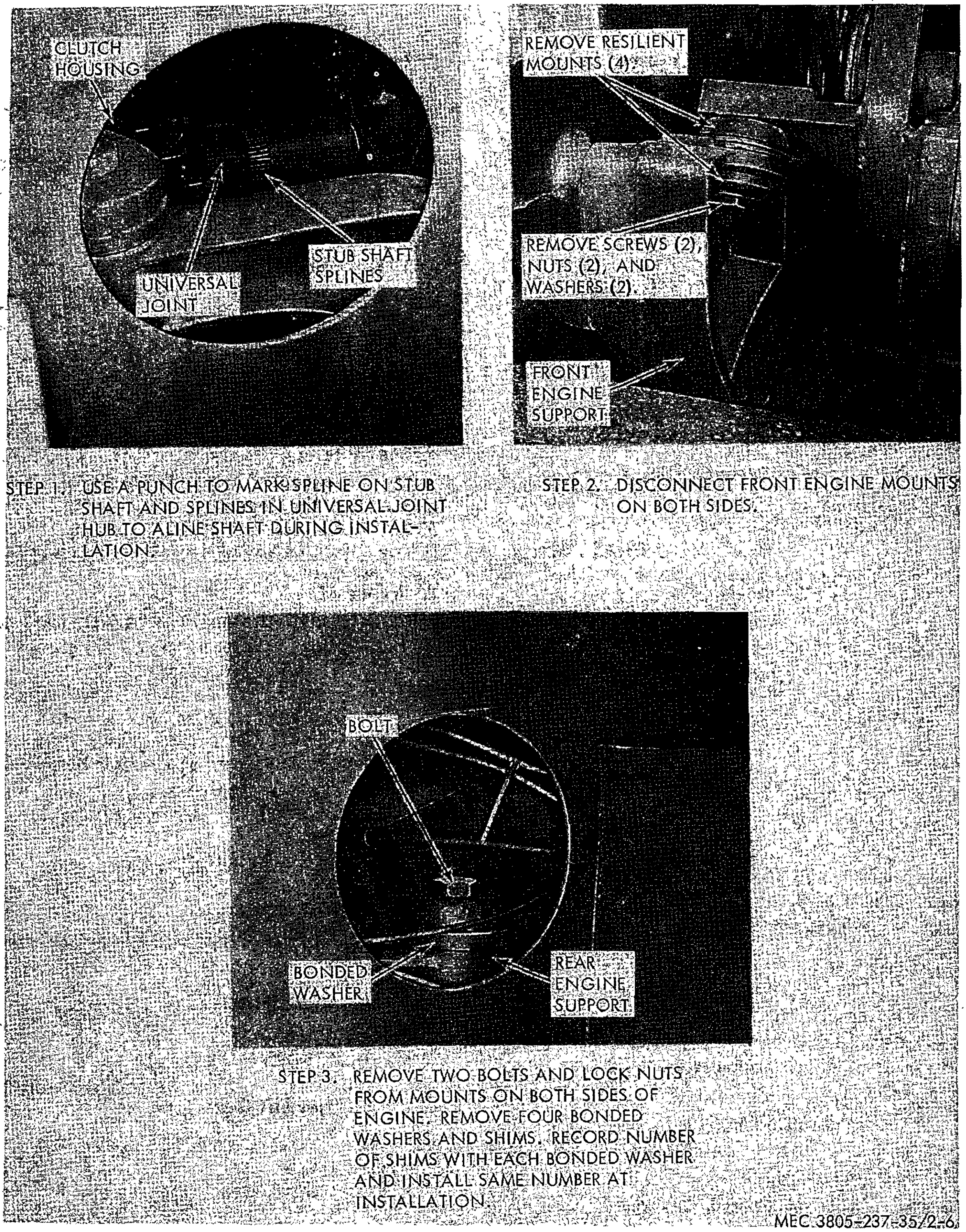



*Figure 2-6. Engine, removal and installation.*

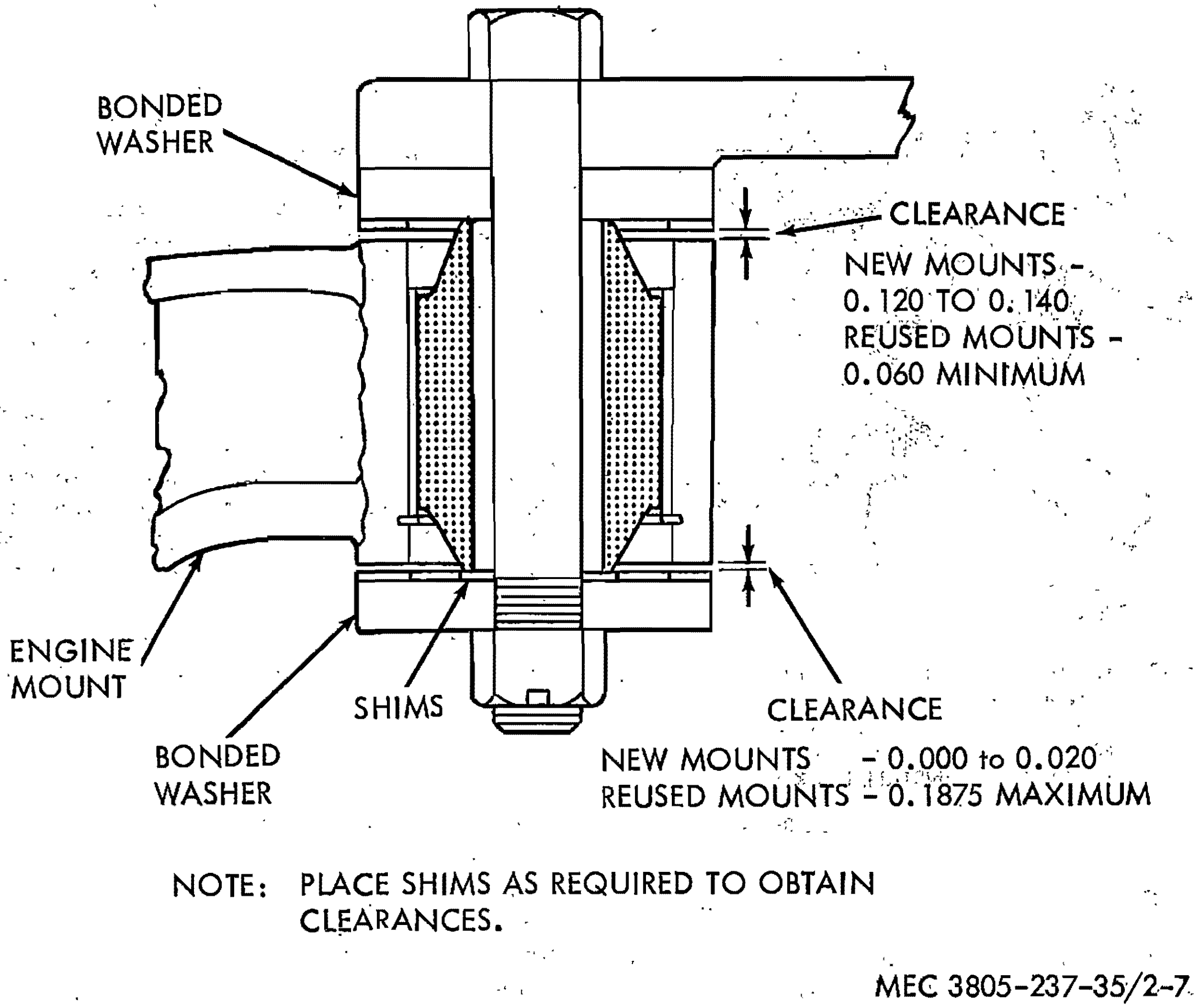



*Figure 2-7. Rear engine mount clearance.*

*b. Removal.* Remove scarifier lift gear assembly in the numerical sequence as indicated on figure 2-12.

(1) Remove bearing caps (7) from lift links on both sides of the machine.

(2) Remove hydraulic line bracket (3) and move hoses and tubes away from the gear assembly.

(3) Place a chain around gear assembly and connect chain to a suitable hoist. Raise gear assembly slightly before removing five screws (10).

(4) Use hoist to remove gear assembly from motor grader.

*c. Installation.*

(1) Use a suitable hoist to raise lift gear assembly into position for installation.

(2) Install scarifier lift gear assembly in reverse of numerical sequence as illustrated on figure 2-12.

(3) Install five bolts (10) through mounting plates and frame from the left hand side.

## 2-35. Circle Reverse Mechanism

*a. General.* The circle reverse mechanism, consisting of a transfer housing and circle reverse gear assembly are mounted on the

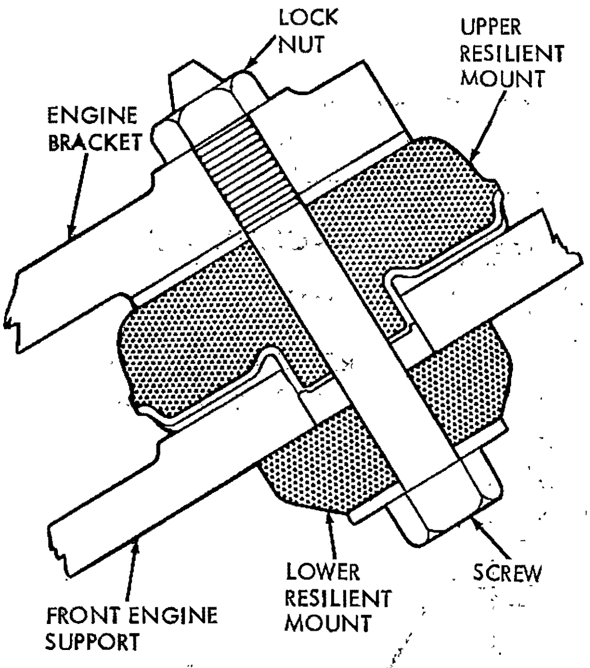



*Figure 2-8. Tightening front engine mounts.*

left side of the drawbar at the moldboard circle. Control shaft rotation is received by the transfer housing and transmitted to the gear assembly through a coupling shaft.

*b. Removal.* Refer to figure 2-13 and remove the transfer housing and circle reverse gear assembly.

*Note.* When removing circle reverse gear assembly, record amount of shims if any are present.

*c. Installation.*

(1) Refer to figure 2-13 and install the circle reverse gear assembly and transfer housing.

(2) Install circle reverse gear assembly on drawbar with teeth on drive gear in mesh with ring gear in circle. Attach splined coupling to shaft and rotate coupling with a pipe wrench counterclockwise until gear assembly is flush with drawbar.

*Note.* All circle reverse gear assembly pads must be flush against drawbar. Install any shims, removed during disassembly, in their original position.

(3) Install long bolts and nuts to hold circle reverse gear assembly in place. Install short bolts and nuts. Tighten nuts securely.

## 2-36. Lateral Shift Gear Assembly

*a. General.* The lateral shift gear assembly is mounted on a cross brace of the frame forward of the power control box. A short control shaft connects it to the power control box. A shift arm, operated by the gear assembly, is connected to the lateral shift link with a ball and socket. The shift link extends to a horizontal link above the drawbar. By changing the horizontal link from one side of the drawbar to the other, the moldboard blade can be positioned for side sloping on either side of the grader.

*b. Removal.* Refer to figure 2-14 and remove the lateral shift gear assembly from the motor grader.

*c. Installation.* Refer to figure 2-14 and install the lateral shift gear assembly.

## 2-37. Front Lean Wheel Gear Assembly

*a. General.* The front wheel lean gear assembly is mounted between the bars of the front axle inside of the right front wheel. Operation of the gear assembly provides leaning action for the front wheels. Motion for the leaning action is provided through a gear rack and vibrating bar connected to the top of the two wheel spindle forks.

*b. Removal.* Refer to figure 2-15 and remove the front lean wheel gear assembly from the motor grader.

*c. Installation.* Refer to figure 2-15 and install the front lean wheel gear assembly.

(1) Tighten tapered nuts in Step 9 to a torque of 240 foot pounds.

(2) Install anchor bolt, lockwashers and nut, but do not tighten until gear assembly has been alined with gear rack.

(3) Install vibrating bar and right hand vibrating pin.

(4) Install gear rack on vibrating bar, with enough shims between rack

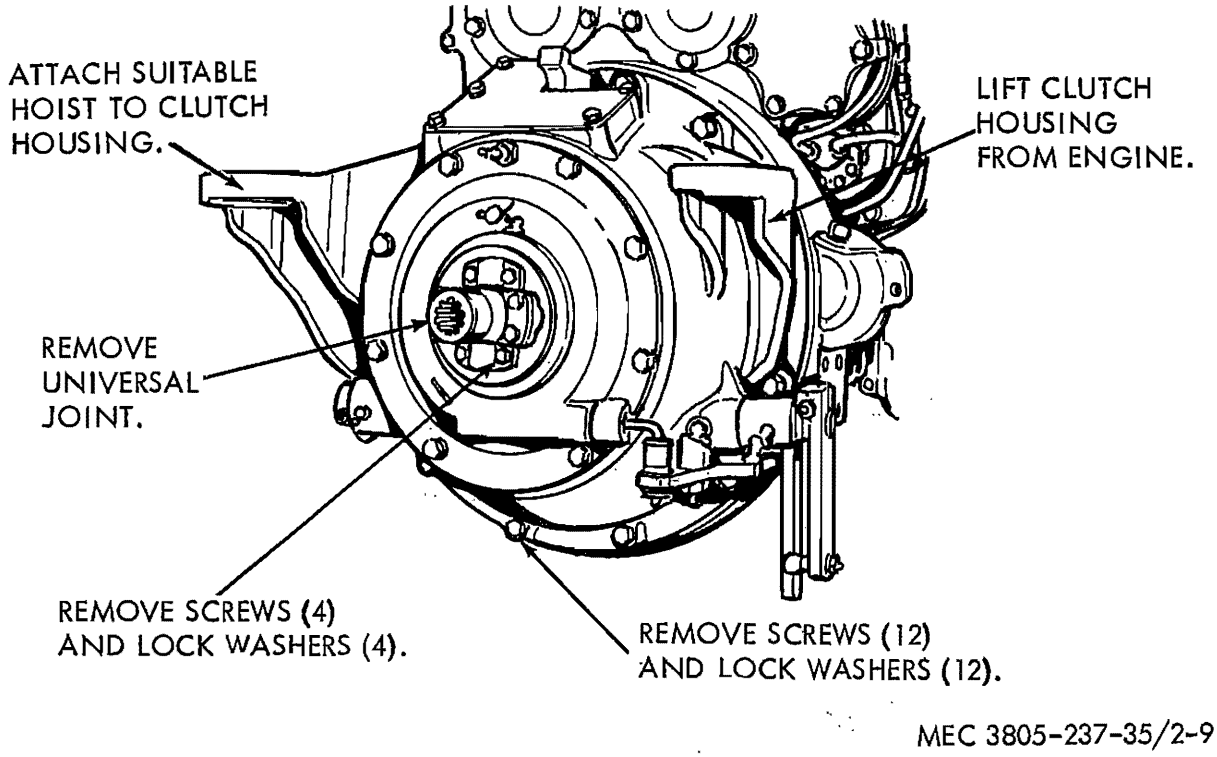



*Figure 2-9. Clutch housing, removal and installation.*

and vibrating bar to raise left hand end of vibrating bar 1/2 to 3/4 inch out of line with top hole in spindle fork as shown in figure 2-16.

(5) Place chain around vibrating bar and axle as shown in step 3. Depress vibrating bar with crow bar or lever to aline holes. Install left hand vibrating bar pin through holes and secure.

(6) Install anchor bracket but do not tighten screws or nut.

(7) Install vibrating link do not tighten nut on shoulder bolt.

(8) Measure gap between anchor bracket and vibrating bar. Remove link and anchor bracket and install sufficient number of shims between anchor bracket and vibrating bar to fill gap.

*Note.* Add or remove anchor bracket shims until shoulder bolt is free to move or rotate in holes in vibrating links.

(9) Tighten anchor bracket screw and nut. Install and tighten shoulder bolt locknut.

## 2-38. Power Control Box and Vertical Drive Assembly

*a. General.* The power control box and vertical drive assembly are powered all the time the engine is running. A drive, or power take-off shaft, directly coupled to the engine fly wheel, extends through the hollow clutch and transmission drive shafts. A flanged coupling between the transmission and vertical drive assembly is secured with a shear bolt. This bolt will break and halt operation if too great a load or shock is imposed on any of the grader motions. The propeller shaft drives a bevel gear keyed to a vertical drive shaft. This vertical drive shaft enters the bottom of the power control box and drives two bevel drive gears. Each control shaft extending from the power control box is equipped with two gears and a sliding clutch. As the shifter lever is moved the clutch moves to en-

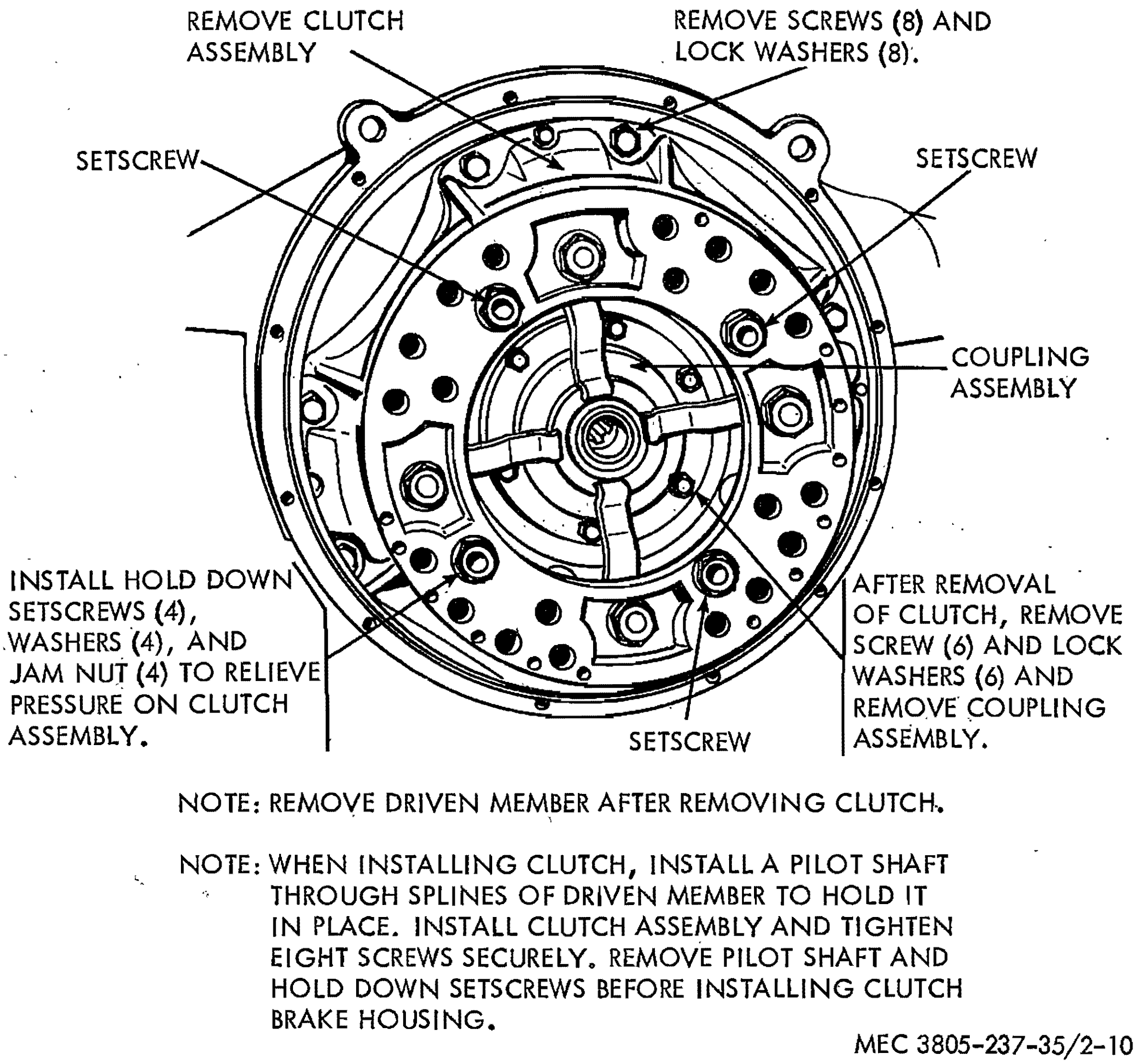



*Figure 2-10. Clutch assembly, removal and installation.*

gage a clutch gear driven by the drive gear, rotating the control shaft. Mounted on the outlet drive shafts are anti-coast brake drums and brakes. When the control lever is released the brake is applied to aid in stopping the control shaft and controlling any coasting of the grader motion.

*b. Removal.*

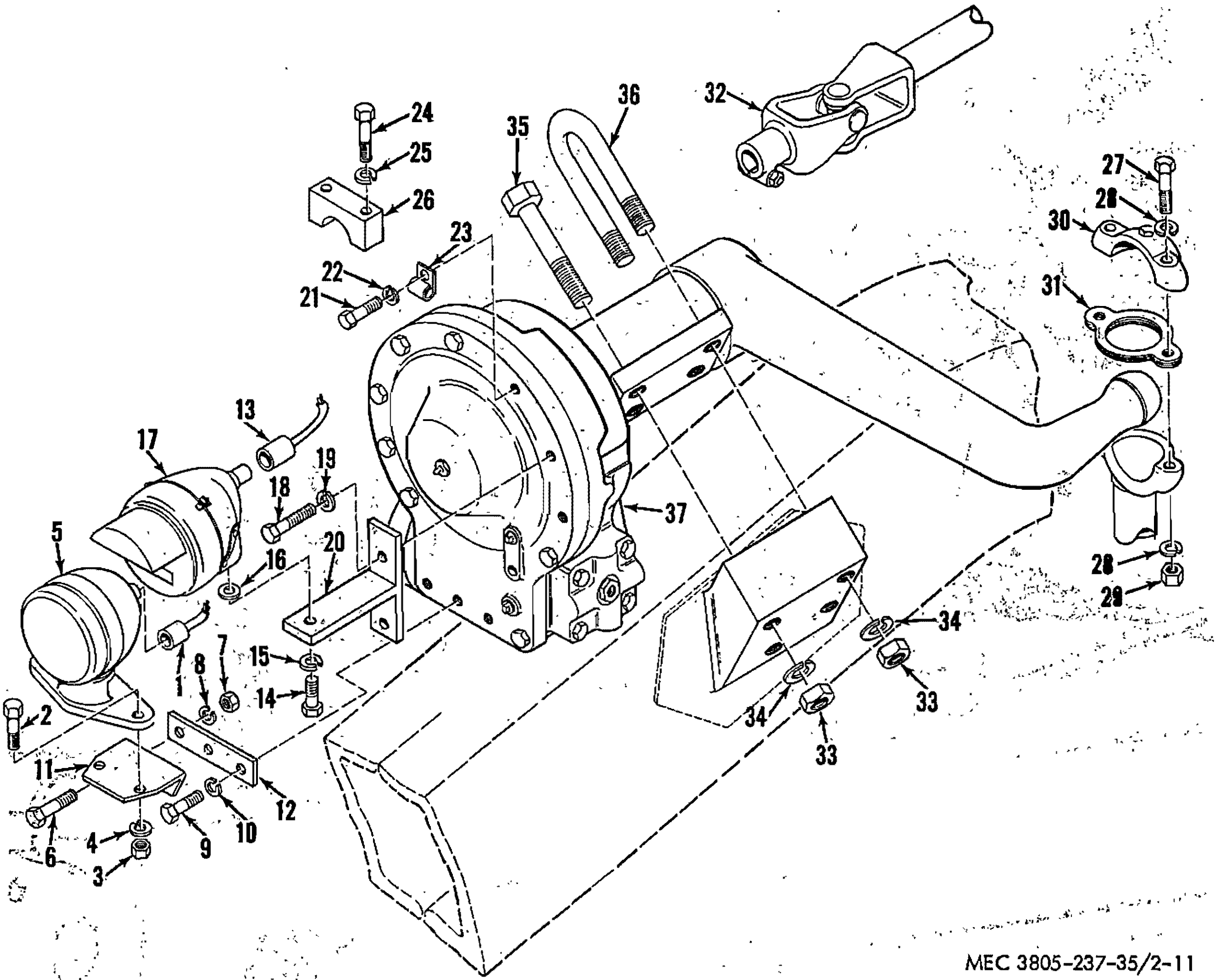
(1) Refer to figure 2-3, step 8, and disconnect propeller shaft coupling.

(2) Refer to figure 2-17 and remove the power control box and vertical drive housing.

*c. Installation.*

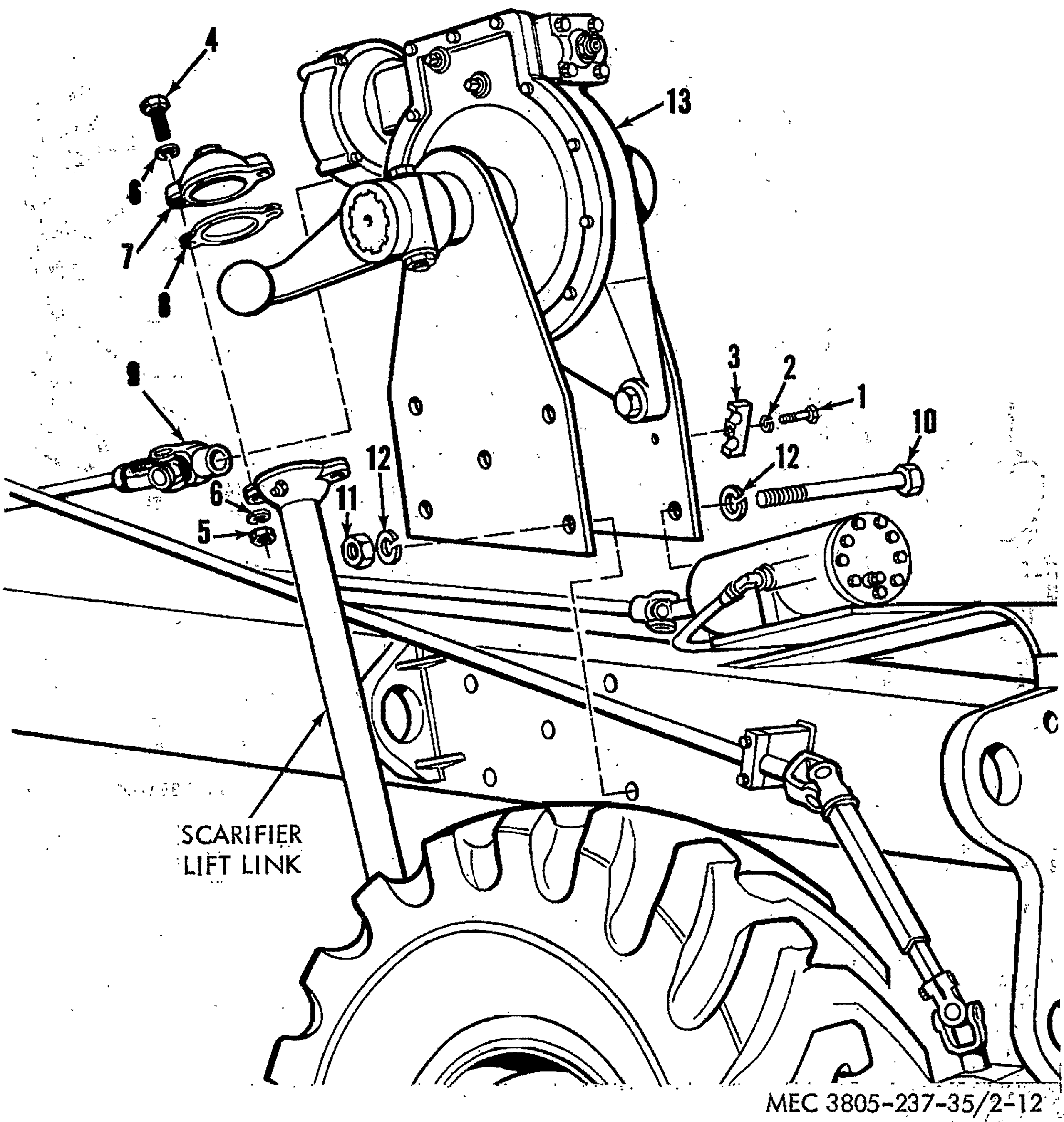
(1) Refer to figure 2-17 and install the power control box and vertical drive housing.

(2) When installing hydraulic pumps and adapter, guide drive shaft from vertical drive housing into splines of pump drive gear in pump adapter.




| | | | |
|---|---|---|---|
| 1 | Headlight wire | 20 | Blackout light bracket (LH only) |
| 2 | Screw, cap, hex-head | 21 | Screw, cap, hex-head |
| 3 | Nut | 22 | Washer, lock |
| 4 | Washer, lock | 23 | Wire clamp |
| 5 | Headlight | 24 | Screw, cap, hex-head (2) (RH only) |
| 6 | Screw, cap, hex-head | 25 | Washer, lock (2) (RH only) |
| 7 | Nut | 26 | Bearing cap (2) (RH only) |
| 8 | Washer, lock | 27 | Screw, cap, hex-head (2) |
| 9 | Screw, cap, hex-head (2) | 28 | Washer, lock (4) |
| 10 | Washer, lock (2) | 29 | Nut (2) |
| 11 | Headlight bracket | 30 | Bearing cap |
| 12 | Spacer bar (LH only) | 31 | Shim |
| 13 | Blackout light wire (LH only) | 32 | Universal joint |
| 14 | Screw, cap, hex-head (LH only) | 33 | Nut (4) |
| 15 | Washer, lock (LH only) | 34 | Washer, lock (4) |
| 16 | Bearing washer (LH only) | 35 | Screw, cap, hex-head (2) |
| 17 | Blackout headlight (LH only) | 36 | U bolt |
| 18 | Screw, cap, hex-head (2) (LH only) | 37 | Moldboard lift gear assembly |
| 19 | Washer, lock (2) (LH only) | | |

*Figure 2-11. Moldboard lift gear assembly, removal and installation.*




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head (2) | 8 | Shim |
| 2 | Washer, lock (2) | 9 | Universal joint |
| 3 | Hydraulic line bracket | 10 | Bolt (5) |
| 4 | Screw, cap hex-head, 3/4–10 X 3 1/4 in. (4) | 11 | Nut, 1–8 (5) |
| 5 | Nut, 3/4–10 (4) | 12 | Washer, lock, 1 in. (10) |
| 6 | Washer, lock, 3/4 (4) | 13 | Scarifier lift gear assembly |
| 7 | Bearing cap (2) | | |

*Figure 2–12. Scarifier lift gear assembly, removal and installation.*

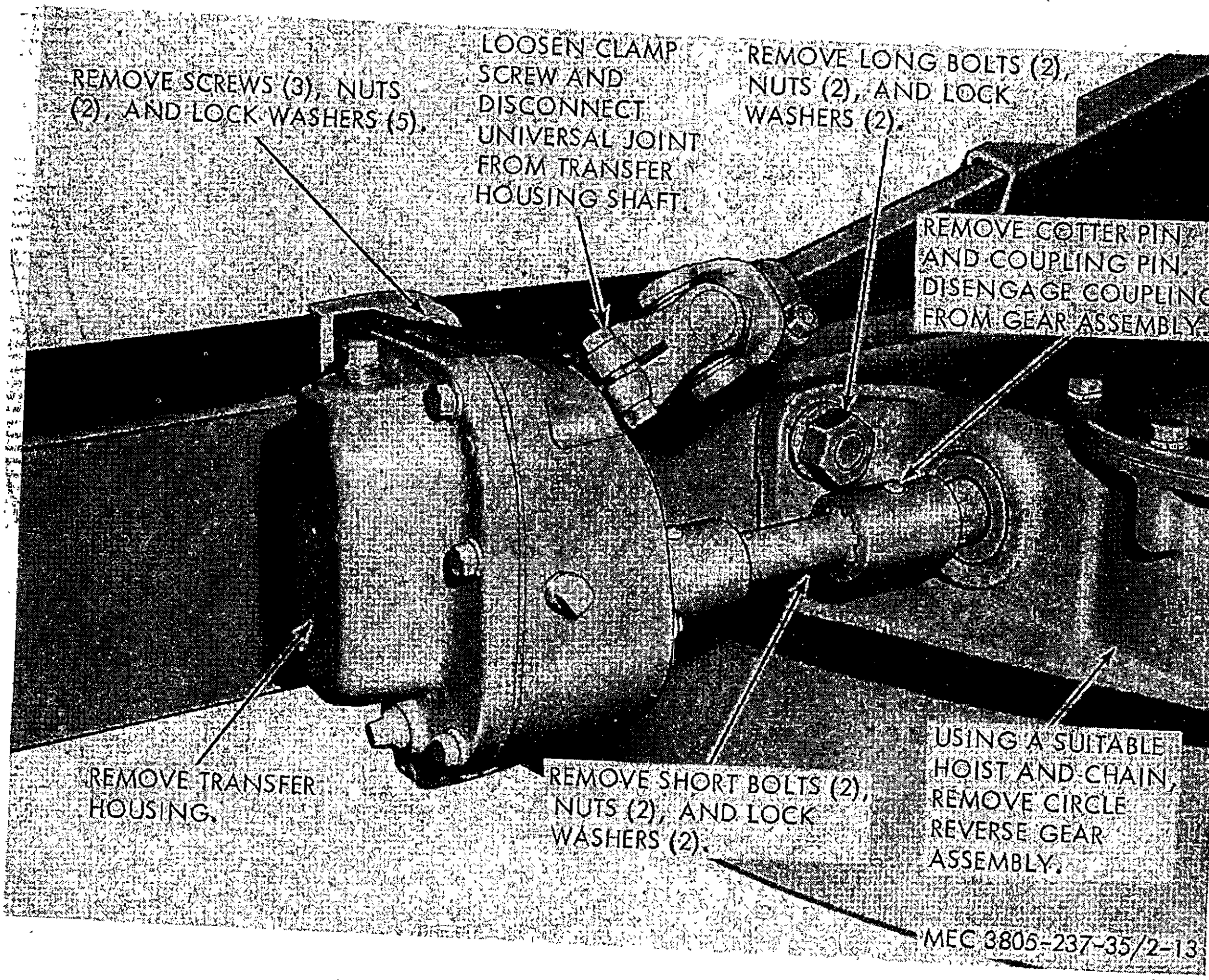



*Figure 2-13. Transfer housing and circle reverse gear assembly, removal and installation.*

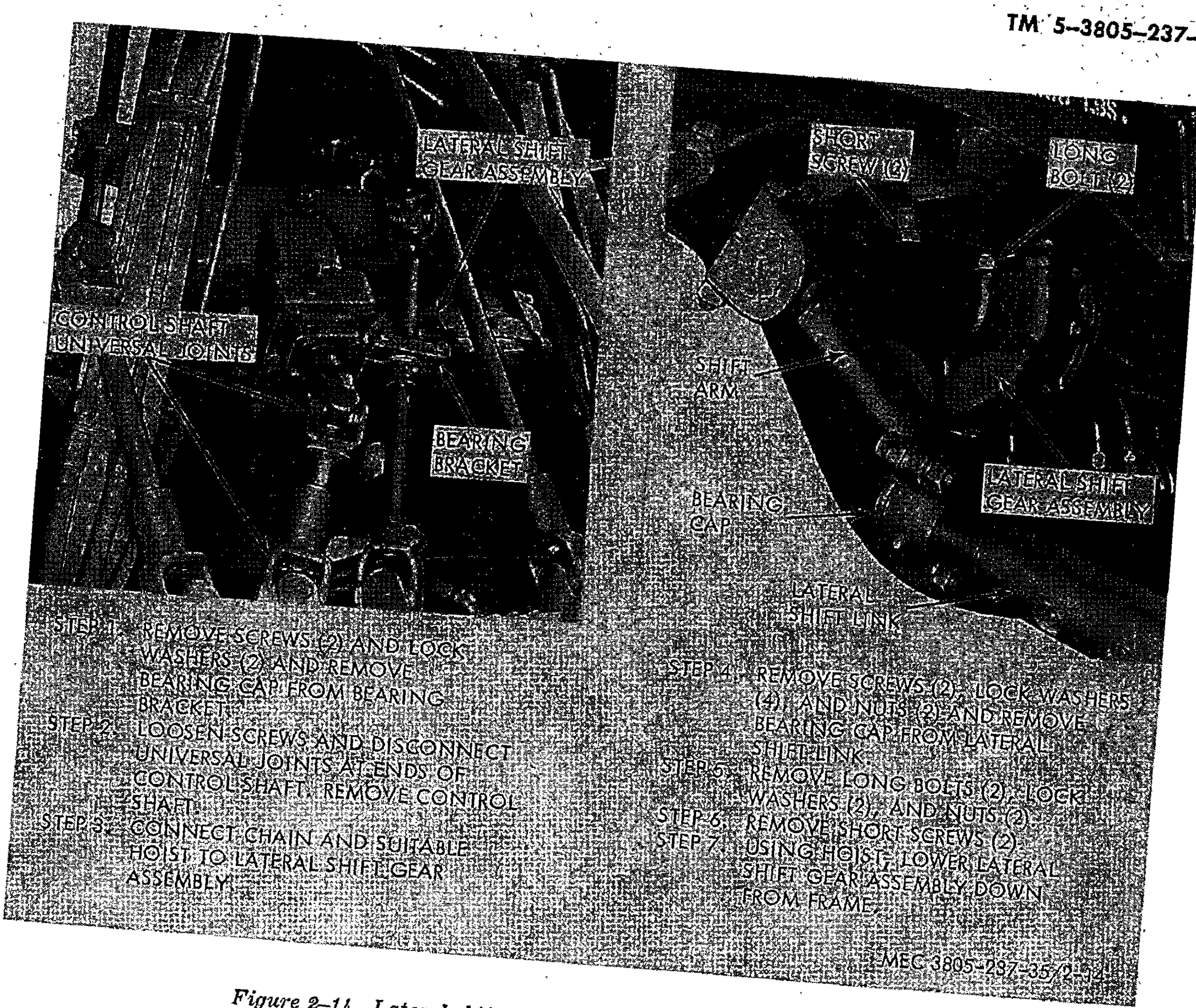
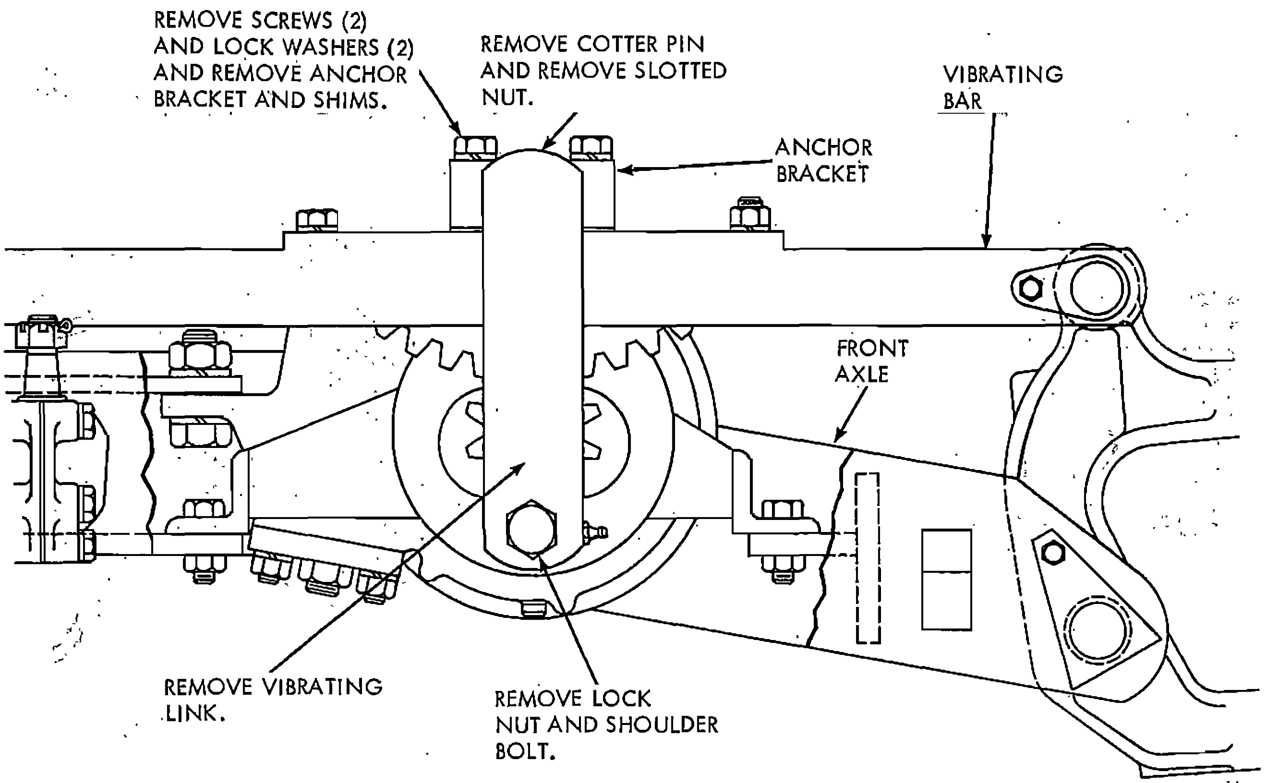



*Figure 2-14. Lateral shift gear assembly, removal and installation.*




STEP 1. REMOVE VIBRATING LINK.
STEP 2. REMOVE ANCHOR BRACKET.

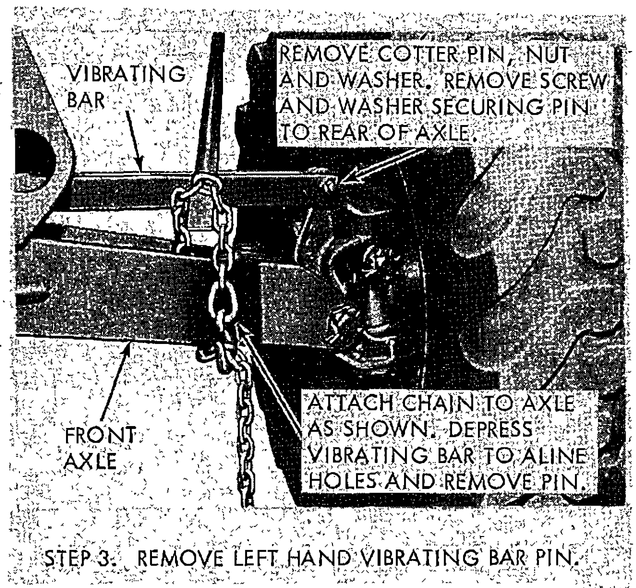



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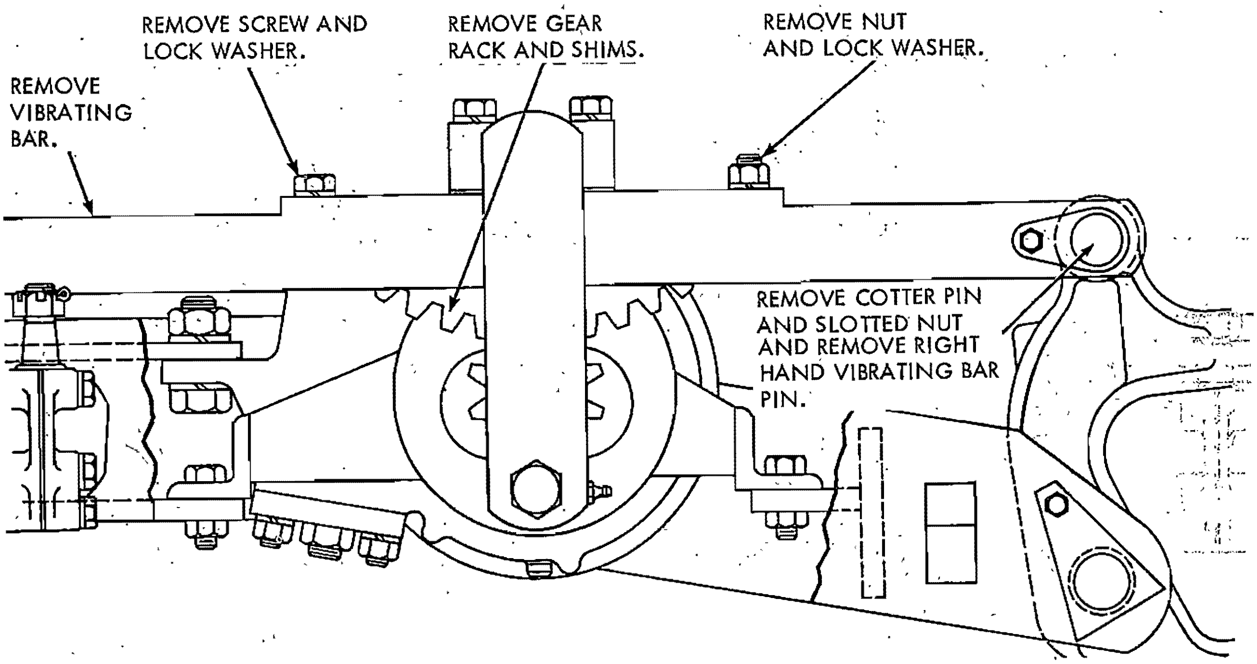
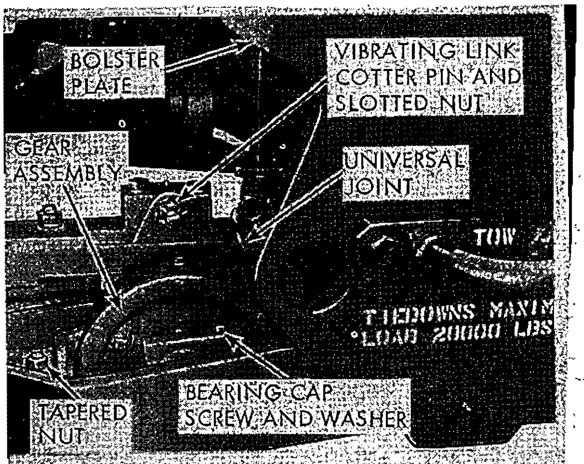
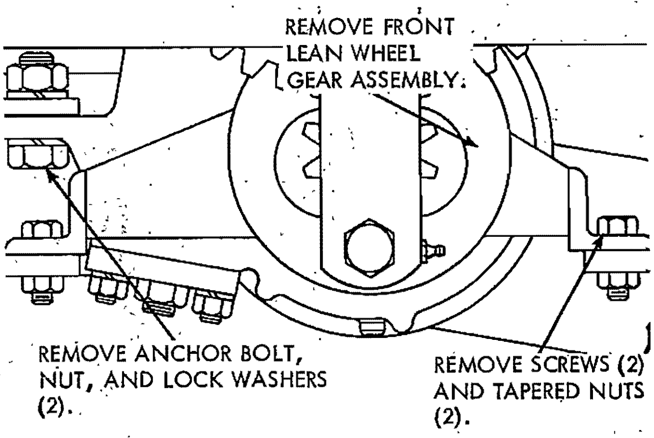
*Figure 2-15 (1). Front lean wheel gear assembly removal and installation.*




STEP 4. REMOVE GEAR RACK AND SHIMS.
STEP 5. REMOVE RIGHT HAND VIBRATING BAR PIN, SCREW, AND WASHER.
STEP 6. REMOVE VIBRATING BAR.
NOTE: TIP VIBRATING BAR ON SIDE AND LIFT BAR UP AND OUT TOWARDS LEFT SIDE OF GRADER. GUIDE BAR OUT FROM BETWEEN BOLSTER PLATE AND AXLE.




STEP 7. REMOVE SCREW AND LOCK WASHER FROM BEARING BRACKET.
STEP 8. DISCONNECT UNIVERSAL JOINT FROM GEAR ASSEMBLY BY LOOSENING CLAMP SCREW.




STEP 9. REMOVE FRONT WHEEL LEAN GEAR ASSEMBLY.

MEC 3805-237-35/2-15 (2)

*Figure 2-15 (2)*—Continued.

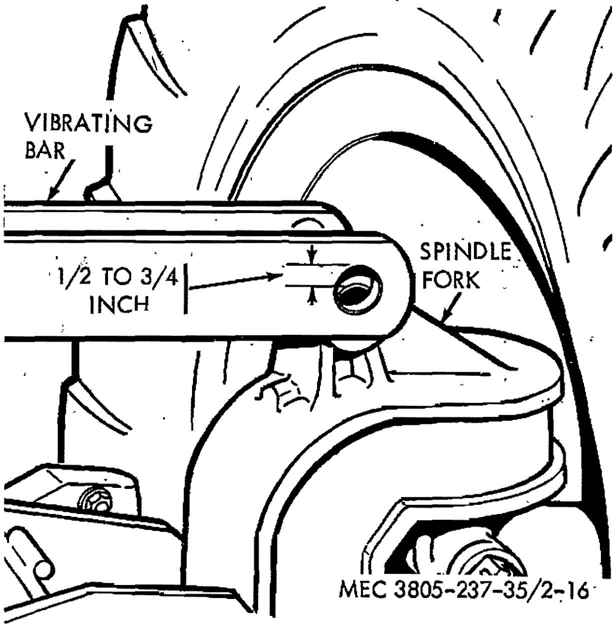
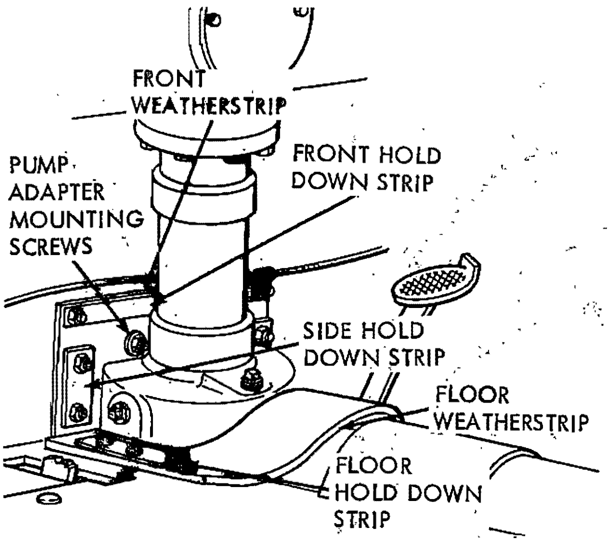
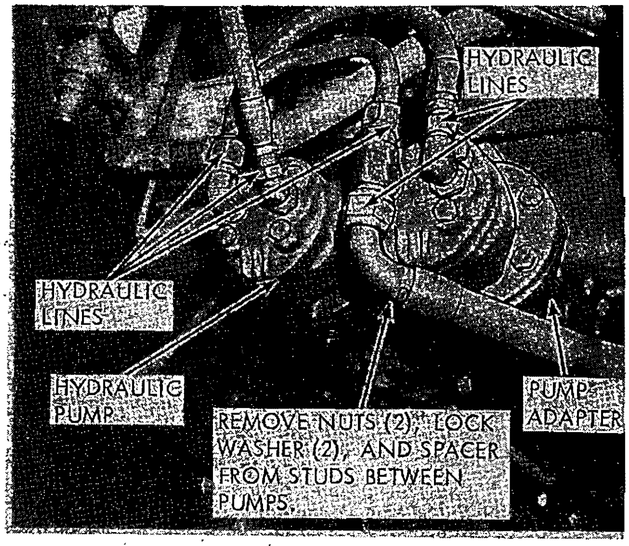



*Figure 2-16. Adjustment of left hand end of vibrating bar.*




STEP 1. REMOVE TWO PUMP ADAPTER MOUNTING SCREWS, SPACERS, LOCK WASHERS, AND NUTS.

STEP 2. REMOVE FOUR SCREWS, LOCK WASHERS, AND NUTS AND REMOVE TWO SIDE HOLD DOWN STRIPS.

STEP 3. REMOVE SIX BOLTS, LOCK WASHERS, FLAT WASHERS, AND NUTS AND REMOVE TWO FLOOR HOLD DOWN STRIPS. REMOVE FLOOR WEATHERSTRIP.

STEP 4. REMOVE TWO SCREWS, LOCK WASHERS, AND NUTS AND REMOVE UPPER FRONT HOLD DOWN STRIP. REMOVE FRONT WEATHERSTRIP.

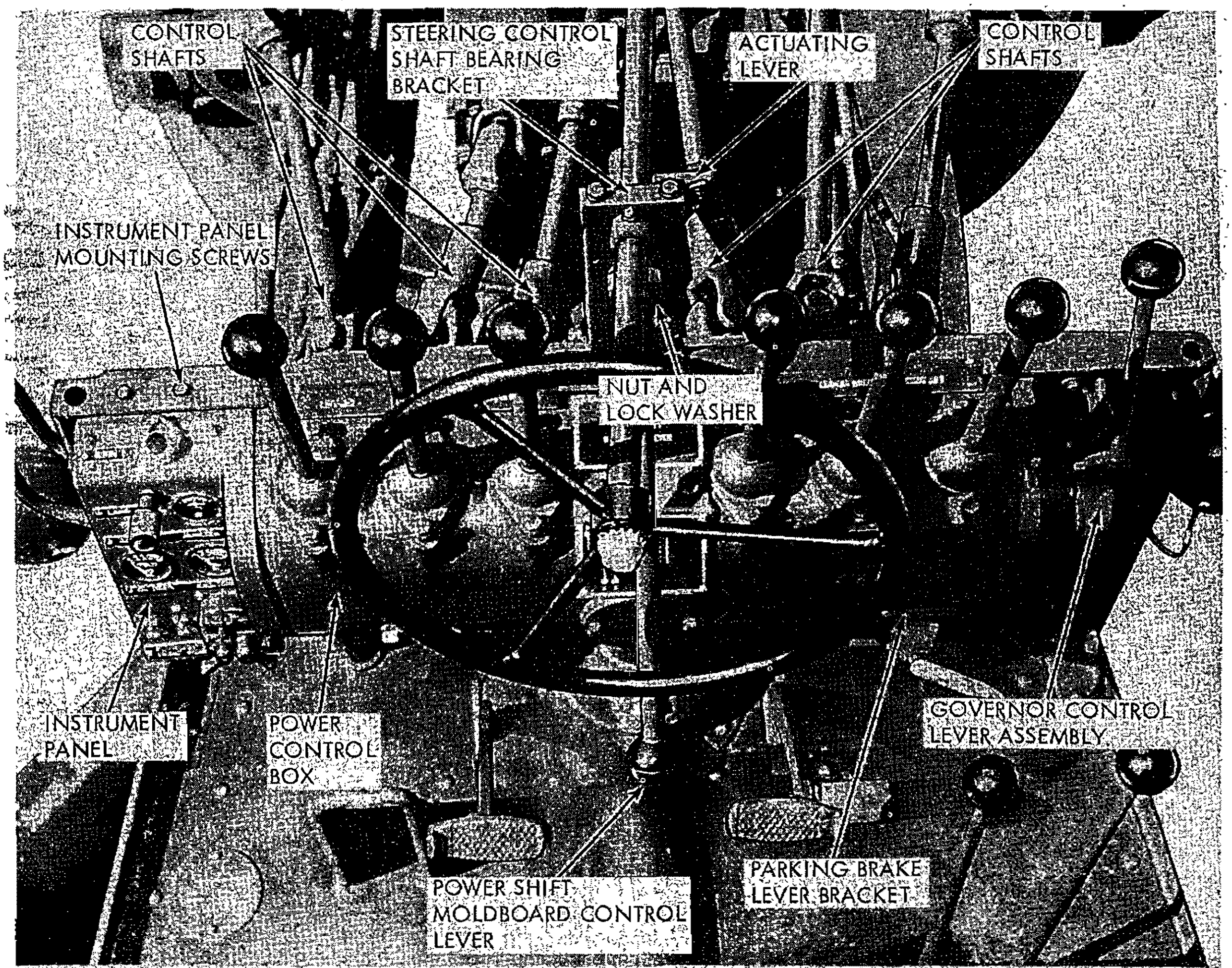
STEP 5. DISCONNECT FIVE HYDRAULIC LINES FROM PUMPS.

STEP 6. REMOVE EIGHT SCREWS AND LOCK WASHERS AND REMOVE TWO HYDRAULIC PUMPS. REMOVE TWO SCREWS AND LOCK WASHERS FROM INSIDE OF PUMP ADAPTER.

STEP 7. REMOVE TWO NUTS AND LOCK WASHERS FROM STUDS BETWEEN PUMPS. REMOVE SPACER FROM LOWER STUD AND REMOVE ADAPTER, GASKET, AND SHIMS.

MEC 3805-237-35/2-17 (1)

***Figure 2-17 (1). Power control box, removal and installation.***




STEP 8. REMOVE TWO SCREWS AND LOCK WASHERS AND REMOVE STEERING CONTROL SHAFT BEARING BRACKET. MOVE SHAFT FROM CONTROL BOX.

STEP 9. DRIVE SPRING PIN FROM ACTUATING LEVER AND END OF POWER SHIFT MOLDBOARD LEVER. REMOVE NUT AND LOCK WASHER AND REMOVE POWER SHIFT MOLDBOARD CONTROL LEVER, BEARING, AND ACTUATING LEVER FROM BRACKET.

STEP 10. REMOVE THREE INSTRUMENT PANEL MOUNTING SCREWS AND LOCK WASHERS, TWO ON TOP AND ONE ON BOTTOM. PLACE INSTRUMENT PANEL ON FLOOR OUT OF WAY OF POWER CONTROL BOX.

STEP 11. REMOVE TWO FLAT HEAD COUNTERSUNK SCREWS AND LOCK WASHERS AND REMOVE PARKING BRAKE LEVER BRACKET FROM POWER CONTROL BOX.

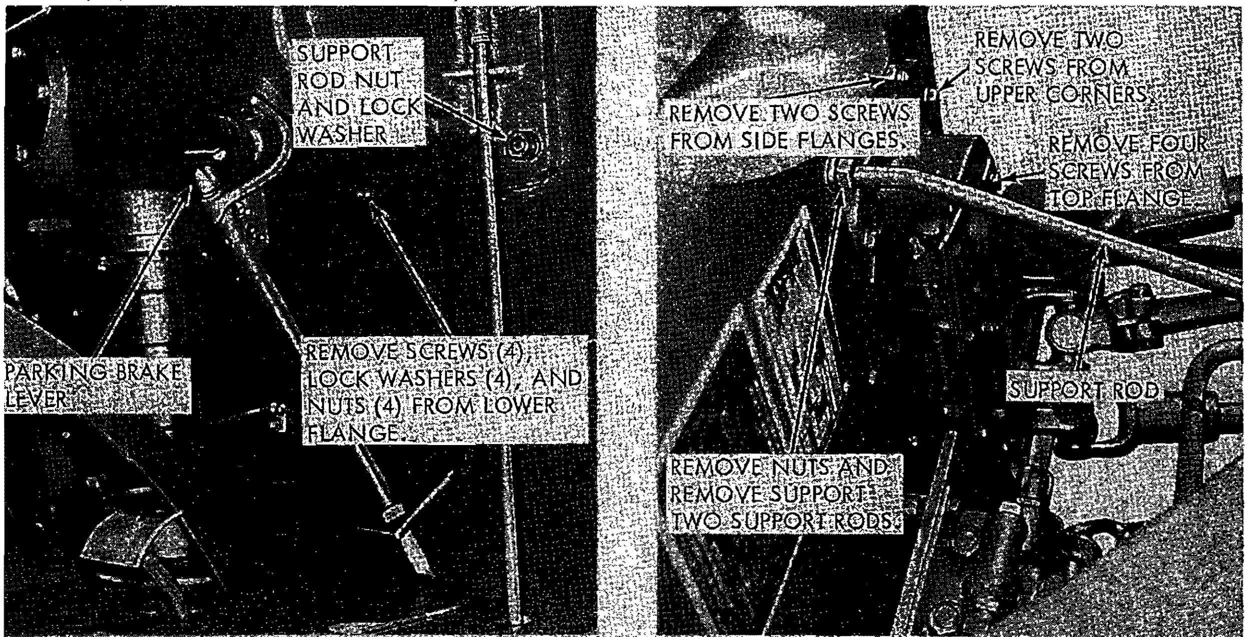
STEP 12. REMOVE SCREW, TWO WASHERS AND NUTS AND REMOVE GOVERNOR CONTROL LEVER ASSEMBLY FROM FRONT SHEET.

STEP 13. LOOSEN CLAMPING SCREWS AND DISCONNECT SIX CONTROL SHAFTS FROM POWER CONTROL BOX CLUTCH DRIVE SHAFTS.

STEP 14. REMOVE TWO SCREWS AND INSTALL LIFTING EYES IN POWER CONTROL BOX. ATTACH CHAIN AND HOIST TO LIFTING EYES.

MEC 3805-237-35/2-17 (2)

*Figure 2–17 (2)*—Continued.




STEP 15. REMOVE FOUR 5/16-18 x 1-1/2 IN. SCREWS, 5/16 IN. LOCK WASHERS, AND 5/16-18 NUTS FROM LOWER FLANGE OF POWER CONTROL BOX.
NOTE: LIFT HOIST AND CHAIN TO SUPPORT POWER CONTROL BOX BEFORE REMOVING ATTACHING PARTS.

STEP 16. REMOVE TWO 1/2-13 x 1-3/4 IN. SCREWS, 1/2 IN. LOCK WASHERS AND 1/2-13 NUTS, ONE FROM EACH UPPER CORNER OF CONTROL BOX.

STEP 17. REMOVE TWO 1/2-13 x 1 IN. SCREWS AND 1/2 IN. LOCK WASHERS, ONE FROM EACH SIDE FLANGE OF CONTROL BOX.

STEP 18. REMOVE TWO 3/8-16 x 1 IN. SCREWS AND 3/8 IN. LOCK WASHERS FROM TOP FLANGE OF POWER CONTROL BOX.

STEP 19. REMOVE FOUR NUTS AND LOCK WASHERS FROM TWO SUPPORT RODS AND MOVE RODS AWAY FROM POWER CONTROL BOX.

STEP 20. LIFT POWER CONTROL BOX SLIGHTLY WITH HOIST AND MOVE CONTROL BOX BACK TO CLEAR LIP AT TOP OF FRONT SHEET.

STEP 21. LIFT POWER CONTROL BOX AND VERTICAL DRIVE ASSEMBLY FROM MOTOR GRADER.
NOTE: USE CARE WHEN GUIDING VERTICAL HOUSING UP THROUGH FLOOR PLATE.

MEC 3805-237-35/2-17 (3)

*Figure 2-17 (3)*—Continued.

# CHAPTER 3

# TRANSMISSION

## Section I. PARKING BRAKE

### 3-1. General

The parking brake mounted on the front of the lower transmission is a two shoe, internal expansion type. The brake is mechanically applied by means of a manually operated lever.

### 3-2. Removal

*a.* Drill out staking on lower transmission lower shaft locknut. Refer to figure 3-1 and remove brake drum.

*Caution:* **Remove all of staked material to prevent damage to shaft when locknut is removed.**

*b.* Disconnect brake cable from bellcrank (para 2-30).

*c.* Remove strut spring (4, fig. 3-2) and strut (5) to gain access to two of backing plate mounting screws.

*d.* Remove screws (6, fig. 3-2) and lockwashers (7) securing backing plate assembly to adapter on lower transmission. Remove backing plate assembly.

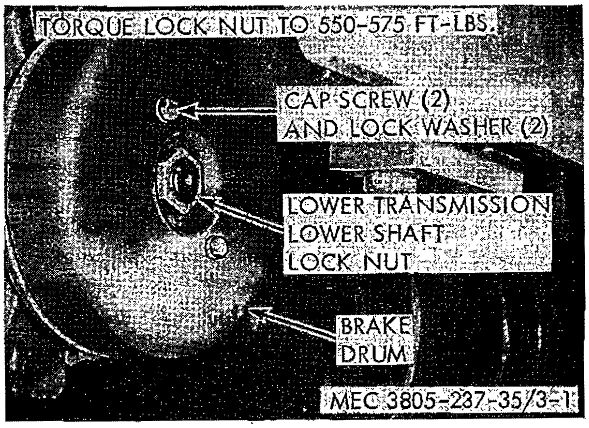



*Figure 3-1 Brake drum, removal or installation.*

### 3-3. Disassembly

*a.* Disassemble the brake assembly in the numerical sequence as illustrated in figure 3-2. Index numbers 1 through 7 were removed in paragraph 3-2.

*b.* Remove two screws, nuts and lockwashers and remove abutment cap and seal from cable. Remove cable from backing plate.

### 3-4. Cleaning

Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

### 3-5. Inspection and Repair

*a.* Inspect brake shoes and linings for wear or damage. Change oil soaked linings. Replace shoes when lining is worn to within 1/32 to 1/16 inch of the closest rivet head.

*b.* Inspect springs for weak or broken condition. Replace springs if defective.

*c.* Inspect adjusting screw, nut, and socket for cracks or damaged threads. Replace defective parts.

*d.* Inspect shoe hold-down pins and spring cups for cracked or bent condition. Replace defective parts.

*e.* Inspect brake lever for bent or broken condition. If defective, replace lever.

*f.* Inspect drum and backing plate for cracks or distortion. Inspect brake shoe contact surface of drum for grooves or wear. Replace drum or backing plate if defective.

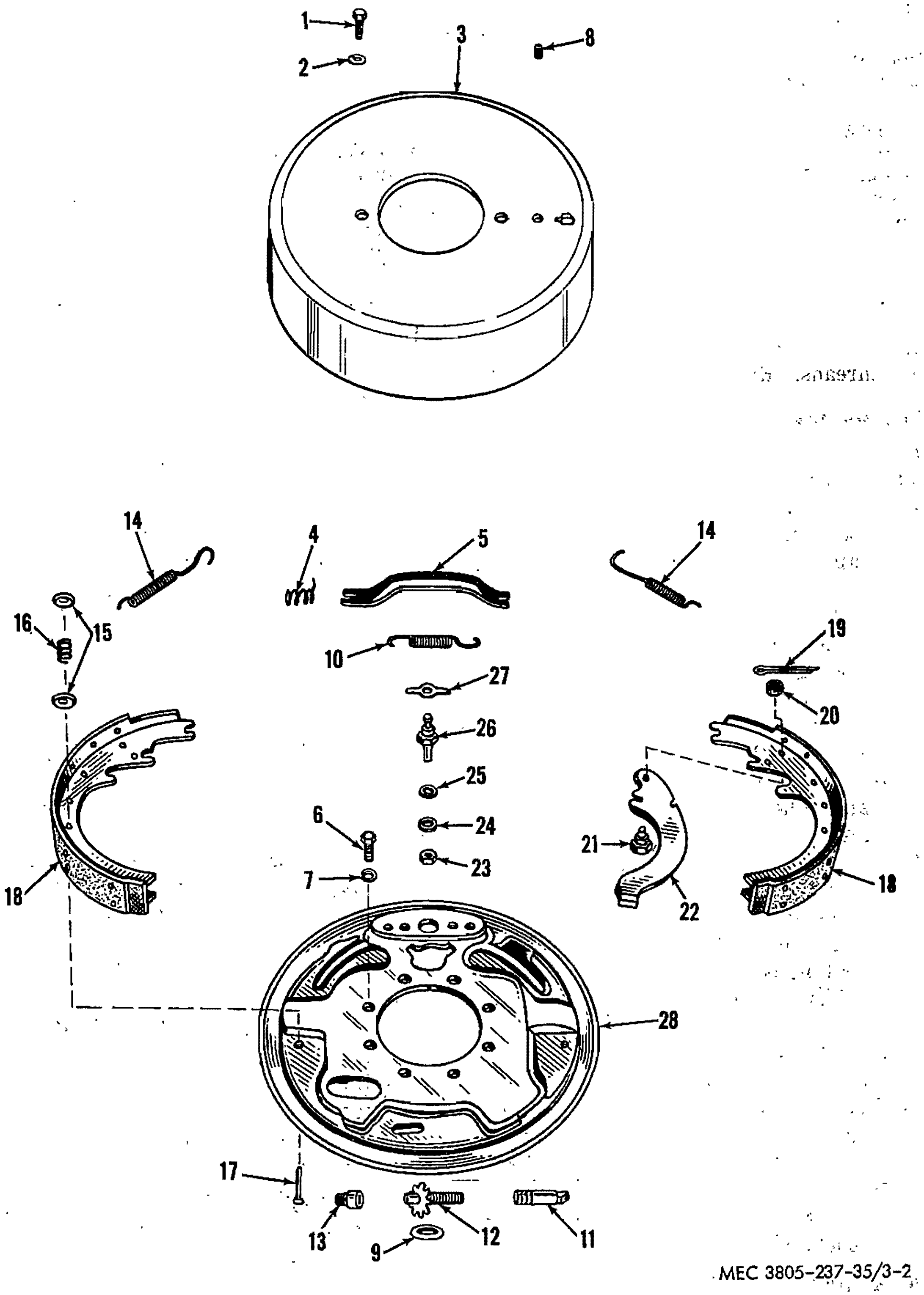



*Figure 3-2. Parking brake, exploded view.*

| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-hd, 1/2-13 × 3/4 in. (2) | 15 | Cup (4) |
| 2 | Washer, lock, 1/2 in .(2) | 16 | Spring (2) |
| 3 | Brake drum | 17 | Shoe hold-down pin |
| 4 | Spring | 18 | Brake shoe |
| 5 | Strut | 19 | Pin, cotter, 3/32 × 5/8 in. |
| 6 | Screw, cap, hex-hd, 3/8-16 × 1 in. (8) | 20 | Nut, slotted hex, 5/16-18 |
| 7 | Washer, lock, 3/8 in. (8) | 21 | Lever pin |
| 8 | Setscrew, socket-hd, 5/8-18 × 1/2 in. | 22 | Lever |
| 9 | Cover plug | 23 | Nut, hex |
| 10 | Adjusting screw spring | 24 | Washer, lock, 5/8 in |
| 11 | Pivot nut | 25 | Washer, flat, 5/8 in. |
| 12 | Adjusting screw | 26 | Anchor pin |
| 13 | Adjusting screw socket | 27 | Shoe guide plate |
| 14 | Anchor to shoe spring (2) | 28 | Backing plate |

*Figure 3-2*—Continued.

*g*. Inspect anchor pin and lever pin for damaged threads. Replace defective pins.

## 3-6. Reassembly

*a*. Insert spring end of cable into opening in backing plate from back of plate. Position abutment cap, which is part of cable, against backing plate. Install felt seal and remaining abutment cap and secure with two screws, lockwashers, and nuts.

*b*. Reassemble the brake in reverse of numerical sequence as illustrated on figure 3-2 and the following. Parts 1 through 7 of figure 3-2 will be installed when the brake in installed on the grader.

(1) When installing brake shoes, install the shoe on the side of the backing plate where the cable enters the plate.

(2) Assemble brake lever (22, fig. 3-2) to other shoe. Install cable into slotted end of brake lever. Bushing on end of cable must be located in recess in edges of slot. Ends of slot must be forced together to hold cable in place.

(3) Install the assembled lever and shoe on the backing plate.

(4) Assemble adjusting screw, nut, and socket prior to installation. Shorten screw as much as possible to facilitate installation.

(5) Adjusting screw must be over slot in backing plate.

## 3-7. Installation

*a*. Install backing plate assembly on adapter on front of lower transmission. Secure backing plate with screws (6, fig. 3-2) and lockwashers (7).

*b*. Expand shoes and install strut (5) and spring (4).

*c*. Refer to figure 3-1 and install brake drum. Place transmission in gear and torque locknut to a reading of 550 to 575 foot pounds.

*d*. Stake locknut.

*e*. Do not connect brake cable to bell crank until after brake adjustment has been performed.

## 3-8. Adjustment

*a*. Loosen hex nut (23, fig. 3-2) and remove adjusting slot cover (9).

*b*. Turn adjusting screw until shoes move out against drum. Tap around outside of drum to center brakes shoes.

*c*. Tighten nut on anchor pin. Loosen adjusting screw approximately 6 of 8 notches.

*d*. Remove setscrew (8, fig. 3-2) and turn drum as required to check clearance between brake lining and drum using a feeler gage inserted through the setscrew hole.

*e*. Clearance at upper ends of shoes must be .004 in. To adjust, loosen nut (23, fig. 3-2) on anchor pin and tap pin downward to increase clearance or upward to decrease clearance. Tighten nut after adjustment.

*f*. Turn adjusting screw (12, fig. 3-2) as required to obtain 0.008 in. clearance at lower ends of shoes.

*g*. Install adjustment slot cover.

*h*. Adjust cable and connect to bell crank (para 2-30).

## Section II. SHIFTING MECHANISM

### 3-9. General

This section covers the shifter mechanism and levers. The shifter levers, shifter lever universal balls, ball caps, and associated parts may be removed as an assembled group of parts and will be covered separately from the shifter housing, rocker shafts, rails, and forks.

### 3-10. Shifter Levers

*a. General.* The shifter levers permit the operator to select the desired transmission arrangement to meet the required conditions of operation. One lever controls the shifting of the upper transmission gears and the other controls the shifting of the lower transmission gears.

*b. Removal and Disassembly.* Refer to TM 5-3805-237-12 for removal and disassembly. To remove universal balls (19, fig. 3-3) from levers (20 and 21), press out pins (18).

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect boots and rubber cover for split or torn condition. Inspect for deterioration of material. Replace defective parts.

(2) Inspect metal parts for wear and damage. Replace defective parts.

(3) Inspect universal balls and pins for burs, gouges, or rough surfaces. Repair all damaged or rough surfaces.

*e. Reassembly and Installation.*

(1) Install universal ball (19, fig. 3-3) on lower or upper transmission lever (20 or 21). Support ball in a block with a matching radius.

(2) Lubricate pin (18) heavily and press pin into ball and lever until end of pin is flush with surface of universal ball. Check for free movement of ball or lever.

(3) Repeat procedure for other lever.

(4) Refer to TM 5-3805-237-12 and reassemble remainder of shift lever parts.

### 3-10. Shifter Mechanism

*a. General.* The shifter mechanism consists of the housing, rocker shaft and levers, shifter rails, and shifter forks. Shifter rails and forks are located in both the upper and lower transmission housings.

*b. Removal.*

(1) Refer to paragraph 2-30 and remove drive unit from frame.

(2) Refer to paragraph 3-2 and remove parking brake assembly.

(3) Remove upper transmission cover plates and gaskets by removing mounting screws, nuts, and lockwashers. Remove screws and lockwashers and remove lower transmission right side cover plate and gasket.

(4) Disassemble the shifter mechanism in numerical sequence as illustrated in figure 3-4. Front shifter fork (9) and rear shifter fork (10) are removed from upper transmission. Rear shifter fork (53) and front shifter fork (54) are removed from the lower transmission.

(5) Discard all gaskets and preformed packings.

*c. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

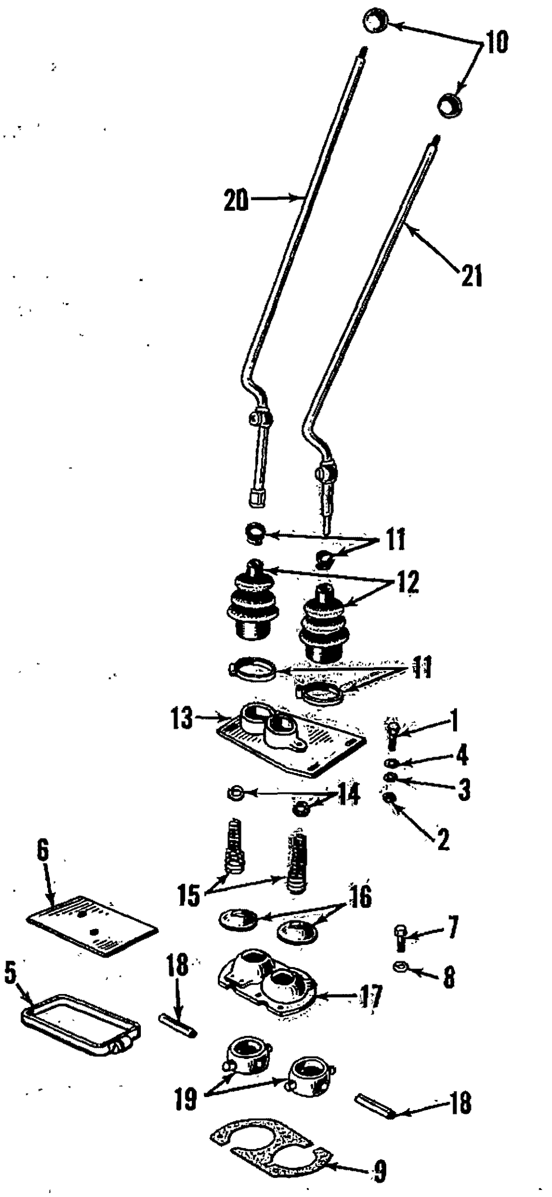
*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Replace all worn or damaged parts.

*e. Installation.*

(1) Install shifter mechanism parts in reverse of numerical sequence as illustrated in figure 3-4. The following additional instructions should be observed.




MEC 3805-237-35/3-3

Bolt, carriage, 3/8-16 × 1 1/4 in. (5)
Nut, hex, 3/8-16 (5)
Washer, lock, 3/8 in.
Washer, flat, 3/8 in.
Clamp
6 Rubber cover
7 Screw, cap (4)
8 Washer, lock (4)
9 Shim (4)
10 Ball (2)
11 Hose clamp (4)

*Figure 3-3. Transmission shifter levers, exploded view.*

12 Boot (2)
13 Cover plate
14 Retaining ring (2)
15 Cap spring (2)
16 Seal cap (2)
17 Ball cap
18 Pin (2)
19 Universal ball
20 Lower transmission lever
21 Upper transmission lever

*Figure 3-3*—Continued.

(2) Lubricate preformed packings and working surfaces of shafts and bushing before installation. Use shellac or gasket seal on all gaskets.

(3) When installing interference pins (47), the first pin must be installed round end first. Install biscuit (48) and then install second interference pin with round end of pin outward.

(4) Press or drive bushing (34) into housing (28) until bushing is flush with inside shoulder of housing. Leave shaft end mounting screws (35) loose until housing is installed.

(5) Place front and rear shifter forks in upper transmission and over shifter collars with long hubs of forks toward each other before installing rails.

*Note.* The prongs of the front (reverse) shifter fork (9), which is mounted on the upper shifter rail, are larger than the prongs on the lower shifter fork (10).

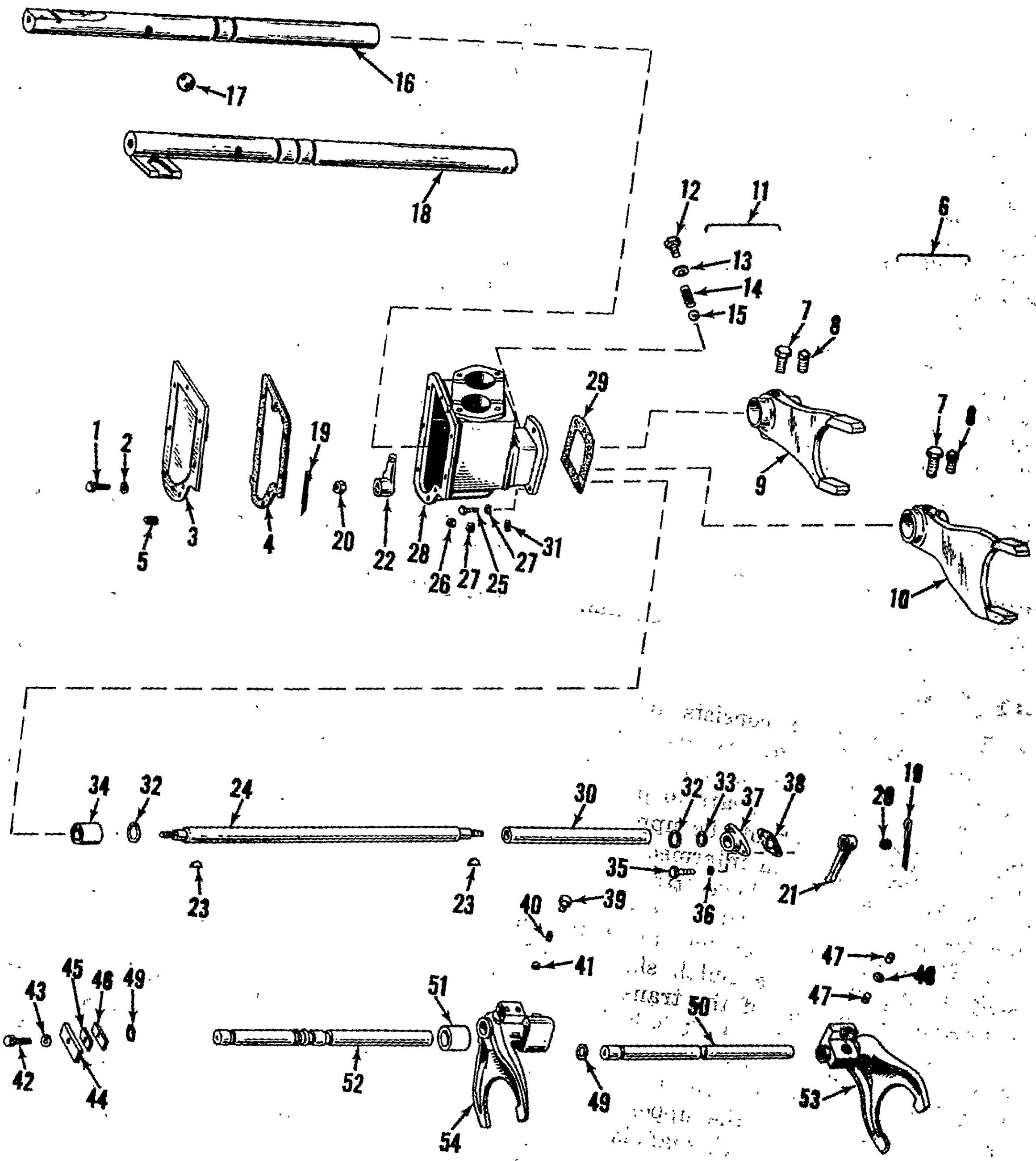
(6) Insert interlocking ball into vertical hole in upper rail opening in housing. Ball must be in neutral groove of lower rail before installation of upper rail.

(7) Turn shifter forks (9 and 10) until setscrew holes are alined. Install cap screws (7) and setscrews (8). Do not tighten cap screws. Tighten setscrews and then loosen 1/4 turn. Retighten setscrews to a torque of 65 foot pounds. Tighten cap screws and install locking wire.

(8) Install upper and lower transmission plates and gaskets

(9) Refer to paragraph 3-7 and install parking brake.

(10) Refer to paragraph 2-30 and install drive unit in frame.




1 Screw, cap, hex-hd, 3/8-16NC × 1 in. (8)
2 Washer, lock, 3/8 in. (8)
3 Cover plate
4 Gasket
5 Plug, pipe, sq-hd, magnetic
6 Lockwire
7 Screw, cap, drilled
8 Setscrew
9 Front shifter fork
10 Rear shifter fork
11 Lockwire
12 Poppet screw (4)
13 Gasket (4)
14 Spring (4)

*Figure 3-4. Shifter mechanism, exploded view.*

15 Ball (4)
16 Upper shifter rail
17 Interlock ball
18 Lower shifter rail
19 Pin, cotter, 1/8 × 1 1/4 in. (2)
20 Nut, lock (2)
21 Rocker lever
22 Rocker lever
23 Key, woodruff (2)
24 Rocker shaft
25 Screw, cap, hex-hd (3)
26 Nut, hex
27 Washer, lock, 3/8 in. (4)
28 Shifter housing
29 Gasket
30 Tube
31 Plug, pipe, magnetic
32 Preformed packing (2)
33 Preformed packing
34 Bushing
35 Screw, cap, hex-hd
36 Washer, lock
37 Shaft end
38 Gasket
39 Poppet cap screw
40 Poppet spring
41 Poppet ball
42 Screw, cap, hex-hd, 1/2-13 × 2 in.
43 Washer, lock, 1/2 in.
44 Clamp bar
45 Lock plate
46 Shim
47 Interference pin (2)
48 Interference biscuit
49 Preformed packing
50 Lower shifter rail
51 Stop
52 Upper shifter rail
53 Rear shifter fork
54 Front shifter fork

*Figure 3-4*—Continued.

## Section III. TRANSMISSION

### 3-12. General

*a.* The transmission consists of an upper transmission which contains gears for reverse and high and low speeds, and a lower transmission which contains gears to provide three speed ranges for each of the upper transmission arrangements. An intermediate plate encloses the front of the lower transmission and the rear of the upper transmission.

*b.* The upper shaft of the upper transmission is driven by the clutch shaft which is connected to the end of the transmission with a universal joint. The shaft is hollow and encloses the power take-off shaft which is supported by a bearing and bearing cage mounted on the front end of the upper transmission. Disassembly of the clutch shaft is covered with the clutch and the power take-off shaft and bearing cage is covered with the power box vertical drive.

### 3-13. Removal and Disassembly

*a. Preliminary Operations.*

(1) Refer to paragraph 2-30 and remove drive unit from frame.

(2) Refer to paragraph 2-31 and remove engine.

(3) Refer to paragraph 3-2 and remove parking brake assembly.

(4) Refer to TM 5-3805-237-12 and drain transmission.

(5) Refer to paragraph 3-11 and remove shifter mechanism.

*b. Upper Transmission Housing.*

(1) Remove upper transmission housing and external parts in the numerical sequence as illustrated in figure 3-5. Observe the following additional instructions.

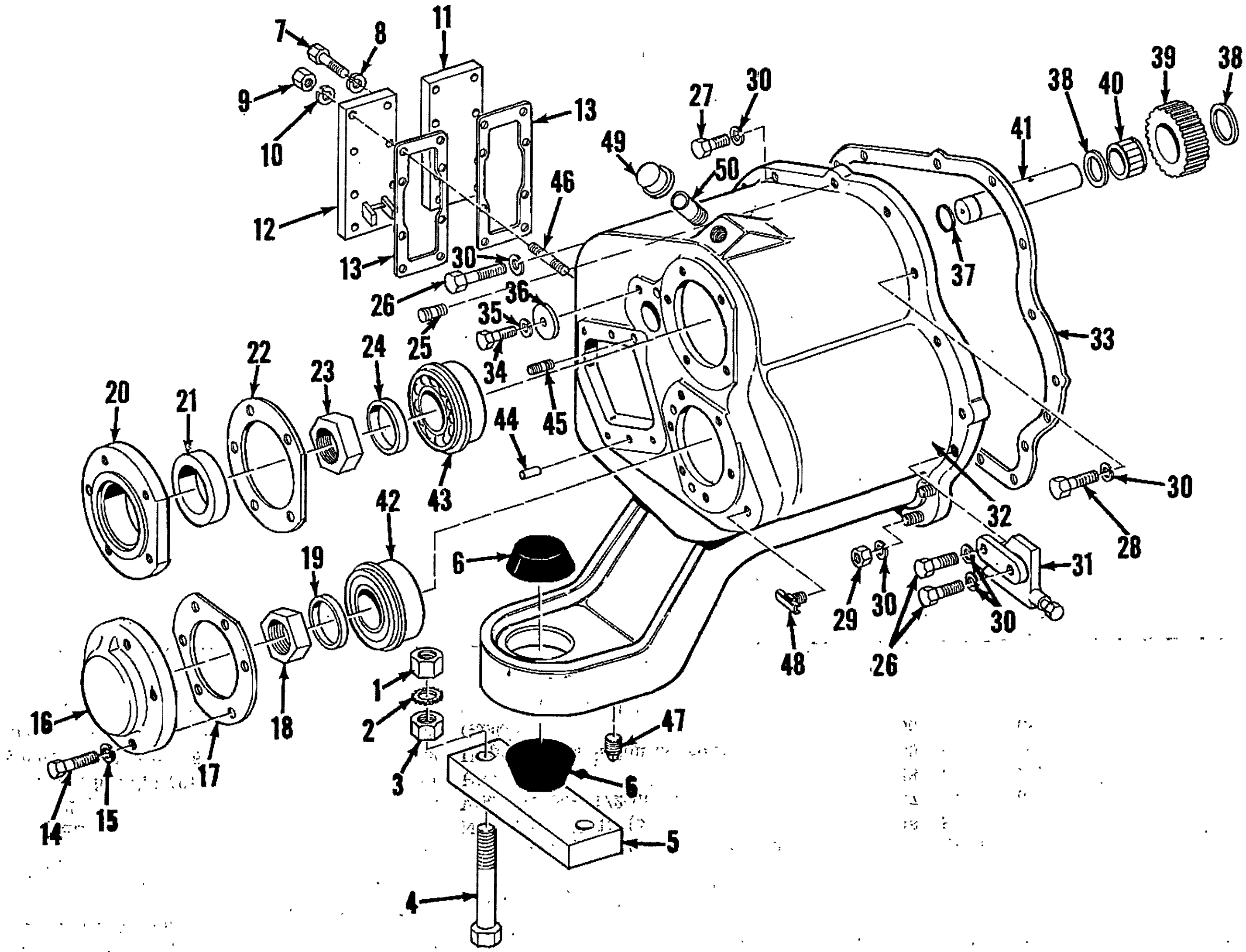
(2) Support bar and cover plates, index numbers 1 through 13, were previously removed.

(3) To remove shaft locknuts (18 and 23) drill out staked portion and using bar, shift transmission into two gears to lock transmission. Upper shaft nut is torqued to between 550 and 575 foot pounds and lower shaft nut to between 300 and 325 foot pounds.

*Caution:* **Remove all of staked material to prevent damage to shaft when shaft lock nut is removed.**

(4) Install a nut on dowel pin (25) to facilitate removal.

(5) Install puller bolts on opposite sides of each bearing (upper and lower shaft). Attach pullers to puller bolts and pull housing. Bearings




MEC 3805-237-35/3-5

*Figure 3-5. Upper transmission housing, exploded view.*

1 Nut, hex jam, 1–14 (2)
2 Washer, lock, 1 in.
3 Nut, hex, 1–14 (2)
4 Bolt (2)
5 Bar
6 Support biscuit
7 Screw, cap, hex-hd (13)
8 Washer, lock, 3/8 in. (13)
9 Nut, hex (3)
10 Washer, lock, 3/8 in. (3)
11 Cover plate
12 Cover plate
13 Gasket (2)
14 Screw, cap, hex-hd (6)
15 Washer, lock, 1/2 in. (6)
16 Bearing cap
17 Gasket
18 Lock nut
19 Spacer
20 Seal retainer
21 Seal
22 Gasket
23 Lock nut
24 Seal collar
25 Dowel pin
26 Screw, cap, hex-hd (6)
27 Screw, cap, hex-hd, 1/2-13 × 4-1/2 in.
28 Screw, cap, hex-hd, 1/2-13 × 2 in. (4)
29 Nut, hex, 1/2-13 (5)
30 Washer, lock, 1/2 in. (16)
31 Pivot plate
32 Upper transmission housing
33 Gasket
34 Screw, cap, hex-hd
35 Washer, lock, 1/2 in.
36 Washer
37 Preformed packing
38 Spacer (2)
39 Reverse idler gear
40 Bearing
41 Shaft
42 Bearing
43 Bearing
44 Dowel pin (2)
45 Stud
46 Stud
47 Plug, pipe
48 Drain cock
49 Cap, pipe
50 Nipple, pipe

*Figure 3–5*—Continued.

will come with housing leaving shafts and gears in place.

*Note.* Pull on both pullers equally.

(6) Press out bearings (42 and 43). Do not remove retaining rings.

(7) Discard gaskets, seals, and preformed packings.

c. *Upper Transmission Shafts and Gears.*

(1) Remove shafts and assembled gears from intermediate plate and disassemble in the numerical sequence as illustrated in figure 3-6. Observe the following additional instructions.

(2) Use a gear puller to remove bearing races from shafts.

(3) A specially designed tool (Table 2-2) may be fabricated to aid in removing and installing retaining rings.

d. *Intermediate Plate.*

(1) Remove and disassemble intermediate plate and lower transmission shaft external parts in numerical sequence as illustrated in figure 3-7. Observe the following additional instructions.

(2) Drill out staked material from upper shaft locknut and shift transmission into two gears to lock transmission prior to removing nut. Nut is torqued to 550 to 575 foot pounds. Lower shaft nut was removed with parking brake.

*Caution:* **Remove all staked material to prevent damage to shaft when locknut is removed.**

(3) To remove bearing cage (12) install cap screws into puller holes in cage and use a puller to remove the cage.

*Caution:* **If shaft is not held back in transmission during removal of bearing cage, the oil flinger will be damaged.**

(4) Install nuts on dowel pins to facilitate removal.

(5) To remove intermediate plate from lower transmission housing, install nuts on studs on opposite sides of bearing and attach a puller to the nuts.

e. *Lower Transmission Shafts and Gears.*

(1) Remove oil flinger (1, fig. 3-8) from lower shaft. Lift assembled upper shaft from housing then remove assembled lower shaft. Upper shaft bearing and lower shaft bearing race will remain in housing.

(2) Disassemble upper and lower shafts in numerical sequence as illustrated in figure 3-8.

(3) Use a puller to remove gear bearing and bearing inner race from spiral pinion shaft.

f. *Transmission Housing and Engine Supports.*

(1) Remove lower transmission housing and engine supports in numerical sequence as illustrated in figure 3-9.

(2) Cover plate (4) was removed with shifter mechanism.

(3) Discard all gaskets.

## 3-14. Cleaning

a. Remove all accumulated grease and dirt from transmission housings, gears, and shafts.

b. Clean all parts in cleaning compound, solvent (Spec P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

## 3-15. Inspection and Repair

a. Inspect all parts for wear or damage. Check gear teeth and splines for chipped or broken condition. Replace all defective parts.

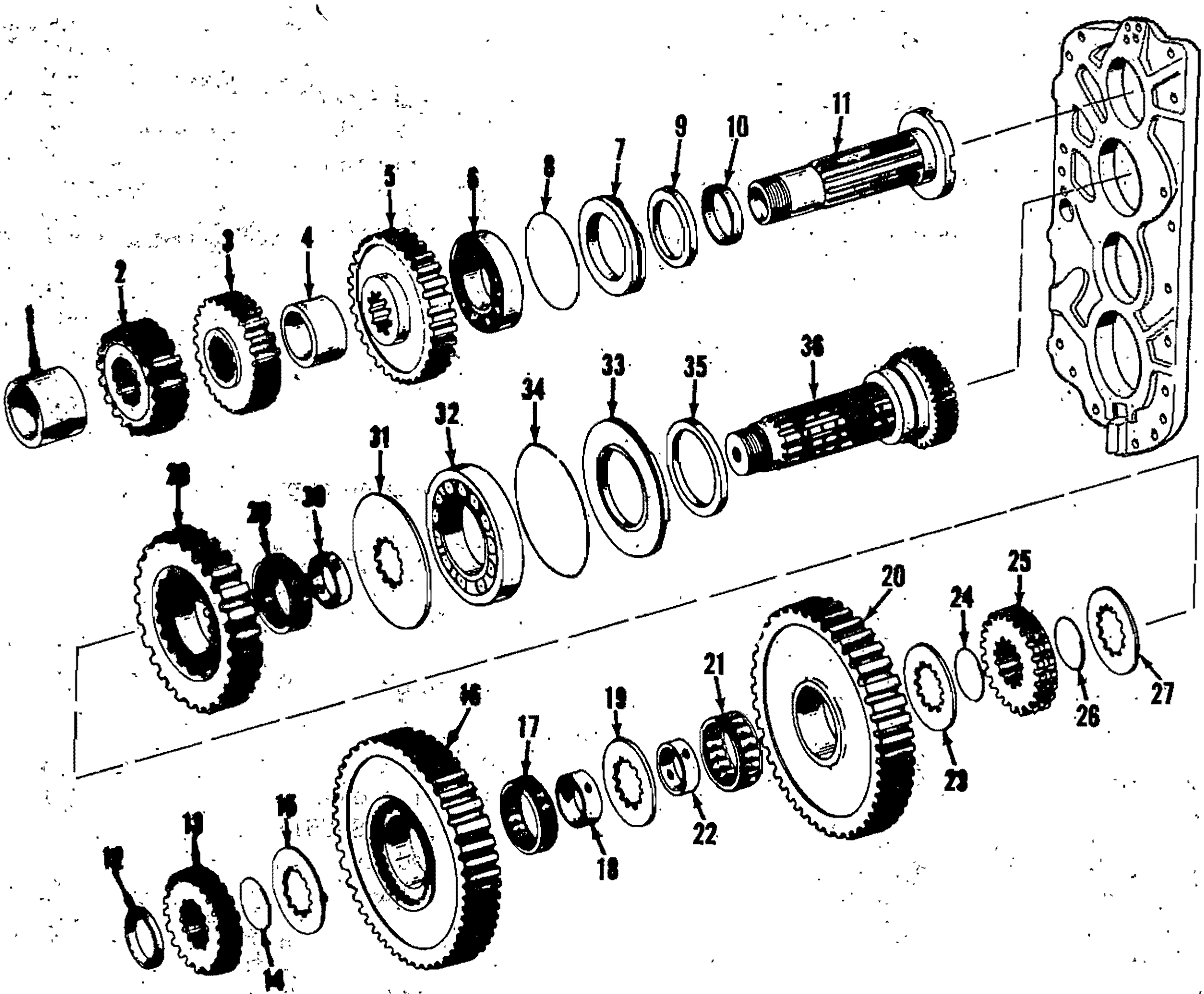
b. Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair or replacement standards.

## 3-16. Reassembly and Installation

a. *Transmission Housing and Engine Supports.*

(1) Install lower transmission housing in reverse of numerical sequence as illustrated in figure 3-9. Observe the following additional instructions.

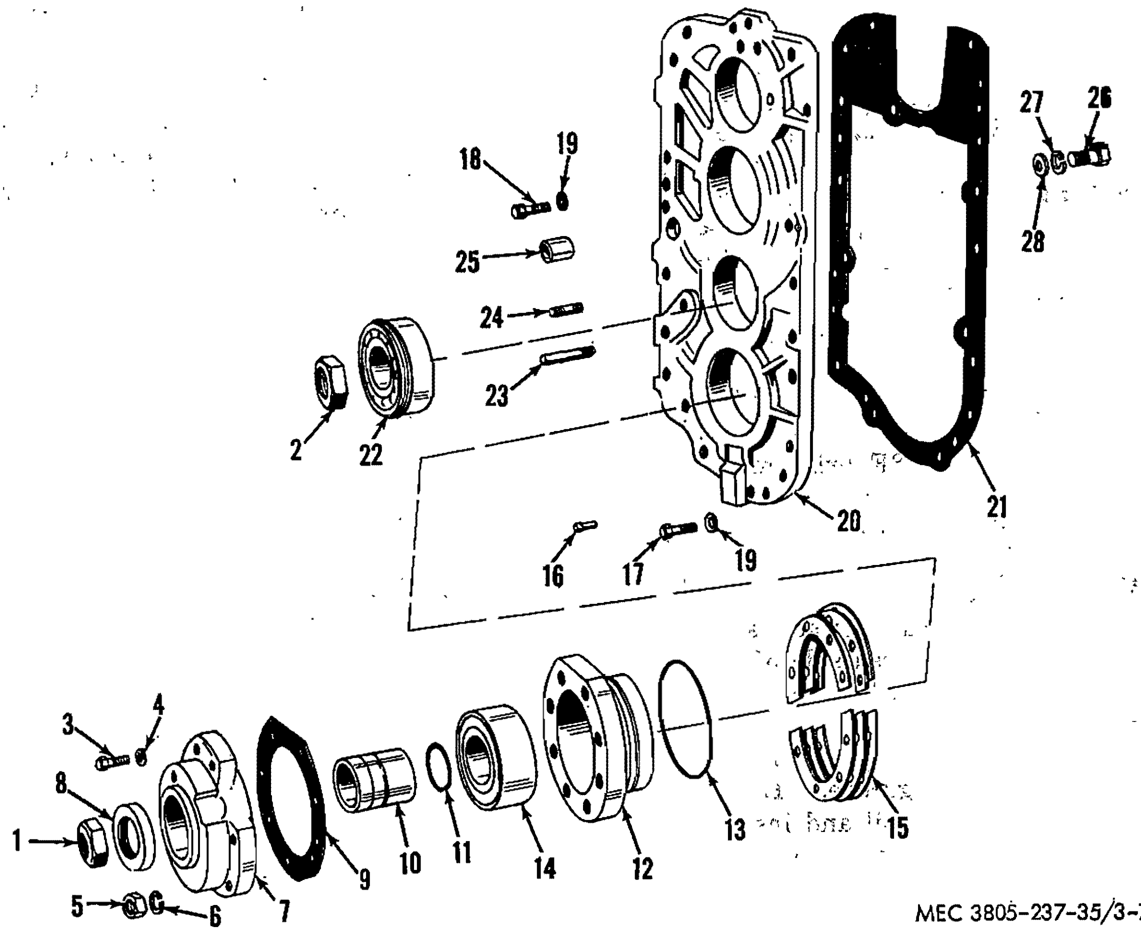
(2) Press or drive bearing (24) and bearing race (26) against retaining rings in housing. Bearing race




MEC 3805-237-35/3-6

1 Spacer
2 Reverse driver gear
3 Low driver gear
4 Spacer
5 High driver gear
6 Bearing
7 Seal retainer
8 Preformed packing
9 Grease seal
10 Seal collar
11 Upper shaft
12 Spacer
13 Shifter gear
14 Retaining ring
15 Spacer
16 Reverse driven gear
17 Bearing
18 Bearing race
19 Spacer
20 Low driven gear
21 Bearing
22 Bearing race
23 Spacer
24 Retaining ring
25 Shifter gear
26 Retaining ring
27 Spacer
28 High driven gear
29 Bearing
30 Bearing race
31 Spacer
32 Bearing
33 Seal retainer
34 Preformed packing
35 Grease seal
36 Gear and shaft

*Figure 3-6. Upper transmission shafts and gears, exploded view.*




| | | | |
|---|---|---|---|
| 1 | Lock nut | 15 | Shims |
| 2 | Lock nut | 16 | Dowel pin |
| 3 | Screw, cap, hex-hd, 1/2-13 × 1 1/2 in. (2) | 17 | Screw, cap, hex-hd, 1/2-13 × 2 1/2 in. (4) |
| 4 | Washer, lock, 1/2 in. (2) | 18 | Screw, cap, hex-hd, 1/2-13 × 2 in. (11) |
| 5 | Nut, hex, 1/2-13 (6) | 19 | Washer, lock, 1/2 in. (15) |
| 6 | Washer, lock, 1/2 in. (6) | 20 | Intermediate plate |
| 7 | Backing plate adapter | 21 | Gasket |
| 8 | Grease seal | 22 | Bearing |
| 9 | Gasket | 23 | Stud |
| 10 | Spacer | 24 | Stud |
| 11 | Preformed packing | 25 | Bushing |
| 12 | Bearing cage | 26 | Screw, cap, hex-hd, 3/8-16 × 1 in. (2) |
| 13 | Preformed packing | 27 | Washer, lock, 3/8 in. (2) |
| 14 | Bearing | 28 | Washer (2) |

*Figure 3-7. Intermediate plate, exploded view.*

(26) must be flush or within the wall of the housing.

(3) Use shellac or gasket seal on all gaskets.

(4) Do not install cover plate on right side until shifters have been installed.

(5) When mounting lower transmission

housing on final drive housing, install mounting screws and lockwashers but do not tighten fully. Drive in dowel pins using nuts on pins to prevent damage to threads. Torque mounting screws to 190 foot pounds.

*b. Lower Transmission Shafts and Gears.*

(1) Reassemble lower transmission shafts and gears in reverse of numerical sequence as illustrated in figure 3-8 prior to installation in housing. Observe the following additional instructions.

(2) Heat bearing (30), bearing races (17 and 27), and bearing with race (11) in oil to 350°F prior to installation. Hold in place until set. Radius of bearing (30) must be against spiral pinion.

(3) Install shifter gear (14) with counterbore away from second gear (15). Chamfered side of spacer (13) must be toward shifter gear.

(4) Install first gear (7) on upper shaft with chamfered end toward retaining ring groove. Heat bearing sleeve (6) in oil and install on shaft with chamfered side toward gear.

(5) Install both shafts in housing before installing oil flinger (1). Install flinger on shaft with long end of hub toward threaded end of shaft and with square slot in hub over head of pin (2) in shaft.

*c. Intermediate Plate.*

(1) Install intermediate plate and lower transmission shaft parts in reverse of numerical sequence as illustrated in figure 3-7. Observe the following additional instructions.

(2) Lubricate preformed packings before installation. Use shellac or gasket seal on all gaskets.

(3) When installing intermediate plate on lower transmission, aline dowel pin holes and install mounting cap screws and lockwashers. Do not tighten screws. Install nut on dowel pin to prevent damage to threads and drive pin through intermediate plate into lower transmission housing. Remove nut. Tighten cap screws to a torque reading of 190 foot pounds.

(4) Drive bearing (22) over upper shaft of lower transmission and into intermediate plate with open ends of retaining ring alined with oil hole in plate.

(5) Install preformed packing (13) on bearing cage (12) and install bearing cage in intermediate plate. Do not install shims (15) until pinion depth adjustment has been preformed (*d* below). Place a block of wood between spiral pinion and ball pinion in final drive housing. Drive bearing (14) into bearing cage.

(6) Press grease seal (8) into backing plate adapter (7) with lip of seal away from hub of adapter. Install adapter on bearing cage. Install spacer with preformed packing end of spacer next to bearing.

(7) Install nut (2) on upper shaft. Shift transmission into two gears and tighten nut to a torque of 550 to 575 foot pounds. Stake nut.

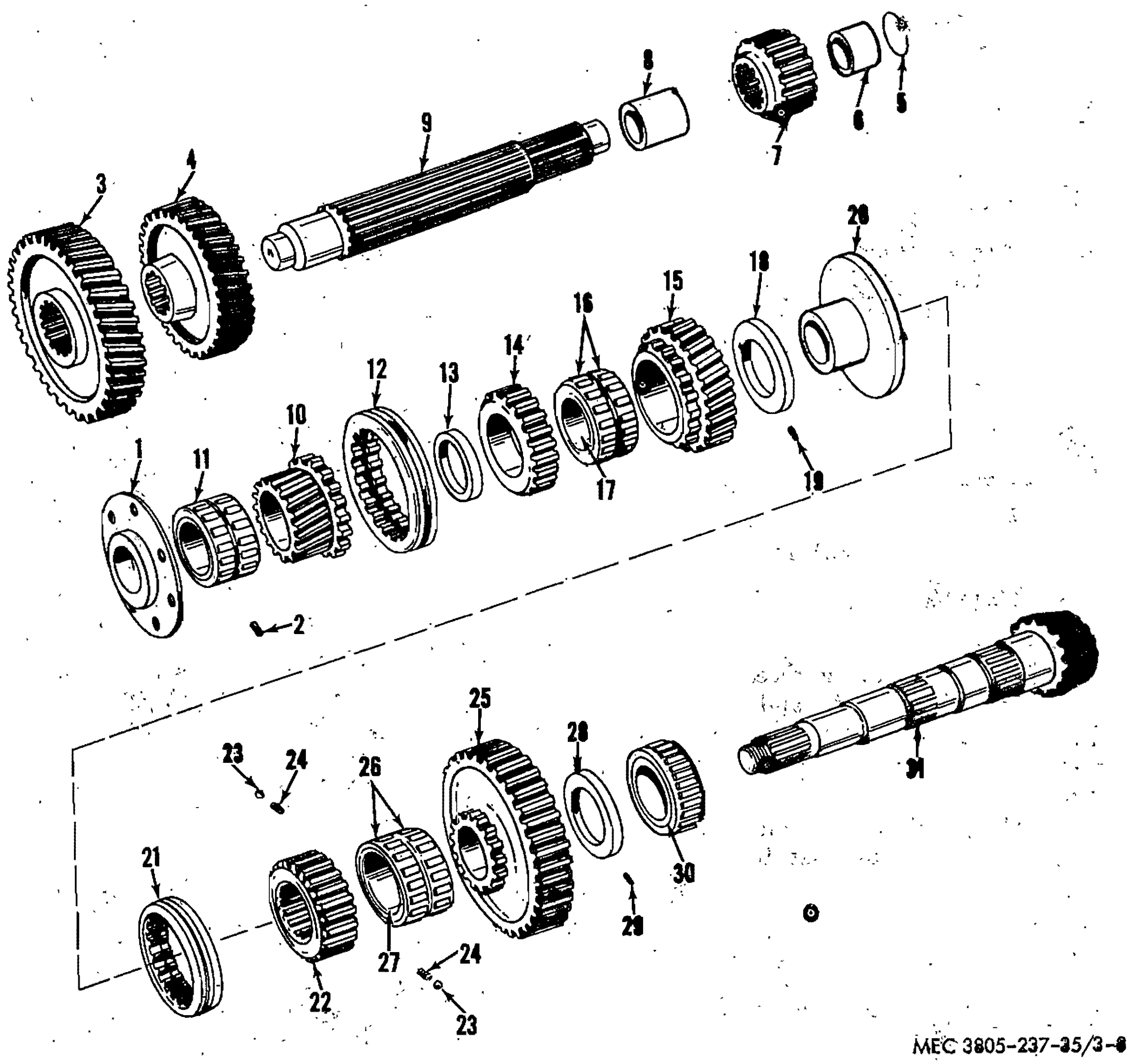
(8) Lower shaft locknut will be installed after parking brake is installed. Refer to *d*. below for pinion shaft depth adjustment and installation of shims.

*d. Spiral Pinion Shaft Depth Adjustment.*

(1) Install brake drum on lower transmission shaft. Install locknut (1, fig. 3-7) and tighten to a torque reading of 550 to 575 foot pounds. Do not stake nut.

(2) Insert a gauge block 1.325 to 1.330 inch long between spiral pinion and the spacer which is between the spiral ring gear and bull pinion jack shaft on the final drive (fig. 3-10).

(3) Using a block of wood, drive front end of spiral pinion shaft back in the lower transmission until face of pinion is against the gage block.




1 Oil flinger
2 Pin
3 Third gear
4 Second gear
5 Retaining ring
6 Bearing sleeve
7 First gear
8 Spacer
9 Upper shaft
10 Third gear
11 Bearing
12 Shifter collar
13 Spacer
14 Shifter gear
15 Second gear
16 Roller assembly
17 Inner race
18 Spacer
19 Pin
20 Spacer
21 Shifter collar
22 Shifter gear
23 Poppet
24 Poppet spring
25 First gear
26 Roller assembly
27 Inner race
28 Spacer
29 Pin
30 Bearing
31 Spiral pinion shaft

*Figure 3-8. Lower transmission shafts and gears, exploded view.*

(4) Check gap between bearing cage (12, fig. 3-7) and intermediate plate (20).

(5) Install shims (15, fig. 3-7) as required to equal gap measurement. Tighten bearing cage stud nuts to a torque of 65 foot pounds.

(6) Recheck pinion depth setting. Shift gears into neutral.

*e. Upper Transmission Shafts and Gears.*

(1) Assemble upper transmission shafts and gears in reverse of numerical sequence as illustrated in figure 3-6. Observe the following additional instructions.

(2) Press oil seal (35) into seal retainer with lip of seal away from milled surface of retainer. Install retainer on lower shaft (36) with milled surface toward gear.

(3) Heat bearing (32) in oil and install on hub of shaft with large radius of bearing toward gear. Install spacer (31) with shoulder toward bearing.

(4) To install bearing races (18, 22 and 30), heat in oil and install with chamfer on race toward adjacent spacer. Hold in place until set.

(5) A specially designed tool (Table 2-2) may be used to aid in installing retaining rings past the grooves in the shaft.

(6) Make a chalk mark on front of intermediate plate at bearing bore for lower shaft. Mark to be in line with retainer lock on rear of intermediate plate. Aline milled surface of seal retainer with mark and insert shaft assembly. Bump end of shaft until milled surface of retainer is against the retainer lock.

(7) Press oil seal (9) into retainer (7) with lip of oil seal away from milled surface of retainer.

(8) Heat grease seal collar (10) in oil and install collar on shaft with chamfered edge of collar away from threaded end of shaft. Hold collar in position until set.

(9) Install oil seal and retainer on spacer with milled surface of retainer away from threaded end of shaft.

(10) Heat bearing (6) in oil and install on shaft with sleeve of bearing away from retainer. Hold bearing until set.

(11) Install high driver gear on shaft with long hub of gear toward threaded end of shaft.

(12) After gears have been installed on shaft, install spacer (1) with recess in spacer toward reverse driver gear (2).

(13) Install upper shaft assembly into intermediate plate; milled surface on oil seal retainer must be in upward position. Bump end of shaft until milled surface of seal retainer is against retainer lock on back of intermediate plate. Lock will prevent retainer from rotating in bore.

*f. Upper Transmission Housing.*

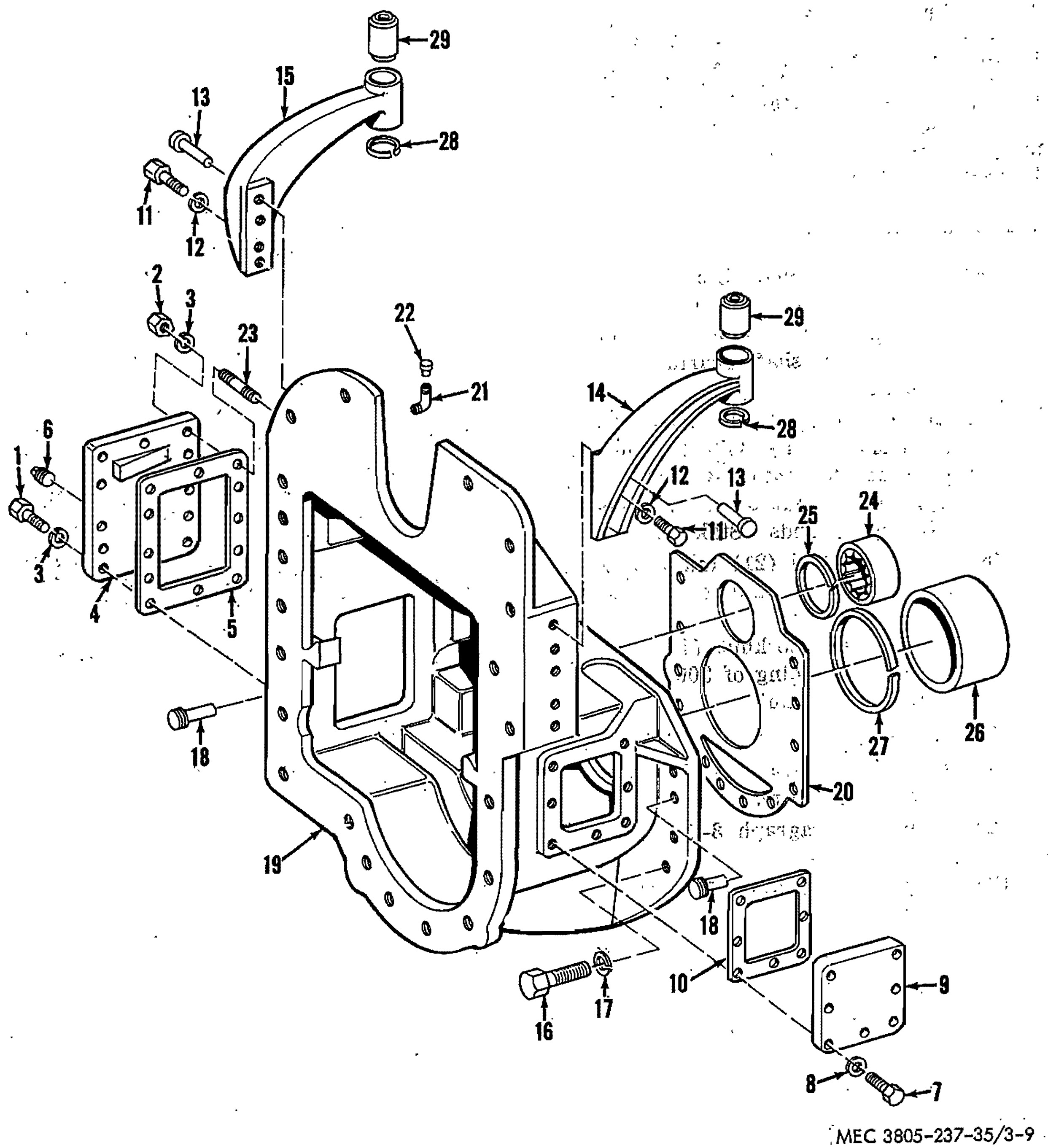
(1) Reassemble and install upper transmission housing in reverse of numerical sequence as illustrated in figure 3-5. Support bar and mounting bolts (1 through 6) will be installed when drive unit is installed in frame. Observe the following additional instructions.

(2) Use shellac or gasket seal on all gaskets.

(3) Install reverse idler gear in housing with hub of gear toward front of housing. Do not install shaft bearings (42 and 43) until housing has been installed on intermediate plate.

(4) Install housing gasket, housing, mounting cap screws, stud nuts, and lockwashers. Do not tighten screws and nuts. Pivot plate (31) is attached with housing mounting cap screws. Do not tighten cap screws and nuts.

(5) Install nut on dowel pin (25) and drive pin through housing into intermediate plate. Remove nut from dowel pin. Tighten housing mounting cap screws and nuts.




1 Screw, cap, hex-hd, 3/8-16 × 1 in. (9)
2 Nut, hex, 3/8-24
3 Washer, lock, 3/8 in. (10)
4 Cover plate
5 Gasket
6 Plug, pipe
7 Screw, cap, hex-hd, 3/8-16 × 1 in. (8)
8 Washer, lock, 3/8 in. (8)
9 Cover plate
10 Gasket

*Figure 3-9. Lower transmission housing and engine supports, exploded view.*

11 Screw, cap, hex-hd, 5/8-11 × 1 7/8 (6)
12 Washer, lock, 5/8 in. (6)
13 Dowel pin (4)
14 Left-hand engine mount
15 Right-hand engine mount
16 Screw, cap, hex-hd, 3/4-10 × 2 1/2 in. (10)
17 Washer, lock, 3/4 in. (10)
18 Dowel pin
19 Lower transmission housing
20 Gasket
21 Elbow
22 Breather
23 Stud
24 Bearing
25 Retaining ring
26 Bearing race
27 Retaining ring
28 Retaining ring (2)
29 Tubular support

*Figure 3-9*—Continued.

(6) Drive lower shaft bearing (42) on shaft and into housing bore until retaining ring is against housing. Drive upper shaft bearing (43) into housing.

(7) Install seal collar (24) with chamfer of collar toward shaft locknut. Shift transmission into two gears and tighten lock nut to between 550 and 575 foot pounds. Stake nut.

(8) Lip of oil seal (21) must be toward bearing when retainer and seal are installed on shaft.

(9) Torque shaft locknut (18) on lower shaft to a reading of 300 to 325 foot pounds. Stake nut.

*g. Reassembly of Grader.*

(1) Refer to paragraph 3-11 and install shifter mechanism.

(2) Refer to paragraph 3-7 and install parking brake.

(3) Refer to paragraph 2-31 and install engine.

(4) Refer to paragraph 2-30 and install drive unit in frame.

(5) Refer to TM 5-3805-237-12 and fill transmission with lubricant.

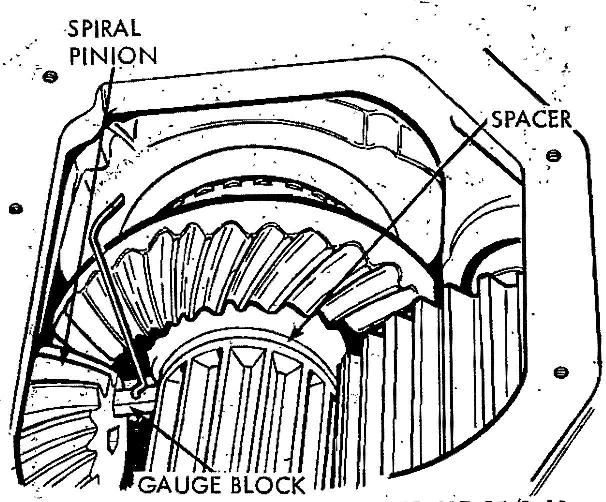



*Figure 3-10. Checking transmission pinion shaft depth.*

# CHAPTER 4
# TANDEM ASSEMBLIES AND FINAL DRIVE
# REPAIR INSTRUCTIONS

## Section I. TANDEM ASSEMBLIES

### 4-1. General

*a.* The tandem assemblies consist of the rear wheel axles, bearings, axle housings, sprockets, and driving chains. The sprockets and chains are enclosed in the tandem housings mounted on the sides of the drive unit. The wheel axles and sprockets are located at the front and rear of the tandem housing and are supported by eccentric housings. The eccentric housings may be rotated to change the tension on the drive chain.

*b.* The tandems can be repaired without removal from the grader. The instructions in this section cover removal and complete overhaul.

*c.* The left and right tandem assemblies are mounted on opposite sides and are otherwise identical. To avoid repetition only one assembly is covered in detail in this section.

*d.* The tandem front and rear axles and related parts are identical except the bearing outer eccentric housings and the driven axles. The front bearing outer eccentric housing is drilled and tapped for the brake backing plate mounting screws. Two separate chains drive the front and rear axles from sprockets mounted on a shaft at the center of the tandem. For this reason the sprockets are located in different relative positions on the front and rear axles.

### 4-2. Removal

*a.* Jack up side of grader and support grader with blocks under frame.

*b.* Refer to TM 5-3805-237-12 and remove wheels.

*c.* Disconnect hydraulic brake line from brake. Remove brake backing plate assembly by removing the screws and lockwashers securing brake backing plate assembly to front eccentric bearing housing.

*d.* Drain tandem. Refer to current Lubrication Order.

*e.* Remove screws (4, fig. 4-1), lockwashers (5), cover plate (6), and gasket (7) from center opening in side of tandem housing.

*f.* Remove lockwire (1, fig. 4-3) cap screws (2), and axle bolting plate (3). Remove screws (4) and lockwashers (5) attaching axle inner carrier to tandem housing.

*g.* Using a hoist and blocks, move tandem assembly away from grader. Drive sprocket (6, fig. 4-3) will remain in tandem.

*h.* Removal procedures are the same for tandem assembly on opposite side of grader.

### 4-3. Disassembly

*a.* Disassemble the tandem assembly in numerical sequence as illustrated in figure 4-1. Index numbers 1 through 7 were removed during removal of tandem. Observe the following additional instructions.

*b.* To remove top port hole cover plates (8 and 9), loosen captive nuts and slide covers to one side to release end of lower plate.

*c.* Remove drive sprocket (6, fig. 4-3) after chains have been uncoupled.

*d.* Bearing cup (27, fig. 4-1) may be driven out of the eccentric bearing housing (22) with a rod or drift inserted through pipe plug holes in bore of housing.

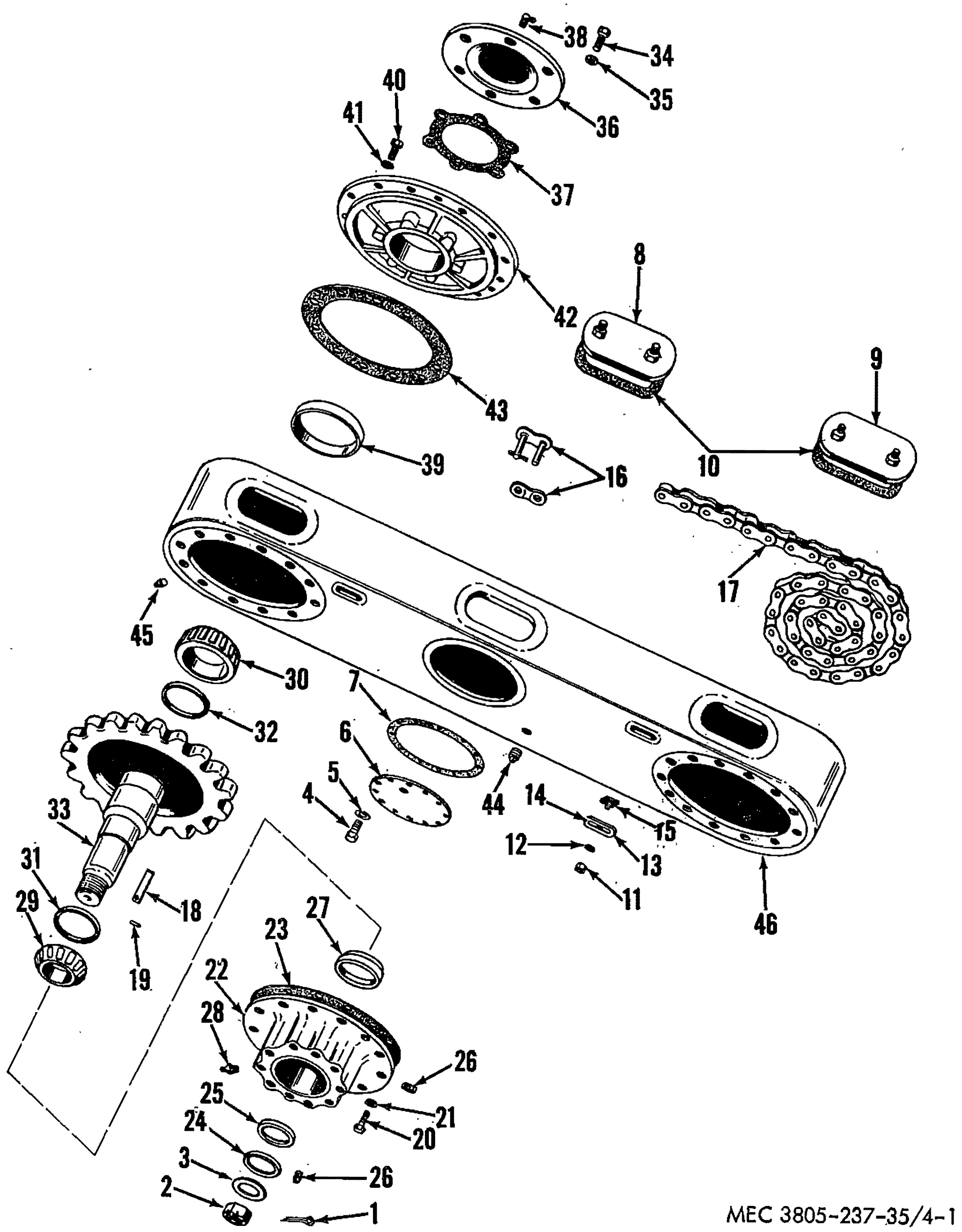



*Figure 4-1. Tandem assembly, exploded view.*

1 Pin, cotter (2)
2 Nut (2)
3 Washer (2)
4 Screw, cap, hex-hd, 1/2-13 × 3/4 in. (12
5 Washer, lock, 1/2 in. (12)
6 Cover plate
7 Gasket
8 Port hole cover
9 Port hole cover (2)
10 Gasket (3)
11 Nut, hex, 3/8-16 (4)
12 Washer, lock, 3/8 in. (4)
13 Cap (4)
14 Gasket (4)
15 Cap clamp (4)
16 Coupling link (2)
17 Chain (2)
18 Key (2)
19 Spring pin (4)
20 Screw, cap, hex-hd, 1/2-13 × 1 1/2 in. (24)
21 Washer, lock, 1/2 in. (24)
22 Eccentric bearing housing (2)
23 Gasket (2)
24 Grease seal (2)
25 Grease seal (2)
26 Plug pipe (8)
27 Bearing cup (2)
28 Lubricating fitting (2)
29 Bearing cone and rollers (2)
30 Bearing cone and rollers (2)
31 Grease seal (2)
32 Grease seal (2)
33 Driven axle
34 Screw, cap, hex-hd, 1/2-13 × 1 1/2 in. (12)
35 Washer, lock, 1/2 in. (12)
36 Hub cap (2)
37 Shim
38 Lubrication fitting (2)
39 Bearing cup (2)
40 Screw, cap, hex-hd, 1/2-13 × 1 1/2 in. (24)
41 Washer, lock, 1/2 in. (24)
42 Inner eccentric bearing housing
43 Gasket
44 Plug, pipe (2)
45 Tandem housing

*Figure 4-1*—Continued.

*e.* Use a puller to remove bearing cones and rollers (29 and 30) from driven axle (33).

*f.* Repeat the front axle disassembly procedures for the rear axle.

*g.* Disassemble the other tandem assembly following the procedures described in *a.* through *f.* above.

*h.* Discard all gaskets and seals.

## 4-4. Cleaning

*a.* Remove all dirt and grease from exterior of housings.

*b.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

## 4-5. Inspection and Repair

*a.* Inspect all parts for wear and damage. Replace damaged or worn parts.

*b.* Check bearings thoroughly for tight spots, galling, and wear. Replace defective bearings.

*c.* Check bearings and shafts for evidence of seizing or scoring. Replace defective parts.

## 4-6. Reassembly

*a.* Reassemble tandem assembly in reverse of numerical sequence as illustrated in figure 4-1. Observe the following additional instructions.

*b.* Use shellac or gasket seal on all gaskets. Use new seals, gaskets, and preformed packings. Lubricate seals and packings prior to installation.

*c.* After reassembly of the front axle and housing in the tandem housing, reassemble the rear axle in the same manner. The parts are identical except the sprocket on the front shaft is closed to the inner end and the outer eccentric bearing housing is drilled and tapped for mounting the brake.

*d.* Press or drive seals (31 and 32) in place on the driven axle (33). Heat bearing cones and rollers (29 and 30) in oil to 350°F and install on axle. Hold bearing cones and rollers in place until set.

*e.* Do not install bearing cup (39) and hub cap (36) until axle and housings have been reassembled.

*f.* Install grease seal (25) in housing with lip toward inside of tandem. Install grease seal (24) with casing next to first seal. Install bearing cup (27) with narrow edge inward.

*g.* When installing eccentric housings (22 and 42), notches on housings should be toward center of tandem and one bolt hole above horizontal centerline of tandem.

*h.* After installation of shaft and housings, drive bearing cup (39) into inner eccentric bearing housing, narrow edge first.

*i.* To pre-load bearings, install hub cap (36) without shims (37). Install cap screws and tighten evenly until a slight drag is placed on bearings when sprocket is turned by hand. Measure gap between hub cap and inner eccentric bearing housing using a feeler gauge or shims to determine the number of shims to be installed. Add shims as required to fill gap. This will provide a 0.005 in. to 0.010 in. preload. Install shims and hub cap.

*j.* Install drive sprocket (6, fig. 4-3) in center opening with large hub of sprocket toward final drive.

*k.* Install chains with cotter pins of front chain inward and cotter pins of rear chain outward. Pull chains through tandem and around sprockets using a soft wire. Install coupling links.

*l.* Torque port hole cover nuts to 25 to 30 foot pounds.

*m.* Repeat the above procedures and assemble the other tandem.

## 4-7. Installation

*a.* Coat mating surfaces of tandem and axle inner carrier with shellac. Slide tandem on carrier using studs to pilot tandem into place. Position sprocket so drive shaft splines will be alined.

*b.* Install screws (4, fig. 4-3) and lockwashers (5) to secure axle inner carrier to tandem. Install bolting plate (3) and screws (2) on end of shaft. Secure screws with lockwire.

*c.* Install screws (4, fig. 4-1), lockwashers (5), cover plate (6), and gasket (7).

*d.* Adjust the tandem drive chains by rotating the inner and outer eccentric housings in the direction shown by arrows in figure 4-2 until chains are tight. Loosen chain, moving the housings to nearest set of bolting holes. Notches in front and rear and inner and outer housings must be in same relative positions so tandem will mount in a level position on the grader and axle bearings and sprockets will be properly alined. Adjust chains on both tandems.

*e.* After adjustment install capscrews and lockwashers and tighten screws.

*f.* Refer to current Lubrication Order and lubricate tandems.

*g.* Install brake backing plate, mounting screws and lockwashers. Connect hydraulic lines and bleed system.

*h.* Refer to TM 5-3805-237-12 and install wheels.

*i.* Remove blocking.

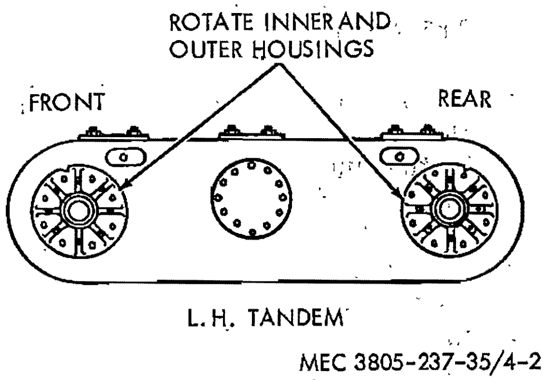



*Figure 4-2. Drive chain adjustment.*

# Section II. FINAL DRIVE

## 4-8. General

*a.* The final drive is driven by the transmission output spiral bevel pinion and in turn drives the chain sprockets in the tandem assemblies.

*b.* The final drive consists of a spiral bevel ring gear which mounts on a bull pinion shaft and a bull gear which is splined to the two drive axles. The drive axles are located in axle carrier assemblies mounted on the sides of the tandems.

## 4-9. Removal

*a.* Refer to paragraph 2-30 and remove drive unit from frame.

*b.* Refer to paragraph 2-31 and remove engine.

*c.* Refer to paragraph 3-13 and remove transmission.

*d.* Block up final drive and remove tandem assemblied (par. 4-2).

## 4-10. Disassembly

*a. Drive Axles and Carriers.*

(1) Disassemble the drive axles and carriers in the numerical sequence as illustrated in figure 4-3. Observe the following additional instructions.

(2) Drive sprocket and axle caps (1 through 9) were removed during removal of drive unit and tandems.

(3) Block up bull gear (14, fig. 4-4) before removing axle outer carrier (28, fig. 4-3). Use suitable lifting equipment to support carrier.

(4) Remove the drive axle and carriers on the opposite side of the final drive following the same procedure.

(5) Discard gaskets, preformed packings, and grease seals.

*b. Housing, Gears and Motor Support.*

(1) Remove motor support and disassemble final drive housing and gears in the numerical sequence as illustrated in figure 4-4. Observe the following additional instructions.

(2) Use suitable lifting equipment on heavy parts as required.

(3) Remove assembled bull gear (14), bearing cones and rollers (18), and bearing lock through rear opening in housing.

(4) Remove assembled shaft and pinion (33), bevel gear (30), and bearing cones and rollers (29) through top opening of housing.

(5) Use puller to remove bearing cups and bearing cones and rollers.

(6) Discard all gaskets and preformed packings.

## 4-11. Cleaning

*a.* Scrape all dirt from exterior of housing and carriers.

*b.* Remove all accumulated grease and dirt from final drive parts.

*c.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*d.* Clean all oil holes, channels and crevices which may retain sludge or other residue.

## 4-12. Inspection and Repair

*a.* Inspect all parts for wear and damage. Replace damaged or worn parts.

*b.* Check bearings thoroughly for tight spots, galling, and wear. Replace defective bearings.

*c.* Check parts against tolerances listed in Table 1-1. Replace all parts that do not conform to repair and replacement standards.

## 4-13. Reassembly

*a. Housing, Gears, and Motor Support.*

(1) Reassemble final drive housing and gears in reverse of numerical sequence as illustrated in figure 4-4. Observe the following additional instructions.

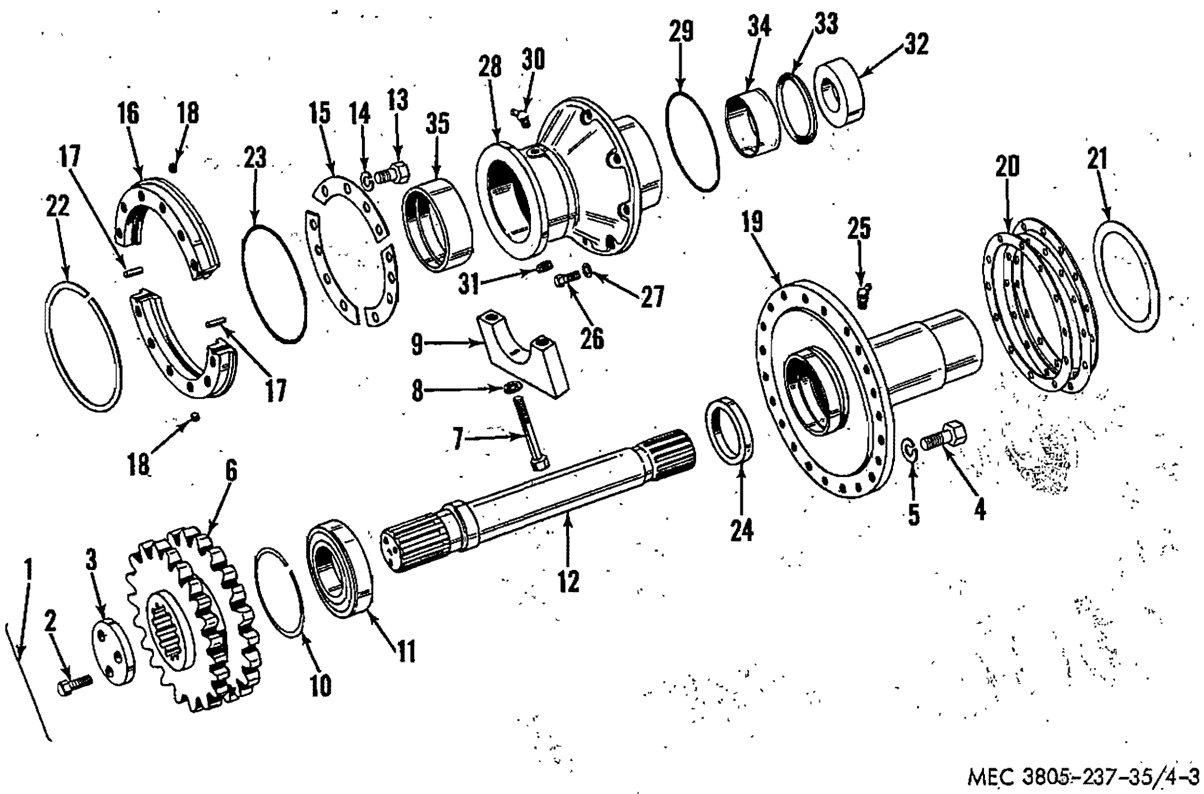
(2) Lubricate all seals and preformed packings prior to installation. Use new seals, packings, and gaskets. Use shellac or gasket seal on gaskets.

(3) Heat washer (31) in oil to 350°F and install on shaft with chamfered side of bore against pinion.

(4) Heat bevel gear (30) in oil. Press pinion shaft and key into gear. Gear must be tight against washer.

(5) Heat bearing cones and rollers (29) in oil and press onto shaft.

(6) Press or drive bearing cups (28) into bearing cages (24 and 25). Cups must seat in bottom of bores.

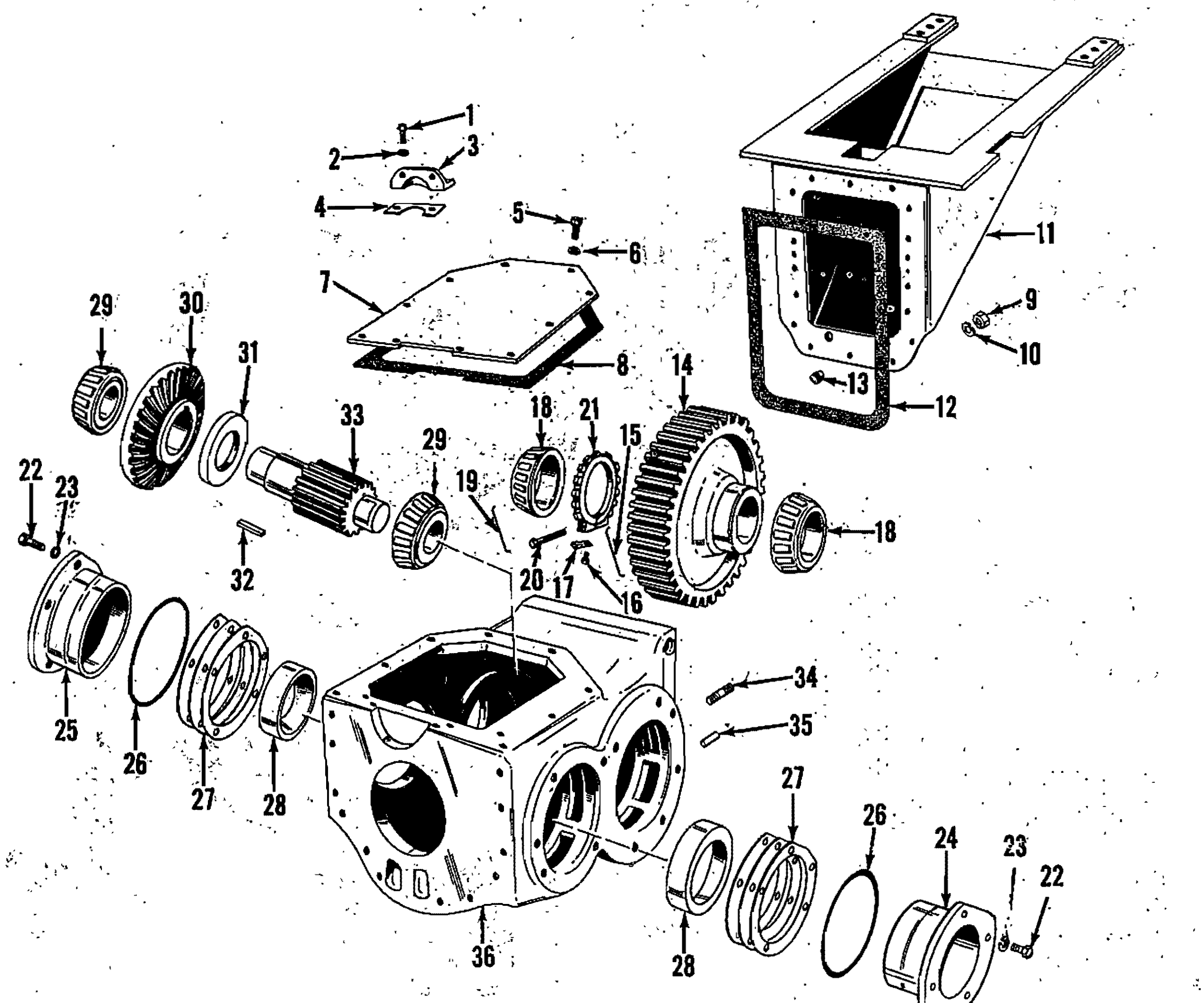



1 Locking wire
2 Screw, cap, drilled head (3)
3 Bolting plate
4 Screw, cap, hex-hd, 5/8-11 × 1 3/4 in. (22)
5 Washer, lock, 5/8 in. (22)
6 Drive sprocket
7 Bolt (2)
8 Washer, lock, 7/8 in. (2)
9 Axle cap
10 Retaining ring
11 Bearing
12 Drive axle
13 Screw, cap, hex-hd, 1/2-13 × 2 1/2 in. (12)
14 Washer, lock, 1/2 in. (12)
15 Seal retainer (3)
16 Axle carrier flange
17 Grease seal
18 Plug, pipe
19 Axle inner carrier
20 Gasket (4)
21 Thrust ring
22 Split thrust ring
23 Grease seal
24 Grease seal
25 Lubrication fitting
26 Screw, cap, hex-hd, 3/4-10 × 2 1/2 in. (7)
27 Washer, lock, 3/4 in. (7)
28 Axle outer carrier
29 Preformed packing
30 Lubrication fitting
31 Plug pipe
32 Bearing cup
33 Grease seal
34 Bushing
35 Bushing

*Figure 4-3. Drive axle and carriers, exploded view.*

(7) Using a hoist, lower the assembled pinion shaft and bevel gear into top of final drive housing. Install left hand bearing cage (24) into housing. Left hand bearing cage has large hub. Do not install shims (27). Install screws and tighten.

(8) Hold pinion shaft and bevel gear in position and install right hand bearing cage (short hub) as shown




1 Screw, cap, hex-hd, 3/8-16 × 1 in. (4)
2 Washer, lock, 3/8 in. (4)
3 Closure cap
4 Gasket
5 Screw, cap, hex-hd, 3/8-16 × 1 in. (10)
6 Washer, lock, 3/8 in. (10)
7 Cover plate
8 Gasket
9 Nut, hex, 1/2-20 (18)
10 Washer, lock, 1/2 in. (18)
11 Lower engine support
12 Gasket
13 Plug, pipe
14 Bull gear
15 Lock wire
16 Screw, cap (2)
17 Lock
18 Bearing cone and rollers
19 Lock wire
20 Cap screw
21 Bearing lock
22 Screw, cap, hex-hd, 3/4-10 × 2 in. (8)
23 Washer, lock, 3/4 in. (8)
24 Left hand bearing cage
25 Right hand bearing cage
26 Preformed packing (2)
27 Shim
28 Bearing cup (2)
29 Bearing cone and rollers (2)
30 Bevel gear
31 Washer
32 Key
33 Shaft and pinion
34 Stud
35 Dowel
36 Final drive housing

*Figure 4-4. Final drive housing and gears, exploded view.*

in figure 4-5. Do not install shims at this time.

(9) Tighten screws on right hand bearing cage evenly while rotating bevel gear. Tighten until there is a slight drag on the gear.

(10) Wrap a piece of heavy cord around pinion teeth and pull with a spring scale. Tighten right hand cage screws evenly until scale shows a reading between 14 1/2 pounds and 18 pounds.

(11) Measure gap between bearing cage and housing (fig. 4-6) and install shims to fill the gap. Install bearing cage and recheck rolling torque.

*Note.* All shims are temporarily placed under right hand bearing cage to prevent damage to bevel gear when transmission is installed. They will be redistributed after transmission has been installed and backlash has been checked. Bearing cage capscrews should be loosened before preloading bull gear bearings.

(12) Install bearing lock (21) on bull gear hub threads far enough to allow bearing cone and rollers to be installed.

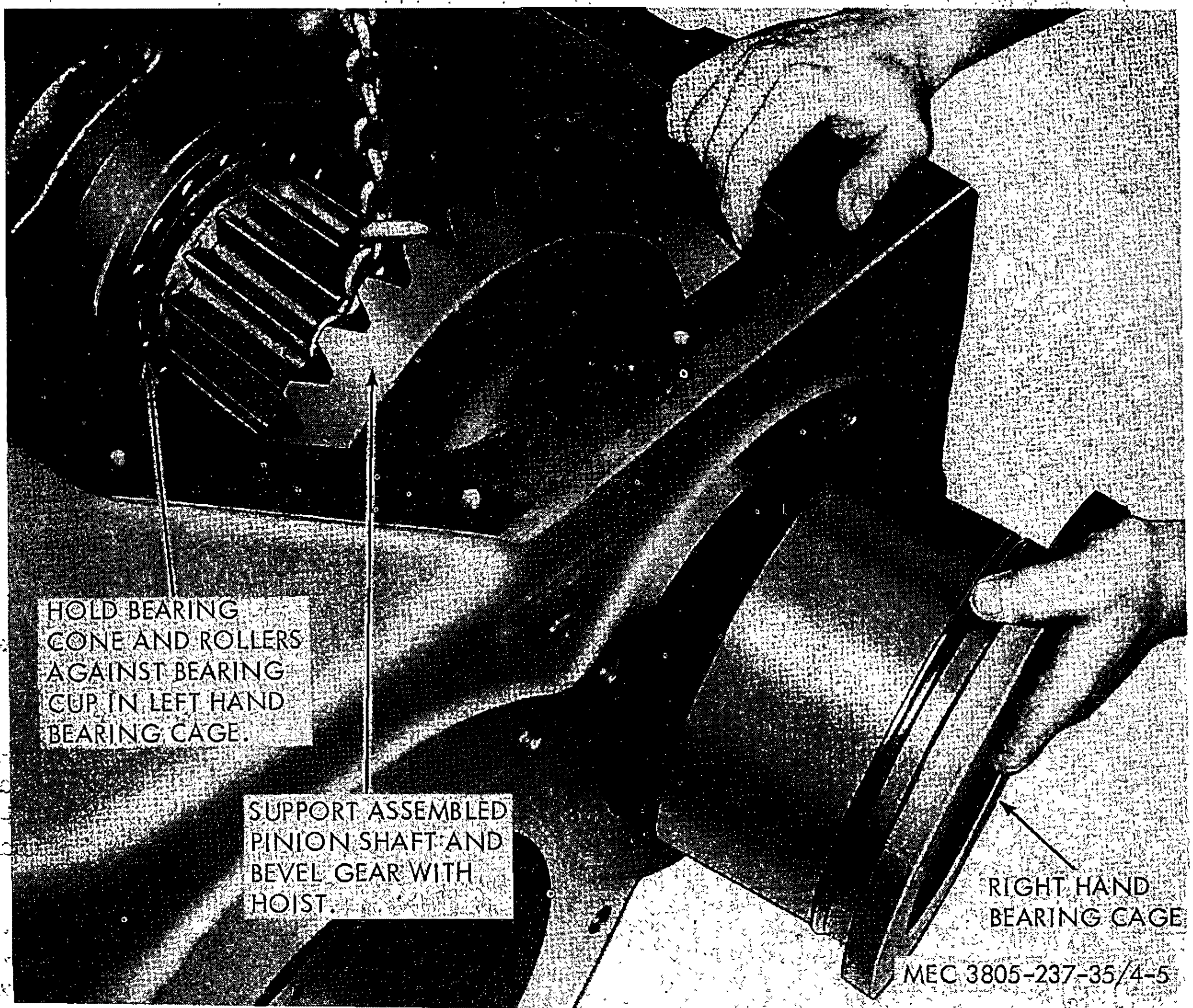



*Figure 4-5. Final drive right hand bearing cage, installation.*

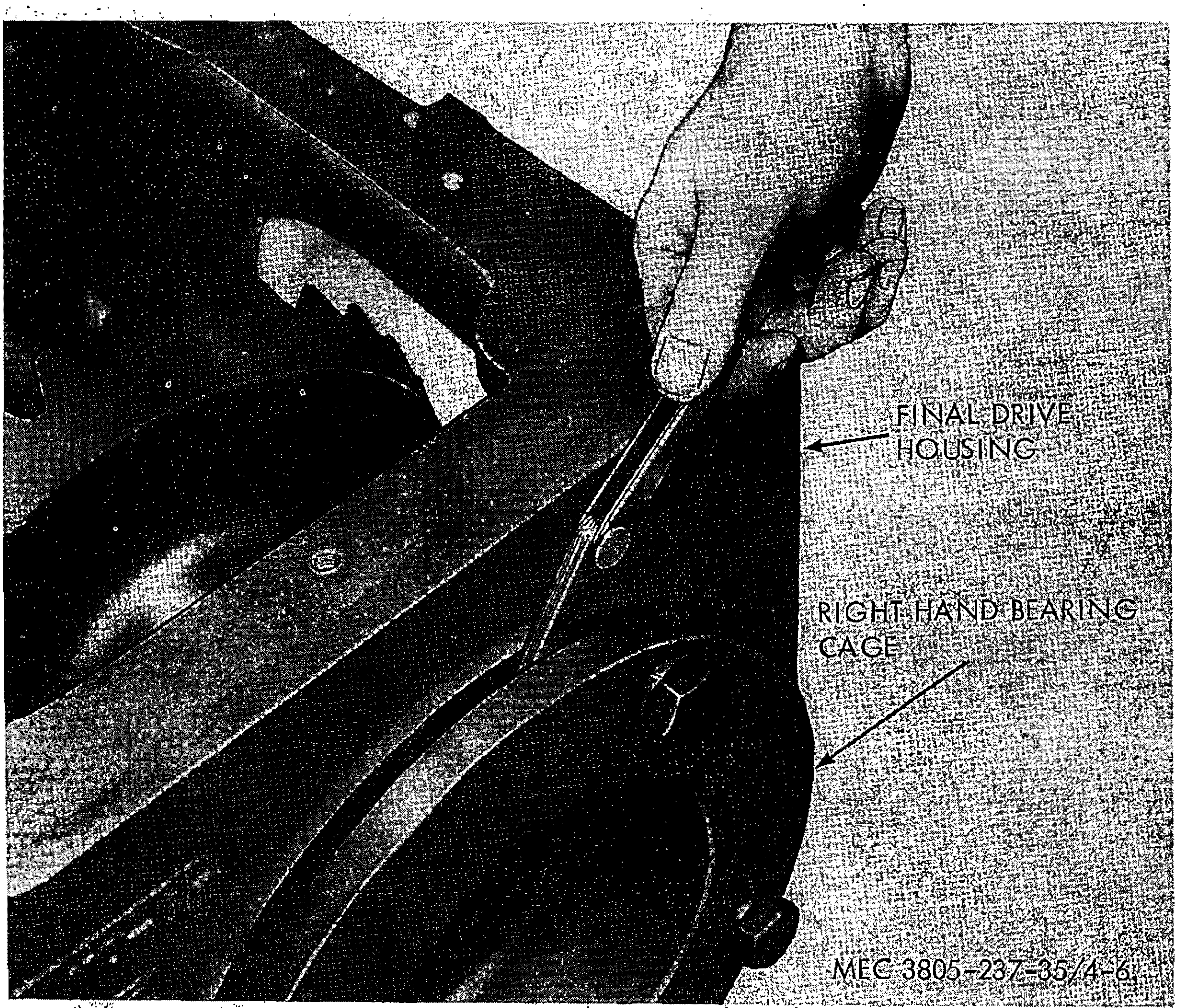



*Figure 4-6. Checking gap between final drive housing and bearing cage.*

(13) Heat bearing cone and rollers (18) to 350°F in oil and press each cone and roller on bull gear in turn and hold in place until set.

(14) Install bull gear and bearings in housing and block up bull gear to aline bearings with openings in sides of housing. Bearing lock (21) must be on right side.

(15) Cover plate (7) and closure cap (3) will be installed after transmission has been installed. Do not install lower engine support until axle outer carriers have been installed and bull gear blocking has been removed.

*b. Drive Axles and Carriers.*

(1) Reassemble and install drive axles and carriers in reverse of numerical sequence as illustrated on figure 4-3. Observe the following additional instructions.

(2) Lubricate all bushing, seals, and preformed packings prior to installation. Use new seal, packings, and gaskets. Use shellac or gasket seal on all gaskets.

(3) Press or drive bushings (34 and 35) into axle outer carrier (28). Install outer bushing (35) with outer end of lengthwise groove in line with inner end of groove in face of carrier.

(4) Install preformed packing. Press or drive grease seal (33) into bottom of its bore in carrier with lip of seal away from bushing.

(5) Press or drive bearing cup (32) into bottom of its bore in carrier with small diameter of cup toward seal.

(6) Assemble both axle outer carriers. Check centering of bull gear and install outer axle carriers using a hoist to support each carrier as it is installed. Torque mounting screws to a reading of 275 foot pounds.

(7) Remove blocking from under bull gear and install lower engine support.

(8) Install grease seal (23) and split thrust ring on outer carrier. Hang gaskets (20) on outer carrier.

(9) Press or drive grease seal (24) into axle inner carrier with lip of seal toward long hub of carrier.

(10) Install thrust ring (21) on inner carrier and insert axle inner carrier into outer carrier. Do not damage grease seals.

(11) Thrust ring (21) must be between flanges of carriers. Gaskets (20) must be between flange of axle inner carrier and carrier flange (16). Split thrust ring (22) must be between carrier flange (16) and axle outer carrier (28). Grease seals (17) are placed in grooves between ends of carrier flanges (16). Grease seal (23) must be in flange groove and held in place by retainers (15).

(12) Check freedom of rotation of axle inner carrier. Carrier must rotate freely with no end movement.

(13) If inner carrier will not rotate freely, remove carrier and add additional shim type gaskets (20) between axle inner carrier (19) and axle carrier flange (16).

(14) If axle inner carrier has end play, remove carrier and add a new split thrust ring (22) between axle outer carrier (28) and axle carrier flange (16).

(15) Install axle inner carrier on opposite side and check freedom of rotation and end play.

(16) Turn bearing lock (21, fig. 4-4) until it touches bearing cone and rollers. Tighten clamping bolt (20) and then loosen 1 1/2 turns.

(17) Check bearing pre-load by wrapping a heavy cord around bull gear hub and pulling cord with a spring scale. Tighten bearing lock until 19 1/2 to 25 pounds of rolling torque is obtained.

(18) Install lock (17 fig. 4-4) to prevent movement of bearing lock. Tighten screws and install lock wires. Tighten bearing lock clamp bolt and wire to bearing lock.

(19) Press or drive bearing (11) on drive axle (12) with shielded side of bearing toward outer end of axle using a piece of pipe or similar sleeve to exert force only on the inner race of the bearing.

(20) Install axles and secure with retaining rings (10).

(21) Sprocket (6) and bolting plate (3) will be installed with tandem.

## 4-14. Installation

*a.* Refer to paragraph 4-7 and install tandem assemblies.

*b.* Refer to paragraph 3-16 and install transmission. Adjust spiral pinion shaft depth as described in paragraph 3-16*d* during installation.

*c.* With transmission shaft depth adjusted, the backlash between the pinion of the transmission shaft and the final drive bevel gear (30, fig. 4-4) can be checked and adjusted.

(1) Install a dial indicator to a rear radial movement of spiral bevel gear. Correct backlash should be 0.010 inch to 0.014 inch. Check backlash reading at three or more positions on gear.

(2) Estimate axial change required and move shims (27, fig. 4-4) as required from under right hand bearing cage and install under left hand bearing cage. Recheck backlash and move shims as required until correct backlash is obtained.

*Note.* Do not change total thickness of shims determined during bearing pre-load adjustment. Backlash adjustment is made by moving shims from one bearing cage to the other.

(3) After backlash adjustment install lockwashers on bearing cage screws and tighten screws to a torque reading of 275 foot pounds.

(4) Install cover plate (7, fig. 4-4) and gasket (8) and closure cap (3) and gasket (4).

*d.* Refer to pargraph 2-31 and install engine.

*e.* Refer to paragraph 2-30 and install drive unit in frame.

# CHAPTER 5

# GEAR ASSEMBLY REPAIR INSTRUCTIONS

## Section I. GENERAL

### 5-1. General

This chapter contains repair instructions for the gear assemblies which power the moldboard, scarifier, and front lean wheel movements.

### 5-2. Description

*a.* The gear assemblies in this section consist of the following:

(1) Moldboard lift gear assembly.

(2) Scarifier lift gear assembly.

(3) Circle reverse gear assembly and transfer housing.

(4) Lateral shift gear assembly.

(5) Front lean wheel gear assembly.

*b.* Gear assemblies covered in this section provide mechanical motion to lift and shift the moldboard, circle the moldboard, lift the scarifier, and provide leaning action for the front wheels.

## Section II. MOLDBOARD LIFT GEAR ASSEMBLY

### 5-3. General

*a.* The moldboard is lifted and lowered by two gear assemblies, one on each side of the frame. A lift arm on each gear assembly is splined to the gear shaft and connected by a ball and socket to the moldboard lift link.

*b.* The gear assemblies are similar and the repair procedures in this section apply to both gear assemblies.

### 5-4. Removal

Refer to paragraph 2-33 to remove the gear assemblies from the motor grader.

*Note.* The gear assemblies can also be disassembled and repaired without removing the assembly from the motor grader.

### 5-5. Disassembly

*a.* Disassemble the moldboard lift gear assembly in the numerical sequence as illustrated in figure 5-1.

*b.* Use care when pressing bushings from housings and thrust bearings and pressing gears from shafts. Do not damage components.

*c.* Discard all preformed packings and gaskets after removal.

### 5-6. Cleaning

*a.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

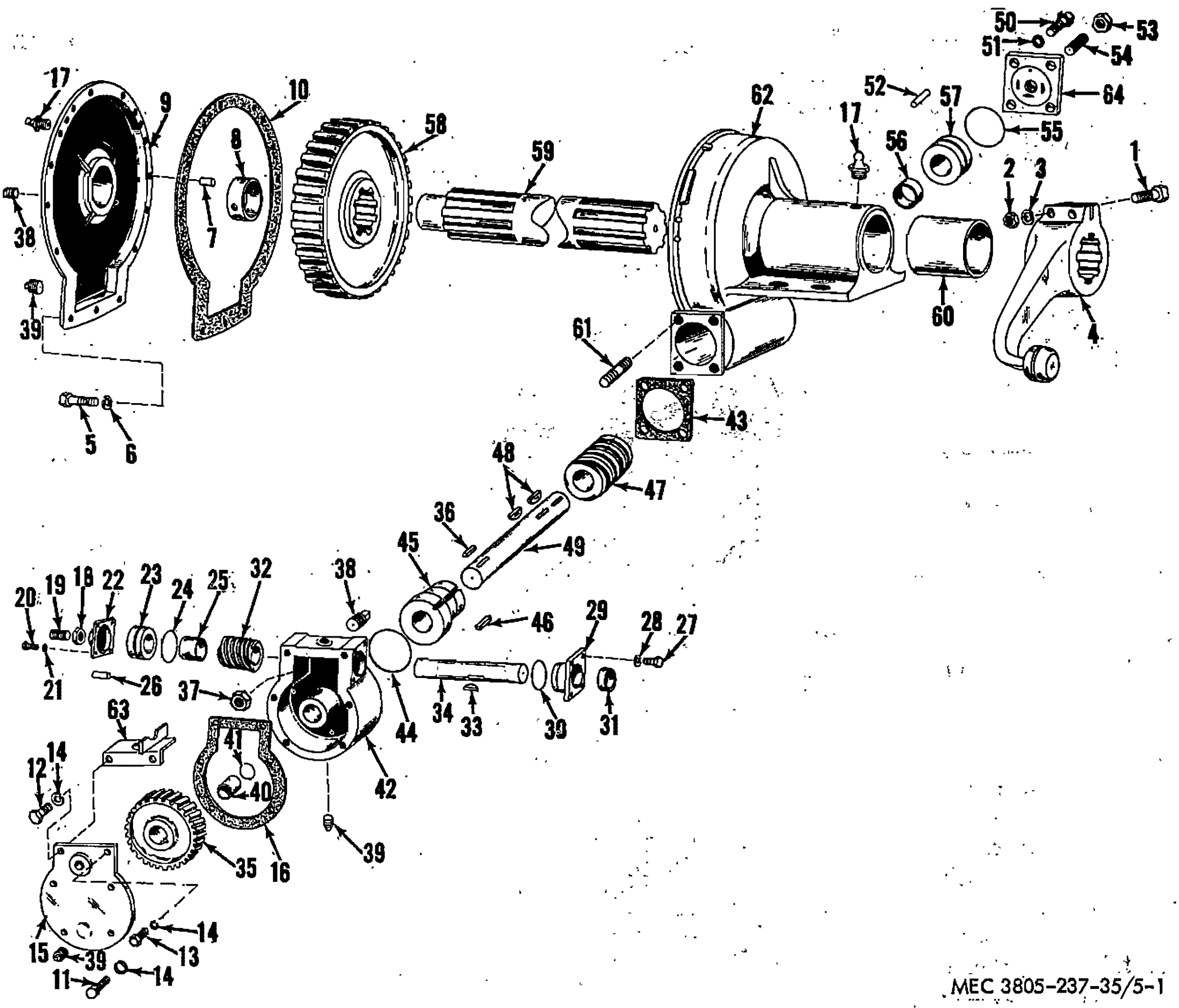
*b.* Remove all accumulated grease and dirt from gear assembly parts.

### 5-7. Inspection and Repair

*a.* Inspect all parts for wear and damage.

*b.* Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

*c.* Replace all worn or damaged parts.




1 Arm bolt (2)
2 Nut, 7/8-9 (2)
3 Washer, lock, 7/8 in. (4)
4 Lift arm
5 Screw, cap, hex-head, 1/2-13 × 1 3/8 (13)
6 Washer, lock, 1/2 in. (13)
7 Dowel pin (2)
8 Bushing
9 Housing cover
10 Cover gasket
11 Screw, cap, hex-head, 5/16-18 × 1 in. (4)
12 Screw, cap, hex-head, 5/16-18 × 1 1/4 in.
13 Screw, cap, hex-head, 5/16-18 × 1 1/4 in.
14 Washer, lock, 5/16 in. (6)
15 Gear cover
16 Cover gasket
17 Lubrication fitting (4)
18 Nut, 3/4-10
19 Setscrew
20 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (4)
21 Washer, lock, 3/8 in. (4)
22 Bearing cap
23 Thrust bearing
24 Preformed packing
25 Bushing
26 Roll pin
27 Screw, cap, hex-head, 3/8-16 1 1/8 in. (4)
28 Washer, lock, 3/8 in. (4)

*Figure 5-1. Moldboard lift gear assembly, exploded view.*

| | | | |
|---|---|---|---|
| 29 | Bearing cap | 47 | Worm gear |
| 30 | Preformed packing | 48 | Key, woodruff (2) |
| 31 | Oil seal | 49 | Worm shaft |
| 32 | Spiral pinion | 50 | Screw, cap, hex-head, 5/8-11 X 1 3/4 in. (4) |
| 33 | Key, woodruff | 51 | Washer, lock, 5/8 in. (4) |
| 34 | Pinion shaft | 52 | Dowel pin |
| 35 | Worm gear | 53 | Nut, 1-8 |
| 36 | Key, square | 54 | Setscrew |
| 37 | Nut (4) | 55 | Preformed packing |
| 38 | Pipe plug, 1/2-14 (3) | 56 | Bushing |
| 39 | Pipe plug, magnetic, 1/2-14 (2) | 57 | Thrust bearing |
| 40 | Bushing | 58 | Lift gear |
| 41 | Retaining ring | 59 | Lift gear shaft |
| 42 | Gear reduction housing | 60 | Bushing |
| 43 | Housing gasket | 61 | Stud (4) |
| 44 | Preformed packing | 62 | Lift gear housing |
| 45 | Thrust bearing | 63 | Bracket (RH only) |
| 46 | Key, square | 64 | Cap |

*Figure 5-1*—Continued.

## 5-8. Reassembly

*a.* Reassemble moldboard lift gear assembly in reverse of numerical sequence as illustrated in figure 5-1 and the following instructions.

*b.* Lubricate preformed packings and working surfaces of shafts and bushings before installation. Use shellac or gasket seal on all gaskets.

*c.* Press bushings in bore of thrust bearings and housings until bushings are flush with outside surfaces.

*d.* Press lift shaft (59) into bore of lift gear (58) with long hub of gear facing end of shaft as shown in figure 5-2. Hub of gear must be 2 1/8 inches from end of shaft.

*e.* Install two woodruff keys (48) in worm shaft (49) and press shaft into bore of worm gear (47) until shaft extends 2 1/32 inch from face of worm gear.

*f.* Install four studs (61) in tapped holes in lift gear housing (62) with a stud driver. Torque studs to torque reading of 100 to 110 foot pounds.

*g.* When installing gear reduction housing (42) on lift gear housing, torque four nuts (37) to a torque reading of 135 to 145 foot pounds.

*h.* Install woodruff key (33) in pinion shaft (34) and press shaft into bore of spiral pinion (32) until shaft extends 2 1/32 inch from face of pinion.

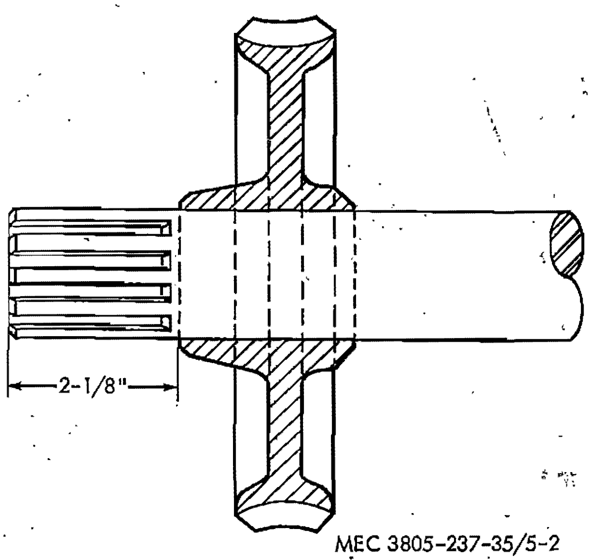



*Figure 5-2. Installing lift gear on lift gear shaft.*

*i.* After installing bearing cap (29) on reduction gear housing, use a piece of shim stock over shaft as shown in figure 5-3 and install oil seal (31) in bearing cap. The lip of the oil seal must be facing toward the inside of the housing. Press seal into bore of bearing cap, using a suitable tool.

*j.* After installation, adjust main thrust bearing by tightening setscrew (54) until a drag is felt when worm shaft is rotated. Loosen setscrew slightly until drag is eliminated.

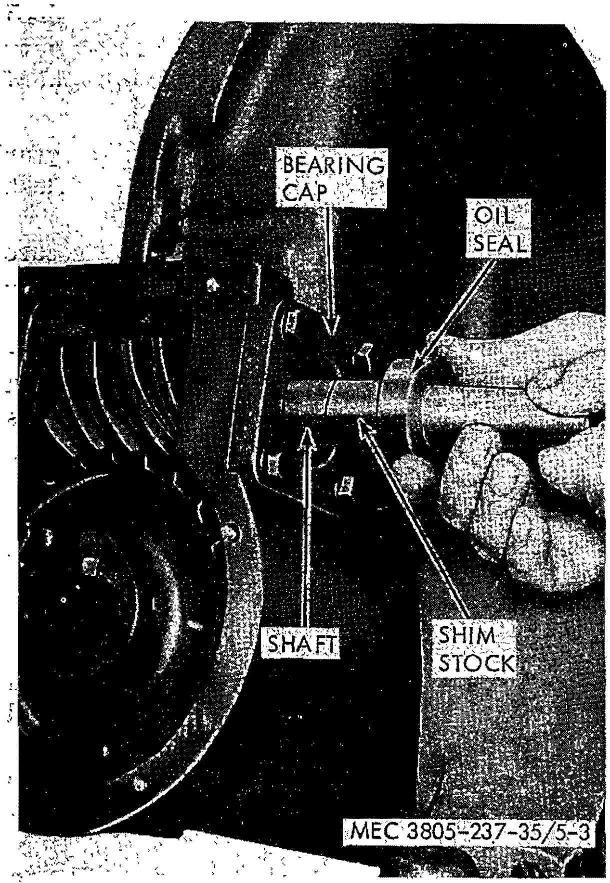



*Figure 5-3. Installing oil seal in bearing cap.*

Hold setscrew and tighten locking nut (53) to hold adjustment.

*k.* Adjust thrust bearing in gear reduction housing in the same manner.

*l.* Install two pilots in holes in lift gear housing (62) and install cover gasket (10) and cover (9) on housing. Tap cover with leather mallet to seat dowl pins in housing. Remove pilots.

*m.* Install lift arm (4) on splines of shaft. To spread opening in arm, drive a cold chisel in slot. Aline splines in arm with splines on shaft and install arm. Use a mallet to tap arm on shaft until arm is even with chamfer on shaft.

*n.* Remove chisel from slot and secure arm to shaft with arm bolts (1), nuts (2), and lockwashers (3). Install bolts with heads of bolts toward main frame.

*Note.* The above instructions apply to the right hand moldboard lift gear assembly. The same instructions apply for the left hand gear assembly with two exceptions. Install lift worm shaft (50) into main housing from the right hand side.

## 5-9. Installation

Refer to paragraph 2-33 and install moldboard lift assembly on motor grader.

# Section III. SCARIFIER LIFT GEAR ASSEMBLY

## 5-10. General

*a.* The scarifier is mounted forward of the moldboard on the main frame. Motion to raise and lower the scarifier is provided by a gear assembly mounted above the scarifier.

*b.* The scarifier gear assembly is similar to the moldboard lift gear assemblies. As the scarifier does not require tilting or shifting, one gear assembly is used. Two lift arms, driven by the gear assembly shaft, are attached by ball and sockets to the scarifier lift links.

*c.* Because of the nature of the scarifier operation, tremendous shock loads are transmitted to the gear assembly. A frequent check of the assembly and operation should be performed.

## 5-11. Removal

Refer to paragraph 2-34 and remove scarifier lift gear assembly from the unit.

## 5-12. Disassembly

*a.* Disassemble the lift gear assembly in the numerical sequence as illustrated in figure 5-4.

*b.* Use care when pressing bushings from housings and thrust bearings and pressing shafts from gears. Do not damage components.

*c.* Discard all preformed packings and gaskets after removal.

## 5-13. Cleaning

*a.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

*b.* Remove all accumulated grease and dirt from gear assembly parts.

## 5-14. Inspection and Repair

*a.* Inspect all parts for wear and damage.

*b.* Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

*c.* Replace all worn or damaged parts.

## 5-15. Reassembly

*a.* Reassemble scarifier lift gear assembly in reverse of numerical sequence as illustrated in figure 5-4 and the following instructions.

*b.* Lubricate preformed packings and working surfaces of shafts and bushings before installation. Use shellac or gasket seal on all gaskets.

*c.* Press bushing (53) into bore in gear housing (55), from inside of housing, until bushing is flush with bottom of chamfer.

*d.* Install four studs (51) in housing and torque-tighten studs to 100 to 110 foot pounds.

*e.* Heat lift gear (50) in oil to approximately 350°F. Support gear in a press, aline splines on shaft with splines in gear and press shaft into gear until the face of the short hub of the gear is 9.068 inches from the end of the shaft as shown in figure 5-5.

*f.* When installing bearing cap (42), dowel pin in cap must enter hole in thrust bearing (48). Hole in bearing must be centered at top.

*g.* Install two keys (29) in worm shaft (39) and press worn gear (38) on shaft until face of worm is 3-347 inches from short end of shaft as shown in figure 5-6.

*h.* Press bushing (33) into reduction gear housing (32) until edge of bushing is flush with bottom of chamfer.

*i.* Install reduction gear housing and secure with four nuts (31). Torque-tighten nuts to 135 to 145 foot pounds.

*j.* Adjust worm thrust bearing by tightening setscrew (44) until a drag is felt when rotating shaft. Loosen setscrew until drag is eliminated. Hold setscrew and tighten locking nut (43) to hold adjustment.

*k.* Press bushings (25 and 26) into reduction housing until edge of bushings are flush with bottom of chamfer.

*l.* After installation of covers (16 and 23), install oil seals (17, 24, and 53) over shafts and into covers and housings. Insert a thin piece of shim stock around shaft and slide seal over shim stock and shaft into housing, with lip of seal toward inside of housing. Remove shim stock and press seal into housing, using a suitable tool.

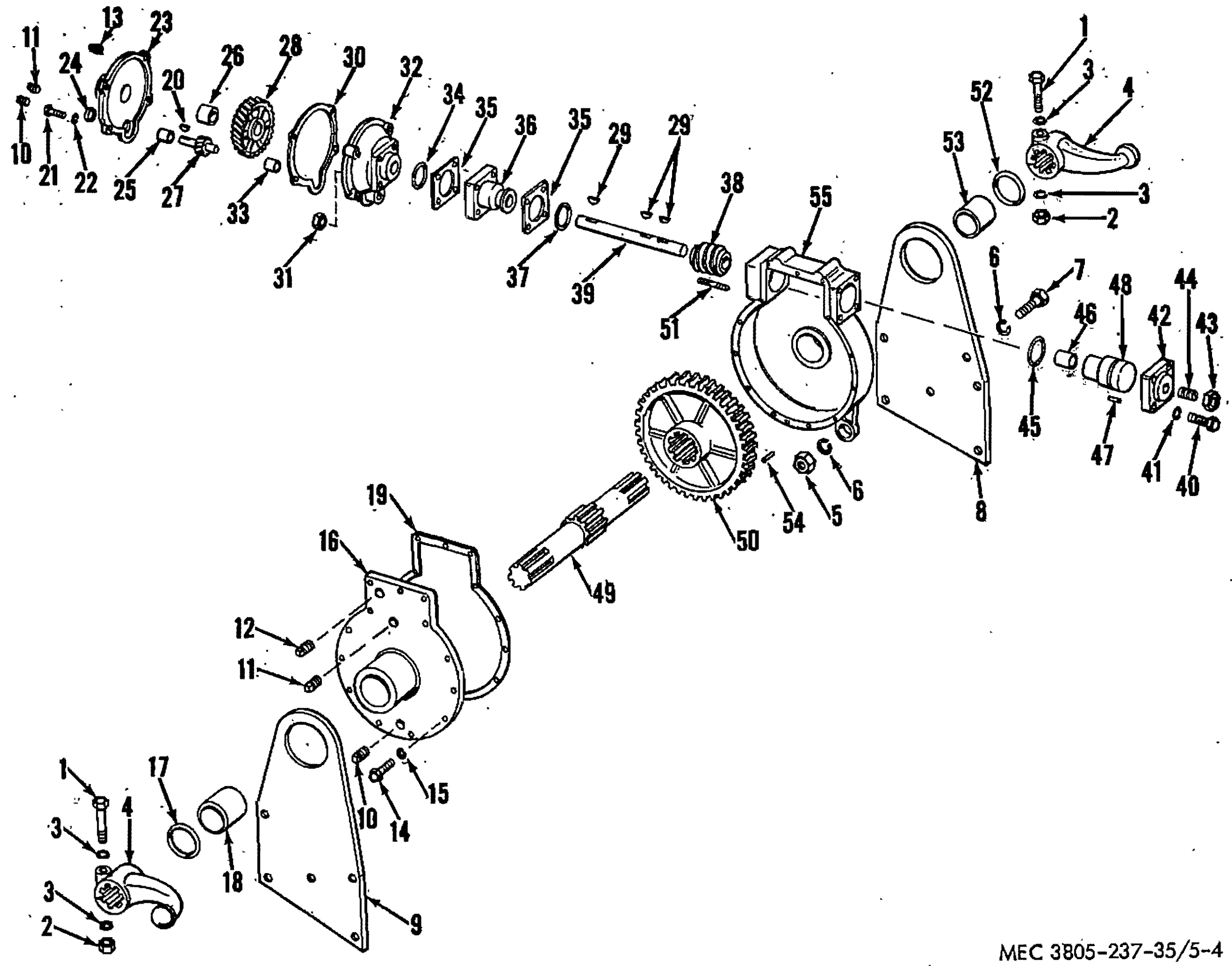
*m.* When installing two lift arms (4) on shaft, spread slot in arm with a chisel. Slide arms on splines of shaft and tap arms until they are 1/8 inch from hubs of housing and cover.

*Note.* Arms must be mated with splines on shaft to bring balls on ends of arms within 1/8 inch of alinement with shaft both in parallel and in plane.

*n.* Remove chisel from arm and secure arms to shaft with two arm bolts (1), four lockwashers (3), and two nuts (2).

## 5-16. Installation

Refer to paragraph 2-34 and install the scarifier lift gear assembly on the motor grader.




1 Arm bolt (2)
2 Nut, 7/8-9 (2)
3 Washer, lock, 7/8 in. (4)
4 Lift arm (2)
5 Nut, 1 1/4-12
6 Washer, lock, 1 1/4
7 Mounting bolt
8 L. H. mounting plate
9 R. H. mounting plate
10 Pipe plug, magnetic (2)
11 Pipe plug, 1/2 in. (2)
12 Pipe plug, vented
13 Pipe plug, 1/8 in.
14 Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (13)
15 Washer, lock, 1/2 in, (13)
16 Housing cover
17 Oil seal
18 Bushing
19 Cover gasket
20 Key, woodruff
21 Screw, cap, hex-head, 1/2-13 × 2 1/2 in. (4)
22 Washer, lock, 1/2 in. (4)
23 Reduction housing cover
24 Oil seal
25 Bushing
26 Bushing
27 Pinion shaft
28 Reduction gear
29 Key, woodruff (3)
30 Cover gasket
31 Nut (4)
32 Reduction gear housing
33 Bushing
34 Preformed packing
35 Housing gasket (2)
36 Thrust bearing
37 Preformed packing

*Figure 5-4. Scarifier lift gear assembly, exploded view.*

38 Worm gear
39 Worm shaft
40 Screw, cap, hex-head, 5/8-11 × 1 3/4 (4)
41 Washer, lock, 5/8 in. (4)
42 Bearing cap
43 Nut
44 Setscrew
45 Preformed packing
46 Bushing (2)
47 Dowel pin
48 Thrust bearing
49 Lift shaft
50 Lift gear
51 Stud (4)
52 Oil seal
53 Bushing
54 Dowel pin (2)
55 Gear housing

*Figure 5-4*—Continued.

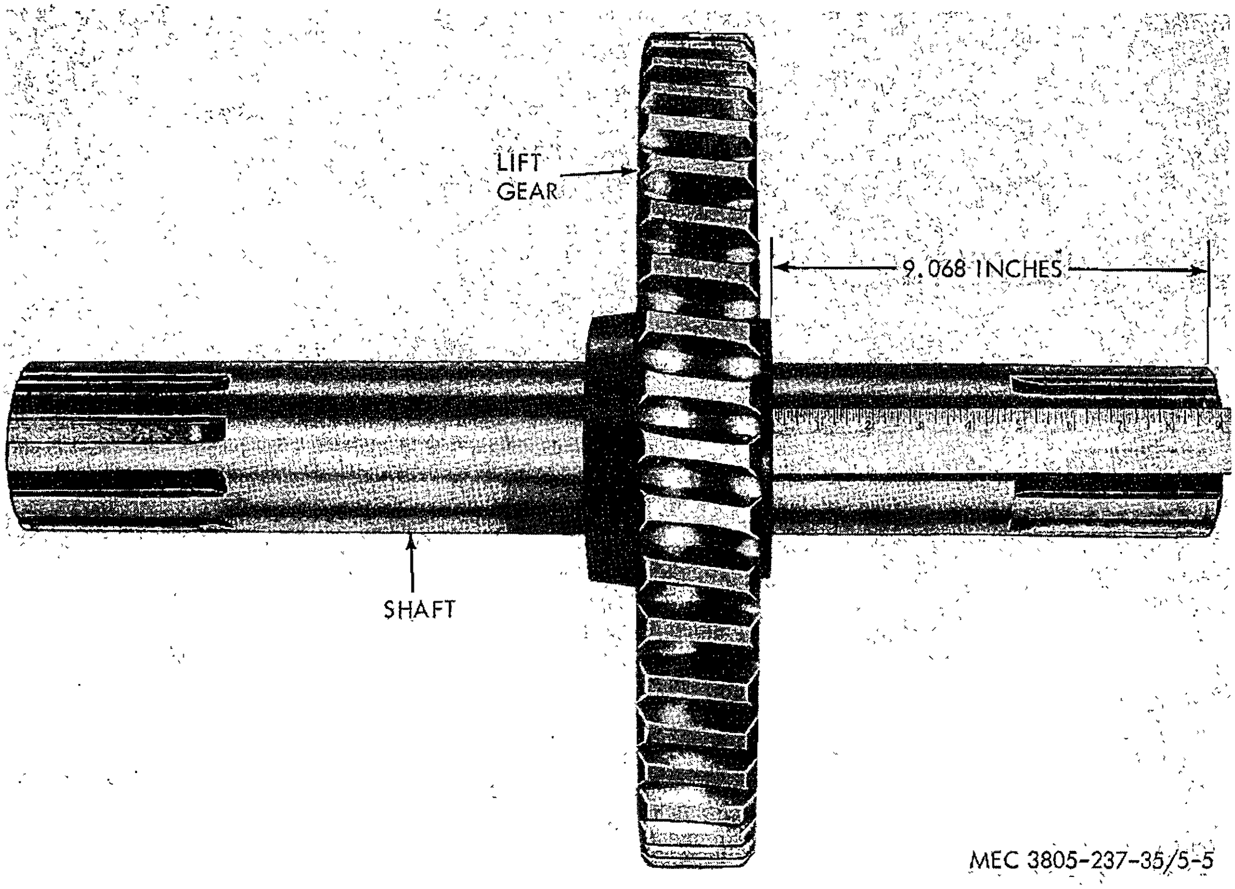



*Figure 5-5. Installing lift gear on shaft.*

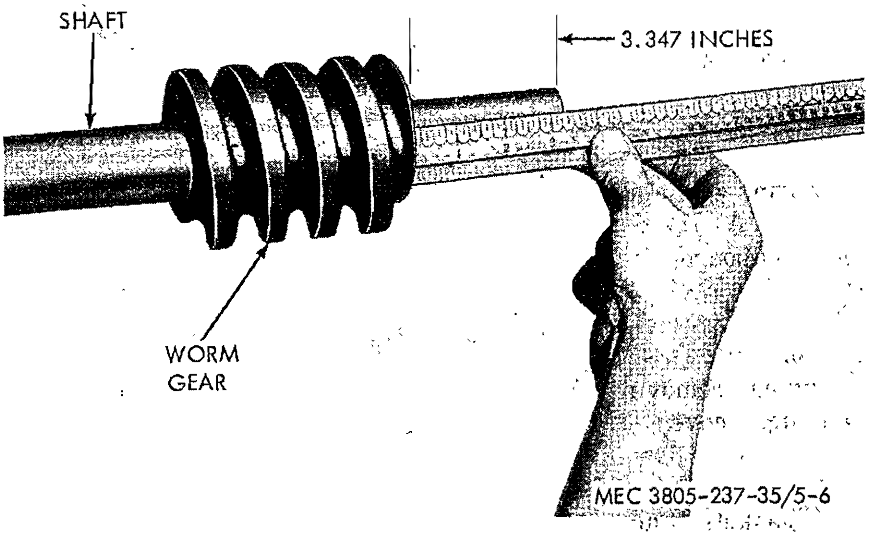



*Figure 5-6. Installing worm gear on shaft.*

## Section IV. CIRCLE REVERSE MECHANISM

### 5-17. General

*a.* The moldboard of the motor grader is mounted on arms of the moldboard circle. The two moldboard lift links are attached to the drawbar above the circle. To fully pivot the moldboard, a gear assembly, mounted on the left side of the drawbar, drives the circle.

*b.* The circle is suspended from the drawbar at three points. The points have adjusting and wear plates. When rotating, the circle rides on the wear plates. The lower part of the circle is a large ring gear. In mesh with this ring gear is a drive gear attached to the shaft of the circle reverse gear assembly. When the gear assembly is driven by the control shaft, through the transfer housing, the circle rotates around the drive gear.

*c.* As the circle rotates, the moldboard rotates to the position desired by the operator. When the proper moldboard lift gear assembly is actuated, the circle will lift or lower the blade. The front end of the drawbar pivots in a ball and socket at the front end of the frame, allowing the circle to be raised to the angle required by the operator.

### 5-18. Removal

Refer to paragraph 2-35 to remove the circle reverse mechanism from the motor grader. The transfer housing and circle reverse gear assembly are separated when removed from the grader.

### 5-19. Disassembly

*a. Transfer Housing.* The transfer housing is connected to the control shaft and transfers the motion from the control shaft back to the circle reverse gear assembly.

(1) Disassemble the transfer housing in the numerical sequence as illustrated on figure 5-7.

(2) Drive dowel pins (15) from housing and cover before attempting to remove housing cover (17).

(3) When removing housing cover (17), move cover down at an angle from housing to disengage from upper transfer gear.

*b. Circle Reverse Gear Assembly.* The circle reverse gear assembly worm gear is driven by the coupling shaft from the transfer housing. Rotation of the worm gear drives the large worm gear splined to the shaft of the drive gear. As the drive gear rotates it drives the moldboard circle.

(1) Disassemble the circle reverse gear assembly in the numerical sequence illustrated on figure 5-8.

(2) Use care when removing bushings from housing, cover and thrust bearing. Do not damage components.

(3) Discard all gaskets and preformed packing after removal.

## 5-20. Cleaning

*a.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use near an open flame.**

*b.* Remove all accumulated grease and dirt from transfer housing and gear assembly parts.

## 5-21. Inspection and Repair

*a.* Inspect all parts for wear and damage.

*b.* Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

*c.* Check backlash of gears in transfer housing, during assembly, against tolerances specified in repair and rebuild standards.

*d.* Inspect drive gear (21) for any damage to welds holding teeth to plates.

*e.* Replace all worn or damaged parts.

## 5-22. Reassembly

*a. Preparation.* Lubricate preformed packings and working surfaces of shafts and bushings before installation. Use shellac or gasket seal on all gaskets.

*b. Circle Reverse Gear Assembly.* Reassemble the circle reverse gear assembly in reverse of numerical sequence as illustrated on figure 5-8 and the following instructions.

(1) Press bushings into shoulder bushing (22), thrust bearing (15), housing (31) and cover (3) until bushings are flush with bottom of chamfer.

(2) Press worm gear (16) on shaft over keys until face of worm gear is 5 13/32 inches from long end of shaft.

(3) Install oil seal (24) in housing after installation of worm gear and shaft (18). Use a thin piece of shim stock to slide oil seal over splines and shaft. The lip of the oil seal must be toward inside of housing.

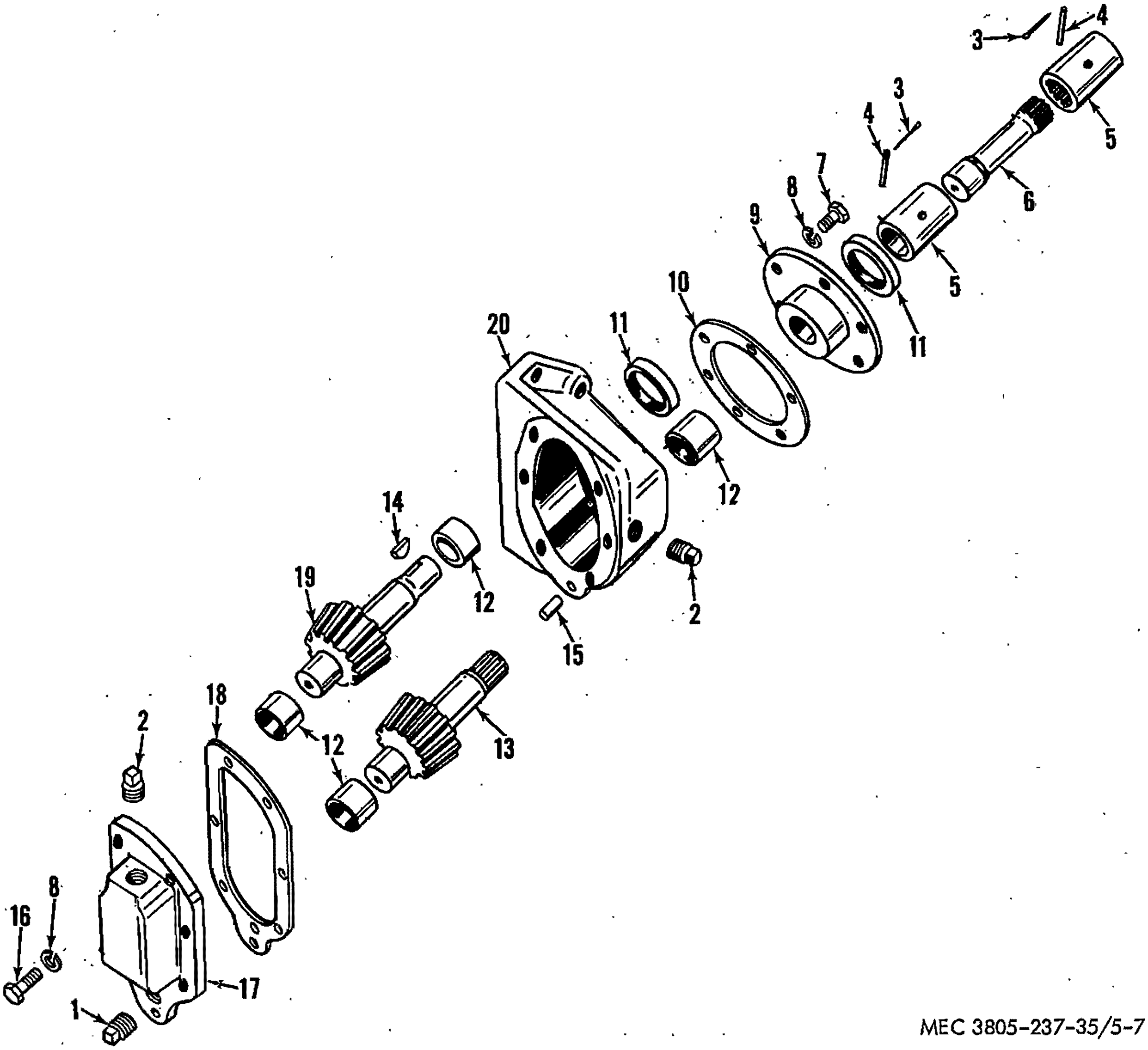
(4) After installation of bearing cap (11), adjust thrust bearing by tightening setscrew (10) until a drag is felt when shaft is rotated. Loosen setscrew until drag is eliminated. Hold setscrew in position and tighten nut (9) to hold adjustment.

*c. Transfer Housing.* Reassemble the transfer housing in reverse of numerical sequence as illustrated on figure 5-7 and the following instructions.

(1) Press bushings into transfer housing (20), housing cover (17), and gear cover (9) until bushings are flush with bottom of chamfer.

(2) Install housing cover on housing and install screws (16) and lockwashers (8). Do not tighten screws. Install two dowel pins (15) in cover and housing. Tighten screws securely.

(3) After installing gear cover (9), install oil seals (11), with lips toward inside of housing, over shafts. Use a




| | | | |
|---|---|---|---|
| 1 | Pipe plug, 1/2 in. (2) | 11 | Oil seal (2) |
| 2 | Pipe plug, magnetic | 12 | Bushing (4) |
| 3 | Pin, cotter, 1/8 × 3/4 in. (2) | 13 | Transfer gear |
| 4 | Pin, drilled (2) | 14 | Key, woodruff |
| 5 | Coupling (2) | 15 | Dowel pins (2) |
| 6 | Coupling shaft | 16 | Screw, cap, hex-head, 3/8-16 × 1 3/8 (2) |
| 7 | Screw, cap, hex-head, 3/8-16 × 1 in. (6) | 17 | Housing cover |
| 8 | Washer, lock (12) | 18 | Cover gasket |
| 9 | Gear cover | 19 | Upper transfer gear |
| 10 | Cover gasket | 20 | Transfer housing |

*Figure 5-7. Circle reverse transfer housing, exploded view.*

piece of shim stock to slide seals over shafts. Press seals into housing and gear cover.

## 5-23. Installation

Refer to paragraph 2-35 and install the circle reverse mechanism on the motor grader.

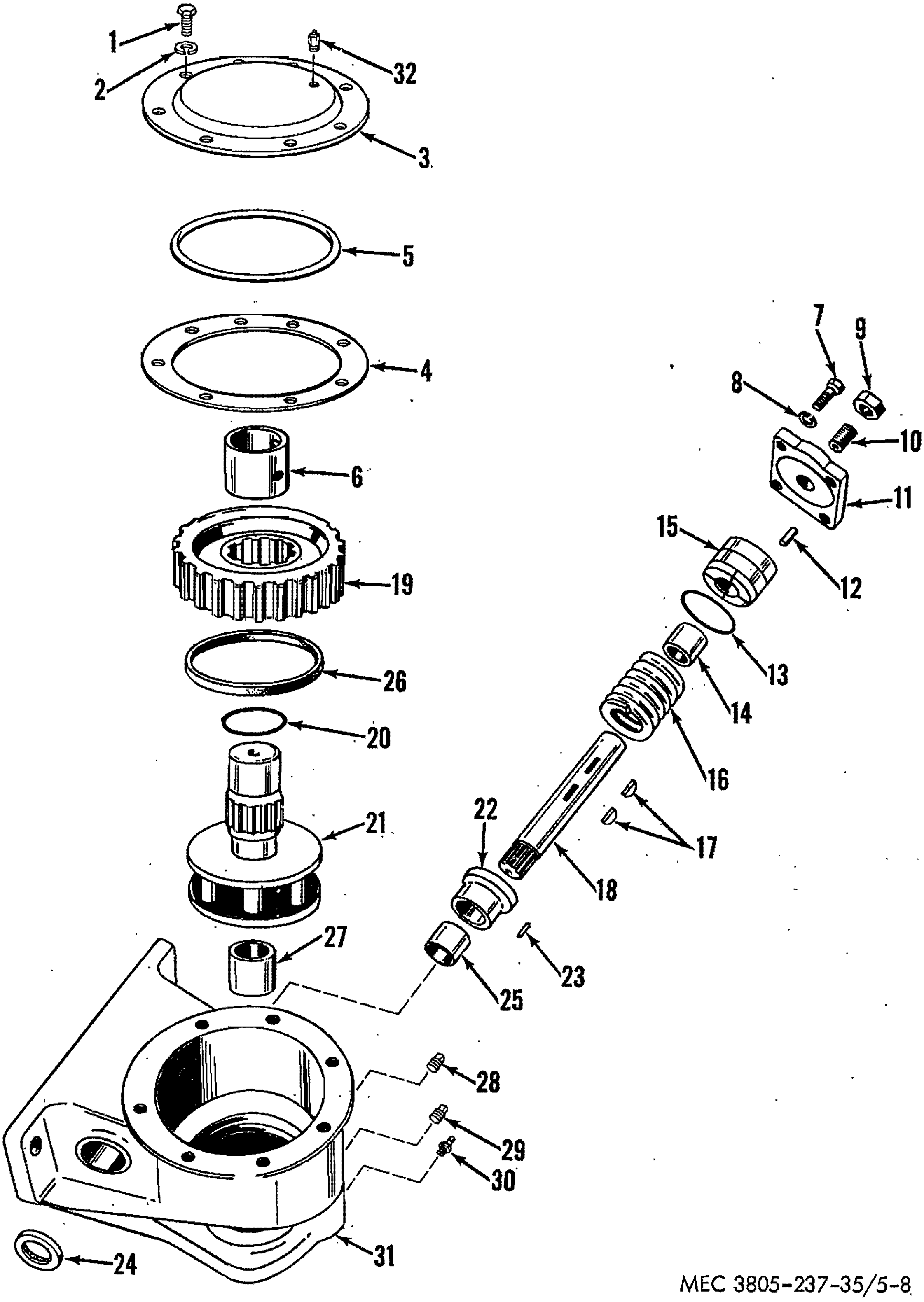



*Figure 5-8. Circle reverse gear assembly, exploded view.*

1 Screw, cap, hex-head, 1/2-13 × 1 1/4 in. (7)
2 Washer, lock, 1/2 in. (7)
3 Gear assembly cover
4 Cover gasket
5 Preformed packing
6 Bushing
7 Screw, cap, hex-head, 5/8-11 × 1 3/4 in. (4)
8 Washer, lock, 5/8 in. (4)
9 Nut
10 Setscrew
11 Bearing cap
12 Dowel pin
13 Preformed packing
14 Bushing
15 Thrust bearing
16 Worm gear
17 Key, woodruff (2)
18 Gear shaft
19 Worm gear
20 Preformed packing
21 Drive gear
22 Shoulder bushing
23 Dowel pin
24 Oil seal
25 Bushing
26 Oil seal
27 Bushing
28 Pipe plug, 1/2 in.
29 Pipe plug, magnetic
30 Lubrication fitting
31 Gear housing
32 Relief valve

*Figure 5-8*—Continued.

## Section V. LATERAL SHIFT GEAR ASSEMBLY

### 5-24. General

*a.* Lateral shift of the moldboard is accomplished with the lateral shift gear assembly. The gear assembly is mounted under the main frame just forward of the power control box.

*b.* The shift arm is connected to the lateral shift link by a ball and socket. The shift link extends to the lateral shift arm mounted on the moldboard circle. By connecting the shift arm to either side of the circle, the operator can extend the moldboard shift as needed.

*c.* Operating the lateral shift in conjunction with the moldboard lifts makes possible the angling of the blade up to 90° from the horizontal. The gear assembly is driven by a control shaft extending from the power control box.

### 5-25. Removal

Refer to paragraph 2-36 and remove the lateral shift gear assembly from the motor grader.

### 5-26. Disassembly

*a.* Disassemble the lateral shift gear assembly in the numerical sequence as illustrated on figure 5-9 and the following instructions.

*b.* Use care when removing bushings from thrust bearings, housing, and housing cover. Do not damage components.

*c.* After removing thrust cap (44), use a soft driver and hammer to drive gear shaft (48) from worm gear (49). Support gear to prevent it falling when shaft is removed. Rotate shaft while driving out.

*d.* Discard all gaskets and preformed packings after removal.

### 5-27. Cleaning

*a.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use near an open flame.**

*b.* Remove all accumulated dirt and grease from gear assembly parts.

### 5-28. Inspection and Repair

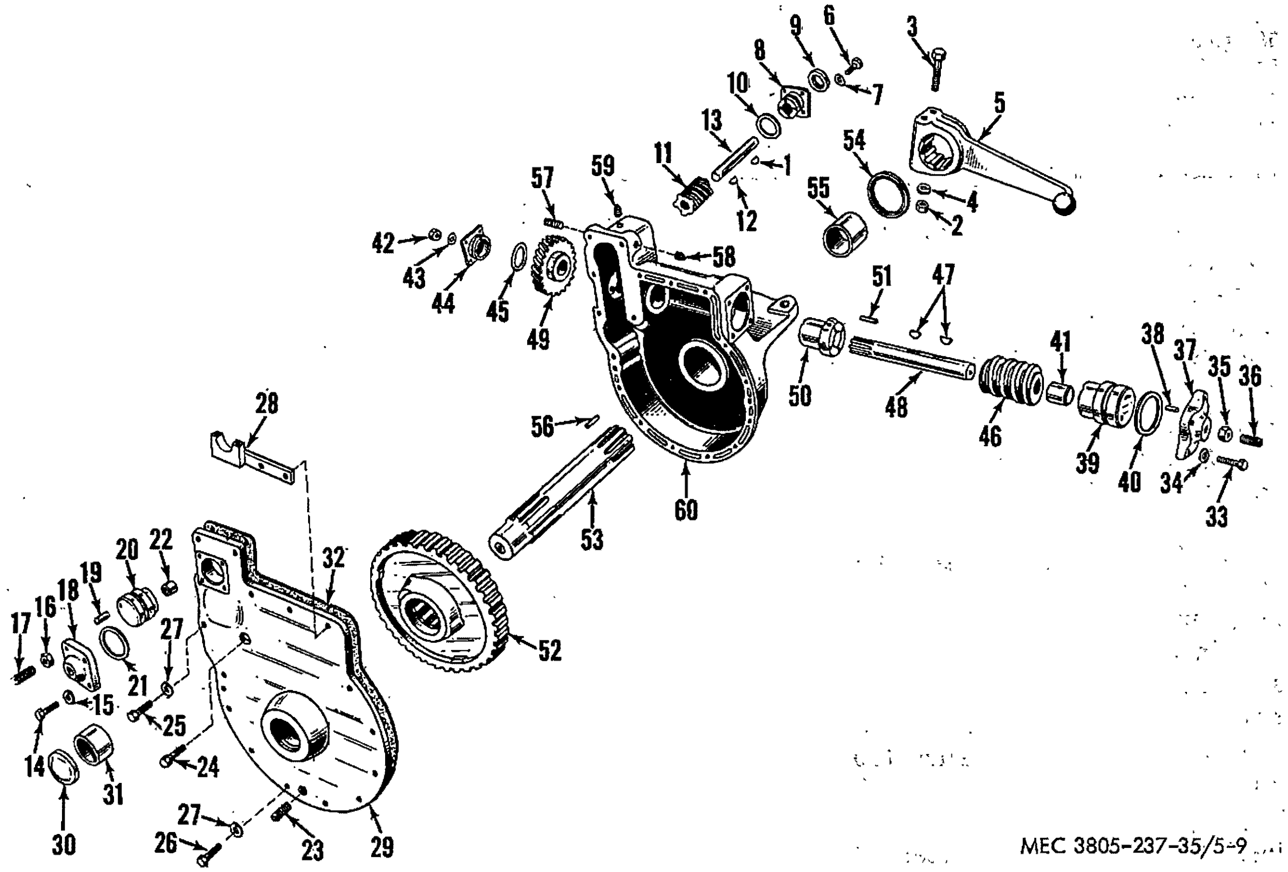
*a.* Inspect all parts for wear and damage.

*b.* Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*c.* Replace all worn or damaged parts.

### 5-29. Reassembly

*a.* Lubricate preformed packings and working surfaces of shafts and bushings before installation. Use shellac or gasket seal on all gaskets.



MEC 3805-237-35/5-9

1 Key, woodruff
2 Nut, 7/8-9 (2)
3 Shift arm bolt (2)
4 Washer, lock, 7/8 in. (4)
5 Shift arm
6 Screw cap hex-head, 3/8-16 × 1 1/8 in. (4)
7 Washer, lock, 3/8 in. (4)
8 Bearing cap
9 Oil seal
10 Preformed packing
11 Small worm gear
12 Key, woodruff
13 Worm gear shaft
14 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (4)
15 Washer, lock, 3/8 in. (4)
16 Nut
17 Setscrew
18 Bearing cap
19 Dowel pin
20 Thrust bearing
21 Preformed packing
22 Bushing
23 Pipe plug, magnetic
24 Screw, cap, tapered
25 Screw, cap, hex-head, 1/2-13 × 1 3/4 in. (4)
26 Screw, cap, hex-head, 1/2-13 × 1 3/8 in. (12)
27 Washer, lock, 1/2 in. (16)
28 Bearing bracket
29 Housing cover
30 Expansion plug
31 Bushing
32 Cover gasket
33 Screw, cap, hex-head, 5/8-11 × 1 3/4 in. (4)
34 Washer, lock, 5/8 in. (4)
35 Nut
36 Setscrew
37 Bearing cap
38 Dowel pin
39 Thrust bearing
40 Preformed packing
41 Bushing
42 Nut, 3/8-24 (4)
43 Washer, lock, 3/8 in. (4)
44 Thrust cap
45 Preformed packing
46 Large worm gear
47 Key, woodruff (2)
48 Gear shaft
49 Worm gear
50 Thrust bearing
51 Dowel pin
52 Drive gear

*Figure 5-9. Lateral shift gear assembly, exploded view.*

53 Gear shaft
54 Oil seal
55 Bushing
56 Dowel pin (2)
57 Stud (4)
58 Pipe plug, 1/2 in.
59 Pipe plug, vented
60 Gear housing

*Figure 5-9*—Continued.

*b.* Reassemble the lateral shift gear assembly in reverse of the numerical sequence as illustrated on figure 5-9 and the following instructions.

*c.* Press bushing (55) into bore of housing until edge of bushing is flush with the bottom of the bore.

*d.* Install four studs (57) in the housing and torque studs to 25 to 35 foot pounds.

*e.* Heat drive gear (52) in oil to approximately 350°F. Press gear shaft (53) into gear until shaft extends 1 3/4 inches from long hub of gear as shown in figure 5-10.

*f.* Install two keys (47) in gear shaft (48) and press shaft into worm gear (46) until shaft extends 2 1/32 inch from face of gear.

*g.* Install thrust bearing (50) in housing, with dowel pin entering hole in housing. Install worm gear (46) and shaft through thrust bearing. Install worm gear (49) up in slot in housing, with long hub of gear towards shaft. Aline splines in gear with splines on shaft.

*h.* Place a block of wood behind worm gear as shown in figure 5-11. Using a soft driver and hammer, drive gear on splines of shaft until shaft is flush with face of outer gear hub.

*Note.* Thrust bearing must stay on dowel pin while driving gear on shaft.

*i.* After installing bearing cap (37), adjust large worm gear thrust bearing by tightening setscrew (36) until a drag is felt when the shaft is rotated. Loosen setscrew until drag is eliminated. Hold setscrew and tighten nut (35) to hold adjustment.

*j.* When installing housing cover (29), install two screws (25) in the two holes immediately adjacent to the rounded area below bearing cap mounting surface for bearing cap (18). Install the taper head screw (24) in cover and torque screw to 60 foot pounds. Install two remaining screws (25) when attaching bearing bracket (28).

*k.* Install key (12) in gear shaft (13) and press shaft into worm gear (11) until end of shaft extends 1 inch from face of gear.

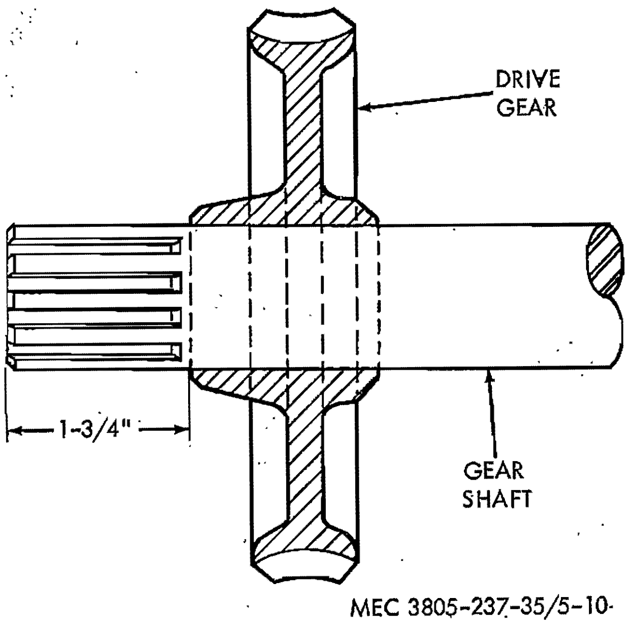



*Figure 5-10. Installing drive gear on gear shaft.*

*l.* Install oil seals (9 and 54), with lip of seal toward inside of housing, after installation of gear shafts. Place a piece of shim stock around shaft and slide oil seal over shaft and into housing. Press oil seals into bore of housing and bearing cap, using a suitable tool.

*m.* After installation of oil seal, adjust small worm gear thrust bearing by tightening setscrew (17) until a drag is felt when shaft is rotated. Loosen setscrew until drag is eliminated. Hold setscrew and tighten nut (16) to hold adjustment.

*n.* To install lateral shift arm (5), drive a chisel or wedge into slot in arm to expand bore. Aline splines in arm with splines on shaft to allow arm to extend down from housing. Slide arm on shaft. Leave a minimum clearance of 1/32 inch between arm and housing and secure arm to housing with two arm bolts (3), four lockwashers (4) and nuts (2).

## 5-30. Installation

Refer to paragraph 2-36 and install lateral shift gear housing on the motor grader.

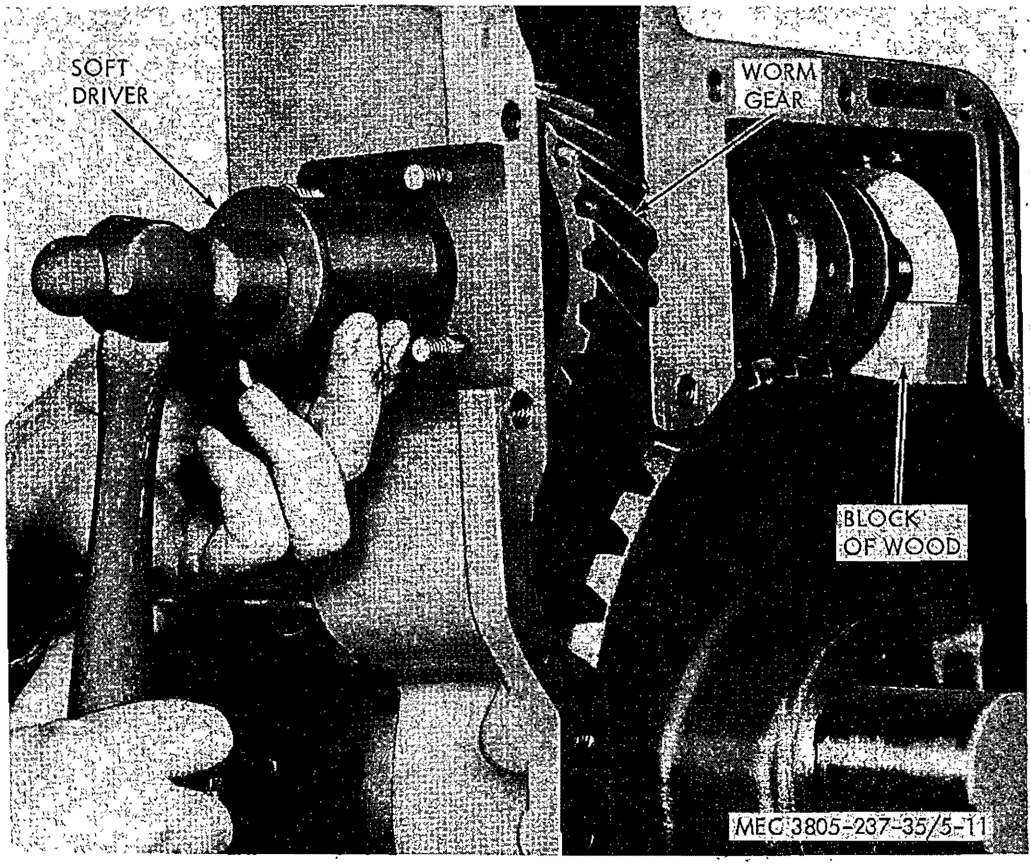



*Figure 5-11. Installing worm gear and shaft.*

## Section VI. FRONT LEAN WHEEL GEAR ASSEMBLY

### 5-31. General

*a.* The nature of the work performed by the motor grader in grading with an angled moldboard blade tends to pull or drift the grader to one side or the other while in operation. To counteract this side torque, a gear assembly and vibrating bar attached to the front axle will tilt or lean the front wheels away from the side shift and help to maintain a straight line of travel.

*b.* The front wheel lean gear assembly is mounted on the front axle at the right side of the frame. The leaning gear pinion engages a gear rack attached to the vibrating bar. The vibrating bar is connected to the top of the wheel spindles. Rotation of the lean gear moves the rack in an arc, moving the vibrating bar. When the bar moves the wheels lean in the direction desired.

### 5-32. Removal

Refer to paragraph 2-37 and remove the front lean wheel gear assembly from the motor grader.

### 5-33. Disassembly

*a.* Disassemble the front lean wheel gear assembly in the numerical sequence as illustrated on figure 5-12 and the following instructions.

*b.* If not marked, mark drive gear (24) and pinion (25) with a punch to provide proper alinement during assembly. Place puller screws in the holes of drive gear. Attach a suitable puller to the screws and pull gear from shaft of pinion.

*c.* Use care when pressing bushings from cover, housing, and thrust bearing. Do not damage components.

*d.* Discard all preformed packings and gaskets after removal.

## 5-34. Cleaning

*a.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*b.* Clean all accumulated grease and dirt from gear assembly parts.

## 5-35. Inspection and Repair

*a.* Inspect all parts for wear and damage.

*b.* Check all parts against tolerance listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

*c.* Replace all worn or damaged parts.

## 5-36. Reassembly

*a.* Reassemble the front lean wheel gear assembly in reverse of the numerical sequence as illustrated on figure 5-12 and the following instructions.

*b.* Lubricate all preformed packings and working surfaces of shafts and bushings before installation. Use shellac or gasket seal on all gaskets.

*c.* Press bushing (39) into housing (40) until end of bushing is flush with inside of housing. Press oil seal (38) and grease seal (37), with lips of seals toward inside of housing, into bore to seat behind bushing.

*d.* Press bushing (36) into housing until end of bushing is flush with bottom of chamfer.

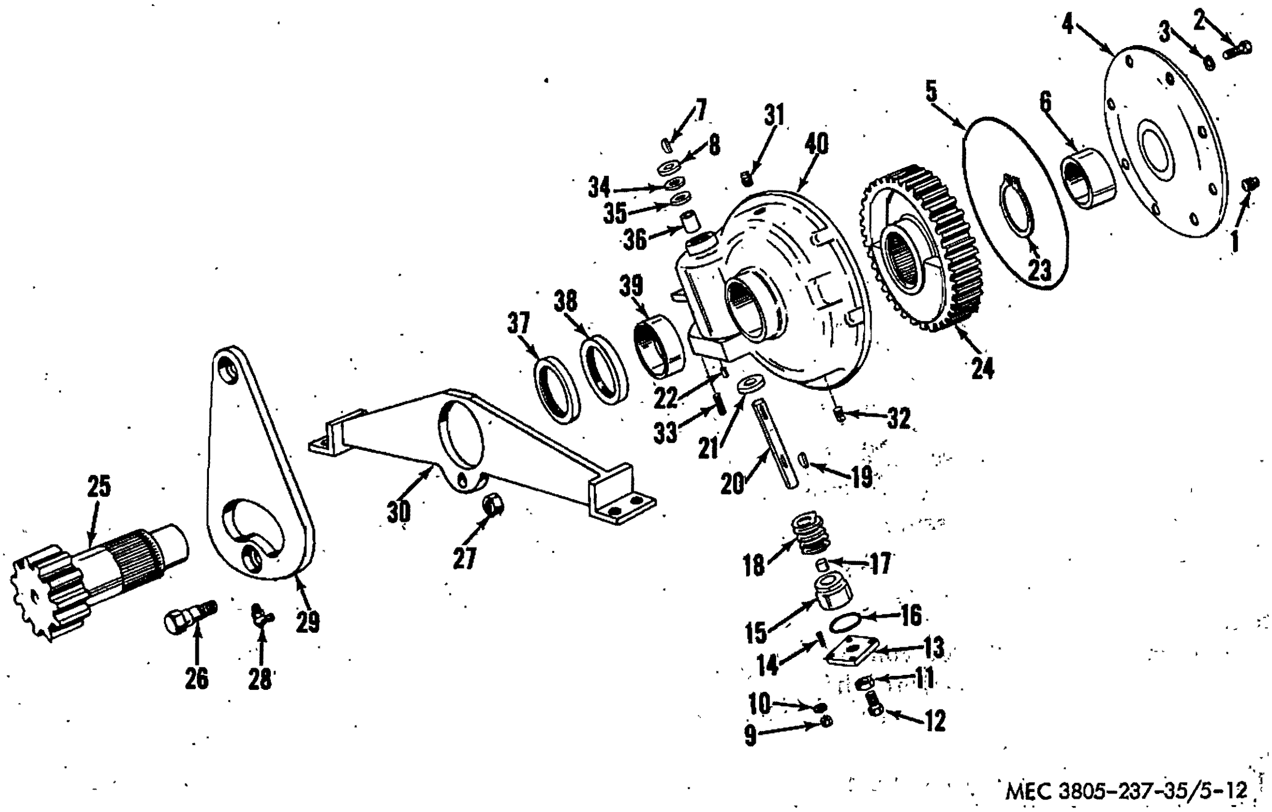
*e.* After installing support (30) and vibrating link (29), install lean gear pinion (26) into housing. Set housing on a suitable support, aline punch mark on drive gear (24) with mark on shaft and press drive gear on shaft until gear meets shoulder.

*f.* Press worm gear (18) on shaft (20) over key (19) until end of shaft extends 1 3/8 inches from face of worm.

*g.* After installing worm gear and shaft, install oil seal (35) and grease seal (34) in housing around shaft, with lips of seals towards inside of housing. Use a strip of shim stock around shaft to slide seal into position.

## 5-37. Installation

Refer to paragraph 2-37 and install the front lean wheel gear assembly on the motor grader.




| | | | |
|---|---|---|---|
| 1 | Pipe plug, 1/2 in. | 21 | Thrust bearing |
| 2 | Screw, cap, hex-head, 3/8-16 × 1 1/8 in. (6) | 22 | Spring pin |
| 3 | Washer, lock, 3/8 in. (6) | 23 | Retaining ring |
| 4 | Housing cover | 24 | Drive gear |
| 5 | Preformed packing | 25 | Lean gear pinion |
| 6 | Bushing | 26 | Shoulder bolt |
| 7 | Key, woodruff | 27 | Lock nut |
| 8 | Felt seal | 28 | Lubrication fitting |
| 9 | Nut, 5/8-11 (4) | 29 | Vibrating link |
| 10 | Washer, lock, 5/8 in. (4) | 30 | Housing support |
| 11 | Nut | 31 | Pipe plug, vented |
| 12 | Setscrew | 32 | Pipe plug, magnetic |
| 13 | Bearing cap | 33 | Stud |
| 14 | Dowel pin | 34 | Grease seal |
| 15 | Thrust bearing | 35 | Oil seal |
| 16 | Preformed packing | 36 | Bushing |
| 17 | Bushing | 37 | Grease seal |
| 18 | Worm gear | 38 | Oil seal |
| 19 | Key, woodruff | 39 | Bushing |
| 20 | Gear shaft | 40 | Gear housing |

*Figure 5-12. Front lean wheel gear assembly, exploded view.*

# CHAPTER 6
# POWER CONTROL BOX AND VERTICAL DRIVE HOUSING REPAIR INSTRUCTIONS

## 6–1. General

*a.* Power for moldboard lift and lateral shift gear assemblies, scarifier lift gear assembly, circle reverse mechanism, and front lean wheel gear assembly is supplied through the power control box. The power control box drives the control shafts leading to each gear assembly.

*b.* Drive for the power control box is supplied through the vertical drive housing. Whenever the engine is operating, the vertical drive housing is driven by a propeller shaft directly coupled to the engine flywheel. This shaft extends through the clutch and the upper transmission shaft, which is hollow. The propeller shaft is coupled to the drive shaft of the vertical drive housing by a coupling containing a shear bolt. Too great a load placed on the gear assemblies, power control box, or vertical drive housing will break the bolt and halt operation of the unit before any damage can be done to the operating parts.

*c.* A vertical shaft and bevel pinion in the vertical drive housing drives the power control box. Gears in the control box are driven whenever the engine is operating. Shift levers, connected to clutches, shift the motions. When the levers are shifted the clutches engage the drive gears and rotate the control shafts and through the shafts, the gear assemblies.

*d.* The shaft of the vertical drive housing extends out of the front of the housing and is splined to a pump drive gear. An adapter mounted on the drive housing, houses the drive gears for the steering and moldboard power shaft hydraulic pumps. The pumps are always operating when the engine is operating to supply hydraulic pressure to steer the grader and shift the moldboard.

## 6–2. Vertical Drive Housing

*a. Removal.* Refer to paragraph 2–38 and remove the vertical drive housing and power control box from the motor grader.

*b. Disassembly.*

(1) Remove drain plug (1, fig. 6–1) and drain lubricant from vertical drive housing.

(2) Remove six screws (2) and lockwashers (3) and remove vertical drive housing from power control box. Remove and check thickness and number of shims (4).

(3) Disassemble vertical drive housing in the numerical sequence as illustrated on figure 6–1.

(4) Do not remove bearing races (except bearing race (16)) unless races require replacement.

(5) Check amount and thickness of all shims when they are removed to install required number at reassembly.

(6) Discard all gaskets and preformed packings after removal.

*c. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P–S–661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly flammable. Do not use solvent near an open flame.**

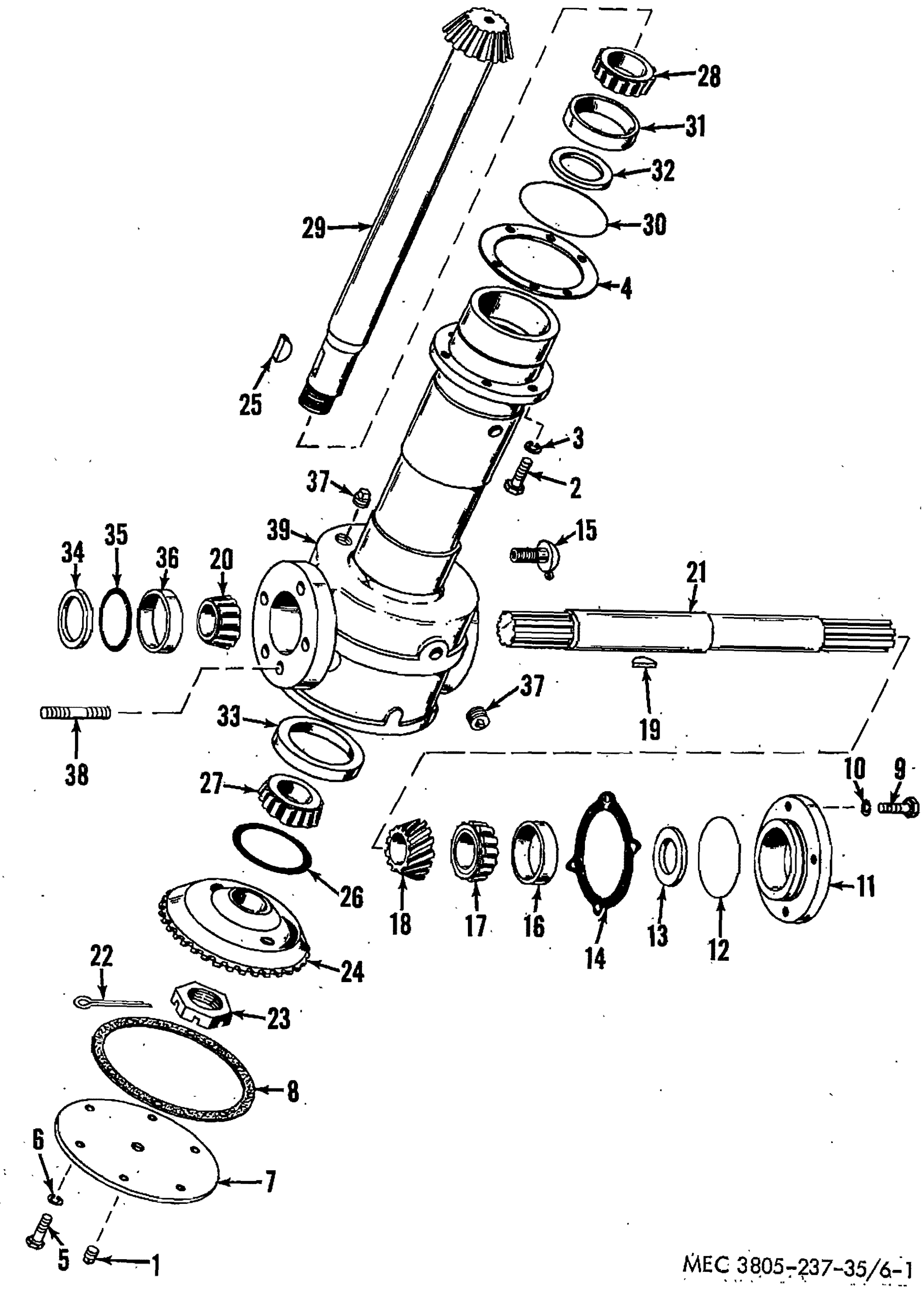



*Figure 6-1. Vertical drive housing, exploded view.*

| | | | |
|---|---|---|---|
| 1 | Pipe plug, magnetic | 21 | Drive shaft |
| 2 | Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (6) | 22 | Pin, cotter, 5/32 × 2 in. |
| 3 | Washer, lock, 3/8 in. (6) | 23 | Lock nut |
| 4 | Shims (0.010, 0.005 thick) | 24 | Bevel gear |
| 5 | Screw, cap, hex-head, 3/8-16 × 1 in. (6) | 25 | Key, woodruff |
| 6 | Washer, lock, 3/8 in. (6) | 26 | Laminated shim (2) |
| 7 | Cover plate | 27 | Lower roller bearing |
| 8 | Plate gasket | 28 | Upper roller bearing |
| 9 | Screw, cap, hex-head, 5/16—18 × 1 1/4 in. (4) | 29 | Vertical drive shaft |
| 10 | Washer, lock, 5/16 in. (4) | 30 | Preformed packing |
| 11 | Seal cap | 31 | Upper bearing race |
| 12 | Preformed packing | 32 | Oil seal |
| 13 | Oil seal | 33 | Lower bearing race |
| 14 | Shims (0.005, 0.007, 0.0020 thick) | 34 | Bearing spacer |
| 15 | Breather | 35 | Shim |
| 16 | Bearing race | 36 | Bearing cone |
| 17 | Roller bearing | 37 | Pipe plug (3) |
| 18 | Bevel pinion | 38 | Stud (2) |
| 19 | Key, woodruff | 39 | Vertical drive housing |
| 20 | Roller bearing | | |

*Figure 6-1*—Continued.

(2) Clean all accumulated grease and dirt from vertical drive housing parts.

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

(3) Replace all worn or damaged parts.

*e. Reassembly.*

(1) Reassemble the vertical drive housing in reverse of numerical sequence as illustrated on figure 6-1 and the following instructions.

(2) Lubricate preformed packings before installation. Use shellac or gasket seal on all gaskets.

(3) Install upper and lower bearing races (31 and 33) in vertical drive housing with small end of taper towards inside of housing. Install oil seal (32) ahead of race with lip of seal toward top of housing.

(4) Lubricate roller bearings (17, 20, 27 and 28) with a good light grade of machine oil before installing.

(5) Press upper roller bearing (28) on vertical drive shaft (29), large diameter first, until bearing is seated against shoulder below bevel gear on shaft.

(6) Install vertical drive shaft through seal in top of housing, using care so as not to damage seal. Use a piece of shim stock wrapped around shaft to protect seal when starting shaft through seal. Remove shim stock.

(7) After installing vertical drive shaft, install lower roller bearing (27) over shaft and into race, pressing bearing in with a suitable tool.

(8) Install shims (26) bevel gear (24) and key (25) on drive shaft. Tighten locknut (23) securely on shaft. Back nut off one slot or enough to aline slot with hole in shaft and install cotter pin (22).

(9) Using a block of wood or soft driver, tap the lower end of shaft sharply to pre-load the bearings. Bearing preload is 4 to 8 inch pounds.

(10) Install key (19) in shaft (21) and install bevel gear (18) on shaft. Drive bevel gear on shaft until seated firmly against shoulder.

(11) Install roller bearings (17 and 20) on shaft, with small diameter of bearings facing ends of shaft. Drive bearings on shaft until seated firmly against shoulders.

(12) Install shaft, with bearings and gear, into housing as shown in figure 6-2. Bevel pinion and bevel gear must

run flush at toe end of gears. Install bearing race (16) in bore and drive in place with a soft hammer.

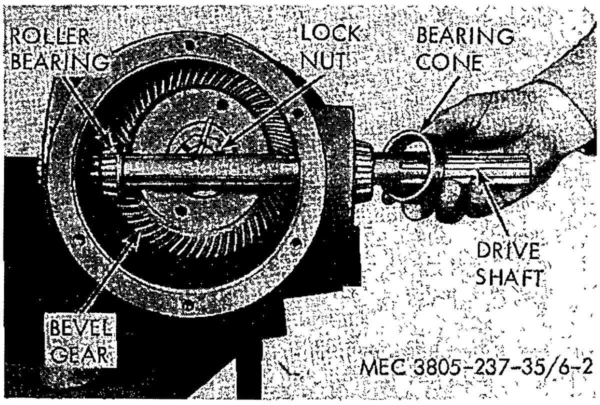



*Figure 6-2. Installing drive shaft.*

(13) Press oil seal (13) into seal cap, with lip of seal towards inside of vertical drive housing. Wrap a piece of thin shim stock over splines of drive shaft and slide seal cap and shims (14) on housing. Remove shim stock. Tighten screws (9) securely.

(14) Install pump adapter (fig. 2-17) and shims on vertical drive housing without gasket. Tighten screws securely.

(15) Check pre-load of bearings with a torque wrench as shown in figure 6-3. Install a suitable adapter on splines of drive shaft extending from seal cap to connect torque wrench. Preload bearings to 4 to 8 inch pounds.

(16) To obtain correct reading, remove or add shims under seal cap. If necessary, remove or add shims from under pump adapter to obtain correct reading.

*Note.* When removing or adding shims as above, make certain bevel pinion and bevel gear remain flush at toe ends of gears.

(17) Use a dial indicator to check backlash between gears. Backlash should be 0.004 to 0.012 inches. Measure backlash at tightest point. Remove or add shims (26) from above bevel gear to obtain correct backlash.

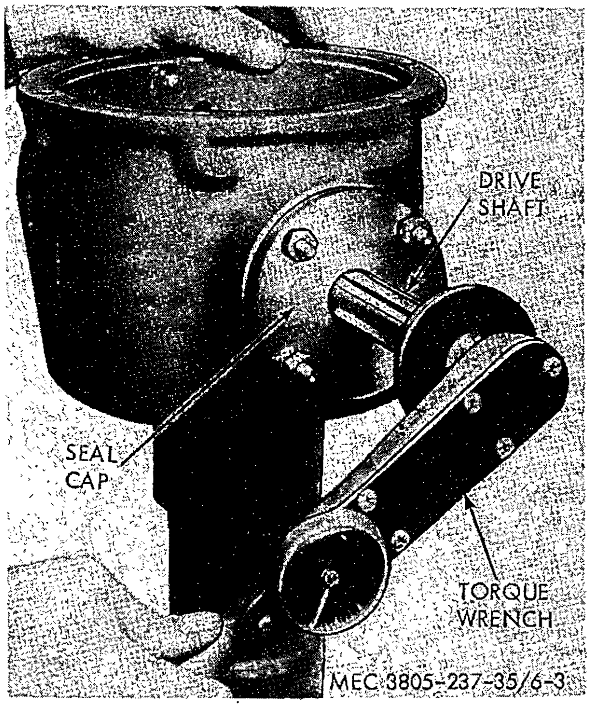



*Figure 6-3. Pre-load bearings.*

(18) Clean both gears to remove all oil. Spread a marker type of dye, such as Prussian blue, on the working surface of the gear teeth. Rotate the gears several revolutions in the forward speed direction. Inspect gear teeth for contact patterns. Refer to figure 6-4 for correct tooth patterns and adjustment

(19) After setting bearing pre-load, pinion depth, backlash, and tooth contact, remove pump adapter.

*Note.* Attach correct amount of shims to pump adapter for installation with adapter after vertical drive housing has been installed in motor grader.

*f. Installation.*

(1) Install vertical drive housing on power control box with gear on vertical drive shaft (29) engaging bevel gears in power control box. Install same amount of shims (4) between drive housing and power control box as were present when vertical drive housing was removed from power control box.

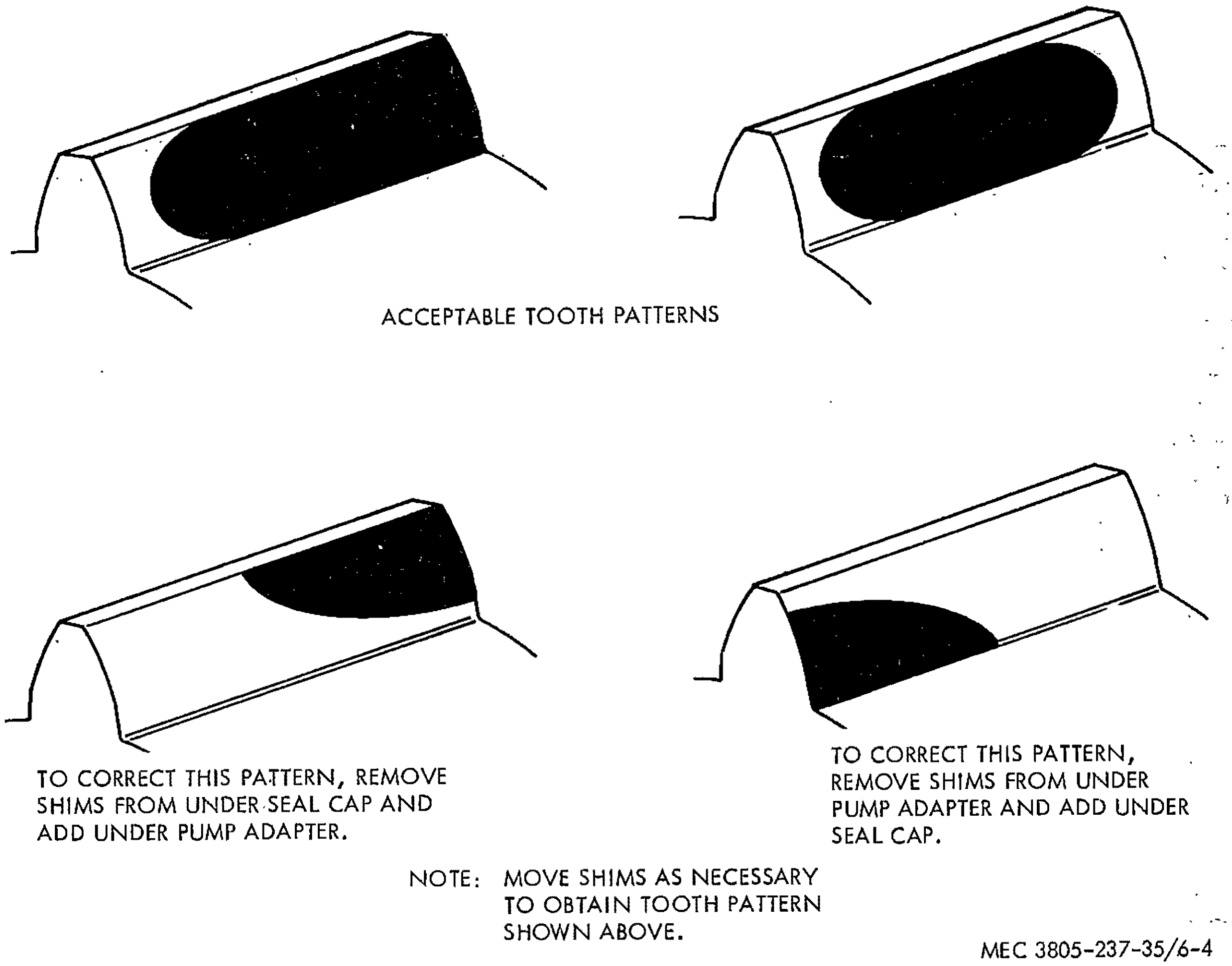



*Figure 6-4. Gear teeth contact patterns.*

(2) Shims should give correct distance between gear on vertical drive shaft and shaft of bevel gears in power control box.

*Note.* Refer to assembly of power control box (para 6-3) to adjust backlash between gears.

## 6-3. Power Control Box

*a. Removal.*

(1) Refer to paragraph 2-38 and remove power control box and vertical drive housing from motor grader.

(2) Refer to paragraph 6-2 and remove vertical drive housing from power control box.

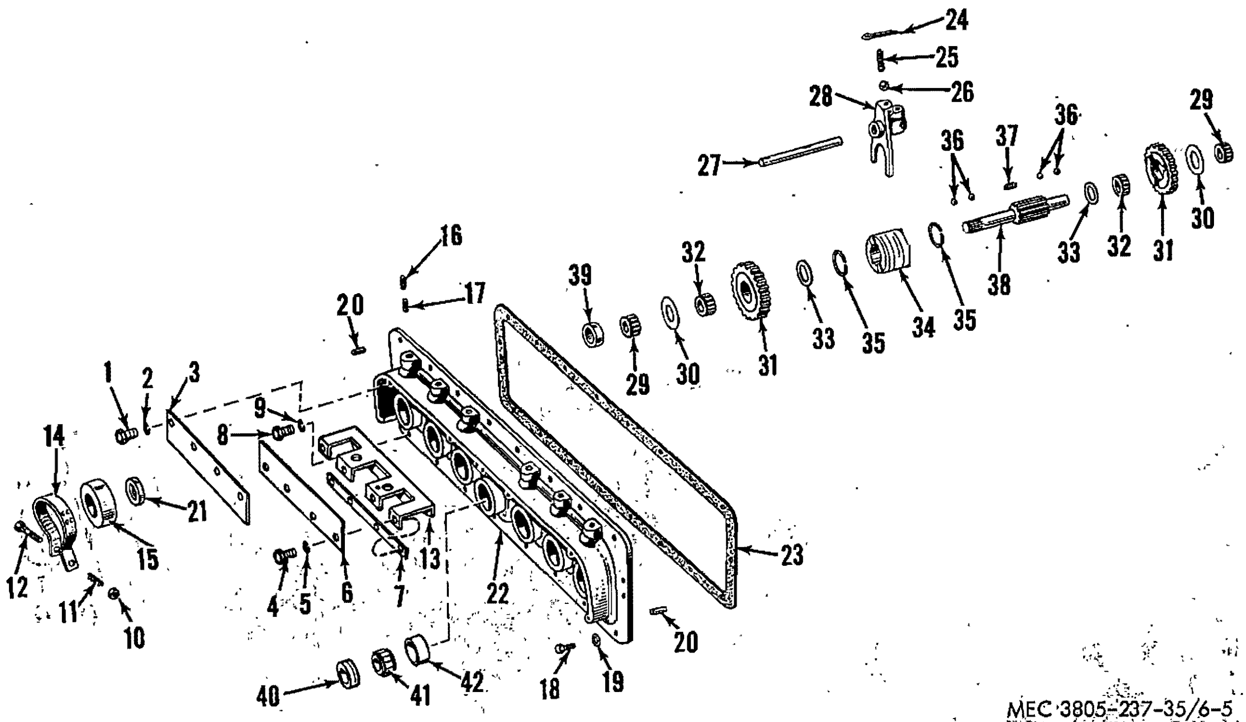
*b. Disassembly.*

(1) Remove drain plug (35, fig. 6-6) and drain lubricant from power control box.

(2) Remove and disassemble power control box cover and clutch assemblies in numerical sequence as ilustrated on figure 6-5.

*Note.* Remove 12 screws (1, fig. 6-6) and lockwashers (2) and remove six shift lever assemblies and twelve shims (3 and 4) before removing power control box cover (22, fig. 6-5).

(3) Disassemble remainder of power control box in numerical sequence as illustrated on figure 6-6.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 5/16 × 1 1/2 in. (8) | 21 | Oil seal (6) |
| 2 | Washer, lock, 5/16 in. (8) | 22 | Power box cover |
| 3 | Upper strap (2) | 23 | Cover gasket |
| 4 | Screw, cap, hex-head, 5/16–18 × 1 1/2 in. (8) | 24 | Pin, cotter, 3/16 × 1 1/4 in. (6) |
| 5 | Washer, lock, 5/16 in. (8) | 25 | Compression spring (6) |
| 6 | Lower strap (2) | 26 | Poppet ball (6) |
| 7 | Locking bar (2) | 27 | Shifter rail |
| 8 | Screw, cap, hex-head, 3/8–16 × 1 3/8 in. (4) | 28 | Shifter fork |
| 9 | Washer, lock, 3/8 in. (4) | 29 | Roller bearing (12) |
| 10 | Nut, lock (6) | 30 | Thrust washer (12) |
| 11 | Compressor spring (6) | 31 | Clutch gear (12) |
| 12 | Bolt carriage, 5/16–18 × 2 1/2 in. (6) | 32 | Roller bearing (12) |
| 13 | Anchor plate (2) | 33 | Thrust washer (12) |
| 14 | Brake band and lining (6) | 34 | Clutch (6) |
| 15 | Brake drum (6) | 35 | Retaining ring (12) |
| 16 | Setscrew, socket-head, cup point, 3/8–16 × 5/8 in. (6) | 36 | Ball (75) |
| 17 | Setscrew, socket-head, cone point, 3/8–16 × 3/4 in. (6) | 37 | Separator spring (15) |
| 18 | Screw, cap, hex-head, 3/8–16 × 1 in. (14) | 38 | Clutch shaft (6) |
| 19 | Washer, lock, 3/8 in. (14) | 39 | Bearing race (6) |
| 20 | Dowel pin (2) | 40 | Oil seal |
| | | 41 | Roller bearing |
| | | 42 | Bearing race |

*Figure 6–5. Power control box cover and clutches, exploded view.*

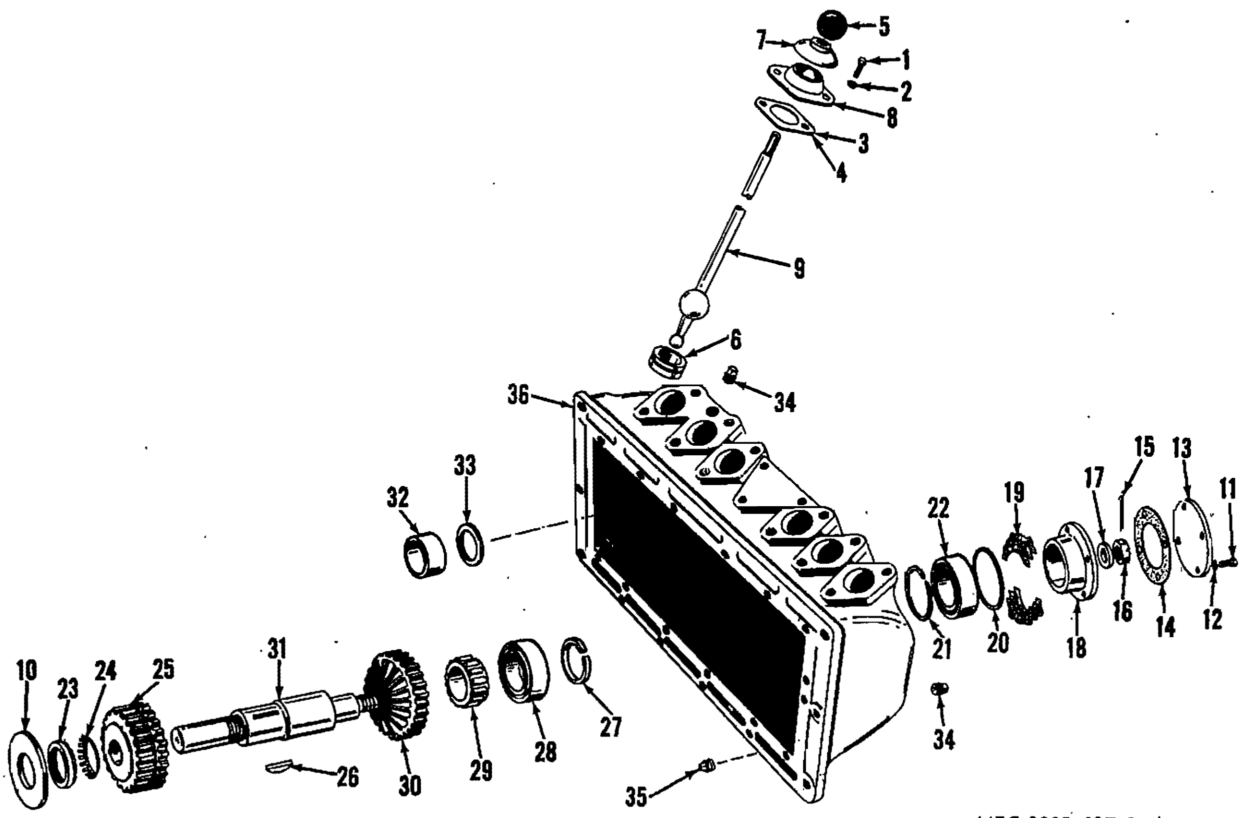
(3) Do not remove bearing races unless races require replacement.

(4) Check amount and thickness of shims when they are removed to install required number at reassembly.

(5) Discard all gaskets and preformed packings after removal.

*c. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P–S–661)




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 3/8-16 × 1 in. (12) | 19 | Shims |
| 2 | Washer, lock, 3/8 in. (12) | 20 | Preformed packing |
| 3 | Shim (6) | 21 | Retaining ring |
| 4 | Laminated shim (6) | 22 | Ball bearing |
| 5 | Lever ball (6) | 23 | Bearing nut |
| 6 | Ball seat (6) | 24 | Key washer |
| 7 | Lever cap | 25 | Front bevel gear |
| 8 | Cap | 26 | Key, woodruff |
| 9 | Shift lever | 27 | Spacer |
| 10 | Spacer | 28 | Ball bearing |
| 11 | Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (4) | 29 | Roller bearing |
| 12 | Washer, lock, 3/8 in. (4) | 30 | Rear bevel gear |
| 13 | Bearing cover | 31 | Gear shaft |
| 14 | Cover gasket | 32 | Bearing race |
| 15 | Pin, cotter, 3/32 × 1 1/2 in. | 33 | Spacer |
| 16 | Nut, slotted, 3/4-16 | 34 | Pipe plug (2) |
| 17 | Spacer | 35 | Pipe plug, magnetic |
| 18 | Bearing retainer | 36 | Power control box housing |

*Figure 6-6. Power control box housing, levers, and drive gears, exploded view.*

and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Remove all accumulated grease and dirt from power control box parts.

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage. Check housing and cover for

cracks or any evidence of metal fatigue. Check closely for evidence of lubricant leaks.

(2) Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(3) Replace the anti-coasting brakes when the linings are worn to within 1/32 to 1/16 inch of closest rivet head.

(4) Replace all worn or damaged parts.

*e. Reassembly.*

(1) Reassemble power control box gears and housing in reverse of numerical sequence as illustrated on figure 6-6.

*Note.* Do not install shift levers (1 through 9) until clutches and power control box cover (fig. 6-5) have been installed.

(2) Install woodruff key (26) in shaft and press shaft in front bevel gear (25), using a suitable arbor press, until gear is firmly seated against shoulder on shaft.

*Note.* Bevel gear face must be towards shoulder on shaft.

(3) Install key washer (24) on shaft, with inside tab of washer in keyway. Install and tighten bearing nut (23) securely. Bend tabs on key washer into slots on nut.

(4) Press roller bearing (29) and ball bearing (28) in rear bevel gear (30) and press gear on shaft, with bevel gear face towards front bevel gear. Install spacer (27) on shaft.

*Note.* Measure distance between flat inner faces of bevel gears. Distance should be 0.766 to 0.802 inches. Adjust gears on shaft to obtain this clearance.

(5) Press ball bearing (22) into bearing retainer (18) and install retaining ring (21) in cage. Slide bearing retainer in housing. Install gears and shaft, with threaded end of shaft through retainer, and secure with spacer (17) and nut (16), as shown in figure 6-7. Tighten nut securely.

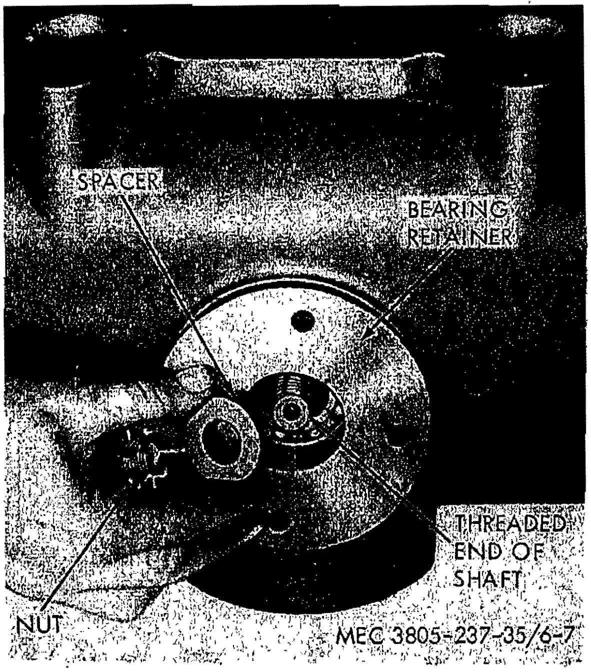



*Figure 6-7. Installing bearing retainer.*

(6) Install bearing race (42, fig. 6-5) in power box cover (22). Install roller bearing (41) in bearing race. Install cover on power box housing, with shaft of drive gears through bearing. Secure cover with screws (18) and lockwashers (19).

(7) Install vertical drive housing on power box, with same number of shims as when removed. Secure drive housing with six screws (2, fig. 6-1) and lockwashers (3).

(8) Tighten slotted nut (fig. 6-7) until there is no backlash when gears are rotated. Back off slotted nut two slots. continue to back off enough to aline hole in shaft with slot in nut. Install cotter pin (15, fig. 6-1).

(9) Use a feeler gage to measure distance between bearing retainer (fig. 6-7) and housing. Add 0.010 inch to this distance and install amount of shims (19, fig. 6-6) to equal feeler gage measurement plus the 0.010.

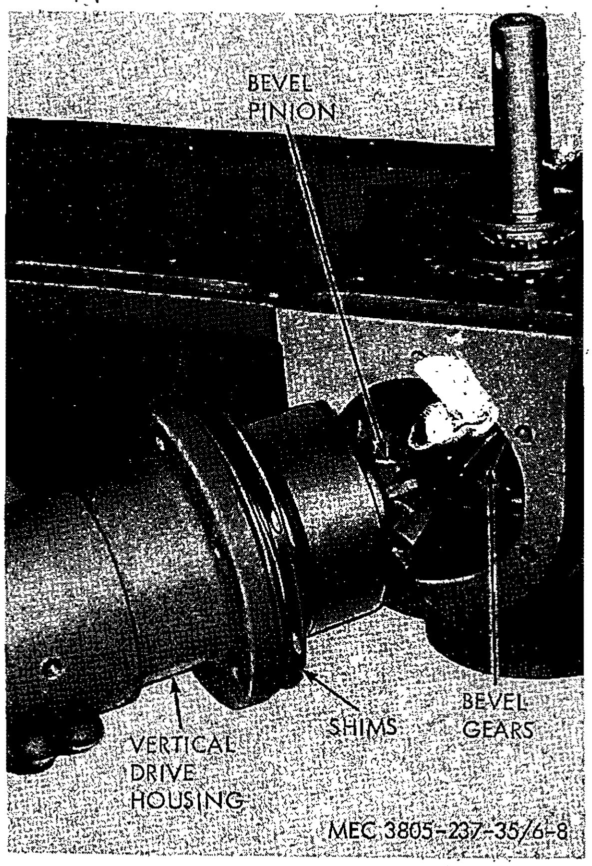



*Figure 6-8. Installing vertical drive housing.*

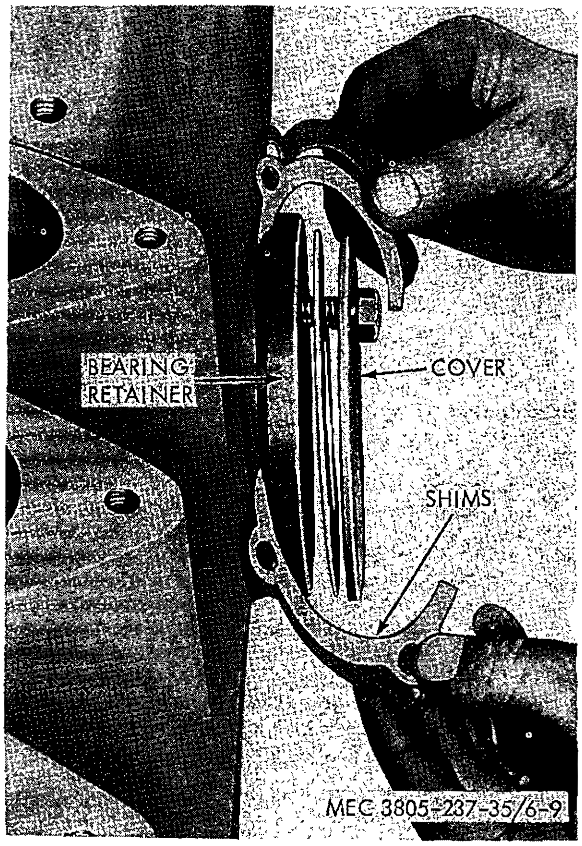



*Figure 6-9. Installing cover and shims.*

(10) Install cover (13, fig. 6-6), gasket (14), and shims as shown in figure 6-9. Tighten screws securely.

*Note.* The procedure described above will provide a backlash of approximately 0.008 to 0.010 inches between gears.

(11) Refer to paragraph 6-2 and remove vertical drive housing from power control box.

(12) Refer to figure 6-5 and remove power control box cover.

*Note.* The following instructions ((13) through (15)) apply to all six clutch assemblies.

(13) Install one retaining ring (35, fig. 6-5) in bore of clutch (34). Refer to figure 6-10 and assemble clutch on shaft.

(14) Refer to figure 6-11 and install clutch gears, bearings, and thrust washers and shifter forks on clutch shaft and clutch.

(15) Install six roller bearing races (39, fig. 6-6) and six races (32, fig. 6-6) and six spacers (33, fig. 6-6) in cover and housing. Races must be pressed in bores until edge of race is flush with inside surface of housing and cover.

(16) Install 12 roller bearings (29, fig. 6-5) in the races in housing and cover.

(17) Refer to figure 6-12 and install clutch assemblies in power control box.

*Note.* Install clutch assembly containing fifteen balls and no separator springs in second position from right end of power control box.

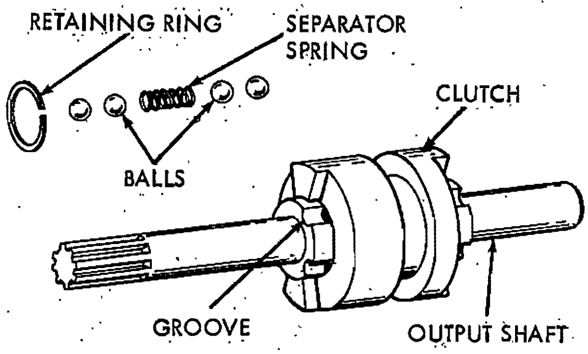



*Figure 6-10. Assembling clutch.*

(18) Refer to figure 6-5 and complete assembly of power control box.

(19) Install oil seal (40, fig. 6-5) over gear shaft by placing a piece of shim stock around shaft and sliding oil seal, with lip of seal towards inside of housing, over shim stock and into bore of cover. Remove shim stock and press seal in place.

(20) Install shift levers (fig. 6-6) on power control box. Install sufficient number of shims (3 and 4) to provide 1/32 inch vertical movement of shift lever.

*f. Installation.*

(1) Refer to paragraph 6-2 and install vertical drive housing on power control box.

(2) Refer to paragraph 2-38 and install power control box and vertical drive housing on motor grader.

*g. Adjustment.*

(1) After installation of power control, adjust anti-coast brakes.

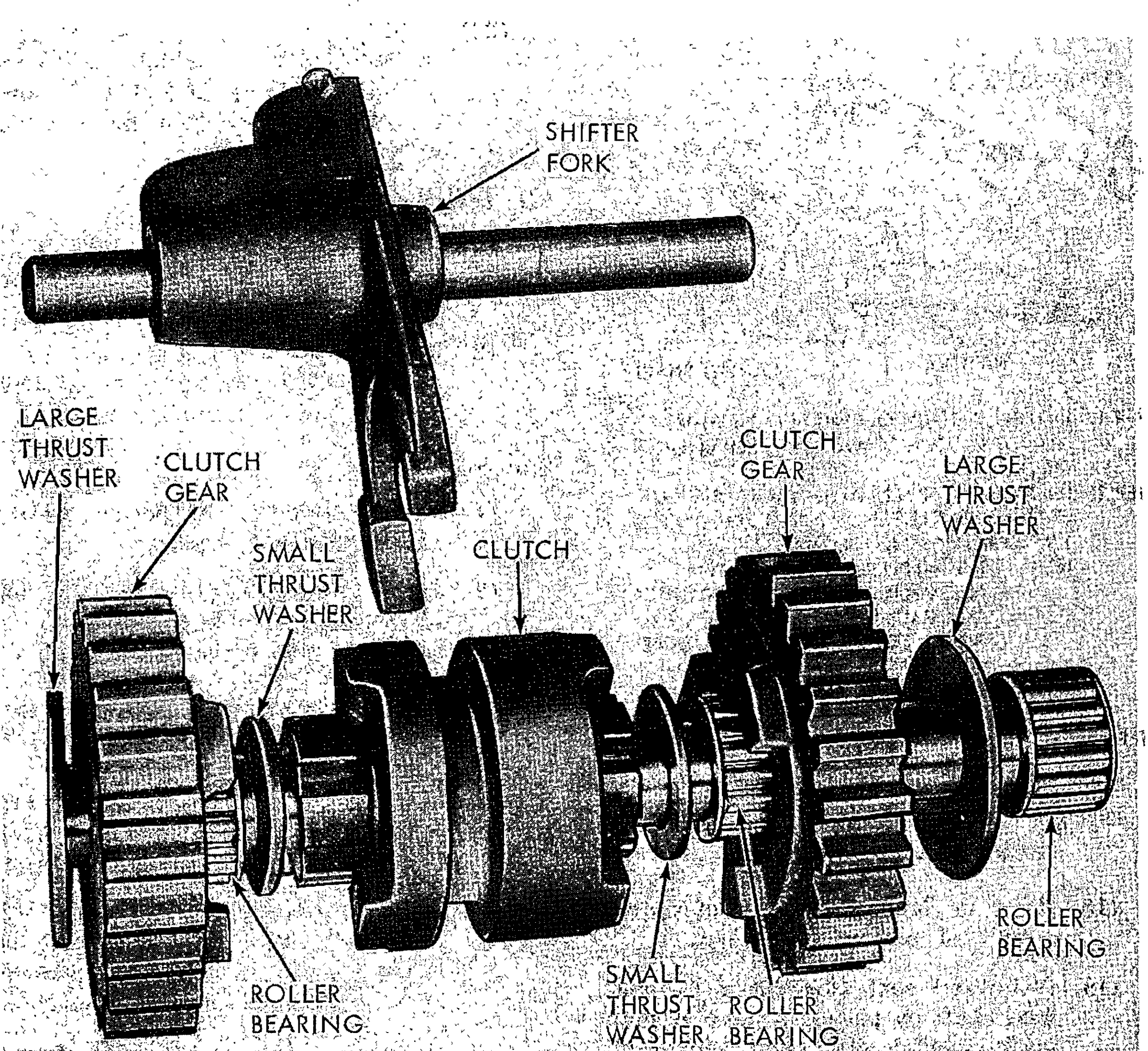
(2) Tighten locknuts (10, fig. 6-5) until a pull of 90 inch pounds is required to rotate the brake drum.

*Note.* Adjust thrust bearings on gear assemblies (TM 5-3805-237-12) before adjusting anti-coast brakes.

(3) Refer to TM 5-3805-237-12 to start engine and operate motor grader. Check all motions for brake action.

(4) If brake is too tight, shift lever will not work smoothly, but will be forced back out of engagement. Loosen locknut enough to compensate.

(5) If brake is too loose it will not eliminate coasting and will cause the brake drum and shaft to vibrate. Tighten nut to compensate.




STEP 1. REFER TO FIGURE 6-5 AND ASSEMBLE SHIFTER FORK.
NOTE: COUNTERSUNK END OF SHIFTER RAIL MUST EXTEND FROM FLAT SIDE OF FORK.

STEP 2. INSTALL COMPONENTS ON CLUTCH SHAFT IN THE ORDER SHOWN ABOVE.
NOTE: BEVELED SIDE OF SMALL THRUST WASHER MUST BE INSTALLED TOWARD CLUTCH.

STEP 3. INSTALL TWO OUTER ROLLER BEARINGS IN HOUSING AND COVER.

STEP 4. INSTALL LEGS OF SHIFTER FORK IN GROOVE IN CLUTCH.

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*Figure 6-11. Installing clutch drive components.*

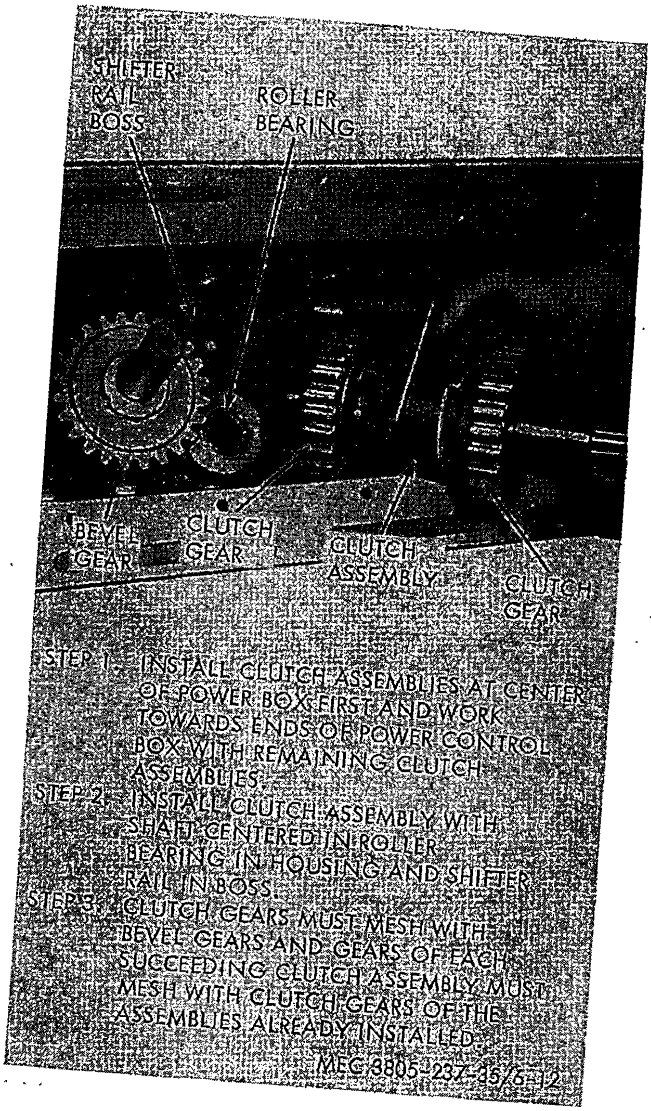



*Figure 6-12. Installing clutch assembly.*

# CHAPTER 7
# HYDRAULIC SYSTEM REPAIR INSTRUCTIONS

## Section I. GENERAL

### 7-1. Description

*a.* The hydraulic system of the motor grader, exclusive of the wheel brakes, consists of a hydraulic reservoir, two hydraulic pumps, steering assembly, power shift moldboard control valve and lever, rotary valve, and power shift moldboard cylinder. A schematic diagram of the hydraulic system is illustrated in figure 7-1.

### 7-2. Components

*a.* The two hydraulic pumps are driven by the vertical drive housing and are mounted

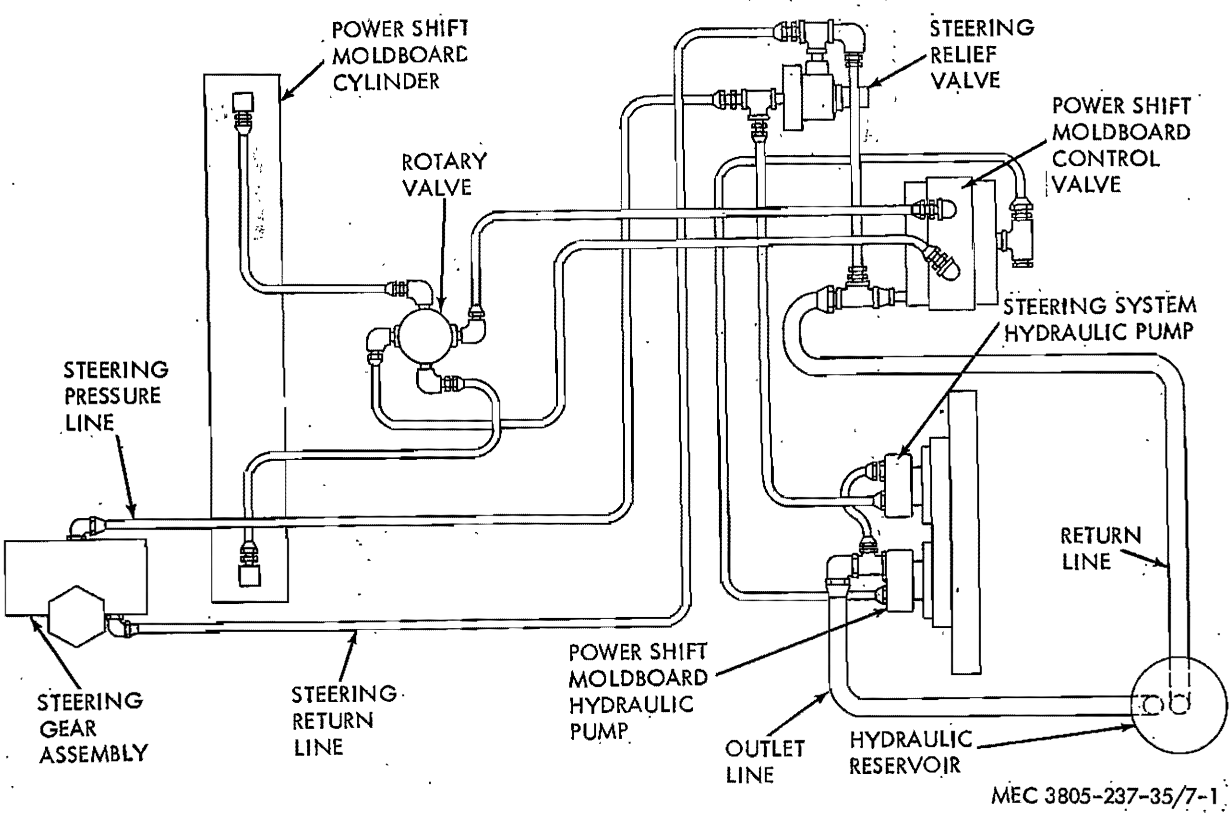



*Figure 7-1. Hydraulic system, schematic diagram.*

beneath the frame in front of the power control box. A hose from the hydraulic reservoir carries oil to a tee at the power shift moldboard pump, and a tube leading from the tee connects to the inlet side of the steering system pump.

*b.* Oil under pressure is fed from the power shift pump to the right hand side of the control valve (fig. 7–1) and out through two lines to the rotary valve mounted on the drawbar forward of the moldboard. Movement of the power shift lever opens the valve to either hose, sending oil to the power shift moldboard cylinder (fig. 7–1) which shifts the moldboard. Oil returned to the reservoir leaves the control valve through a tee on the left side of the valve.

*c.* Oil under pressure from the steering system hydraulic pump (fig. 7–1) flows to a tee at the pressure relief valve. This relief valve protects the system by allowing a pressure adjustment. Normal pressure at idle should be 700 to 800 psi (pounds per square inch) and at high idle, 1150 to 1200 psi. When pressure exceeds 1200 psi the relief valve will open and bypass oil back to the reservoir. From the tee at the relief valve the pressure is carried to the steering gear assembly mounted above the front axle. Rotation of the steering wheel and control shaft rotate an actuating shaft connected to a valve. The valve moves a piston with a rack on the left side. Movement of the piston rack turns a gear splined to a vertical shaft. The vertical shaft is connected to the steering arm and tie rods which turn the wheels.

## Section II. HYDRAULIC LINES

### 7–3. General

The hydraulic lines shown in the schematic (fig. 7–1) are used to carry the hydraulic pressure through the system. Lines are normally clamped to the frame for support and can be removed by removing clamps and disconnecting lines.

### 7–4. Removal

*a.* Remove steering hydraulic lines in numerical sequence as illustrated on figure 7–2.

*b.* Remove power shift moldboard hydraulic lines in numerical sequence as illustrated on figure 7–3.

*Note.* To keep dirt of any type from entering hydraulic system, cap all tubes, hoses, and ports whenever disconnections are made.

### 7–5. Cleaning

Clean metal tubes with cleaning compound, solvent (Spec. P–S–661) and blow dry with compressed air. Clean hoses with compressed air. Plug all tubes and hoses to keep dirt from entering.

### 7–6. Inspection and Repair

*a.* Check all tube assemblies for bent or cracked condition. Check all connections and fittings for evidence of metal fatigue or leakage.

*b.* Check all hose assemblies for wear or deterioration. Check connections for metal fatigue or leakage.

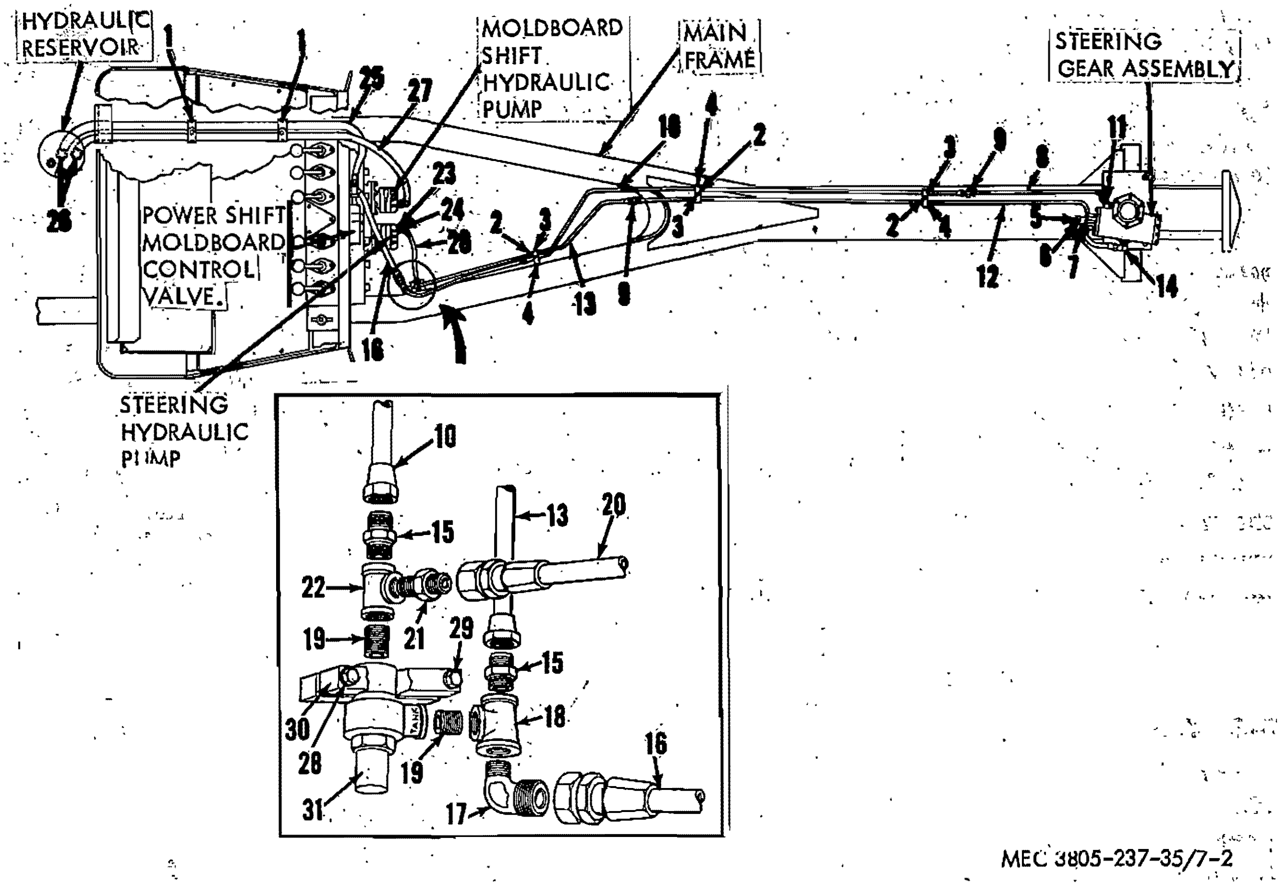
*c.* Check threads on all fittings for damage.

*d.* Replace all damaged parts.

### 7–7. Installation

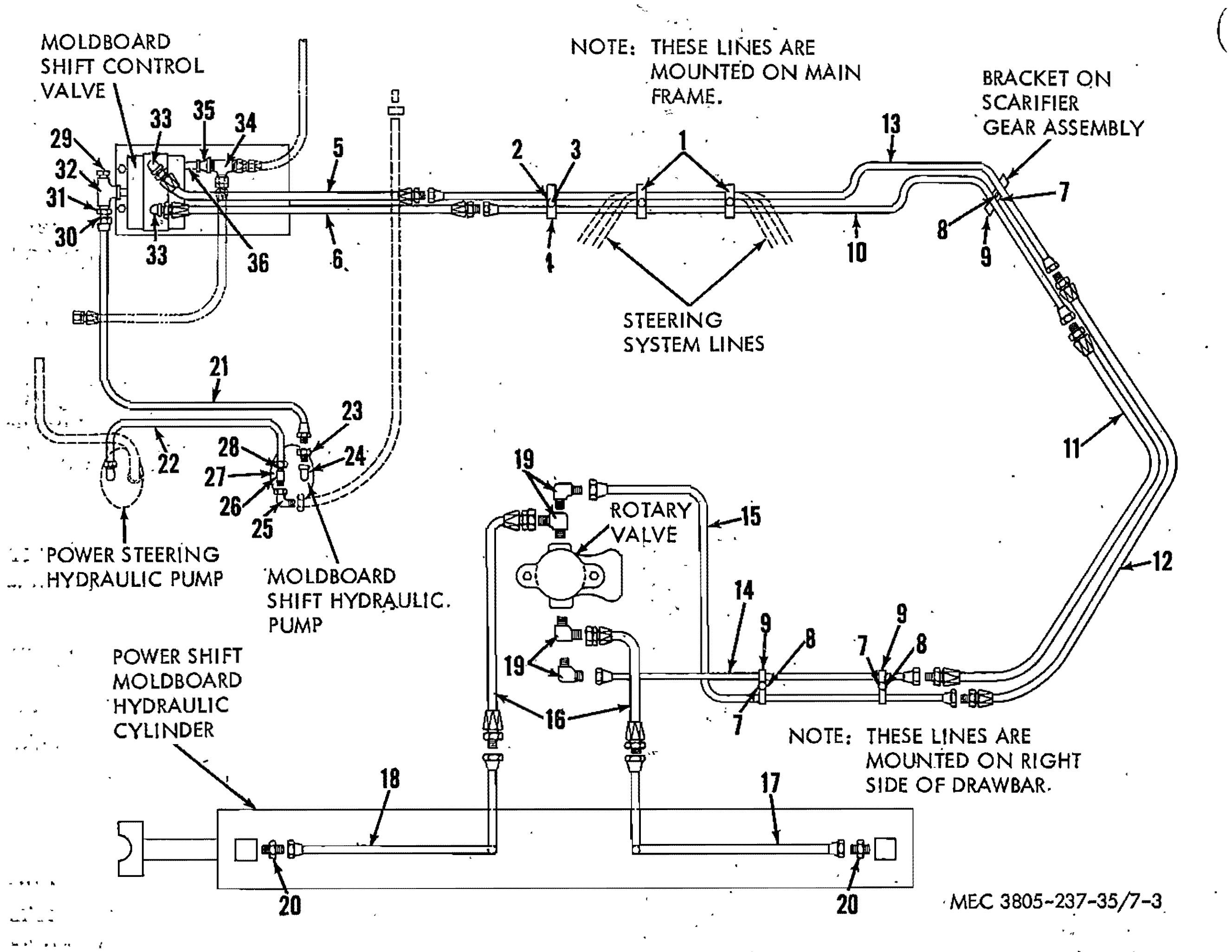
*a.* Install power shift moldboard hydraulic lines by reversing the numerical sequence as illustrated on figure 7–3.

*b.* Install steering system hydraulic lines by reversing the numerical sequence as illustrated on figure 7–2.




1 Clamp (4)
2 Screw, cap, hex-head, 3/8-16 × 2 1/4 in. (3)
3 Washer, lock, 3/8 in. (3)
4 Clamp (3)
5 Screw, cap, hex-head
6 Washer, lock
7 Clamp
8 Short pressure tube
9 Adapter (2)
10 Long pressure tube
11 Elbow, 45°
12 Long return tube
13 Short return tube
14 Elbow, 90°
15 Adapter (2)
16 Hose assembly
17 Elbow, 90°
18 Reducing tee
19 Pipe nipple (2)
20 Hose assembly
21 Adapter
22 Pipe tee
23 Elbow, 45°
24 Pipe bushing
25 Hose assembly
26 Adapter (2)
27 Hose assembly
28 Screw, cap, hex-head, 3/8-16 × 2 in. (2)
29 Washer, lock, 3/8 in. (2)
30 Bracket
31 Steering relief valve

*Figure 7-2. Steering hydraulic lines, removal and installation.*




1 Clamp (2) (remove with power steering lines)
2 Screw, cap, hex-head, 3/8-16 × 1 1/2 in.
3 Washer, lock, 3/8 in.
4 Clamp
5 Tube assembly
6 Tube assembly
7 Screw, cap, hex-head, 3/8-16 × 1 1/2 in. (2)
8 Washer, lock, 3/8 in. (2)
9 Clamp (2)
10 Tube assembly
11 Tube assembly
12 Tube assembly
13 Tube assembly
14 Tube assembly
15 Tube assembly
16 Hose assembly (2)
17 Tube assembly
18 Tube assembly
19 Adapter elbow, 90° (4)
20 Adapter (2)
21 Hose assembly
22 Tube assembly
23 Pipe bushing
24 Street elbow, 90°
25 Pipe nipple
26 Pipe bushing
27 Pipe tee
28 Elbow, 90°
29 Pipe plug
30 Adapter
31 Pipe nipple
32 Pipe tee
33 Ebow, 45° (2)
34 Adapter tee
35 Reducing coupling
36 Pipe nipple

*Figure 7-3. Power shift moldboard hydraulic lines, removal and installation.*

## Section III. HYDRAULIC PUMPS

### 7-8. General

*a.* The two hydraulic pumps are mounted on a pump adapter driven by the vertical drive housing. The right pump supplies the power steering system and the left pump, the power shift moldboard system.

*b.* When the engine is running the two pumps are operating. Bypass or return lines from the pumps circulate the oil and return it to the hydraulic reservoir. Oil flow to the power steering system is controlled by rotation of the steering wheel. The power shift moldboard lever operates a plunger in the control valve. Depending upon which way the plunger is moved, valve ports open to send oil to the rotary valve and to one side of the moldboard shift hydraulic cylinder.

### 7-9. Removal

*a.* Refer to paragraph 2-38 and remove the hydraulic pumps and adapter from the vertical drive housing.

*b.* Cap or plug openings in the pumps to prevent the entrance of dirt or other foreign matter.

*c.* Check pumps and tag for reassembly. The power shift moldboard hydraulic system pump has a wider housing than that of the steering system hydraulic pump. A larger volume of oil is required to shift the moldboard. Improper installation of the pumps will also cause pump rotation to be directly opposite that required to produce a pumping action.

### 7-10. Disassembly

*a.* Refer to figure 7-3 and remove fittings from hydraulic pump.

*b.* Disassemble the hydraulic pump and pump adapter in numerical sequence as illustrated on figure 7-4.

*Note.* The sequence shown on the illustration applies to both pumps.

*c.* Scribe a line across the cover, housing, and adapter to line up parts at reassembly.

*d.* Discard all preformed packings and gaskets after removal.

### 7-11. Cleaning

*a.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*b.* Remove all accumulated grease and dirt from pump parts, paying particular attention to pump ports.

*Note.* Do not use waste or soft cloths to clean pump. Any lint left from the cloths will clog the hydraulic system.

### 7-12. Inspection and Repair

*a.* Inspect wear plates, housing and adapter for wear patterns, cracks, erosion, and damage.

*b.* Inspect gear shafts for wear and out-of-round condition.

*c.* Replace wear plates if there is any evidence of erosion paths at the relief pockets.

*d.* Replace all worn or damaged parts.

### 7-13. Reassembly

*a.* Inspect all parts for cleanliness before installing. Handle parts carefully to avoid nicks and scoring. Lubricate preformed packings before installation.

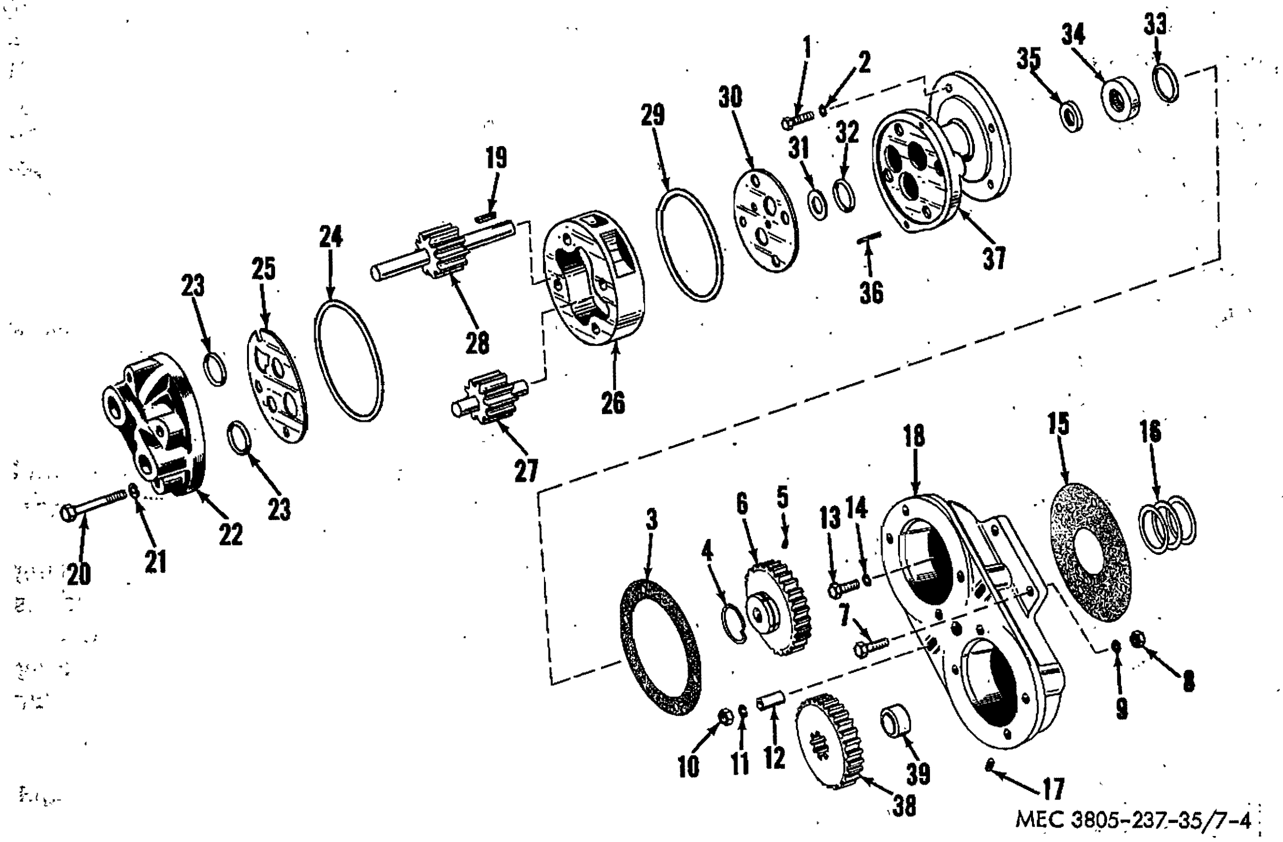
*b.* Reassemble the hydraulic pump and pump adapter in reverse of the numerical sequence shown in figure 7-4 and the following instructions.

*c.* Press oil seal (35) into adapter bore with lip of seal towards inside of pump. Press ball bearing (34) in adapter and secure with retaining ring (33).

*d.* Install adapter wear plate (30) in adapter with counterbore relief in wear plate towards gears.

*e.* Use care when installing shaft of drive gear (28) in adapter. Do not damage oil seal.

*f.* When installing gear housing (26) in adapter around pump gears, tap housing lightly with a soft hammer to seat housing in adapter.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (4) | 21 | Washer, lock, (4) |
| 2 | Washer, lock, 1/2 in. (4) | 22 | Pump cover |
| 3 | Adapter plate gasket | 23 | Preformed packing (2) |
| 4 | Retaining ring (2) | 24 | Preformed packing |
| 5 | Setscrew, 5/16-24 × 1/2 in. (2) | 25 | Cover wear plate |
| 6 | Pump gear (2) | 26 | Gear housing |
| 7 | Screw, cap, hex-head, 1/2-13 × 3 1/2 in. (2) | 27 | Driven gear |
| 8 | Nut, 1/2-13 (2) | 28 | Drive gear |
| 9 | Washer, lock, 1/2 in. (2) | 29 | Preformed packing |
| 10 | Nut, 1/2-13 (2) | 30 | Adapter wear plate |
| 11 | Washer, lock, 1/2 in. (2) | 31 | Washer (3) |
| 12 | Spacer | 32 | Preformed packing (3) |
| 13 | Screw, cap, hex-head, 1/2-13 × 1 3/8 in. (2) | 33 | Retaining ring |
| 14 | Washer, lock, 1/2 in. (2) | 34 | Ball bearing |
| 15 | Adapter gasket | 35 | Oil seal |
| 16 | Shim (3) | 36 | Dowel pin (2) |
| 17 | Pipe plug, magnetic | 37 | Pump mounting adapter |
| 18 | Adapter housing | 38 | Drive gear |
| 19 | Key, square | 39 | Spacer |
| 20 | Screw, cap, hex-head (4) | | |

*Figure 7-4. Hydraulic pump and pump adapter, exploded view.*

*g.* Install cover wear plate (25) on housing with counterbore relief toward housing.

*h.* Tap cover (22) lightly to seat cover over wear plate. Install screws (20) and washers (21) and torque screws to 70 foot pounds.

*i.* After completing assembly of pump, rotate gear (6). Pump gears must rotate freely without binding.

### 7-14. Installation

*a.* Refer to paragraph 2-38 and install pumps and adapter on vertical drive housing.

*Note.* Install pumps correctly on pump adapter. Check tags placed on pump when removed.

*b.* Refer to figure 7-3 and install fittings and hydraulic lines on pump.

*c.* Fill hydraulic reservoir with correct grade of oil (current LO) and start engine. Operate steering system and power shift moldboard through at least two complete cycles. Check hydraulic reservoir and add sufficient oil to bring level to full mark on dipstick.

## Section IV. STEERING SYSTEM

### 7-15. General

*a.* The hydraulic or power steering system used on the motor grader relieves the operator of any excessive effort to guide the grader. Any slight movement of the steering wheel is reflected in an immediate response by the steering gear assembly and the front wheels.

*b.* A control shaft connects the steering wheel to the steering gear assembly. This control shaft actuates valves and a piston within the gear assembly. Movement of the piston turns a gear keyed to the vertical shaft. The shaft is splined to a steering arm connected to the tie rods with a ball and socket.

*c.* This section contains repair instructions for the steering control shaft, steering gear assembly, and steering system relief valve.

### 7-16. Steering Wheel and Control Shaft

*a. Removal.* Remove the steering wheel and control shaft in the numerical sequence as illustrated on figure 7-5.

*b. Cleaning.* Clean parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*c. Inspection and Repair.*

(1) Inspect steering wheel for cracks or damage.

(2) Inspect control shafts and bearings for wear or damage.

(3) Check universal joints for free movement and inspect for damage.

(4) Replace all worn or damaged parts.

*d. Installation.* Install the steering wheel and control shaft in reverse of numerical sequence as illustrated on figure 7-5.

*Note.* Pack universal joints with correct grade of grease (current LO) before installing pipe plugs.

### 7-17. Steering System Relief Valve

*a. Removal.* Refer to paragraph 7-4 and remove the steering system relief valve (31, fig. 7-3).

*b. Disassembly.* Disassemble the steering system relief valve in numerical sequence as illustrated on figure 7-6. Discard gasket.

*c. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*d. Inspection and repair.*

(1) Inspect ball and valve for wear and evidence of scoring or leakage.

(2) Check spring for serviceable condition.

(3) Replace worn or damaged parts.

*e. Reassembly.* Reassemble steering system relief valve in reverse of the numerical sequence as illustrated on figure 7-6.

*f. Installation.* Refer to paragraph 7-7 and install the steering system relief valve (31, fig. 7-3). Refill hydraulic reservoir if necessary.

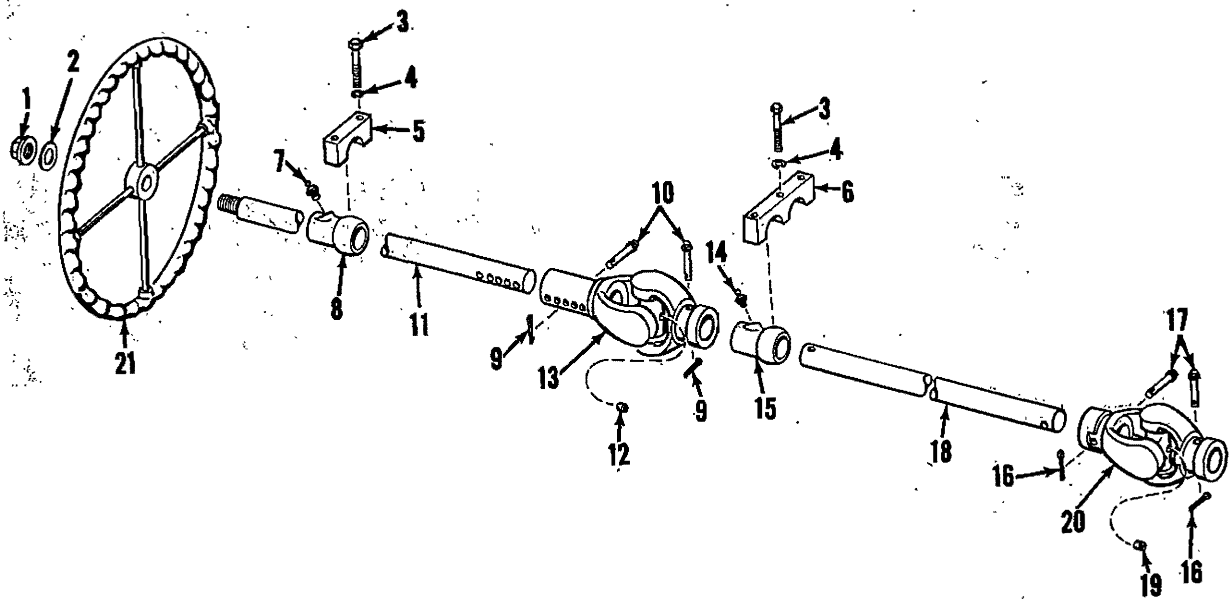
*g. Adjustment.*

(1) Refer to figure 7-7 and install a pressure gage in hydraulic pump.

(2) Start the engine (TM 5-3805-237-12) and operate steering system.

(3) Check hydraulic reservoir and fill reservoir to full mark on dipstick if necessary. Refer to current LO for correct oil.

(4) Operate engine at high idle speed and check gage. Reading must be between 1150 and 1200 psi. Decrease engine speed to low idle.




| | | | |
|---|---|---|---|
| 1 | Cap nut | 12 | Pipe plug |
| 2 | Washer, lock | 13 | Universal joint, w/extension |
| 3 | Screw, cap, hex-head, 3/8-16 × 2 in. (5) | 14 | Lubrication fitting |
| 4 | Washer, lock, 3/8 in. (5) | 15 | Shaft bearing |
| 5 | Bearing bracket | 16 | Pin, cotter, 1/8 × 3/4 in. (2) |
| 6 | Bearing bracket | 17 | Pin (2) |
| 7 | Lubrication fitting | 18 | Front control shaft |
| 8 | Shaft bearing | 19 | Pipe Plug |
| 9 | Pin, cotter, 1/8 × 3/4 in. (2) | 20 | Universal Joint |
| 10 | Pin (2) | 21 | Steering Wheel |
| 11 | Rear control shaft | | |

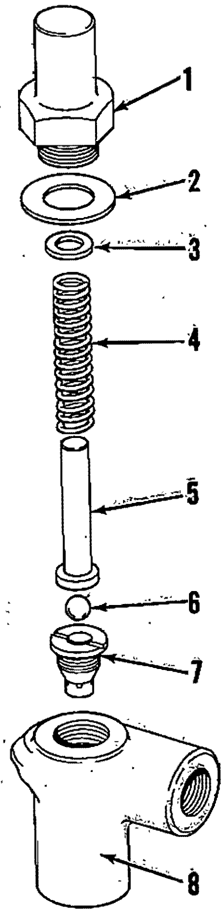
*Figure 7-5. Steering wheel and control shaft, exploded view.*

Gage should read between 700 and 800 psi.

(5) If readings are not as stated remove relief valve cap (fig. 7-7) and add shims (3, fig. 7-6) to increase pressure or remove shims to decrease pressure. Install cap.

(6) If adjustment of relief valve does not produce correct pressure, repair or replace hydraulic pump (para 7-10).

(7) Refer to figure 7-7 and remove gage from pump. Refill hydraulic reservoir if necessary.




1 Cap
2 Gasket
3 Shim
4 Spring
5 Spacer
6 Ball
7 Valve
8 Housing

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*Figure 7-6. Steering system relief valve, exploded view.*

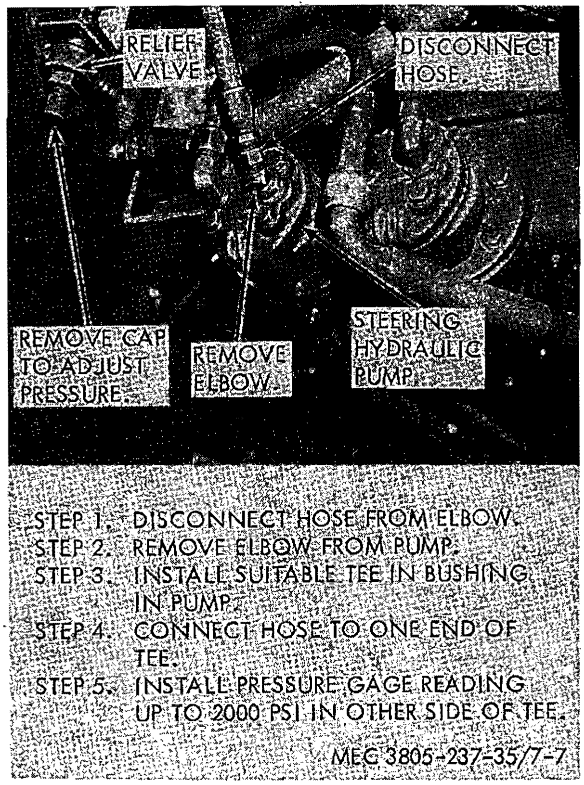



*Figure 7-7. Pressure gage, installation and removal.*

## Section V. STEERING GEAR ASSEMBLY

### 7-18. General

The steering gear assembly provides the power for turning the wheels. A vertical power steering shaft connects to the steering arm and the rods.

### 7-19. Steering Gear Assembly

*a. Removal.*

(1) Refer to paragraph 7-16 and disconnect the control shaft universal joint (20, fig. 7-5) from the steering gear.

(2) Disconnect tubes (8 and 12, fig. 7-2) and remove elbows (11 and 14, fig. 7-2) from steering gear assembly.

(3) Refer to TM 5-3805-237-12 and remove boot, steering arm, tie rods and drag links from motor grader.

(4) Remove steering gear assembly in numerical sequence illustrated on figure 7-8, items 6 through 19.

*b. Disassembly.* Drain hydraulic oil from steering gear assembly. Disassemble steering gear assembly in numerical sequence illustrated on figure 7-8, items 20 through 53. Discard preformed packings, quad rings, and gaskets after removal.

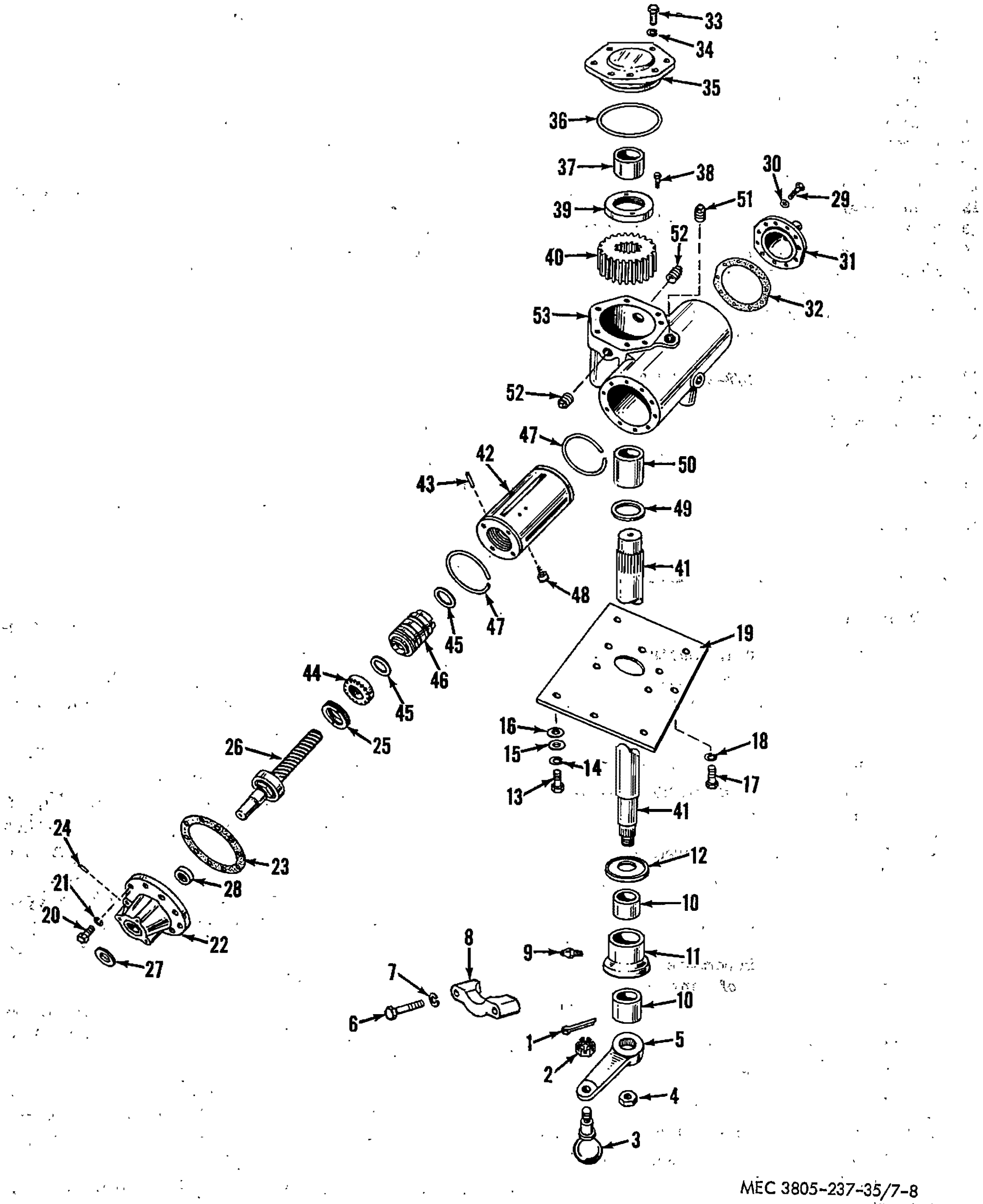



*Figure 7-8. Steering gear assembly, exploded view.*

1 Pin, cotter, 1/4 × 1 3/4 in.
2 Nut, slotted, 7/8-14
3 Steering ball
4 Lock nut
5 Steering arm
6 Screw, cap hex-head, 5/8-11 × 3 in. (2)
7 Washer, lock, 5/8 in. (2)
8 Bearing cap
9 Lubrication fitting
10 Bushing (2)
11 Self-aligning bearing
12 Rubber seal
13 Screw, cap, hex-head, 5/8-11 × 1 1/2 in. (4)
14 Washer, lock, 5/8 in. (4)
15 Shim, 5/16 in. thk (4)
16 Shim, 5/32 in. thk (8)
17 Screw, cap, hex-head, 9/16-18 × 1 3/4 (8)
18 Washer, lock, 9/16 in. (8)
19 Mounting plate
20 Screw, cap, hex-head, 3/8-24 × 1 3/8 (10)
21 Washer, lock, 3/8 in. (10)
22 Bearing retainer
23 Retainer gasket
24 Locking pin
25 Bearing lock nut
26 Actuating shaft
27 Oil seal
28 Oil seal
29 Screw, cap, hex-head, 3/8-24 × 1 3/8 in. (10)
30 Washer, lock, 3/8 in. (10)
31 Cylinder head
32 Cylinder head gasket
33 Screw, cap, hex-head, 9/16-18 × 1 in. (7)
34 Washer, lock, 9/16 in. (7)
35 Housing cover
36 Preformed packing
37 Bushing
38 Screw, cap socket head, 5/16-24 × 3/4 in. (2)
39 Gear retaining nut
40 Drive gear
41 Power steering shaft
42 Piston
43 Locking pin
44 Valve adjusting nut
45 Reversing spring (2)
46 Actuating valve
47 Piston ring (2)
48 Valve positioning pin
49 Quad ring
50 Bushing
51 Pipe plug
52 Pipe plug (2)
53 Steering gear housing

*Figure 7-8*—Continued.

*c. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

**Warning: The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Keep all parts covered or protected from dirt, lint, or other foreign matter while awaiting inspection, repair, and reassembly.

*Note.* It is imperative that no dirt or foreign matter of any kind enter the hydraulic system.

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect actuating valve, piston, and piston rings for evidence of cracks and scoring.

(3) Check parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and replacement standards.

(4) Replace all worn or damaged parts.

*e. Reassembly.* Reassemble steering gear assembly in reverse of the numerical sequence illustrated in figure 7-8, items 53 through 20 and the following instructions.

(1) Install valve positioning pin (48) in piston until head is below surface of piston and flat sides of pin are alined with axis of piston bore.

(2) Install actuating valve (46) in bore of piston (42) with positioning slot on valve engaging positioning pin in piston.

*Note.* Do not force valve over pin. Adjust pin by turning pin until pin is alined with slot.

(3) Install valve adjusting nut (44) in piston and tighten nut with a spanner wrench until actuating valve cannot be moved.

(4) Starting at the locking pin hole in the piston, count and scribe a mark on the sixteenth slot.

(5) Remove adjusting nut, actuating valve, and positioning pin from piston.

(6) Install one reversing spring (45) in bore of piston. Install positioning pin as described in (1) above.

(7) Install actuating valve in piston and second reversing spring on top of valve.

(8) Install valve adjusting nut and tighten nut until seated on reversing spring. If marked slot is not in line with locking pin hole in side of piston, loosen nut to aline slot with hole.

(9) Install locking pin (43) in hole in piston and into adjusting nut. End of pin must be flush with or below outer surface of piston.

(10) Install two piston rings (47) in grooves in piston. Using a suitable ring compressor, install piston into housing.

(11) When installing cover (35) on housing, torque screws (33) to 53 foot pounds.

(12) Install oil seal (28) in bore of retainer from inside of cap with lip of seal towards inside of retainer. Install oil seal (27) in bore with lip of seal toward outside of cap.

(13) If new bearing locknut (25) is being installed, tighten nut until bearing is seated. Insert 3/32 inch diameter drill through locking pin hole and drill hole 3/16 inch deep in nut. Remove nut and actuating shaft and clean cap, shaft, and nut thoroughly to remove all drill chips.

(14) When installing bearing retainer (22) and cylinder head (31) on housing, torque screws (20 and 29) to 33 foot pounds.

*f. Installation.* Install the steering gear assembly in reverse of the numerical sequence as illustrated on figure 7-8, items 19 through 13 and the following instructions.

(1) Install steering gear assembly on mounting plate (19).

(2) Lift steering gear assembly with chain and hoist and install on motor grader. Guide power steering shaft through frame to prevent damage to shaft.

(3) Install rubber seal (12) over shaft before shaft is lowered through self-alining bearing.

(4) Install steering gear assembly on grader and secure mounting plate with four screws (13) and lockwashers (14).

(5) Install shims (15 and 16) between mounting plate and bars. Shims must center and aline power steering shaft in self-alining bearing so that shaft rotates freely without any binding.

(6) Refer to TM 5-3805-237-12 and install drag links, tie rods, steering arm, and boot on motor grader.

(7) Start engine and operate steering system (TM 5-3805-237-12) through the full steering range at least three times. Check hydraulic reservoir and fill if necessary.

## Section VI. POWER SHIFT MOLDBOARD SYSTEM

### 7-20. General

*a.* The power shift moldboard hydraulic system consists of a hydraulic pump, control valve, shift lever, rotary valve, and moldboard cylinder. Movement of the shift lever to one side or the other will slide the moldboard to that side.

*b.* The shift lever is mounted below the steering wheel and extends through the front sheet to a lever and linkage connected to the control valve plunger. Movement of the plunger sends oil to one end or the other of the moldboard cylinder through the rotary valve.

*c.* Oil pressure within the cylinder moves the piston in either direction. The piston rod is connected to the moldboard on one end and the cylinder tube is connected to the RH tilt plate on the other end. A slide, welded to the moldboard and supported by the moldboard tilt plates allows the moldboard to move in either direction.

## 7-21. Control Valve

*a. General.* The power shift moldboard control valve is mounted on a plate above the hydraulic pumps in front of the power control box. The valve is actuated by a power shift lever and linkage connected to the valve plunger.

*b. Removal.*

(1) Remove power shift moldboard lever in the numerical sequence as illustrated on figure 7-9.

(2) Refer to figure 7-10 and remove the control valve from the motor grader.

*Note.* Plug openings in control valve after removal of fittings to prevent entrance of dirt.

*c. Disassembly.* Disassemble the control valve in the numerical sequence as illustrated on figure 7-11.

*d. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

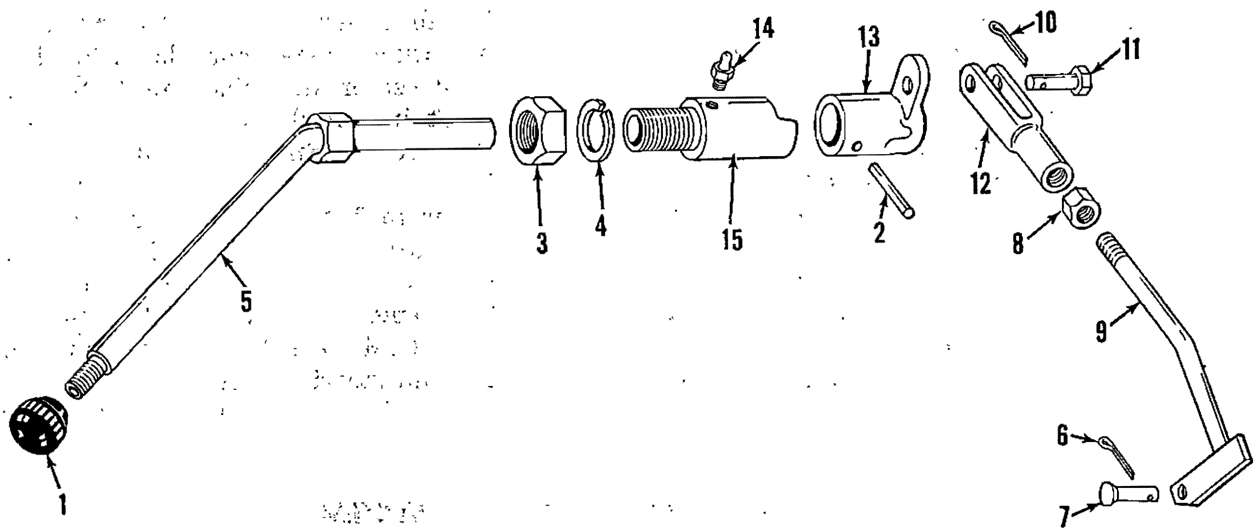
***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) After cleaning, cover or seal all parts to prevent entrance of dirt or foreign matter until repair or reassembly.

*e. Inspection and Repair.*

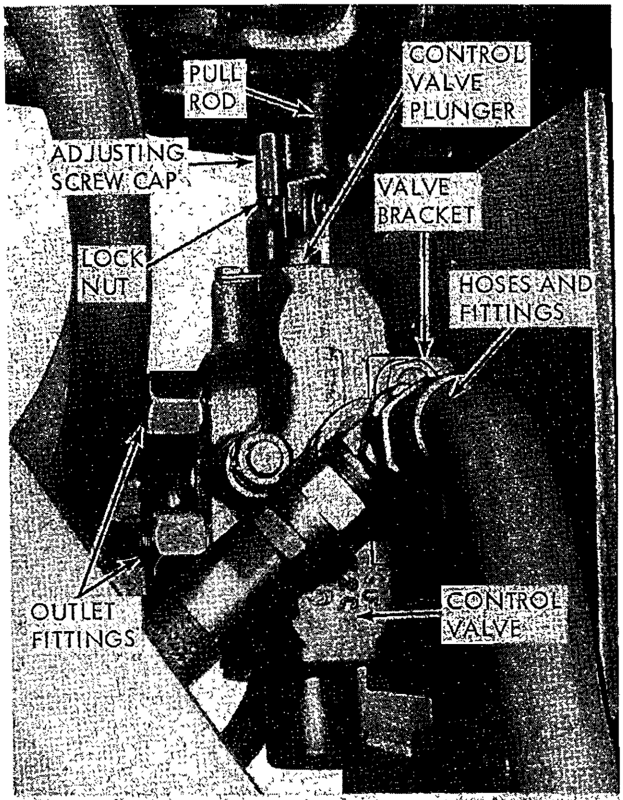
(1) Check all parts for wear or damage.

(2) Inspect plunger and relief valve parts for scoring, nicks, and scratches.




| | | | | | |
|---|---|---|---|---|---|
| 1 | Lever ball | 6 | Pin, cotter, 3/32 × 3/4 | 11 | Pin |
| 2 | Spring pin | 7 | Pin | 12 | Yoke |
| 3 | Nut, 1 1/4-12 | 8 | Nut, 3/4-16 | 13 | Pull rod lever |
| 4 | Washer, lock, 1 1/4 in. | 9 | Pull rod | 14 | Lubrication fitting |
| 5 | Lever | 10 | Pin, cotter, 3/32 × 3/4 | 15 | Lever bearing |

*Figure 7-9. Power shift moldboard lever, exploded view.*




STEP 1. REFER TO FIGURE 7-3 AND DISCONNECT HOSES AND REMOVE FITTINGS FROM CONTROL VALVE.
NOTE: PLUG ALL HOSES AND VALVE OPENINGS TO PREVENT ENTRANCE OF DIRT.
STEP 2. REMOVE THREE SCREWS AND LOCK WASHERS SECURING VALVE BRACKETS TO PLATE.
STEP 3. REMOVE CONTROL VALVE.
STEP 4. TO ADJUST PRESSURE, REMOVE ADJUSTING SCREW CAP, LOOSEN LOCK NUT, AND TURN ADJUSTING SCREW AS NECESSARY.

MEC 3805-237-35/7-10

*Figure 7-10. Power shift moldboard control valve, removal and installation.*

(3) Inspect all seal rings for tears, abrasions, multilation, and deterioration.
(4) Inspect three housings for wear or scoring in valve bores.
(5) Check springs for serviceable condition.
(6) Replace all worn, damaged, or deteriorated parts.

*f. Reassembly.* Reassemble the control valve in reverse of numerical sequence as illustrated on figure 7-11. Tighten nuts (3) to a torque of 50 foot pounds.

*g. Installation.*
(1) Refer to figure 7-10 and install the moldboard shift control valve.
(2) Refer to figure 7-9 and install the power shift moldboard lever.
(3) Start the engine and operate the moldboard shift lever (TM 5-3805-237-12) to shift the moldboard to extreme travel limits on both sides.
(4) Check and refill hydraulic reservoir if necessary.

*h. Adjustment.*
(1) Remove hose and upper outlet fitting (fig. 7-10) from center section of control valve.
(2) Install a 2,000 psi pressure gage in the fitting port.
(3) Remove adjusting screw cap (fig. 7-10) and loosen locknut.
(4) Start engine and run at fast idle. Using a screw driver, turn adjusting screw in or out until a reading of 1,000 psi on gage is obtained. Hold adjusting screw and tighten locknut. Install adjusting screw cap.
(5) Shut off engine. Remove gage from port and install hose and outlet fitting.

## 7-22. Rotary Valve

*a. General.* To allow the moldboard to rotate and keep the hydraulic lines connected to the moldboard shift cylinder, the hydraulic oil flows through a rotary valve. The valve is mounted on the underside of the drawbar and the valve support is connected by a link to the circle tie rod. As the moldboard rotates, the support rotates. The rotary portion (lower part) of the valve rotates with the support and the outlets in the rotary portion maintain connections to the moldboard shift cylinder.

*b. Removal.*
(1) Refer to figure 7-3 and disconnect hoses, tubes, and fittings from the rotary valve.

(2) Refer to figure 7-12 and remove the rotary control valve from the motor grader.

*d. Disassembly.* Disassemble the rotary valve in numerical sequence as illustrated on figure 7-13. Discard all preformed packings after removal.

*e. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) After cleaning, cover and seal all parts to prevent entrance of dirt or foreign matter until repair or reassembly.

*f. Inspection and Repair.*

(1) Inspect rotary portion of valve and valve body for scoring, wear, or damage.

(2) Replace all scored, worn, or damaged parts.

*g. Reassembly.* Reassemble the rotary valve in reverse of the numerical sequence as illustrated on figure 7-13. After tightening two screws (6) securely, stake each screw in four places.

*h. Installation.*

(1) Refer to figure 7-12 and install the rotary control valve on the motor grader.

(2) Refer to figure 7-3 and install fittings and connect hose and tube assemblies to rotary valve.

(3) Start engine and operate power shift moldboard (TM 5-3805-237-12) through at least two complete cycles. Refill hydraulic reservoir (current LO) with proper oil to full mark on dipstick if necessary.

## 7-23. Moldboard Shift Hydraulic Cylinder

*a. General.* The moldboard shift hydraulic cylinder is mounted on the moldboard. The ends of the cylinder and piston rod are connected by a ball and socket to the moldboard and RH tilt plate. As pressure in the cylinder extends or retracts the piston rod, the moldboard shifts from one side or the other of the circle. A circular bar acts as a slide for the moldboard and is supported by the two moldboard tilt plates.

*b. Removal.*

(1) Lower moldboard to the ground to facilitate removal.

(2) Refer to figure 7-3 and disconnect hydraulic tube assemblies and remove fittings from moldboard shift cylinder. Plug all tube assemblies and cylinder ports to prevent entrance of dirt or foreign matter.

(3) Remove four screws, lockwashers, and flat washers and remove large shield from moldboard.

(4) Remove screw, lockwasher, and nut and remove small shield from protecting ball socket.

(5) Refer to figure 7-14 and remove the moldboard shift hydraulic cylinder.

*c. Disassembly.* Disassemble the moldboard shift hydraulic cylinder in numerical sequence as illustrated on figure 7-15. Discard all preformed packings after removal.

*Note.* Loosen packing gland (20) and slide gland and packing set (19) along piston rod. Use a spanner wrench and unscrew packing nut (17) from cylinder. Remove piston rod and parts from cylinder. Disassemble piston rod.

*d. Cleaning.*

(1) Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Cover or seal all parts to prevent the entrance of dirt or foreign matter while awaiting repair and reassembly.

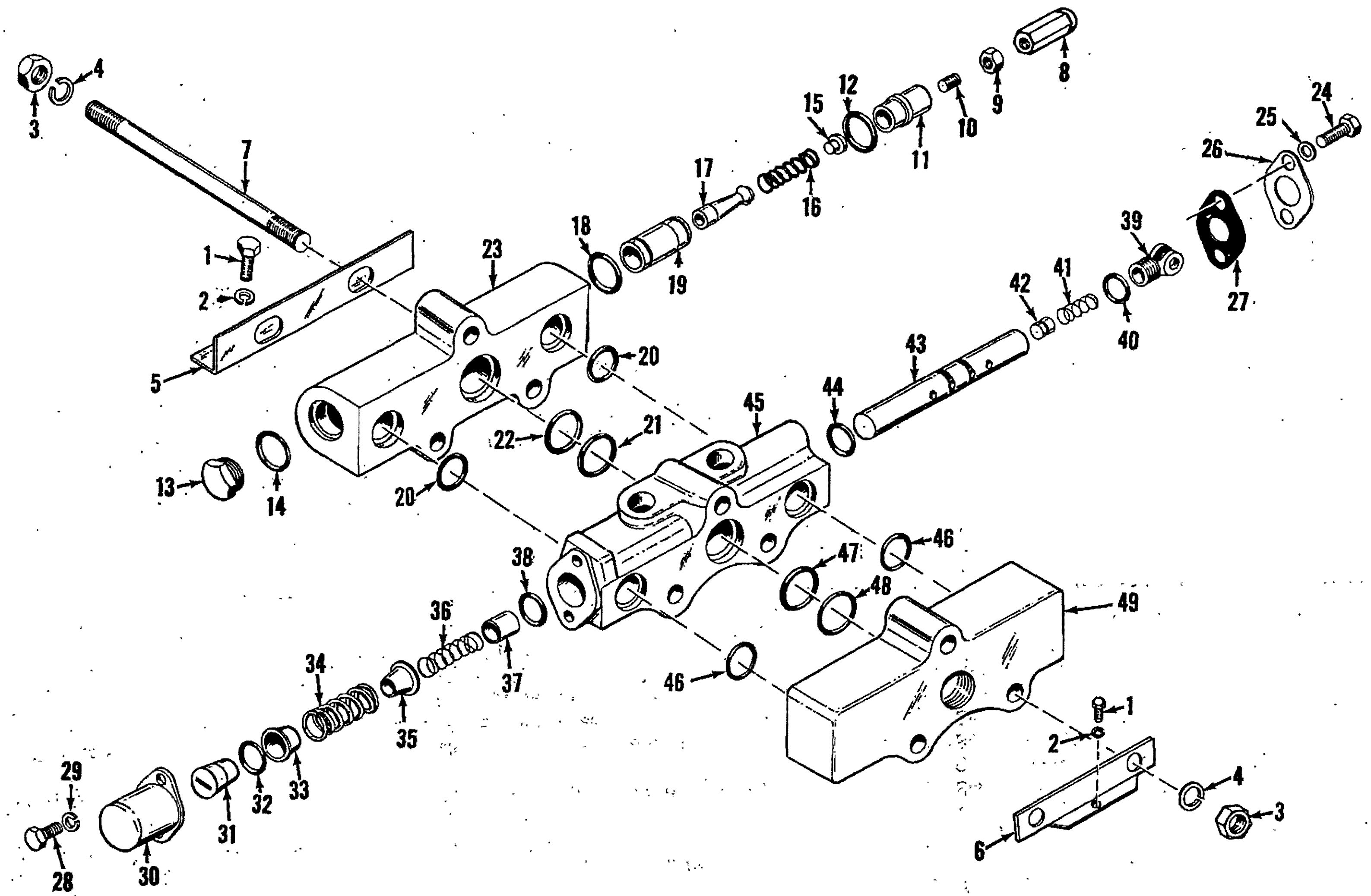
*e. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect pistons, piston rod, and inside of cylinder tube for scoring and scratches.

(3) Replace all worn, scored, or damaged parts.

*f. Reassembly.* Reassemble the moldboard shift cylinder in reverse of the numerical sequence as illustrated on figure 7-15 and the following instructions.




MEC 3805-237-35/7-11

*Figure 7-11. Moldboard shift control valve, exploded view.*

1 Screw, cap, hex-head, 3/8-16 × 5/8 in. (3)
2 Washer, lock, 3/8 in. (3)
3 Nut, 5/8-18 (6)
4 Washer, lock, 5/8 in. (6)
5 Right mounting bracket
6 Left mounting bracket
7 Stud (3)
8 Acorn nut
9 Lock nut
10 Adjusting screw
11 Valve cap
12 Seal ring
13 Bottom cap
14 Seal ring
15 Spring guide
16 Valve spring
17 Valve plunger
18 Seal ring
19 Valve seat
20 Seal ring (2)
21 Seal ring (2)
22 Spacer
23 Inlet housing
24 Screw, cap, hex-head-,3/8-16 × 1/2 in. (2)
25 Washer, lock, 3/8 in. (2)
26 Retaining plate
27 Wiper
28 Screw, cap hex-head, 3/8-16 × 5/8 in.
29 Washer, lock, 3/8 in. (2)
30 Spring cover
31 Spring cap
32 Seal ring
33 Spring guide
34 Plunger lower spring
35 Spring guide
36 Plunger upper spring
37 Plunger check
38 Seal ring
39 Plunger eye
40 Seal ring
41 Check spring
42 Plunger check
43 Valve plunger
44 Seal ring
45 Center housing
46 Seal ring (2)
47 Spacer
48 Seal ring
49 Outlet housing

*Figure 7-11*—Continued.

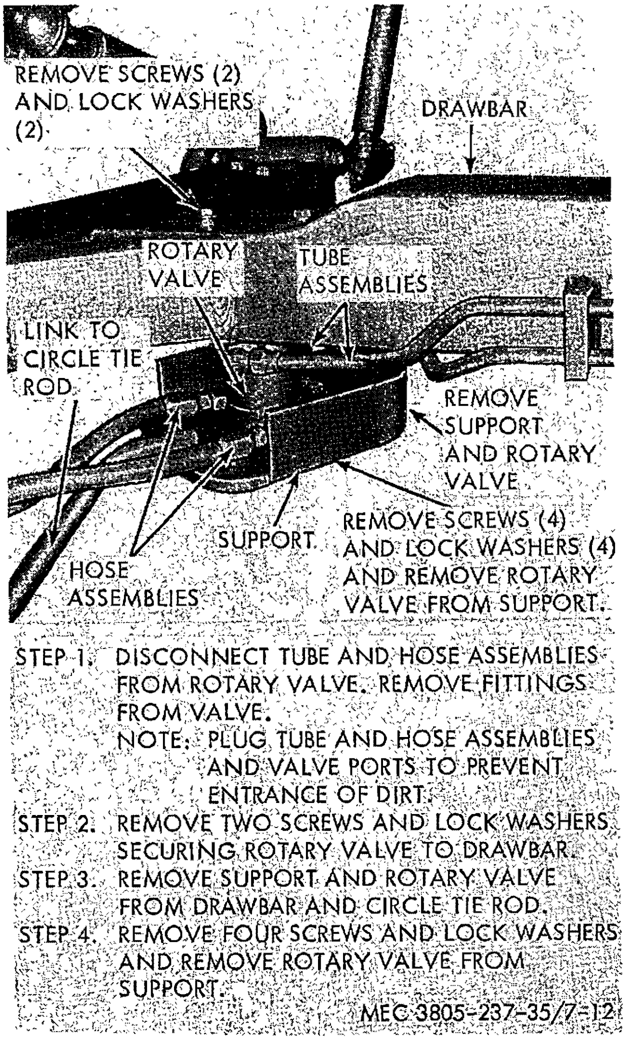



*Figure 7-12. Rotary valve, removal and installation.*

*Note.* Coat all parts with oil before reassembly.

(1) Install wiper ring (21) in packing gland (20) with V of ring fitting on inside shoulder of gland.

(2) Install packing gland, packing set (19) and bushing (18) on piston rod.

(3) Install one piston half (14) on piston rod and install four sections of packing set (15) on piston rod with V in sections pointing toward threaded end of rod.

(4) Install center section of packing set (15) and four sections of packing set on rod with V in sections pointing away from threaded end of rod. Install remaining piston half on rod.

(5) After installing nut (13) and cotter pin (12), place a piece of thin shim stock around piston and slide piston rod and parts into cylinder tube.

(6) When installing packing gland (20), tighten securely and aline slot in gland with tapped hole in packing nut. Install screw (8) and lockwasher (9) to secure packing gland.

*g. Installation.*

(1) Refer to figure 7-14 and install moldboard shift cylinder on motor grader.

(2) Install small shield on moldboard and secure with screw, lockwasher and nut.

(3) Install large shield on moldboard and secure with four screws, lockwashers, and flat washers.

(4) Refer to figure 7-3 and install fittings and connect tube assemblies to shift cylinder.

1 Screw, cap, hex-head (2 rqr)
2 Washer, lock (2 rqr)
3 Screw, cap, hex-head, 5/16-18 x 7/8 in. (4 rqr)
4 Washer, lock, 5/16 in. (4 rqr)
5 Valve support
6 Screw, machine, flat-head, 3/8-16 x 3/4 in. (2 rqr)
7 Bolting plate
8 Pipe plug (2 rqr)
9 Rotary portion
10 Felt washer
11 Preformed packing (3 rqr)
12 Valve body

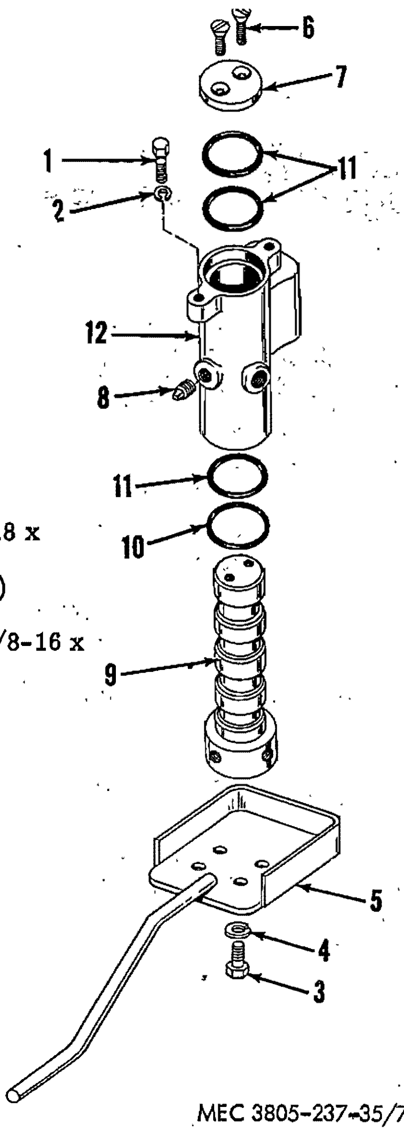



*Figure 7-13. Rotary valve, exploded view.*

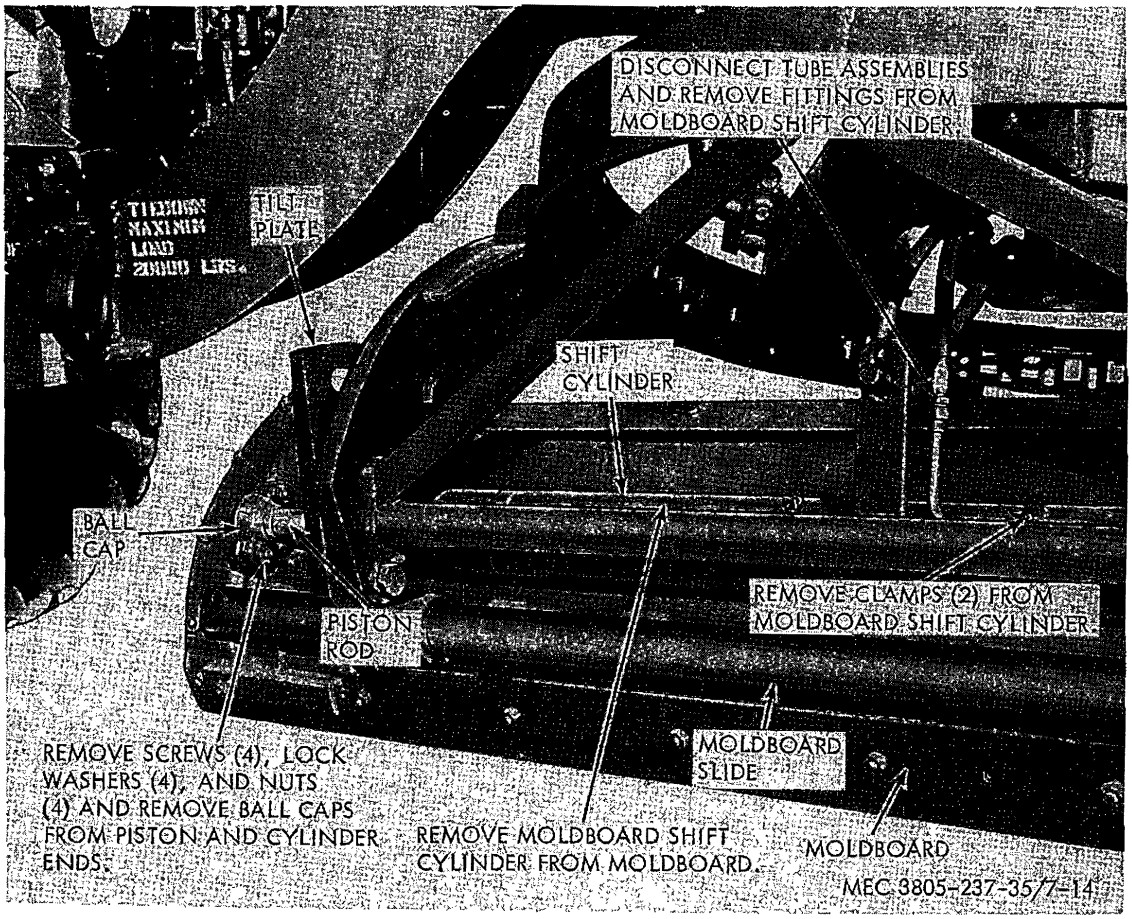



*Figure 7-14. Moldboard shift hydraulic cylinder, removal and installation.*

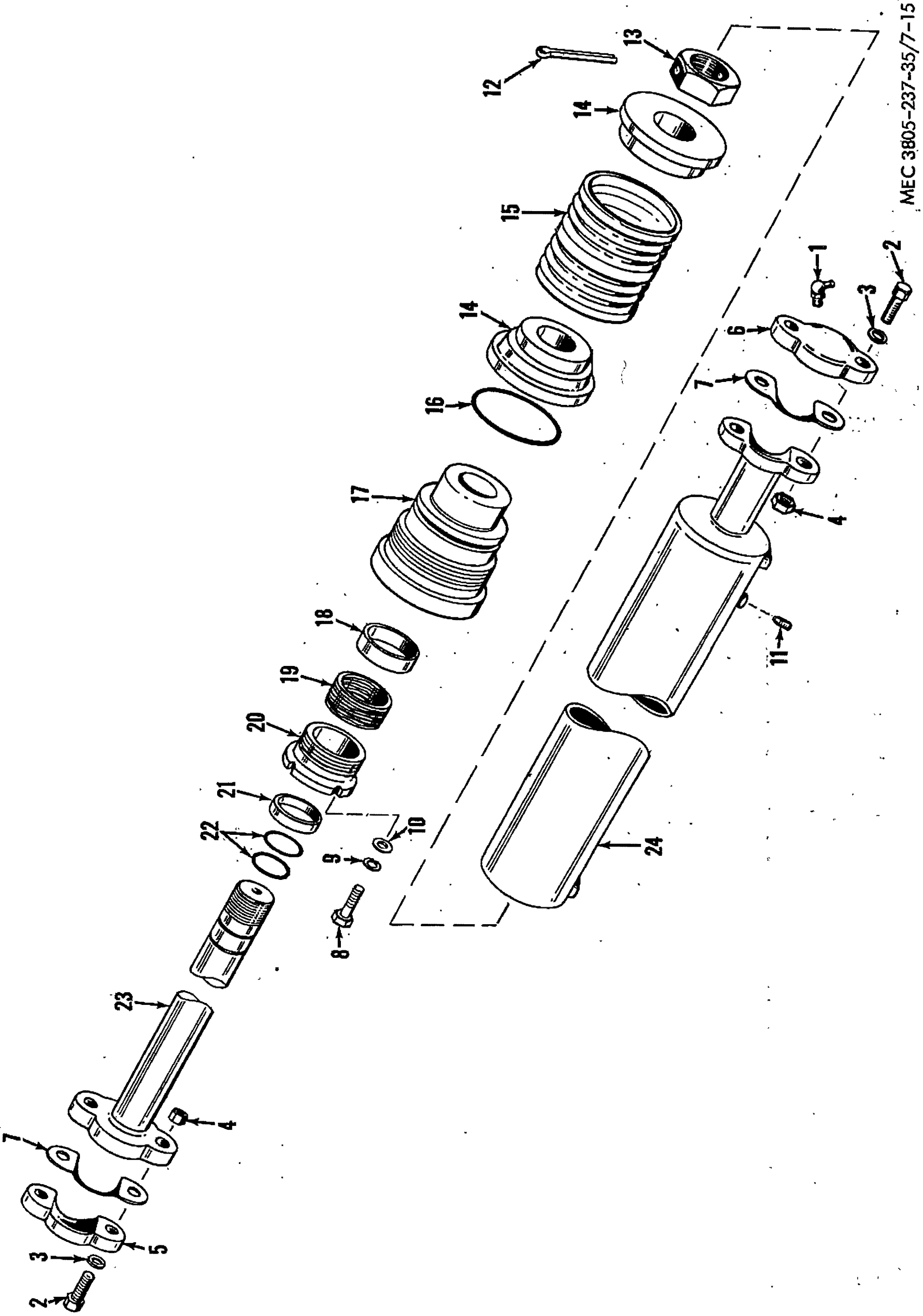



*Figure 7-15. Moldboard hydraulic cylinder, exploded view.*

1 Lubrication fitting
2 Screw, cap, hex-head, 3/4-10 × 1/4 in.
3 Washer, lock, 3/4 in. (8)
4 Nut, 3/4-10 (4)
5 Ball cap
6 Ball cap
7 Shim
8 Screw, cap, hollow-head
9 Washer, lock
10 Lead slug
11 Setscrew
12 Pin, cotter
13 Nut
14 Piston half (2)
15 Packing set
16 Preformed packing
17 Packing nut
18 Bushing
19 Packing set
20 Packing gland
21 Wiper
22 Preformed packing (2)
23 Piston rod
24 Cylinder tube

*Figure 7-15*—Continued.

# CHAPTER 8

# WHEELS, BRAKES, AND FRONT AXLE

# REPAIR INSTRUCTIONS

## Section I. GENERAL

### 8-1. General

*a.* The six wheels on the motor grader are identical in most respects. Brakes for the motor grader are incorporated in the tandem front wheels. The brake drums are part of the wheels. The brake mechanism is mounted on a backing plate secured to the tandem housing.

*b.* A hydraulic master cylinder, operated by a linkage from the brake pedal, supplies the pressure to operate the self adjusting brakes. The hydraulic fluid in the brake cylinder is entirely separate from the hydraulic systems used to steer the grader and operate the moldboard shift.

*c.* The front wheels and axle have a leaning feature explained earlier in the manual. To provide steering, the front axle is attached to spindles and drag links. The spindles and drag links are moved through the action of the tie rods and steering arm.

### 8-2. Contents

*a.* This chapter contains repair instructions for the wheels, brakes, brake system, and front axle.

*b.* Included in the repair of the brake system will be the brake linkage, master cylinder, tubing, and the brake assemblies.

## Section II. WHEELS AND BRAKES

### 8-3. General

*a.* The front and rear wheels are mounted in the same manner, with the front wheels dished to allow movement of spindles and vibrating bar. Bearing caps on the front wheels enclose the wheel bearings and locknut. On the rear wheels the locknut is exposed. The rear wheels are mounted on tapered axles and have puller screw holes to aid in removal of wheel.

*b.* The brake assemblies are mounted on the tandem housings and enclosed by the rear wheel brake drums. The brake mechanism can be serviced without removing from the tandem housing.

*c.* Included in the brake system repair will be the brake pedal and linkage, hydraulic lines, and brake master cylinder.

### 8-4. Wheels

*a. Removal.* Refer to TM 5-3805-237-12 to remove the wheels from the motor grader and to remove the tires from the wheels.

*b. Disassembly.* Partial disassembly of the wheels is accomplished when wheels are removed from the motor grader. Disassemble the remainder of wheel components in the numerical sequence as illustrated on figure 8-1. Discard all gaskets and preformed packings after removal.

*Note.* The quantities listed are for one wheel. Where components are part of the front or rear wheel only, it will be indicated in parenthesis after the part.

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

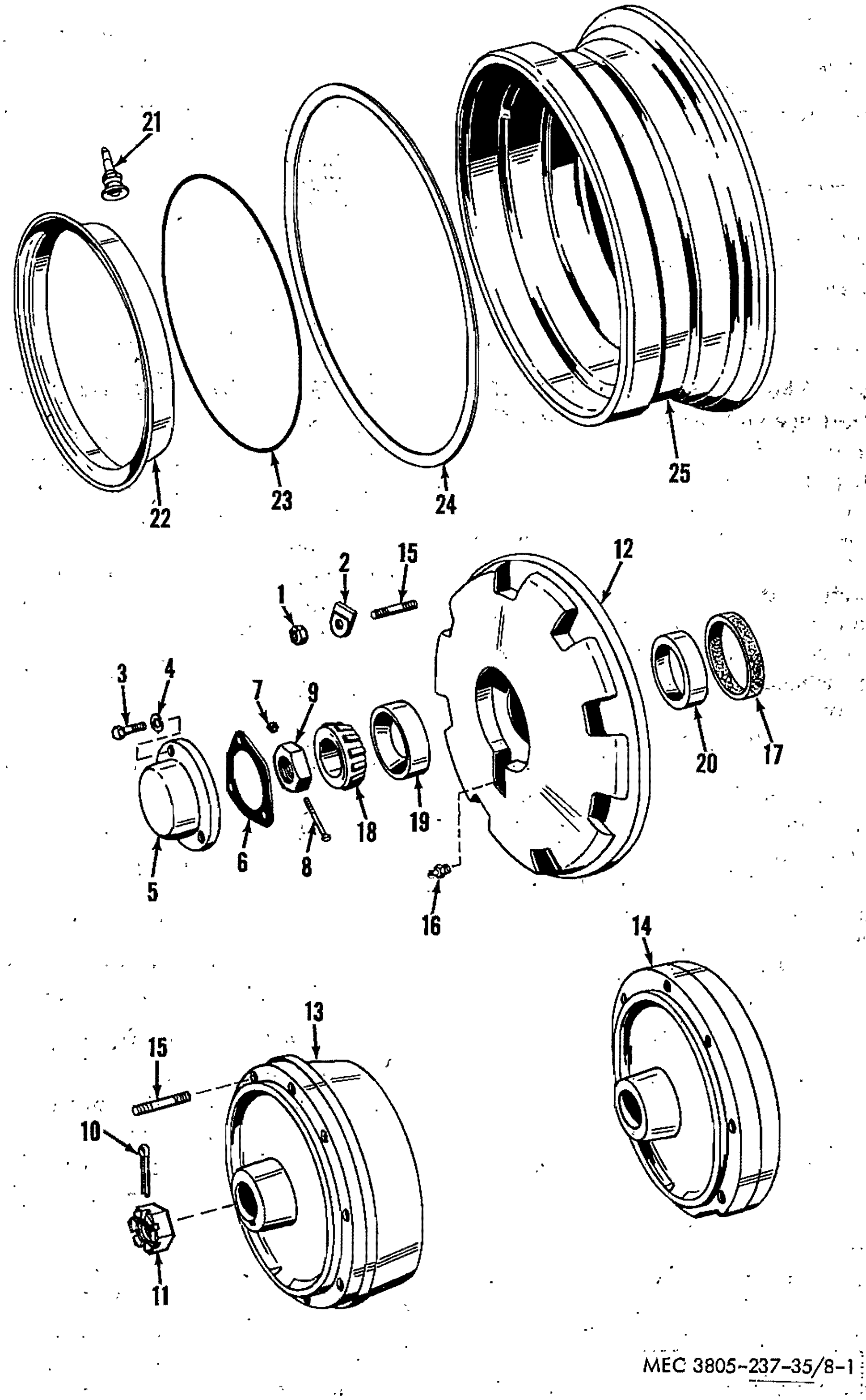



*Figure 8-1. Front and rear wheels, exploded view.*

1 Nut (9 rqr, front wheel) (8 rqr, rear wheel)
2 Rim clamp (9 rqr, front wheel) (8 rqr, rear wheel)
3 Screw, cap, hex-hd, 7/16-14 × 1 in. (3 rqr) (front wheel only)
4 Washer, lock, 7/16 in. (3 rqr) (front wheel only)
5 Hub cap (front wheel only)
6 Cap gasket (front wheel only)
7 Nut, lock, 5/16 in. (front wheel only)
8 Screw, cap, hex-head, 5/16-18 × 2 7/8 in. (front wheel only)
9 Nut, drilled (front wheel only)
10 Pin, cotter (rear wheel only)
11 Nut, slotted, 5/16 in. (rear wheel only)
12 Front wheel
13 Tandem front wheel (w/brake drum)
14 Tandem rear wheel
15 Stud (9 rqr, front wheel) (8 rqr, rear wheel)
16 Lubrication fitting (front wheel only)
17 Felt retainer (front wheel only)
18 Roller bearing (front wheel only)
19 Outer bearing cup (front wheel only)
20 Inner bearing cup (front wheel only)
21 Tire valve
22 Wheel flange
23 Preformed packing
24 Lock ring
25 Rim base

*Figure 8-1*—Continued.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Check all parts against tolerances listed in Table 1-1. Replace all parts that do not conform to repair and rebuild standards.

(3) Inspect bearing cups and surfaces in wheels for scoring, nicks, and wear.

(4) Replace all worn or damaged parts.

*e. Reassembly.* Reassemble the wheels in reverse of numerical sequence as illustrated on figure 8-1 and the following instructions.

(1) Press inner and outer bearing cups (19 and 20) into wheel until seated in bottom of counter bore in wheel.

(2) Press felt retainer (17) into bore until seated against cup.

*f. Installation.* Refer to TM 5-3805-237-12 to install the wheels and to the following instructions.

*Note.* The following instructions apply to the front wheels only.

(1) Install wheel bearing nut (9) and tighten. Attach a spring scale to a wheel stud. Tighten nut until a pull of 10 to 20 pounds is necessary to turn wheel.

(2) Install screw (8) and nut (7) through nut and axle. If hole in nut does not line up with hole in axle, loosen nut to aline holes.

(3) Refer to TM 5-3805-237-12 to install wheel rim base and tires.

## 8-5. Wheel Brake Hydraulic Lines

*a. General.* The brakes in the tandem front wheels are actuated by depressing the brake pedal (fig. 8-2) in the cab. Depressing the pedal increases the pressure in the brake master cylinder. This pressure flows to the wheel cylinders through brake hydraulic lines. The lines are mounted on the frame and tandem housings. Removal of brake lines is accomplished by removing the clamps and disconnecting the lines.

*b. Removal.* Remove the brake hydraulic lines in numerical sequence as illustrated in figure 8-3.

*c. Cleaning.* Clean all tube assemblies in cleaning compound, solvent (Spec. P-S-661) and dry with compressed air. Clean hose assemblies with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all tube assemblies for cracks, bent condition, and evidence of leakage.

(2) Inspect hose assemblies for cracks, breaks, and deterioration.

(3) Inspect fittings for cracks and damaged threads.

(4) Replace all damaged parts.

*e. Installation.* Refer to figure 8-3 and install the brake hydraulic lines. Refer to TM 5-3805-237-12 and fill master cylinder and bleed brake hydraulic system.

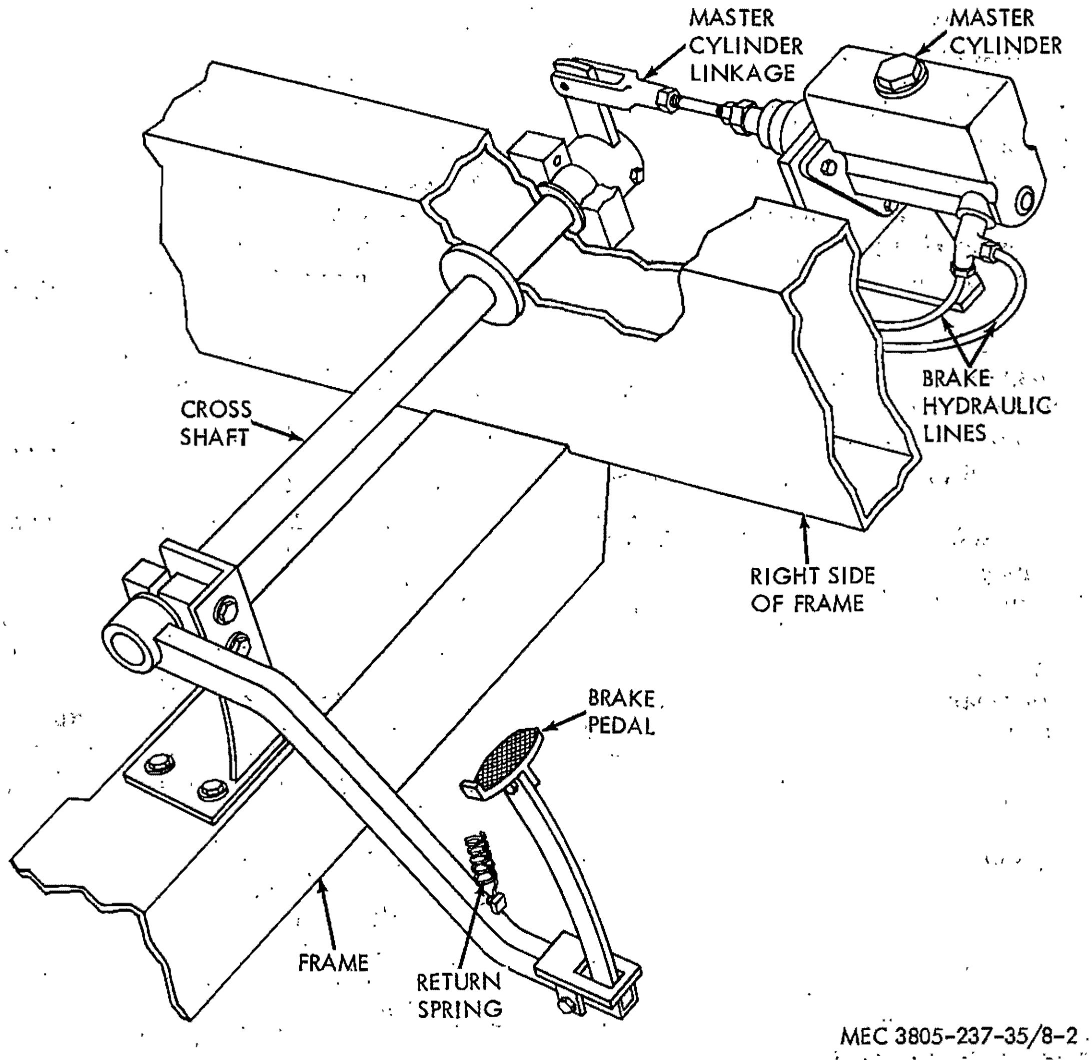



*Figure 8-2. Brake Linkage, operational view.*

## 8-6. Brake Assembly

*a. General.* The brake assemblies are of the expanding shoe type and are self-adjusting. Due to the nature of the motor grader operation the wear on the shoes must be checked periodically. The wheel cylinders must be inspected thoroughly when brakes are disassembled.

*b. Removal.*

(1) Refer to paragraph 8-5 and disconnect tube assembly from brake assembly.

(2) Refer to paragraph 4-2 and remove brake assembly from tandem assembly.

*c. Disassembly.*

(1) Disassemble the brake assembly in numerical sequence as illustrated on figure 8-4.

*Note.* The brake assemblies are for the left and right hand tandems. The assemblies differ in that the adjusting levers and cables are connected to the rear brake shoe on each brake.

(2) Disassemble the wheel cylinder assembly in the numerical sequence as illustrated on figure 8-5.

*d. Cleaning.*

(1) Clean all metal parts (except brake lining and cylinder cups and boots) in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Clean cylinder cups and boots in hydraulic fluid (HBA).

*e. Inspection and Repair.*

(1) Inspect brake shoes and linings for wear and damage. Replace shoes when lining is worn to within 1/32 to 1/16 inch of the closest rivet head.

(2) Check springs for weak or broken condition. Replace all defective springs.

(3) Inspect backing plate for cracks, dents and deformation.

(4) Inspect brake wheel cylinder parts for wear, scoring, and damage, particularly on pistons and body. Inspect boots for deterioration.

(5) Replace all damaged, worn, and defective parts.

*f. Reassembly.*

(1) Reassemble the wheel cylinder assembly in reverse of the numerical sequence as illustrated on figure 8-5.

(2) Reassemble the brake assembly in reverse of the numerical sequence as illustrated on figure 8-4 and the following instructions.

(3) Install anchor pins (29) with the arrows on pins pointing toward each other. Tighten nuts (27) snug.

*Note.* Anchor pins must be free to rotate for adjustment.

(4) Cable guide (11) is held in place by return spring (9).

(5) Lubricate threads on adjusting screw (21) and nut (23) before installing.

(6) Install shoe connecting spring (24) with hooks on spring toward bottom of brake shoes.

(7) When installing cable (10), cable must be in groove of cable guide and must not be twisted or kinked.

(8) After installing adjusting lever (13), disengage lever, and turn adjusting screw out until approximately six threads are showing. Engage end of adjusting lever with sprocket on adjusting screw.

*g. Installation.*

(1) Refer to paragraph 4-2 and install brake assembly on tandem housing.

*Note.* Check rear of backing plate. The letter R or the letter L stamped after the number indicates right and left hand brake assemblies.

(2) Refer to paragraph 8-5 and connect brake hydraulic lines to the brake assemblies.

(3) Refer to TM 5-3805-237-12 to fill and bleed the brake hydraulic system.

*h. Adjustment.*

(1) Open four adjusting slot covers on rear of backing plate as shown in figure 8-6.

(2) Insert an 0.010 inch thick feeler gage in each lower adjusting slot.

*Note.* Feeler gage must be between lining and brake drum.

(3) Insert flat tool or screw driver in slot in backing plate to engage sprocket on adjusting screw (21, fig. 8-4).

(4) Tighten adjusting screw by pulling down on tool until lining produces a slight drag on feeler gage when gage is moved.

*Note.* If adjusting screw is drawn up too tight, sprocket will lock against adjusting lever. Wheel must be removed to release lever.

(5) Remove tool from slot. Tap brake drum lightly to center brake shoes in drum.

(6) Insert two 0.010 inch feeler gages in upper adjusting slots, with feeler gage between brake lining and drum.

(7) Tighten upper end of brake lining by rotating anchor pins. Rotate right anchor pin in a clockwise direction,

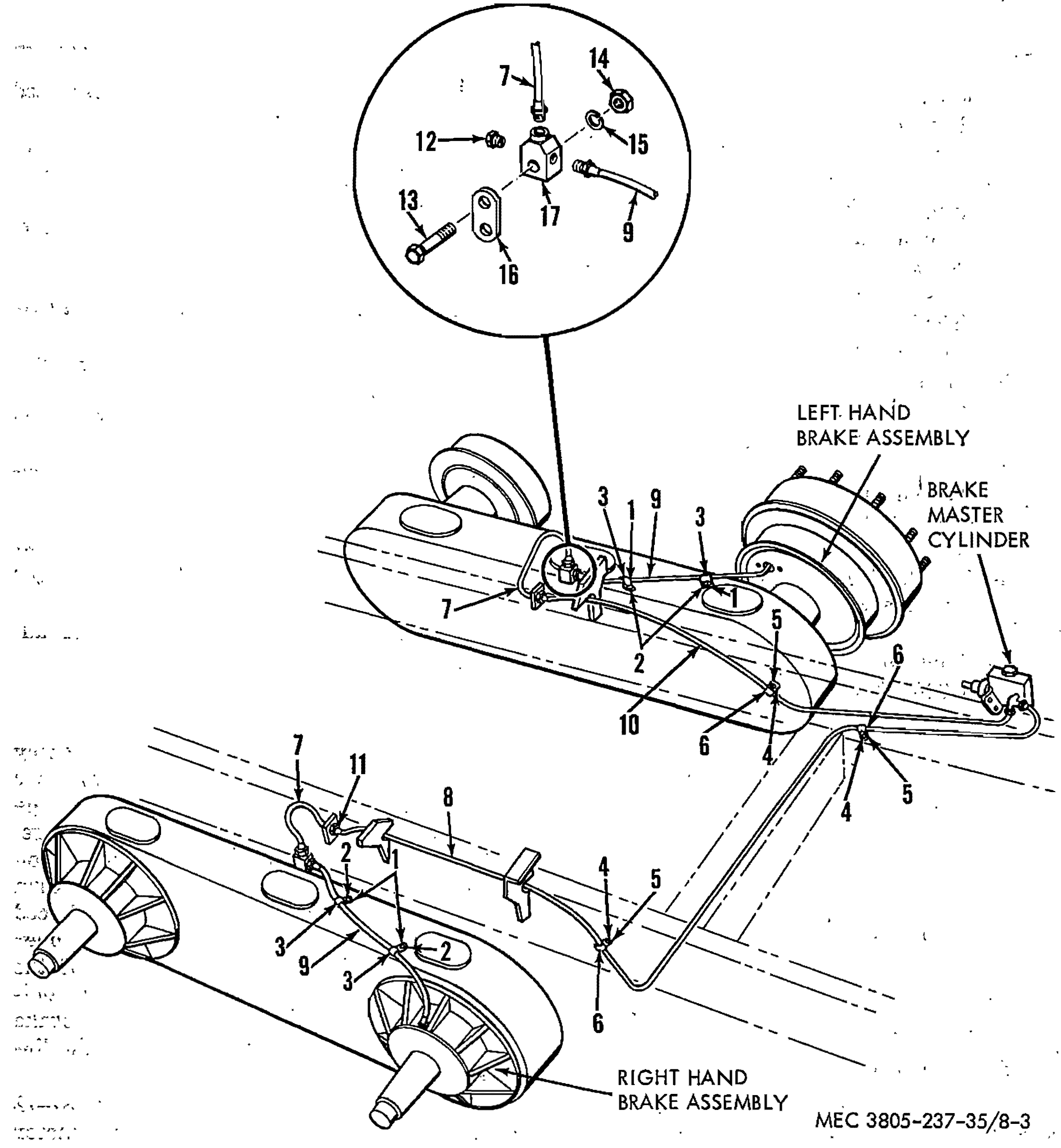



*Figure 8-3. Brake hydraulic lines, removal and installation.*

1 Screw, cap, hex-hd, 5/16-18 × 1/2 in. (4)
2 Washer, lock, 5/16 in. (4)
3 Clamp (4)
4 Screw, cap, hex-hd, 5/16-18 × 1/2 in. (3)
5 Washer, lock, 5/16 in. (3)
6 Clamp (3)
7 Hose assembly (2)
8 Tube assembly, LH
9 Tube assembly (2)
10 Tube assembly, RH
11 Hose union (2)
12 Nut, jam (2)
13 Screw, cap, hex-hd, 3/8-16 × 1 1/2 in. (2)
14 Nut, 3/8-16 (2)
15 Washer, lock, 3/8 in. (2)
16 Tee bracket
17 Axle tee

*Figure 8-3*—Continued.

left anchor pin in a counterclockwise direction to move brake shoes closer to drum.

(8) Tighten anchor pins until a slight drag is felt on feeler gages when gages are moved.

(9) Check 0.010 inch gages in lower slots to insure clearance as established above is maintained. Adjust if necessary.

(10) After establishing correct clearances at all four points, remove gages and close adjusting slot covers.

(11) Hold anchor pins in position with wrench on flats of pin. Tighten anchor pin lock nuts to a torque of 400 to 440 foot pounds.

*i. Road Test.* To insure complete lining contact with brake drums, run-in brakes as follows:

(1) Start and operate motor grader (TM 5-3805-237-12).

(2) Operate motor grader at half-throttle in low gear. Apply brakes firmly for approximately 10 seconds. Release brakes completely for 15 seconds. Depress brake pedal and hold for 10 more seconds and release.

(3) Repeat application of brakes 25 to 30 times. If brakes tend to overheat, allow a longer time between applications.

(4) Allow brakes to cool after run-in and adjust brakes (*h* above).

## 8-7. Brake Linkage

*a. General.* Pressure on the brake pedal moves a linkage attached to the brake master cylinder. The linkage is mounted on a cross shaft beneath the cab. The shaft is also used as a pivot for the clutch linkage.

*b. Removal.* Remove the brake linkage in the numerical sequence as illustrated on figure 8-7.

*c. Cleaning.* Clean all accumulated dirt and grease from linkage parts.

*d. Inspection and Repair.*

(1) Check return spring for weak or broken condition.

(2) Inspect all parts of linkage for damage.

(3) Inspect bearings for wear and scoring.

(4) Replace all defective, worn, or damaged parts.

*e. Installation.*

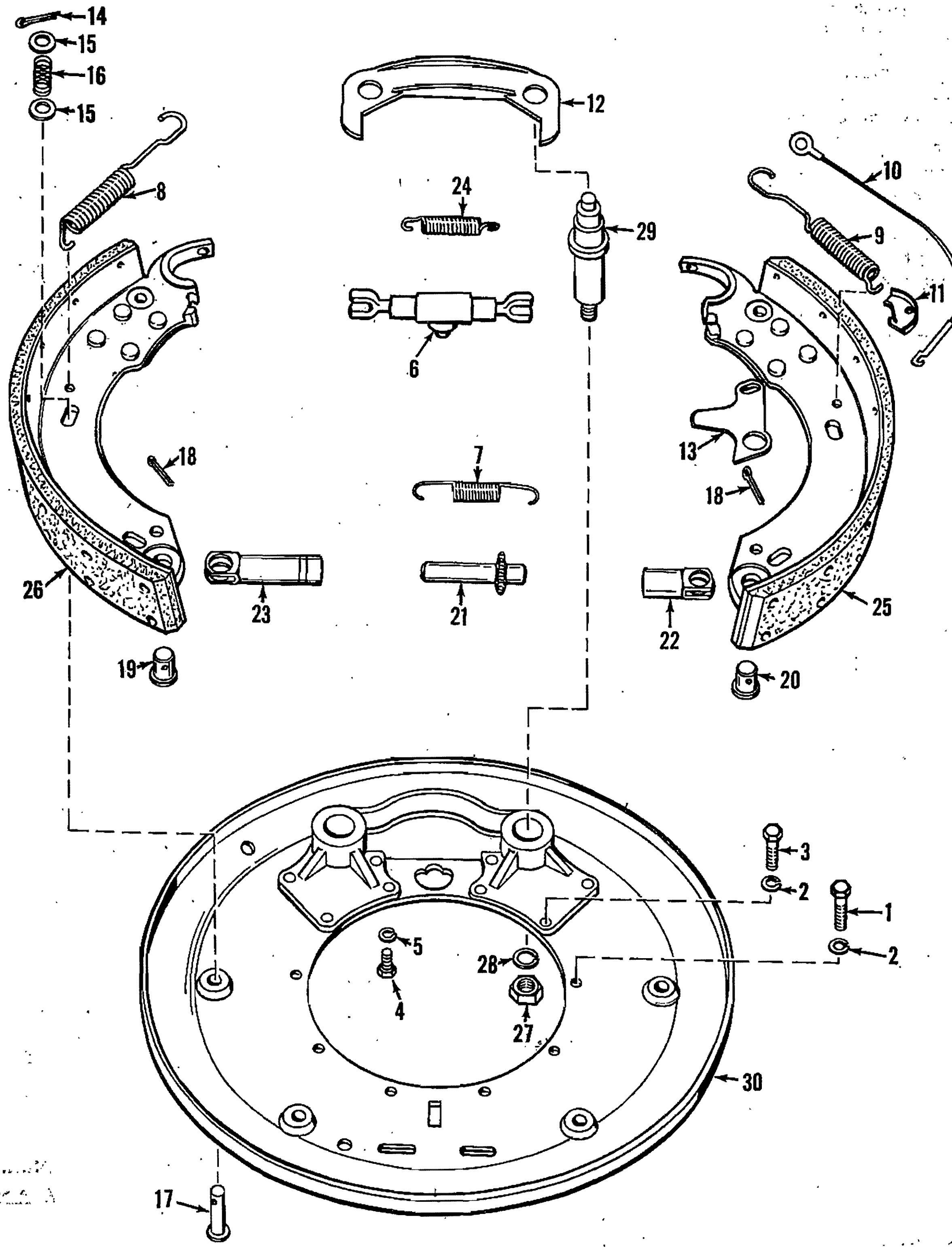
(1) Install the brake linkage in reverse of the numerical sequence as illustrated on figure 8-7.

(2) Refer to TM 5-3805-237-12 for adjustment of the brake linkage.

## 8-8. Brake Master Cylinder

*a. General.* Hydraulic pressure to apply the brakes is supplied by the master cylinder (fig. 8-7). Movement of the brake linkage forces a piston in the cylinder against a return spring in the cylinder. As the piston moves in the cylinder it closes an oil return port. Fluid trapped in the cylinder is forced out through the brake hydraulic lines under pressure. The fluid enters the center of the wheel cylinder, moving the two pistons outward. Links connected to the top of the brake shoes are forced against the shoes and the linings contact the brake drums.

*b. Removal.* Refer to TM 5-3805-237-12 to remove the master cylinder from the motor grader.

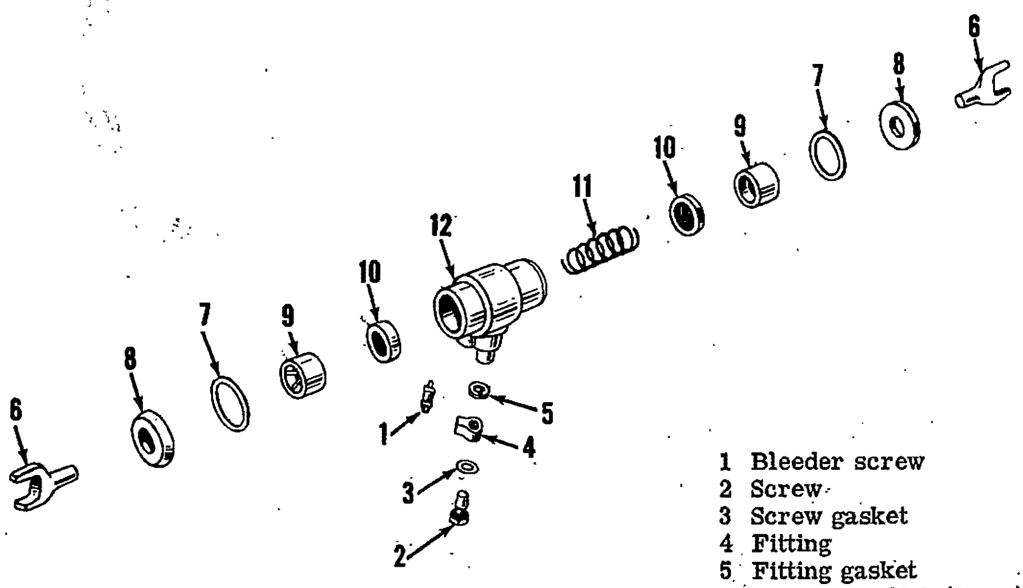



MEC 3805-237-35/8-4

*Figure 8-4. Brake assembly, exploded view.*

1 Screw, cap, hex-hd, (6)
2 Washer, lock, (10)
3 Screw, cap, hex-hd, (4)
4 Screw, cap, hex-hd, 5/16-18 × 3/4 in. (2)
5 Washer, lock, 5/16 in. (2)
6 Wheel cylinder assembly
7 Adjuster spring (blue)
8 Front return spring (red)
9 Rear return spring (black)
10 Automatic adjusting cable
11 Cable guide
12 Reinforcement plate
13 Adjusting lever
14 Pin, cotter, 5/32 × 3/4 (4)
15 Spring cup (8)
16 Hold-down spring (4)
17 Pin (4)
18 Pin, cotter, 5/32 × 1 1/4 (2)
19 Plain pin
20 Grooved pin
21 Adjust screw (RH and LH)
22 Screw socket
23 Pivot nut (RH and LH)
24 Shoe connecting spring
25 Rear shoe
26 Front shoe
27 Nut (2)
28 Washer, lock (2)
29 Anchor pin (2)
30 Backing plate

*Figure 8-4*—Continued.




1 Bleeder screw
2 Screw
3 Screw gasket
4 Fitting
5 Fitting gasket
6 Connecting link (2 rqr)
7 Boot retaining strap (2 rqr)
8 Boot (2 rqr)
9 Piston (2 rqr)
10 Spring cup (2 rqr)
11 Return spring
12 Cylinder body

MEC 3805-237-35/8-5

*Figure 8-5. Wheel cylinder assembly, exploded view.*

*c. Disassembly.* Disassemble the brake master cylinder in the numerical sequence as illustrated on figure 8-8.

*d. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. DO NOT USE SOLVENT NEAR AN OPEN FLAME.**

*e. Inspection and Repair.*

(1) Inspect boot for deterioration and damage particularly in the creases.

Extend and retract boot by hand to check flexibility. Replace boot if not in serviceable condition.

(2) Inspect piston and cylinder bore for scoring, scratches, and wear.

(3) Replace all worn, damaged, or unserviceable parts.

*f. Reassembly.* Reassemble the master cylinder in reverse of the numerical sequence as illustrated on figure 8-8.

*g. Installation.*

(1) Refer to TM 5-3805-237-12 and install the master cylinder on the motor grader.

(2) Refer to TM 5-3805-237-12 and fill master cylinder and bleed brake system.

(3) After installation, move push rod into master cylinder by hand. Push rod should move approximately 1/32 inch before contacting piston. This distance is required to prevent blocking of the bypass port in the cylinder.

(4) To adjust travel of the push rod, shorten or lengthen distance between push rod and clevis in brake linkage.

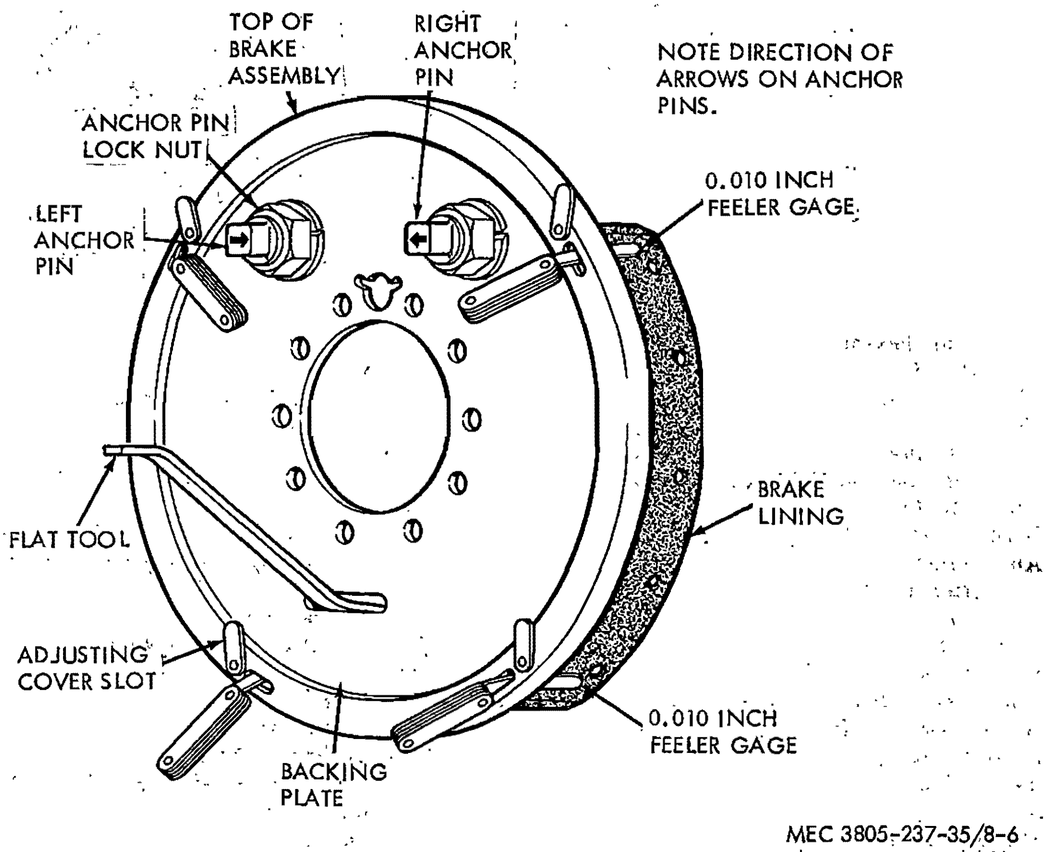
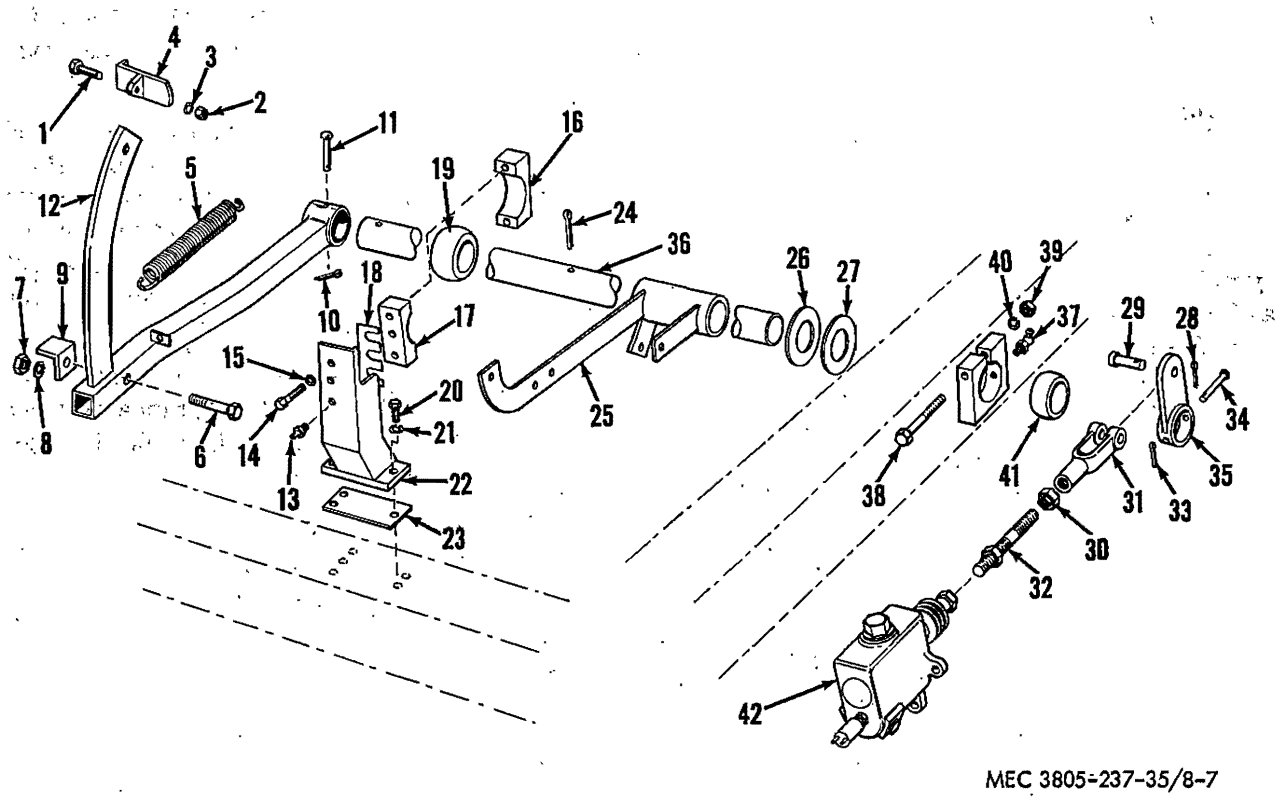
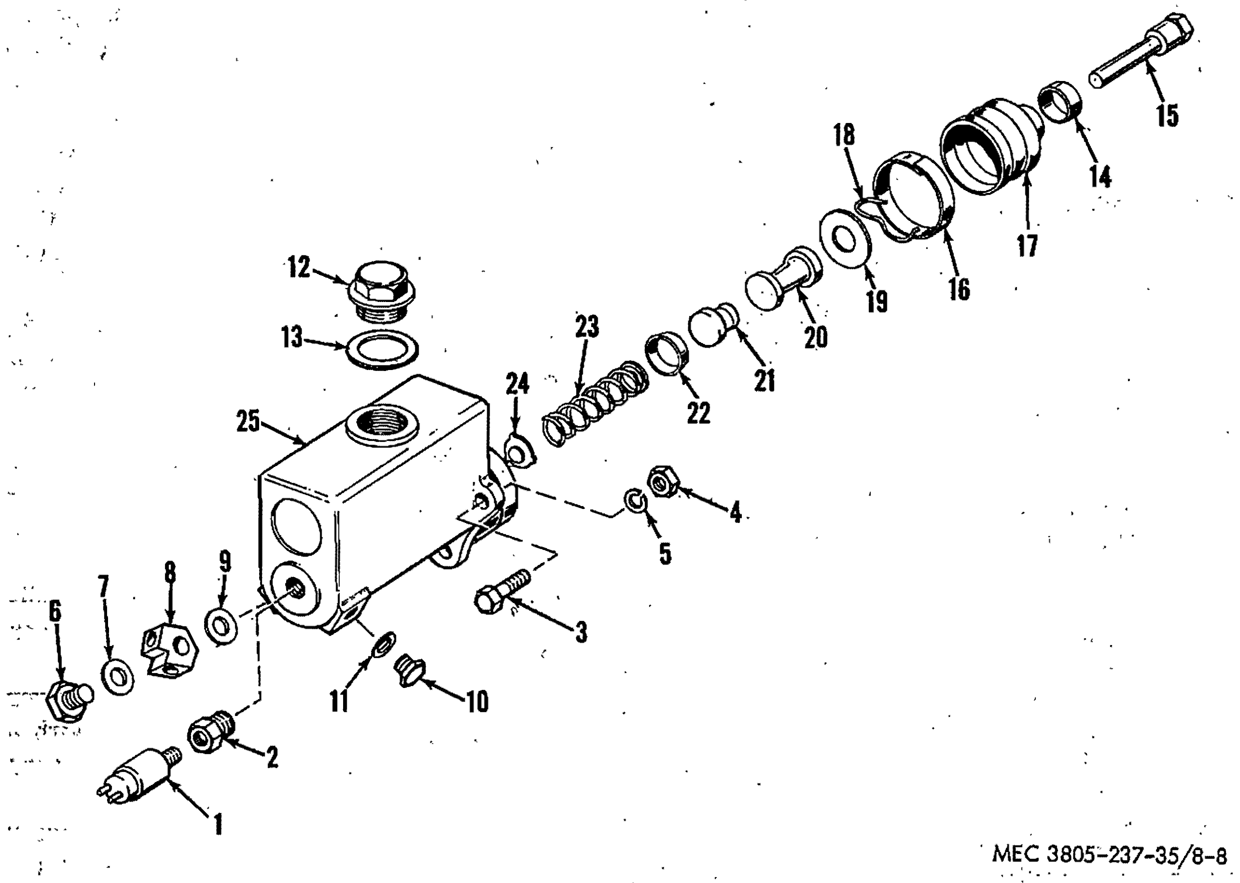



*Figure 8-6. Brake adjustment, schematic view.*




1 Screw, cap, hex-hd, 3/8-16 × 1 1/2 in.
2 Nut, 3/8-16
3 Washer, lock, 3/8 in.
4 Pedal pad
5 Return spring
6 Screw, cap, hex-hd, 5/16-18 × 2 in.
7 Nut, 5/16-18
8 Washer, lock, 5/16 in.
9 Angle bracket
10 Pin, cotter, 1/8 × 3/4 in.
11 Pin
12 Brake lever
13 Lubrication fitting
14 Screw, cap, hex-hd, 1/2-13 × 3 1/4 in. (2)
15 Washer, lock, 1/2 in. (2)
16 Bearing, cap
17 Bearing base
18 Shim
19 Sleeve bearing
20 Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (3)
21 Washer, lock, 1/2 in. (3)
22 Shaft support
23 Shim
24 Pin, cotter, 1/8 × 3/4 in.
25 Clutch linkage lever
26 Shim
27 Washer
28 Pin, cotter
29 Clevis pin
30 Nut, jam, 7/16-20 (2)
31 Clevis
32 Cylinder rod
33 Pin, cotter, 1/8 × 3/4 in.
34 Pin
35 Lever
36 Cross shaft
37 Lubrication fitting
38 Screw, cap, hex-hd, 3/8-16 × 3 1/2 in.
39 Nut, 3/8-16
40 Washer, lock, 3/8 in.
41 Sleeve bearing
42 Master cylinder

*Figure 8-7. Brake linkage, exploded view.*




1 Stop light switch
2 Fitting
3 Screw, cap, hex-hd, 3/8-16 × 1 1/4 in. (3)
4 Nut, 3/8-16 (3)
5 Washer, lock, 3/8 in.
6 Fitting
7 Gasket
8 Double outlet fitting
9 Gasket
10 Plug
11 Gasket
12 Filler cap
13 Gasket
14 Boot strap
15 Push rod
16 Boot strap
17 Boot
18 Stop wire
19 Piston stop
20 Piston
21 Cup retainer
22 Piston cup
23 Piston spring
24 Check valve
25 Cylinder housing

*Figure 8-8. Brake master cylinder, exploded view.*

## Section III. FRONT AXLE AND ASSOCIATED PARTS

### 8-9. General

*a.* The front axle supports the front of the motor grader and mounts the front wheels. A vibrating bar and front lean wheel gear assembly are mounted on the axle to provide the leaning wheel feature for guiding the motor grader.

*b.* The axle is supported by the front bolster plate in the center and pinned to the spindle forks on each end.

*c.* The tie rods and drag links connect the two spindle forks to the steering gear assembly.

### 8-10. Tie Rods and Associated Parts

*a. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the tie rods, steering arm, drag links from the motor grader. Remove front wheels from spindles.

(2) Refer to paragraph 2-37 and remove front lean wheel gear assembly and vibrating bar.

(3) Place a jack or blocking beneath the front axle to support motor grader.

(4) Remove the remainder of parts from the motor grader in the numerical sequence as illustrated on figure 8-9.

*Note.* Figure 8-9 illustrates parts for one end of the motor grader front axle. The quantities given are for both ends.

*b. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*c. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(3) Inspect boot for tears, damage, and deterioration.

(4) Replace all worn or damaged parts.

*d. Installation.*

(1) Install the parts in reverse of the numerical sequence as illustrated on figure 8-9 and the following instructions.

(2) Heat spindle bushing (32) in oil to 350°F and install on lower end of spindle.

(3) Install seal washer (35) and closure washer (34) on spindle. Heat roller bearing (33) to 350° and install on spindle. Hold bearing under pressure until it sets.

(4) Install spindle, with attached parts, in spindle fork. Install seal washer (28) and closure washer (27). Lug on closure washer must be on flat surface on spindle.

(5) Install spindle lower bearing (25) and screws (23). Do not install lockwashers (24) or fully tighten capscrews at this time.

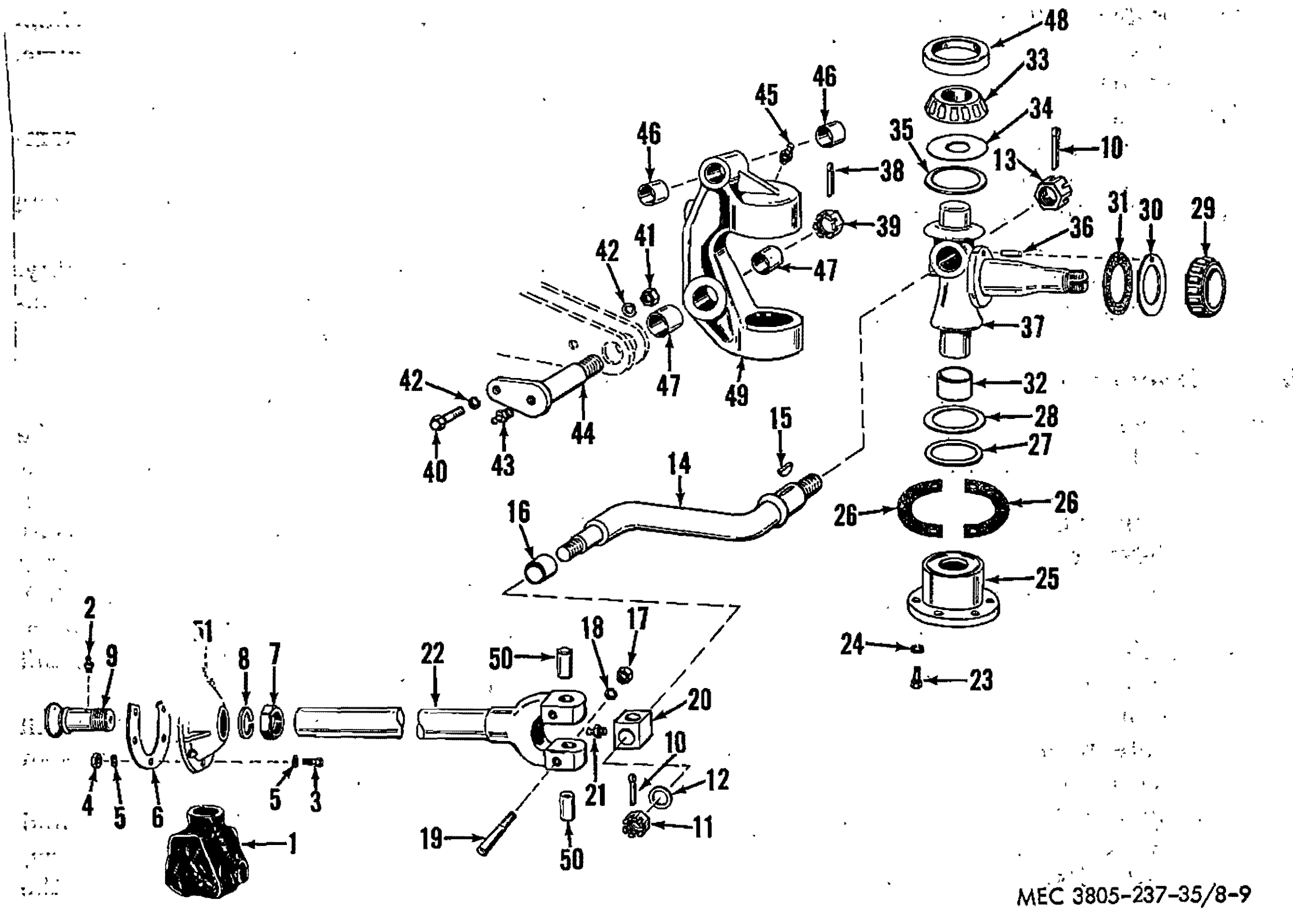
(6) Install key (15) in drag link (14) and drive drag link into spindle. Secure drag link with slotted nut (13) and cotterpin (10).

(7) Tighten screws (23) until spindle cannot be moved by pulling on drag link.

(8) Measure gap between spindle lower bearing (25) and spindle fork with a feeler gage. Count split shims (26) to fill the gap.

(9) Remove lower bearing and install correct amount of shims, lower bearing, screws, and lockwashers. Tighten screws. Hook a spring scale to drag link and tighten screws until a pull of 4 to 8 pounds is required to move spindle. Tap down on spindle with a soft hammer to be sure bearing is free.

(10) Install felt washer (31), spacer (30) and roller bearing (29) on spindle. Hole in spacer must engage dowel pin and felt washer must fit on shoulder of spacer.




1 Boot
2 Lubrication fitting
3 Screw, cap, hex-head, 1/2-13 × 3 in. (5)
4 Nut, 1/2-13 (5)
5 Washer, lock, 1/2 in. (10)
6 Shim
7 Nut, jam 1 1/4 (2)
8 Washer, lock, 1 1/4 in. (2)
9 Tie rod end (2)
10 Pin, cotter, 1/8 × 1 1/2 in. (4)
11 Slotted nut (2)
12 Washer (2)
13 Slotted nut (2)
14 Drag link (2)
15 Key (2)
16 Bushing
17 Nut, 1/2 × 13 (4)
18 Washer, lock, 1/2 in. (4)
19 Pin (4)
20 Swivel block (2)
21 Lubrication fitting (2)
22 Tie rod, w/yoke (2)
23 Screw, cap, hex-head, 3/8-16 × 1 3/8 in. (12)
24 Washer, lock, 3/8 in. (12)
25 Spindle lower bearing (2)
26 Shim
27 Closure washer (2)
28 Seal washer (2)
29 Roller bearing (2)
30 Spacer (2)
31 Felt washer (2)
32 Bushing (2)
33 Roller bearing (2)
34 Closure washer (2)
35 Seal washer (2)
36 Dowel pin (2)
37 Spindle (2)
38 Pin, cotter, 3/8 × 2 1/2 in. (2)
39 Slotted nut (2)
40 Screw, cap, hex-head, 3/8-16 × 1 1/2 in. (2)
41 Nut, 3/8-16 (2)
42 Washer, lock, 3/8 in. (4)
43 Lubrication fitting (2)
44 Spindle fork pin (2)
45 Lubricating fitting
46 Fork upper bushing (4)
47 Fork lower bushing (4)
48 Bearing cup (2)
49 Spindle fork (2)
50 Pin (4)
51 Socket (2)

*Figure 8-9. Tie rods, drag links, and spindle forks, exploded view.*

(11) Refer to TM 5-3805-237-12 and install tie rods and steering arm on grader.
(12) Refer to paragraph 2-37 and install front lean wheel gear assembly and vibrating bar on axle.
(13) Refer to TM 5-3805-237-12 and install wheels on grader. Pack bearings and spindle with wheel bearing grease (WB) before installation.

## 8-11. Front Axle

*a. Removal.*

(1) Refer to TM 5-3805-237-12 and remove front wheels, tie rods, and drag links.
(2) Refer to paragraph 2-37 and remove the vibrating bar and front lean wheel gear assembly.
(3) Refer to paragraph 8-10 and remove the spindle forks.
(4) Support the grader frame and bolster plate with the moldboard or jacks and blocking.
(5) Remove the front axle in the numerical sequence as illustrated on figure 8-10. Items 1 through 31 were removed with the vibrating bar.

*b. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

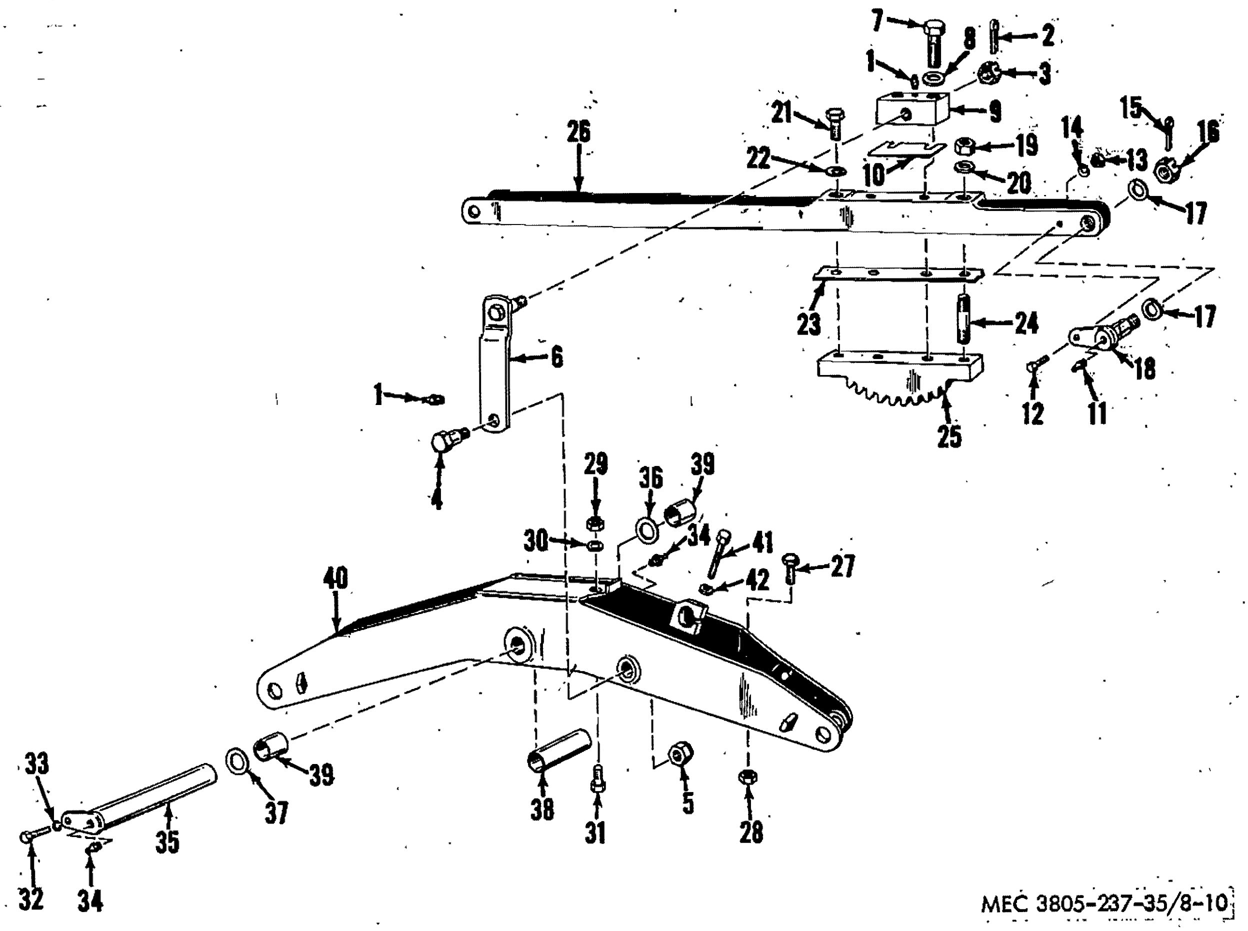
*c. Inspection and Repair.*

(1) Inspect all parts for wear and damage.
(2) Inspect working surfaces of links and pins for scoring and wear.
(3) Check all threads for serviceability.
(4) Replace all worn, damaged, or unserviceable parts.

*d. Installation.*

(1) Install front axle bushings, tube, bolster pin and front axle on the motor grader in reverse of the numerical sequence as illustrated on figure 8-10. Install one shim (36) between axle and front bolster plate. Install remaining shims (37) between axle and rear bolster plate.
(2) Refer to paragraph 8-10 and install the spindle forks.
(3) Refer to paragraph 2-37 and install the vibrating bar and front lean wheel gear assembly.
(4) Refer to TM 5-3805-237-12 and install the tie rods, steering arm, drag links, and front wheels on the motor grader.

*e. Adjustment.* Refer to TM 5-3805-237-12 and adjust the caster and camber of the front wheels.




1 Lubrication fitting (2)
2 Pin, cotter, 3/16 × 2 1/4 in.
3 Nut, slotted, 1/2-13
4 Shoulder bolt
5 Lock nut
6 Vibrating link
7 Screw, cap, hex-hd, 3/4-10 × 4 in. (2)
8 Washer, lock, 3/4 in. (2)
9 Anchor bracket
10 Shim
11 Lubrication fitting
12 Screw, cap, hex-hd, 3/8-16 × 1 1/2 in. (2)
13 Nut, 3/8-16 (2)
14 Washer, lock, 3/8 in. (2)
15 Pin, cotter,5/32 × 1 1/2 in. (2)
16 Nut, slotted, 3/4-16 (2)
17 Washer, flat, 3/4 (4)
18 Vibrating bar pin (2)
19 Nut, 3/4-10
20 Washer, lock 3/4
21 Screw, cap, hex-hd, 3/4-10 × 2 in.
22 Washer, lock, 3/4 in.
23 Shim
24 Stud
25 Gear rack
26 Vibrating bar
27 Screw, cap, hex-hd (4)
28 Nut, tapered (4)
29 Nut, anchor
30 Washer, lock
31 Screw, anchor
32 Screw, cap, hex-hd, 1/2-13 × 1 in.
33 Washer, lock, 1/2 in.
34 Lubrication fitting (2)
35 Bolster Pin
36 Shim
37 Shim
38 Tube
39 Bushing (2)
40 Front axle
41 Screw, cap, hex-hd, 1/2-13 × 3 1/4 in.
42 Washer, lock, 1/2 in.

*Figure 8-10. Front axle and vibrating bar, exploded view.*

# CHAPTER 9

# FRAME UNIT COMPONENT REPAIR INSTRUCTIONS

## Section I. CONTROL SHAFTS

### 9-1. General

*a.* The basic support for the motor grader is the Y shaped frame. Most of the components are mounted to, and supported by the frame. Special provisions in the frame construction permit installation of the operating parts and allow moldboard movements through pivot points built into the frame.

*b.* The components covered in this section include the control shafts, with the exception of the steering control shaft, the scarifier, moldboard, moldboard circle, and the drawbar.

### 9-2. Control Shafts

*a. Removal.*

(1) Remove the lateral shift control shaft in the numerical sequence as illustrated in figure 9-1.

(2) Remove the moldboard lift control shafts in the numerical sequence as illustrated in figure 9-2.

*Note.* The quantities given are for one control shaft. Repeat for second shaft.

(3) Remove the circle reverse control shaft in the numerical sequence as illustrated on figure 9-3.

(4) Remove the scarifier lift control shaft in the numerical sequence as illustrated on figure 9-4.

(5) Remove the front lean wheel control shaft in the numerical sequence as illustrated on figure 9-5.

*b. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*c. Inspection and Repair.*

(1) Inspect shafts for bent condition and damage.

(2) Check all universal joints for good condition and proper operation.

(3) Inspect bearings and bearing caps for wear and evidence of binding.

(4) Straighten bent shafts, if possible.

(5) Replace all worn or damaged parts. Replace universal joints which do not operate properly.

*d. Installation.*

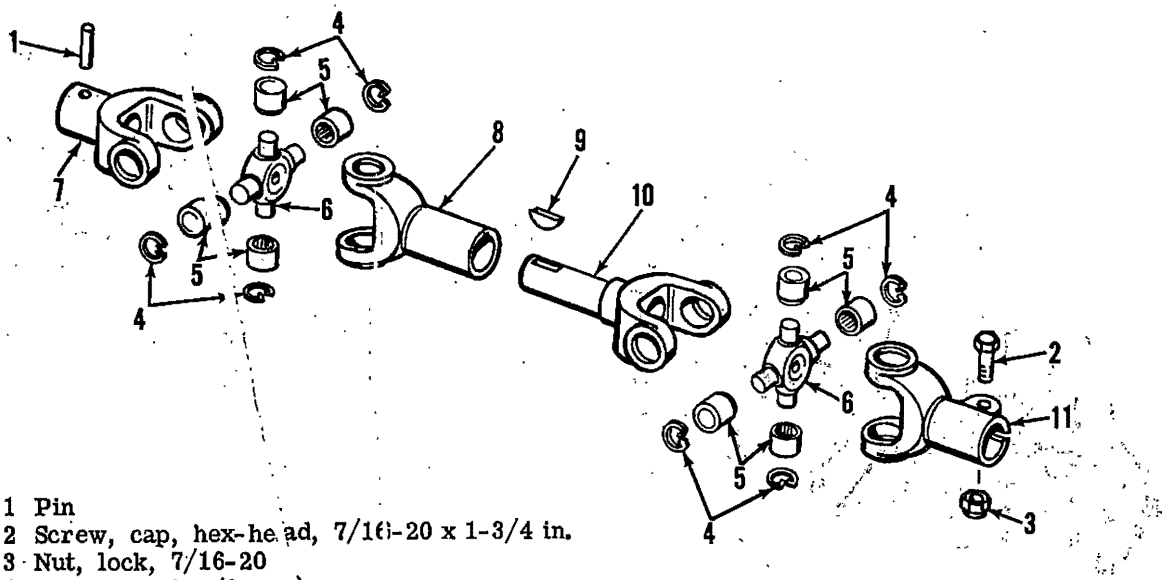
(1) Install the front lean wheel control shaft in reverse of the numerical sequence as illustrated on figure 9-5.

(2) Install the scarifier lift control shaft in reverse of the numerical sequence as illustrated on figure 9-4.

(3) Install the circle reverse control shaft in reverse of the numerical sequence as illustrated on figure 9-3.

(4) Install the moldboard lift control shaft in reverse of the numerical sequence as illustrated on figure 9-2.

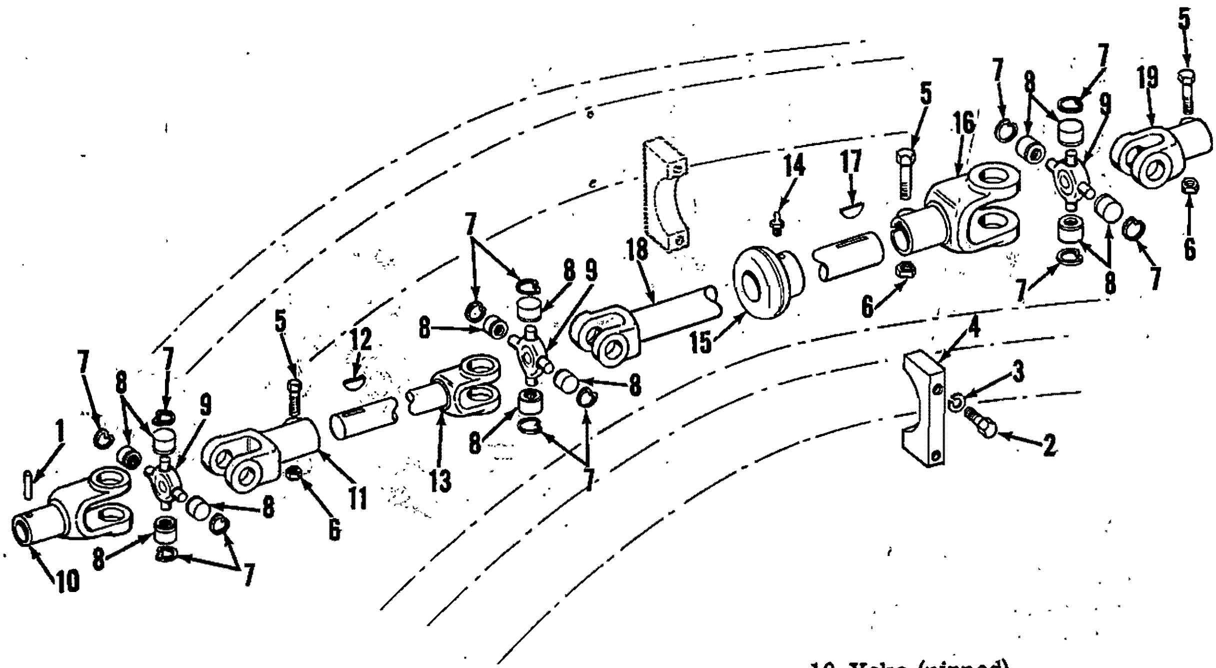
(5) Install the lateral shift control shaft in reverse of the numerical sequence as illustrated on figure 9-1.




1 Pin
2 Screw, cap, hex-head, 7/16-20 x 1-3/4 in.
3 Nut, lock, 7/16-20
4 Retaining ring (8 rqr)
5 Needle bearing (8 rqr)
6 Journal (2 rqr)
7 Yoke (pinned)
8 Yoke, w/shaft
9 Key, woodruff
10 Yoke, w/shaft
11 Yoke (clamp)

MEC 3805-237-35/9-1

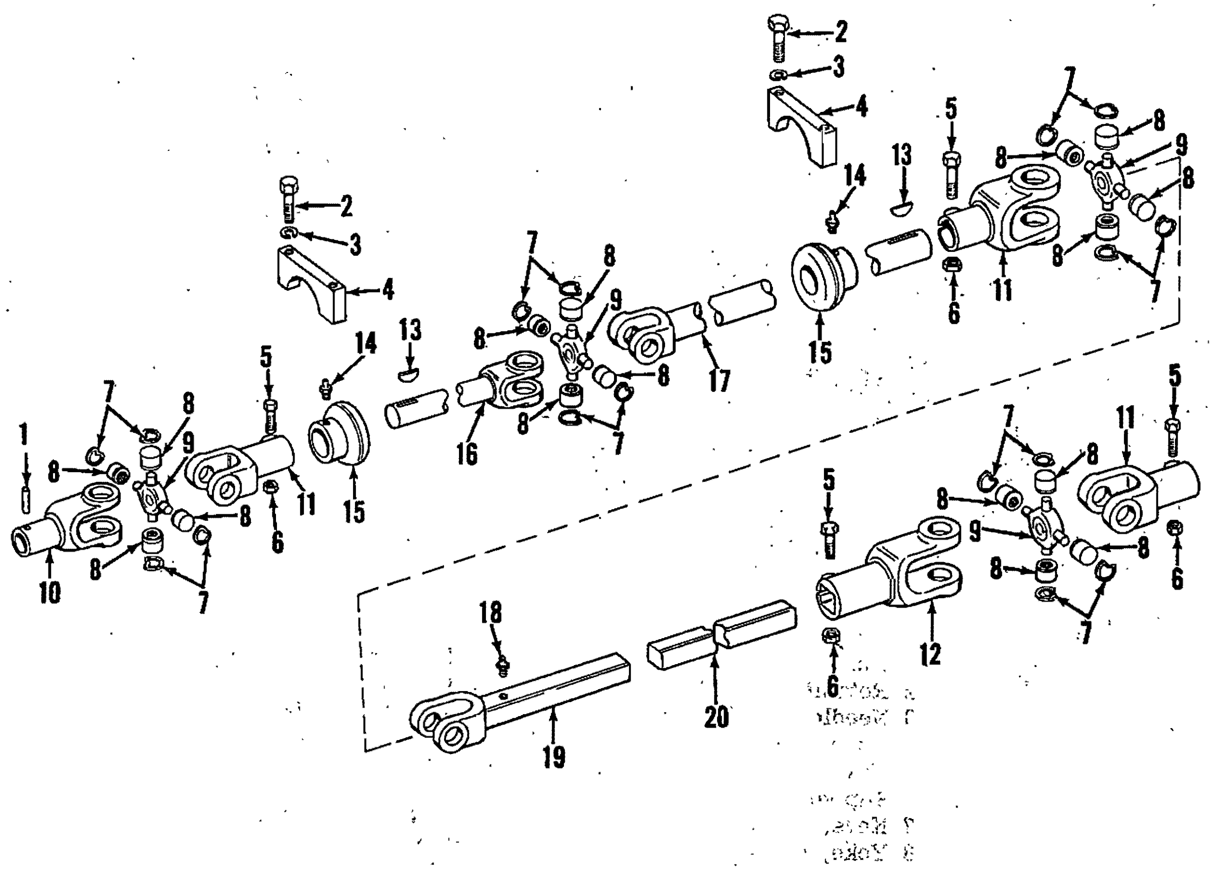
*Figure 9-1. Lateral shift control shaft, exploded view.*




1 Pin
2 Screw, cap, hex-head, 3/8-16 x 2 in. (2 rqr)
3 Washer, lock, 3/8 in. (2 rqr)
4 Bearing cap
5 Screw, cap, hex-head, 7/16-20 x 1-3/4 in. (3 rqr)
6 Nut, 7/16-20 (3 rqr)
7 Retaining ring (12 rqr)
8 Needle bearing (12 rqr)
9 Journal (3 rqr)
10 Yoke (pinned)
11 Yoke (clamp)
12 Key, woodruff
13 Yoke, w/shaft
14 Lubrication fitting
15 Bearing
16 Yoke
17 Key, woodruff
18 Yoke, w/shaft
19 Yoke (clamp)

MEC 3805-237-38/9-2

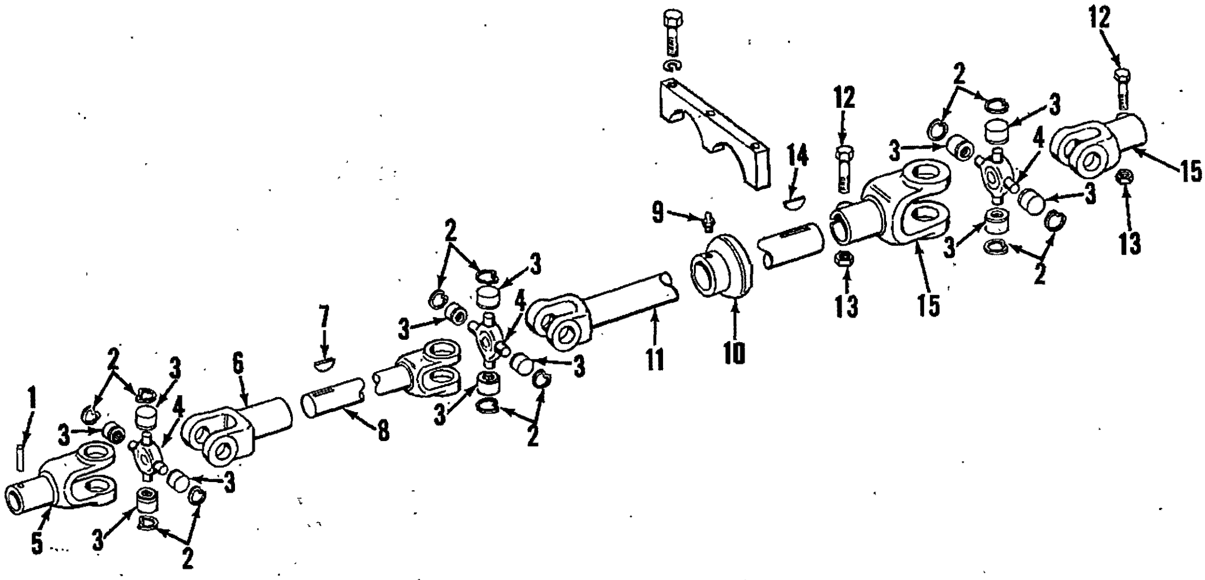
*Figure 9-2. Moldboard lift control shaft, exploded view.*



1 Pin
2 Screw, cap, hex-head, 3/8-16 x 2 in. (4 rqr)
3 Washer, lock, 3/8 in. (2 rqr)
4 Bearing cap (2 rqr)
5 Screw, cap, hex-head, 7/16-20 x 1-3/4 in. (4 rqr)
6 Nut, lock, 7/16-20 (4 rqr)
7 Retaining ring (16 rqr)
8 Needle bearing (16 rqr)
9 Journal (4 rqr)
10 Yoke (pinned)
11 Yoke (clamp) (3 rqr)
12 Yoke (clamp) (square shaft)
13 Key, woodruff (2 rqr)
14 Lubrication fitting (2 rqr)
15 Bearing (2 rqr)
16 Yoke, w/shaft
17 Yoke, w/shaft
18 Lubrication fitting
19 Yoke, w/square shaft
20 Square shaft

MEC 3805-237-35/9-3

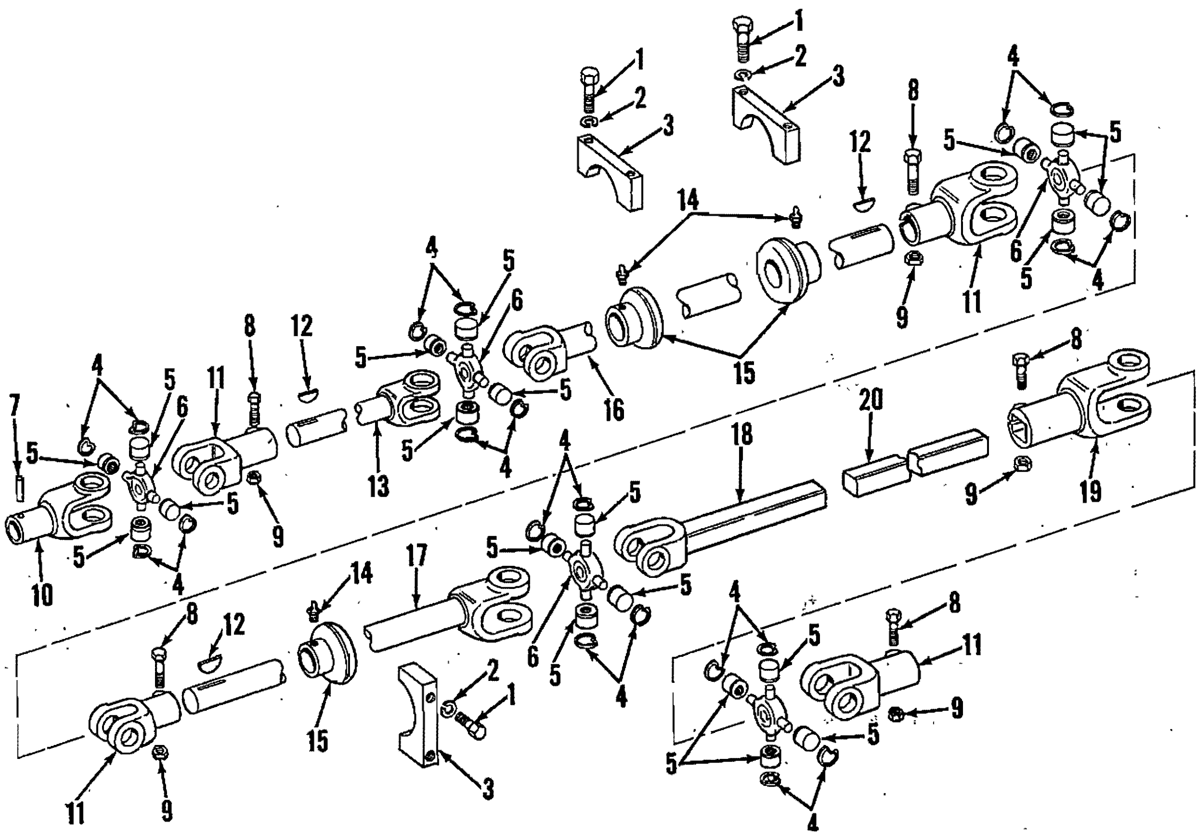
*Figure 9–3. Circle reverse control shaft, exploded view.*




| | |
|---|---|
| 1 Pin | 9 Lubrication fitting |
| 2 Retaining ring (12 rqr) | 10 Bearing |
| 3 Needle bearing (12 rqr) | 11 Yoke, w/shaft |
| 4 Journal (3 rqr) | 12 Screw, cap, hex-head, 7/16-20 x 1-3/4 in. (2 rqr) |
| 5 Yoke (pinned) | 13 Nut, lock, 7/16-20 (2 rqr) |
| 6 Slip yoke | 14 Key, woodruff (2 rqr) |
| 7 Keys, woodruff | 15 Yoke (clamp) (2 rqr) |
| 8 Yoke, w/shaft | |

MEC 3805-237-35/9-4

*Figure 9-4. Scarifier lift control shaft, exploded view.*



1 Screw, cap, hex-head, 3/8-16 x 2 in. (6 rqr)
2 Washer, lock, 3/8-16
3 Bearing cap
4 Retaining ring (20 rqr)
5 Needle bearing (20 rqr)
6 Journal (5 rqr)
7 Pin
8 Screw, cap, hex-head, 7/16-20 x 1-3/4 in. (5 rqr)
9 Nut, lock, 7/16-20 (5 rqr)
10 Yoke (pinned)
11 Yoke (clamp) (4 rqr)
12 Key, woodruff (3 rqr)
13 Yoke, w/shaft
14 Lubrication fitting (3 rqr)
15 Bearing (3 rqr)
16 Yoke, w/shaft
17 Yoke, w/shaft
18 Yoke, w/square shaft
19 Yoke (clamp) (square)
20 Square shaft

MEC 3805-237-35/9-5

*Figure 9-5. Front lean wheel control shaft, exploded view.*

## Section II. MOLDBOARD

### 9-3. General

*a.* The primary operation of the motor grader is grading with the moldboard. The moldboard can be set at almost any angle to the frame and can be lifted up on either side to perform bank sloping.

*b.* The moldboard is equipped with a blade and boots that can be replaced. They are the wear points on the moldboard and will require periodic inspection to determine their serviceability.

## 9-4. Moldboard

*a. Removal.*

(1) Refer to paragraph 7-23 and remove the moldboard shift cylinder.

(2) Remove the moldboard in the numerical sequence as illustrated on figure 9-6.

(3) Place blocks to support moldboard. Remove two nuts (1), two locks (2), two cotter pins (3) and two nuts (4).

(4) Operate motor grader (TM 5-3805-237-12) and raise moldboard slightly to disengage tilt plates (5 and 6) from moldboard circle.

*Note.* Cut welds to free pivot bolts (7) and pitch adjusting bolts (8) from moldboard circle and pry tilt plates away from circle.

(5) Move motor grader to the rear to free moldboard.

(6) Slide tilt plates from moldboard slide bar.

(7) Remove blades and boots from moldboard.

*b. Cleaning.* Clean all dirt, mud, and debris from moldboard parts.

*c. Inspection and Repair.*

(1) Inspect boots and blades for wear, cracks, mutilation, and other damage.

(2) Inspect moldboard slides and cylinder ball for wear and damage that could cause restriction to movement.

(3) Inspect moldboard for cracks and damage, paying particular attention to the areas around the plow bolt holes.

(4) Inspect tilt plates for cracks and damage. Check locking teeth for chipping and broken teeth. Check ball on right hand tilt plate for any damage that might restrict cylinder movement.

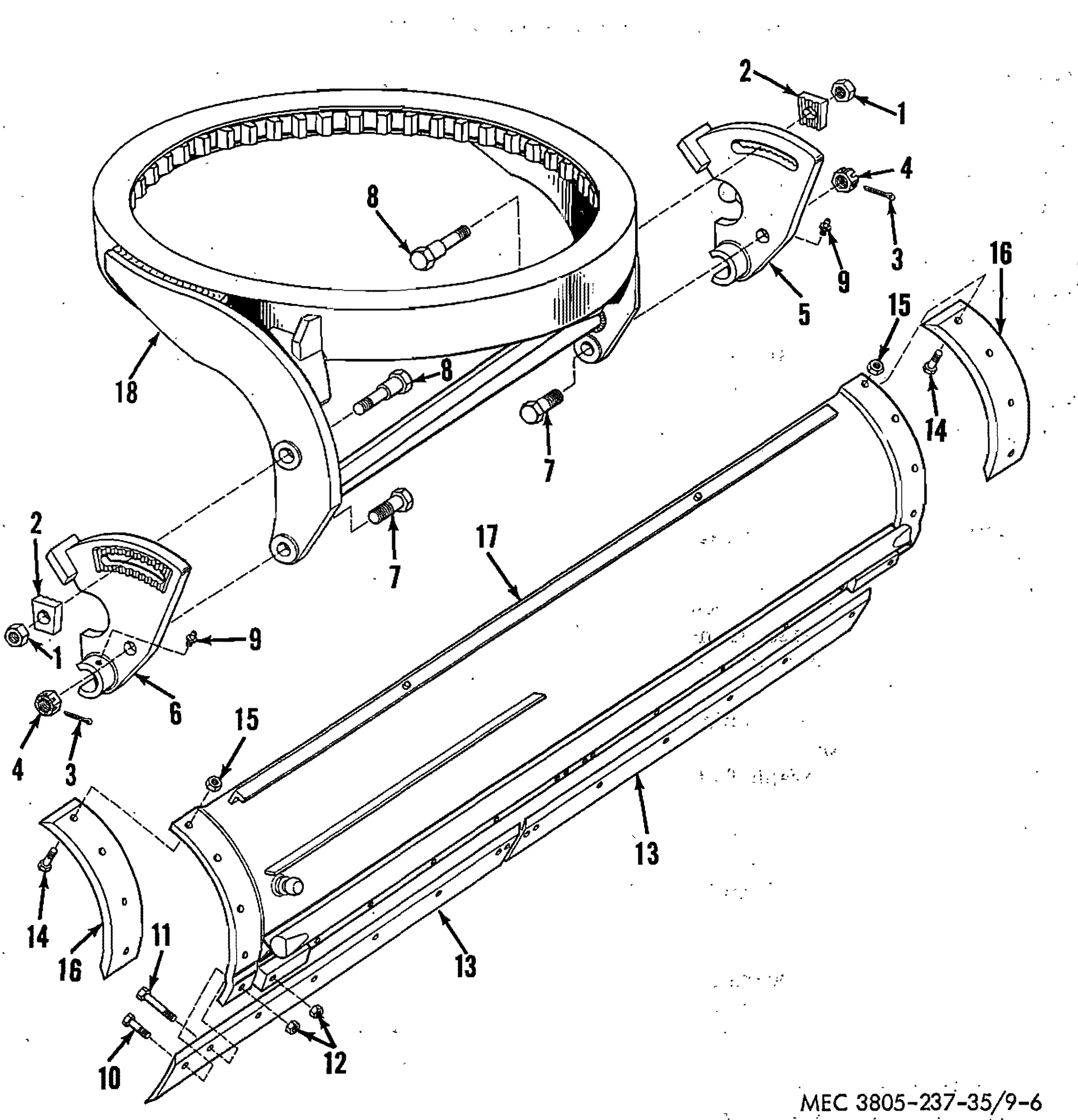
*d. Installation.*

(1) Install the moldboard and components in reverse of the numerical sequence as illustrated on figure 9-6.

(2) After installation of tilt plates, weld pivot bolts and pitch adjusting bolts to moldboard circle. Weld only in one spot to secure bolts.

(3) Refer to paragraph 7-23 and install moldboard cylinder.

(4) Refer to TM 5-3805-237-12 to adjust pitch of moldboard.




| | | | |
|---|---|---|---|
| 1 | Nut (2) | 10 | Plow bolt (14) |
| 2 | Adjustment lock (2) | 11 | Plow bolt (2) |
| 3 | Pin, cotter, 3/16 × 2 1/2 in. (2) | 12 | Nut (16) |
| 4 | Nut, slotted, 1 1/2-6 (2) | 13 | Blade (2) |
| 5 | Tilt plate, RH | 14 | Plow bolt, 3/4-10 × 2 1/4 in. (8) |
| 6 | Tilt plate, LH | 15 | Nut, 3/4-10 (8) |
| 7 | Pivot bolt (2) | 16 | Boot (2) |
| 8 | Pitch adjusting bolt (2) | 17 | Moldboard |
| 9 | Lubrication fitting (2) | 18 | Moldboard circle |

*Figure 9-6. Moldboard and tilt plates, exploded view.*

## Section III. MOLDBOARD CIRCLE AND DRAWBAR

### 9-5. General

*a.* The moldboard circle supports the moldboard and is mounted below the drawbar. Three sets of adjusting and wear plates mount the circle on the drawbar. The lower portion of the circle is a large ring gear with teeth matching the circle reverse gear assembly drive gear.

*b.* The drawbar is supported by the moldboard lift and lateral shift links at the rear and a ball and socket arrangement into the frame at the front. Rotation of the drawbar in this ball and socket allows tilting of the blade.

### 9-6. Moldboard Circle and Drawbar

*a. Removal.*

(1) Refer to paragraph 2-35 and remove the circle reverse transfer housing and circle reverse gear assembly.

(2) Refer to paragraph 7-22 and remove the rotary valve, tubing, and hoses from drawbar.

(3) Refer to paragraph 9-4 and remove the moldboard.

(4) Attach a suitable hoist or place a dolly under the moldboard circle. Refer to figure 9-7 and remove wear plates, adjusting plates, and retaining plate from drawbar and circle and remove moldboard circle.

(5) Place supports under the moldboard circle and refer to TM 5-3805-237-12 and remove the moldboard lift and shift links.

(6) Support the front of the drawbar and remove ball and socket mounting bolts as shown in figure 9-8.

(7) Using a suitable hoist or dolly remove drawbar from motor grader.

*b. Disassembly.* Disassemble remainder of drawbar and circle parts in the numerical sequence as illustrated in figure 9-9. Disassemble the moldboard shift and lift links in the numerical sequence as illustrated on figure 9-10.

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect moldboard circle for worn or broken gear teeth.

(2) Inspect wear plates and retaining plates for excessive wear.

(3) Inspect drawbar ball and link balls for wear or elongation.

(4) Inspect link bearing caps for wear and multilation.

(5) Replace all worn, damaged, mutilated or elongated parts.

*Note.* Wear plates and retaining plates can be reversed to provide new wearing surfaces.

*e. Reassembly.*

(1) Reassemble the lift and lateral shift links as far as necessary in reverse of the numerical sequence as illustrated on figure 9-10.

(2) Reassemble the drawbar and moldboard circle in reverse of the numerical sequence as illustrated on figure 9-9.

*f. Installation.*

(1) Use a hoist or dolly and install drawbar in position and refer to figure 9-8 and install the drawbar ball and socket.

(2) Use a hoist or dolly and place moldboard circle in position and refer to figure 9-7 and install the moldboard circle.

(3) Refer to paragraph 9-4 and install the moldboard.

(4) Refer to paragraph 7-22 and install the rotary valve, tubing, and hoses.

(5) Refer to paragraph 2-35 and install the circle reverse gear assembly and transfer housing.

(6) Refer to TM 5-3805-237-12 and install the moldboard lift and lateral shift links.

*g. Adjustment.* For proper operation and a minimum of wear on the plates, the wear and retaining plates can be adjusted through

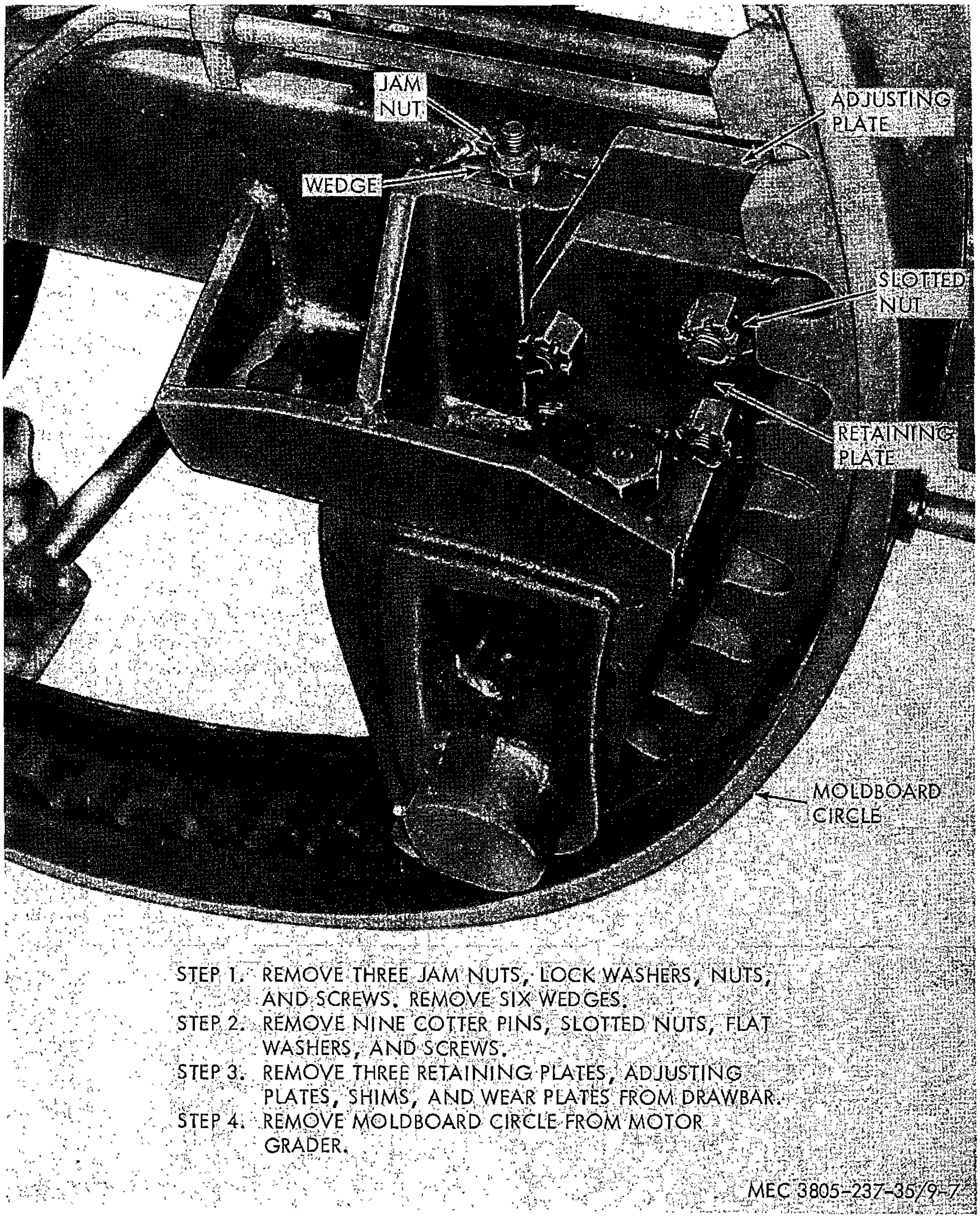
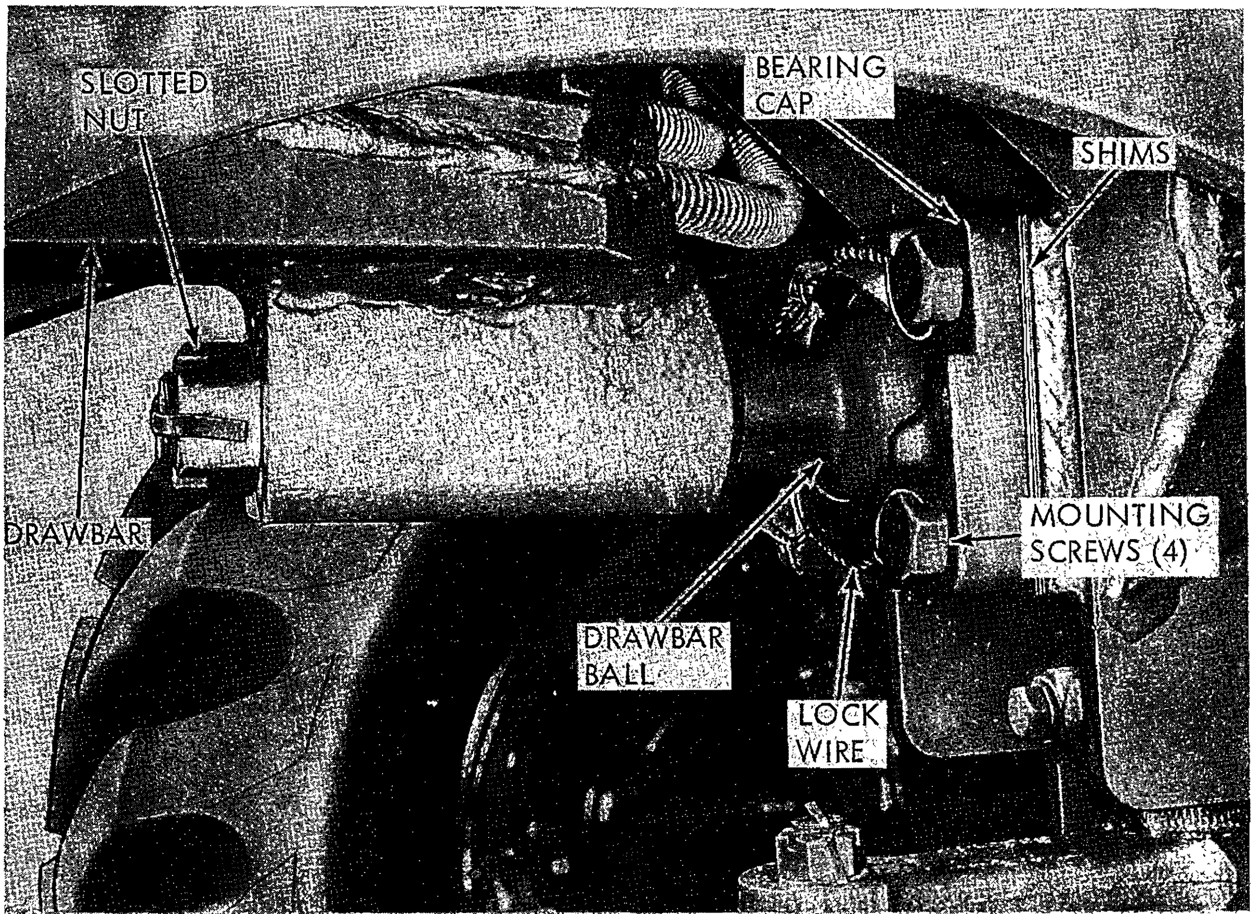



*Figure 9-7. Moldboard circle, removal and installation.*




STEP 1. REMOVE LOCK WIRE FROM FOUR SCREWS.
STEP 2. REMOVE FOUR MOUNTING SCREWS.
STEP 3. REMOVE DRAWBAR FROM MOTOR GRADER.
STEP 4. REMOVE COTTER PIN AND SLOTTED NUT AND REMOVE DRAWBAR BALL.
STEP 5. REMOVE BEARING CAP AND SHIMS. COUNT NUMBER OF SHIMS.

NOTE: WHEN INSTALLING DRAWBAR, INSTALL SUFFICIENT NUMBER OF SHIMS TO ALLOW BALL TO ROTATE FREELY WITHOUT BINDING. NO LESS THAN 0.090 INCH TOTAL SHIM THICKNESS SHOULD EVER BE INSTALLED.

MEC 3805-237-35/9-8

*Figure 9-8. Drawbar ball and socket, removal and installation.*

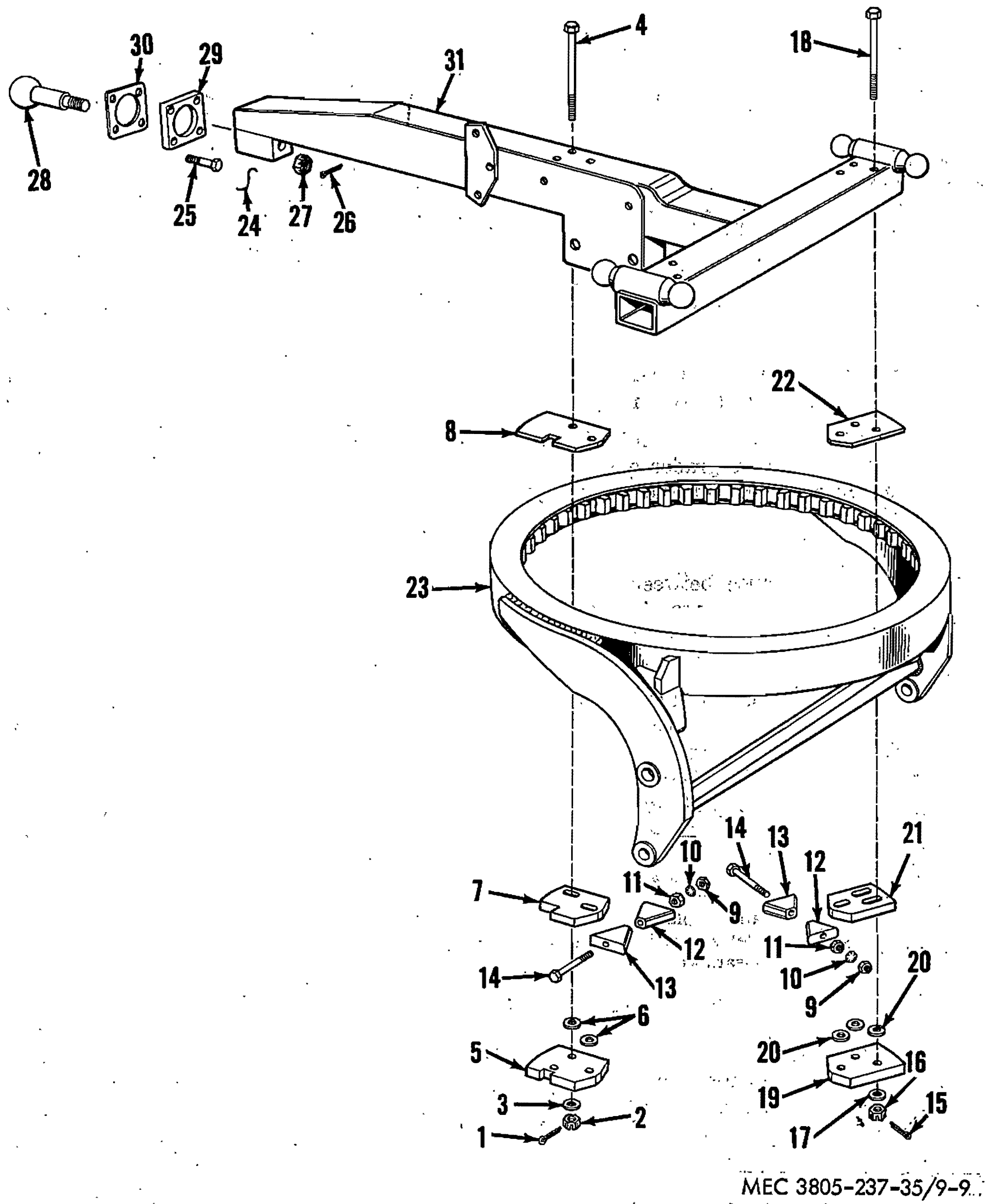



*Figure 9-9. Drawbar and moldboard circle, exploded view.*

1 Pin, cotter, 5/32 × 1 1/2 in. (3)
2 Nut, slotted, special (3)
3 Washer, flat 7/8 in. (3)
4 Screw, cap, hex-head, drilled (3)
5 Retaining plate
6 Shim
7 Adjusting plate
8 Wear plate
9 Nut, jam, 5/8-11 (3)
10 Washer, lock, 5/8 in. (3)
11 Nut, 5/8-11 (3)
12 Wedge (3)
13 Wedge (3)
14 Screw, cap, hex-head, 5/8-11 × 4 in. (3)
15 Pin, cotter, 5/32 × 1 1/2 in. (6)
16 Nut, slotted, special (6)
17 Washer, flat, 7/8 in. (6)
18 Screw, cap, hex-head, drilled (6)
19 Retaining plate (2)
20 Shim
21 Adjusting plate (2)
22 Wear plate (2)
23 Moldboard circle
24 Lock wire (2)
25 Screw, cap, hex-head, drilled (4)
26 Pin, cotter, 5/16 × 2 1/2 in.
27 Nut, slotted, 1 1/2-12
28 Drawbar ball
29 Drawball bearing cap
30 Shims
31 Drawbar

*Figure 9-9*—Continued.

the use of the shims. Clearance must be maintained between the upper or wear plate and the top of the moldboard circle flange.

(1) Refer to TM 5-3805-237-12 to operate the motor grader and raise the moldboard clear of the ground with the moldboard circle in a horizontal position.

(2) Check clearance between wear plate and top of the flange. Vertical clearance should be 1/16 inch at all three points.

(3) If clearance is not 1/16 inch, lower moldboard to the ground and remove retaining plate (fig. 9-7). Add or remove shims between lower or retaining plate and adjusting plate to provide required clearance.

*Note.* When it is impossible to achieve this clearance by removing shims, reverse position of retaining plate (plate unworn side against circle) and add shims as necessary to provide clearance.

(4) Install plates (fig. 9-7) and adjust for horizontal clearance. This can be adjusted with the wedges (fig. 9-7). In adjusting for horizontal clearance, the mesh of the ring gear with the drive gear must be also adjusted.

(5) Set the adjusting plates (fig. 9-7) at all three points so the circle can be rotated.

(6) Note point at which drive gear meshes deepest with ring gear. Loosen jamnut (fig. 9-7) on front and left adjusting plates. Move wedges with adjusting nut until adjusting plates contact the circle. Check clearance between drive gear tooth and ring gear. Minimum clearance is 3/16 inch between the top of the drive gear tooth and the bottom of the tooth in the ring gear.

(7) Use a 3/16 inch rod with two right angle bends. Place one end of rod at top of teeth and other end at bottom. Adjust plates by moving wedges to obtain this clearance (fig. 9-11).

(8) Check clearance between ring gear teeth and left side of circle reverse gear assembly (fig. 9-11). This clearance must be at least 1/8 inch.

(9) This adjustment is accomplished with the two rear adjusting plates. Loosen the wedges on the right rear block. Tighten wedges on left rear block to push circle out. Check adjustment and tighten wedge jam nuts.

(10) Check clearance between top or drive gear tooth and bottom of ring gear tooth. If adjustment has changed, adjust with front and left plates as in (6) above to get this clearance.

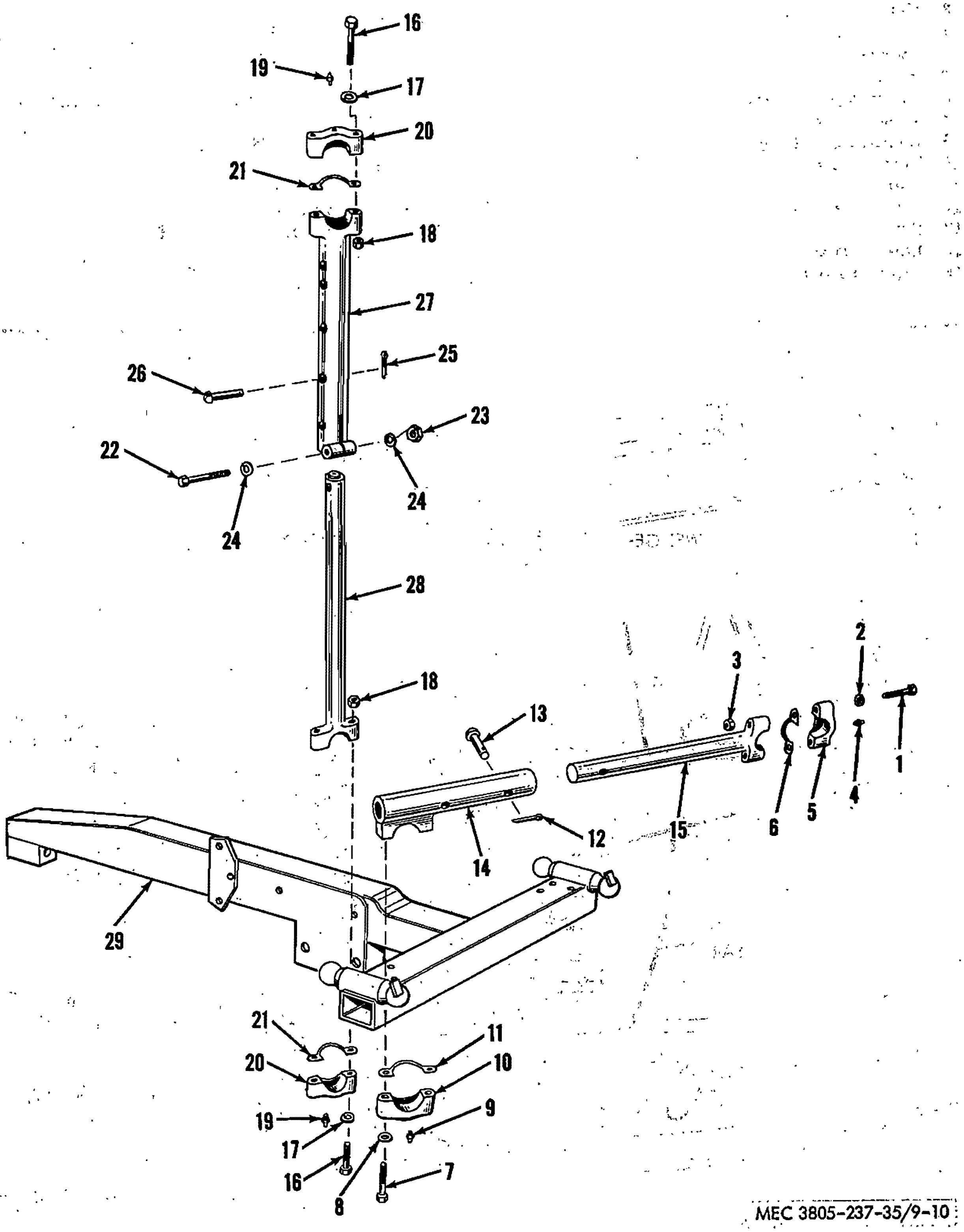



*Figure 9-10. Moldboard lift and shift links, exploded view.*

1 Screw, cap, hex-head, 3/4-10 × 3 1/4 (2)
2 Washer, lock, 3/4 in. (4)
3 Nut, 3/4-10 (2)
4 Lubricating fitting
5 Bearing cap
6 Shim
7 Screw, cap, hex-head (2)
8 Washer, lock, 5/8 in. (2)
9 Lubricating fitting
10 Bearing cap
11 Shim
12 Pin, cotter, 1/8 × 1 1/2 in.
13 Pin
14 Lateral tube
15 Adjusting link
16 Screw, cap, hex-head, 3/4-10 × 3 1/4 (8)
17 Washer, lock, 3/4 in. (16)
18 Nut, 3/4-10 (8)
19 Lubricating fitting (4)
20 Bearing cap (4)
21 Shim
22 Screw, cap, hex-head, 5/8-11 × 4 in. (2)
23 Nut, 5/8-11 (2)
24 Washer, lock, 5/8 in. (4)
25 Pin, cotter, 1/8 × 1 1/2 in. (2)
26 Pin
27 Adjusting tube
28 Adjusting link (RH and LH)
29 Drawbar

*Figure 9-10*—Continued.

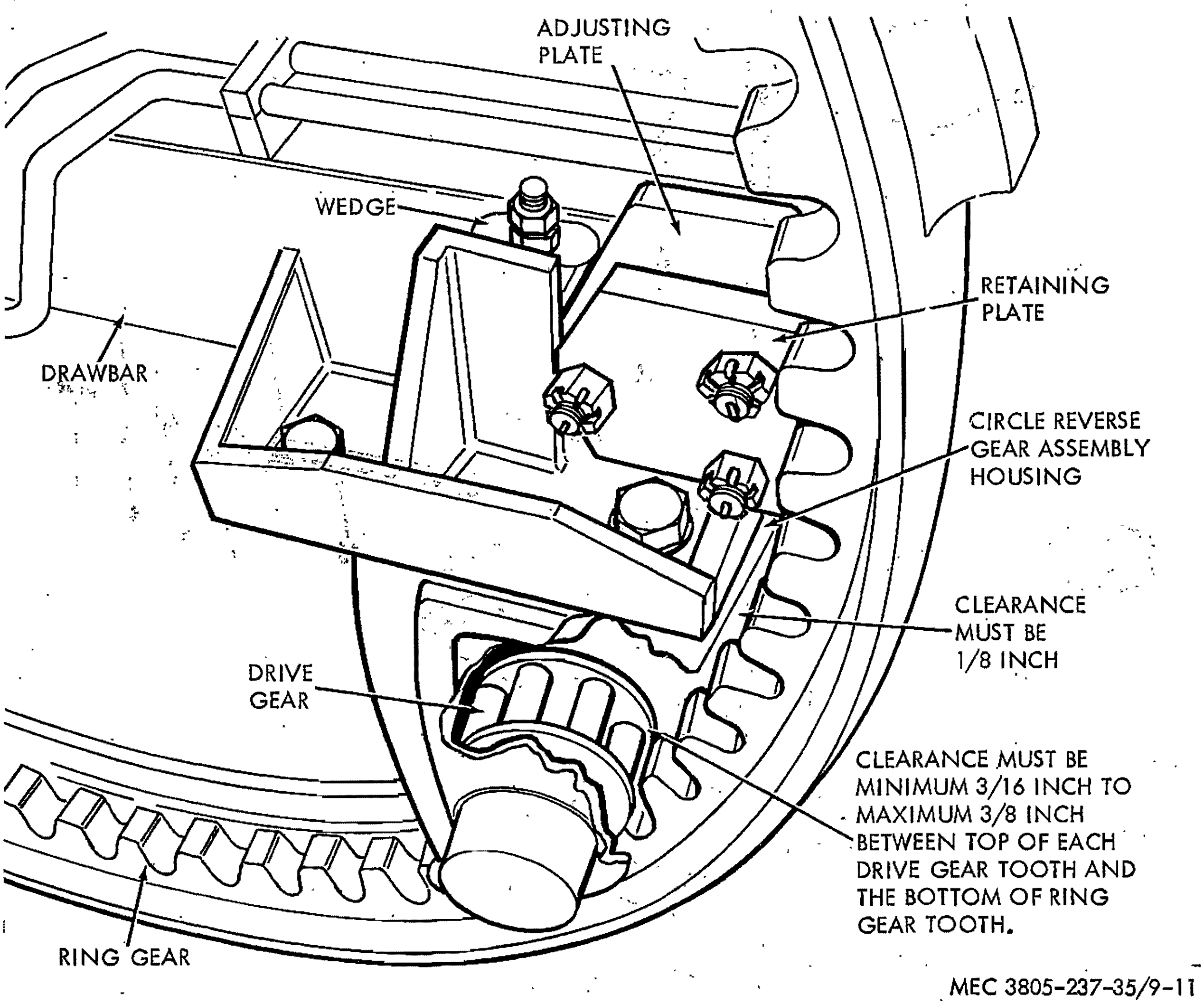



*Figure 9-11. Adjusting moldboard circle gears.*

*Caution:* **The clearance between the top of the drive gear tooth and the bottom of the ring gear tooth must be 3/16 inch minimum to 3/8 inch maximum. Do not operate moldboard circle under load when clearance is more than 3/8 inch. Damage to circle reverse gear assembly could result.**

(11) Tighten all wedge nuts and plate mounting nuts securely.

## Section IV. SCARIFIER

### 9-7. General

*a.* The scarifier teeth are mounted in the scarifier block. The teeth provide the working portion of the scarifier. Because of the nature of the work performed in scarifying operations the teeth are replaceable.

*b.* The scarifier block is mounted on two drawbars which are pinned to the grader frame. A series of holes in the block allow adjustment of the scarifier angle to adjust depth and degree of cut during operation. Two balls, attached to the drawbar, are connected to the scarifier lift links. The two links, in turn are connected to the two lift arms of the scarifier gear assembly.

### 9-9. Scarifier and Lift Links

*a. Removal.* Remove the scarifier and lift links in the numerical sequence as illustrated on figure 9-12.

*b. Cleaning.* Clean dirt and debris from scarifier parts with water.

*c. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect bolts and pins for damaged threads, binding, and mutilation.

(3) Inspect bearing caps and scarifier ball for evidence of wear and scoring.

(4) Replace all worn, damaged, or mutilated parts.

*d. Installation.*

(1) Install scarifier and lift links in reverse of the numerical sequence as illustrated on figure 9-12.

(2) Torque nuts on scarifier lift balls to 1,500 foot pounds.

(3) Install lift link bearing caps with proper amount of shims to allow links to move freely without binding.

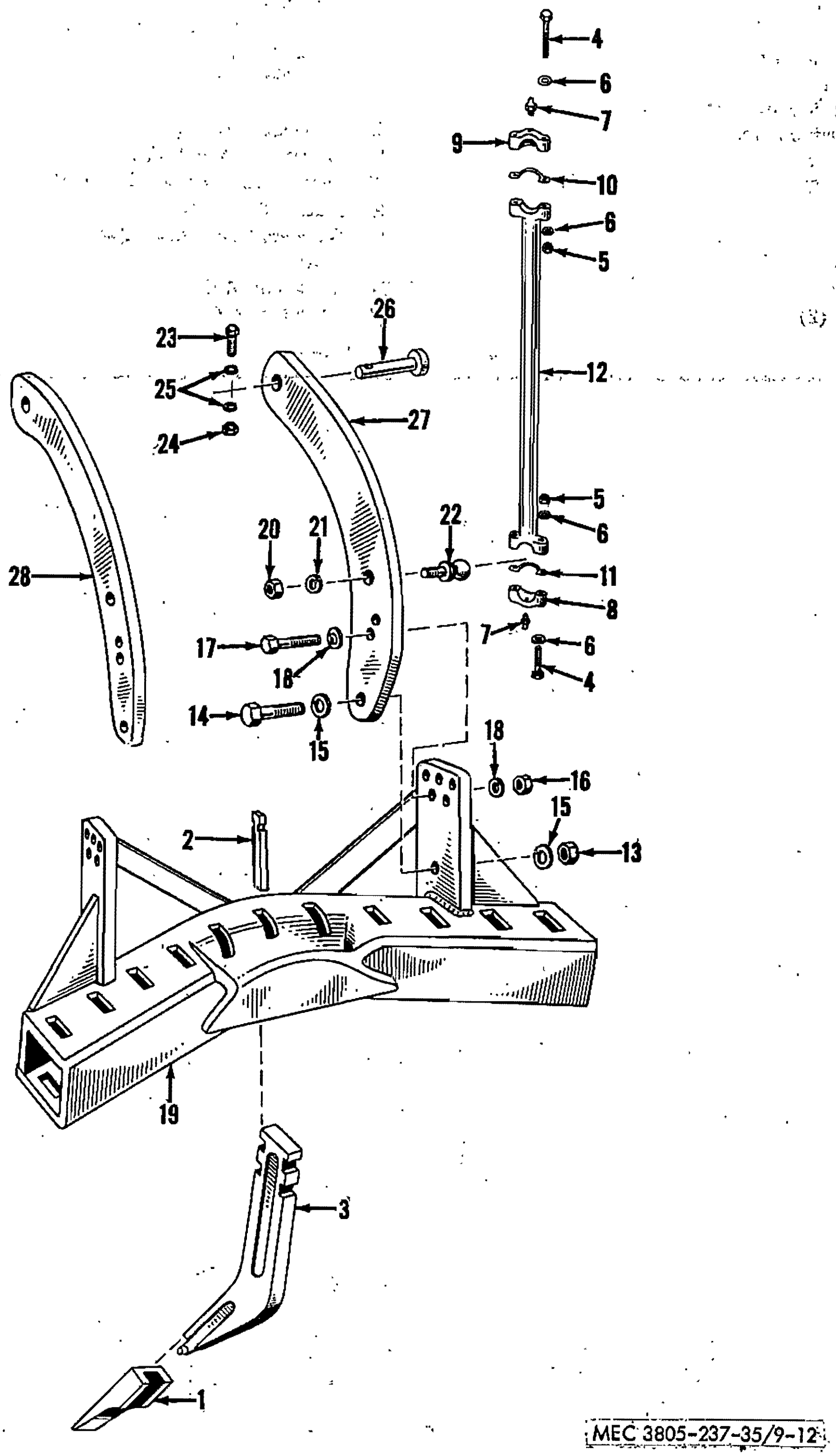



*Figure 9–12. Scarifier block and lift links, exploded view.*

1 Scarifier tooth (11)
2 Lock wedge (11)
3 Shank (11)
4 Screw, cap, hex-head, 5/8-11 × 2 3/4 in. (8)
5 Nut, 5/8-11 (8)
6 Washer, lock, 5/8 in. (16)
7 Lubrication fitting (4)
8 Bearing cap (2)
9 Bearing cap (2)
10 Shim
11 Shim
12 Lift link (2)
13 Nut, 1 1/4 (2)
14 Bolt, special (2)
15 Washer, lock (2)
16 Nut, 1 1/8 (2)
17 Bolt, special (2)
18 Washer, lock (2)
19 Scarifier block
20 Nut, 1 1/2 (2)
21 Washer, lock (2)
22 Scarifier lift ball (2)
23 Screw, cap, hex-head, 5/8-11 × 4 1/4 in. (2)
24 Nut, 5/8-11 (2)
25 Washer, lock, 5/8 in. (4)
26 Drawbar pin
27 Drawbar, RH
28 Drawbar, LH

*Figure 9-12*—Continued.

# CHAPTER 10

# CLUTCH ASSEMBLY AND SHAFTS REPAIR INSTRUCTIONS

## Section I. GENERAL

### 10-1. Description

*a.* The clutch assembly is connected to the engine flywheel. A clutch housing encloses the clutch brake and clutch and provides a support for the clutch shaft and linkage. The clutch assembly is a 16 inch, single disk, spring-loaded type.

*b.* Depressing the clutch pedal will operate the clutch linkage, disengage the clutch, and apply the clutch brake. The brake is designed to stop operation of the transmission and allow smoother shifting operations and less clashing of the gears.

### 10-2. Shafts

*a.* A propeller shaft, connected directly to the flywheel leads through the hollow transmission drive shaft, through the transmission shaft to the shear bolt coupling. From the coupling the shaft is connected to the power control box vertical drive housing. This shaft provides power to the power control box vertical drive housing and the power control box whenever the engine is operating.

*b.* The transmission drive shaft is connected by universal joints to the clutch shaft and upper transmission shaft.

## Section II. SHAFTS

### 10-3. Power Control Box Propeller Shaft

*a. Removal.*

(1) Refer to paragraph 2-38 and remove the power control box and vertical drive housing from the motor grader.

(2) Refer to figure 10-1 and remove the propeller shaft from the motor grader.

*b. Disassembly.* Disassemble the propeller shaft and bearing retainer in the numerical sequence as illustrated on figure 10-2.

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect splines on yoke and couplings for damaged or broken splines. Inspect couplings in vicinity of shear bolt for chacks and damage.

(3) Inspect universal joint bearings and journals for damage.

(4) Inspect splines and threads on long shaft for damage.

(5) Replace all worn or damaged parts.

*e. Reassembly.* Reassemble the propeller shaft as far as necessary in the reverse of the numerical sequence as illustrated on figure 10-2.

*f. Installation.*

(1) Refer to figure 10-1 and install the propeller shaft and bearing retainer. Long shaft must extend through transmission and clutch shaft and engage splines in coupling (41, fig. 10-2) mounted on flywheel.

*Note.* After installing bearing retainer and shaft, use a lead hammer and tap end of shaft sharply to seat splines in coupling.

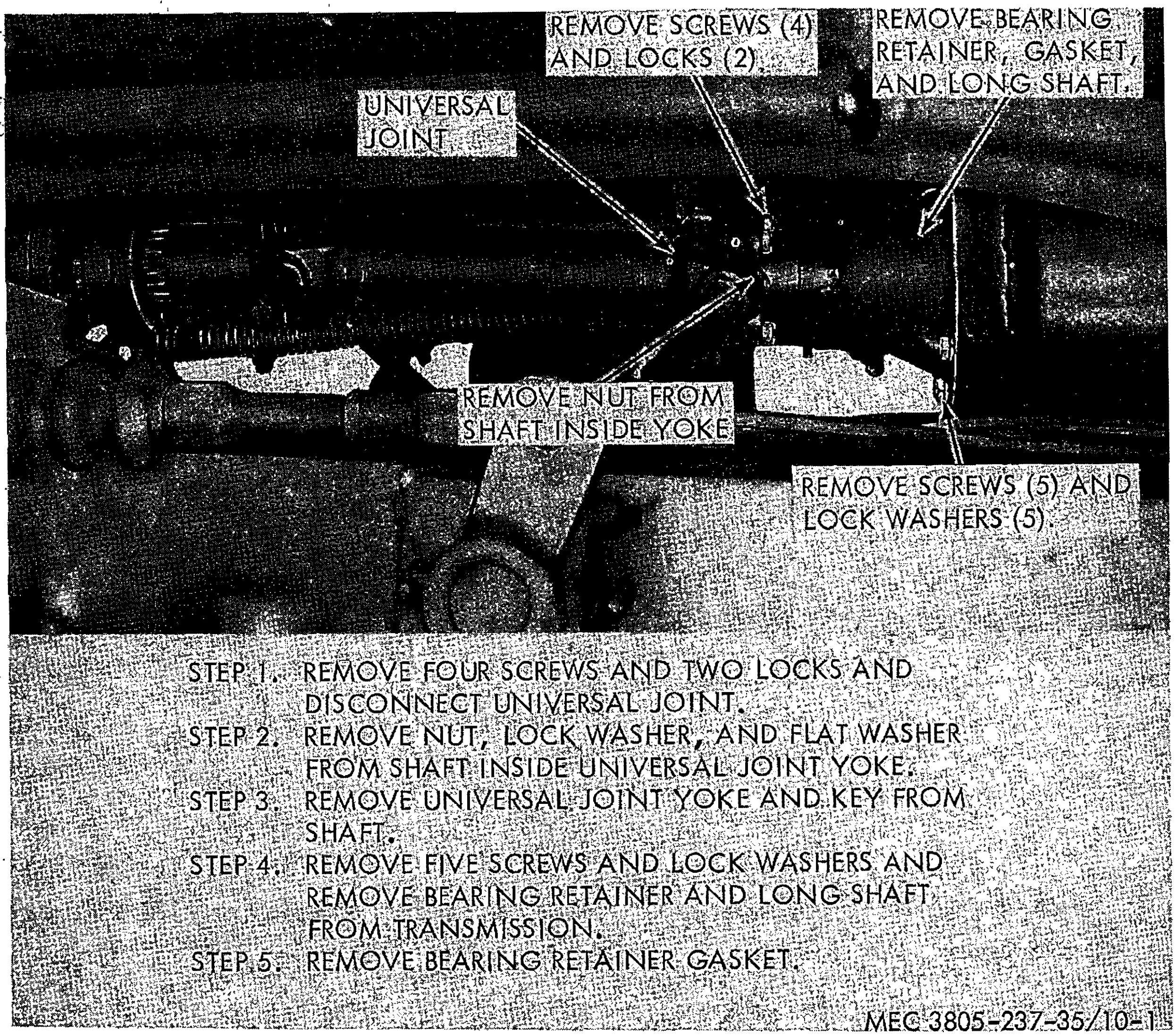



*Figure 10-1. Power control box propeller shaft, removal and installation.*

(2) Refer to paragraph 238 and install the power control box and vertical drive housing on the motor grader.

## 10-4. Transmission Drive Shaft

*a. Removal.*

(1) Refer to paragraph 2-31 and remove the engine and clutch from the motor grader.

(2) Refer to figure 2-9 and remove the universal joint from the clutch shaft.

(3) Remove and disassemble the remainder of the drive shaft in the numerical sequence as illustrated on figure 10-3.

*b. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*c. Inspection and Repair.*

(1) Inspect universal joints for damage and proper operation.

(2) Inspect splined yokes for damage to splines and connecting members.

(3) Inspect faces of transmission and clutch shafts for damage.

(4) Replace all worn or damaged parts.

*d. Installation.*

(1) Assemble and install the transmission drive shaft on the transmission in reverse of the numerical sequence as illustrated on figure 10-3.

(2) Refer to figure 2-9 and install the universal joint on the clutch shaft.

(3) Refer to paragraph 2-31 and install the engine and clutch in the motor grader.

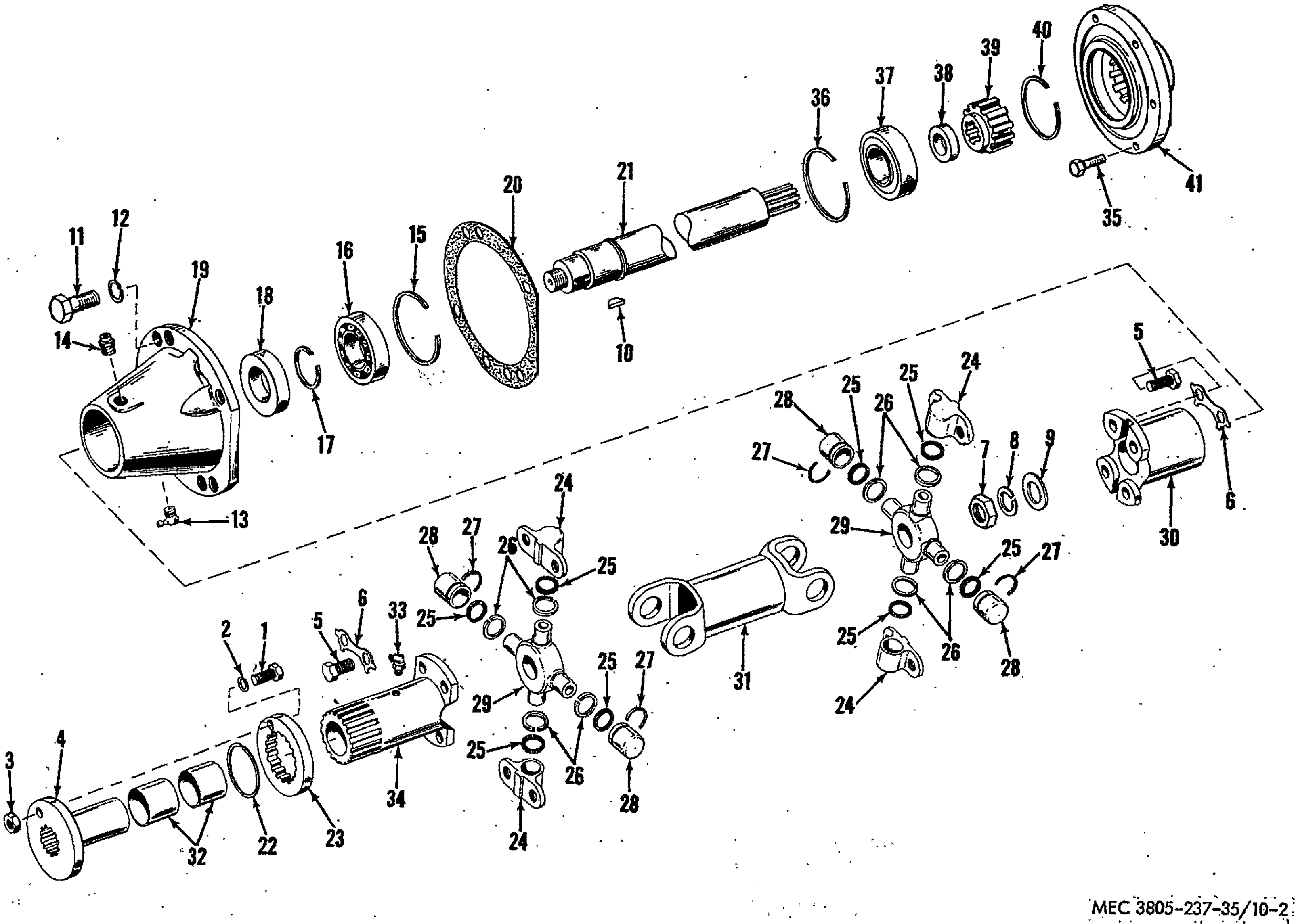
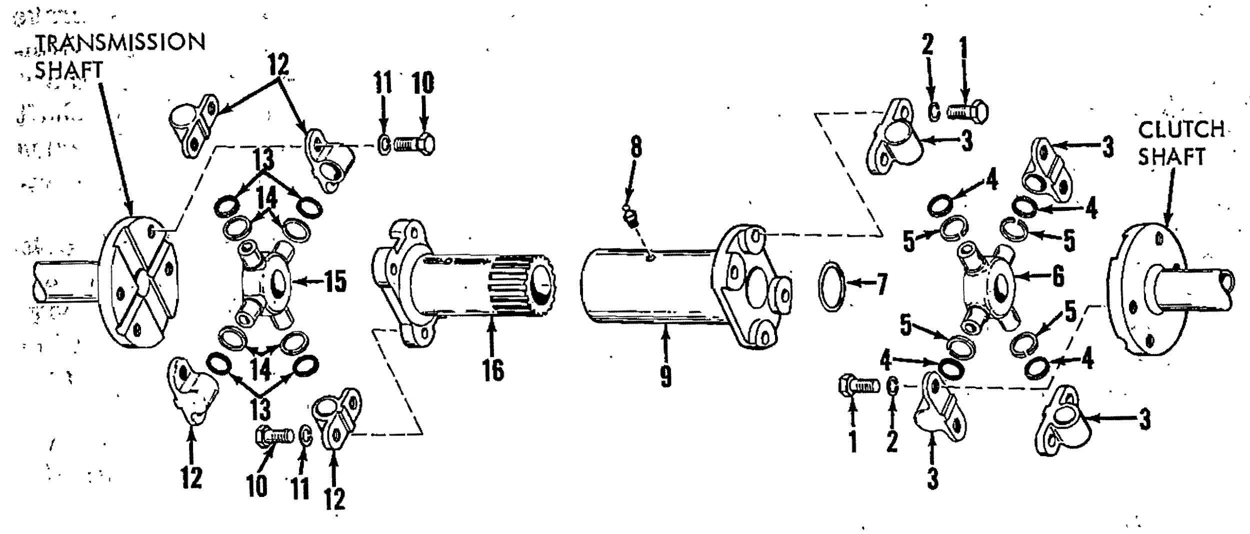



*Figure 10-2. Propeller shaft and bearing retainer, exploded view.*

1 Shear bolt
2 Washer, lock, 3/16 in.
3 Nut, 3/16–18
4 Coupling, w/shaft
5 Screw, cap, hex-head (8)
6 Lock plate (4)
7 Nut, shaft
8 Washer, lock
9 Washer, flat
10 Key, woodruff
11 Screw, cap, hex-head, 3/8–16 × 2 in. (5)
12 Washer, lock, 3/8 in. (5)
13 Lubrication fitting
14 Relief fitting
15 Retaining ring
16 ST87 bearing
17 Retaining ring
18 Oil seal
19 Bearing retainer
20 Retainer gasket
21 Long drive shaft
22 Retaining ring
23 Coupling flange
24 Cap bearing (4)
25 Washer, cork (8)
26 Dust shield (8)
27 Retaining ring (4)
28 Bearing (4)
29 Journal (2)
30 Universal yoke
31 Tube, w/yokes
32 Bushing (2)
33 Lubrication fitting
34 Yoke, w/splines
35 Screw, cap, hex-head, 3/8–16 × 1 3/4 in. (6)
36 Retaining ring
37 Ball bearing
38 Felt washer
39 Universal coupling
40 Retaining ring
41 Coupling (on flywheel)

*Figure 10–2*—Continued.




1 Screw, cap hex-head (8)
2 Washer, lock (8)
3 Cap, bearing (4)
4 Washer, cork (4)
5 Dust shield (4)
6 Journal
7 Oil ring
8 Lubrication fitting
9 Universal yoke
10 Screw, cap, hex-head (8)
11 Washer, lock (8)
12 Cap, bearing (4)
13 Washer, cork (4)
14 Dust shield (4)
15 Journal
16 Yoke, w/splined stub

*Figure 10-3. Transmission drive shaft, exploded view.*

## Section III. CLUTCH LINKAGE AND BRAKE HOUSING

### 10-5. Clutch Linkage

*a. Removal.*

(1) Remove the clutch linkage in the numerical sequence as illustrated on figure 10-4.

(2) Refer to paragraph 8-7 to remove brake linkage and remove brake lever (47, fig. 10-4) from brake shaft.

*b. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*c. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect ball joints for wear and out of round condition. Check ball joints and swivel for proper operation.

(3) Inspect springs for weak or broken condition.

(4) Replace all worn, damaged, or defective parts.

*d. Installation.*

(1) Install bushings (52, fig. 10-4) in clutch lever (53) and refer to paragraph 8-7 to install clutch lever on brake shaft.

(2) Install clutch and clutch brake linkage in the reverse of the numerical sequence as illustrated on figure 10-4.

### 10-6. Clutch Brake and Clutch Housing

*a. Removal.*

(1) Refer to paragraph 10-5 and disconnect the clutch linkage from the clutch shaft.

(2) Refer to paragraph 2-32 and remove the clutch housing and brake from the clutch assembly and engine.

*b. Disassembly.* Disassemble the clutch brake and housing in the numerical sequence as illustrated on figure 10-5.

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-662) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect brake lining for wear and damage. Inspect brake drum for wear and scoring. Repair drum if possible by grinding braking surface. Replace shoes when lining is worn to within 1/32 to 1/16 inch of the closest rivet head.

(3) Inspect splines, mating surfaces, and threads of clutch shaft for wear and damage.

(4) Inspect release sleeve and bearing for serviceability. Inspect sliding surface of sleeve support for scratches, dents, and scoring.

(5) Replace all worn or damaged parts.

*e. Reassembly.* Reassemble the clutch brake and housing in reverse of the numerical sequence as illustrated on figure 10-5 and the following instructions.

*Note.* Do not install inspection plate (48) on clutch housing until after housing is installed on engine.

(1) Press oil seal (44) in brake housing (45) with lip of seal toward ball bearing (43).

(2) Install bearing and retaining ring (42) in housing and press oil seal (41) in housing with lip of seal toward ball bearing.

(3) Install clutch shaft (40) in brake housing, with lips of oil seals firmly seated against shoulders on shaft.

(4) Install brake drum (39) on shaft with short spline in drum in wide slot on shaft. Tap drum until firmly seated.

(5) Install tab washer (38) on shaft with tabs pointing away from brake drum. Install round nut (37) on shaft with taper of nut toward washer. Tighten nut securely and bend tabs on washer into slots on nut.

(6) After assembling brake housing, adjust cam lock as shown on figure 10-6.

(7) When installing clutch operating shaft (15) through shifter fork (16) check position of slots in shifter forks. Slot angle must be toward release sleeve.

(8) Tighten all mounting screws securely.

*f. Installation.*

(1) Refer to paragraph 2-32 and install the clutch housing and brake on the engine.

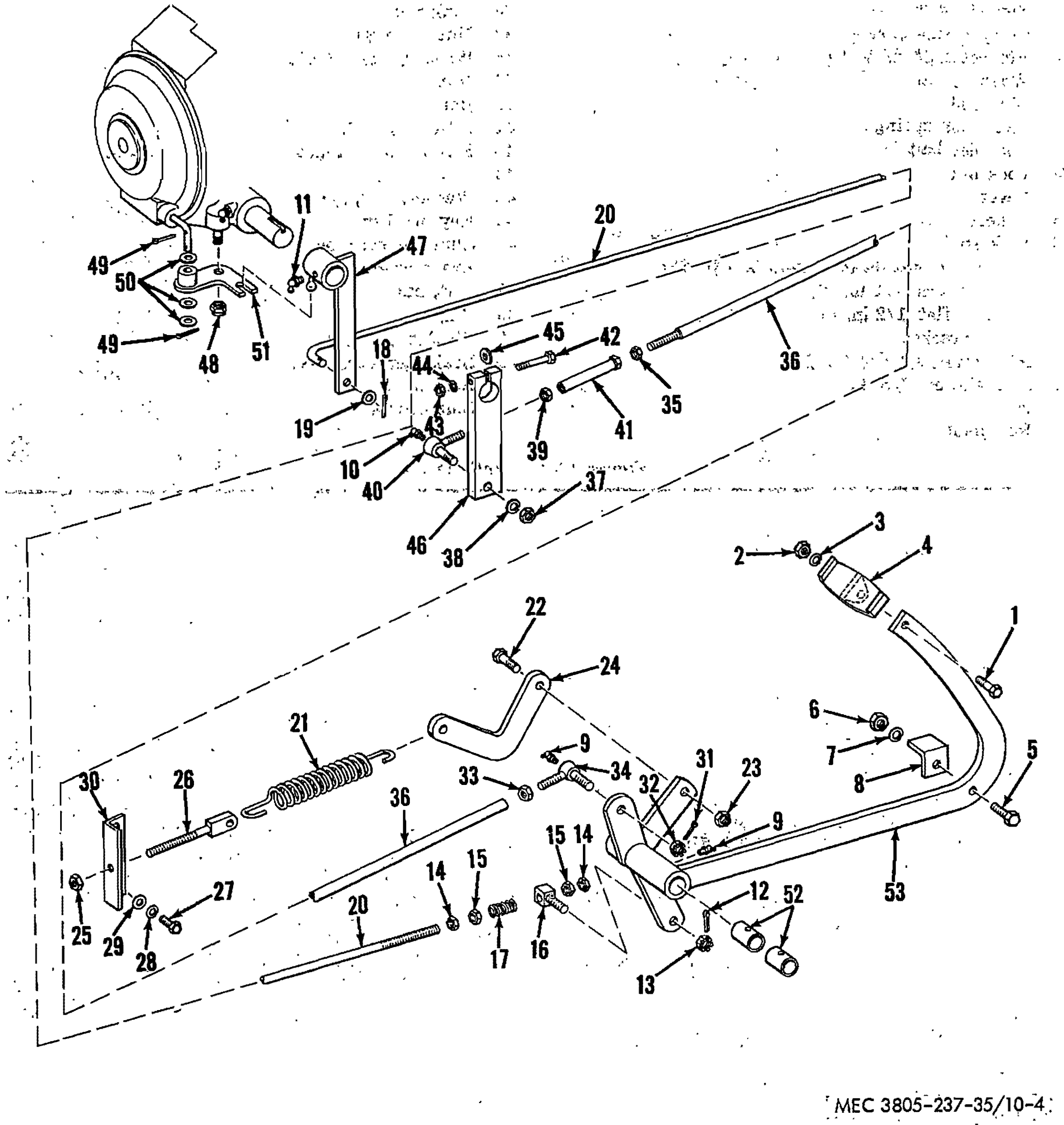
(2) When installing clutch housing, be sure splines on clutch shaft engage splines in clutch plate.

(3) Check clutch levers for uniform pressure against release sleeve.

(4) Rotate clutch operating shaft by hand to check that all parts operate freely through their full range of travel.

(5) Install inspection plate (48, fig. 10-5) and secure with six screws (46) and lockwashers (47).

(6) Refer to paragraph 10-5 and attach clutch linkage to clutch operating shaft.

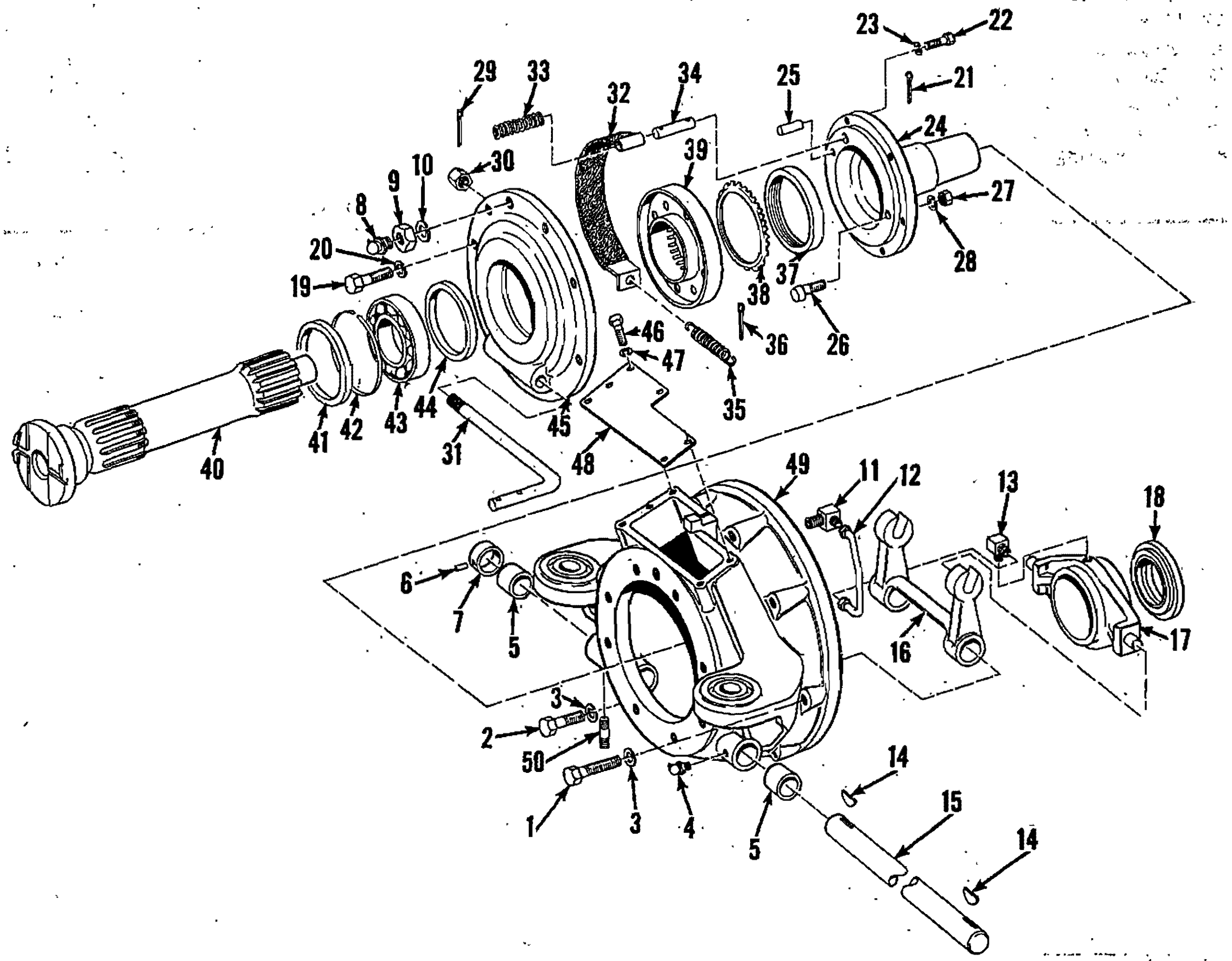



1 Screw, cap, hex-head, 3/8-16 × 1 1/8 in.
2 Nut, 3/8-16
3 Washer, lock, 3/8 in.
4 Pedal pad
5 Screw, cap, hex-head, 5/16-18 × 1 3/8 in.
6 Nut, 5/16-18
7 Washer, lock, 5/16 in.
8 Bracket
9 Lubrication fitting (4)
10 Lubrication fitting
11 Lubrication fitting
12 Pin, cotter, 3/32 × 1 1/4 in.
13 Nut, slotted, 1/2-20
14 Nut, jam, 1/2-20 (2)

*Figure 10-4. Clutch and clutch brake linkage, exploded view.*

15 Nut, 1/2-20 (2)
16 Swivel
17 Compression spring
18 Pin, cotter, 3/32 × 1 in.
19 Washer, flat
20 Link rod
21 Extension spring
22 Shoulder bolt
23 Lock nut
24 Lever
25 Tapered nut
26 Link stud
27 Screw, cap, hex-head, 1/2-13 × 1 in. (2)
28 Washer, lock, 1/2 in. (2)
29 Washer, flat, 1/2 in. (2)
30 Angle bracket
31 Pin, cotter, 3/32 × 1 1/2 in.
32 Nut, slotted, 7/8-14
33 Nut
34 Ball joint
35 Nut, jam, 1-14
36 Link rod
37 Nut, 7/16-20
38 Washer, lock, 7/16 in.
39 Nut
40 Ball joint
41 Adjusting link
42 Screw, cap, hex-head, 3/8-16 × 2 3/4 in.
43 Nut, 3/8-16
44 Washer, lock, 3/8 in.
45 Key, washer
46 Clutch release lever
47 Brake lever
48 Lock nut
49 Pin, cotter
50 Washer, flat (3)
51 Brake actuating lever
52 Bushing (2)
53 Clutch lever

*Figure 10-4*—Continued.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 7/16-14 × 2 1/2 in. | 19 | Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (8) |
| 2 | Screw, cap, hex-head, 7/16-14 | 20 | Washer, lock, 1/2 in. (8) |
| 3 | Washer, lock, 7/16 in. (12) | 21 | Pin, cotter, 1/8 × 1 in. (2) |
| 4 | Lubrication fitting (2) | 22 | Screw, cap, hex-head, 3/8-16 × 1 1/8 in. (6) |
| 5 | Bushing (2) | 23 | Washer, lock, 3/8 in. (6) |
| 6 | Pin | 24 | Sleeve support |
| 7 | Shaft collar | 25 | Dowel pin |
| 8 | Lubrication fitting | 26 | Cam lock |
| 9 | Nut, 5/8-11 | 27 | Nut, 1/2-20 |
| 10 | Washer, lock, 5/8 in. | 28 | Washer, lock, 1/2 in. |
| 11 | Fitting | 29 | Pin, cotter, 1/8 × 1 in. |
| 12 | Lubrication tube | 30 | Nut |
| 13 | Elbow | 31 | Brake pull rod |
| 14 | Key, woodruff (2) | 32 | Brake band |
| 15 | Clutch operating shaft | 33 | Spring |
| 16 | Shifter fork | 34 | Pivot pin |
| 17 | Release sleeve | 35 | Return spring |
| 18 | Release bearing | 36 | Pin, cotter, 1/8 × 1 in. |

*Figure 10-5. Clutch brake and clutch housing assembly, exploded view.*

37 Round nut
38 Tab washer
39 Brake drum
40 Clutch shaft
41 Oil seal
42 Retaining ring
43 Ball bearing
44 Oil seal
45 Brake housing
46 Screw, cap, hex-head, 5/16-18 × 3/4 in. (6)
47 Washer, lock, 5/16 in. (6)
48 Inspection plate
49 Clutch housing
50 Stud

*Figure 10-5*—Continued.

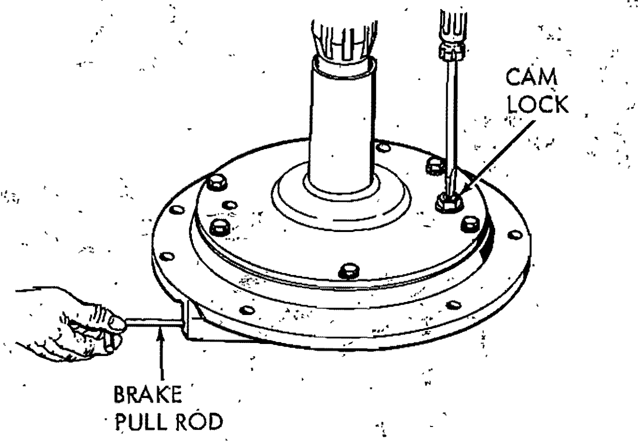



*Figure 10-6. Adjusting cam lock.*

## Section IV. CLUTCH ASSEMBLY

### 10-7. General

*a.* The clutch assembly provides the connection between the engine and the motor grader drive train. The 16 inch dry plate clutch is mounted directly to the engine flywheel and is inclosed by the clutch brake housing.

*b.* A driven member, with clutch facings on both sides, is mounted between the pressure plate and the flywheel. The clutch shaft is splined to the driven member. A pressure plate supported by the backing plate, is under pressure of 24 springs. As the backing plate is secured to the flywheel, the pressure plate is rotating whenever the engine is running. The springs maintain contact between the pressure plate and driven member at all times. Depressing the clutch pedal actuates a linkage and forces the release sleeve against the clutch levers. As the levers pivot they force the pressure plate back against the spring pressure and move it out of contact with the driven member. This halts transmission operation, enabling the operator to shift the transmission gears.

## 10-8. Clutch Assembly

*a. Removal.*

(1) Refer to paragraph 10-5 and disconnect clutch linkage from clutch operating shaft.

(2) Refer to paragraph 2-32 and remove the clutch housing and clutch assembly from the engine.

*Note.* Refer to paragraph 10-3 for illustration and repair of coupling illustrated on figure 2-10.

*b. Disassembly.* Disassemble clutch assembly in numerical sequence as shown on figure 10-7.

*c. Cleaning.* Clean all metal parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

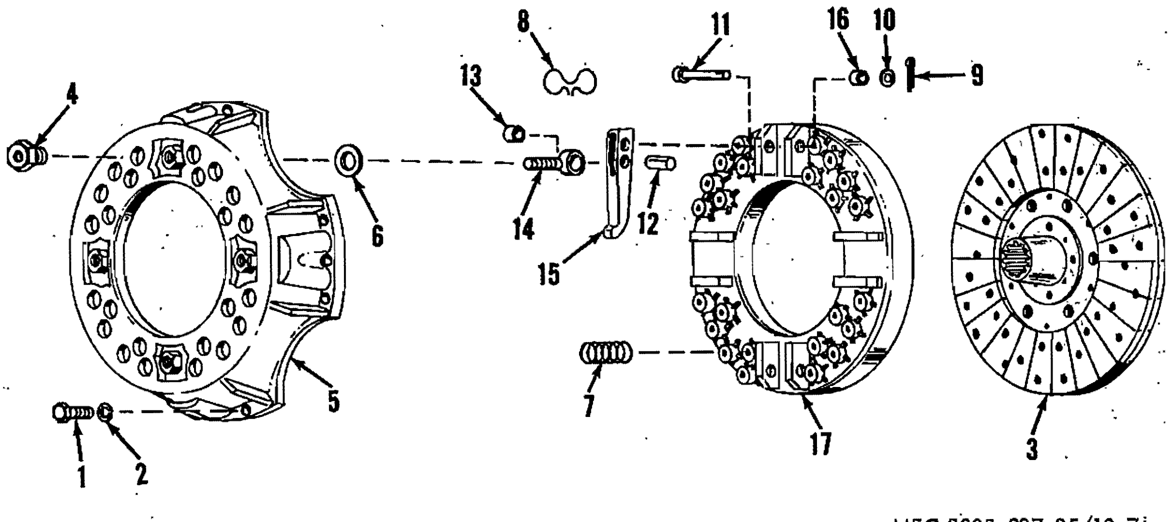
(2) Inspect clutch springs for weak or broken condition. Free length of springs should be 3 5/16 inches. Spring pressure at 2 1/8 inches should be 130 to 140 pounds.

(3) Inspect pressure plate for cracks, scores, or any signs of warping. Face of plate must be in good serviceable condition.

(4) Inspect face of drive member for heat cracks, scoring, wear and distortion. Inspect splines in hub for chipped or broken splines.

(5) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(6) Replace all worn, damaged, or unserviceable parts.




1 Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (8)
2 Washer, lock, 1/2 in. (8)
3 Driven member
4 Adjusting nut (4)
5 Backing plate
6 Washer (4)
7 Pressure spring (includes insulator and cup) (24)
8 Anti-rattle spring (4)
9 Pin, cotter (4)
10 Washer, flat (4)
11 Lever pin (4)
12 Pivot pin (4)
13 Needle bearing (4)
14 Eye bolt (4)
15 Clutch lever (4)
16 Clutch bearing (8)
17 Pressure plate

*Figure 10-7. Clutch assembly, exploded view.*

*e. Reassembly.* Reassemble clutch in the reverse of the numerical sequence as shown on figure 10-7 and the following instructions.

(1) Lubricate pins, bearings, and levers before installing.

(2) Install lever pin (11) with head against thrust of pressure plate.

(3) After installing levers (15) on pressure plate, install anti-rattle springs (8) with the prongs on springs toward long end of levers.

(4) Install washer (6) on adjusting nut (4) with cup of washer away from back plate.

(5) Install backing plate on pressure plate over the 24 springs. Install four hold down setscrews (3/8-16 × 4 inches), 3/8-16 jamnuts, and flat washers into tapped holes (fig. 10-8) in inner spring circle.

(6) Tighten setscrews to draw pressure plate up until lever eye bolts meet adjusting nuts. Tighten adjusting nuts on eye bolts until levers raise to backing plate.

(7) Place clutch assembly on a flat surface with the backing plate up. Tighten setscrews until distance from flat surface to face of pressure plate measures 15/32 inches as illustrated on figure 10-9.

(8) Rotate lever adjusting nuts, as required, to raise or lower levers until face of levers are 2 11/16 from the flat surface as illustrated on figure 10-9.

*Note.* Do not remove hold down setscrews until after clutch assembly has been installed on flywheel.

*g. Installation.*

(1) Refer to paragraph 2-32 and install clutch assembly and clutch brake housing on engine and engine in motor grader.

(2) Refer to paragraph 10-5 and attach clutch linkage to clutch operating shaft.

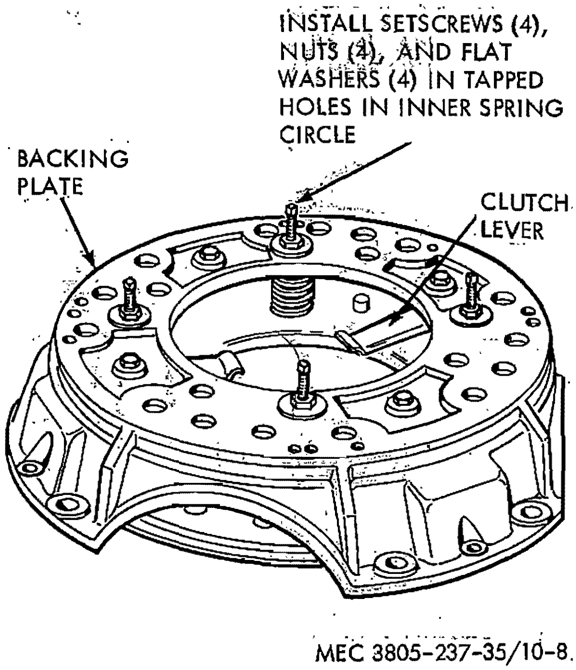



*Figure 10-8. Setscrews installed in clutch assembly.*

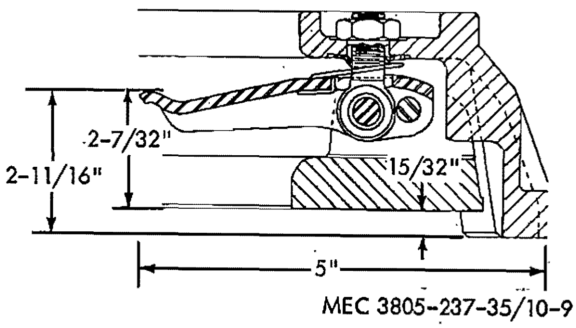



*Figure 10-9. Clutch pressure plate and lever adjustment.*

# CHAPTER 11

# ENGINE ACCESSORY REPAIR INSTRUCTIONS

## Section I. STARTER

### 11-1. General

*a.* The motor grader engine is equipped with an electrical starter, a direct current generator, and a voltage regulator. Other engine accessories such as the water pump, fuel pump, filters, and blower will be covered in their appropriate sections of the engine repair instructions.

*b.* The starter is a solenoid operated, 24 volt, overrunning-sprag clutch type with a fully enclosed shift lever and plunger. When the starter button is depressed the solenoid is energized and the plunger shifts the starter drive into engagement with the flywheel ring gear and closes contacts to complete the circuit to the starter motor.

*c.* Once the clutch is engaged, the clutch will not disengage during intermittent engine firing, preventing damage to the starter gear and ring gear. When the engine starts the clutch of the starter drive allows the starter gear to rotate faster than the starter armature, preventing damage to the starter from overrunning.

*d.* When the starter button is released, a return spring moves the plunger to open the contacts and move the shift lever, disengaging the gears.

*e.* The starter armature is supported at three points by bronze bearings which are lubricated by oil wicks.

### 11-2. Starter

*a. Removal.* Refer to TM 5-3805-237-12 and remove the starter from the engine.

*b. Testing.* When a starter is tested, check for unusual noises or vibration that might indicate an unserviceable condition. If either condition exists, do not attempt any further testing until starter has been repaired.

(1) *No load test.*

(*a*) Connect the starter in a test stand as illustrated on figure 11-1.

(*b*) Energize the solenoid by connecting the jumper lead from the solenoid battery terminal to the solenoid switch terminal. Check rotation speed. Adjust the variable resistance to obtain 22.0 volts. The minimum speed should be 7,000 rpm (revolutions per minute). Check the current draw on the ammeter. Maximum current draw should be 90 amperes.

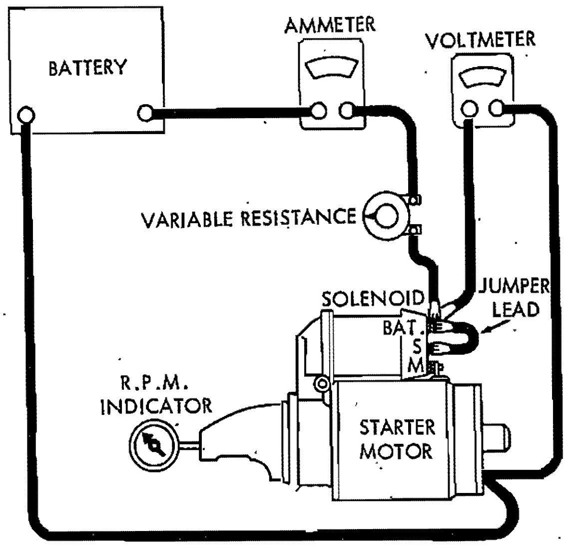



*Figure 11-1. No-load test hook up.*

*Caution:* **When testing starter never operate the starter more than 30 seconds at a time. Allow the starter to cool off at least 2 minutes between cycles. Overheating, caused by excessive cranking, can seriously damage the starter.**

(*c*) If the above conditions are not met, disassemble and repair the starter.

(2) *Lock torque test.*

(*a*) Connect the starter in a test stand as illustrated in figure 11-2. The starter should be securely mounted and a brake arm hooked to the starter gear.

*Caution:* **During test, make certain end of brake arm does not slip off gear when current is applied.**

(*b*) Lock torque test is 32 foot pounds at 500 ampers at approximately 3.0 volts.

(*c*) If the above conditions are not met, disassemble and repair the starter.

(3) *Waterproof test.*

(*a*) Connect an air line to the frame of the starter. Remove a plug and a wick, install a fitting, and connect to an air hose.

(*b*) Submerge the starter in clean water up to the gear housing and clutch assembly area. Do not allow water to enter the gear housing or clutch area.

(*c*) Apply air pressure slowly. Watch for air bubbles. Increase the air pressure to 6 psi.

(*d*) With the air pressure remaining at 6 psi, allow the starter to remain submerged for one minute. No leaks should be indicated during this period.

(*e*) If leaks are indicated, disassemble and repair starter.

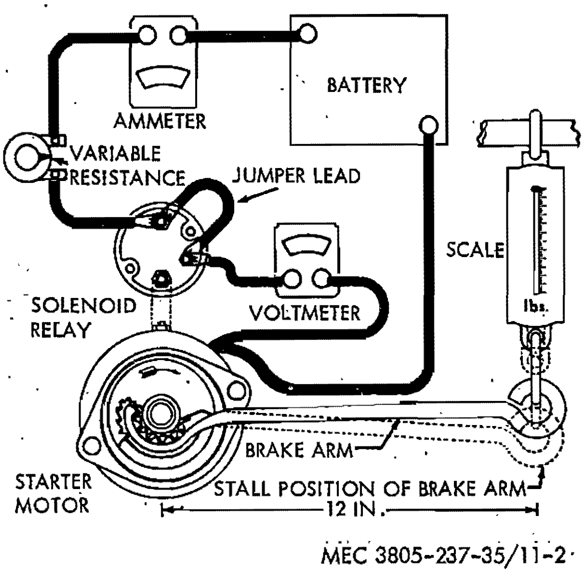



*Figure 11-2. Lock torque test hookup.*

*c. Disassembly.*

(1) Remove and disassemble commutator end plate and brush holder in the numerical sequence as illustrated on figure 11-3.

(2) Disassemble the drive housing, lever housing, clutch, and starter frame in the numerical sequence as illustrated on figure 11-4. Scribe a mark on the drive housing and lever housing to locate position for reassembly.

(3) Disassemble the solenoid assembly (14, fig. 11-3) in the numerical sequence as illustrated on figure 11-5.

*c. Cleaning.*

(1) Clean all parts, with the exception of the field windings, armature, brushes, solenoid, and insulators, in cleaning compound, solvent (Spec-P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Clean field windings with a cloth dampened in the solvent. Do not damage protective insulation coating. Dry thoroughly with compressed air.

(3) Remove all loose particles from armature. Clean commutator lightly with number 00 sandpaper and remove dust with compressed air. Use

a sharp instrument to clean all dirt and dust from between commutator bars.

(4) Clean brush holder and solenoid with a cloth dampened in solvent and dry thoroughly. Clean brushes with a dry cloth only.

*d. Inspection and Repair.*

(1) Inspect armature shaft bearing surfaces for wear and scoring. Inspect splines on armature for wear and damage. Check condition of soldered wires. Replace armature if worn, damaged or scored. Resolder wires if necessary.

(2) Inspect condition of commutator for high mica, scoring, or out-of-round condition. Check runout with a dial indicator. If commutator is out-of-round 0.020 inch or worn, turn down commutator.

(3) Check armature for shorts on a growler. Clean slots of commutator if necessary. Check for grounds with a test lamp. Replace armature if shorts and grounds cannot be corrected. Refer to TM 5-764 for procedures for testing the armature.

(4) Inspect brushes for cracks, wear, damage and loose or broken wires. If brushes are worn to less than 3/8 inch, replace brushes.

(5) Check all bearings, housings, springs, and shafts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(6) Replace all worn or defective parts.

*e. Reassembly.*

*Note.* Lubricate all working surfaces of shaft and bearings and the wicks with engine oil (OE 10) before installing.

(1) Reassemble the solenoid in reverse of the numerical sequence as illustrated on figure 11-5.

(2) Reassemble the housings, armature, and frame in reverse of the numerical sequence as illustrated on figure 11-4.

(3) After installing field windings in frame, check windings with a multimeter as follows:

(*a*) Touch one probe to the terminal stud (39, fig. 11-4) and other probe to each field winding connection, Multimeter should show a reading or closed circuit for each check. If circuit is open, replace field windings.

(*b*) Touch one probe to terminal stud and other probe to unpainted surface on frame. If meter shows a reading windings are grounded and should be replaced.

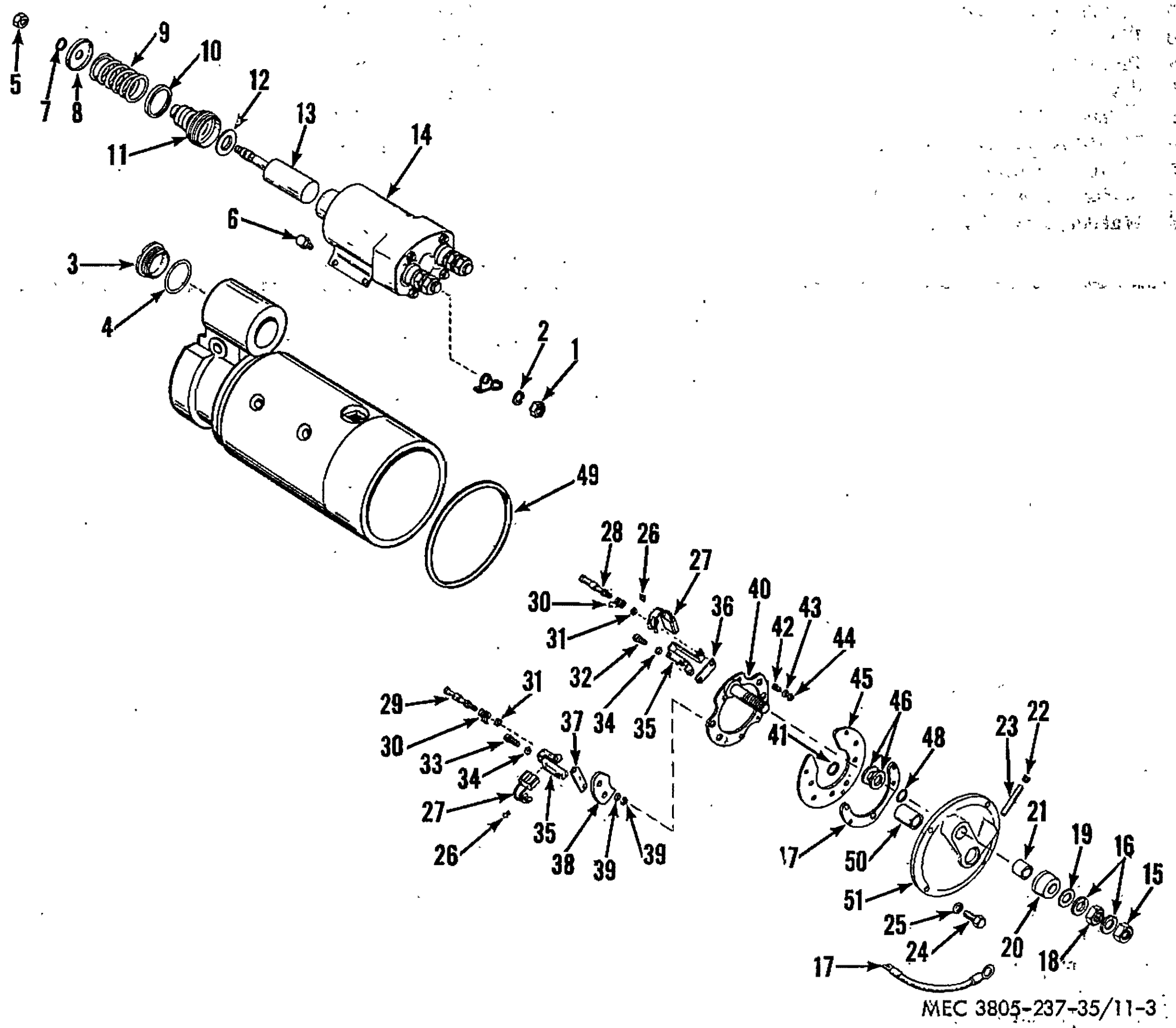
(*c*) After installing drive clutch and lever, check clutch for free movement on armature shaft and locking action when reversed. If clutch does not lock immediately replace clutch.

(*d*) Reassemble brush holder and commutator end in the reverse of the numerical sequence as illustrated on figure 11-3.

(*e*) After installing solenoid and plunger parts, check clearance of pinion gear by pushing clutch towards commutator end as shown in figure 11-6. Clearance should be 23/64 inch.

(*f*) After completing reassembly of starter, test starter as described in *b* above.

*f. Installation.* Refer to TM 5-3805-237-12 and install starter.

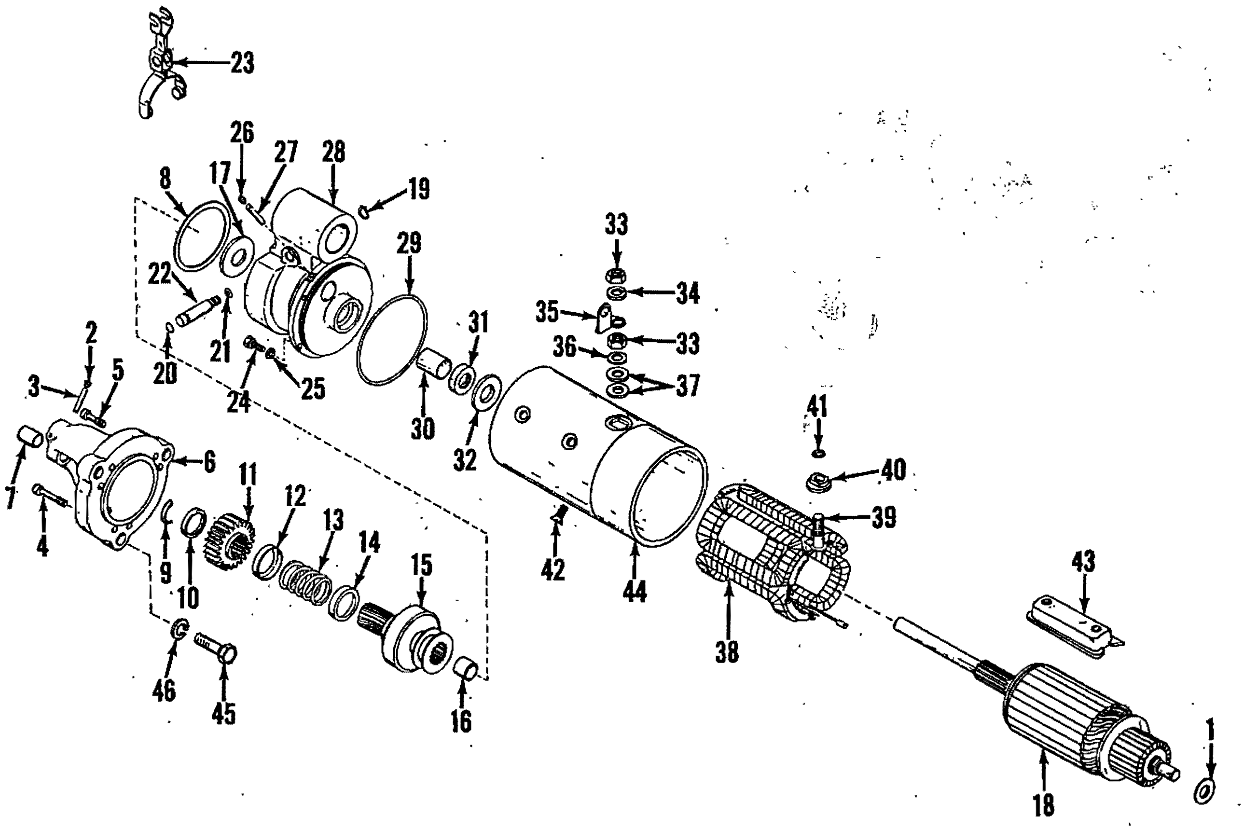



| | | | |
|---|---|---|---|
| 1 | Nut, 1/2-13 (2) | 18 | Nut, jam, 3/8-16 |
| 2 | Washer, 1/2 in. (2) | 19 | Washer, flat, 3/8 in. |
| 3 | Plug | 20 | Insulator |
| 4 | Gasket | 21 | Insulating bushing |
| 5 | Nut, lock | 22 | Plug |
| 6 | Screw, w/washer (4) | 23 | Wick |
| 7 | Retaining ring | 24 | Screw, cap, hex-head (4) |
| 8 | Spring retainer | 25 | Washer, lock (4) |
| 9 | Plunger spring | 26 | Screw, machine (8) |
| 10 | Spring retainer | 27 | Brush (8) |
| 11 | Boot | 28 | Brush holder screw (2) |
| 12 | Flat washer | 29 | Brush holder screw (2) |
| 13 | Solenoid plunger | 30 | Brush spring (8) |
| 14 | Solenoid | 31 | Washer, lock (4) |
| 15 | Nut, 3/8-16 | 32 | Screw, machine (4) |
| 16 | Washer, lock, 3/8 in. (2) | 33 | Screw, machine (4) |
| 17 | Solenoid lead | 34 | Washer, lock (8) |

*Figure 11-3. Solenoid, commutator end plate, and brush holder, exploded view.*

35 Brush holder (4)
36 Plate (2)
37 Plate (2)
38 Insulator (2)
39 Washer (8)
40 Brush holder plate, w/stud
41 Preformed packing
42 Screw, machine, No. 8 × 1/2 in. (3)
43 Washer, lock, No. 8 (3)
44 Washer, flat, No. 8 (3)
45 Insulator
46 Insulating washer (2)
47 Support plate
48 Preformed packing
49 Preformed packing
50 Bearing
51 Commutator end plate

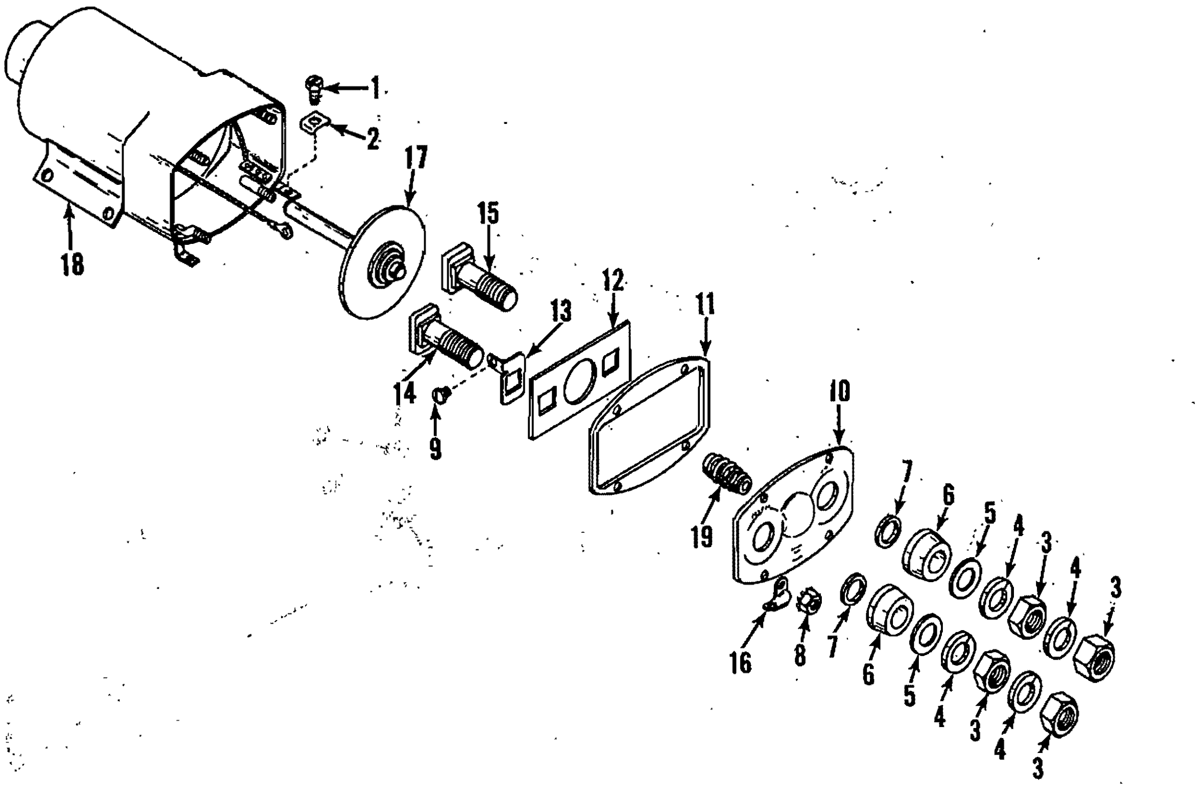
*Figure 11-8*—Continued.




MEC 3805-237-35/11-4

| | | | |
|---|---|---|---|
| 1 | Spacing washer | 24 | Screw, cap, hex-head, 1/4 × 28 × 1 in. (5) |
| 2 | Plug | 25 | Washer, lock, 1/4 in. (5) |
| 3 | Wick | 26 | Plug |
| 4 | Screw, cap, socket head, 5/16-18 × 1 1/2 in. (5) | 27 | Wick |
| 5 | Screw, cap, socket head, 5/16-18 × 55/64 in. (1) | 28 | Lever housing |
| 6 | Pinion housing | 29 | Preformed packing |
| 7 | Bearing | 30 | Bearing |
| 8 | Housing gasket | 31 | Oil seal |
| 9 | Washer, split (2) | 32 | Thrust washer |
| 10 | Gear retainer | 33 | Nut, 1/2-13 (2) |
| 11 | Starter pinion gear | 34 | Washer, lock, 1/2 in. |
| 12 | Spring retainer | 35 | Connector |
| 13 | Clutch spring | 36 | Washer, flat, 1/2 in. |
| 14 | Spring retainer | 37 | Insulating washer (2) |
| 15 | Starter drive | 38 | Field windings |
| 16 | Bearing | 39 | Terminal stud |
| 17 | Thrust washer | 40 | Insulator |
| 18 | Armature | 41 | Gasket |
| 19 | Retaining ring | 42 | Pole shoe screw (8) |
| 20 | Preformed packing | 43 | Pole shoe (4) |
| 21 | Preformed packing | 44 | Frame |
| 22 | Lever shaft | 45 | Screw, cap, hex-head, 5/8-11 × 2 in. (3) |
| 23 | Shift lever | 46 | Washer, lock, 5/8 in. (3) |

*Figure 11-4. Pinion housing, lever housing, and frame, exploded view.*




| | | | |
|---|---|---|---|
| 1 | Screw, machine (2) | 11 | Plate gasket |
| 2 | Terminal clip (2) | 12 | Insulator |
| 3 | Nut, 1/2-13 (4) | 13 | Terminal |
| 4 | Washer, lock, 1/2 in. (4) | 14 | Terminal stud |
| 5 | Washer, flat, 1/2 in. (2) | 15 | Terminal stud |
| 6 | Insulating bushing (2) | 16 | Ground connector |
| 7 | Insulating washer (2) | 17 | Contact disk assembly |
| 8 | Nut, w/washer, No. 10 (4) | 18 | Case and coil assembly |
| 9 | Screw, machine | 19 | Spring |
| 10 | Plate | | |

*Figure 11-5. Starter solenoid switch, exploded view.*

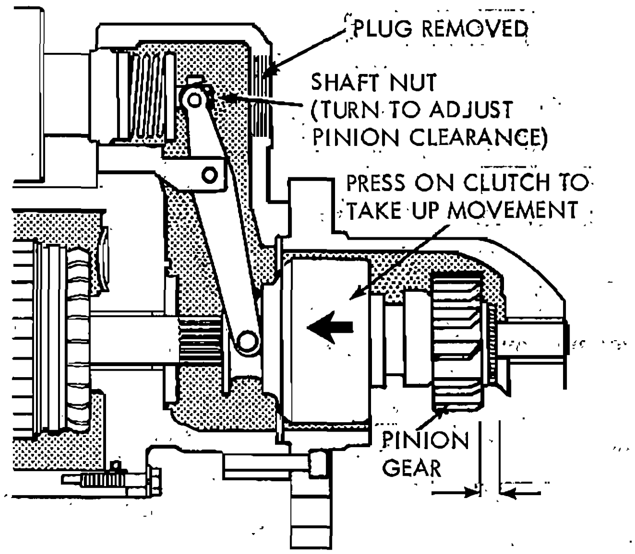



*Figure 11-6. Checking pinion gear clearance.*

## Section II. GENERATOR

### 11-3. General

*a.* The battery charging generator is a belt driven direct current generator. The generator is mounted by an adjustable bracket on the right side of the engine.

*b.* The generator belt is driven by the crankshaft pulley. An elbow, mounted on top of the generator, secures a receptacle connector. Connected to the receptacle is a shielded cable which carries the current to the voltage regulator mounted at the rear wall of the fuel tank.

### 11-4. Generator

*a. Removal.* Refer to TM 5-3805-237-12 and remove the generator from the motor grader.

*b. Disassembly.* Disassemble the generator and remove generator bracket in the numerical sequence as illustrated on figure 11-7. Scribe a line on commutator end bell and frame and drive end bell and frame to locate at reassembly before removing end bells.

*c. Cleaning.*

(1) Clean all parts, with the exception of the field windings, armature, brushes, solenoid and insulators, in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

(2) Clean field windings with a cloth dampened in cleaning solvent. Do not damage protective insulation coating. Dry thoroughly with compressed air.

(3) Remove all loose particles from armature. Clean commutator lightly with number 00 sandpaper and remove dust with compressed air. Use a sharp instrument to clean all dirt and dust from between commutator bars.

(4) Clean brushholders with a cloth dampened in solvent and dry thoroughly. Clean brushes with a dry cloth only.

*d. Inspection and Repair.*

(1) Inspect armature shaft bearing surfaces for wear and scoring. Check condition of soldered wires. Replace armature if worn, damaged, or scored. Resolder wires if necessary.

(2) Inspect condition of commutator for high mica, scoring, or out-of-round condition. Check runout with a dial indicator. If commutator is out-of-round 0.001 inch or worn, turn down commutator.

(3) Inspect armature shaft and bearings for the following tolerances. Replace parts not conforming to tolerances.

| | |
|---|---|
| **Bearings** | |
| Inside diameter | 0.9839 to 0.9843 |
| Outside diameter | 2.4404 to 2.4409 |
| **Shaft** | |
| Outside diameter | 2.4404 to 2.4409 |

(4) Check armature for shorts on a growler. Clean slots of commutator if necessary. Check armature for grounds with a test lamp. Replace armature if shorts and grounds cannot be corrected. Refer to TM 5-764 for procedures for testing armature.

(5) Inspect brushes for cracks, wear, damage, and loose or broken wires. If brushes are worn to less than 35/64 inch, replace brushes.

(6) Check brush springs for cracks or broken condition. Check brush spring tension. Brush spring must have tension of 25 ounces. Replace cracked, broken, or defective springs.

(7) Replace all worn, broken, or damaged parts.

*e. Reassembly.*

(1) Reassemble the generator in reverse of the numerical sequence as illustrated on figure 11-7 and the following instructions.

(2) Press ball bearings into end bells, using a suitable arbor press.

(3) When installing end bells, aline scribe mark on end bell with scribe mark on frame for correct installation.

*f. Testing.*

(1) *Field current draw.*

(*a*) Connect generator on a test stand as shown in figure 11-8.

(*b*) Adjust variable resistance until voltage is 24 volts.

(*c*) Field current must be as specified (24 to 28.5 volts and 0.85 to 0.89 amps).

(*d*) If current draw is not within limits, repair generator.

(2) *Generator output.*

(*a*) Connect generator on a test stand as shown in figure 11-9. Connect generator to a test stand driving motor.

(*b*) Operate motor to drive generator in a clockwise rotation as viewed from the drive end. Close battery switch and adjust carbon pile rheostat until voltage is 24 to 28.5 volts.

(*c*) Increase speed slowly to 1950 rpm. The current output should be 28.5 volts and 18 amps.

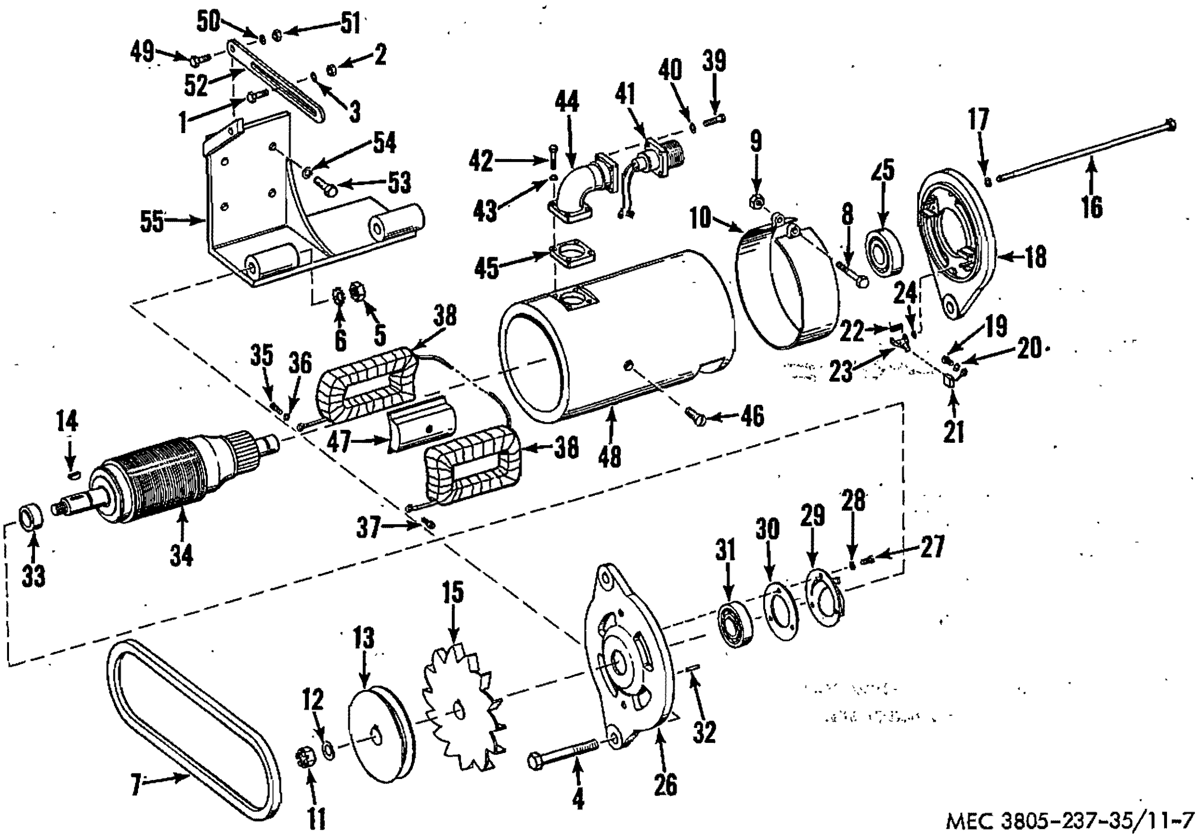
(*d*) If reading is not as specified, repair generator.

*g. Installation.*

(1) Install mounting brackets and adjusting arm in reverse of numerical sequence as illustrated on figure 11-7.

(2) Refer to TM 5-3805-237-12 and install generator on motor grader.

(3) Repolarize generator by momentarily connecting battery in series with B lead (fig. 11-8) and ground. This allows a surge of current to flow through the field windings to ground and properly polarizes the generator.




MEC 3805-237-35/11-7

1 Screw, cap, hex-head, 3/8-16 × 1 in.
2 Nut, 3/8-16
3 Washer, lock, 3/8 in.
4 Screw, cap, hex-head, 7/16-14 × 3 in. (2)
5 Nut, 7/16-14 (2)
6 Washer, lock, 7/16 in. (2)
7 Generator belt
8 Screw, machine, No. 10-32 × 1 1/4 in.
9 Nut, No. 10-32
10 Access cover band
11 Nut, lock.
12 Washer
13 Pulley
14 Key, woodruff
15 Fan
16 Shoulder bolt, 5/16-18 × 8 in. (2)
17 Washer, lock, 5/16 in. (2)
18 Commutator end bell
19 Screw, machine, No. 6-32 × 5/16 in. (2)
20 Washer, lock, No. 6 (2)
21 Brush (2)
22 Brush spring (2)
23 Brush holder (2)
24 Washer (2)
25 Ball bearing
26 Drive end bell
27 Screw, machine, No. 10-32 × 3/8 in. (3)
28 Washer, lock, No. 10 (3)
29 Collector ring
30 Bearing retainer
31 Ball bearing
32 Dowel pin
33 Spacer
34 Armature
35 Screw, machine, No. 6-32 × 5/16 in.
36 Washer, lock, No. 6
37 Screw, machine, No. 6-32 × 1/4 in.
38 Field coil winding
39 Screw, machine, No. 6-32 × 3/8 in. (4)
40 Washer, lock, No. 6 (4)
41 Receptacle connector
42 Screw, machine, No. 8-32 × 7/8 in. (4)
43 Washer, lock, No. 8 (4)
44 Elbow
45 Spacer
46 Pole shoe screw (2)
47 Pole shoe (2)
48 Generator frame
49 Screw, cap, hex-head, 3/8-16 × 1 in.
50 Nut, 3/8-16

*Figure 11-7. Generator and mounting bracket, exploded view.*

51 Washer, lock, 3/8 in.
52 Adjusting arm
53 Screw, cap, hex-head, 3/8-16 × 1 in. (4)
54 Washer, lock, 3/8 in. (4)
55 Mounting bracket

*Figure 11-7*—Continued.

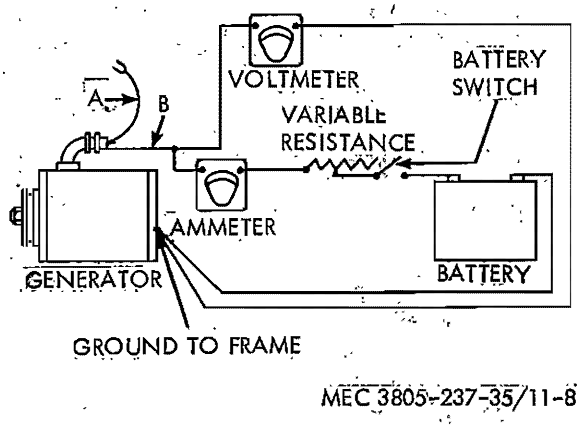



*Figure 11-8. Generator field current draw test wiring diagram.*

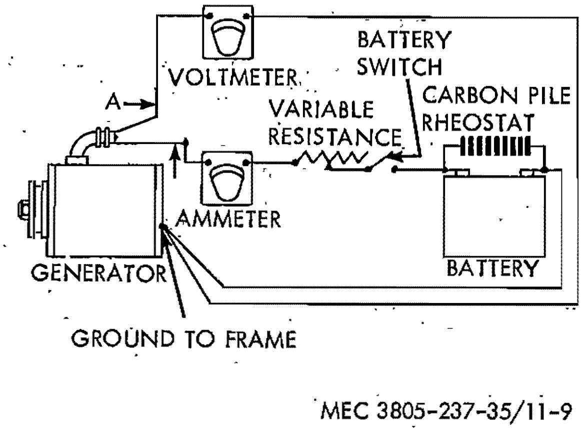



*Figure 11-9. Generator output test wiring diagram.*

## Section III. VOLTAGE REGULATOR

### 11-5. General

*a.* The voltage regulator operates to keep the battery charged, to protect the battery and circuits from overload, and to protect the generator. The voltage regulator consists of a cutout relay, a voltage regulator, a current regulator, and an actuating relay.

*b.* The cutout and actuating relays function together. They close the circuit between the generator and battery when the generator voltage is sufficient to charge the battery and open the circuit when generator voltage falls below the battery voltage. The voltage regulator controls the output voltage of the generator and prevents overloading the battery and the vehicle electrical system. The current regulator adjust the current flow in reference to the load imposed on the battery and generator.

### 11-6. Voltage Regulator

*a. Removal.* Refer to TM 5-3805-237-12 and remove the voltage regulator.

*b. Disassembly.* Disassemble the voltage regulator in the numerical sequence as illustrated in figure 11-10.

*c. Cleaning.* Clean all metal parts with a clean, lint-free cloth. Wipe all leads, windings, insulators, resistors, gaskets, and panels with a cloth.

***Caution:* Never use solvent to clean gaskets, insulators, or resistors. Handle windings and leads with extreme care. Never twist or pull winding leads.**

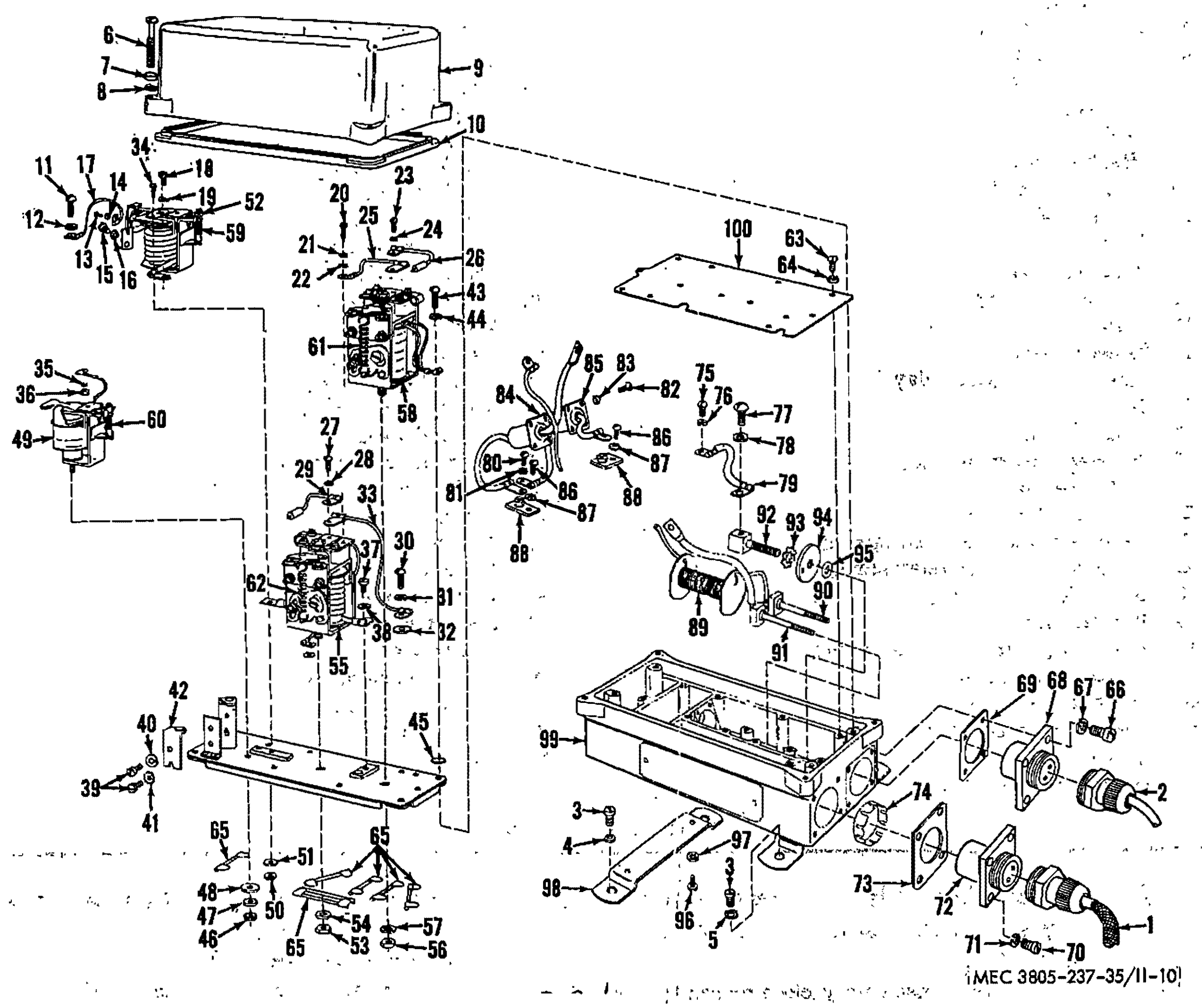
*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect resistors for cracks and broken leads. Replace cracked resistors. Solder leads if possible.

(3) Inspect springs for weak or broken condition. Replace weak or broken springs.

(4) Inspect contact points for evidence of burning or cracked condition. Replace points if burned or cracked. Bend brackets to aline points if possible.




1 Shielded cable
2 Power cable
3 Screw, cap, hex-head, 5/16-18 × 1/2 in. (4)
4 Washer, lock, int-teeth, 5/16 in. (3)
5 Washer, lock, ext-teeth, 5/16 in. (2)
6 Screw, machine (4)
7 Washer, lock (4)
8 Cup (2)
9 Cover
10 Cover gasket
11 Screw, machine
12 Washer, lock
13 Screw, machine
14 Washer, lock
15 Screw, machine
16 Washer, lock
17 Current regulator lead
18 Screw, machine
19 Washer, lock
20 Screw, machine
21 Washer, lock
22 Washer, flat
23 Screw, machine
24 Washer, lock
25 Lead
26 Resistor and lead
27 Screw, machine
28 Washer, lock
29 Resistor and lead
30 Screw, machine
31 Washer, lock
32 Washer, flat
33 Lead
34 Screw, machine
35 Washer, lock
36 Washer, flat
37 Screw, machine
38 Washer, lock
39 Screw, machine (2)
40 Washer, lock

*Figure 11-10. Voltage regulator, exploded view.*

| | | | |
|---|---|---|---|
| 41 | Washer, lock, ext-teeth | 71 | Washer, lock (4) |
| 42 | Relay contact bracket | 72 | Receptacle connector |
| 43 | Screw, machine (4) | 73 | Gasket |
| 44 | Washer, lock (4) | 74 | Ground spring |
| 45 | Washer, flat (2) | 75 | Screw, machine |
| 46 | Nut | 76 | Washer, lock |
| 47 | Washer, lock | 77 | Screw, machine |
| 48 | Washer, flat | 78 | Washer, lock |
| 49 | Cutout relay | 79 | Ammeter shunt |
| 50 | Nut | 80 | Screw, machine |
| 51 | Washer, lock | 81 | Washer, lock |
| 52 | Actuating relay | 82 | Screw, machine (8) |
| 53 | Nut | 83 | Washer, lock |
| 54 | Washer, lock | 84 | Capacitor |
| 55 | Current regulator relay | 85 | Capacitor |
| 56 | Nut | 86 | Screw, machine (2) |
| 57 | Washer, lock | 87 | Washer, lock (2) |
| 58 | Voltage regulator relay | 88 | Terminal support (2) |
| 59 | Actuator spring | 89 | Choke coil |
| 60 | Cutout relay spring | 90 | Terminal |
| 61 | Voltage regulator relay spring | 91 | Terminal |
| 62 | Current regulator relay spring | 92 | Terminal |
| 63 | Screw, machine (13) | 93 | Washer, lock |
| 64 | Washer, lock (13) | 94 | Insulator |
| 65 | Resistor group (7 resistors rqr) | 95 | Washer, flat |
| 66 | Screw, machine (4) | 96 | Screw, machine (4) |
| 67 | Washer, lock (4) | 97 | Washer, lock (4) |
| 68 | Receptacle connector | 98 | Mounting bracket |
| 69 | Gasket | 99 | Base |
| 70 | Screw, machine (4) | 100 | Shield |

*Figure 11-10*—Continued.

(5) Use a fine file to clean contact points. Clean points with a cloth after filing.

*Note.* Never use emery cloth or sandpaper to dress points. Do not touch points after cleaning.

(6) Replace all worn or damaged parts.

*e. Reassembly.* Reassemble the voltage regulator in reverse of the numerical sequence as illustrated on figure 11-10. Do not install cover (9, fig. 11-10) until after adjusting voltage regulator.

*f. Adjustment.* Adjust the relays to obtain the following measurements.

(1) *Cutout relay.*

Air gap between armature and coil ....0.042 in.
Point opening ........0.040 in.
Closing voltage ......14.0 to 17.0 volts
Sealing voltage ........19.5 to 23.0 volts

(2) *Actuating relay.*

Air gap between armature and coil ....0.037 inch
Point opening ........0.037 inch
Closing voltage .......25.0 to 27.0 volts
Adjust voltage to .....26.0 volts

(3) *Voltage regulator relay.*

Air gap between armature and coil ....0.084 inch
Closing voltage ......28.0 to 29.5 volts
Adjust voltage to .....28.5 volts

*g. Installation.*

(1) Install cover (9, fig. 11-10) and gasket (10) and secure with screws (6), washers (7) and cups (8).

(2) Refer to TM 5-3805-237-12 and install voltage regulator.

# CHAPTER 12

# ENGINE REPAIR INSTRUCTIONS

## Section I. GENERAL

### 12-1. General

*a.* The engine used in the motor grader is a 4-cylinder, in-line, diesel engine. The engine is mounted in the rear of the motor grader, behind the fuel tank.

*b.* The engine operates on the two-cycle principle, with intake and exhaust taking place during part of the compression and power strokes. Exhaust gases are expelled by scavenge air from the blower. The air enters a set of ports which are above the piston when piston is at the bottom of its stroke. This air also helps to cool the inside of the cylinder.

*c.* As the piston rises only clean air is in the chamber. The piston closes the ports and compresses the air. Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the fuel injector. The intense heat generated during the high compression of the air ignites the fine fuel spray immediately and combustion continues until the injected fuel is burned.

*d.* Pressure from the burning fuel forces the piston down on the power stroke. Exhaust valves open when the piston is halfway down, allowing the burnt gases to escape through the exhaust manifold. As the piston moves it uncovers the air inlet ports and the cylinder is again cleaned with scavenging air and the cycle is repeated.

### 12-2. Engine Repair

*a.* The engine will be repaired in separate sections following in this chapter. The sections will break the engine down into separate systems and each system will be covered.

*b.* Modifications to the standard engine consist of the generator and oil filter installations, a flywheel adapted to the clutch, an emergency stop control, and a cold weather start device.

*c.* Some of the repairs as applied to the engine can be accomplished without removing the engine from the motor grader. However, for purpose of this manual, necessary repairs will be made to the engine after it has been removed from the grader.

## Section II. AIR SYSTEM

### 12-3. General

*a.* The air intake system of the engine consists of a dry element air cleaner, elbows and tubes, air inlet housing, and a blower assembly.

*b.* The air cleaner is mounted on the left side of the grader and is connected to the air inlet housing by rubber elbows and tubes. The air is drawn through a covered inlet into and through the filter element, and carried to the inlet housing.

*c.* The air inlet housing delivers the air to the blower assembly through a screen. The blower assembly increases the air pressure and delivers it directly to the cylinders.

### 12-4. Air Cleaner

*a. Removal.* Refer to paragraph 2-30 and remove the air cleaner from the motor grader.

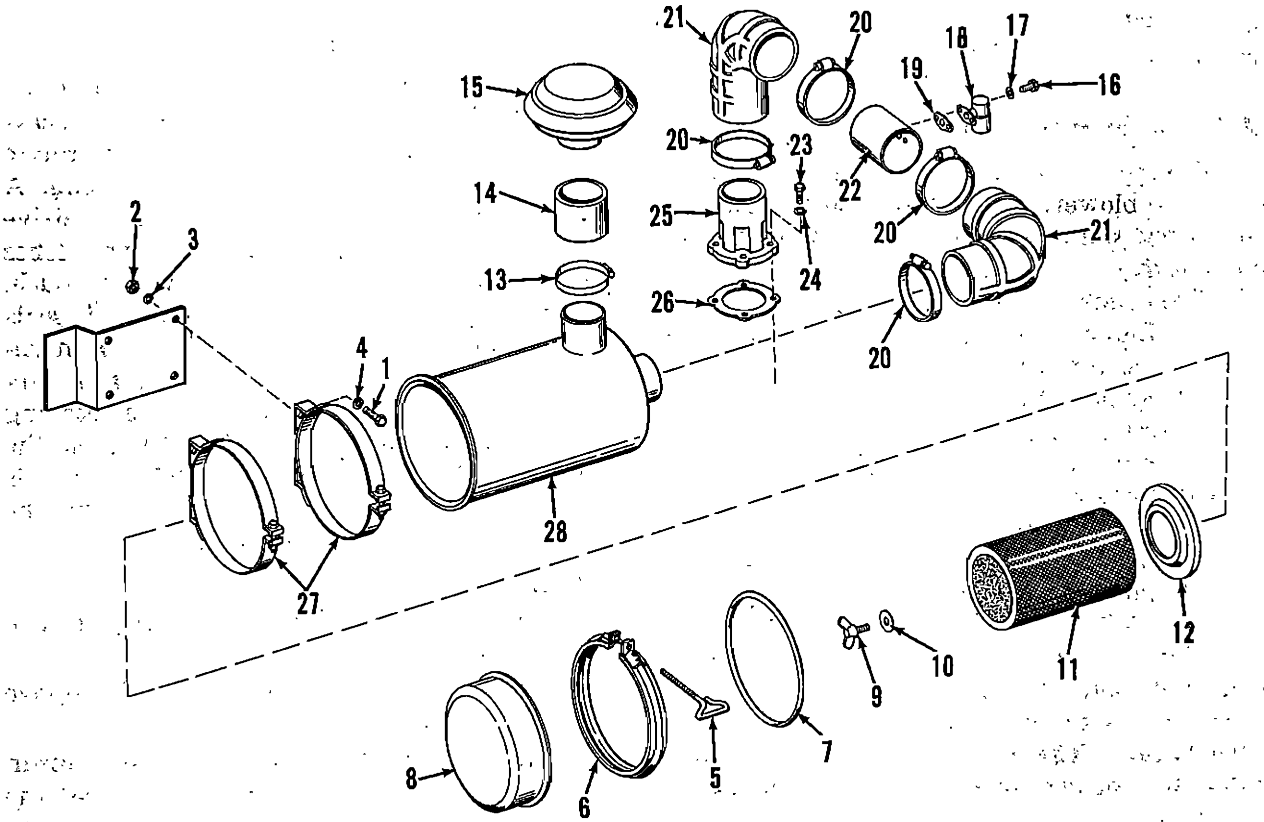
*b. Disassembly.* Disassemble the air cleaner in the numerical sequence as illustrated in figure 12-1.

*c. Cleaning.* Clean dust and dirt from all parts. Use a brush and air pressure to clean caked dust from tube and elbows.

*d. Inspection and Repair.*

(1) Inspect all parts for dents and damage.

(2) Inspect elbows and tube for cracks and evidence of leaks.




1 Screw, cap, hex-head, 3/8-16 × 2 3/4 in. (4)
2 Nut, 3/8-16 (4)
3 Washer, lock, 3/8 in. (4)
4 Washer, flat, 3/8 in. (4)
5 Bolt
6 Band
7 Gasket
8 Dust cup
9 Thumb screw
10 Washer
11 Element
12 Element gasket
13 Clamp
14 Hose
15 Intake cap
16 Screw, cap, hex-hd, (2)
17 Washer, lock (2)
18 Air cleaner indicator
19 Gasket
20 Clamp (4)
21 Rubber elbow (2)
22 Tube
23 Screw, cap, hex-head, 5/16 × 1 1/4 in. (4)
24 Washer, lock, 5/16 in. (4)
25 Air inlet adapter
26 Gasket
27 Band (2)
28 Housing

*Figure 12-1. Air Cleaner, exploded view.*

(3) Inspect gaskets for damage and deterioration.

(4) Replace all damaged, leaking, or deteriorated parts. Straighten dents if possible.

*e. Reassembly.* Reassemble the air cleaner in reverse of the numerical sequence as illustrated on figure 12-1.

*f. Installation.* Refer to paragraph 2-30 and install the air cleaner on the motor grader.

## 12-5. Air Inlet Housing

*a. General.* The air inlet housing is mounted on the blower. The cold weather start and emergency shutdown are connected to the air inlet housing.

*b. Removal.*

(1) Refer to paragraph 2-30 and remove the air cleaner.

(2) Remove the air inlet adapter from air inlet housing as illustrated on figure 12-1 (item nos. 23 through 26).

(3) Remove and disassemble the air inlet housing, cold weather start, and emergency shutdown in the numerical sequence as illustrated on figure 12-2.

*c. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect cold weather start tube for kinks or breaks. Inspect fittings for serviceable condition.

(3) Inspect emergency shutdown wire, linkage, and valve for evidence of binding or damage.

(4) Inspect air inlet housing, striker plate, and screen for cracks and damage.

(5) Replace all gaskets. Replace all worn, damaged, or unserviceable parts.

*e. Installation.*

(1) Reassemble and install the air inlet housing, cold weather starting aid, and emergency shutdown in reverse of the numerical sequence as illustrated on figure 12-2.

(2) Install the air inlet housing adapter (items 26 through 23, fig. 12-1) on air inlet housing.

(3) Refer to paragraph 2-30 and install the air cleaner.

## 12-6. Blower Assembly

*a. General.* The blower supplies the fresh air under pressure for combustion and scavenging. Two hollow three-lobe rotors rotate with very close clearances in the housing. A set of two timing gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance. Lobes do not touch, therefore lubrication is not required. Oil seals in the blower end plates prevent oil from entering the air chamber. The rotors are supported on the end plate by a roller bearing and a radial and thrust ball bearing on the gear end. Lubrication for the drive gears is received through oil drain holes from the crankshaft housing and cylinder head.

*b. Removal.*

(1) Refer to paragraph 2-30 and remove the air cleaner.

(2) Refer to paragraph 12-5 and remove the air inlet housing.

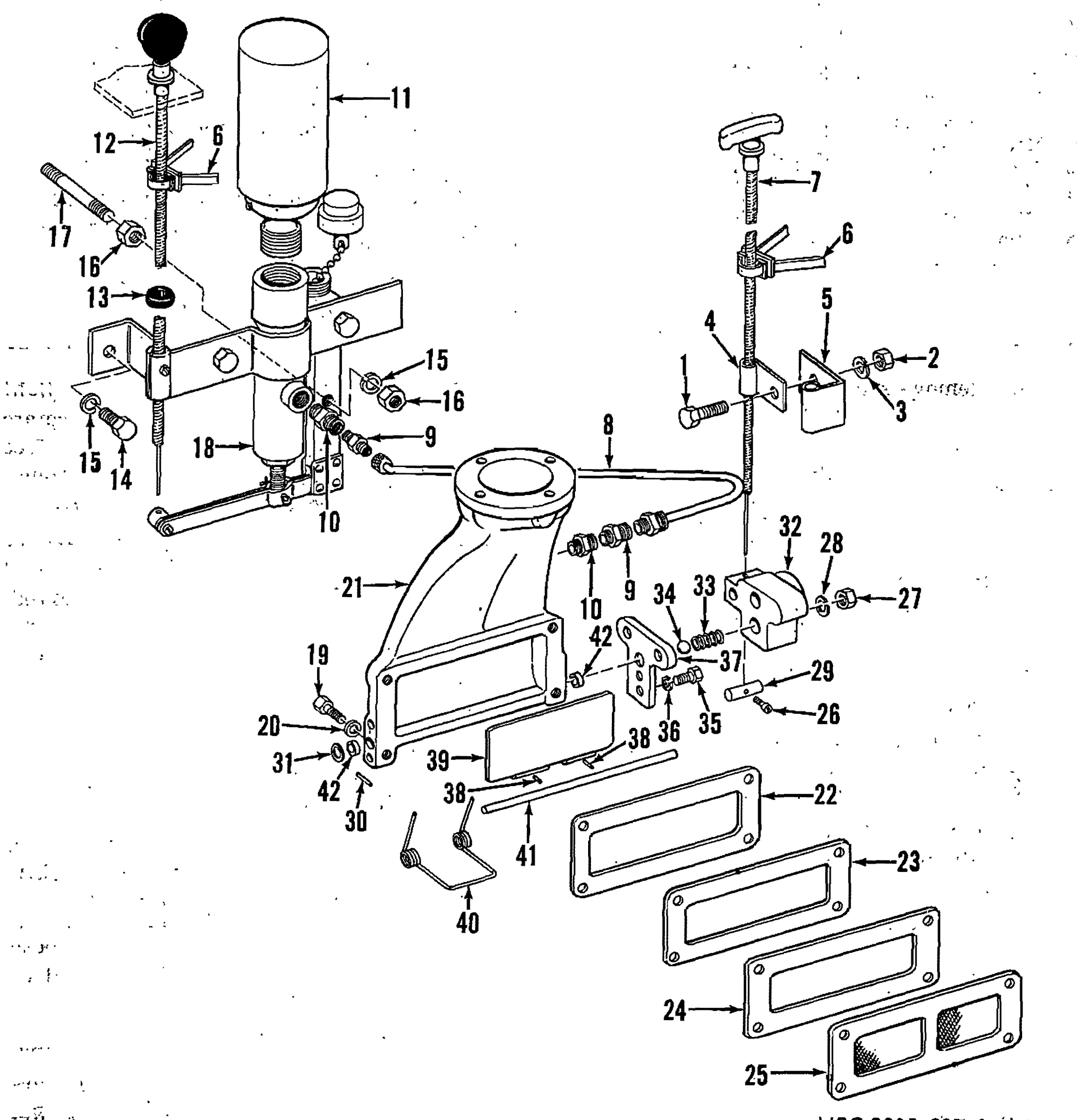
(3) Refer to TM 5-3805-237-12 to drain the cooling system and remove the water pump from the blower. Refer to paragraph 12-16 and remove the fuel pump.

(4) Refer to paragraph 12-19 and remove the governor.

(5) Remove two screws and lockwashers and remove clamp and crankcase oil level gage and tube from blower.

(6) Loosen clamps on blower drive shaft cover seal above the fuel pump.

(7) Remove four screws (1, fig. 12-3) and lockwashers (2). Slide the blower assembly toward the fan end of the engine to free blower drive shaft from drive hub and drive shaft cover and lift blower assembly from engine. Remove gasket (44).




1 Screw, cap, hex-head, 1/4-20 × 3/8 in.
2 Nut, 1/4-20
3 Washer, lock, 1/4
4 Clamp
5 Clamp
6 Nylon tie (4)
7 Emergency shutdown cable
8 Cold weather start tube
9 Connector (2)
10 Fitting (2)
11 Fuel container
12 Cold weather start cable
13 Grommet
14 Screw, cap, hex-head, 1/4-20 × 1 1/2 in. (4)

*Figure 12-2. Coldweather start, emergency shutdown, and air inlet housing, exploded view.*

15 Washer, lock, 1/4 in. (6)
16 Nut, 1/4-20 (2)
17 Rod
18 Cold weather start valve
19 Screw, cap, hex-head, 3/8-16 × 1 5/8 in. (4)
20 Washer, lock, 3/8 in. (4)
21 Air inlet housing
22 Housing gasket
23 Striker plate
24 Plate gasket
25 Inlet screen
26 Screw, machine, No. 10-32 × 3/8 in.
27 Nut, 3/8-24
28 Washer, lock, 3/8 in.
29 Stop
30 Pin
31 Washer, flat, 3/8 in.
32 Lever
33 Spring
34 Ball
35 Screw, cap, hex-head, 1/4-20 × 1/2 in.
36 Washer, lock, 1/4 in.
37 Lock plate
38 Pin (2)
39 Shutdown valve
40 Valve spring
41 Valve shaft
42 Seal ring (2)

*Figure 12-2*—Continued.

(8) Remove six screws with seal washers and remove governor drive housing from blower drive cover.

c. *Disassembly.*

(1) Disassemble the blower assembly in the numerical sequence as illustrated in figure 12-3 and the following instructions. Discard all gaskets and oil seals.

(2) Do not pry covers (8 and 14) from blower. Tap covers to remove.

(3) To hold rotors (39 and 40) in place while removing drive coupling bolt (10), place a clean cloth between rotors and rotate until cloth locks the rotors.

(4) Use a suitable puller to remove gears (25 and 26) from rotor shafts. Gears must be pulled simultaneously. Count number of shims (27) if present, under each gear.

(5) Remove end plates (33 and 35), using a suitable puller.

(6) Use a suitable tool and an arbor press to remove bearings and oil seals from end plates.

d. *Cleaning.* Clean all metal parts in diesel fuel (current LO) and dry thoroughly with compressed air.

e. *Inspection and Repair.*

(1) Inspect roller and ball bearings for corrosion or pitting. Apply light engine oil to bearing and rotate bearing by hand to check for free rolling. Replace bearings if rough spots or corrosion are indicated.

(2) Inspect blower rotor lobes, particularly the sealing rib, for burs and scoring. If slightly scored or burred, dress rotor lobes with fine emery cloth. Replace badly scored rotors.

(3) Inspect splines on rotor shafts for wear and burs. Replace rotor if shaft is badly worn.

(4) Inspect inside of rotor housing for burs and scoring. Clean inside of housing to a smooth finish with fine emery cloth if necessary. Replace badly scored housings.

(5) Check ends of housing for smooth faces to accept end plates. Replace housing if faces are scored.

(6) Inspect finished inside face of housing for burs and scoring. Clean burs with fine emery cloth if possible. Replace housing if faces are badly worn.

(7) Inspect gears for wear and damage. If gears are worn or damaged, replace gears as a set. When gears are worn to where backlash exceeds 0.004 inch, replace gears.

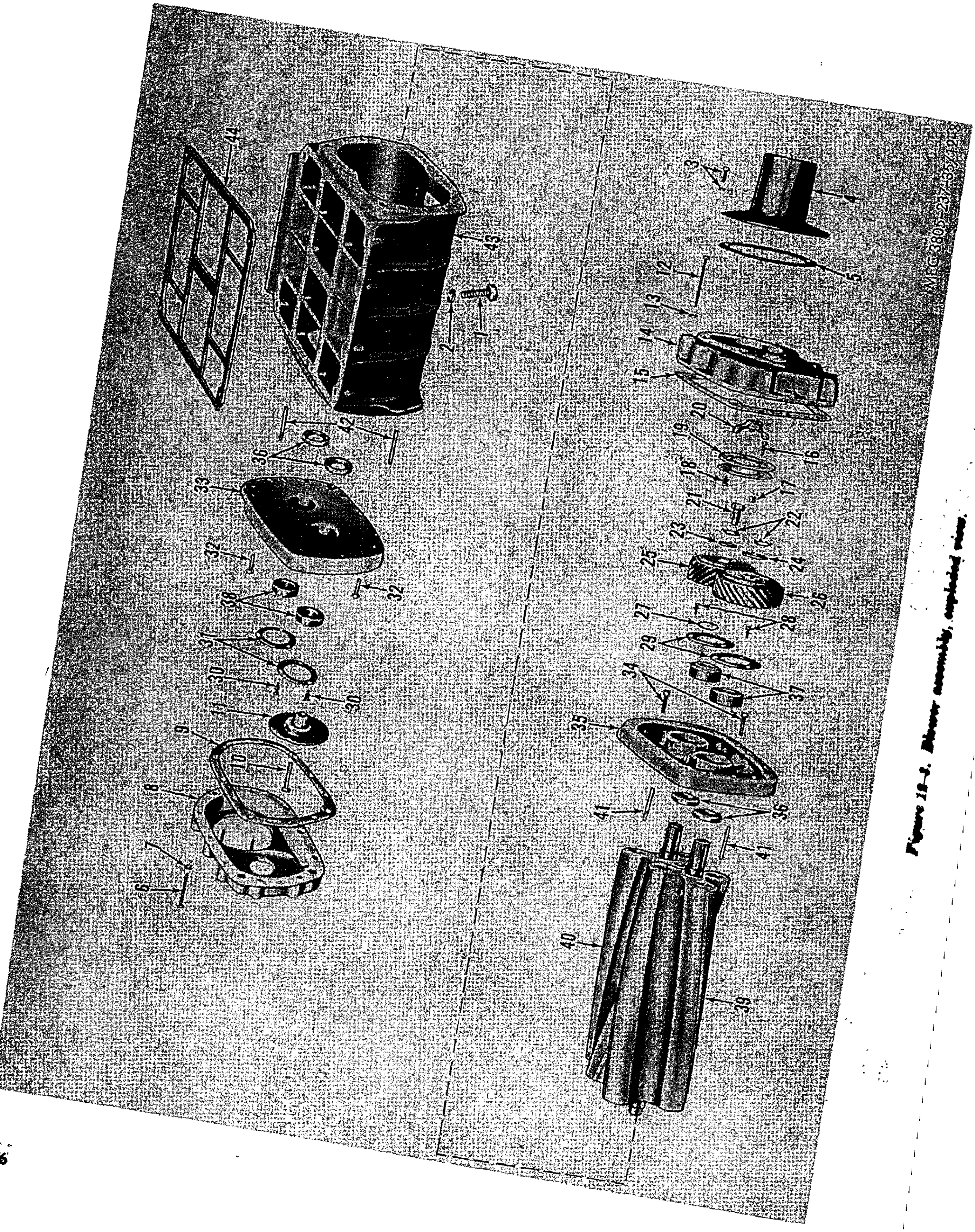


Figure 18-3. Blower assembly, exploded view.

1 Screw, cap, hex-head, 7/16-12 × 2 in. (4)
2 Washer, flat, 7/16 in. (4)
3 Screw, w/seal washer (6)
4 Drive shaft cover
5 Cover gasket
6 Screw, cap, hex-head, 5/16-18 × 2 1/2 in. (10)
7 Washer, lock, 5/16 in. (10)
8 Front cover
9 Cover gasket
10 Drive coupling bolt
11 Drive coupling
12 Screw, cap, hex-head, 5/16-18 × 2 1/2 in. (10)
13 Washer, lock, 5/16 in. (10)
14 Rear cover
15 Cover gasket
16 Screw, w/washer (3)
17 Spacer (3)
18 Screw, w/washer (3)
19 Hub plate (2)
20 Gear hub
21 Screw, cap, hex-head, 1/2-20 × 1 1/4 in. (2)
22 Washer, lock, ext-teeth 1/2 in. (2)
23 Gear retaining washer
24 Coupling disk
25 Upper gear
26 Lower gear
27 Shim
28 Screw, w/washer, 1/4-20 × 3/4 in. (6)
29 Bearing retainer (2)
30 Screw, w/washer, 1/4-20 × 3/4 in. (6)
31 Bearing retainer (2)
32 Screw, machine, 5/16-18 × 1 1/2 in. (2)
33 Front end plate
34 Screw, machine, 5/16-18 × 1 1/2 in. (2)
35 Rear end plate
36 Oil seal (4)
37 Ball bearing (2)
38 Roller bearing (2)
39 Lower rotor
40 Upper rotor
41 Dowel pin (4)
42 Dowel pin (4)
43 Blower housing
44 Gasket

*Figure 12-3*—Continued.

(8) Inspect blower drive shaft in engine and drive hub for damaged splines, wear, and bent condition. Replace drive shaft and hub if bent or damaged.

(9) Inspect all parts for wear and damage.

(10) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(11) Replace all worn or damaged parts.

*f. Reassembly.* Reassemble the blower assembly in reverse of the numerical sequence as illustrated on figure 12-3 and the following instructions.

(1) Install oil seals (36) in plates with lip of seal towards bearing bore in plate.

(2) Install front end plate (33) on housing with marking TOP on plate at top of blower. Secure with screws (32).

(3) Install blower rotors (39 and 40) in housings, with shafts through oil seals and omitted splines on shafts facing up. Be careful not to damage oil seals when installing rotors. Install rear end plate (35) on housing and shafts in the same manner. Do not install screws (34).

*Note.* Dowel pins (41 and 42) must project 3/8 inch from end plates after installation.

(4) Lubricate roller bearings (38) with engine oil (OE 10) and press bearings over shafts and into front end plate, using a suitable tool. Install bearing retainers (29) and secure with screws (28). Torque screws to 7 to 9 foot pounds.

(5) Install coupling (11) on shaft and tighten screw (10) to a torque of 18 foot pounds. Wedge a clean cloth between rotors to tighten screw.

(6) Install cover (8) and gasket (9) and tighten screws (6) to a torque of 13 to 17 foot pounds.

(7) Install screws (34) in end plate and tighten securely. Lubricate ball bearings (37) with engine oil (OE 10) and, using a suitable tool, install bearings around shafts and into bores in end plate.

(8) Make a preliminary check of rotor end clearances with a feeler gage. Check for minimum clearances shown on figure 12-5. Clearances should be fairly close to requirements.

(9) Before installing rotor gears (25 and 26) observe the following:

(*a*) The upper rotor gear (25) must have a right-hand helix; the lower rotor gear must have a left-hand helix.

(*b*) A spline is omitted on each rotor shaft and a spline is omitted on each gear. The gears must be installed on rotor shafts with the omitted splines in alinement.

(*c*) The omitted splines on shaft must be up toward top of blower. A punch mark on the end of the shaft locates the omitted spline.

(10) If shims (27) were used, install same amount of shims under gears as were removed during disassembly.

(11) Rotate rotors to bring omitted splines on shaft in line and facing toward top of blower.

(12) Place teeth of gears (25 and 26) in mesh with each other and with omitted splines in the gears in alinement and facing in the same direction. Start the gears on the shafts, with splines alined correctly.

(13) Use a 1/2 inch flat washer under each screw (21) and tighten screws uniformly to draw gears into position. Remove screws and flat washers from shafts.

(14) Install gear retaining washer (23) on upper shaft and coupling disk (24) on lower shaft. Install screws with special lockwashers (22) on shafts and tighten screws to a torque of 55 to 65 foot pounds. Lugs on gear retaining washer must engage slots in upper gear hub and tab on special lockwasher must engage slot in gear retaining washer. Lugs on coupling disk must engage slots in

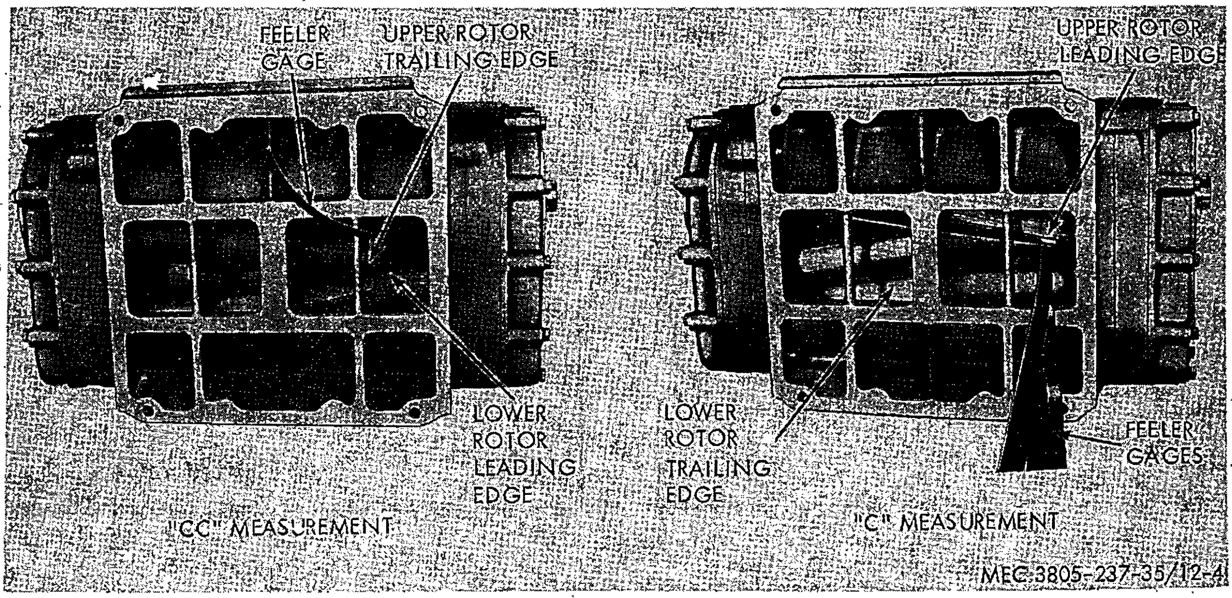



*Figure 12-4. Checking rotor clearances.*

lower gear and tab on lockwasher must engage slot in coupling disk.

(15) Check clearances of rotors as illustrated on figure 12-4. Rotate clearances can be adjusted by moving one of the gears in or out on the shaft in relation to the other gear. Refer to figure 12-6 for location of shims to adjust lobe clearances.

(16) Adjust lobe clearances as follows. Use feeler gages between lobes as illustrated on figure 12-4 to check clearances.

(*a*) Clearance between trailing edge of upper rotor (figs. 12-5 and 12-6) and leading edge of lower rotor (CC clearance) measured at both inlet and outlet sides of blower assembly should be between 0.002 and 0.006 inch. Keep clearance to 0.002 inch if possible by placing shims as indicated on figure 12-6.

(*b*) Clearance between leading edge of upper rotor and trailing edge of lower rotor (figs. 12-5 and 12-6) (C clearance) must be kept to the minimum of 0.012 inch.

(*c*) Take measurements between rotor lobes at one inch from governor end, at center, and one inch from drive end.

(*d*) Remove or install shims under gears until clearances are as specified. Remove both gears from rotors when number of shims requires changing.

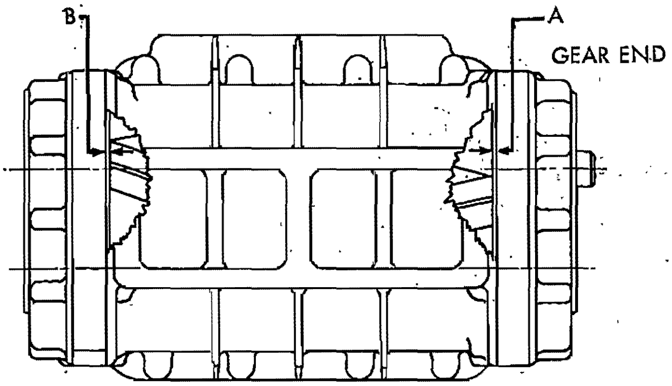
(17) Check clearance between each rotor lobe and blower housing at both ends of housing (A and B clearance). Twelve measurements are required in all as illustrated in figure 12-7.

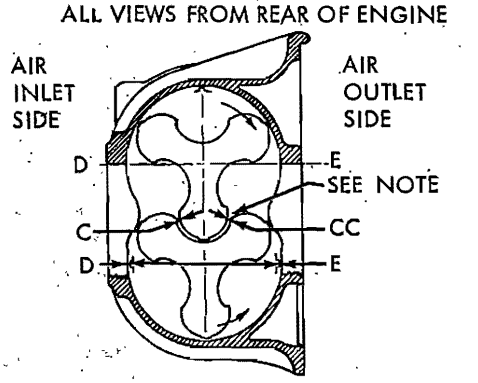
(18) Install hub plates (19) on gear hub (20) and secure with screws (18). Install three spacers (17) and gear hub on upper drive gear and secure with screws (16). Tighten screws (16) to a torque of 25 to 30 foot pounds.

*Note.* Splines in gear hub must run true within 0.020 inch total indicator reading.

(19) Install rear cover (14) and new gasket (15) on housing and secure with screws 12 and lockwashers (13). Tighten screws to a torque of 13 to 17 foot pounds.

(20) Install drive shaft cover (4) and new gasket (5) and secure with screws (3). Tighten screws only finger tight.

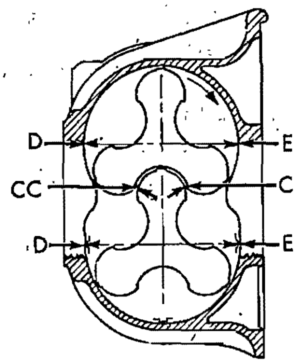



NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF UPPER ROTOR AND LEADING SIDE OF LOWER ROTOR (CC) FROM BOTH OUTLET AND INLET SIDE OF BLOWER

REQUIRED CLEARANCES

| AREA | A | B | C | CC | D | E |
|---|---|---|---|---|---|---|
| MIN. | .007 | .009 | .014 | .002 | .016 | .004 |
| MAX. | | | | .006 | | |




MEC 3805-237-35/12-5

*Figure 12-5. Rotor clearance chart.*

*g. Installation.*

(1) Install governor drive housing and gasket on blower front end cover and secure with six screws and seal washers.

(2) Cover only block side of gasket (44, fig. 12-3) with gasket cement. Slide cover (4) over drive shaft to aline shaft with splines in gear hub and install blower assembly on engine. Secure blower with screws (1) and lockwashers (2). Tighten screws to a torque of 55 to 60 foot pounds.

(3) Tighten screws (3) securing cover to blower housing. Secure cover seal and clamps to cover.

(4) Install clamp and oil level gage tube on blower rear cover with two screws and lockwashers.

(5) Refer to paragraph 12-19 and install the governor.

(6) Refer to TM 5-3805-237-12 and install the water pump on the blower. Refer to paragraph 12-16 and install the fuel pump.

(7) Refer to paragraph 12-5 and install the air inlet housing.

(8) Refer to paragraph 2-30 and install the air cleaner.

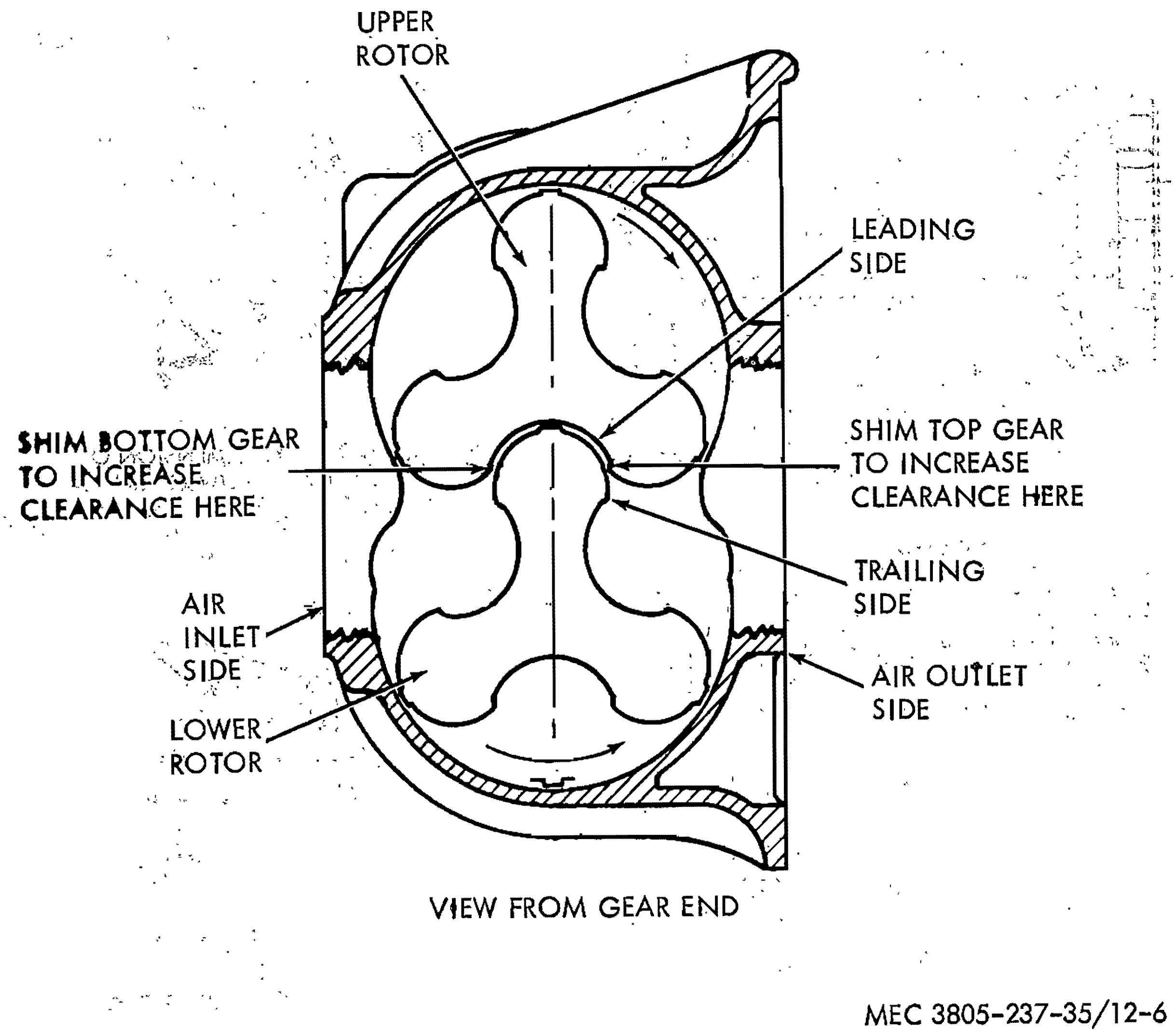



*Figure 12-6. Location of shims to adjust lobe clearances.*

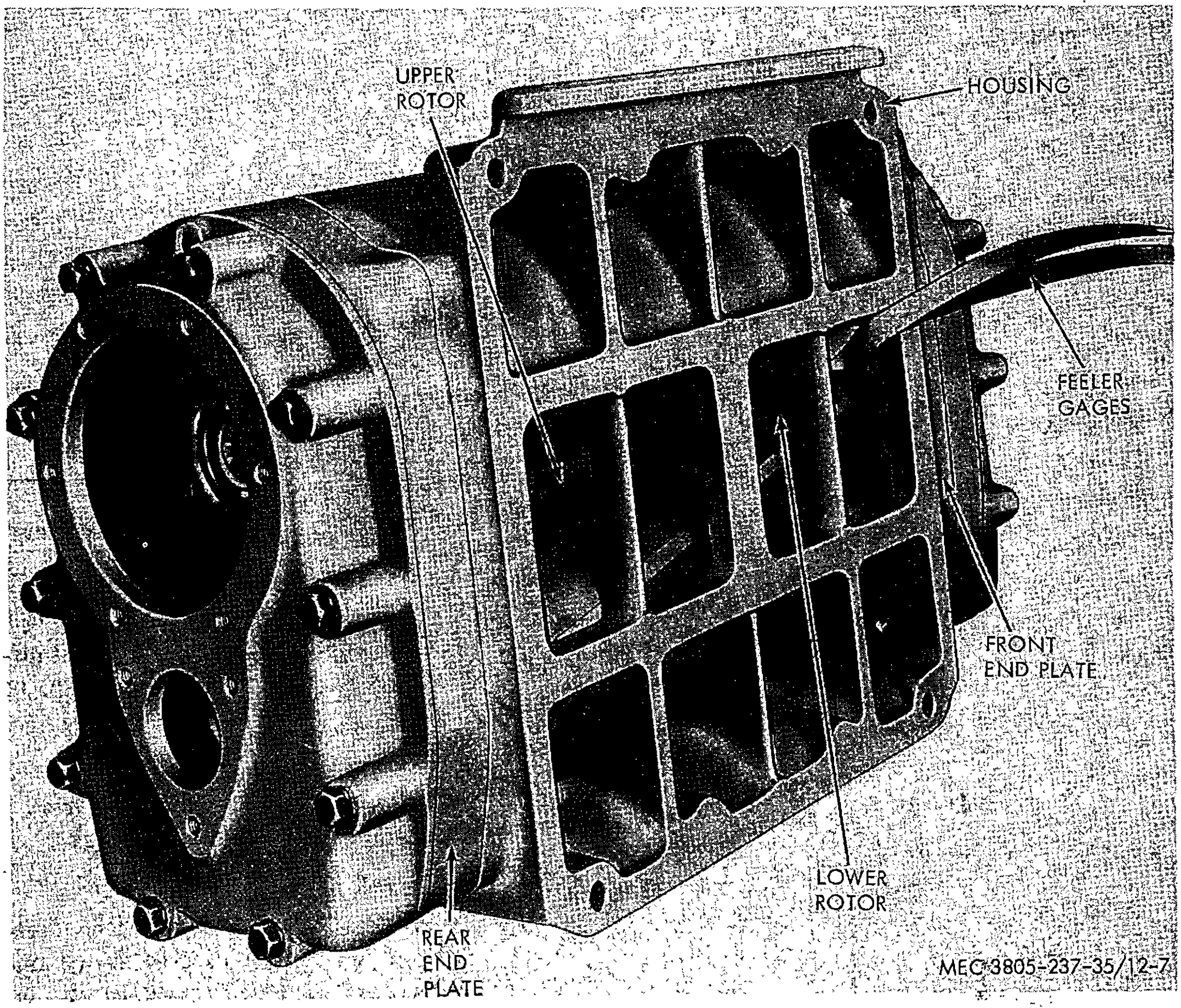



*Figure 12-7. Checking clearance between rotor lobe and housing.*

## Section IV. EXHAUST SYSTEM

### 12-7. General

*a.* The engine exhaust system consists of an air cooled exhaust manifold connected directly to the cylinder head exhaust ports, an exhaust flange or extension, and a vertically mounted muffler. A curved portion of the pipe extending from the muffler serves to direct the exhaust gases away from the operator and aids in keeping water, dirt, and debris out of the exhaust system.

*b.* After the fuel is burned in the cylinders and has forced the piston down in the power stroke the scavenging air from the blower forces the exhaust gases from the cylinder. The gases enter the exhaust manifold, rise up through the flange, and pass through the muffler. A series of baffles within the muffler deaden the sound as the gases pass through and are ejected into the atmosphere.

### 12-8. Exhaust System

*a. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the exhaust muffler and exhaust flange from the engine.

(2) Remove the exhaust manifold from the engine in the numerical sequence as illustrated in figure 12-8 (items 10 through 16). Discard gaskets.

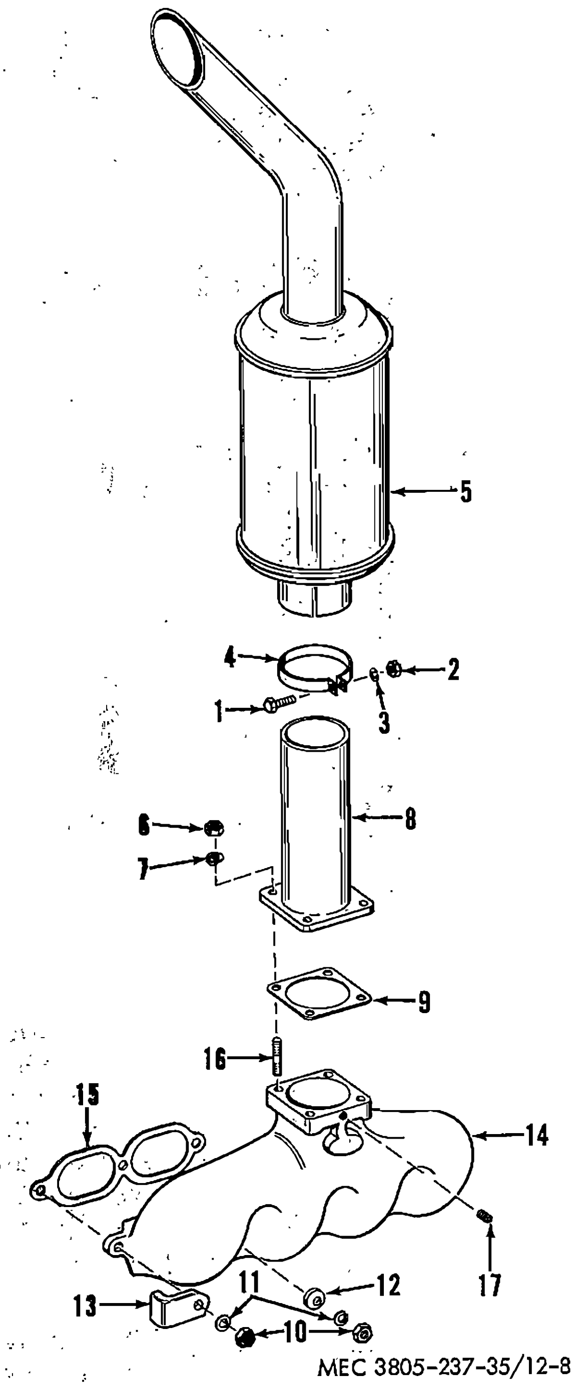



*Figure 12-8. Exhaust system, exploded view.*

1 Screw, cap, hex-head, 5/16-18 × 1 1/4 in.
2 Nut, 5/16-18
3 Washer, lock, 5/16 in.
4 Clamp
5 Muffler
6 Nut, 7/16-20 (4)
7 Washer, lock, 7/16 in.
8 Muffler, flange
9 Flange gasket
10 Nut, 7/16-20 (5)
11 Washer, lock, 7/16 in. (5)
12 Washer (3)
13 Bracket (2)
14 Exhaust manifold
15 Manifold gasket (2)
16 Stud (4)
17 Pipe plug

*Figure 12-8*—Continued.

b. *Cleaning.* Remove loose scale and carbon from manifold, flange, and muffler.

c. *Inspection and Repair.*

(1) Inspect manifold, flange, and muffler for cracks and evidence of leaks.

(2) Inspect studs for damage.

(3) Replace cracked or damaged parts or parts showing evidence of leaks.

d. *Installation.*

(1) Install the exhaust manifold (items 16 through 10) in reverse of the numerical sequence as illustrated on figure 12-8.

(2) Tighten studs to a torque of 25 to 40 foot pounds.

(3) Install manifold nuts (10) on studs and tighten nuts, starting with the two center nuts and working to the ends, to a torque of 30 to 35 foot pounds.

(4) Refer to TM 5-3805-237-12 and install the exhaust flange and muffler. Tighten flange nuts (6) to a torque of 20 to 25 foot pounds.

## Section V. COOLING SYSTEM

### 12-9. General

*a.* The cooling system on the motor grader consists of a radiator, cooling fan, water pump, water manifold, and hoses and tubes. Engine coolant is circulated by the water pump through the engine oil cooler, cylinder block, cylinder head, and water outlet manifold.

*b.* The radiator is mounted on the rear of the motor grader and is protected by a grille. Shrouds attached to the radiator protect the cooling fan. Two taillights, floodlight, and blackout light are mounted on the grille. An inlet hose connects the radiator to the thermostat housing and a similar hose connects the radiator outlet to the oil cooler.

*c.* The coolant flows through the oil cooler to the water pump. From the water pump it enters the lower part of the cylinder block. Passages in the block circulate the coolant around the cylinder bores and up into the cylinder head to cool the valves and fuel injectors.

*d.* A water manifold mounted on the cylinder head carries the collant to the thermostat housing. When the thermostat is open the coolant returns to the radiator through the inlet hose. If the engine has not reached operating temperature and the thermostat is closed, the coolant is by-passed directly to the water pump and through the engine, aiding in decreasing the time required to reach operating temperature.

### 12-10. Radiator, Grille, and Shrouds

*a. Removal.* Refer to TM 5-3805-237-12 and remove the radiator, grille, and shrouds from the motor grader.

*b. Disassembly.* Disassemble the radiator, grille, and shrouds in the numerical sequence as illustrated on figure 12-9.

*c. Cleaning.* Clean all dirt and debris from radiator, grille, and shrouds with water.

*d. Inspection and Repair.*

(1) Inspect radiator tanks and core for leaks and damage. Braze leaks if possible. Replace a badly damaged or leaking radiator.

(2) Inspect shrouds, guards, and grille cover for dents, cracks, and damage. Straighten dents. Replace a badly damaged shroud or guard. Repair guards by welding if possible.

(3) Inspect hoses for kinks, breaks, or evidence of leaks. Replace cracked or leaking hose.

(4) Inspect lights for damaged lenses and burned out lamps. Refer to TM 5-3805-237-12 to replace lenses and lamps.

(5) Inspect all parts for damage. Replace damaged parts. Replace all gaskets.

*e. Reassembly.* Reassemble the radiator, grille, and shrouds in reverse of the numerical sequence as illustrated on figure 12-9.

*f. Installation.* Refer to TM 5-3805-237-12 and install the radiator on the motor grader.

### 12-11. Fan and Pulley

*a. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the radiator, shrouds, and fan from the motor grader.

(2) Remove the fan shaft and fan pulley and hub from the engine in the numerical sequence as illustrated on figure 12-10.

*b. Disassembly.* Disassemble the fan hub and pulley in the numerical sequence as illustrated on figure 12-10.

(1) Using an arbor press and suitable tool, press fan shaft (17, fig. 12-10) from fan pulley and hub (13).

(2) Press oil seals, bearings, shims, and spacer from pulley and hub.

*c. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry with compressed air.

*Warning:* **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect fan blades for dents and bent condition. Blades must be in good condition or excessive vibration may result. Straighten bent blades to correct contour if possible. If badly bent, replace fan.

(3) Inspect bearings for serviceable condition. Inspect fan shaft for wear, burs, and scoring. Remove burs with fine emery cloth. Replace fan shaft if worn or badly scored.

(4) Replace all worn or damaged parts.

*e. Reassembly.*

(1) Reassemble the fan hub and pulley in reverse of the numerical sequence as illustrated on figure 12-1.

(2) Press ball bearing (12) and oil seal (11) in bore of pulley and hub. Pack bore of hub with high temperature bearing grease (BR).

(3) Press spacer (10) and oil seal (9) in hub. Place pulley and hub on a block and press fan shaft (17) through bearing, oil seal, and spacer. Do not damage oil seal when installing shaft through hub.

(4) Install shims (8) (same number as removed at disassembly) and roller bearing (7) in hub and secure with washer (6) and screw (5). Place cap (4) in bore of hub.

(5) Install support (25) on engine and secure with two screws (20) and screw (23).

*f. Installation.*

(1) Place fan belts (26) around fan pulleys and crankshaft pulleys and install fan shaft on support. Secure with four screws (14).

(2) Refer to TM 5-3805-237-12 and adjust fan belt tension.

(3) Refer to TM 5-3805-237-12 and install the radiator and shrouds on the motor grader.

## 12-12. Water Pump, Thermostat, and Water Outlet Manifold

*a. General.* The water pump is driven by a shaft from the blower. The coolant enters the pump from the oil cooler. A bypass tube connects the thermostat housing to the water pump and re-circulates coolant through the engine until the engine reaches operating temperature. Coolant enters the thermostat housing from the water manifold.

*b. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the thermostat and water pump from the engine. Remove screw (7, fig. 12-12) and drive coupling (8, fig. 12-12) from blower.

(2) Remove water outlet manifold from engine in the numerical sequence as illustrated on figure 12-11 (items 17 through 24). Discard all gaskets.

*c. Disassembly.* Disassemble the water pump in the numerical sequence as illustrated on figure 12-12 and the following instructions. Discard all packings and gaskets.

(1) Use a short steel bar and an arbor press and press the shaft through the impeller to shear the taper pin (22) and remove the shaft from the pump and impeller.

(2) Remove impeller (21) and seal assembly (19) from the pump body.

(3) Inspect steel insert (18) and if insert is worn, tap or press insert from body.

(4) Remove the water slinger from the shaft.

(5) If drive coupling (15) is damaged, install a round steel bar, slightly smaller in diameter than coupling bore, in a vice. Place coupling and shaft and bearing on bar. Use a steel pipe, with a larger inside diameter than the bearing, to drive coupling from shaft.

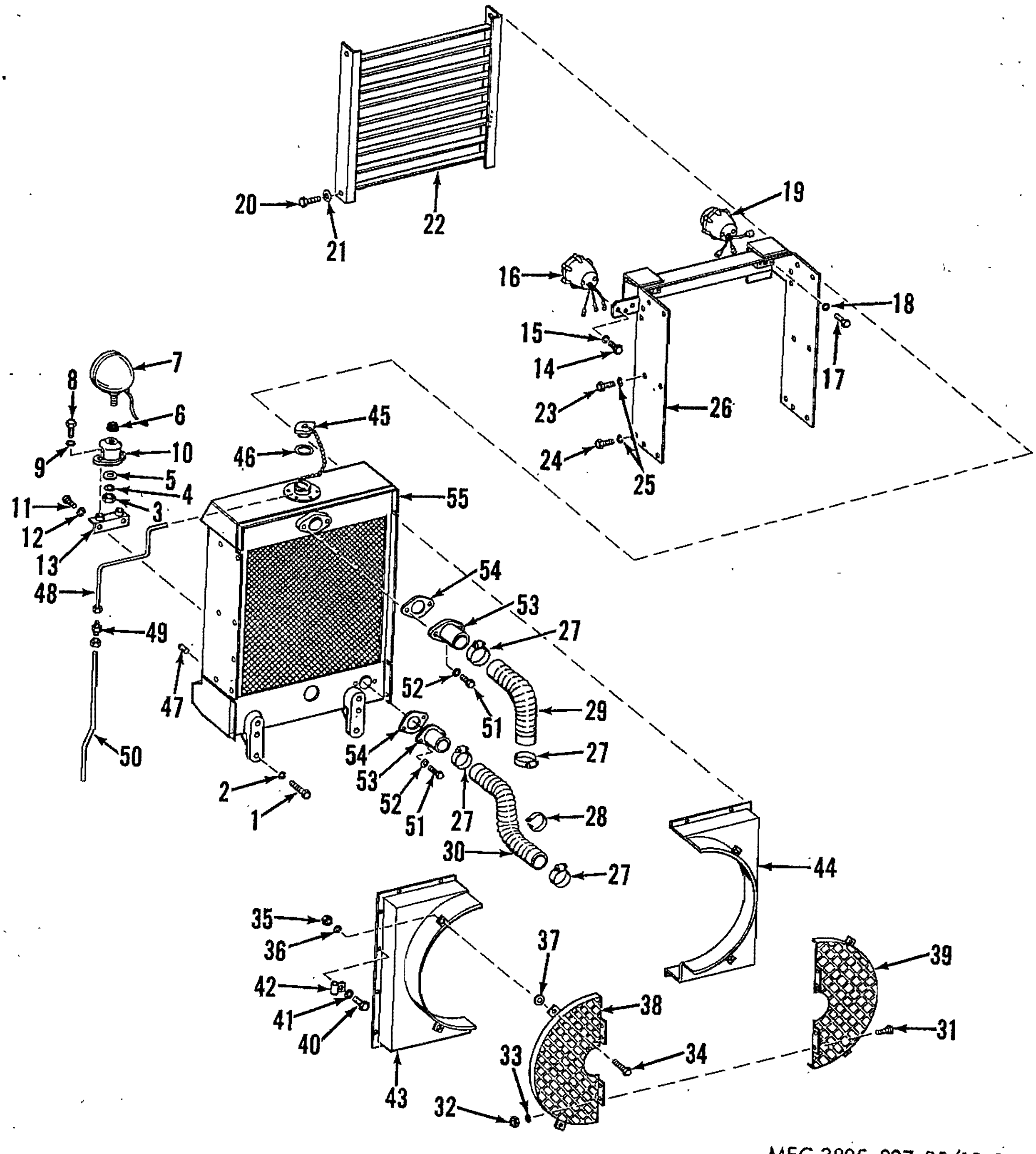
(6) Use a punch to drive sheared taper pin from shaft and impeller. Tap against small end of pin.

*d. Cleaning.* Clean all parts, except shaft and bearing, in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly. Clean shaft and bearing in light oil (OE 10).

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

*e. Inspection and Repair.*

(1) Rotate pump shaft bearing slowly by hand. Bearing must rotate smoothly with no evidence of rough

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1 Screw, cap, hex-head, 5/8-16 × 2 in. (6)
2 Washer, lock, 5/8 in. (6)
3 Nut, 5/16-18
4 Washer, lock, 5/16 in.
5 Washer
6 Washer, rubber
7 Floodlight

*Figure 12-9. Radiator, grille, and shrouds, exploded view.*

8 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (2)
9 Washer, lock, 3/8 in. (2)
10 Lamp bracket
11 Screw, cap, hex-head, 1/2-13 × 1 1/4 in. (2)
12 Washer, lock, 1/2 in. (2)
13 Mounting bracket
14 Screw, cap, hex-head, 3/8-16 × 7/8 in. (2)
15 Washer, lock, 3/8 in. (2)
16 Blackout taillight
17 Screw, cap, hex-head, 3/8-16 × 1 in. (4)
18 Washer, lock, 3/8 in. (4)
19 Taillight (2)
20 Screw, cap, hex-head, 5/16-18 × 1/2 in. (4)
21 Washer, lock, 5/16 in. (4)
22 Grille
23 Screw, cap, hex-head, 5/16-18 × 1/2 in. (12)
24 Screw, cap, hex-head, 5/16-18 × 3/4 in. (2)
25 Washer, lock, 5/16 in. (14)
26 Radiator shell
27 Clamp (4)
28 Clamp
29 Inlet hose
30 Outlet hose
31 Screw, cap, hex-head, 1/4-20 × 1/2 in. (4)
32 Nut, 1/4-20 (4)
33 Washer, lock, 1/4 in. (4)
34 Screw, cap, hex-head, 5/16-18 × 3/4 in. (4)
35 Nut, 5/16-18 (4)
36 Washer, lock, 5/16 in. (4)
37 Washer, flat, 5/16 in.
38 Right fan guard
39 Left fan guard
40 Screw, cap, hex-head, 3/8-16 × 1/2 in. (16)
41 Washer, lock, 3/8 in. (16)
42 Clamp (3)
43 Right fan shroud
44 Left fan shroud
45 Radiator cap
46 Cap gasket
47 Drain plug
48 Upper overflow tube
49 Tube union
50 Lower overflow tube
51 Screw, cap, hex-head, 1/2-13 × 1 in. (4)
52 Washer, lock, 1/2 in. (4)
53 Hose flange (2)
54 Flange gasket (2)
55 Radiator

*Figure 12-9*—Continued.

spots. Replace shaft and bearing if rough spots are detected.

(2) Inspect impeller and seal for wear and damage. Replace either if damage is evident. Seal must be replaced as an assembly including the spring.

(3) Inspect pump body and counterbore for wear and scoring. Replace body if counterbore is damaged.

(4) Inspect thermostat housing and manifold for cracks and evidence of leaks. Repair cracks and leaks if possible. Replace damaged housing or manifold.

(5) Refer to TM 5-3805-237-12 and test the thermostat. Replace thermostat if it does not operate properly.

(6) Inspect hoses and clamps for good condition, and evidence of leaks or damage. Replace leaking hose or damaged clamp.

(7) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.* Reassemble the water pump in reverse of the numerical sequence as illustrated on figure 12-12 and the following instructions.

(1) If studs (25) were removed, seal threads on studs and tighten studs in body to a torque of 10-12 foot pounds.

(2) Check counterbore of pump body (26) for any evidence of dirt before installing steel insert. Clean thoroughly before installing insert. Press steel insert (18) into pump body, counterbored end first, until insert contacts shoulder. The insert is a 0.0015 to 0.0033 press fit in the body.

*Note.* Do not damage highly polished seal contact surface on insert when pressing insert into body.

(3) Install slinger (17) on shaft and bearing (16) with flange of slinger 3/16 inch from end of bearing.

(4) Support impeller end of pump body on an arbor press and press slinger end of shaft and bearing into pump body. Press against outer race of bearing until bearing contacts shoulder in pump body. Stake the end of pump body in three places around bearing to prevent bearing from moving.

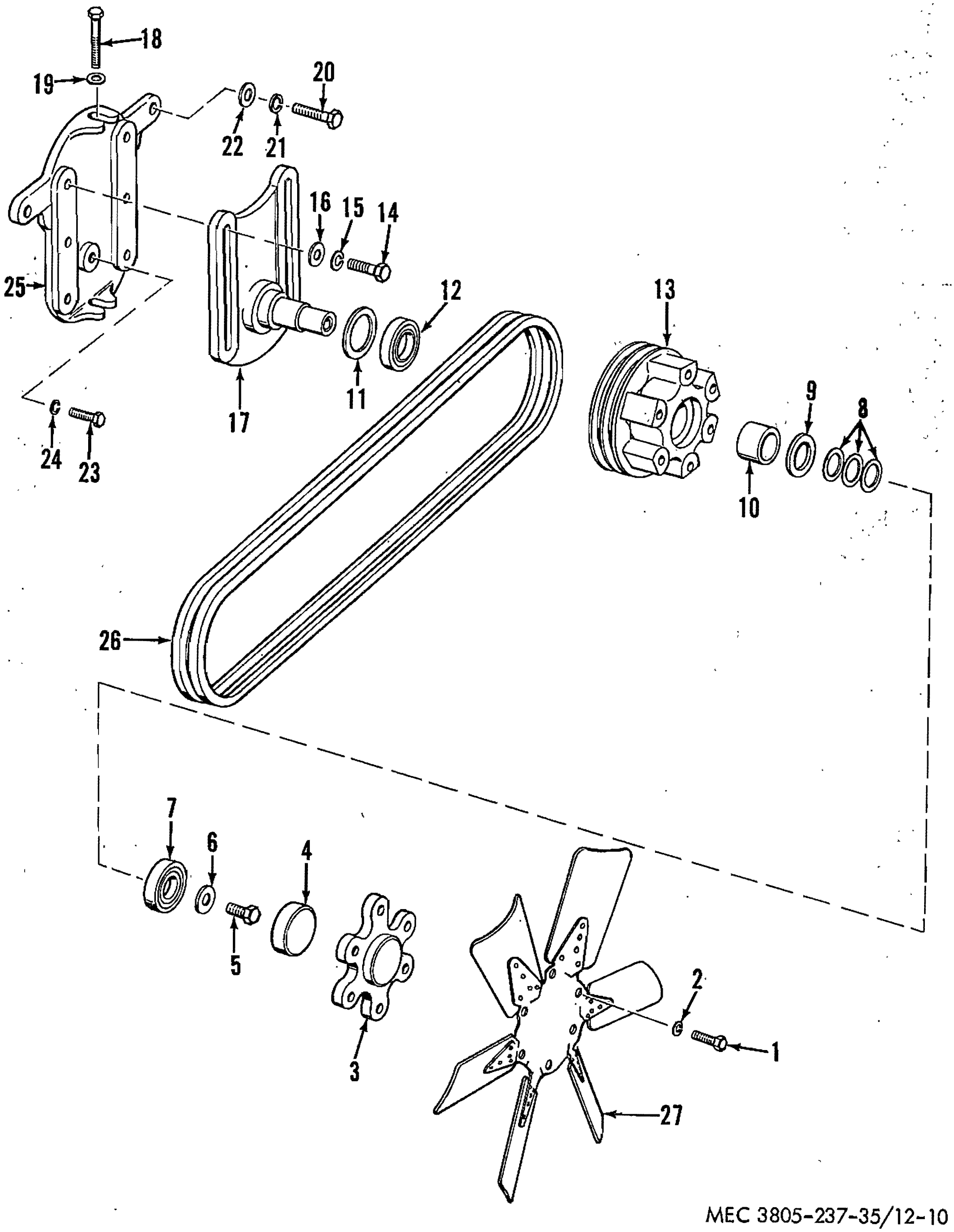



*Figure 12-10. Fan and mounts, exploded view.*

1 Screw, cap, hex-head, 5/16-18 × 1 1/4 in. (6)
2 Washer, lock, 5/16 in. (6)
3 Spacer
4 Cup
5 Screw, cap, hex-head, 1/2-20 × 1/2 in.
6 Washer, bearing
7 Roller bearing
8 Shim
9 Oil seal
10 Spacer
11 Oil seal
12 Ball bearing
13 Pulley and hub
14 Screw, cap, hex-head, 7/16-14 × 1 3/8 in. (4)
15 Washer, lock, 7/16 in. (4)
16 Washer, flat, 7/16 in. (4)
17 Fan shaft
18 Screw, cap, hex-head, 5/16-18 × 5 in.
19 Washer, flat, 5/16 in.
20 Screw, cap, hex-head, 3/8-16 × 4 1/2 in. (2)
21 Washer, lock, 3/8 in. (2)
22 Washer, flat (2)
23 Screw, cap, hex-head, 1/2-13 × 1 1/2 in.
24 Washer, lock, 1/2 in.
25 Fan mounting support
26 Fan belt (2)
27 Fan

*Figure 12-10*—Continued.

(5) Apply a thin film of oil (OE 10) to face of steel insert. Apply a thin coat of liquid soap to the inside diameter of the seal assembly (19). Slide seal assembly on pump shaft until carbon seal washer is firmly seated against steel insert.

(6) Install spring (20) on shaft with small end toward seal. Install impeller (21) on shaft with pin hole in shaft alined midway between two adjacent blades on impeller.

(7) Support bearing end of shaft in an arbor press. Place a piece of steel pipe, with an inside diameter larger than the shaft, down on impeller and press the impeller on the shaft. Face of impeller must be 0.052 to 0.072 inch above face of pump body.

(8) Drill a hole, using a 0.184 drill, through impeller hub to aline with hole in shaft. Drive taper pin (22) into hub and shaft.

(9) Support impeller end of pump shaft and install drive coupling (15) on shaft. Drive coupling on shaft, using a brass hammer, until face of coupling is flush with end of shaft.

*Note.* Drive coupling must be tight on shaft.

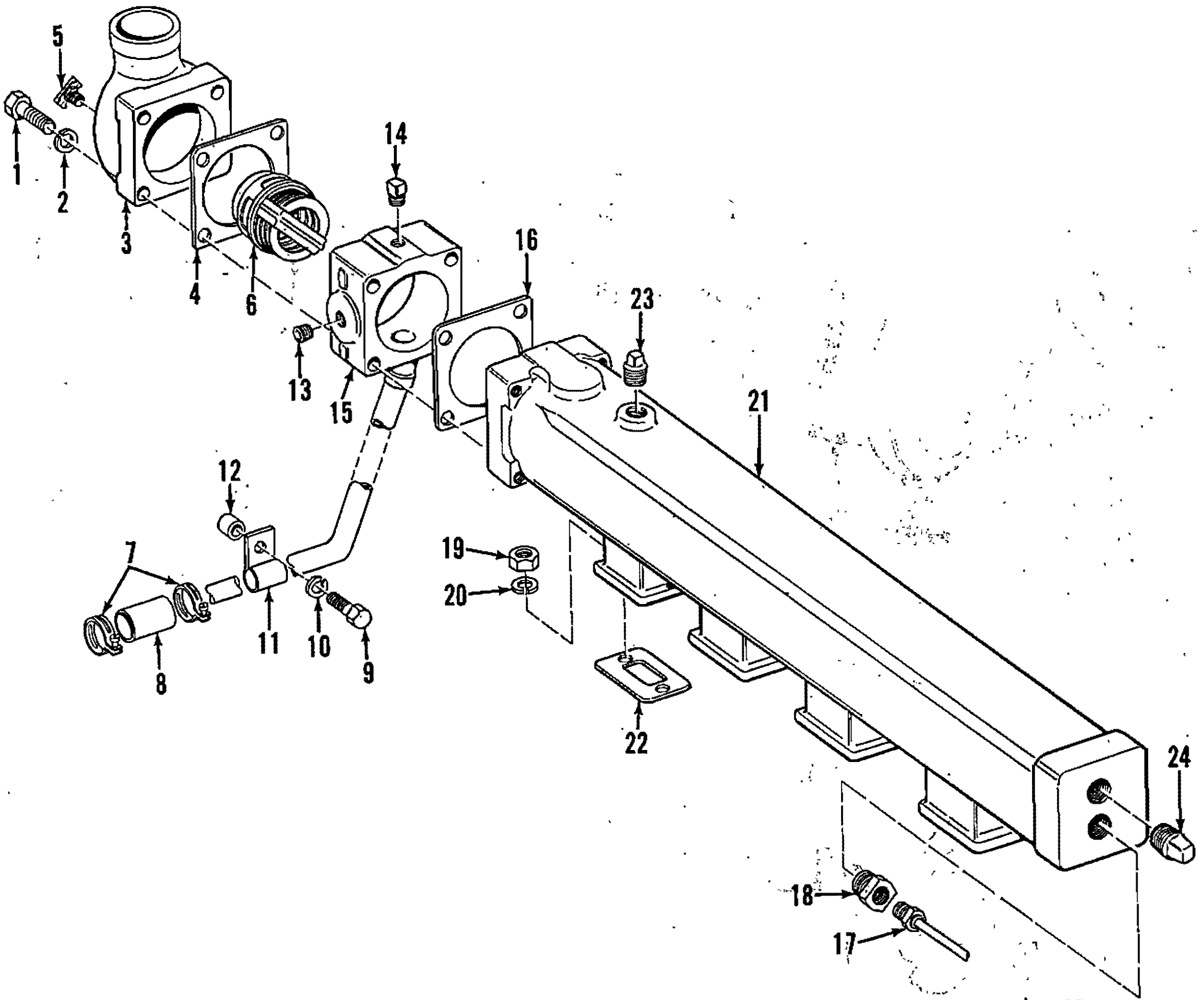
(10) Install pump cover and complete reassembly of water pump.

*g. Installation.*

(1) Install blower drive coupling (8, fig. 12-12) on blower shaft and secure with screw (7, fig. 12-12). Tighten screw to a torque of 15 to 19 foot pounds. Refer to TM 5-3805-237-12 and install the water pump on engine.

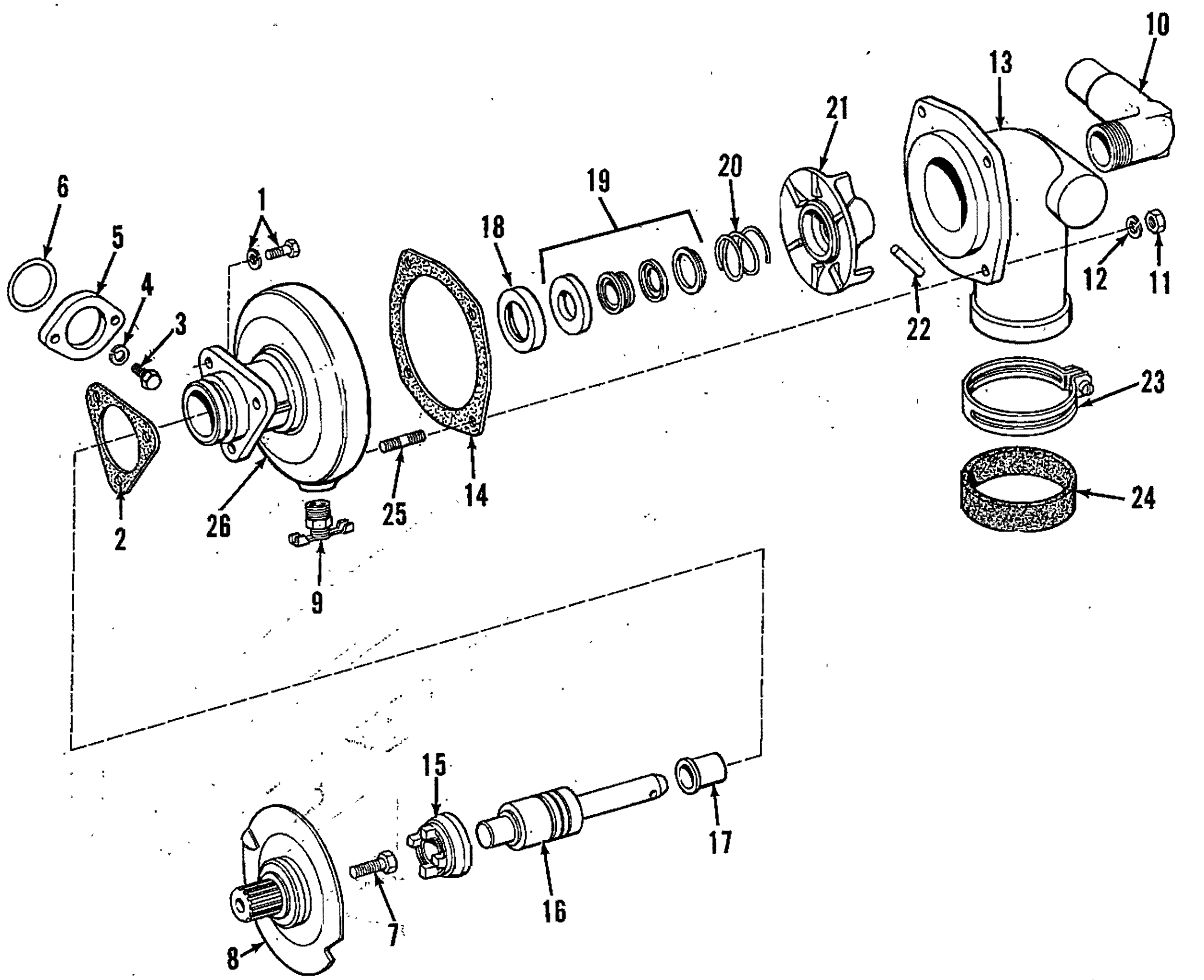
(2) Install water outlet manifold and thermostat housing on engine in reverse of the numerical sequence an illustrated on figure 12-11.

(3) Refer to TM 5-3805-237-12 and install the thermostat in the thermostat housing.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 5/16-18 × 2 1/2 in. (4) | 13 | Pipe plug (2) |
| 2 | Washer, lock, 5/16 in. (4) | 14 | Pipe plug |
| 3 | Outlet elbow | 15 | Housing and bypass tube |
| 4 | Gasket | 16 | Gasket |
| 5 | Drain cock | 17 | Temperature gage sending unit |
| 6 | Thermostat | 18 | Pipe bushing |
| 7 | Clamp(2) | 19 | Nut, 3/8-24 (8) |
| 8 | Hose | 20 | Washer, lock, 3/8 in. (8) |
| 9 | Screw, cap, hex-head, 3/8-16 × 1 7/8 in | 21 | Water outlet manifold |
| 10 | Washer, lock, 3/8 in. | 22 | Gasket (4) |
| 11 | Clamp | 23 | Pipe plug |
| 12 | Spacer | 24 | Pipe plug |

*Figure 12-11. Thermostat and water outlet manifold, exploded view.*




| | | | |
|---|---|---|---|
| 1 | Screw, w/washer (3) | 14 | Cover gasket |
| 2 | Gasket | 15 | Drive coupling |
| 3 | Screw, cap, hex-head, 5/16-18 × 1 1/2 in. (2) | 16 | Shaft and bearing |
| 4 | Washer, lock, 5/16 in. (2) | 17 | Slinger |
| 5 | Outlet flange | 18 | Steel insert |
| 6 | Flange packing | 19 | Seal assembly |
| 7 | Screw ,cap, hex-head, 5/16-24 × 1 1/2 in. | 20 | Spring |
| 8 | Blower drive coupling | 21 | Impeller |
| 9 | Drain cock | 22 | Taper pin |
| 10 | Elbow connector | 23 | Clamp |
| 11 | Nut, 1/4-28 (4) | 24 | Seal |
| 12 | Washer, lock, 1/4 in. (4) | 25 | Stud (4) |
| 13 | Pump cover | 26 | Pump body |

*Figure 12-12. Water pump assembly, exploded view.*

## Section V. FUEL SYSTEM

### 12-13. General

*a.* The fuel system on the motor grader consists of a fuel tank mounted behind the cab assembly, fuel outlet and return lines, a fuel strainer (primary filter), fuel pump, fuel filter (secondary filter) fuel manifolds, and the fuel injectors.

*b.* Control of the fuel is maintained by a mechanical variable speed governor, operated through a linkage by either a foot accelerator or hand throttle. An accelerator-decelerator assembly in the linkage allows the operator to depress a rear pedal and decelerate the engine when slowing or shifting gears.

*c.* The maximum speed of the engine (governor overrrun) is 2,140 rpm, with a governed speed of 1,975 rpm. Drive for the governor is supplied by the blower shaft. The governor is lubricated through oil lines from the engine block.

*d.* Fuel is drawn from the fuel tank (fig. 12-13) through the fuel strainer by the fuel pump. From the fuel pump the fuel is forced under pressure through the fuel filter (fig. 12-13). From the fuel filter the fuel is forced into the inlet manifold and to the inlet side of the injectors. Excess fuel, or fuel not used in engine operation, is returned through the outlet manifold to the fuel tank through the fuel return line. The fuel manifolds are cast as an integral part of the cylinder head. The elbow or fitting from the outlet fuel manifold has a restricted opening to maintain the proper pressure within the fuel system.

*e.* The injectors are located in the cylinder head and are protected by valve rocker cover. Fuel connectors in the cylinder head connect the injectors to the fuel manifolds, with fuel inlet and outlet pipes (fig. 12-13) delivering fuel to and from the injectors.

### 12-14. Fuel Tank and Lines

*a. General.* The fuel tank is mounted at the rear of the cab assembly. The tank supports the cold weather starting aid valve and voltage regulator on the engine compartment side of the tank. A bracket, on the left side of the tank, supports the air cleaner. The right side of the tank support has the hourmeter and battery charging receptacle. A large welded tank within the left side of the fuel tank contains the hydraulic reservoir and filter.

*b. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the following:
  (*a*) Throttle linkage.
  (*b*) Voltage regulator.
  (*c*) Hourmeter and battery charging receptacle.
  (*d*) Hydraulic reservoir filter.
  (*e*) Engine hood.

(2) Refer to paragraph 2-30 and remove the air cleaner.

(3) Refer to paragraph 12-5 and remove the engine emergency shutdown cable and cold weather starting aid.

(4) Refer to paragraph 7-4 and disconnect hydraulic lines from hydraulic reservoir.

(5) Remove all clamps and wires attached to the fuel tank.

(6) Remove the drain plug and drain the fuel tank into a suitable container.

(7) Remove the fuel tank in the numerical sequence as illustrated on figure 12-14 (items 23 through 47) and the following instructions.

(8) Disconnect fuel outlet line (25) from elbow (30) and engine outlet tube.

(9) Disconnect return fuel line (24) from union (26) and fuel strainer.

(10) Remove nylon ties (23) and remove fuel lines.

*c. Cleaning.* Clean dirt and debris from all external parts with water and wipe dry. Clean strainers and interior of fuel tank and hydraulic reservoir with cleaning compound, solvent (Spec. P-S-661) and dry thoroughly. Remove all traces of solvent from fuel tank, strainers, and reservoir.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

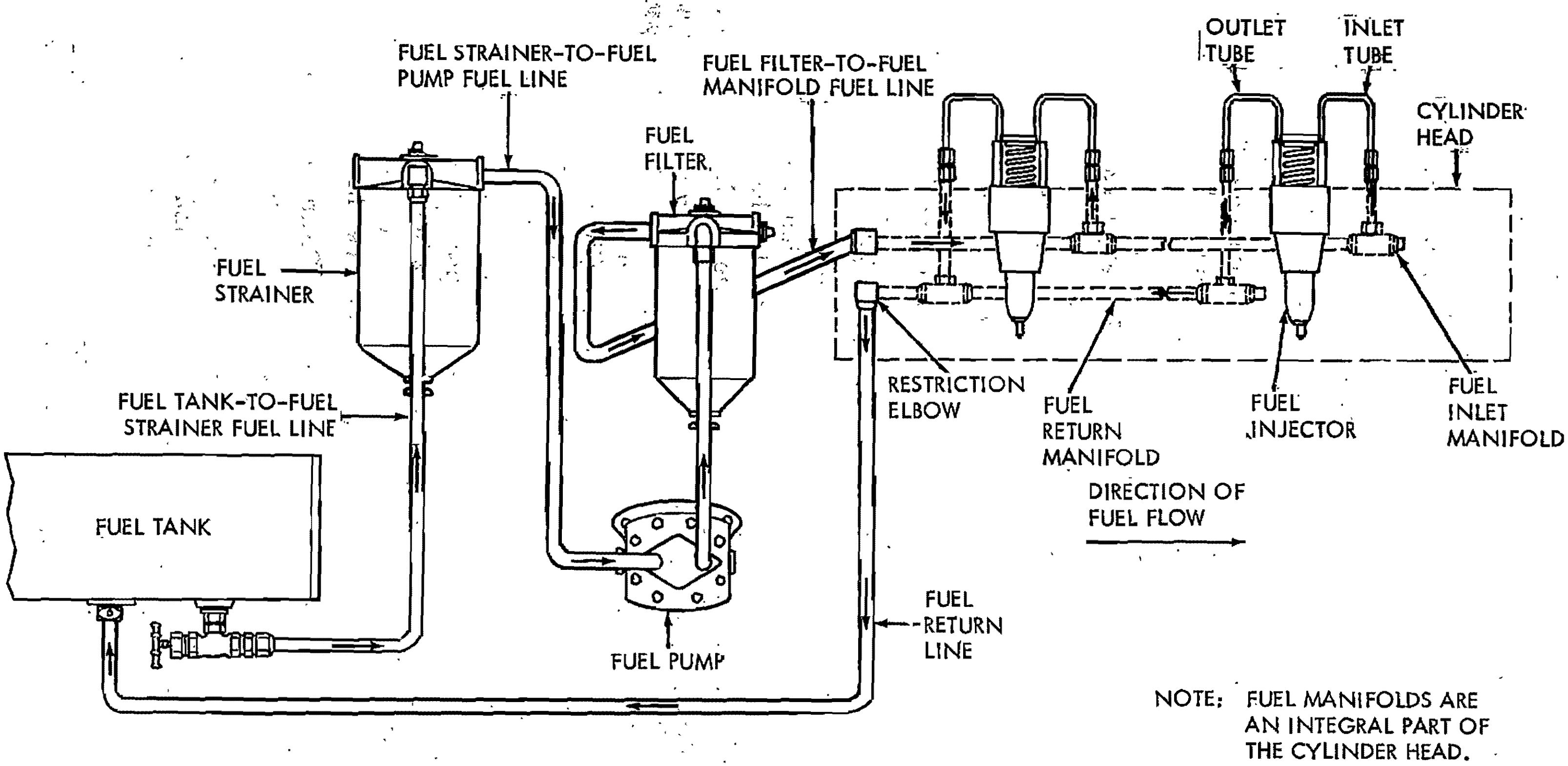



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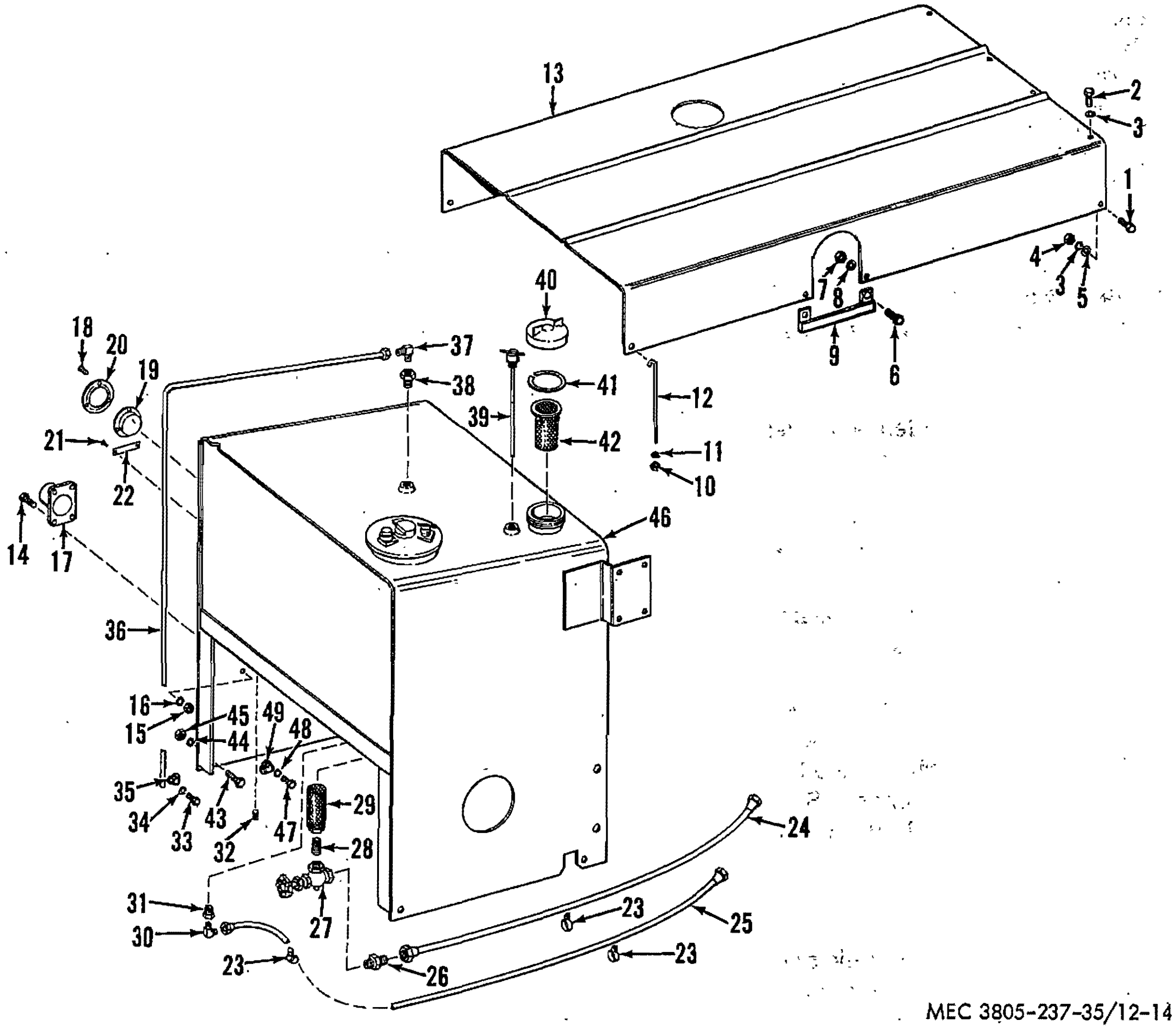
*Figure 12-13. Fuel system, schematic diagram.*




1 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (2)
2 Screw, cap, hex-head, 3/8-16 × 3/4 in. (4)
3 Washer, lock, 3/8 in. (6)
4 Nut, 3/8-16 (2)
5 Washer, cut, 3/8 in. (2)
6 Screw, cap, hex-head, 3/8-16 × 1 1/8 in. (2)
7 Nut, 3/8-16 (2)
8 Washer, lock, 3/8 in. (2)
9 Bar
10 Nut, lock, 5/16-18 (2)
11 Washer, cut, 5/16 in. (2)
12 Hook bolt (2)
13 Engine hood
14 Screw, cap, hex-head, 1/4-20 × 3/4 in. (4)
15 Nut, 1/4-20 (4)
16 Washer, lock, 1/4 in. (4)
17 Battery charging receptacle
18 Screw, machine (3)
19 Hourmeter
20 Resilient mount
21 Screw, machine (2)
22 Identification plate
23 Nylon tie (3)
24 Return fuel line
25 Outlet fuel line
26 Union
27 Shutoff valve
28 Pipe fitting
29 Lower fuel strainer
30 Elbow
31 Pipe bushing
32 Drain plug

*Figure 12-14. Fuel tank and engine hood, exploded view.*

33 Screw, cap, hex-head, 5/16-18 × 1/2 in.
34 Washer, lock, 5/16 in.
35 Clamp
36 Overflow tube
37 Elbow
38 Compression
39 Fuel tank dipstick
40 Fuel tank filler cap
41 Cap gasket
42 Upper fuel strainer
43 Screw, cap, hex-head, 5/8-16 × 1 1/2 in. (4)
44 Washer, flat, 5/8 in. (4)
45 Nut, lock, 5/8-26
46 Fuel tank
47 Screw, cap, hex-head (3)
48 Washer, lock (3)
49 Cushioned clamp (3)

*Figure 12-14*—Continued.

d. *Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect fuel tank, reservoir, and fuel lines for evidence of leaks. Inspect fuel lines for cracks and deterioration.

(3) Repair leaks in tank and reservoir by welding if possible. Replace a badly damaged tank.

(4) Replace leaking, cracked, or deteriorated fuel lines.

(5) Inspect overflow tube for dents and bends. Straighten tube if possible. Replace damaged tube.

(6) Inspect engine hood for cracks, bends, or damage. Straighten hood if possible. Replace a badly damaged hood.

(7) Replace all worn or damaged parts.

e. *Installation.*

(1) Install the fuel tank and components in reverse of the numerical sequence as illustrated on figure 12-14 (items 47 through 23).

(2) Connect outlet and return fuel lines to the fuel strainer and engine outlet tube.

(3) Connect all wires and install clamps on fuel tank.

(4) Refer to paragraph 2-30 and install the air cleaner.

(5) Refer to paragraph 7-4 and connect the hydraulic lines to the reservoir.

(6) Refer to paragraph 12-5 and install the engine emergency shutdown cable and the cold weather starting aid.

(7) Refer to TM 5-3805-237-12 and install the following:

(*a*) Engine hood

(*b*) Hydraulic reservoir filter

(*c*) Hourmeter and battery charging receptacle

(*d*) Voltage regulator

(*e*) Throttle linkage.

## 12-15. Fuel Filter and Fuel Strainer

a. *General.* The fuel strainer and fuel filter are mounted on the right side of the engine forward of the blower. The fuel strainr has a cloth or "sock-type" element and is connected between the fuel tank and the fuel pump. The fuel filter is connected between the fuel pump and the fuel manifold.

b. *Removal.* Refer to figure 12-15 and remove the fuel filter and fuel strainer and lines from the engine.

c. *Disassembly.* Disassemble the fuel filter and fuel strainer in the numerical sequence as illustrated in figure 12-1. Discard all gaskets, seals and elements.

*Note.* Refer to TM 5-3805-237-12 for service instructions pertaining to the fuel filter and strainer.

d. *Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry with compressed air.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

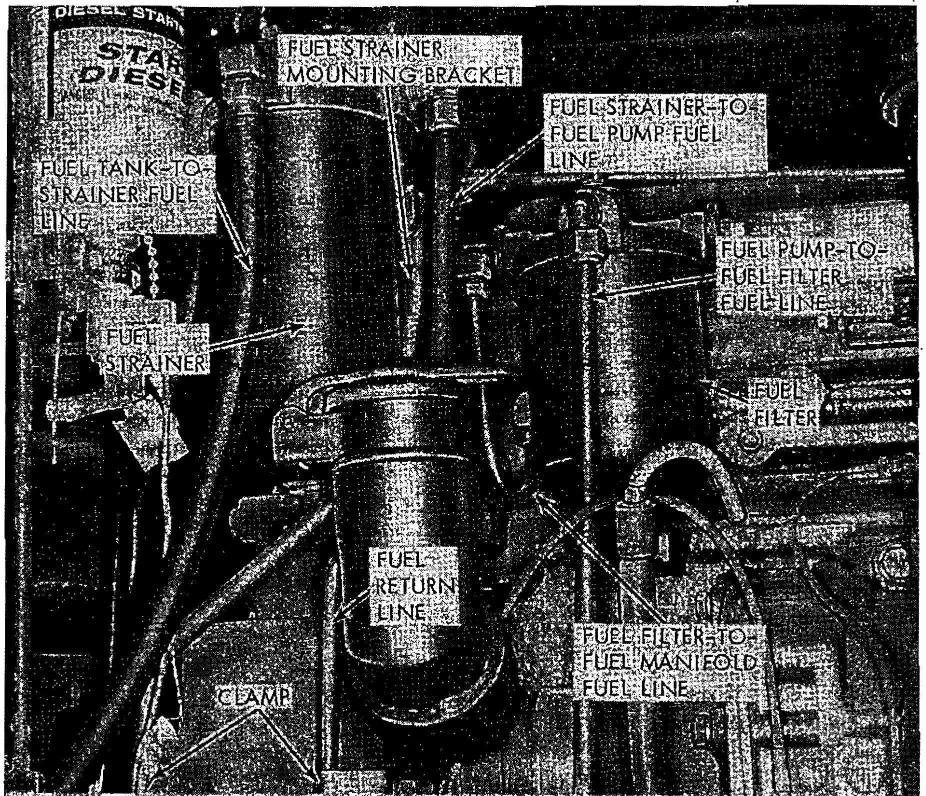
e. *Inspection and Repair.*

(1) Inspect all parts for cracks, damage, and evidence of leaks.

(2) Inspect fuel lines for bends or damage which might restrict flow of fuel. Straighten lines, if possible. Replace damaged fuel lines.

(3) Inspect manifold elbows for damaged threads and leak proof fit. Replace elbows with damaged threads.

(4) Replace all damaged or leaking parts.




STEP 1. OPEN DRAIN COCKS AND DRAIN FILTER AND STRAINER.
STEP 2. DISCONNECT FUEL TANK-TO-STRAINER FUEL LINE FROM STRAINER.
STEP 3. REMOVE SCREW AND WASHER AND REMOVE CLAMP.
STEP 4. DISCONNECT FUEL STRAINER-TO-FUEL PUMP FUEL LINE FROM STRAINER AND FUEL PUMP.
STEP 5. REMOVE TWO SCREWS, LOCK WASHERS, AND NUTS AND REMOVE FUEL STRAINER FROM BRACKET.
STEP 6. REMOVE TWO SCREWS AND LOCK WASHERS AND REMOVE FUEL STRAINER MOUNTING BRACKET.
STEP 7. DISCONNECT FUEL PUMP-TO-FUEL FILTER FUEL LINE FROM FUEL FILTER AND FUEL PUMP. REMOVE NYLON TIES AND REMOVE FUEL LINE.
STEP 8. DISCONNECT FUEL FILTER-TO-FUEL MANIFOLD FUEL LINE FROM FUEL FILTER.
STEP 9. REMOVE TWO SCREWS, LOCK WASHERS, AND FLAT WASHERS AND REMOVE FUEL FILTER.
STEP 10. DISCONNECT FUEL FILTER-TO-FUEL MANIFOLD FUEL LINE FROM ELBOW IN MANIFOLD. REMOVE ELBOW FROM MANIFOLD.
STEP 11. DISCONNECT FUEL RETURN LINE FROM ELBOW IN FUEL MANIFOLD AND FUEL TANK RETURN LINE. REMOVE ELBOW FROM MANIFOLD.
STEP 12. REMOVE NUT AND LOCK WASHER AND REMOVE CLAMP AND FUEL RETURN LINE.

NOTE: AFTER INSTALLING, FILL FILTER AND STRAINER WITH CLEAN DIESEL FUEL TO PRIME FUEL SYSTEM.

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*Figure 12-15. Fuel filter and strainer, removal and installation.*

*f. Reassembly.* Reassemble the fuel filter and fuel strainer in reverse of the numerical sequence as illustrated on figure 12-16.

*g. Installation.* Refer to figure 12-15 and install the fuel filter, fuel strainer, and fuel lines.

(1) Remove pipe plugs in fuel filter and fuel strainer covers and fill strainer and filter with clean fuel to prime filters.

(2) Start grader engine (TM 5-3805-237-12) and check fuel system for leaks.

## 12-16. Fuel Pump

*a. General.* The fuel pump is a positive displacement gear type pump. The pump sucks the fuel from the fuel tank, through the fuel strainer, and delivers it to the fuel filter and injectors. To assure a sufficient quantity of fuel at the injectors the pump circulates an excess supply of fuel. The unused fuel is returned to the fuel tank through the return fuel line. Drive for the fuel pump is supplied from the blower. The shaft rotates in two oil seals to prevent leakage. The pump cover and body are set on two dowel pins to assure correct shaft alinement. The cover and body mating surfaces are perfectly flat and require no gasket. Two gears provide the pumping action. A relief valve in the pump body will by-pass fuel to prevent excessive discharge pressures. Refer to figure 12-17 for a cutaway view of the fuel pump.

*b. Removal.* Refer to figure 12-18 and remove the fuel pump from the engine. Remove the drive coupling fork (2, fig. 12-19) from the pump drive shaft. Remove gasket (3, fig. 12-19).

*c. Disassembly.* Disassemble the pump in the numerical sequence as illustrated on figure 12-19 and the following instructions. Discard all gaskets and oil seals, if removed.

(1) Remove drain tube (4) from pump body. Remove fittings and pipe plug.

(2) Secure the fuel pump in a vise with soft jaws or suitable holding fixture with the pump cover side up. Remove eight screws with seal washers (8) and remove pump cover (9). Carefully remove cover to prevent damage to finished face of body and cover.

(3) Remove drive shaft and drive gear from pump body. Press drive shaft (13), square end up, from drive gear (12) far enough to remove ball (11). Reverse shaft and press shaft from drive gear. Do not press square end through drive gear to prevent damage to oil seal contact surface on shaft.

(4) Remove driven shaft (14) and gear (15) from pump body. Do not separate gear and shaft.

(5) Remove relief valve plug and parts from pump body.

(6) Inspect all seals (21) for damage and condition of sealing surfaces. If seals are damaged, remove seals. Check position of inner oil seal lip before removing. Install new seal in same position.

(7) Clamp pump body in a vise with soft jaws. Use a suitable tool to drive seals from pump body.

*d. Cleaning.* Clean all pump parts in clean fuel oil and blow dry with compressed air.

*e. Inspection and Repair.*

(1) Inspect teeth of gears for scoring, chipping, and wear. Check ball slot in drive gear for wear. Replace gears if scored, clipped, or worn.

*Note.* Driven gear and shaft must be replaced as an assembly.

(2) Inspect the drive and driven shafts for scoring or wear. Check seal contact surface of drive shaft for scoring. Replace shafts if scored or worn.

(3) Inspect pump body and cover for scratches and damage to finished faces. Replace body or cover if face is scored or damaged. Inspect for wear at contact surfaces for shafts and gears. Replace cover or body if worn.

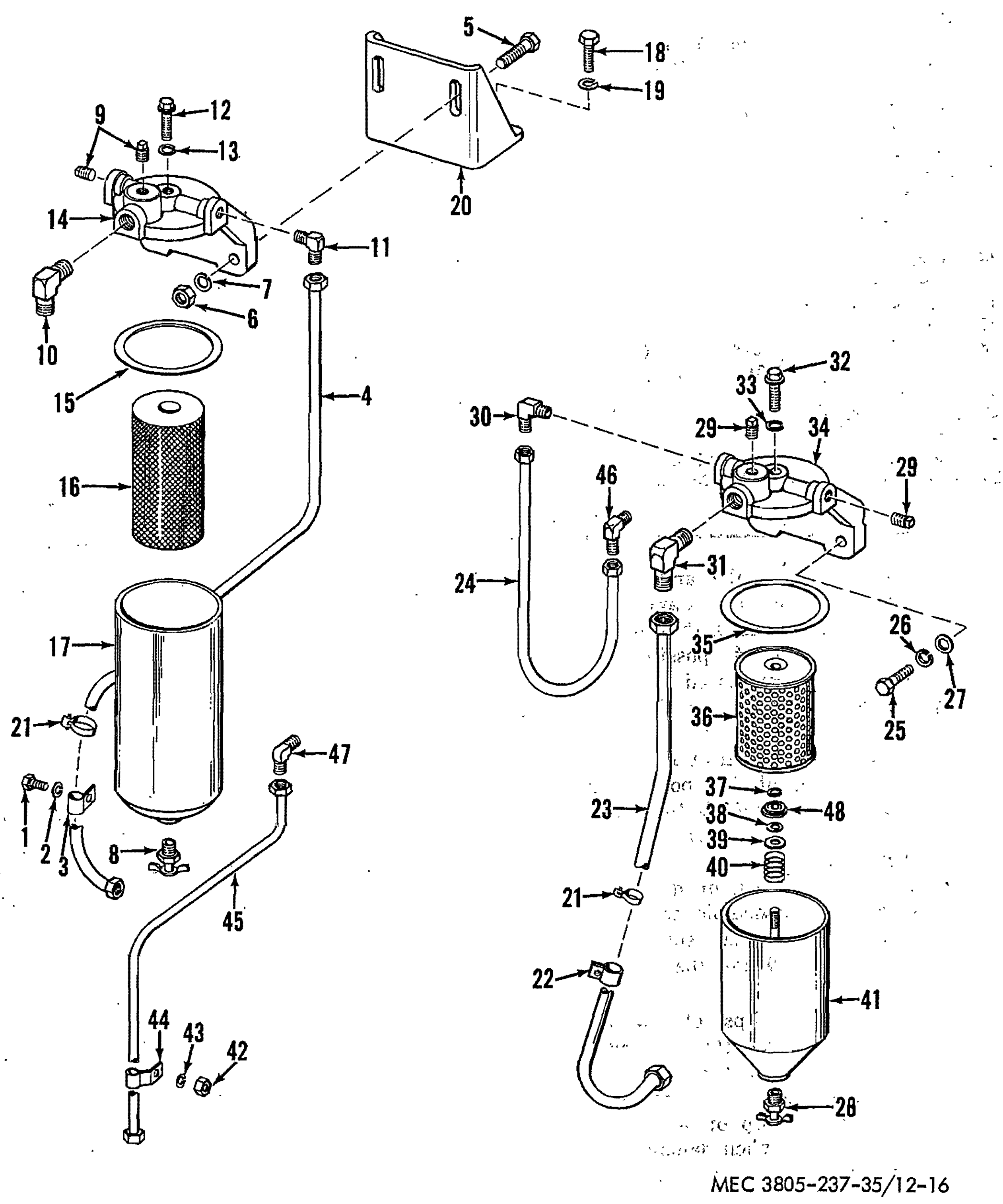



*Figure 12-16. Fuel filter, fuel strainer, and fuel lines, exploded view.*

1 Screw, cap, hex-head, 1/2-13 × 1 1/8 in.
2 Washer, lock, 1/2 in.
3 Clamp
4 Fuel strainer-to-fuel pump fuel line
5 Screw, cap, hex-head, 3/8-24 × 1 1/4 in. (2)
6 Nut, 3/8-24 (2)
7 Washer, lock, 3/8 in. (2)
8 Drain cock
9 Pipe plug (2)
10 Inlet elbow
11 Outlet elbow
12 Cover screw
13 Gasket
14 Cover
15 Cover gasket
16 Element (sock type)
17 Shell
18 Screw, cap, hex-head, 3/8 × 1 in. (2)
19 Washer, lock, 3/8 in. (2)
20 Bracket
21 Nylon tie (2)
22 Clamp
23 Fuel pump-to-fuel filter fuel line
24 Fuel filter-to-fuel manifold fuel line
25 Screw, cap, hex-head, 3/8-16 × 1 in. (2)
26 Washer, lock, 3/8 in. (2)
27 Washer, flat, 3/8 in. (2)
28 Drain cock
29 Pipe plug (2)
30 Outlet elbow
31 Inlet elbow
32 Cover screw
33 Gasket
34 Cover
35 Cover gasket
36 Element
37 Retainer
38 Seal
39 Washer
40 Spring
41 Shell
42 Nut, 3/8-16
43 Washer, lock, 3/8 in.
44 Clamp
45 Fuel return line
46 Elbow
47 Restriction elbow
48 Seat

*Figure 12-16*—Continued.

(4) Inspect relief valve and valve seat in body for score marks and burs. Clean burs and scores with fine corcus or emery cloth if possible. Replace valve if badly scored or burred.

(5) Check relief valve spring for weak or broken condition. Spring should have a free length of 1.97 inches and load rating of 7.3 pounds at 1.18 inches. If spring is broken, or does not meet the above specifications, replace spring.

(6) Replace all worn or damaged parts.

*f. Reassembly.* Reassemble the fuel pump in reverse of the numerical sequence as illustrated on figure 12-19 and the following instructions.

(1) Lubricate the lips of the oil seal, with engine oil (OES) and install the seals in the body, using a suitable installing tool. Install inner oil seal with lip of seal facing the same way as when damaged seal was removed. Install outer oil seal with lip of seal facing out.

(2) Clamp pump body (22) in a vise with soft jaws with the relief valve cavity up. Lubricate relief valve (20) With engine oil (OES) and install valve in cavity with hollow end up. Install relief valve spring (18) in valve and pin (19) inside of spring. Install gasket (17) and plug (16) and tighten securely.

(3) Lubricate drive gear (13) and drive shaft (12) with engine oil (OES). Press drive gear on drive shaft from round end of shaft. Press gear on shaft beyond ball detent in shaft. Place ball (11) in detent and press gear back on shaft until end of slot in gear contacts ball.

(4) Lubricate pump shaft with engine oil (OES) and insert square end of shaft into bore of pump body and through oil seals. Be careful not to damage oil seals while installing shaft.

(5) Install driven gear (15) and shaft (14) in pump body.

(6) Place pump body in a vise with soft jaws with finished face of pump facing up. Apply a very thin coat of gasket sealer to the faces of the pump body and cover. Install cover (9) on pump body, alining holes

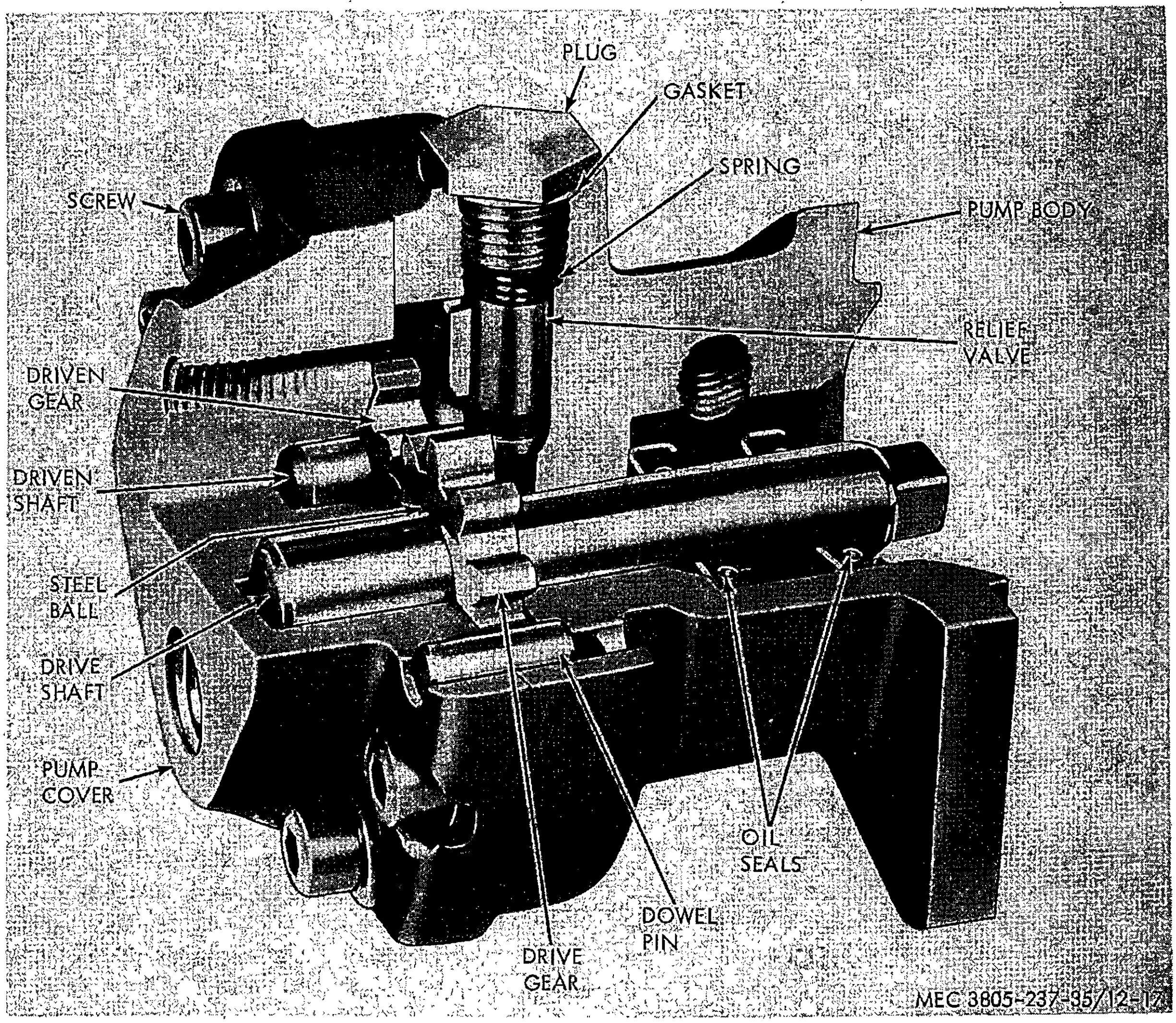



*Figure 12-17. Fuel pump, cutaway view.*

with dowel pins. Secure cover to body with eight screws and seal washers (8). Tighten screws alternately and evenly to secure cover to body.

(10) Remove pump from vise and rotate pump shaft to be sure all parts rotate freely. If binding exists, tap corner of body with a leather hammer to relieve binding, if necessary.

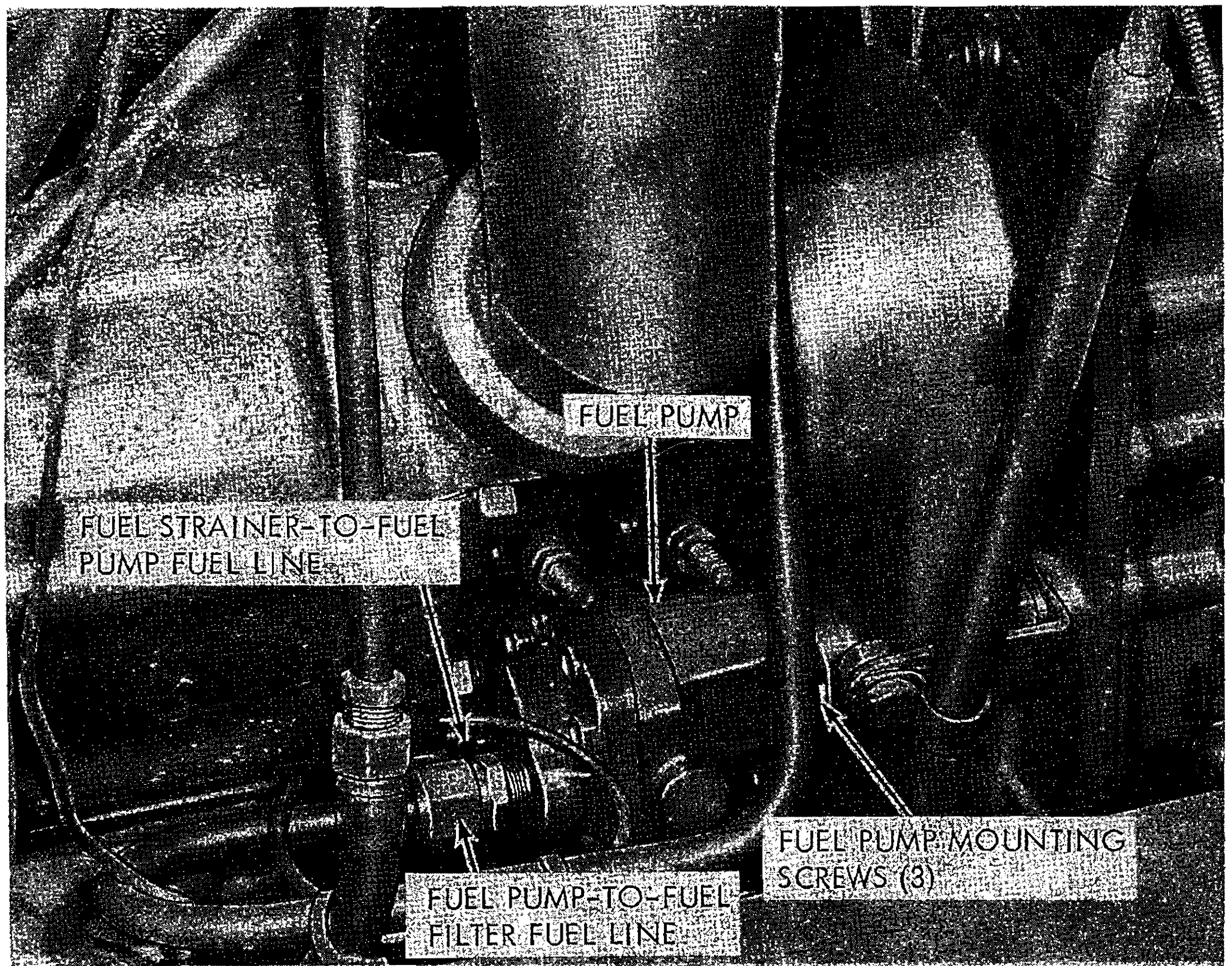
*g. Installation.* Refer to figure 12-18 and install the fuel pump on the engine.

## 12-17. Fuel Injectors

*a. General.*

(1) Six fuel injectors supply fuel to the cylinders. The injectors build the pressure and meter the fuel without use of a fuel injection pump. No high pressure fuel lines or air-fuel mixing or vaporizing devices are required.

(2) This type of injection is known as unit injection, with each injector acting as a unit or pump in its own right. The movement of the plunger (fig. 12-20) creates high fuel pressure by compressing the fuel in a




STEP 1. DISCONNECT FUEL PUMP-TO-FUEL FILTER FUEL LINE FROM FUEL PUMP.
STEP 2. DISCONNECT FUEL STRAINER-TO-FUEL PUMP FUEL LINE FROM FUEL PUMP.
STEP 3. REMOVE THREE FUEL PUMP MOUNTING SCREWS WITH SEAL WASHERS.
STEP 4. REMOVE FUEL PUMP FROM BLOWER.

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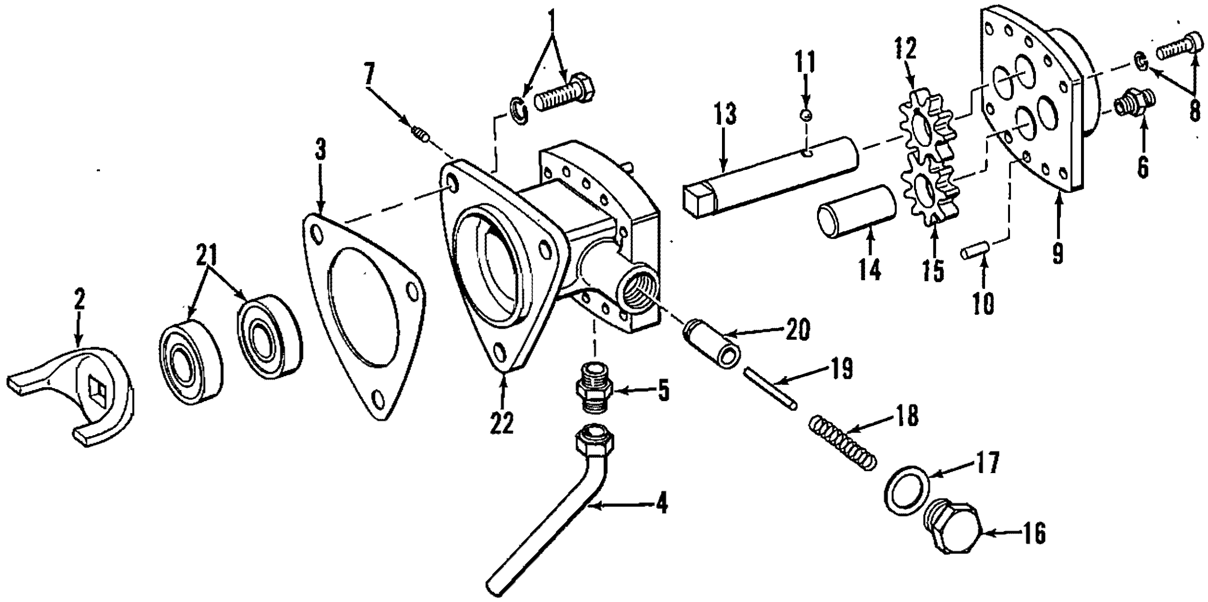
*Figure 12-18. Fuel pump, removal and installation.*

small area. Through timing of the injector control rack (fig. 12-20) the correct amount of fuel is metered and injected under pressure into the cylinder. The pressure at which the fuel leaves the small holes in the spray tip causes the fuel to atomize instantly upon entering the air in the cylinder. Unit type injection provides a continuous flow of fuel.

(3) Metering of the fuel is accomplished by an upper and lower helix ma-




| | |
|---|---|
| 1 Screw, w/seal washer (3 rqr) | 12 Drive gear |
| 2 Drive coupling fork | 13 Drive shaft |
| 3 Pump gasket | 14 Driven shaft |
| 4 Drain tube | 15 Driven gear |
| 5 Fitting | 16 Plug |
| 6 Fitting (2 rqr) | 17 Gasket |
| 7 Pipe plug | 18 Relief valve spring |
| 8 Screw, w/washer (8 rqr) | 19 Pin |
| 9 Pump cover | 20 Relief valve |
| 10 Dowel pin | 21 Oil seal (2 rqr) |
| 11 Ball | 22 Pump body |

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*Figure 12-19 Fuel pump, exploded view.*

chined in the lower end of the injector plunger. Rotation of the plunger allows more fuel to enter the injector. Rotation of the plunger and its relationship to the upper and lower ports are illustrated in figure 12-21.

(4) The fuel flow through the injector is continuous, preventing air pockets in the fuel system. Fuel flow also acts as a coolant for the fuel injector parts subjected to high combustion temperatures.

(5) The injectors used in the engine are 80 mm (millimeter) injectors. This size is used to provide the power requirements of the motor grader engine.

*b. Operation.*

(1) Fuel under pressure enters the inlet side of the injector through the filter cap and filter element (fig. 12-20). A drilled passage carries the fuel into a supply chamber between the plunger bushing and spill deflector (fig. 12-20) and to the area under the plunger within the bushing. Vertical movement of the plunger within the bushing, the bore of which is open to the fuel supply through upper and lower ports in

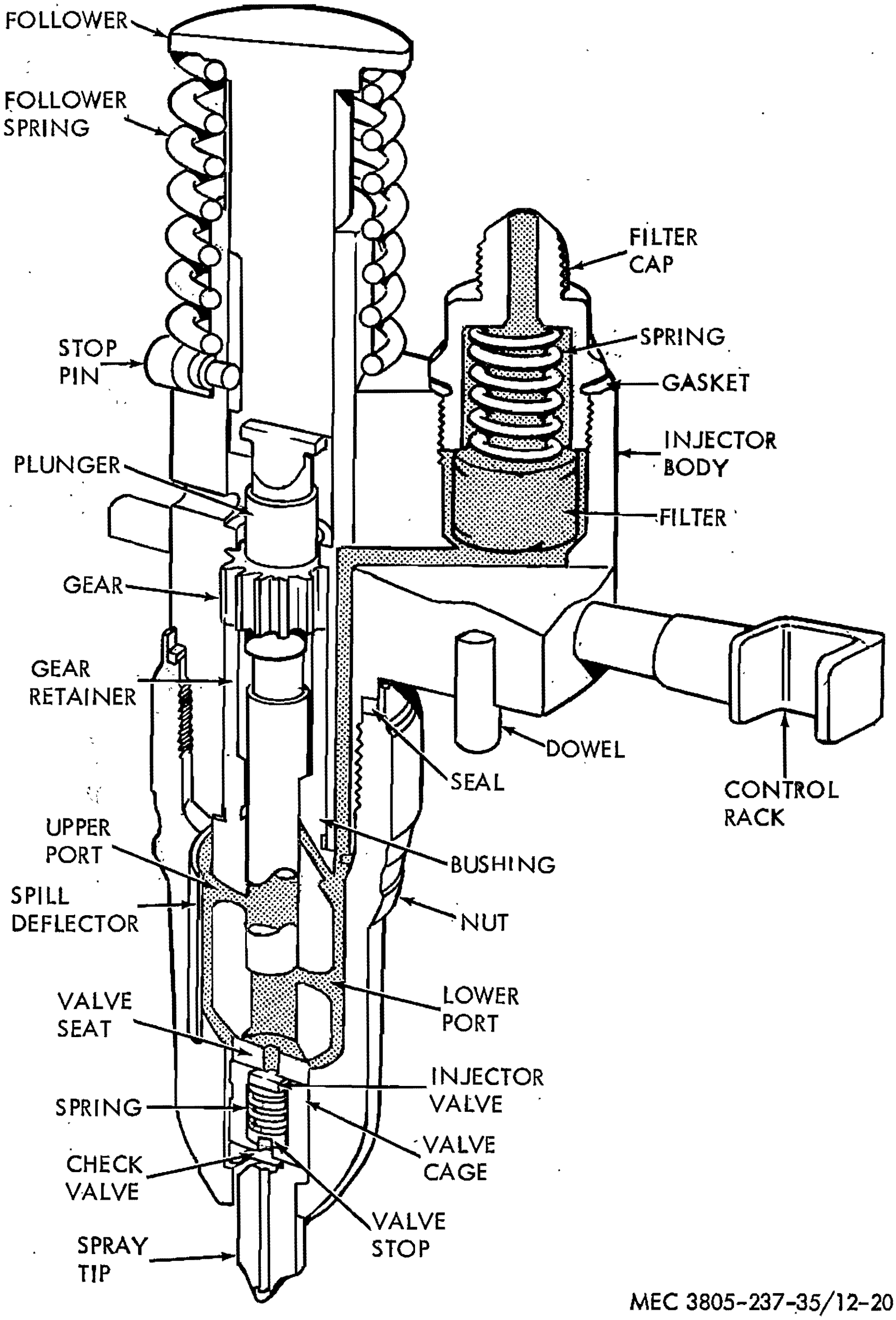



*Figure 12-20. Fuel injector, cutaway view.*

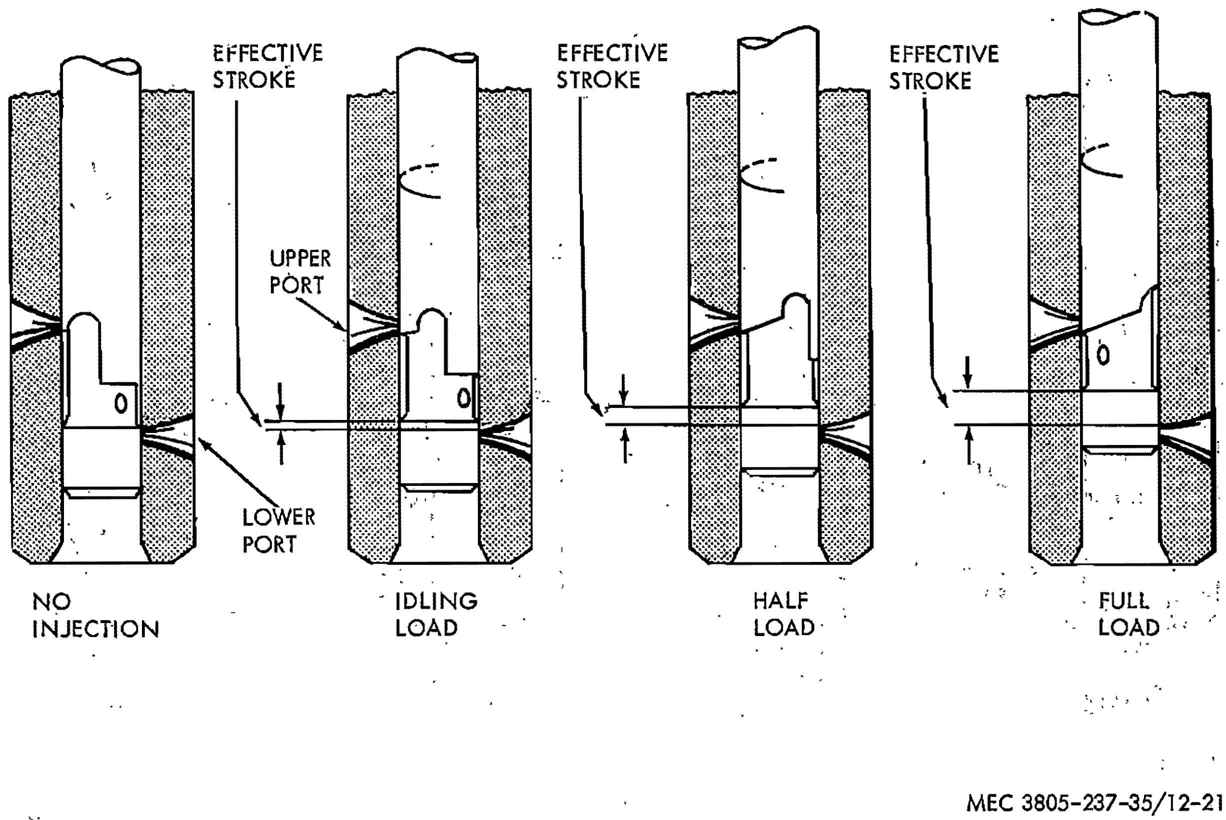



*Figure 12-21. Fuel metering from no load to full load by plunger rotation.*

the bushing, compresses the fuel. The plunger stroke is illustrated on figure 12-22.

(2) Rocker arm motion is transmitted to the plunger by the injector follower (fig. 12-20) which pushes the follower spring and plunger down. This motion compresses the fuel and forces it out through the injector tip.

(3) In addition to the reciprocating vertical motion, the plunger can be rotated within the bushing, during operation, by the gear (fig. 12-20) which meshes with the control rack. The control rack is actuated by a lever on the injector control tube. Motion of the tube and lever is controlled by the governor through the fuel control rod.

(4) As the plunger is forced down by the injector rocker arm, that portion of the fuel trapped under the plunger is displaced into the supply chamber until the port is closed off by the plunger (fig. 12-21). A portion of the fuel trapped below the plunger is forced up through the central passage (fig. 12-21) in the plunger and into the supply chamber through the upper port.

(5) Further downward travel of this plunger closes both ports and the remaining fuel under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

(6) When sufficient pressure is built up the injector valve (fig. 12-20) is forced from its seat and fuel is

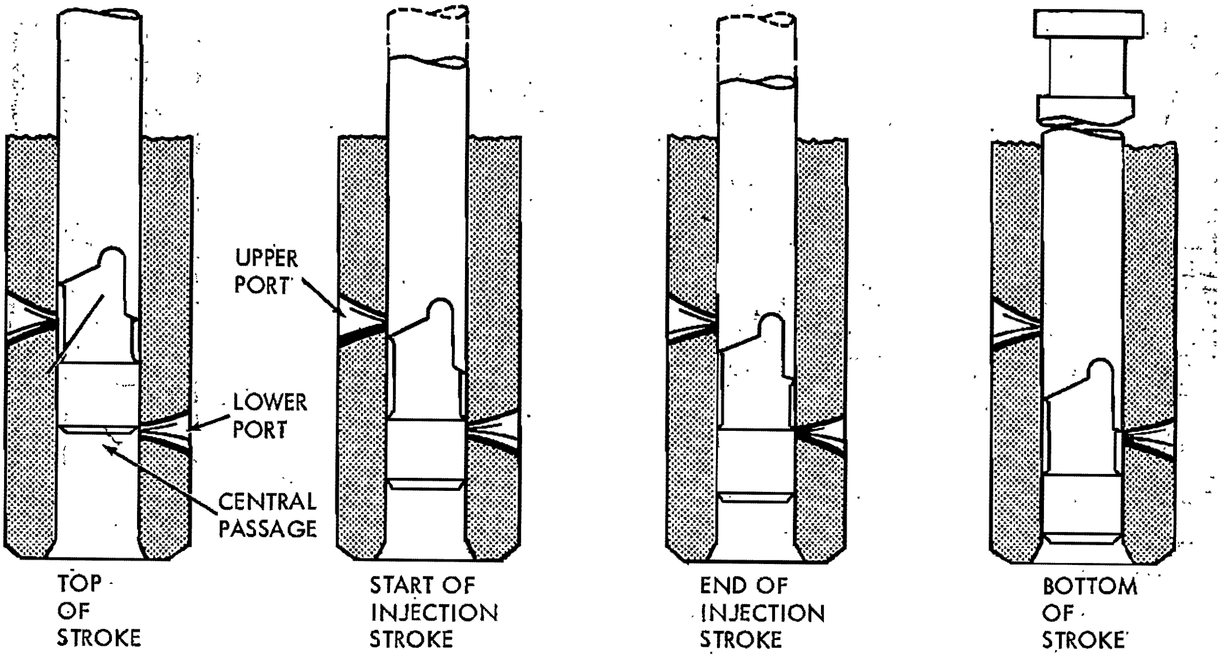



*Figure 12-22. Injector operation and vertical travel of injector plunger.*

forced through the valve and out through the tip.

(7) The check valve (fig. 12-20) prevents air leakage from the combustion chamber into the fuel injector if the injector valve should be held open by dirt or other foreign matter.

(8) At the end of its stroke, the plunger is freed from the rocker arm pressure and is returned to its original position through action of the follower spring (fig. 12-20). The top of the plunger is held in a slot in the follower and so is moved when the follower moves.

(9) As the plunger moves upward the cylinder within the bushing is again filled with fuel. This constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector, and also removes all traces of air which might accumulate in the system and interfere with accurate metering of the fuel.

(10) The fuel outlet in the injector is adjacent to the inlet. A filter element in the outlet is identical to the element in the inlet side. Connected to the outlet is a fuel pipe which carries the excess fuel to the outlet manifold and from there it returns to the fuel tank.

(11) The position of the helix on the plunger is the major element in timing and metering the fuel. Rotation of the plunger and helix retards or advances the closing of the ports

and the beginning and ending of the injection period. It also increases and decreases the amount of fuel injected into the cylinder. Figures 12-21 and 12-22 illustrate the various plunger positions.

(12) Figure 12-21 illustrates the plunger positions from NO LOAD TO FULL LOAD. With the injector control rack (fig. 12-20) pulled out all the way (no injection) the helix does not close the upper port until the lower port is uncovered. With the rack in this position all the fuel is forced back into the supply chamber and no injection takes place. This position occurs when the engine shutoff lever is pulled out, stopping the engine.

(13) Pushing the control rack all the way in gives full injection. In this position the upper port (fig. 12-21) is closed shortly after the lower port has been covered, producing a maximum effective stroke and maximum injection.

(14) From the fully closed position (no injection) to the full injection position (control rack all the way in) rotation of the plunger and the contour of the helix advances the closing of the ports and the beginning of injection. This controls the speed of the engine.

*c. Injector Care and Maintenance Instructions.*

(1) The injectors are the most important single item in engine operation. They are precisely built and must operate efficiently at all times. Therefore the injectors must be maintained in as close to first class condition as possible.

(2) The fuel system must be kept in good order. Correct fuel filters and replacement of filters at proper intervals must be adhered to. Clean water-free fuel must be available for use as much as the situation permits.

(3) Extreme cleanliness and strict attention to injector service instructions must be paramount. Wherever possible injectors should be serviced in a clean, well lighted room with a dust-free atmosphere.

(4) When not actually repairing or working on injector parts, keep parts immersed in clean fuel oil. Place parts in baskets or other containers to immerse in the fuel oil and to keep parts from dirt at bottom of the tank.

(5) Never use waste or rags to clean parts. Lint or other particles can clog injector passages. Use a clean lint free cleaning tissue to wipe parts. A supply of properly filtered compressed air should be available to blow parts dry.

(6) Keep all injector ports in the injector itself and the cylinder head plugged or covered whenever they are exposed to the atmosphere.

(7) After removal, repair, and reinstallation, the injectors must be timed and the control rack positioned for proper engine operation.

(8) Always be sure new filters have been installed before placing an injector in stock.

(9) When placing a reconditioned injector in stock, fill the injector with a preservative oil (PE-1) and seal all openings.

*d. Removal.*

(1) Refer to TM 5-3805-237-12 and remove engine hood.

(2) Refer to figure 12-23 and remove and disassemble the valve rocker cover as follows:

(*a*) Loosen two bolts (3) and remove valve rocker cover (4) and gasket (5) from engine.

(*b*) Remove two pins (1) from bolts and remove two bolts and washers (2) from cover.

(*c*) Remove two studs (6) from cylinder head.

(3) Disconnect and remove the inlet and outlet fuel pipes (fig. 12-24). In-

stall caps on injector fuel inlet and outlet to prevent entrance of dirt.

(4) Turn the engine over with a bar to bring the outer ends of the push rods of the injector and valve rocker arms (fig. 12-24) in line horizontally.

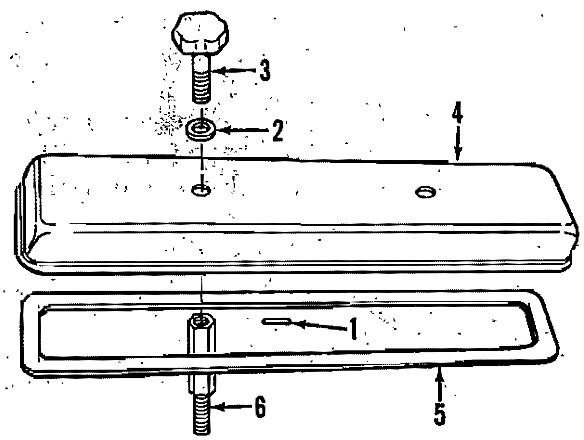
(5) Remove two rocker shaft bracket bolts (fig. 12-24) and swing rocker arms away from injector and valves as illustrated on figure 12-24.

(6) Remove screw and washer (fig. 12-24) and remove injector clamp.

(7) Loosen the inner and outer adjusting screws (fig. 12-24) on injector rack control lever and slide lever away from injector.

(8) Remove the injector from its seat in cylinder head with injector tool (Table 2-1) as illustrated in figure 12-24.

(9) Cover or plug injector hole in cylinder head to keep foreign material out.




1 Pin (2 rqr)
2 Washer (2 rqr)
3 Bolt (2 rqr)
4 Valve rocker cover
5 Gasket
6 Stud (2 rqr)

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*Figure 12-23. Valve rocket cover, exploded view.*

(10) Clean the exterior of the injector with clean fuel oil and dry with compressed air.

(11) If necessary, remove the remaining five injectors from the cylinder head in the same manner.

*e. Testing.* Inspect the injector for any external damage and perform the following tests to check injector operation. Injectors found to be in serviceable condition as the result of these tests may be considered satisfactory for service without disassembly except for a visual inspection of the plunger. Disassemble the injector far enough to inpect the plunger. When disassembling to inspect plunger, remove and clean injector nut and filter caps and install new filters and cap gaskets. After testing, tag each injector to record valve opening pressure and fuel output and to provide identification for each injector.

(1) *Injector rack and plunger movement test.*

(*a*) Push injector with follower (fig. 12-20) against bench. Push against injector to depress follower to the bottom of its stroke.

**Caution: When depressing follower, keep hands away from area of injector spray tip. Any fuel oil remaining in the injector will be forced out under pressure. The force of the pressure could drive the fuel through the skin and into the blood stream where blood poisoning could result. This caution applies to all injector tests.**

(*b*) With follower depressed, move control rack (fig. 12-20) back and forth.

(*c*) Follower must depress freely and rack movement must be free.

(*d*) Any binding or lack of free movement in plunger or rack indicates damaged or dirty internal parts and injector must be repaired.

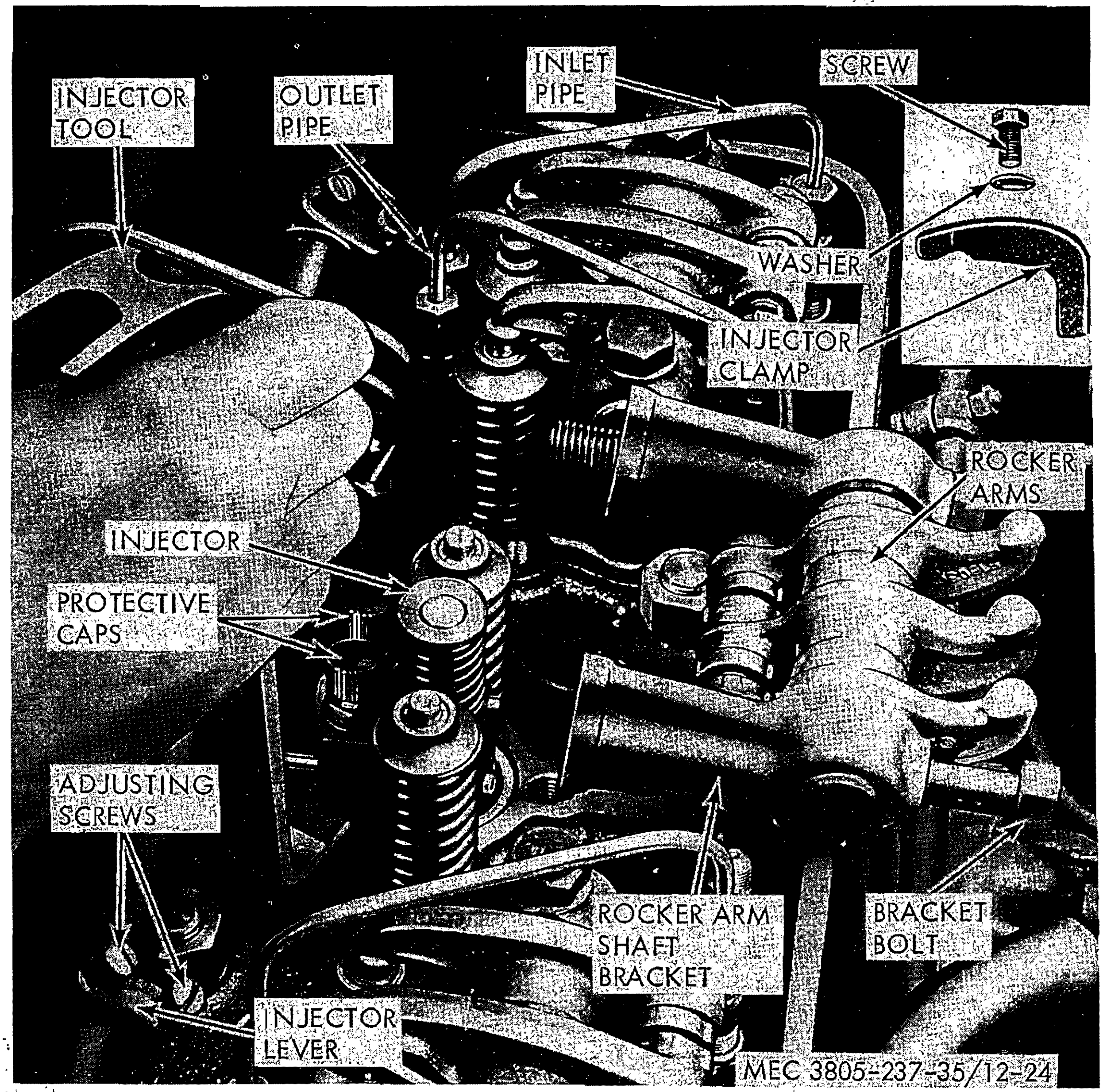


*Figure 12–24. Fuel injector, removal and installation.*

(2) *Valve opening pressure test.*

(*a*) Install injector in a suitable test fixture equipped with a pressure gage installed to read pressure when injector sprays fuel. A test fixture similar to the one illustrated on figure 12–25 should be used.

(*b*) Pump fixture handle to purge all the air from the injector and test fixture.

(*c*) Set fixture to move the injector control rack (fig. 12–20) to the full fuel position (all the way in).

(*d*) Pump handle with smooth even strokes and record pressure on

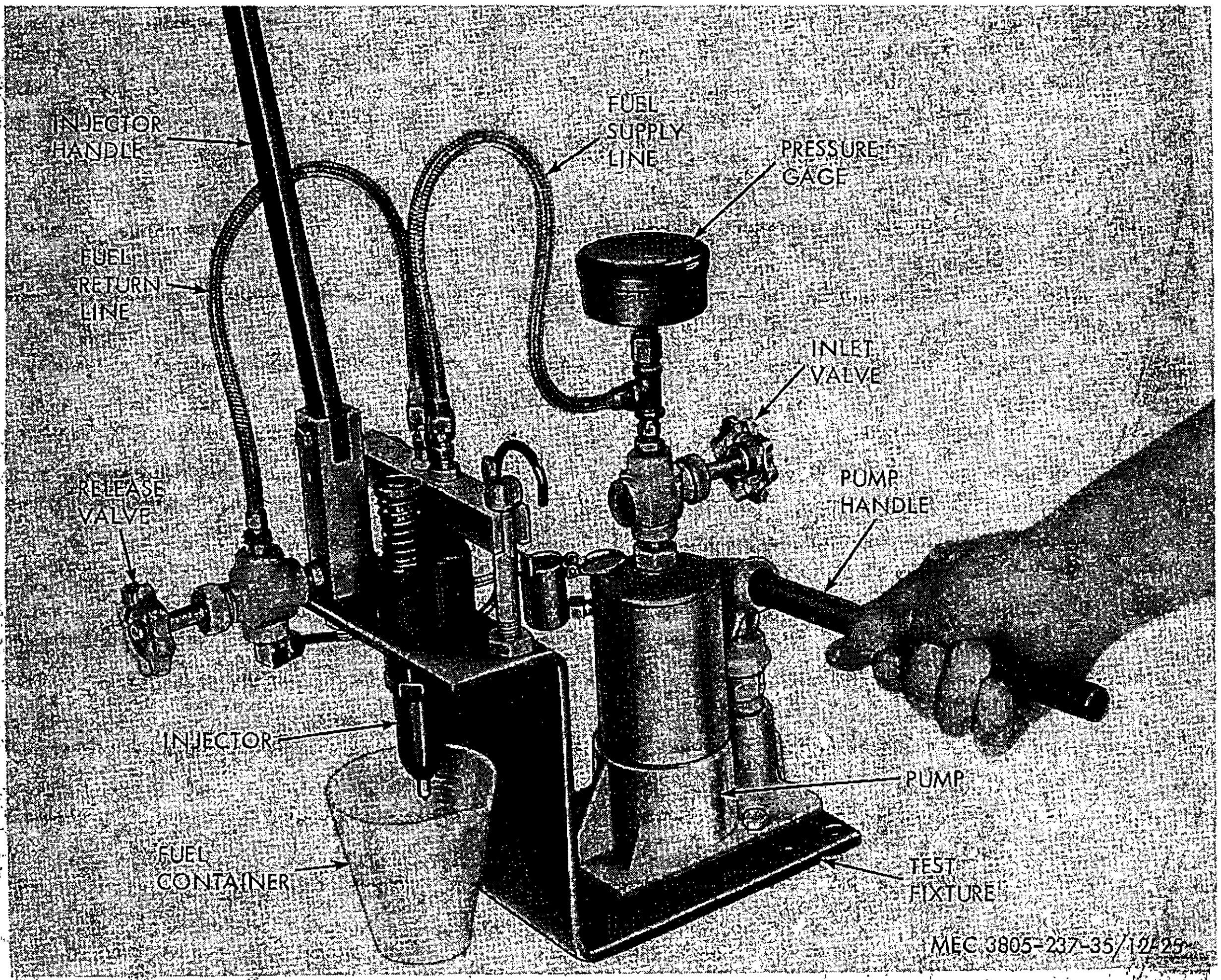


*Figure 12-25. Fuel injector installed in test fixture.*

gage when injector sprays fuel. This is the valve opening pressure.

(e) Pressure should read 450 to 850 psi. If pressure is not in the above range, repair injector.

(3) *Valve holding pressure test.* This test determines whether the lapped surfaces in the injector are sealing properly.

(a) With injector installed in test fixture as above, pump handle to bring pressure up to a point just below the injector valve opening pressure.

(b) Close the fuel shutoff valve on fixture and record and time the pressure drop on the gage. Pressure drop from approximately 450 psi to 250 psi must not be less than 40 seconds.

(c) If pressure drops as indicated in less than 40 seconds, check injector for leaks. Thoroughly dry injector with compressed air. Open fuel shutoff valve and pump handle to increase pressure to approximately 450 psi.

(d) Check injector rack opening for fuel leakage. If leakage is evident, a poor bushing-to-body fit is indicated.

(*e*) Check tip and tip nut for fuel leakage. This could be caused by a loose nut, damaged seal ring, or damaged surface on injector nut or tip.

(*f*) Check filter cap and gasket for fuel leakage. This could be caused by a loose cap or damaged gasket.

(*g*) If a small amount of fuel is leaking from the spray tip this is due to a damaged valve surface or dirt. Leakage at the tip will cause preignition in the engine.

(*h*) If any of the above leakages occur, repair injector.

(4) *High pressure test.* This test is performed to discover any fuel leaks at the filter caps, body plugs, seal ring, and internal lapped surfaces which did not appear in the valve holding test.

(*a*) With the injector installed in the test fixture, thoroughly dry the enjector with compressed air. Check all fuel connections for leaks and correct.

(*b*) Adjust fixture to place injector control rack in the full fuel position (all the way in). Lock injector in position with injector handle (fig. 12-25). Operate pump handle to build up and maintain pressure.

(*c*) Adjust injector handle to depress follower far enough to close both ports in the injector bushing. This can be determined by the fact that the spray will decrease and a rise in pressure will occur.

(*d*) Condition of the plunger and bushing will show in this test. If clearance between the two is excessive, pressure beyond normal valve opening (450 to 850 psi) cannot be obtained. Injector must be repaired if this occurs.

(*e*) If pressure can be increased, operate pump handle to increase pressure to 1,600 to 2,000 psi and inspect all portions of injector for leaks. If leaks occur, repair the injector.

*Note.* Do not increase pressure in test fixture to equal or exceed the capacity of the pressure gage.

(5) *Spray pattern test.* The spray tip should spray the fuel evenly from each orifice and produce an even pattern.

(*a*) With the injector installed in the test fixture and fuel supply valve open, pump the injector handle (fig. 12-26).

(*b*) Observe the spray pattern. Fuel should be discharged from each orifice and the spray should produce a uniform pattern.

(*c*) If spray pattern is not uniform the orifices require cleaning. Disassemble injector and clean the orifices.

(6) *Visual inspection of plunger.* If the injector passes the above tests satisfactorily, the plunger should be inspected.

(*a*) Support the injector in a vise with soft jaws with follower up as illustrated in figure 12-27.

(*b*) Depress the follower spring (fig. 12-27) with one hand. Place a screwdriver as shown and raise the spring above the stop pin.

(*c*) Remove the stop pin from the injector. Allow the spring to raise gradually after removing pin.

(*d*) Remove the injector from the vise and tip it upside down to remove the spring, follower, and plunger.

(*e*) Inspect the plunger for scoring and scratch marks on polished surface. Check edges of helix for cracked and chipped condition. Inspect inner part of helix and plunger for erosion.

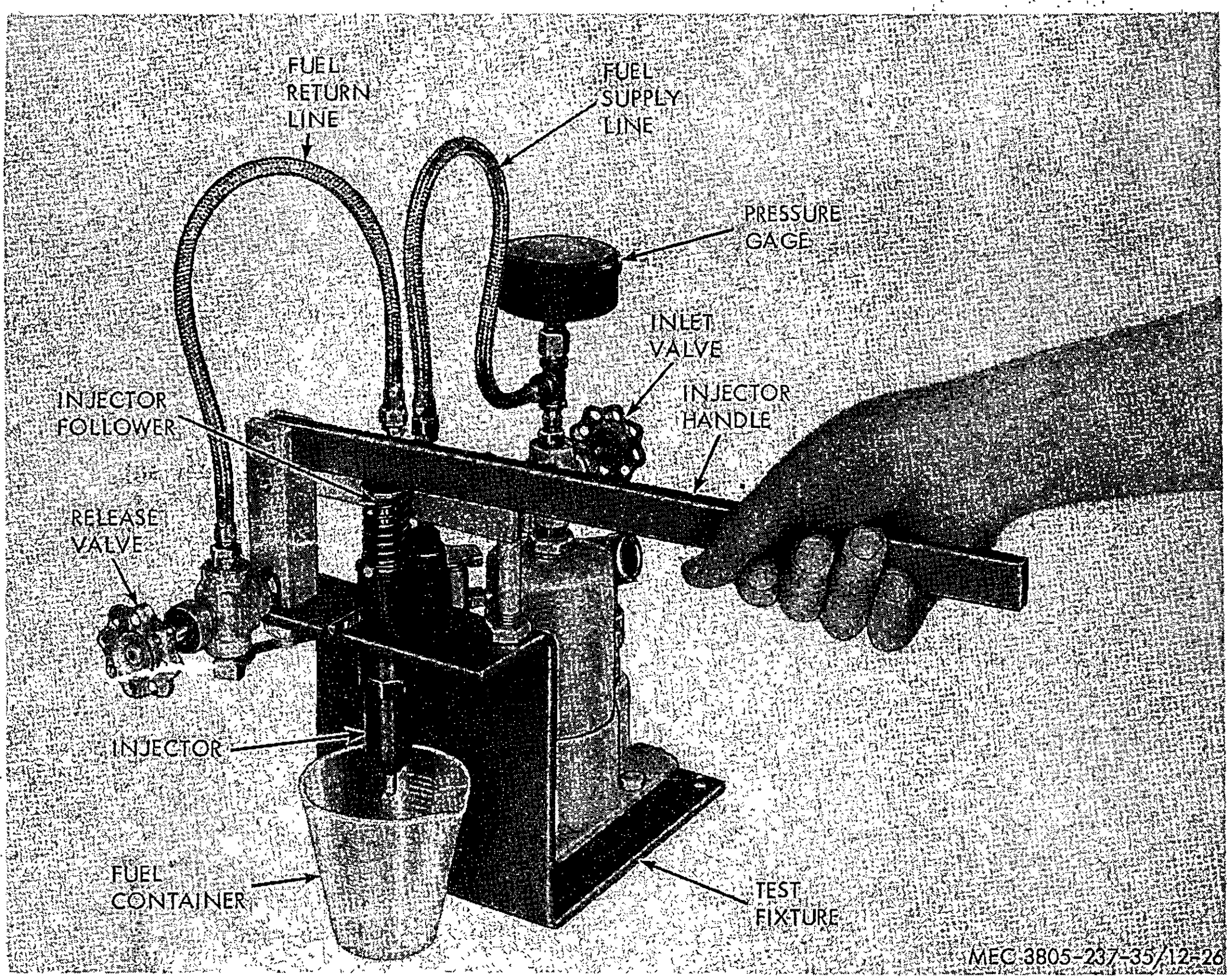


*Figure 12-26. Checking injector spray pattern.*

(*f*) Replace plunger and bushing if plunger is chipped, scored, or eroded. The injector will require disassembly and repair of these conditions exist.

(*g*) If plunger is found to be serviceable, install plunger, follower, follower spring ,and stop pin.

(7) *Fuel output test.* After testing injector as outlined above and inspecting plunger perform a fuel output test.

(*a*) Install injector in the test fixture as shown in figure 12-25. Fill fixture pump with clean fuel oil. Place a clean graduated container under the injector tip to contain the sprayed fuel. Container should be graduated in cubic centimeters.

(*b*) Open valves and pump injector handle to purge air from system. Set control rack at full fuel position (all the way in).

(*c*) Pump injector handle exactly 100 strokes. Check graduated container. The container should hold from a minimum of 3.8 cc to a maximum of 4.4 cc.

(*d*) If quantity is not within limits specified, repair injector.

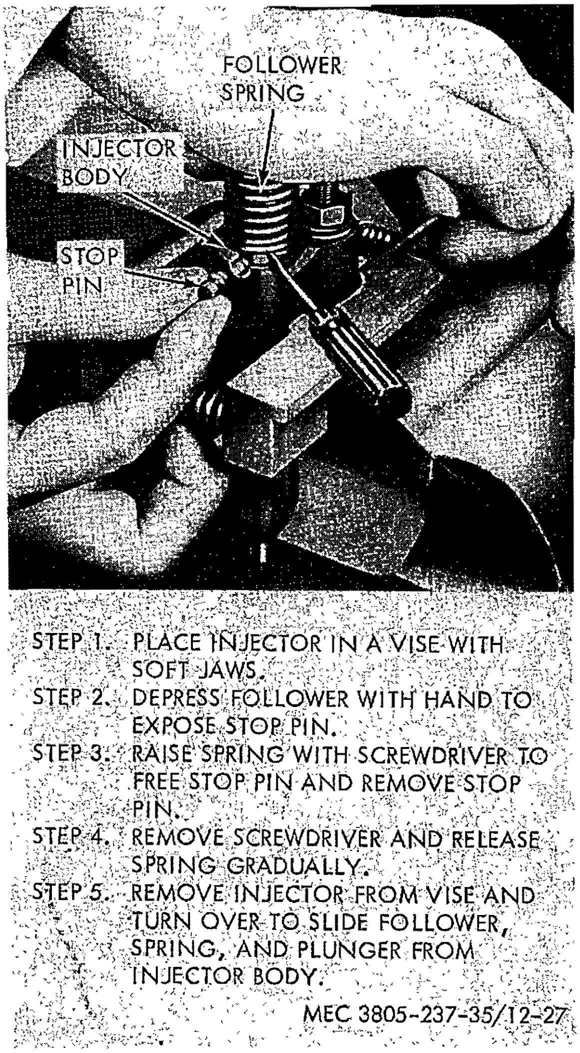


*Figure 12-27. Follower stop pin, removal and installation.*

*f. Disassembly.*

(1) Remove the injector filter cap and filter in the numerical sequence as illustrated on figure 12-28.

(2) Refer to figure 12-27 and remove stop pin, follower, follower spring, and plunger from injector.

(3) Remove the injector tip and bushing parts in the numerical sequence as illustrated on figure 12-29.

(4) It may be necessary to tap the spray tip with a brass tool or a piece of wood to remove spray tip (4) from tip nut (1).

(5) Remove the injector control rack (14) from the injector body.

*g. Cleaning.*

(1) Clean injector parts in clean fuel oil and dry thoroughly with compressed air.

(2) Clean carbon from interior of spray tip with a steel drill rotated by hand. Drill should be slightly smaller in diameter than bore of spray tip.

1 Filter cap (2 rqr)
2 Cup gasket (2 rqr)
3 Spring (2 rqr)
4 Filter element (2 rqr)
5 Injector body

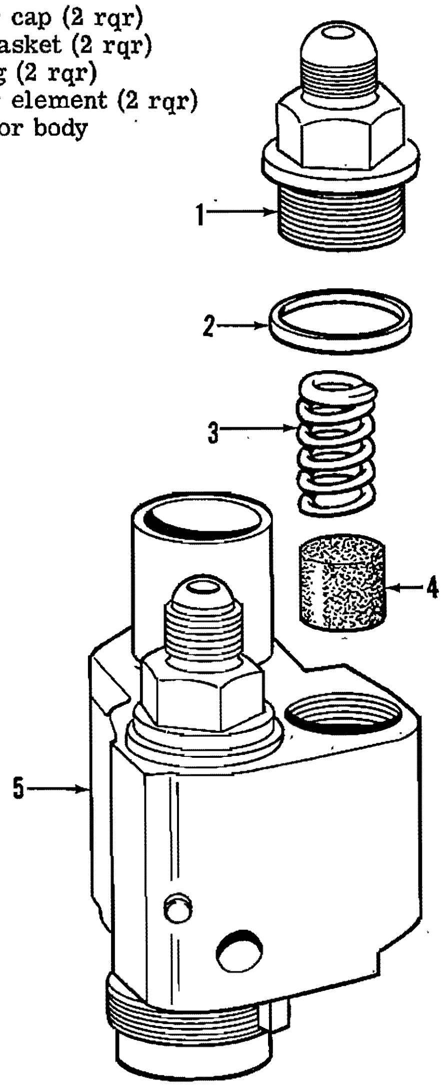


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*Figure 12-28. Filter cap and element, exploded view.*

1 Fuel pipe (2 rqr)
2 Screw, cap, hex-head, 3/8-16 x 2-1/4 in.
3 Washer, 3/8 in.
4 Injector clamp
5 Stop pin
6 Follower
7 Plunger
8 Follower spring
9 Injector body
10 Connector (2 rqr)
11 Nut (2 rqr)
12 Washer (2 rqr)

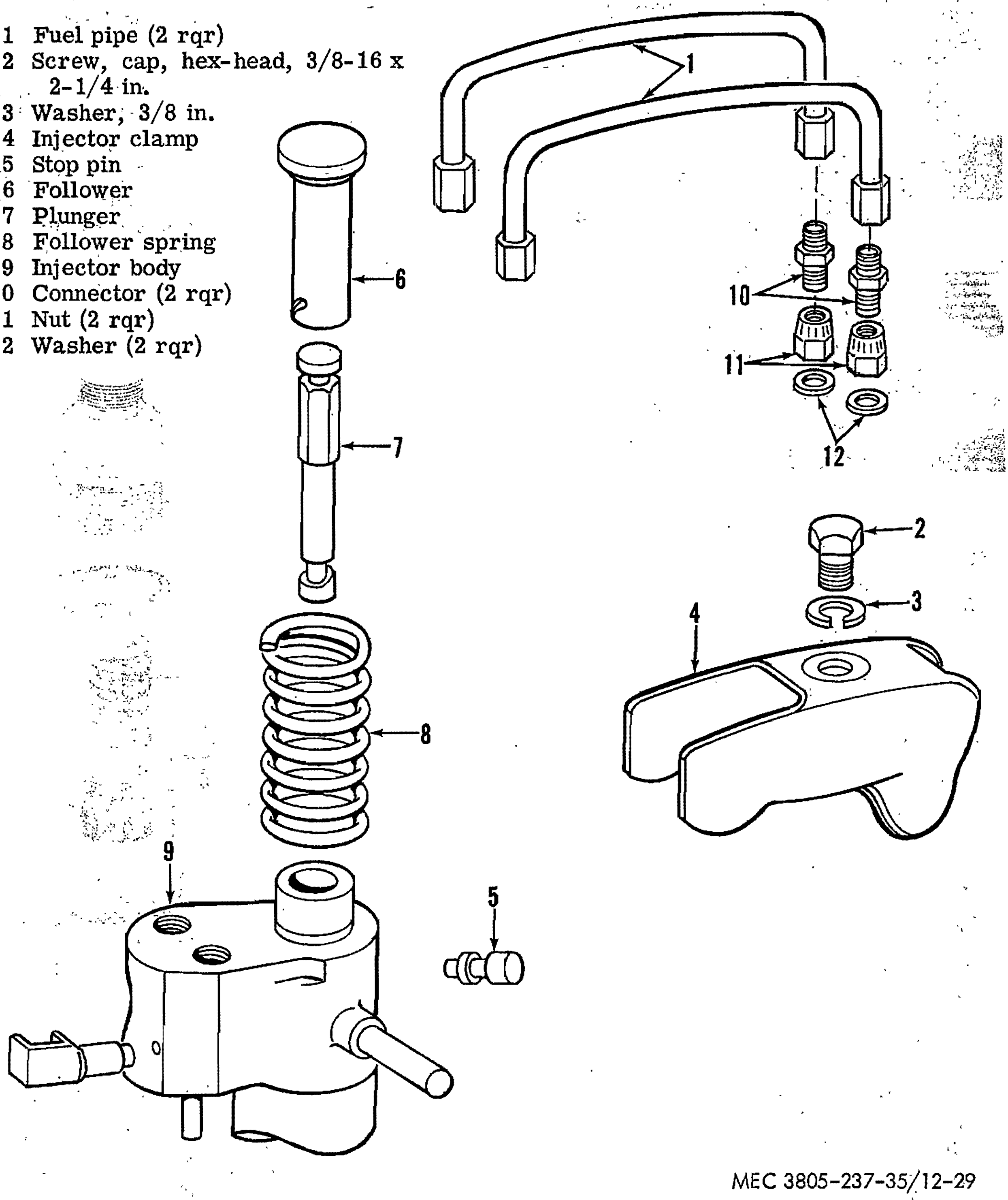



*Figure 12-29. Follower, spring, and plunger, exploded view.*

(3) Clean orifices in spray tip with steel wire 0.006 inch in diameter. Hold wire rigid in a tool with wire extending 1/8 to 3/16 inch from tool. Hone end of wire to taper wire and remove burs. Push wire firmly through holes. Wash spray tip in clean fuel oil and blow dry with compressed air.

(4) Clean and brush all passages in injector body with a soft wire brush.

(5) Use a suitable reamer to ream spray tip bore in tip nut. Reamer diameter should be slightly smaller than bore so only the carbon is removed. Do not mar or bur sides of bore.

(6) When cleaning injector plunger, do not touch finished surfaces with fingers. Wash plunger and bushing with fuel oil. Wrap soft tissue paper around a steel rod and clean interior of bushing. Wash in clean fuel oil and blow dry with compressed air.

(7) After cleaning keep plunger and barrel together. Keep all injector parts for each injector assembly together. Immerse all parts in clean fuel oil.

*h. Inspection and Repair.*

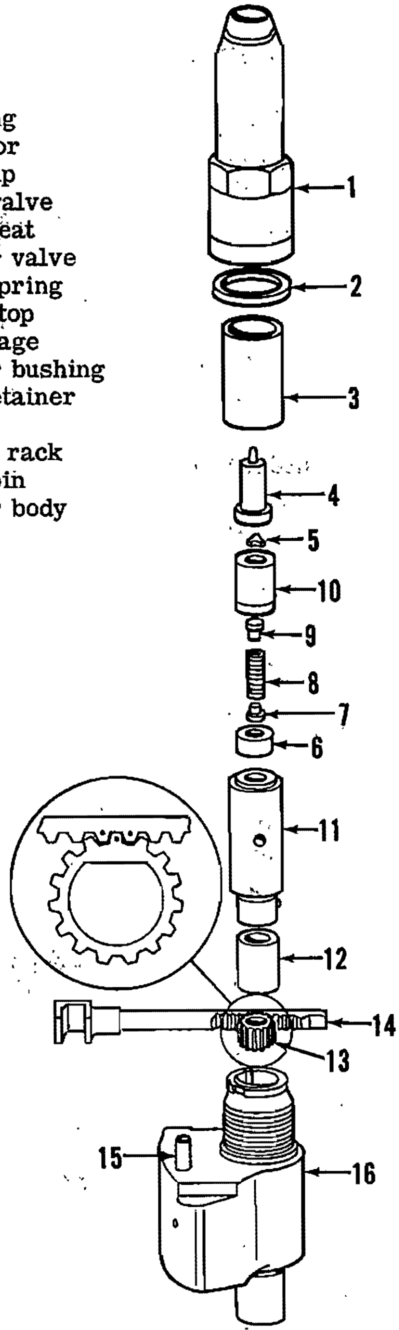
(1) Inspect teeth on gear and control rack for wear and damage. Check bore of gear for wear. Replace gear or rack if worn or damaged.

(2) Inspect injector follower and stop pin for wear and damage. Replace parts if worn or damaged.

(3) Inspect follower spring for weak or broken condition. The spring should have a free length of 2.039 inches and 35 to 41 pounds should be required to compress the spring to a length of 1.027 inches. Replace spring if broken or if a load less than 30 pounds compresses the spring to 1.027 inches.

(4) Inspect seal ring area on injector body for burs and scratches. Inspect bushing contact surfaces in body for scratches, scuff marks on other damage. Repair minor damage by lapping this surface. If dowel pin or body plugs are loose, install new plugs or dowel pin. Replace any body that is damaged beyond repair. Install proper number tag on a replacement body.

1 Tip nut
2 Seal ring
3 Deflector
4 Spray tip
5 Check valve
6 Valve seat
7 Injector valve
8 Valve spring
9 Valve stop
10 Valve cage
11 Plunger bushing
12 Gear retainer
13 Gear
14 Control rack
15 Dowel pin
16 Injector body




MEC 3805-237-35/12-30

*Figure 12-30. Tip nut and valve parts, exploded view.*

(5) Inspect the injector plunger for scoring, erosion, chipping or wear. Inspect portion of plunger that contacts the gear for sharp edges. Remove sharp edges with a fine stone. Clean plunger after stoning.

(6) Inspect bushing for cracks and chipping. Immerse plunger and bushing in clean fuel oil and insert plunger in bushing. Plunger should move freely in bushing. If either plunger or bushing is damaged and must be replaced, both parts must be replaced as a set. The two parts are mated at manufacturer and must not be used with other parts. Do not attempt to rework a plunger.

(7) Inspect spray tip seating surface in tip nut for nicks, burs, or damage. Lap the surface to remove nicks or burs. If damaged beyond repair, replace the tip nut.

(8) Inspect valve spring for weak or broken condition. A load of 4.75 to 5.75 should be required to compress the spring to a length of 0.240 inch. Replace the spring when less than 4.25 pounds will compress spring to 0.240 inch. Replace a weak or broken spring.

(9) Inspect sealing surfaces on the spray tip, valve, and valve cage. Examine the surfaces with a magnifying glass. Inspect for burs, nicks, erosion, cracks, chipping and wear. Check spray tip holes for enlargement. Replace damaged or worn parts.

(10) Lap all serviceable valve parts to assure good sealing surface. Use a good quality 600 grit lapping compound. Move parts on compound and block in a figure eight motion with only enough pressure to keep the part flat on the block at all times. Clean parts, after lapping, in cleaning compound, solvent (Spec. P-S-661) and blow dry with compressed air.

(11) Inspect edge of hole in valve seat (6, fig. 12-30) with a magnifying glass. If edge of hole shows irregularities, it must be repaired or replaced. Use a small sharp fine stone mounted in an electric drill. Secure drill in a vise with stone facing up. Start drill motor and lightly touch stone to hole. Edge of hole must have a smooth chamfer and chamfer must be a perfect circle. After dressing edge of hole, lap face of the seat lightly. Clean valve and check width of chamfer at edge of hole. Chamfer should be 0.002 to 0.005 inch in width. Replace valve seats that cannot be repaired or seats having wider chamfers than the size specified.

*i. Reassembly.*

(1) Install two filters (4, fig. 12-28) in body with dimple end down. Install two springs (3) and gaskets (2). Lubricate threads of caps (1) with engine oil (OES) and install caps on body. Tighten caps to a torque of 65 to 75 foot pounds Place protective plastic caps on valve cap to prevent entrance of foreign matter.

(2) Refer to figure 12-30 and note drill marks on rack and gear. Hold body (16, fig. 12-30), bottom up, and slide control rack (14) through the hole in body. Move rack in body to be able to see drill marks.

(3) Install gear (13) in the injector body with marked tooth on gear engaged between the two marked teeth on the control rack as illustrated on figure 12-30.

(4) Install gear retainer (12) on top of gear. Install bushing (11, fig. 12-30) in injector body with locating pin in slot in body.

(5) Install injector body tip side up, in a vise with soft jaws. Install a new seal ring (2, fig. 12-30) on shoulder of body. Install deflector in body around the bushing.

(6) Install valve seat (6, fig. 12-30) on lapped face of bushing. Install spring (8) on stem of injector valve (7) and install valve stop (9) on other end of spring.

(7) Install spring and parts in bore of valve cage (10) so that stop seats in cage. Install cage in body on valve seat.

(8) Install check valve (5) in center of hole in cage and place spray tip (4) over check valve and against cage.

(9) Lubricate the threads of tip nut (1) with engine oil (OES) and screw nut on valve body by hand. Spray tip and parts must seat correctly in counterbore of nut. Do not force nut over parts. Rotate end of spray tip, if necessary, to aid in installing nut.

(10) Reverse position of injector in vise. Push control rack (14, fig. 12-30) all the way in.

(11) Engage head of plunger (7, fig. 12-29) with slot in follower (6) and slide spring (8) on follower. Install free end of plunger in injector body. Install stop pin (5) in slot in body so follower spring rests on narrow flange of pin.

(12) Aline slot in follower with stop pin hole and flat side of plunger with flat in gear. Press down on the follower and push stop pin in to engage slot in follower. Spring will hold stop pin in position.

(13) Reverse position of injector in vise and tighten tip nut to a torque of 55 to 65 foot pounds. Do not exceed this torque. Excessive torque could result in improper sealing of lapped surfaces.

(14) Check concentricity of tip with a dial indicator. Tip must be concentric to tip nut with 0.008 inch total indicator reading. If runout exceeds this, loosen tip nut, center spray tip and re-torque tip nut. Check concentricity. If tip cannot be adjusted, check assembly of injector.

*j. Testing. After Reassembly.* Perform all the tests as described in *e* above (except inspection of plunger). If injector passes the tests it is satisfactory for use. Failure in any test requires disassembly, cleaning, inspection and repair, and reassembly of the injector.

*k. Installation.*

*Note.* Prior to installation, check injector tube in cylinder head. Ream out carbon if necessary.

(1) If connectors (10, fig. 12-29), nuts (11), and washers (12) were removed from the cylinder head, install parts in head.

(2) Refer to figure 12-24 and install injector in cylinder head, with dowel pin in locating hole in cylinder head. Move injector lever (fig. 12-24) to register with injector control rack.

(3) Install injector clamp (fig. 12-24) and secure with screw and washer. Tighten screw to a torque of 20 to 25 foot pounds. Check placement of clamp so clamp does not interfere with valve or injector springs.

*Note.* Check injector control rack for free movement, Excessive torque could cause control rack to stick or bind.

(4) Move rocker arms (fig. 12-24) in position and tighten bracket bolts to a torque of 90 to 100 foot pounds.

(5) Remove protective caps (fig. 12-24) and connect inlet and outlet pipes (fig. 12-24) to fuel connectors and injector caps. Tighten connectors on pipes (except outlet pipe at injector) to a torque of 12 to 15 foot pounds.

(6) Set injector control rack in the no fuel position (all the way out). Crank engine briefly to bleed any air from injector. Tighten outlet pipe to injector with a torque of 12 to 15 foot pounds.

***Caution:* Do not exceed torque specification. Excessive torque could twist or crack flared end of fuel pipe and result in leaks. Lubricating oil diluted by leaking fuel oil can cause serious damage to engine bearings.**

(7) After installation of injectors, perform a complete engine tune up as outlined in paragraphs 12-49 and 12-50. If only one injector is replaced and other injectors and governor has not been disturbed, the only

adjustments necessary are for valve clearance, timing the injector for one cylinder, and positioning of the injector levers. Refer to paragraphs 12-48, 12-49, and 12-50 for these adjustments.

(8) Refer to figure 12-23 and reassemble and install the valve rocker cover as follows:

(*a*) Install two studs (6) in cylyinder head if they had been removed.

(*b*) Install two bolts (3) and washers (2) in cover and secure with two pins (1).

(*c*) Install gasket (5) and valve rocker cover (4) on cylinder head and secure by tightening two bolts (3).

(9) Refer to TM 5-3805-237-12 and install the engine hood.

## 12-18. Throttle Linkage

*a. General.*

(1) The throttle linkage on the motor grader is connected to the accelerator and decelerator (fig. 12-31), and is also controlled by the governor control lever (hand throttle). The linkage from the controls is mounted on the right side of the engine and crosses over the front of the engine to connect to the governor.

(2) The engine shutdown linkage is connected by a long rod to the ball. The rod is attached to a lever (fig. 12-32) which pivots on a bracket at the rear engine lifting eye. A ball joint and governor rod connect the lever to the governor stop lever.

*b. Removal.*

(1) Remove and disassemble the governor control lever in the numerical sequence as illustrated on figure 12-33.

(2) Remove accelerator and decelerator pedals, accelerator and decelerator assembly, and linkage in the numerical sequence as illustrated on figure 12-34.

(3) Remove the engine throttle linkage in the numerical sequence as illustrated on figure 12-35.

(4) Remove the engine shutdown linkage in the numerical sequence as illustrated on figure 12-36.

*c. Disassembly.* Disassemble the accelerator-decelerator assembly in the numerical sequence as illustrated on figure 12-37.

*d. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air.

***Warning:*** **The solvent is highly inflammable. Do not use the solvent near an open flame.**

*e. Inspection and Repair.*

(1) Inspect all parts for wear and damage.

(2) Inspect all rods and levers for cracks and bent condition. Straighten bent rods if possible. Replace all cracked or badly bent rods and levers.

(3) Inspect friction disks in governor control lever for wear and damage. Replace worn or damaged disks.

(4) Check springs for weak or broken condition. Replace all weak or broken springs.

(5) Replace all worn or damaged parts.

*f. Reassembly.* Reassemble the accelerator-decelerator assembly in reverse of the numerical sequence as illustrated on figure 12-37.

*g. Installation.*

(1) Install the engine shutdown linkage in reverse of the numerical sequence as illustrated on figure 12-36.

(2) Install the engine throttle linkage in reverse of the numerical sequence as illustrated on figure 12-35.

(3) Install the pedals and throttle linkage in reverse of the numerical sequence as illustrated on figure 12-34.

(4) Assemble and install the governor control lever in reverse of the numerical sequence as illustrated on figure 12-33.

*h. Adjustment.* Adjust the various parts of the throttle linkage as described below.

(1) *Governor control lever and accelerator-decelerator.*

(*a*) Locate governor control lever (fig. 12-31) and throttle control shaft

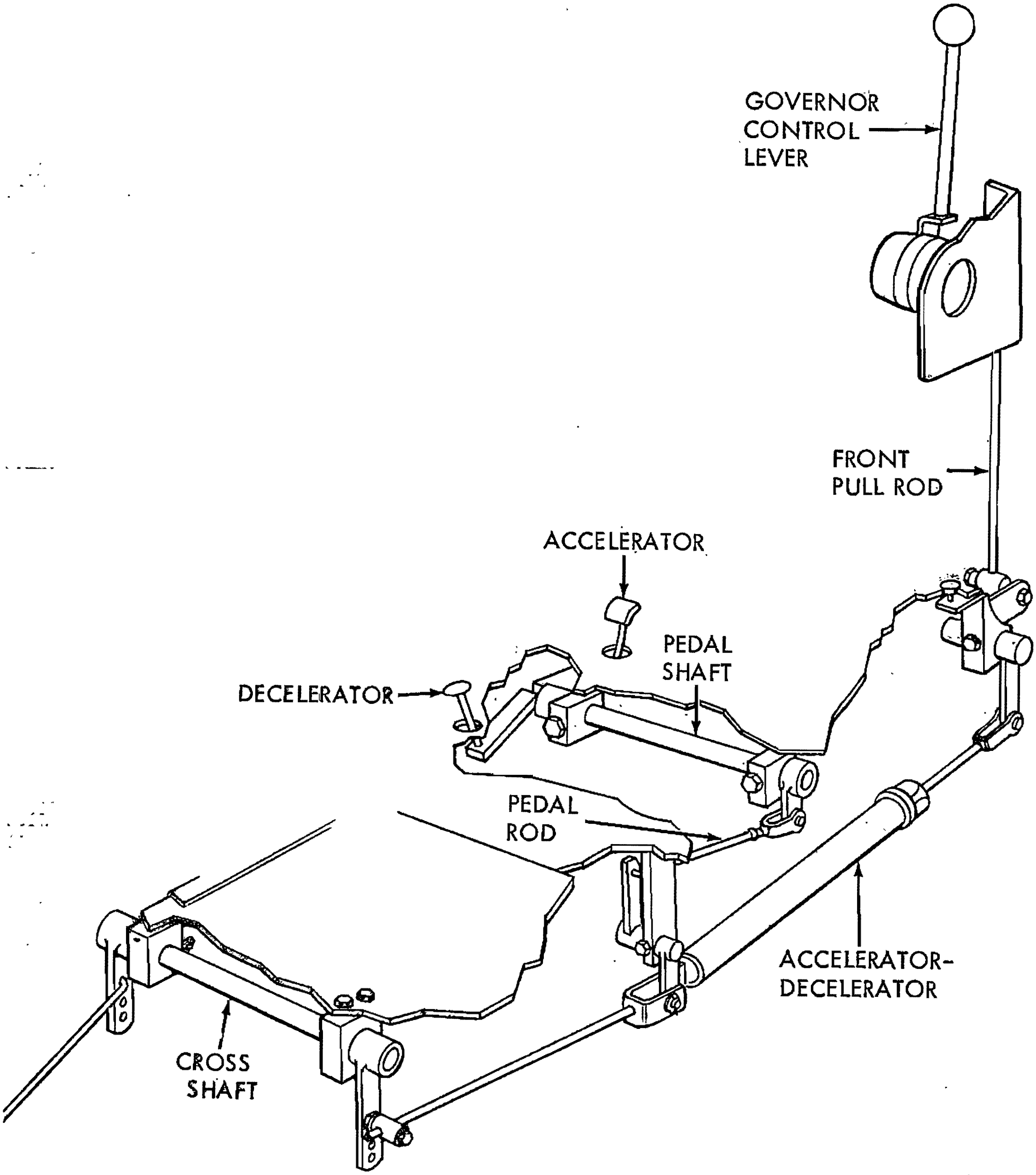



*Figure 12-31. Throttle linkage, schematic view.*

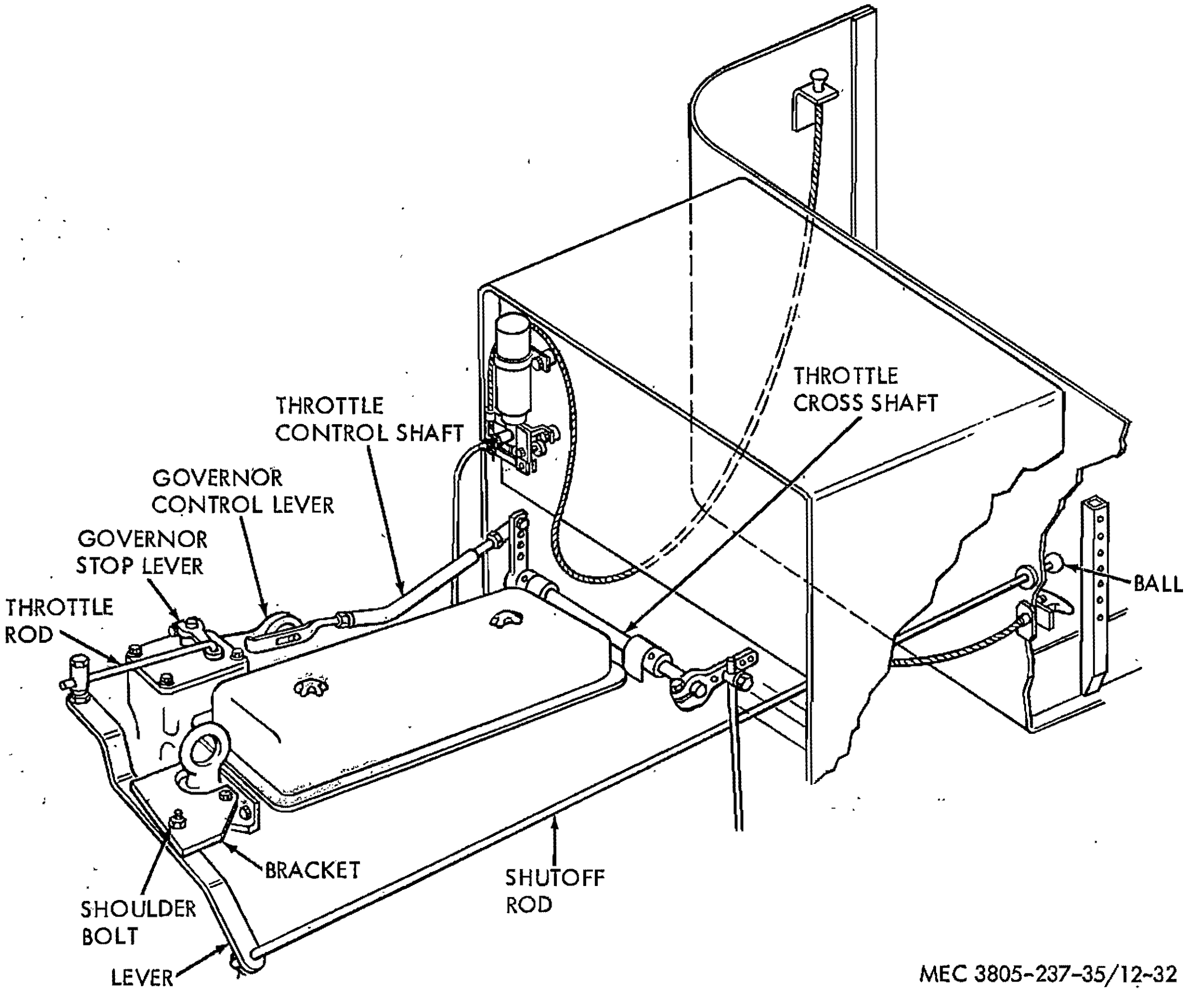



*Figure 12-32. Engine shutdown linkage, schematic view.*

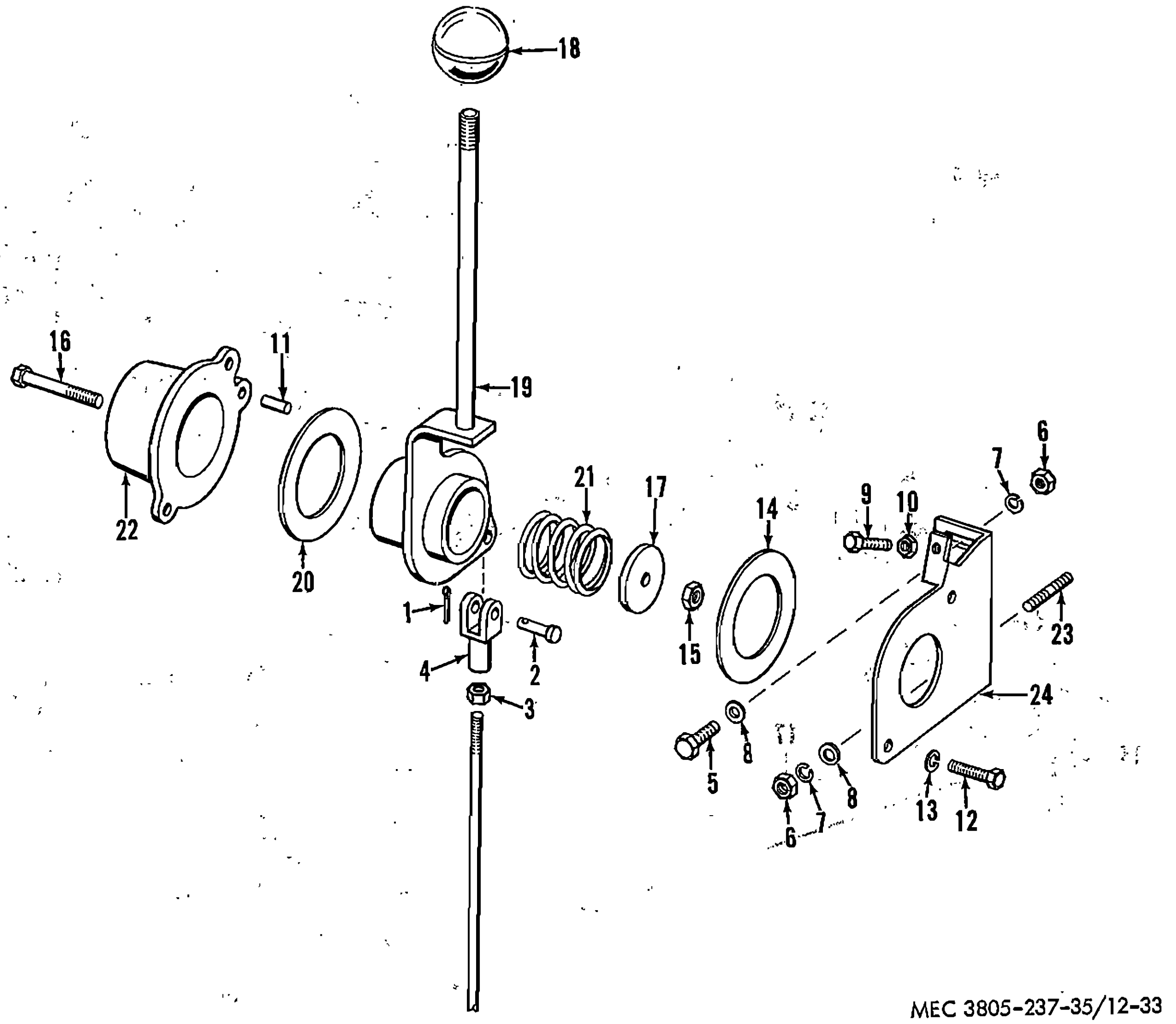
(fig. 12-32) approximately halfway between their stops for high and low speeds.

(*b*) Adjust all rods and clevises so that all vertical rods be as near vertical as possible and all horizontal rods as near horizontal as possible. Tighten all parts securely.

(*c*) Move throttle control shaft (fig. 12-32) against its stop for full engine speed. Adjust front pull rod (fig. 12-31) until accelerator-decelerator rod is pulled out of the housing 3/16 to 1/4 inch. Tighten parts. Push governor control lever (fig. 12-31) against low speed stop, accelerator decelerator rod should be pushed into its housing 3/16 to 1/4 inch.

(*d*) Adjust length of pedal rod (fig. 12-31) to assure that accelerator and decelerator pedals do not strike floor plate.

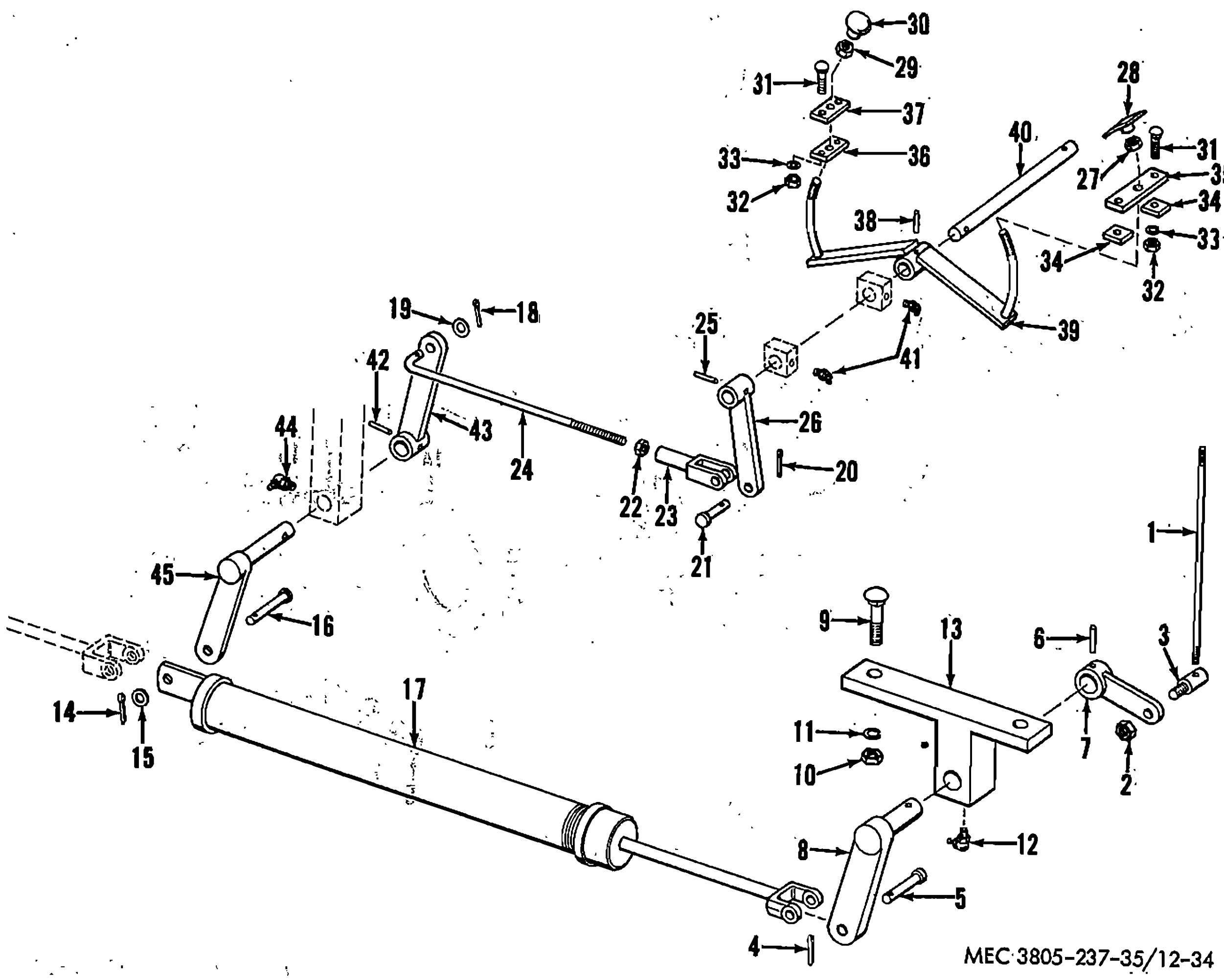
(*e*) Attach a spring scale to governor control lever as close to ball as possible. Pull on scale and move lever through full range of travel. Pull on scale should be 8 to 25 pounds through entire range.




| | | | |
|---|---|---|---|
| 1 | Pin, cotter, 3/32 × 1 in. | 13 | Washer, lock, 3/8 in. (2) |
| 2 | Clevis pin | 14 | Friction disk |
| 3 | Nut | 15 | Nut, 3/8-16 |
| 4 | Yoke | 16 | Screw, cap, hex-head, 3/8-16 × 2 3/4 in. |
| 5 | Screw, cap, hex-head, 1/2-13 × 1 1/2 in. | 17 | Washer |
| 6 | Nut, 1/2-13 (3) | 18 | Ball |
| 7 | Washer, lock, 1/2 in. (3) | 19 | Throttle base |
| 8 | Washer, cut, 1/2 in. (2) | 20 | Friction disk |
| 9 | Setscrew, 1/4-20 × 1 1/2 in. | 21 | Spring |
| 10 | Nut, jam, 1/4-20 | 22 | Throttle cap |
| 11 | Roll pin | 23 | Stud |
| 12 | Screw, cap, hex-head, 3/8-16 × 7/8 in. (2) | 24 | Throttle support |

*Figure 12-33. Governor control lever, exploded view.*

(*f*) Start engine (TM 5-3805-237-12) and allow engine to reach operating temperature. Run engine at idle speed. Loosen nut (17, fig. 12-38) and adjust length of setscrew (18) so that governor control-lever rests against head of setscrew when engine is at idle speed. Tighten nut.




| | | | | | |
|---|---|---|---|---|---|
| 1 | Vertical rod | 16 | Pin | 31 | Carriage bolt (2) |
| 2 | Nut | 17 | Accelerator – decelerator assembly | 32 | Nut (2) |
| 3 | Ball joint | 18 | Pin, cotter, 3/32 × 3/4 in. | 33 | Washer, lock, (2) |
| 4 | Pin, cotter, 3/32 × 1 in. | 19 | Washer, cut, 1/4 in. | 34 | Plate (2) |
| 5 | Clevis pin | 20 | Pin, cotter, 3/32 × 3/4 in. | 35 | Weather strip |
| 6 | Pin | 21 | Clevis pin | 36 | Plate |
| 7 | Lever | 22 | Nut | 37 | Weather strip |
| 8 | Lever | 23 | Yoke | 38 | Pin |
| 9 | Carriage bolt, 3/8-16 × 1/2 in. (2) | 24 | Rod | 39 | Pedal bracket |
| 10 | Nut, 3/8-16 (2) | 25 | Pin | 40 | Shaft |
| 11 | Washer, lock, 3/8 in. (2) | 26 | Lever | 41 | Lubrication fitting (2) |
| 12 | Lubrication fitting | 27 | Locknut | 42 | Pin |
| 13 | Lever support | 28 | Accelerator pedal | 43 | Lever |
| 14 | Pin, cotter, 3/32 × 3/4 in. (2) | 29 | Locknut | 44 | Lubrication fitting |
| 15 | Washer, cut, 1/4 in. (2) | 30 | Decelerator pedal | 45 | Lever |

*Figure 12-34. Pedals and throttle linkage, exploded view.*

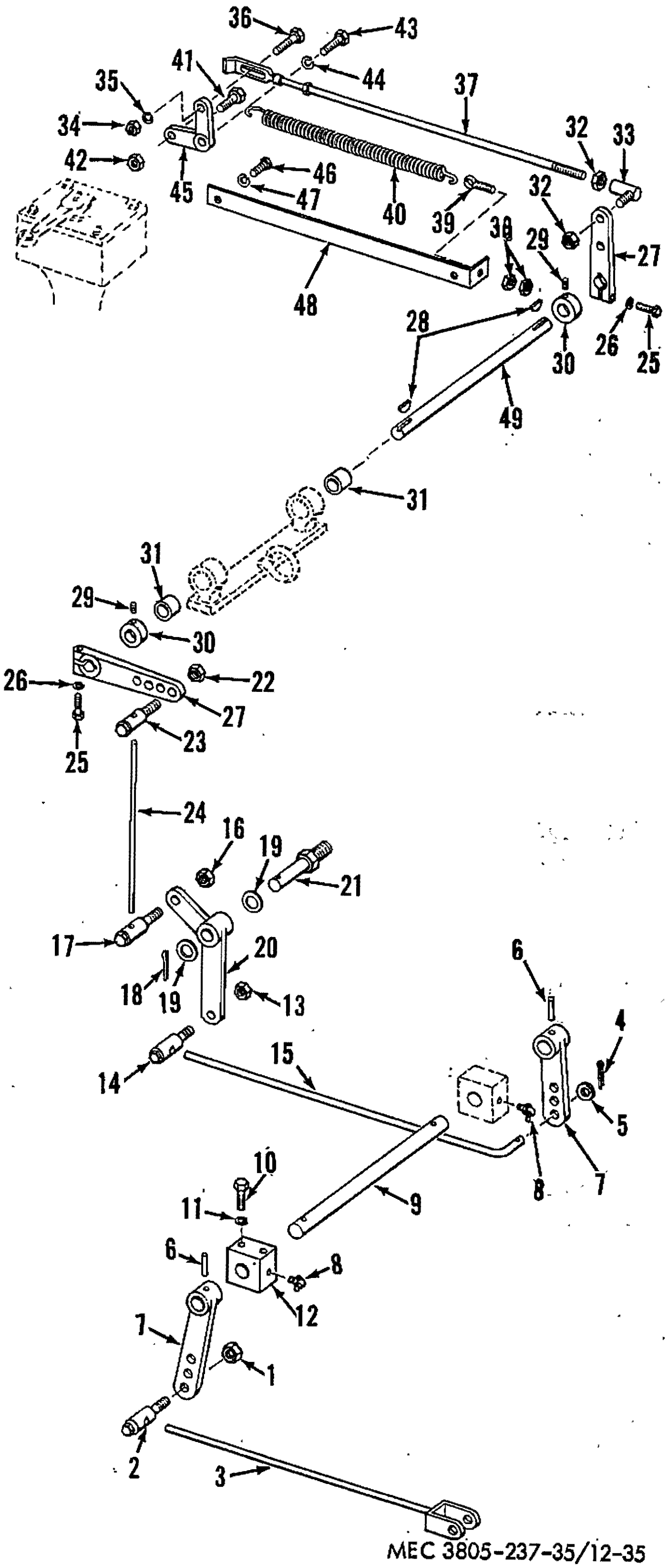



Figure 12-35. Engine throttle linkage, exploded view.

1 Nut
2 Ball joint
3 Rod, w/yoke
4 Pin, cotter, 3/32 × 3/4 in.
5 Washer, cut, 1/4 in.
6 Pin (2)
7 Lever (2)
8 Lubrication fitting (2)
9 Shaft
10 Screw, cap, hex-head, 5/16-18 × 1 in. (2)
11 Washer, lock, 5/16 in. (2)
12 Bearing
13 Nut
14 Ball joint
15 Rod
16 Nut
17 Ball joint
18 Pin, cotter, 3/32 × 1 in.
19 Washer, cut, 1/2 in. (2)
20 Lever
21 Pivot
22 Nut
23 Ball joint
24 Rod
25 Screw, cap, hex-head, 1/4-20 × 3/4 in. (2)
26 Washer, lock, 1/4 in. (2)
27 Lever (2)
28 Key, woodruff (2)
29 Setscrew, 1/4-20 × 1/4 in. (2)
30 Collar (2)
31 Bearing (2)
32 Nut (2)
33 Ball joint
34 Nut, 5/16-24
35 Washer, lock, 5/16 in.
36 Screw, cap, hex-head, 5/16-24 × 1 3/4 in.
37 Throttle control shaft
38 Nut, 1/4-20 (2)
39 Eyebolt
40 Booster spring
41 Screw, cap, hex-head
42 Nut
43 Screw, cap, hex-head, 1/4-20 × 1 in.
44 Washer, lock, 1/4 in.
45 Governor speed control lever
46 Screw, cap, hex-head, 3/8-16 × 5/8 in. (2)
47 Washer, lock, 3/8 in. (2)
48 Booster spring bracket
49 Shaft

*Figure 12-35*—Continued.

(2) *Governor booster spring.*

(*a*) With idle speed adjusted and spring screw (41, fig. 12-35) centered in slot in governor speed control lever (45), adjust booster spring. Loosen two eyebolt nuts (38).

(*b*) Start the engine (TM 5-3805-237-12) and move governor speed control lever (45, fig. 12-35) to the maximum speed position and release. Lever should return to idle speed position. If lever does not return, reduce spring tension by loosening eyebolt nuts (38). If lever does return to idle position, increase spring tension by tightening nuts until a point is reached where lever does not return to idle. Then reduce tension until lever does return to idle. Tighten locknut (38).

## 12-19. Governor

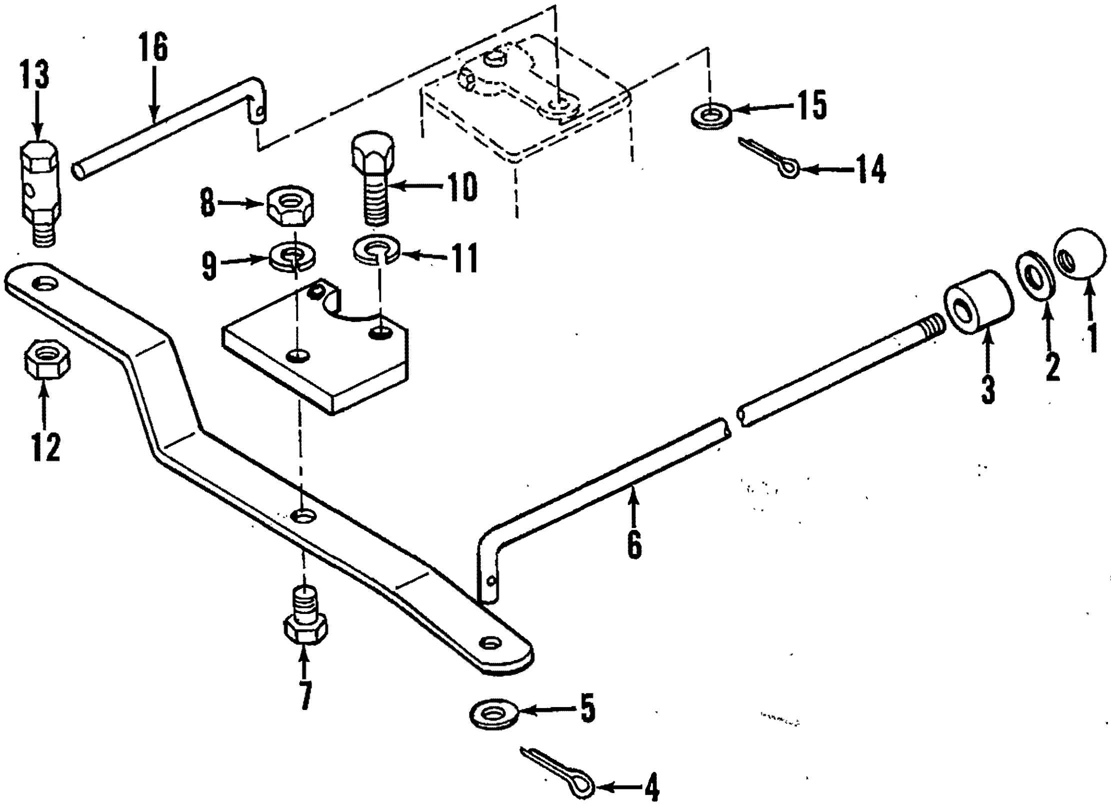
*a. General.*

(1) *Description.*

(*a*) The variable speed mechanical governor used on the engine controls the engine idle speed, limits the maximum no-load speed, and holds the engine at any constant speed, between idle and maximum, as required by the operator. The operator controls governor operation with the accelerator or the governor control lever (hand throttle). The governor control lever can be left in position to maintain engine speed and the decelerator depressed to slow the engine speed when shifting gears or operating grader motions. Releasing the decelerator will return engine speed to that set by the governor control lever.

(*b*) The principal parts of the governor are the control housing cover, variable speed spring housing and shaft, control housing, and weight and housing.

(*c*) A fuel rod (7, fig. 12-38) from the governor control housing is




1 Ball
2 Retaining ring
3 Insulating bushing
4 Pin, cotter, 3/32 x 3/4 in.
5 Washer, cut, 3/8 in.
6 Shutoff rod
7 Shoulder bolt
8 Nut, 3/8-16
9 Washer, lock, 3/8 in.
10 Screw, cap, hex-head, 3/8-16 x 3/4 in. (2 rqr)
11 Washer, lock, 3/8 in.
12 Nut
13 Ball joint
14 Pin, cotter, 3/32 x 3/4 in.
15 Washer, cut, 3/8 in.
16 Governor rod

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*Figure 12-36. Engine shutdown linkage, exploded view.*

linked to the injector tubes. Movement of the rod moves the injector control tubes and control levers. The levers move the injector control racks and position the injector plungers for the amount of fuel to be delivered.

(2) *Operation.*

(*a*) Control of governor operation through the linkage actuates the

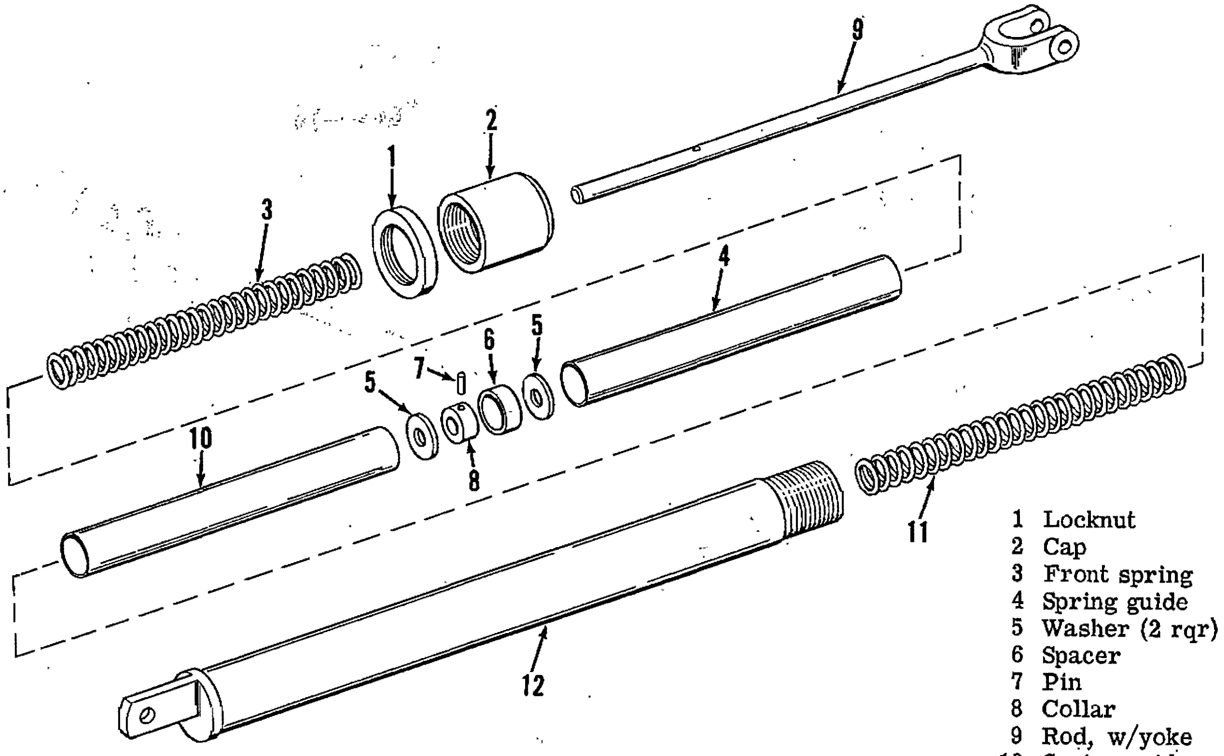
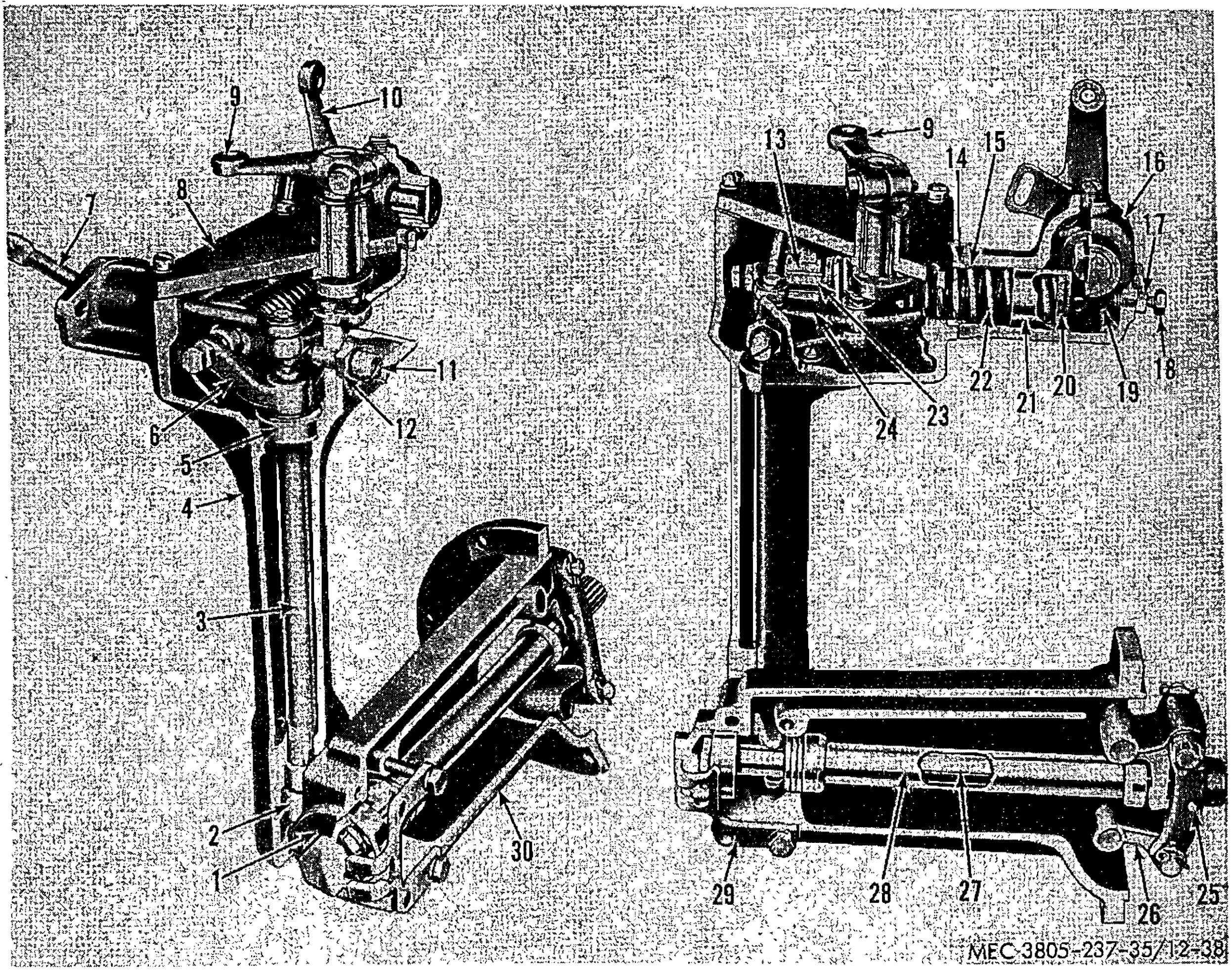



*Figure 12-37. Accelerator-decelerator assembly, exploded view.*

governor speed control lever (10, fig. 12-38) and governor stop control lever. When the engine shutdown linkage is pushed in the governor stop lever, mounted on top of the control housing, moves the injector control racks to the full fuel position. When the engine starts the governor moves the control racks to the idle position. Engine speed is then controlled through movement of the governor speed control lever (10, fig. 12-38).

(*b*) The centrifugal force of the revolving governor weights is converted into linear motion and is transmitted by the governor riser (28) and operating shaft (3) to the operating shaft lever (6). The operating shaft lever contacts the variable speed plunger (23) while the other end of the lever provides a changing fulcrum on which the differential lever (24) pivots.

(*c*) The force of the governor weights is opposed by the variable speed spring (22). Load changes on the engine or a movement of the throttle linkage and a subsequent movement of the governor speed control lever (10) unbalance the force between the weights and the




| | | | | | |
|---|---|---|---|---|---|
| 1 | Weight housing cap | 11 | Buffer screw | 21 | Spring retainer |
| 2 | Operating shaft fork | 12 | Locknut | 22 | Variable speed spring |
| 3 | Operating shaft | 13 | Plunger spring guide | 23 | Spring plunger |
| 4 | Control housing | 14 | Spring retainer stop | 24 | Differential lever |
| 5 | Operating shaft bearing | 15 | Spring retainer stop | 25 | Weight carrier |
| 6 | Operating shaft lever | 16 | Variable speed spring housing | 26 | Weight and carrier assembly |
| 7 | Fuel rod | 17 | Locknut | 27 | Weight shaft assembly |
| 8 | Governor cover | 18 | Idle speed adjusting screw | 28 | Governor riser |
| 9 | Governor stop lever | 19 | Spring lever | 29 | Weight housing cover |
| 10 | Governor speed control lever | 20 | Shim | 30 | Weight housing |

*Figure 12-38. Variable speed mechanical governor, cutaway view.*

spring. When the two forces are equal the engine speed stabilizes for the setting of the speed control lever.

(*d*) A fuel rod (7) connected to the injector control tube levers and control link operating lever assembly is operated by the differential lever through the operating lever connecting link. Moving the fuel rod, through action of the governor in this manner, changes the fuel settings of the injector control racks.

(*e*) Engine idle speed is determined by the centrifugal force required to balance out the variable speed spring in the low speed range. This speed is adjusted by changing the tension on the spring with the idle speed adjusting screw (18).

(*f*) Maximum no load speed is adjusted by changing the tension of the variable speed spring through the installation or removal of spring retainer stops (14 and 15) and shims (20).

(*g*) Lubrication for the governor is supplied by surplus oil returning from the cylinder head for parts in the governor control housing, riser thrust bearings, and the weight shaft end bearing. Oil, picked up by a slinger from a reservoir in the blower housing, provides lubrication for the governor weights and weight carrier. Pressure lubrication is also supplied through an oil line from the cylinder block to the governor weight housing cover.

*b. Governor Operational Check.* Speed variations in engine operation may indicate erratic governor operation. Many other factors could contribute to the variations in speed and should be checked before identifying the governor as the cause.

(1) Excessive load fluctuations could cause speed changes.

(2) All cylinders may not be firing properly. Refer to paragraph 12-46 to check cylinders.

(3) Check for binding in the following:

(*a*) Linkage between governor and injector control tube. With the fuel rod connected to the control tube the mechanism should be free throughout the entire travel of the injector racks.

(*b*) Check injector racks for binding. Injector rack binding or sticking may be due to an injector clamp being too tight. Loosen and retorque clamp.

(*c*) Check for binding between control tube levers and injector racks. This could be the result of improperly positioned control rack. Refer to paragraph 12-20 to properly position control racks.

(*d*) Check for binding of control tube in support brackets. Loosen and reset control tube in brackets (para 12-20).

(*e*) Check for a bent control tube spring. Install a new spring (para 12-20).

(*f*) If after the above checks the governor does not operate the engine properly, remove and repair the governor.

*c. Removal.*

(1) Refer to TM 5-3805-237-12 and remove engine hood. Refer to paragraph 12-17 and remove rocker cover.

(2) Refer to paragraph 12-18 and disconnect the throttle control shaft (37, fig. 12-35) and booster spring (40, fig. 12-35) from the governor speed control lever. Disconnect governor rod (16, fig. 12-36) from governor stop lever. Remove return spring from stop lever.

(3) Remove screw and lockwasher and remove camp from breather tube (fig. 12-39). Remove two screws and lockwashers and remove breather tube and gasket from governor control housing.

(4) Disconnect oil line (fig. 12-39) from governor weight housing cover and cylinder block. Remove elbows from cover and block.

(5) Refer to figure 12-40 and disconnect fuel rod from injector control tube and remove governor from engine.

*d. Disassembly.*

(1) Disassemble the governor cover in the numerical sequence as illustrated on figure 12-41. Press needle bearings (11) from cover using a suitable tool and an arbor press. Discard packing and gasket.

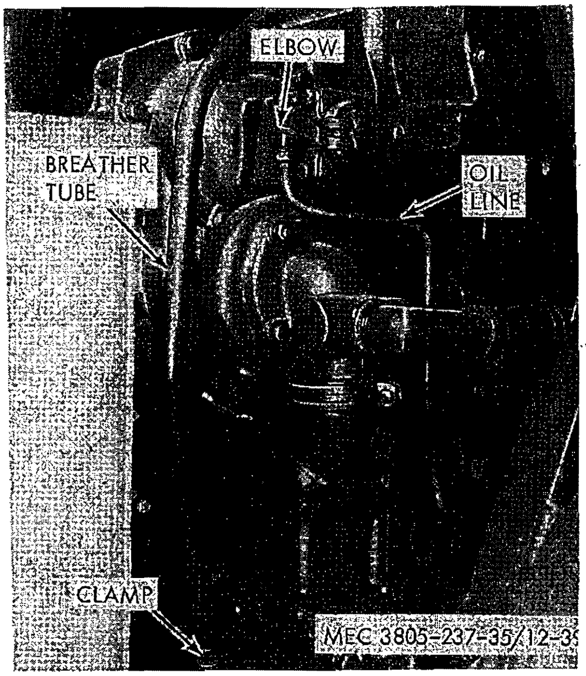



*Figure 12–39. Governor breather tube and oil line, removal and installation.*

(2) Disassemble the variable speed spring housing in the numerical sequence as illustrated on figure 12–42.

(*a*) Place the governor control housing in the jaws of a soft vise.

(*b*) Remove two screws (1) and lockwashers (2) and remove the variable speed spring housing and gasket (3) from the control housing.

(*c*) Remove plunger (4) from plunger guide (5). Remove spring (6), stops (7 and 8), shims (9) and retainer (10) from spring housing.

(*d*) Remove plug (11) and, working through plug hole, remove setscrew (12) from spring lever (20). Remove idle speed adjusting screw (14) and nut (15).

(*e*) Support the spring housing on a press with the shaft up. Using a brass rod press plug (16), bearing (17), and shaft (18) from housing.

(*f*) Remove spring lever (20) from housing (24). Remove key (19). If bearing (23) requires replacement, press bearing, seal ring (22), and washer (21) from the housing.

(3) Disassemble governor control housing in the numerical sequence as illustrated on figure 12–43.

(*a*) Remove cotter pin (8) and washer (9) and remove differential lever (10) from operating lever (19).

(*b*) Remove expanding plug (14). Loosen setscrew (15). Use a brass rod and press operating shaft (24) from operating fork (16), inserting rod through expansion plug hole.

(*c*) Remove operating shaft, with operating lever attached, from housing. Use a brass rod and press operating shaft from operating lever (19) and bearing (20).

(4) Disassemble governor weight housing in the numerical sequence as illustrated on figure 12–44.

(*a*) Secure weight housing in a vise with soft jaws. Remove cap (8) and gasket (9).

(*b*) Straighten tab on lockwasher (11) and remove screw (10). Install a 5/16–24 × 3 inch long bolt in end of weight shaft (21) and press shaft from bearing (14).

(*c*) Slide riser thrust bearing (12) and riser (13) from weight shaft.

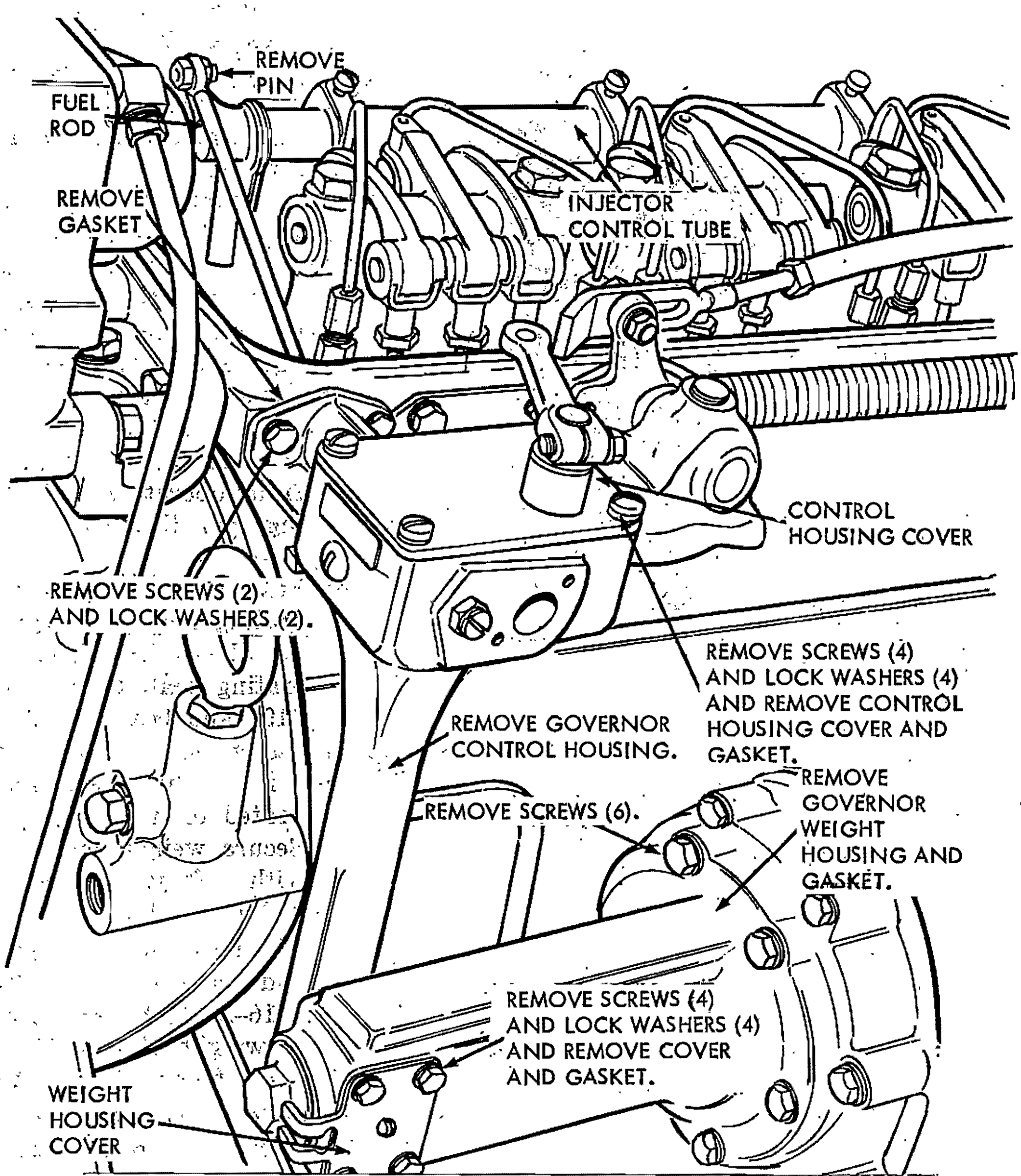
(*d*) Remove retaining rings (15), flat washers (17), pins (16), and weights (19) from carrier (20). If bearings (18) require replacement, press bearings from weights.

(*e*) Press bearing (14) from housing (22) and carrier (20) from operating shaft.

*e. Cleaning.* Clean all parts in clean fuel oil and dry with compressed air.

*f. Inspection and Repair.*

(1) Discard all packings and gaskets.




STEP 1. REMOVE TWO COTTER PINS AND REMOVE PIN CONNECTING FUEL ROD TO INJECTOR CONTROL TUBE LINK.
STEP 2. REMOVE FOUR SCREWS AND LOCK WASHERS AND REMOVE WEIGHT HOUSING COVER AND GASKET.
STEP 3. REMOVE FOUR SCREWS AND LOCK WASHERS AND REMOVE CONTROL HOUSING COVER AND GASKET.
STEP 4. REMOVE COTTER PIN (3, FIG. 12-43) AND WASHER (4, FIG. 12-43) AND REMOVE FUEL ROD FROM CONTROL HOUSING.
STEP 5. REMOVE TWO SCREWS AND LOCK WASHERS SECURING CONTROL HOUSING TO CYLINDER HEAD.
STEP 6. MOVE UPPER END OF CONTROL HOUSING AWAY FROM CYLINDER HEAD AND FREE LOWER END FROM GOVERNOR WEIGHT HOUSING TO CLEAR FORK AND REMOVE GOVERNOR CONTROL HOUSING. REMOVE GASKET FROM CYLINDER HEAD.
STEP 7. REMOVE SIX SCREWS AND LOCK WASHERS AND REMOVE GOVERNOR WEIGHT HOUSING FROM BLOWER.

MEC 3805-237-35/12-40

*Figure 12-40. Governor, removal and installation.*

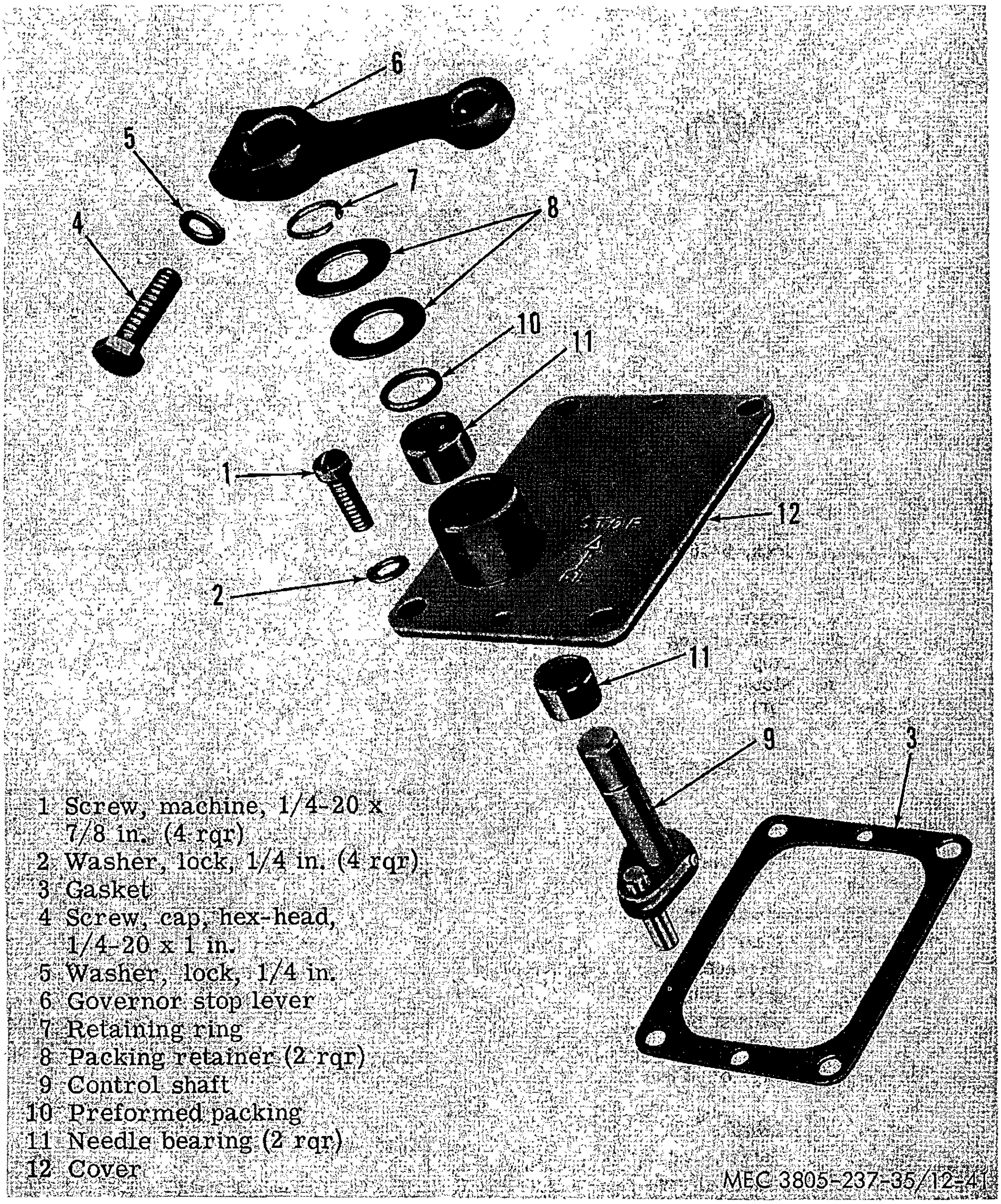
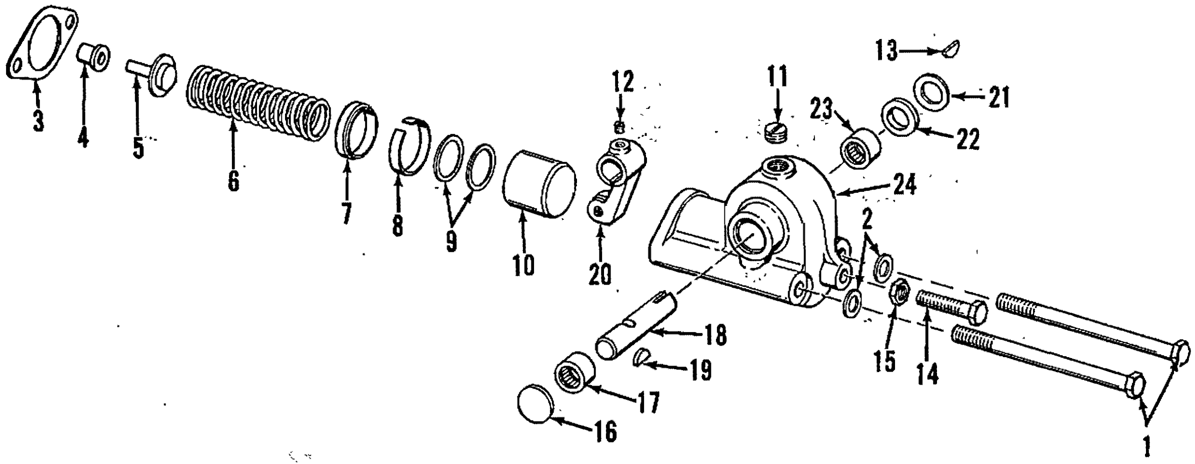



*Figure 12-41. Governor cover, exploded view.*




1 Screw, cap, hex-head, 5/16-18 x 3-1/2 in. (2 rqr)
2 Washer, lock, 5/16 in. (2 rqr)
3 Gasket
4 Plunger guide
5 Spring plunger
6 Variable speed spring
7 Retainer stop
8 Retainer stop
9 Shim (as rqr)
10 Retainer
11 Plug
12 Setscrew, 5/16-24 x 1/4 in.
13 Key, woodruff
14 Idle speed adjusting screw
15 Nut, 1/4-20
16 Expansion plug
17 Bearing
18 Shaft
19 Key, woodruff
20 Spring lever
21 Washer
22 Seal ring
23 Bearing
24 Housing

MEC 3805-237-35/12-42

*Figure 12-42. Variable speed spring housing, exploded view.*

(2) Inspect ball bearings by revolving by hand. Bearings must operate smoothly. Replace all bearings showing wear or rough spots.

(3) Inspect riser thrust bearing for wear, flat spots, and corrosion. Replace bearing if any of these conditions exist.

(4) Inspect all shafts, bushings, and bearings for wear, rough spots, and damage. Replace all worn or damaged parts.

(5) Inspect weight pins and bearings for wear and flat spots. Replace all worn or damaged pins and bearings.

(6) Inspect finished surfaces of governor weights for flat spots and damage. Replace weights if damaged.

(7) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*g. Reassembly.*

(1) Reassemble the governor weight in reverse of the numerical sequence as illustrated on figure 12-44.

(*a*) Press carrier (20) on operating shaft (21).

(*b*) Install one retaining ring (15) in groove of pin (16). Install flat washer (17) over pin and install

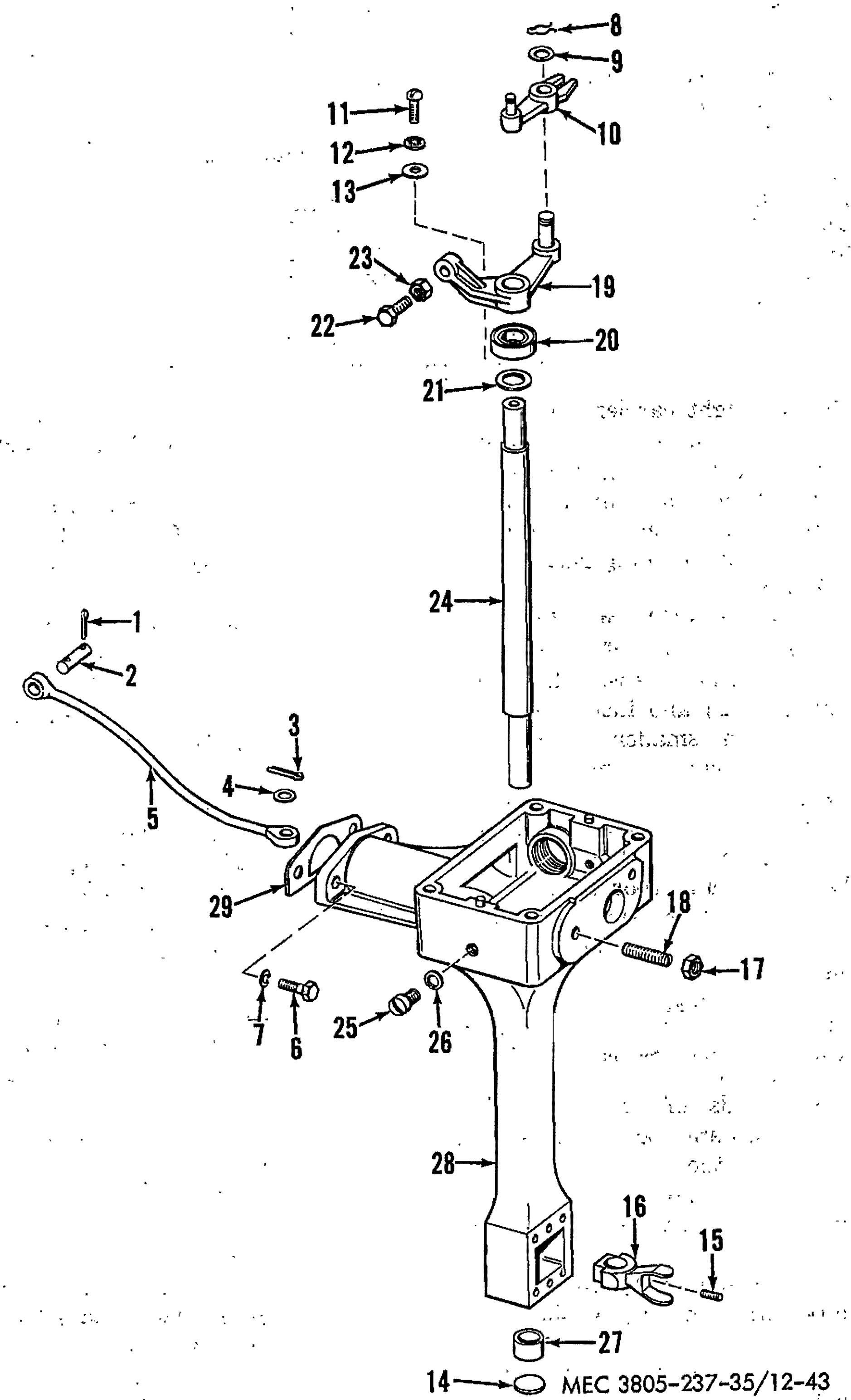



*Figure 12-43. Governor control housing, exploded view.*

1 Pin, cotter, 1/16 × 1/2 in. (2)
2 Pin
3 Hairpin cotter pin
4 Washer
5 Fuel rod
6 Screw, cap, hex-head, 1/4-20 × 3/4 in. (2)
7 Washer, lock, 1/4 in. (2)
8 Hairpin cotter pin
9 Washer
10 Differential lever
11 Screw, machine, No. 10-24 × 7/16
12 Washer, lock, No. 10
13 Washer, flat
14 Expansion plug
15 Setscrew, 1/4-20 × 1/2 in.
16 Fork
17 Nut, 1/4-28
18 Buffer screw
19 Operating lever
20 Bearing
21 Washer
22 Adjusting screw
23 Nut, 1/4-28
24 Operating shaft
25 Plug
26 Washer
27 Bushing
28 Housing
29 Gasket

*Figure 12-43*—Continued.

pin in weight carrier (20). Install two flat washers and governor weight (19) between arms of carrier and slide pin through carrier, washers, and weight. Install flat washer and retaining ring on other end of pin.

(*c*) Slide riser (13) on shaft and against finished surfaces of governor weights. Assemble thrust bearing (12) and install on weight shaft with smaller inside diameter of bearing against riser.

(*d*) Install the shaft, with attached parts in weight housing. Support the splined end of the shaft on the bed of an arbor press. Install bearing (14) on shaft and press bearing, using a suitable tool, on shaft.

*Note.* The bearing must be installed with the numbered side of the bearing facing away from the shaft. The bearing has thrust capacity in one direction only.

(*e*) Coat threads of cap (8) with a thread sealant before installing.

(2) Reassemble the governor control housing in reverse of the numerical sequence as illustrated on figure 12-43.

(*a*) Install washer (21) on operating shaft (24) and press shaft into bore of bearing (20).

(*b*) Press operating lever (19) on shaft with pivot pin up.

(*c*) Press bushing (27) in housing. Lubricate bushing and bearing (20) with engine oil (OES). Install shaft, with attached parts in housing. Position the fork (16) in lower end of housing so the finished side of fork will contact thrust bearing (12, fig. 12-44).

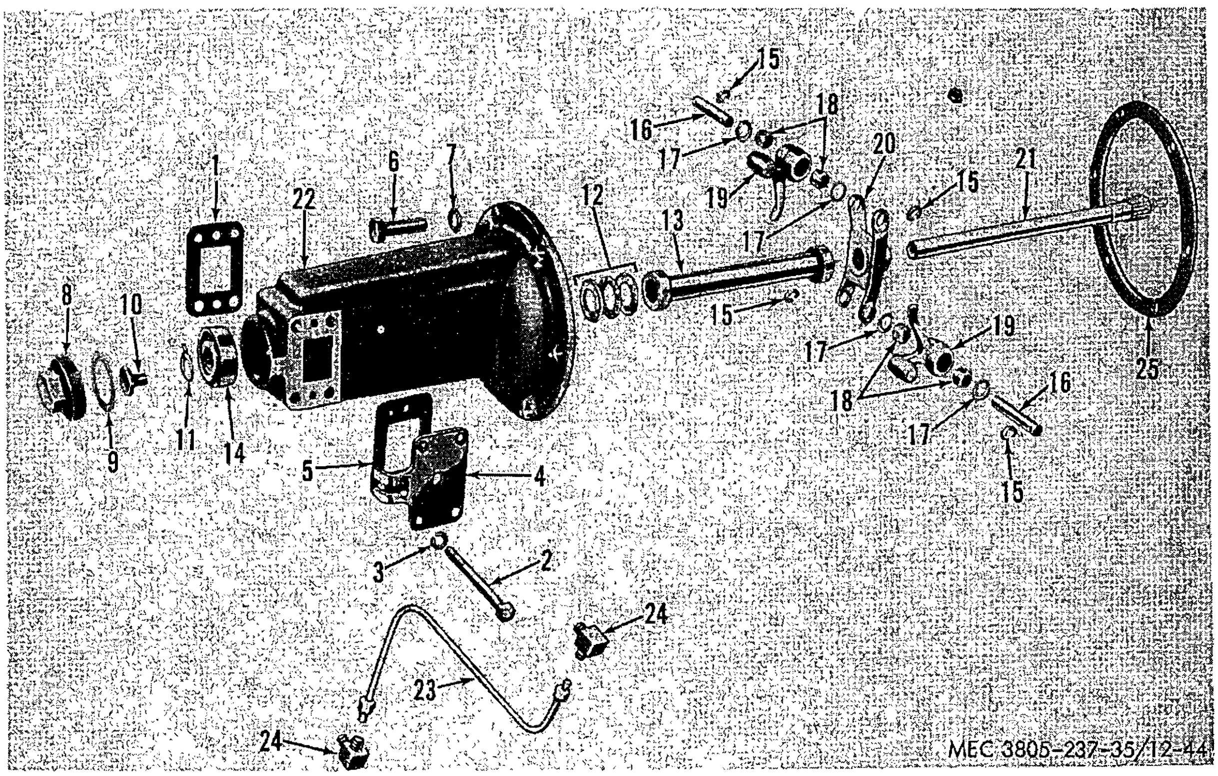
(*d*) Support housing and shaft in an arbor press with upper end of shaft on a steel block. Aline flat in fork with flat on shaft and, using a sleeve, press fork on operating shaft until fork is tight against shoulder. Install setscrew (15) and tighten.

(*e*) Install differential lever (10) on pivot pin of operating lever and secure with washer (9) and cotter pin (8). Install screw (11), lockwasher (12), and flat washer (13) in housing to secure bearing.

(*f*) Install variable spring plunger guide (4, fig. 12-42) in housing.

(3) Reassemble the variable speed spring housing in reverse of the numerical sequence as illustrated on figure 12-42.

(*a*) Install key (19) in center keyway of shaft. Install setscrew (12) in lever (20). Place lever in housing, with keyway lined up with key in shaft. Install shaft through housing and lever. Center the lever




1 Gasket
2 Screw, cap, hex-head, 1/4-20 × 2 3/8 in. (4)
3 Washer, lock, 1/4 in. (4)
4 Cover
5 Gasket
6 Screw, cap, hex-head (6)
7 Washer, sealing (6)
8 Cap
9 Gasket
10 Retaining screw
11 Washer, tab
12 Thrust bearing
13 Riser
14 Ball bearing
15 Retaining ring (4)
16 Pin (2)
17 Washer, flat (8)
18 Needle bearing (4)
19 Weight (2)
20 Weight carrier
21 Weight shaft
22 Weight housing
23 Oil line
24 Elbow (2)
25 Gasket

*Figure 12-44. Governor weight housing, exploded view.*

between bearing bosses and tighten setscrew.

(*b*) Place bearings (17 and 23) over shaft and, using a sleeve and an arbor press, press bearings into housing around shaft. Use sealant on plug (16) and tap plug into housing.

(*c*) Install seal ring (22) and washer (21) in housing around shaft.

(*d*) Install idle speed adjusting screw (14) and nut (15) in housing.

(*e*) Install small end of plunger (5) in plunger guide (4) in control housing. Install solid stop (7) in control housing.

(*f*) Install spring retainer (10) in spring housing against lever (20). Place same number of shims (9) in retainer as were removed. Install split stop (8) in spring housing against retainer.

(*g*) Install spring (6) in retainer, with tightly wound end of spring against shims. Install gasket (3) and screws (1) and lockwashers (2) through housing. Install spring housing on governor control housing. Spring plunger (5) must be engaged by spring. Tighten screws (1) securely.

(4) Reassemble the governor cover in reverse of the numerical sequence as illustrated on figure 12-41.

(*a*) Press bearings (11) into cover. Lubricate bearings with engine oil (OES) and install control shaft (9) through bearings.

(*b*) Install packing (10) and retainers (8) over packing. Install retaining ring (7) in groove in shaft. Install stop lever (6) on shaft and secure with screw (4) and lockwasher (5).

*h. Installation.*

(1) Refer to figure 12-40 and install governor on the engine.

(2) Refer to figure 12-39 and install governor breather tube and oil line on governor.

(3) Install return spring on stop lever. Refer to paragraph 12-18 and connect throttle control shaft (37, fig. 12-35) and booster spring (40, fig. 12-35) to governor speed control lever.

(4) Refer to paragraph 12-17 and install rocker cover. Refer to TM 5-3805-237-12 and install engine hood.

*i. Governor Adjustment.* Refer to paragraphs 12-51 through 12-55 and adjust governor and tune engine.

## 12-20. Fuel Injector Control Tube

*a. General.*

(1) The fuel rod extending from the governor is attached to the control tube lever. This lever is pinned to the injector control tube. Any movement of the fuel rod is reflected in a rotation of the fuel tube.

(2) Each injector control rack is in contact with a lever mounted on the control tube. As the tube rotates the levers move the injector racks to position the injector plungers to time and meter the fuel to be injected into the cylinders. A return spring, connected to a control lever and to a bracket returns the control tube to the no fuel position.

*b. Removal.*

(1) Refer to TM 5-3805-237-12 and remove the engine hood.

(2) Refer to paragraph 12-17 and remove the valve rocker cover.

(3) Refer to paragraph 12-19 and disconnect the fuel control rod from the control tube lever.

(4) Refer to figure 12-45 and remove the injector control tube from the engine as follows:

(*a*) Remove four screws (1) and lockwashers (2) to free brackets (3) from cylinder head.

(*b*) Remove the injector control tube brackets and control tube from the engine as an assembly.

*c. Disassembly.* Disassemble the injector control tube in the numerical sequence as illustrated on figure 12-45. Load limit adjustment plate is secured with rocker arm bracket bolts (fig. 12-24).

*d. Cleaning.* Clean all parts in fuel oil and dry thoroughly with compressed air.

*e. Inspection and Repair.*

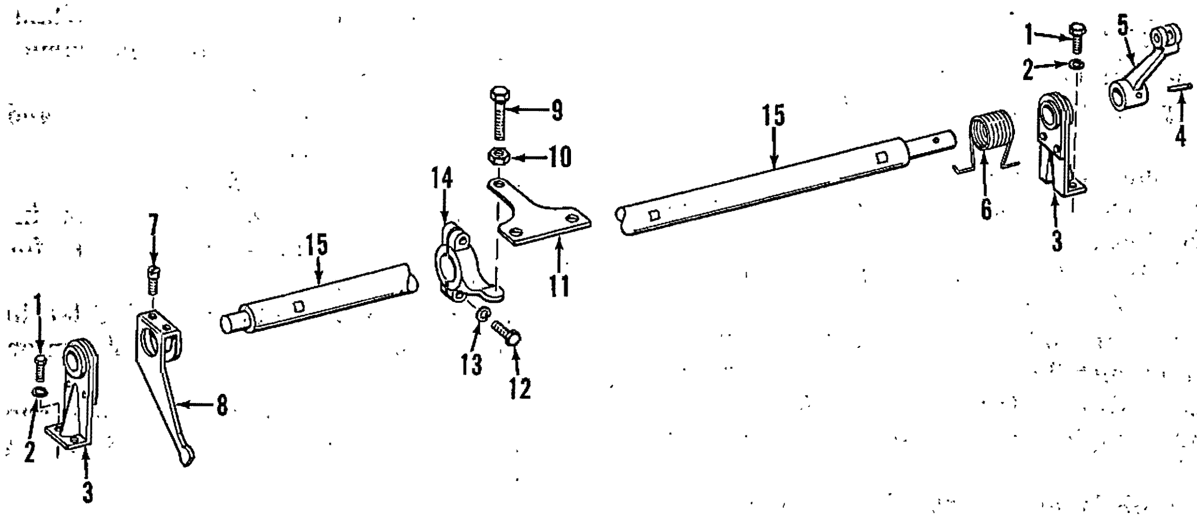
(1) Inspect brackets and integral bearings in brackets for wear and damage. Replace worn or damaged brackets.

(2) Inspect spring for weak or broken condition. Replace weak or broken spring.

(3) Inspect link for wear and damage. Replace link if worn or damaged.

(4) Inspect control lever and torque limit control arm for wear and damage. Replace worn or damaged parts.

(5) Inspect control tube for wear and damage, especially in the lever contact and bearing contact areas. Replace a worn or damaged control tube.




1 Screw, cap, hex-head, 1/4-20 x 5/8 in. (4 rqr)
2 Washer, lock, 1/4 in. (4 rqr)
3 Bracket (2 rqr)
4 Pin
5 Fuel rod link
6 Return spring
7 Adjusting screw (8 rqr)
8 Control rack lever (4 rqr)
9 Screw, cap, hex-head
10 Nut, 5/16-24
11 Load limit adjustment plate
12 Screw, cap, hex-head, 1/4-20 x 1 in. (2 rqr)
13 Washer, lock, 1/4 in. (2 rqr)
14 Torque limit control arm
15 Injector control tube

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*Figure 12-45. Injector control tube, exploded view.*

*f. Reassembly.* Reassemble the injector control tube assembly in the reverse of the numerical sequence as illustrated on figure 12-45.

*g. Installation.*

(1) Install the injector control tube assembly on the cylinder head. Install screws (1) and lockwashers (2).

(2) Tighten screws (1) only finger tight. Slide injector control rack levers on tube until they engage the injector control racks.

(3) Hook one end of return spring (6) in control rack lever and other end in bracket. Tighten screws (1) to a torque of 10 to 12 foot pounds.

(4) Revolve control tube and release. Return spring must pull injector control racks out to the no fuel position after they have been pushed all the way in. If tube binds, tap tube lightly to aline tube in bracket bearings.

(5) Injector racks must return to no fuel position freely with aid of return spring only. If spring does not return racks correctly, replace spring. Do not bend spring to correct for binding.

(6) Refer to paragraph 12-17 and install the valve rocker cover.

(7) Refer to TM 5-3805-237-12 and install the engine hood.

*h. Adjust Control Tube and Injectors.* Refer to paragraph 12-50 and adjust control tube and tune the engine.

## Section VI. LUBRICATION SYSTEM

### 12-21. General

*a.* The engine lubrication system is schematically illustrated on figure 12-46. Lubricating oil is circulated by a gear type pressure pump mounted on the number 1 and number 2 main bearing caps. Drive for the pump is supplied from the crankshaft gear.

*b.* Oil from the pump is forced through the oil cooler. From the cooler the oil is forced into the oil galleries of the cylinder block and distributed to the various engine bearings. Drains from the cylinder head and other engine parts lead back to the oil pan.

*c.* The oil is sucked into the pump through the inlet screen (fig. 12-46). A relief valve, integral within the pump (fig. 12-47) bypasses excess oil from the outlet side to the inlet side of the pump when pressure in the oil gallery exceeds 100 psi. From the pump the oil flows through a pressure regulator valve (fig. 12-46). This valve stabilizes oil pressure throughout the engine at all engine speeds regardless of oil temperature. When the oil pressure at the valve exceeds 45 psi the regulator valve opens and remains open until the pressure drops below opening pressure.

*d.* A portion of the oil is filtered as it returns to the oil pan by a bypass type oil filter (fig. 12-46) mounted on a bracket at the right hand side of the engine.

### 12-22. Oil Filter

*a. General.* The bypass type oil filter receives oil as it drains back to the oil pan. Oil flows into the filter near the top, through the element, and out the bottom of the filter into the cylinder block.

*b. Removal.* Refer to figure 12-48 and remove the oil filter from the engine.

*c. Disassembly.* Disassemble the oil filter in the numerical sequence as shown in figure 12-49.

*d. Cleaning.* Clean all metal parts with cleaning compound, solvent (Spec. P-S-661) and dry thoroughly. Clean oil lines with a damp cloth and blow lines clean with fresh air.

***Warning:* The solvent is highly inflammable. Do not use solvent near open flame.**

*e. Inspection and Repair.*

(1) Inspect all parts for damage and evidence of leaks.

(2) Replace all damaged parts.

(3) Refer to TM 5-3805-237-12 for intervals and service instructions for the oil filter.

*f. Reassembly.* Reassemble the oil filter in reverse of the numerical sequence as shown on figure 12-49.

*g. Installation.* Refer to figure 12-48 and install the mounting bracket and oil filter on the engine.

### 12-23 Oil Cooler

*a. General.*

(1) The lubricating oil cooler (fig. 12-46) is mounted on the left side of the engine beneath the water pump. Oil is forced through the oil cooler and cooled as it passes through the cores.

(2) Coolant from the radiator enters the bottom of the cooler, travels up through the cooler, and out the top into the water pump.

(3) The cooled oil leaves the oil cooler and enters the cylinder block where it is distributed through the oil galleries.

*b. Removal.*

(1) Refer to TM 5-3805-237-12 and drain cooling system.

(2) Refer to figure 12-50 and remove oil cooler and adapter from engine.

*c. Disassembly.* Disassemble the oil cooler in the numerical sequence as illustrated on figure 12-51. Discard all gaskets.

*d. Cleaning.*

(1) Clean inside of oil cooler core and oil passages with a wire brush or metal probe and flushing with cleaning compound, solvent (Spec. P-S-661). Dry thoroughly with compressed air.

***Warning:* The solvent is highly inflammable. Do not us solvent near an open flame.**

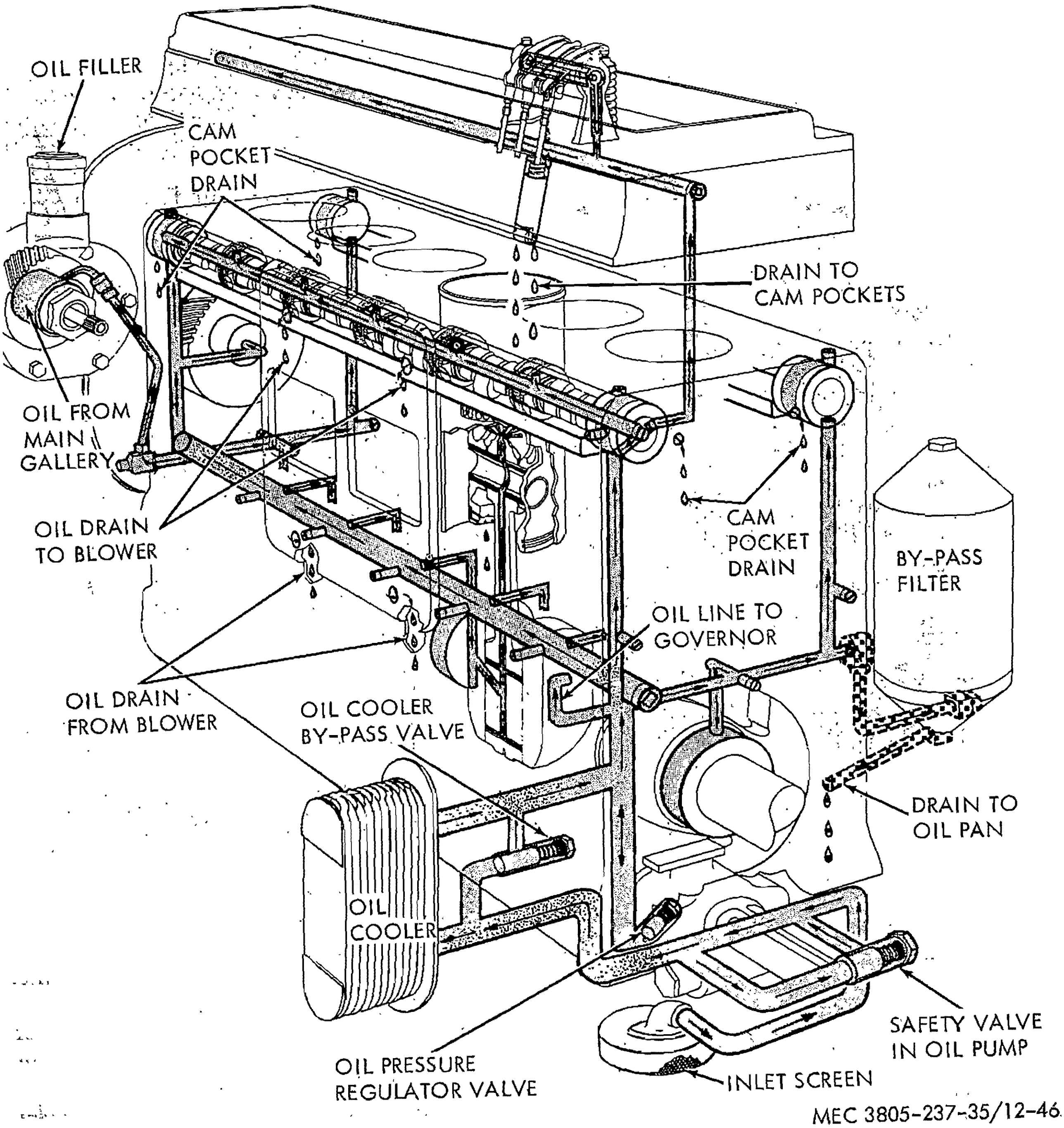



*Figure 12-46. Lubricating system, schematic diagram.*

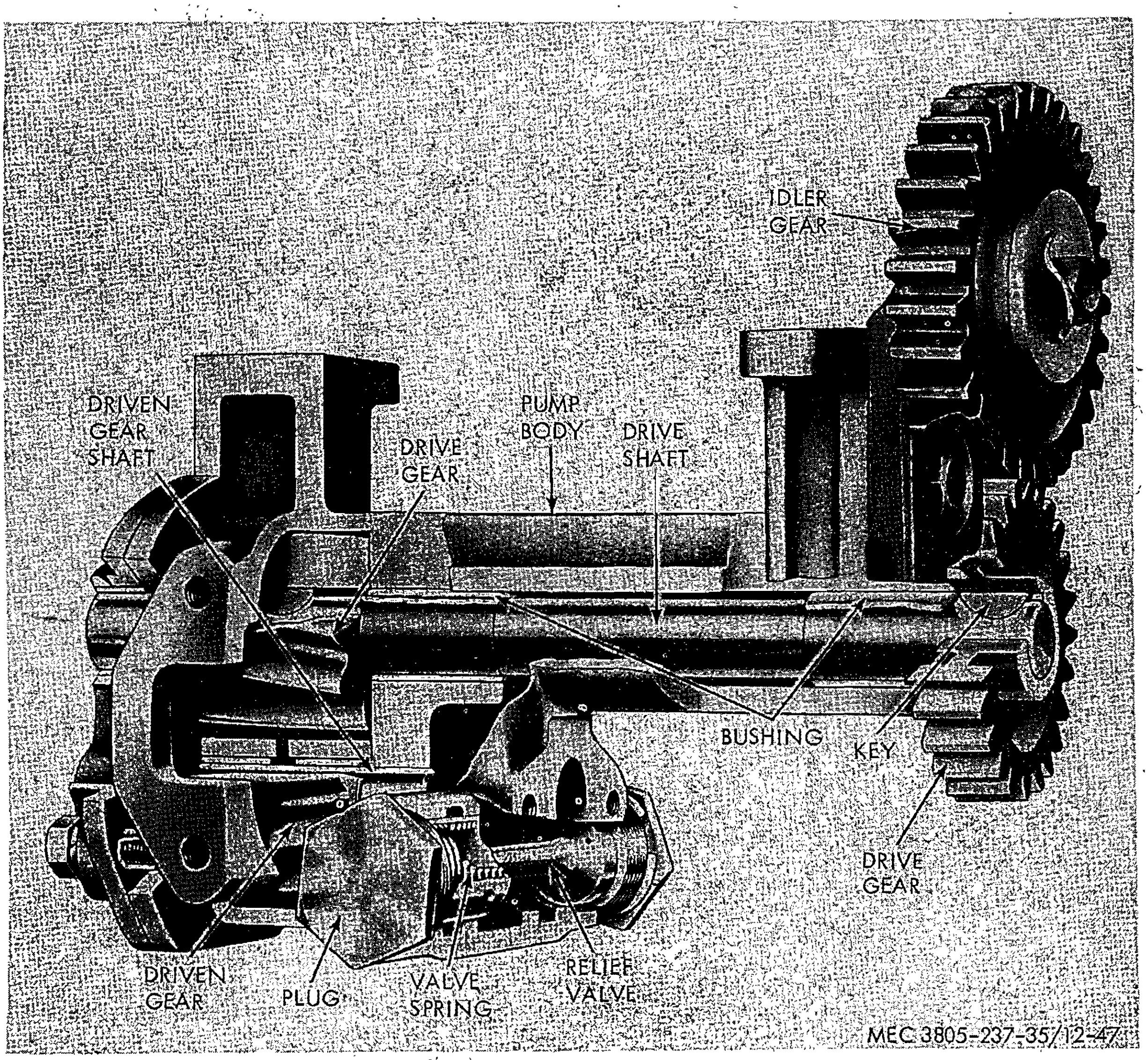



*Figure 12-47. Oil pump, cutaway view.*

(2) Clean scale and mineral formations from housing and outside of core with a wire brush. Flush with water and dry thoroughly.

(3) Clean the bypass valve in solvent and dry thoroughly.

*e. Inspection and Repair.*

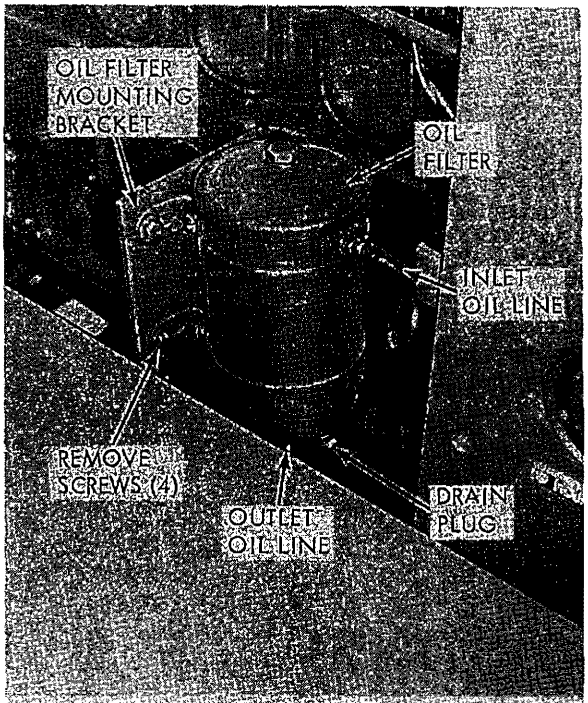
(1) Inspect housing, core, and adapter for cracks, leaks, and damage. Replace cracked, damaged, or leaking parts.

(2) Inspect valve for wear and scoring. Replace a damaged valve.

(3) Inspect valve spring for weak or broken condition. Replace a weak or broken valve spring.

*f. Reassembly.* Reassemble the oil cooler in reverse of the numerical sequence as illustrated on figure 12-51.

*g. Installation.* Refer to figure 12-50 and install the oil cooler and adapter on the engine.




STEP 1. REMOVE DRAIN PLUG AND DRAIN OIL FROM FILTER.
STEP 2. DISCONNECT INLET OIL LINE FROM FILTER AND FROM UNION IN CYLINDER BLOCK.
STEP 3. DISCONNECT OUTLET OIL LINE FROM BOTTOM OF FILTER AND ELBOW IN CYLINDER BLOCK.
STEP 4. REMOVE FOUR SCREWS, LOCK WASHERS, FLAT WASHERS, AND NUTS. REMOVE OIL FILTER FROM BRACKET.
STEP 5. REMOVE TWO SCREWS AND LOCK WASHERS AND REMOVE OIL FILTER MOUNTING BRACKET FROM ENGINE.
STEP 6. REMOVE ELBOW AND UNION FROM CYLINDER BLOCK.

MEC 3805-237-35/12-48

*Figure 12-48. Oil filter, removal and installation.*

## 12-24. Oil Pan

*a. General.*

(1) The shallow oil pan acts as a sump for the oil. A screened intake for the oil pump is suspended in the oil pan and carries the oil from the pan to the pump.

(2) The oil pan is of sheet metal construction. A drain for the pan is suspended on a hanger at the right side of the engine. The oil gage is mounted in a guide secured to an adapter on the left side of the oil pan.

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to TM 5-3805-237-12 and drain oil from engine.

(3) Install the engine on blocks or on an appropriate stand to make the oil pan accessible for removal.

(4) Remove clamp and remove engine oil gage, guide, and adapter from left side of oil pan.

(5) Refer to figure 12-52 and remove the engine oil drain and oil pan.

*c. Cleaning.* Clean all sludge and carbon from oil pan. Scrape inside of pan with a wire brush. Flush oil pan with cleaning compound, solvent (Spec. P-S-661) and dry thoroughly. Clean all gasket fragments and residue from gasket surfaces of oil pan and engine cylinder block.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*d. Inspection and Repair.*

(1) Refer to figure 12-53 and inspect oil pan for cracks and damage. Check for evidence of leaks.

(2) Replace oil pan if badly damaged or leakage is evident.

*e. Installation.*

(1) Coat gasket and gasket surfaces with gasket sealant.

(2) Refer to figure 12-52 and install the oil pan on the engine.

(3) Install adapter, guide, and oil gage on engine and secure with clamp.

(4) Refer to paragraph 2-31 and install the engine in the motor grader.

## 12-25. Oil Pump

*a. General.*

(1) The gear type oil pump is mounted on the first and second bearing caps. A screened inlet and pipe carry the oil from the oil pan to the pump.

(2) The outlet pipe from the oil pump carries oil to the pressure regulator

1 Pipe plug
2 Inlet oil line
3 Outlet oil line
4 Elbow
5 Union
6 Screw, cap, hex-head, 3/8-16 x 1-1/4 in. (4 rqr)
7 Nut, 3/8-16 (4 rqr)
8 Washer, lock, 3/8 in. (4 rqr)
9 Washer, flat, 3/8 in. (4 rqr)
10 Screw, cap, hex-head, 3/8-16 x 2-1/2 in. (2 rqr)
11 Nut, 3/8-16 (2 rqr)
12 Washer, lock, 3/8 in. (2 rqr)
13 Strap (2 rqr)
14 Cover bolt
15 Bolt gasket
16 Cover
17 Cover gasket
18 Cover spring
19 Filter element
20 Spacer
21 Filter shell
22 Screw, cap, hex-head, 7/16-14 x 1 in. (2 rqr)
23 Washer, lock, 7/16 in. (2 rqr)
24 Mounting bracket

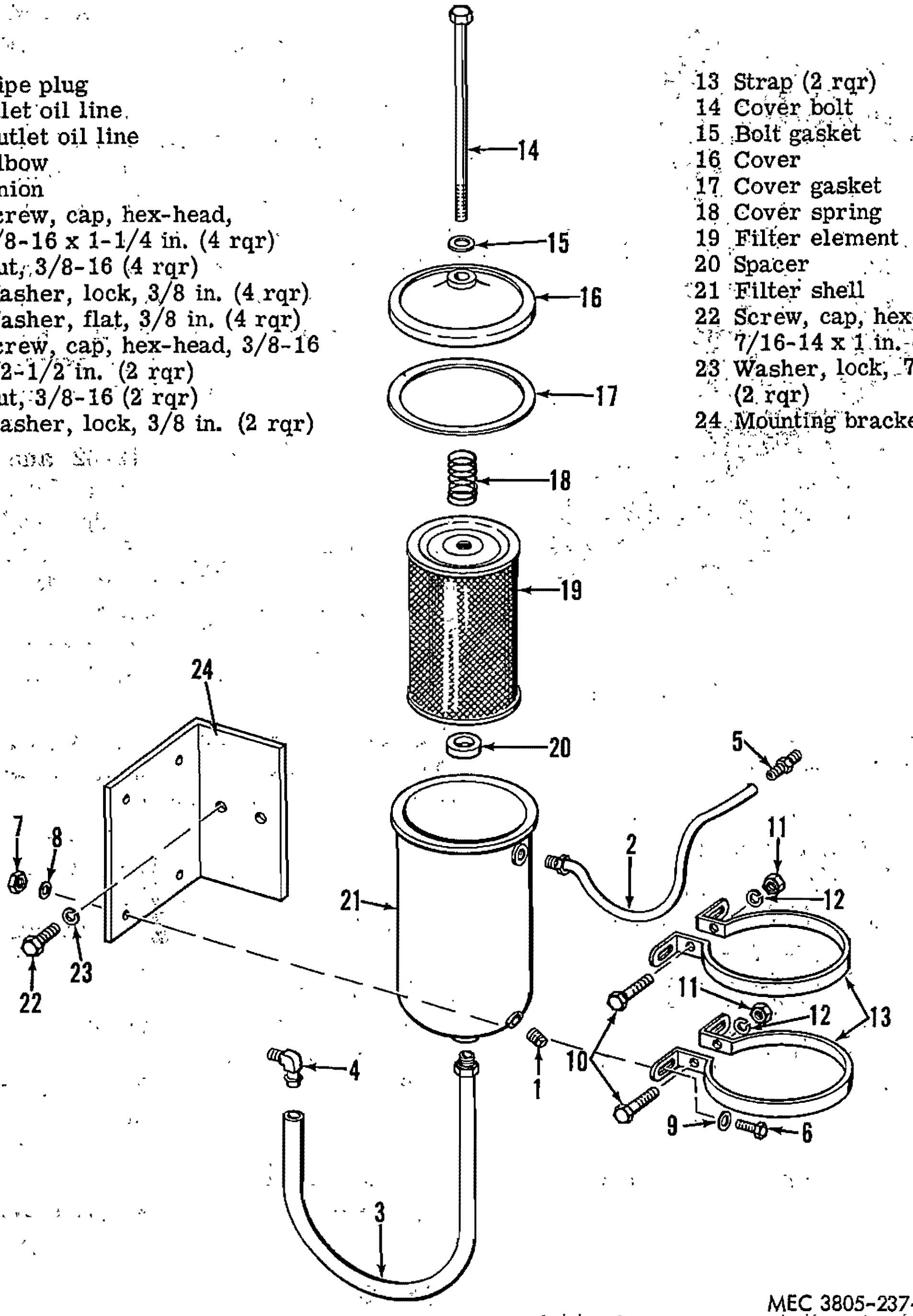



*Figure 12-49. Oil filter, exploded view.*

valve mounted on a corner of the engine block. From there the oil enters the oil cooler and is distributed throughout the engine.

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Install the engine on blocks or a suit-

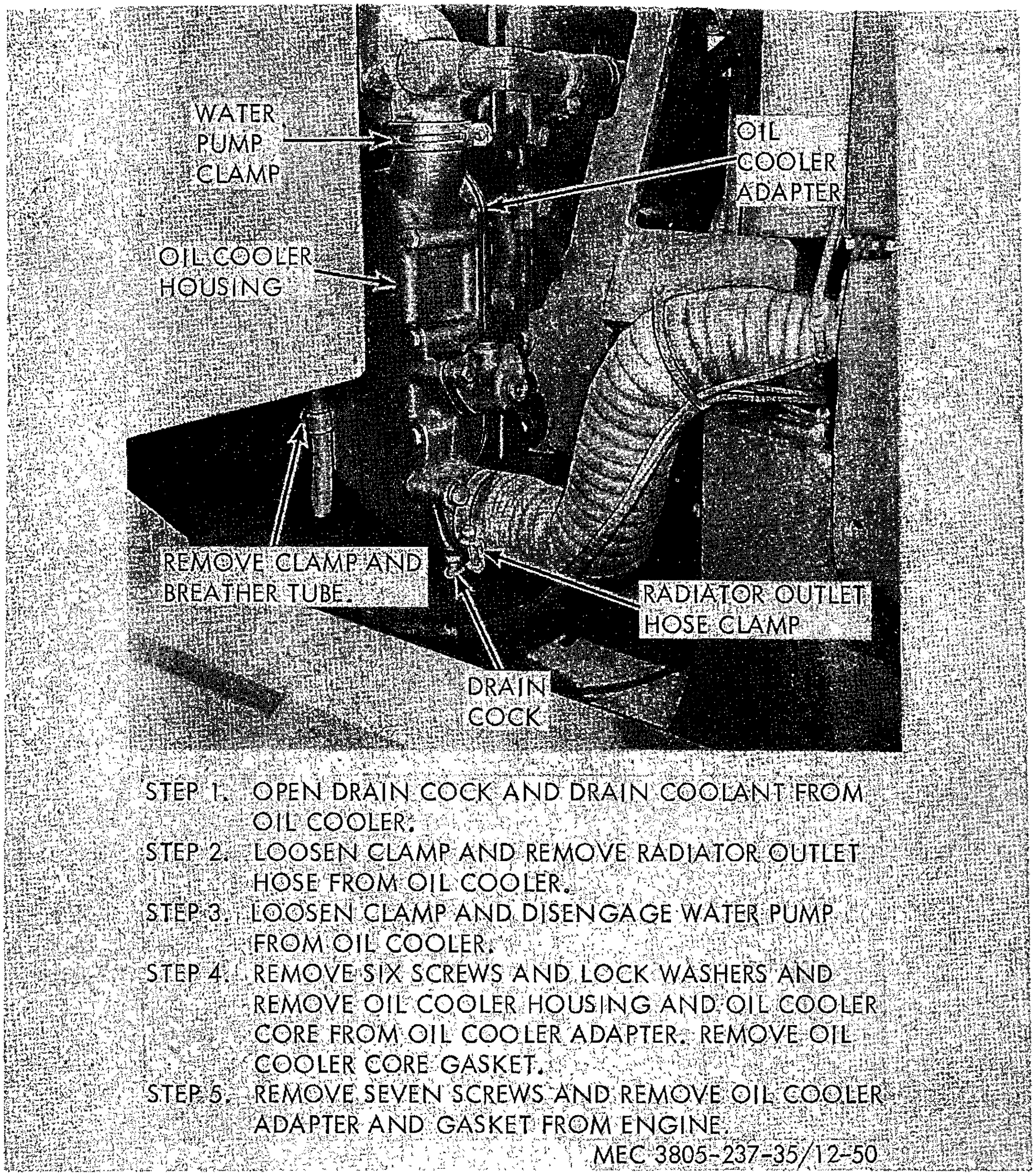



*Figure 12-50. Oil cooler, removal and installation.*

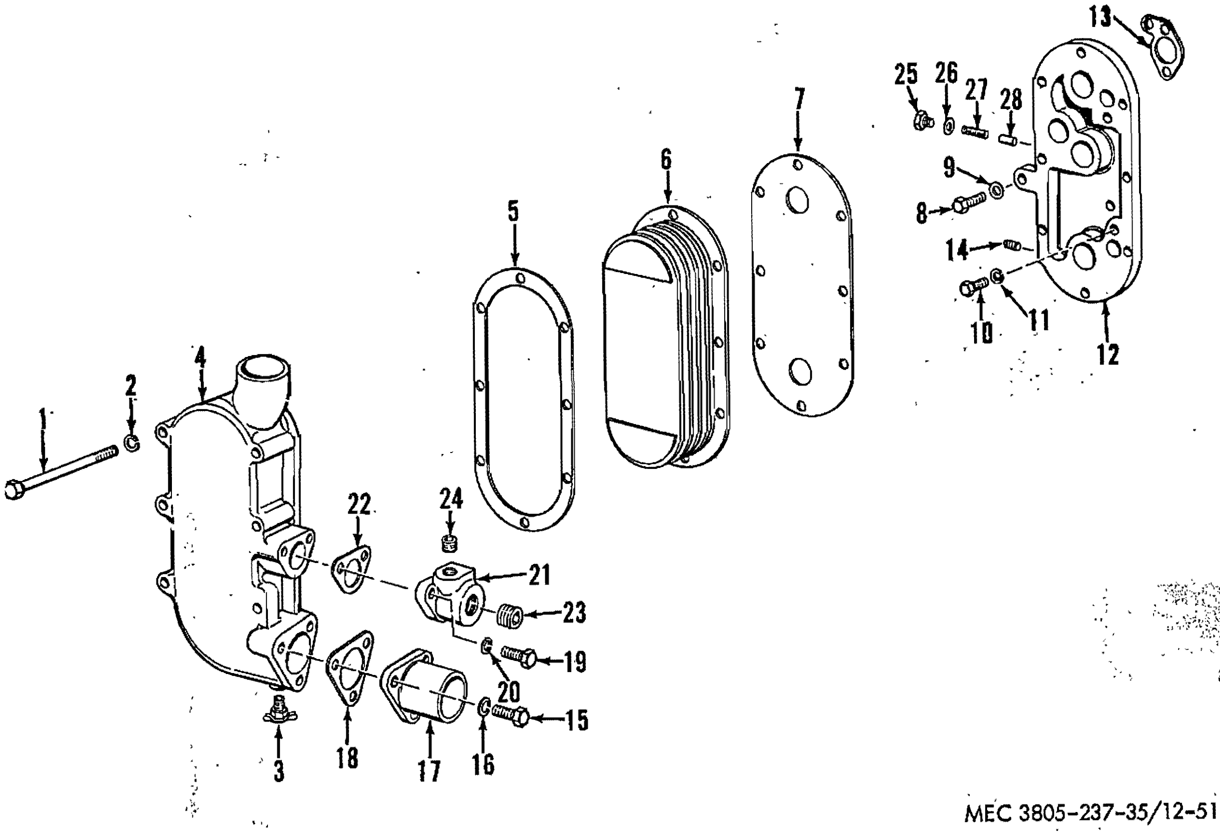
able engine stand to make the oil pan accessible for removal.

(3) Refer to paragraph 12-24 and remove the oil pan from the engine.

(4) Refer to figure 12-54 and remove the oil pump from the engine.

*c. Disassembly.* Disassemble the oil pump in the numerical sequence as illustrated on figure 12-55.

(1) Press scavenge pump drive gear (54) from shaft, using a suitable arbor press.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 5/16-18 × 3 in. (6) | 15 | Screw, cap, hex-head, 5/16-18 × 1 in. (2) |
| 2 | Washer, lock, 5/16 in. (6) | 16 | Washer, lock, 5/16 in. (2) |
| 3 | Drain cock | 17 | Flange |
| 4 | Housing | 18 | Flange gasket |
| 5 | Core outer gasket | 19 | Screw, cap, hex-head, 5/16-18 × 1 in. (2) |
| 6 | Cooler core | 20 | Washer, lock, 5/16 in. (2) |
| 7 | Core inner gasket | 21 | Housing |
| 8 | Screw, cap, hex-head, 3/8-16 × 1 7/8 in. | 22 | Gasket |
| 9 | Washer, flat | 23 | Pipe plug |
| 10 | Screw, cap, hex-head, 3/8-16 × 1 1/8 in. (6) | 24 | Pipe plug |
| 11 | Washer, lock, 3/8 in. (6) | 25 | Valve plug |
| 12 | Adapter | 26 | Gasket |
| 13 | Adapter gasket | 27 | Valve spring |
| 14 | Pipe plug | 28 | Valve |

*Figure 12-51. Oil cooler, exploded view.*

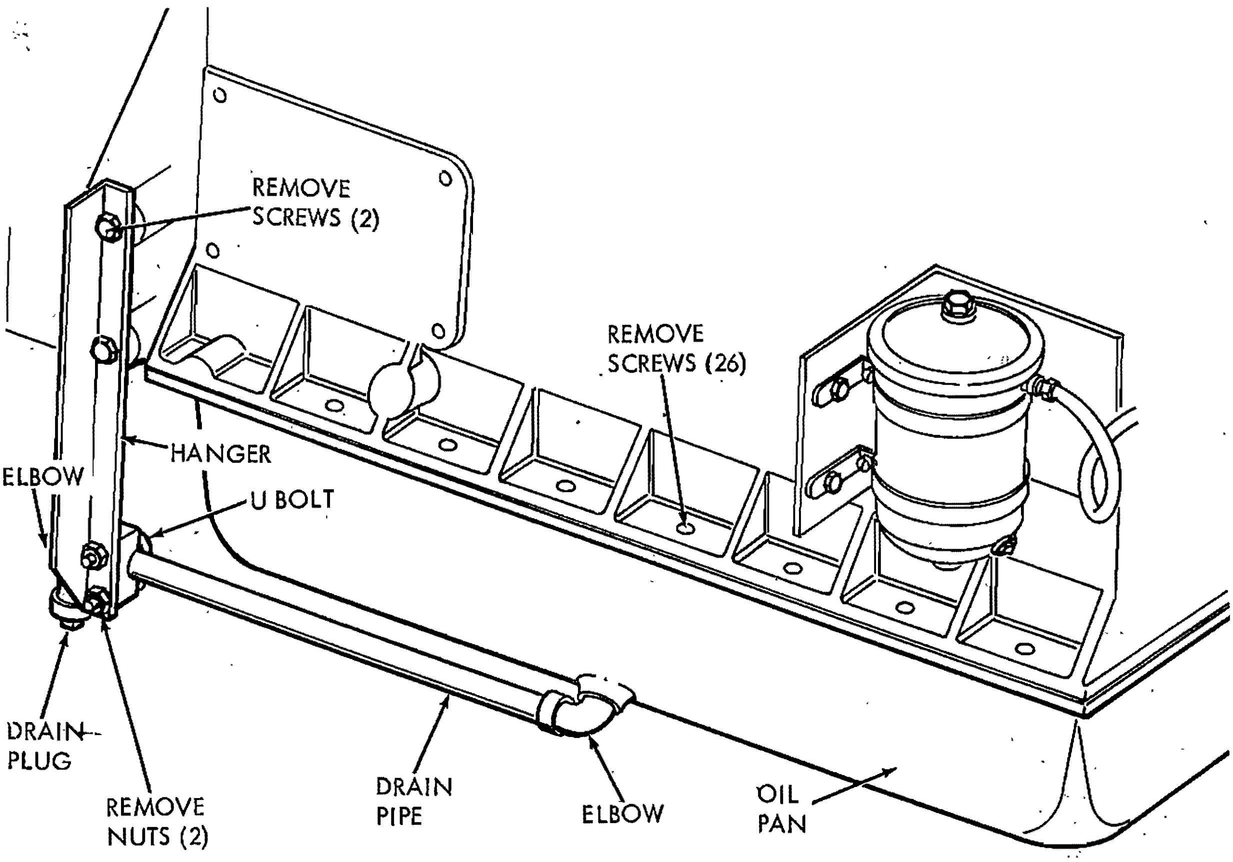



*Figure 12–52. Oil pan, removal and installation.*

*Note.* Do not damage finished surface of oil pump body (75) when removing gear.

(2) Use a suitable puller to remove drive gear (66) from pump shaft.

(3) Press drive shaft (73) from oil pump drive gear (71) using a suitable arbor press.

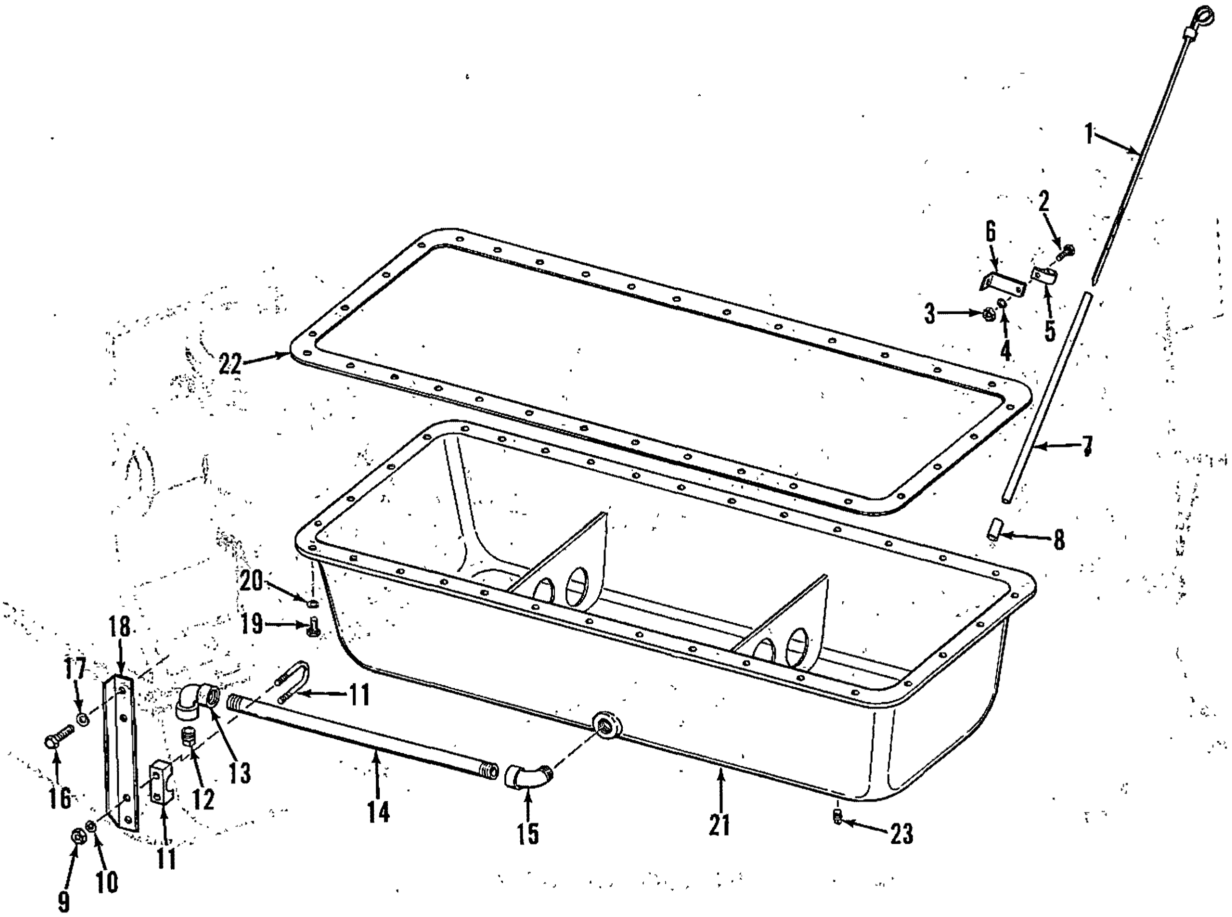
(4) If bushings require replacement, press bushings from bores of gears and pump body.

(5) Discard all gaskets.

*d. Cleaning.* Clean all pump parts in clean fuel oil and dry thoroughly.

*e. Inspection and Repair.*

(1) Inspect gears and shafts for wear and damage. Replace worn or damaged parts.



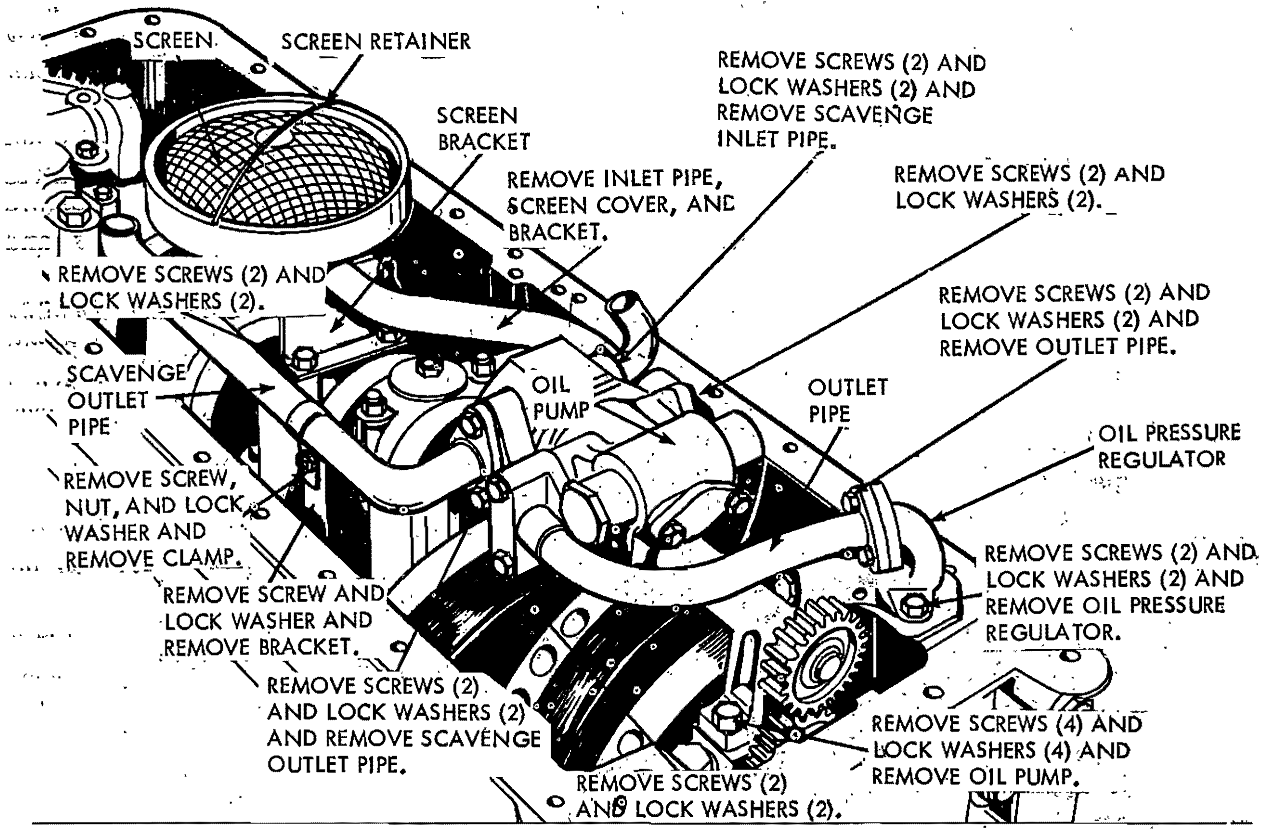

1 Oil gage
2 Screw, cap, hex-head, 5/16-18 x 5/8 in.
3 Nut, 5/16-18
4 Washer, lock, 5/16 in.
5 Clamp
6 Bracket
7 Guide
8 Adapter
9 Nut, 5/16-18 (2 rqr)
10 Washer, lock, 5/16 in. (2 rqr)
11 Bolt, U
12 Pipe plug
13 Elbow
14 Drain pipe
15 Elbow
16 Screw, cap, hex-head, 3/8-16 x 1 in. (2 rqr)
17 Washer, lock, 3/8 in.
18 Hanger
19 Screw, cap, hex-head, 5/16-18 x 3/4 in. (26 rqr)
20 Washer, lock, 5/16 in. (26 rqr)
21 Oil pan
22 Gasket
23 Pipe plug

MEC 3805-237-35/12-53.

*Figure 12-53. Oil pan, exploded view.*

(2) Inspect gear cavities in pump bodies for wear and damage. Replace body if worn or damaged.

(3) Inspect gear bushings for wear and damage. Replace bushings if worn or damaged.




STEP 1. REMOVE SCREEN RETAINER AND SCREEN FROM SCREEN COVER.
STEP 2. REMOVE TWO SCREWS AND LOCK WASHERS SECURING SCAVENGE INLET PIPE TO SCAVENGE PUMP. REMOVE SCAVENGE INLET PIPE AND GASKET.
STEP 3. REMOVE TWO SCREWS AND LOCK WASHERS SECURING BRACKET TO BEARING CAP.
STEP 4. REMOVE TWO SCREWS AND LOCK WASHERS SECURING INLET PIPE TO OIL PUMP AND REMOVE INLET PIPE, SCREEN COVER, AND BRACKET. REMOVE GASKET.
STEP 5. REMOVE SCREW AND LOCK WASHER AND REMOVE CLAMP FROM SCAVENGE OUTLET PIPE.
STEP 6. REMOVE TWO SCREWS AND LOCK WASHERS SECURING SCAVENGE OUTLET PIPE TO SCAVENGE PUMP AND REMOVE SCAVENGE OUTLET PIPE. REMOVE GASKET.
STEP 7. REMOVE SCREW AND LOCK WASHER AND REMOVE BRACKET.
STEP 8. REMOVE TWO SCREWS AND LOCK WASHERS SECURING OUTLET PIPE TO OIL PUMP.
STEP 9. REMOVE TWO SCREWS AND LOCK WASHERS SECURING OUTLET PIPE TO OIL PRESSURE REGULATOR AND REMOVE OUTLET PIPE. REMOVE GASKETS.
STEP 10. REMOVE TWO SCREWS AND LOCK WASHERS SECURING OIL PRESSURE REGULATOR AND REMOVE REGULATOR. REMOVE GASKET.
STEP 11. REMOVE FOUR SCREWS AND LOCK WASHERS SECURING OIL PUMP TO BEARING BRACKETS AND REMOVE OIL PUMP. REMOVE SHIMS.

MEC 3805-237-35/12-54

*Figure 12-54. Oil pump, removal and installation.*

(4) Inspect relief valve and valve seat in body for wear and scoring. Replace valve or body if worn or scored.

(5) Inspect valve spring for weak and broken condition. Spring should have a free length of 2.359 inches and require 48 to 53 pounds to compress it to 1.596 inches. Replace spring if weak, broken, or it does not meet these specifications.

(6) Inspect oil pressure regulator valve and regulator body for wear and scoring. Valve must move freely in body. Replace valve or body if worn or scored or if valve binds in body.

(7) Inspect regulator valve spring for weak and broken condition. Spring should have a free length of 2.484 inches and should require a weight of 14 to 15 pounds to compress it to 1.656 inches. Replace spring if weak or broken if it does not meet these specifications.

(8) Inspect oil pipes for damage. Replace any damaged pipes. Clean screen thoroughly and inspect for damage. Replace damaged screen.

(9) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

(10) Replace all worn or damaged parts.

*f. Reassembly.* Reassemble the oil pump in reverse of the numerical sequence as illustrated on figure 12-55.

(1) Lubricate drive gear shaft (73) with engine oil (OE) before pressing drive gears (71, 66, and 54) on shaft.

(2) Press drive gear (66) on shaft only far enough to leave 0.005 clearance between gear and support. Check and adjust clearance using a feeler gage.

(3) Lubricate valves (44 and 32) with engine oil (OE) before installing valves in oil pump body and oil pressure regulator body. Install springs and tighten plugs securely.

(4) After completion of reassembly (items 75 through 41), check pump by rotating idler gear. Pump gears must rotate freely with no evidence of binding.

*g. Installation.*

(1) Refer to figure 12-54 and install the oil pump, pipes, and inlet screen on the engine.

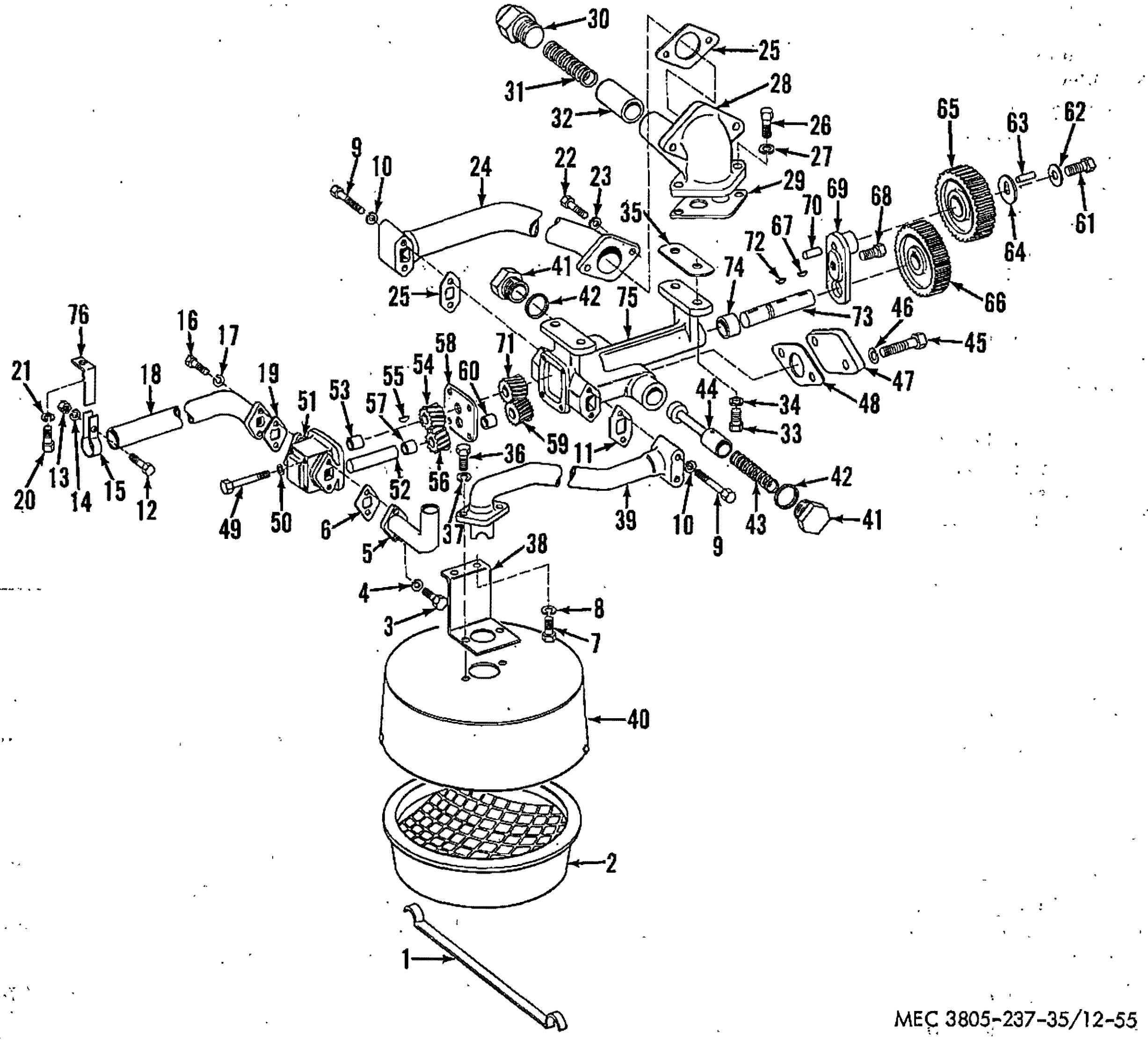
(2) Install pump with idler gear teeth in mesh with drive gear on crankshaft. Teeth must be parallel. Tighten pump mounting bolts and check clearance between idler gear teeth and drive gear teeth with a feeler gage.

(3) Clearance should be 0.005 to 0.012 inch. Install shims (35, fig. 12-55) under oil pump mounting surfaces to achieve this clearance.

*Note.* When adding or removing shims, install same amount of shims on each mounting surface to keep oil pump level on bearing caps.

(4) Refer to paragraph 12-24 and install the oil pan on the engine.

(5) Refer to paragraph 2-31 and install the engine on the motor grader.




1 Screen retainer
2 Screen
3 Screw, cap, hex-head, 5/16-18 × 1 in. (2)
4 Washer, lock, 5/16 in. (2)
5 Scavenge inlet pipe
6 Gasket
7 Screw, cap, hex-head, 3/8-24 × 7/8 in (2)
8 Washer, lock, 3/8 in. (2)
9 Screw, cap, hex-head, 5/16-18 × 1 1/2 in. (4)
10 Washer, lock, 5/16 in. (4)
11 Gasket
12 Screw, cap, hex-head, 1/4-28 × 5/8 in.
13 Nut 1/4-28
14 Washer, lock, 1/4 in.
15 Clamp
16 Screw, cap, hex-head, 5/16-18 × 1 3/4 in. (2)
17 Washer, lock, 5/16 in. (2)
18 Scavenge outlet pipe
19 Gasket
20 Screw, cap, hex-head, 3/8-24 × 7/8 in.
21 Washer, lock, 3/8 in.
22 Screw, cap, hex-head, 5/16-18 × 7/8 in. (2)
23 Washer, lock, 5/16 in. (2)
24 Outlet pipe
25 Gasket (2)
26 Screw, cap, hex-head, 5/16-18 × 1 1/8 in. (2)
27 Washer, lock, 5/16 in. (2)
28 Oil pressure regulator body
29 Gasket

*Figure 12-55. Oil pump, exploded view.*

30 Plug
31 Spring
32 Valve
33 Screw, cap, hex-head, 3/8-24 × 1 in. (4)
34 Washer, lock, 3/8 in. (4)
35 Shim
36 Screw, cap, hex-head, 5/16-18 × 1 1/2 in. (2)
37 Washer, lock, 5/16 in. (2)
38 Bracket
39 Inlet pipe
40 Screen cover
41 Valve plug (2)
42 Gasket (2)
43 Spring
44 Valve
45 Screw, cap, hex-head, 5/16-18 × 3/4 in. (2)
46 Washer, lock, 5/16 in. (2)
47 Pad cover
48 Gasket
49 Screw, cap, hex-head, 5/16-18 × 3 in. (4)
50 Washer, lock, 5/16 in. (4)
51 Scavenge pump body
52 Driven gear shaft
53 Bushing
54 Scavenge pump drive gear
55 Key, woodruff
56 Scavenge pump driven gear
57 Gear bushing
58 Pump spacer
59 Oil pump driven gear
60 Gear bushing
61 Screw, cap, hex-head, 5/16-18 × 7/8 in.
62 Washer, lock
63 Pin
64 Washer, thrust
65 Idler gear
66 Drive gear
67 Key, woodruff
68 Screw, cap, hex-head, 3/8-16 × 7/8 in.
69 Idler gear support
70 Dowel pin
71 Oil pump driven gear
72 Key, woodruff
73 Drive shaft
74 Bushing (2)
75 Oil pump body

*Figure 12-55*—Continued.

## Section VII. FLYWHEEL HOUSING AND ASSOCIATED PARTS

### 12-26. General

*a.* The flywheel housing is mounted against the engine rear end plate. The housing encloses the gear train and the flywheel. Support for the clutch brake housing is supplied by the outer circumference of the housing.

*b.* A lip type oil seal is installed in a counterbore in the housing and contacts the crankshaft. Three covers on the housing can be removed to gain access to the blower drive gear, camshaft gear, and balancer gear.

*c.* The blower drive gear housing and drive gear train are mounted on the front of the flywheel housing. Two clamp type seals hold the blower drive cover to the blower drive support which is mounted on the flywheel housing. An oil line connected to the engine block supplies lubricating oil to the blower drive gear in the flywheel housing. The engine oil filler tube and cap are installed in the blower drive support.

### 12-27. Blower Drive Gear

*a. General.* The blower drive gear cam is splined to receive the blower drive shaft. The cam is mounted in a flexible drive coupling. The coupling is spring-loaded to insure uniform rotation of the blower rotors.

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 12-6 and remove the blower assembly.

(3) Remove clamps attaching fuel lines to blower drive support and flywheel housing. Refer to paragraph 12-15 and remove fuel filters.

(4) Disconnect oil line from elbow in drive support and elbow in crankcase.

(5) Remove six screws and lockwashers and four nuts and remove flywheel housing small hole cover and cover gasket.

(6) Remove retaining ring securing blower drive shaft to blower drive cam and remove blower drive shaft.

(7) Straighten the ears on lockwasher securing drive gear hub nut and loosen hub nut.

(8) Remove two screws and lockwashers securing blower drive support to flywheel housing and end plate. Tap drive support lightly with a rubber hammer and remove drive support. Use care when removing to prevent damage to drive gear teeth. Remove gasket.

*c. Disassembly.* Disassemble blower drive in the numerical sequence as illustrated on figure 12-56. Discard all gaskets.

(1) Install blower drive gear and support in a vise with soft jaws.
(2) Remove screws (15) and lockwashers (16) and remove coupling support (22). Remove springs (19), spring seats (21), and cam (18).
(3) Remove hub locknut (23), lockwasher (24), lockball (26), and thrust washer (25) and remove hub and gear. Remove thrust washer (27).
(4) Press gear hub (28) from drive gear (29).
(5) Press sleeve bearing (31) from drive gear support (32).

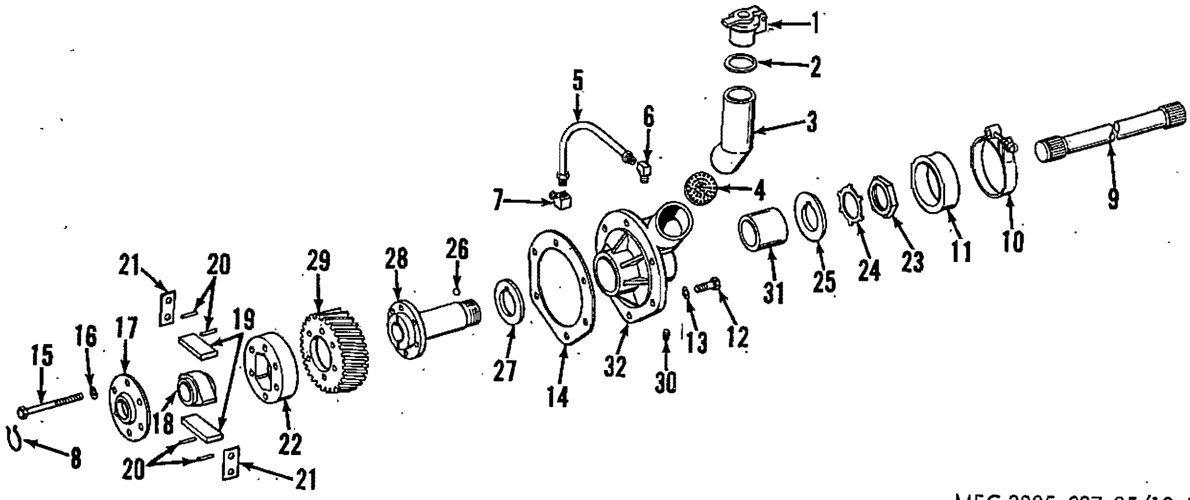
*d. Cleaning.* Clean all metal parts in clean fuel oil and dry thoroughly with compressed air. Check all oil grooves, oil holes, and cavities to be sure they are free of dirt.

*e. Inspection and Repair.*

(1) Inspect thrust washers for wear and scoring. Replace thrust washers if worn or scored.
(2) Inspect sleeve bearings for wear and scoring. Replace bearing if worn or scored.
(3) Inspect blower drive shaft for wear and damage to splines. Replace drive shaft if splines are worn or damaged.
(4) Inspect drive coupling support, cam, spring seats, and spring packs for wear and damage. Replace worn or damaged parts.
(5) Inspect drive hub and drive gear for wear and damage. Inspect gear teeth for scoring and pitting. Replace damaged, scored or pitted parts.
(6) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.* Reassemble the blower drive in reverse of the numerical sequence as illustrated on figure 12-56.

(1) If bearings (31) were removed from the support, install bearings as follows:
   (*a*) Press outer bearing into support until end of bearing is flush to 0.030 inch below the surface of the face of the support.
   (*b*) Press inner bearing into support until end of bearing protrudes 0.045 to 0.055 inch above surface of face of support.
   (*c*) Ream or bore inside diameter of bearings to 1.6260 to 1.6265 inches.
   (*d*) Clearance between bearings and drive hub should be 0.0010 to 0.0025 inch for new parts and a maximum of 0.0050 inch when used parts are installed.
   (*e*) Replacement bearings must withstand a 2,000 pound end load without turning. Bearing bores must be square with inner and outer faces of support within 0.001 inch total indicator reading.
(2) Install thrust washer (27) on protruding end of inner bearing.
(3) Press the drive gear hub (28) into bore of drive gear (29).
(4) Lubricate drive gear hub, bearings in support, thrust surfaces, and thrust washer with engine oil (OE).
(5) Install drive gear and hub in support. Locate lockball (26) in drive gear hub and slide thrust washer (25) into position on hub over lockball.
(6) Install a new lockwasher (24) and locknut (23) on hub. Tighten nut only finger tight. Install two screws (15) in threaded holes in hub. Place a holding bar across screws and secure with a holding device. Tighten locknut to a torque of 50 to 60 foot pounds. Bend tabs of lockwasher




| | | | |
|---|---|---|---|
| 1 | Oil filler cap | 17 | Coupling retainer |
| 2 | Cap gasket | 18 | Drive coupling cam |
| 3 | Oil filler tube | 19 | Coupling spring pack (2) |
| 4 | Tube strainer | 20 | Spring seat (4) |
| 5 | Oil line | 21 | Coupling spring end seat (2) |
| 6 | Elbow | 22 | Drive coupling support |
| 7 | Elbow | 23 | Locknut |
| 8 | Retaining ring | 24 | Lockwasher |
| 9 | Drive shaft | 25 | Thrust washer |
| 10 | Clamp (2) | 26 | Lock ball |
| 11 | Seal ring (2) | 27 | Thrust washer |
| 12 | Screw, cap, hex-head, 3/8-24 × 7/8 in. (2) | 28 | Drive gear hub |
| 13 | Washer, lock, 3/8 in. (2) | 29 | Drive gear |
| 14 | Gasket | 30 | Pipe plug |
| 15 | Screw, cap, hex-head (6) | 31 | Sleeve bearing (2) |
| 16 | Washer, lock, 5/16 in. (6) | 32 | Drive gear support |

*Figure 12-56. Blower drive gear and support, exploded view.*

over nut. Remove two screws from hub.

(7) Assemble the blower drive coupling as follows:

(*a*) Place the drive coupling support (22) on wooden blocks as shown in figure 12-57.

(*b*) Install the spring seats (20 and 21) in drive coupling support as illustrated on figure 12-57.

(*c*) Apply engine (OE) to spring packs (19) and place spring packs in coupling support as illustrated on figure 12-57.

(*d*) Using a piece of circular steel rod, slightly tapered at the rounded large end and with a shaft to fit the cam, place cam (18) on shaft. Push tool through springs to spread springs as illustrated on figure 12-57. Push cam into position between springs until seated in center of support.

(8) Install the coupling support against the drive gear with the blower shaft ring groove of cam away from gear. Install coupling retainer (17) on coupling support with flared edge of retainer away from support.

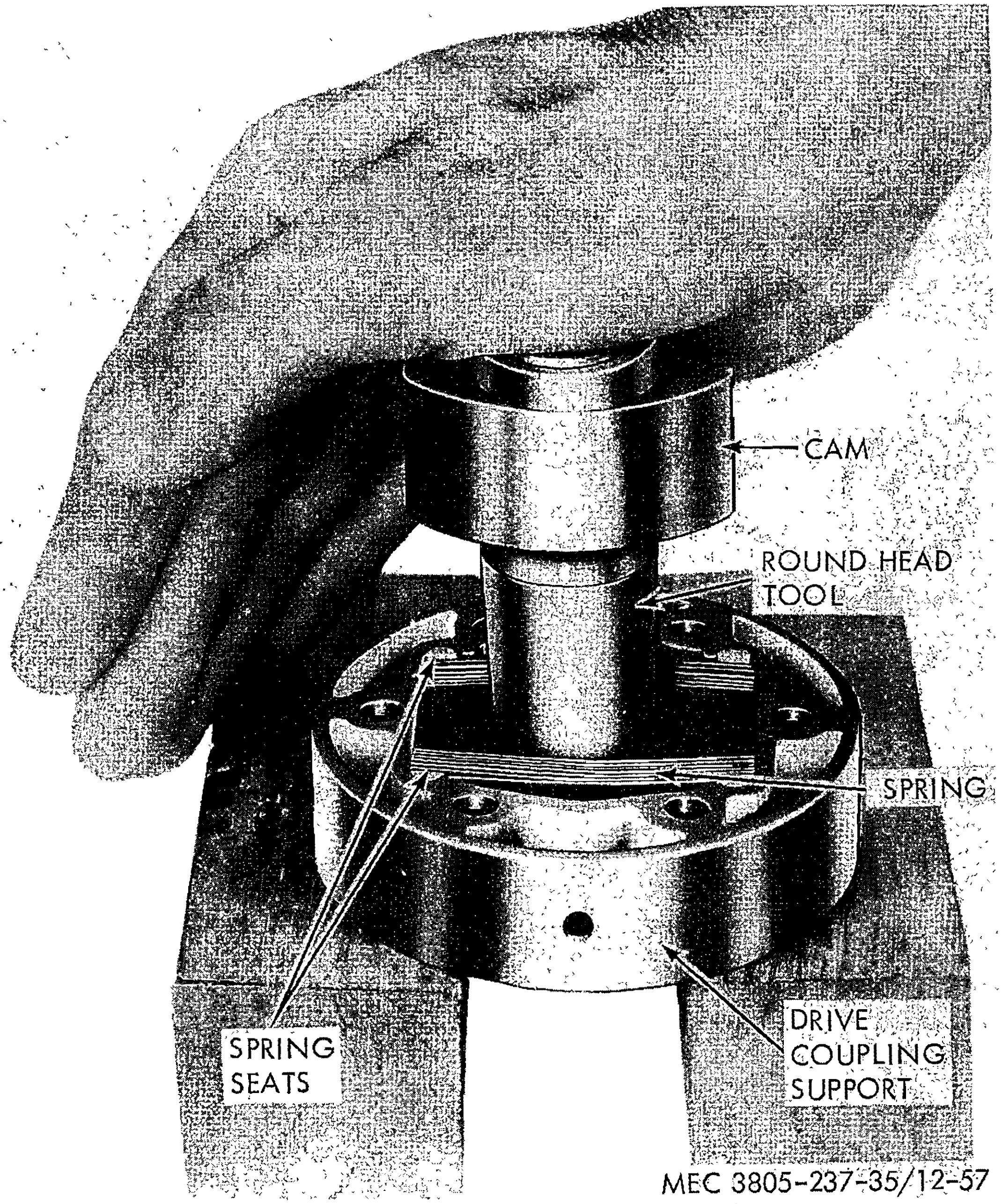



*Figure 12-57. Installing blower drive cam.*

(9) Aline lobes of cam with oil grooves in gear hub as illustrated on figure 12-58. Install six screws (15) and lockwashers (16) and tighten securely.

(10) Check clearance between gear hub and thrust washer (27). Clearance should be 0.005 to 0.008 inch.

*g. Installation.*

(1) Install drive gear on flywheel housing and end plate. Secure with two screws (12, fig. 12-56) and lock washers (13).

(2) Install elbows (6 and 7) and connect oil line (5) to elbows.

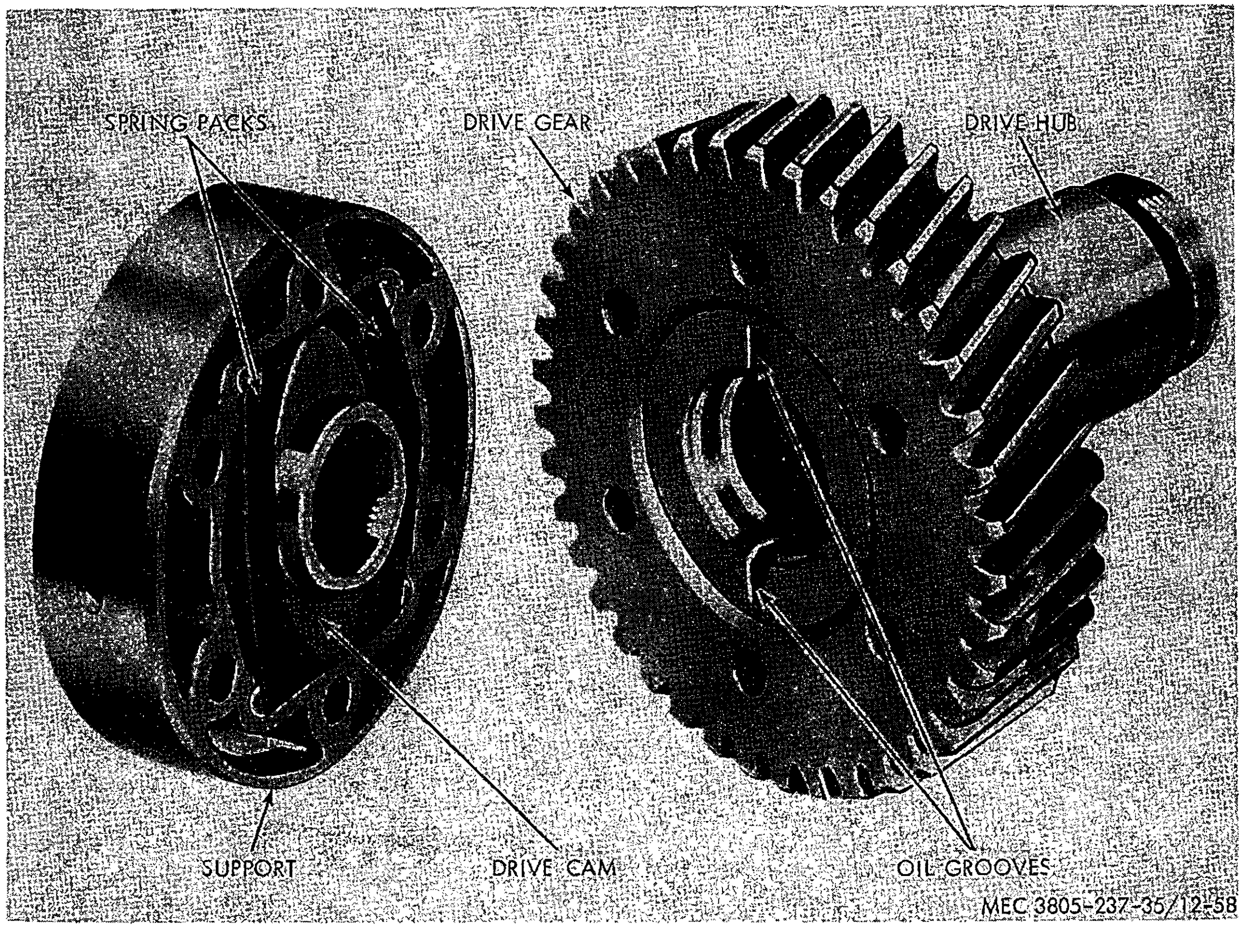



*Figure 12–58. Alining cam and oil grooves in gear hub.*

(3) Refer to paragraph 1–6 and install blower assembly.

(4) Install the drive shaft (9) into the rotor gear hub and blower rotor coupling. Secure drive shaft in cam with retaining ring (8).

(5) Install flywheel housing small hole cover and secure with six screws, six lockwashers and four nuts.

(6) Refer to paragraph 12–15 and install fuel lines and filters.

(7) Refer to paragraph 2–31 and install engine in motor grader.

## 12–28. Flywheel

*a. General.* The flyywheel is mounted inside of the flywheel housing and is attached directly to the crankshaft. Inside the bore of the flywheel is a coupling for the power box propeller shaft.

*b. Removal.*

(1) Refer to paragraph 2–31 and remove the engine from the motor grader.

(2) Refer to paragraph 2–32 and remove the clutch brake housing and clutch assembly from the engine.

(3) Cut the lock wire and remove six screws, lockwashers, and plate securing flywheel to crankshaft.

(4) Install two 7/16–14 × 4 inch puller screws into tapped holes in flywheel as shown in figure 12–59. Install two pilot studs in flywheel as shown.

(5) Install a suitable lifting hook in hole in flywheel and connect hook to a hoist.

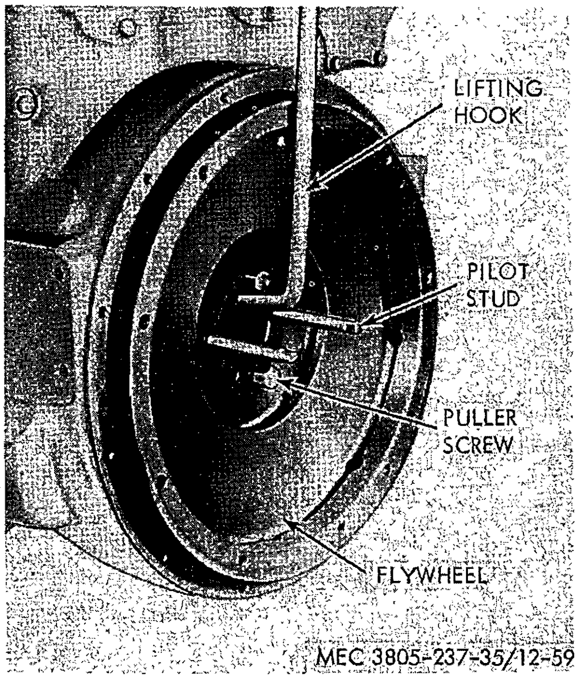



*Figure 12-59. Flywheel, removal and installation.*

(6) Turn puller screws in evenly to pull flywheel off dowels and onto pilot studs.

(7) Lift flywheel off studs and out flywheel housing. Remove puller screws.

*c. Disassembly.* The flywheel ring gear around the circumference of the flywheel may be removed if teeth are damaged or ring gear is cracked.

(1) Place flywheel, crankshaft side down, on a solid flat surface or block with a slightly less diameter than the flywheel.

(2) Drive the ring gear from the flywheel using a suitable drift and hammer. Work the drift around the circumference of the ring gear to avoid binding of ring gear.

*d. Reassembly.*

(1) Support flywheel in a level position with crankshaft side up.

(2) Place ring gear on a metal or concrete surface and heat ring gear with a torch. Keep torch moving around outside of ring gear to heat gear uniformly. Do not heat ring gear over 400°F.

(3) Pick ring gear up with tongs and place on flywheel, with ring gear chamfer facing same way as ring that was removed.

(4) Tap ring gear into place against shoulder on flywheel. If ring gear does not go into place readily more heat may have to be applied.

*e. Installation.*

(1) Install hook in flywheel and lift into position as illustrated on figure 12-59. Place retainer plate inside of hook on flywheel.

(2) Aline holes in flywheel with dowel pins in crankshaft and install flywheel on crankshaft.

(3) Install two screws and lockwashers to hold flywheel in place and remove lifting hook.

(4) Install remaining four screws and lockwashers and tighten six screws to a torque of 150 to 160 foot pounds. Install lock wire between screws.

(5) Mount a dial indicator on the flywheel housing and check runout of flywheel at clutch contact face.

(6) Maximum allowable runout is 0.005 inch total indicator reading.

(7) Refer to paragraph 2-32 and install clutch assembly and clutch brake housing on engine.

(8) Refer to paragraph 2-31 and install engine in motor grader.

## 12-29. Flywheel Housing

*a. General.* The flywheel housing encloses the rear of the engine, houses the flywheel, and allows access to the upper gears. The rear crankshaft oil seal is also housed in the flywheel housing.

*b. Removal.*

(1) Refer to pragraph 2-31 and remove the engine from the motor grader.

(2) Refer to pragraph 2-32 and remove the clutch brake and clutch from the engine.

(3) Refer to TM 5-3805-237-12 and remove the starter.
(4) Refer to paragraph 12-18 and remove the throttle linkage from engine rear lifting bracket.
(5) Refer to paragraph 12-15 and remove fuel filter and bracket from flywheel housing.
(6) Refer to paragraph 12-24 and remove the oil pan.
(7) Refer to paragraph 12-27 and remove the blower drive gear.
(8) Refer to paragraph 12-28 and remove the flywheel.
(9) Remove two screws (19, fig. 12-60) attaching lifting bracket (12) to cylinder head. Attach a suitable hoist to lifting bracket.
(10) Remove six screws (23) and flat washers (24) and six screws (25) and lockwashers (26) from inside of flywheel housing.
(11) Remove eight screws (27 and 28), four nuts (30) and eight lockwashers (31) from rear of flywheel housing. Remove two screws (29) and lockwashers (31).
(12) Using hoist, lift flywheel housing from engine rear end plate. Remove gasket (33).

*Note.* It may be necessary to strike flywheel housing with a leather hammer to jar housing off dowels.

(13) Discard all gaskets.

*c. Disassembly.*

(1) Remove lifting bracket and covers from flywheel in the numerical sequence as shown on figure 12-60.
(2) Support flywheel housing on inner face. Using a suitable driver, drive oil seal (34) and spacer (35), from flywheel housing.

*d. Cleaning.* Clean all parts in cleaning compound, solvent (Spec. P-S-661) and dry thoroughly with compressed air. Clean all old gasket material from flywheel housing and end plate.

***Warning:*** **The solvent is highly inflammable. Do not use solvent near an open flame.**

*e. Inspection and Repair.*

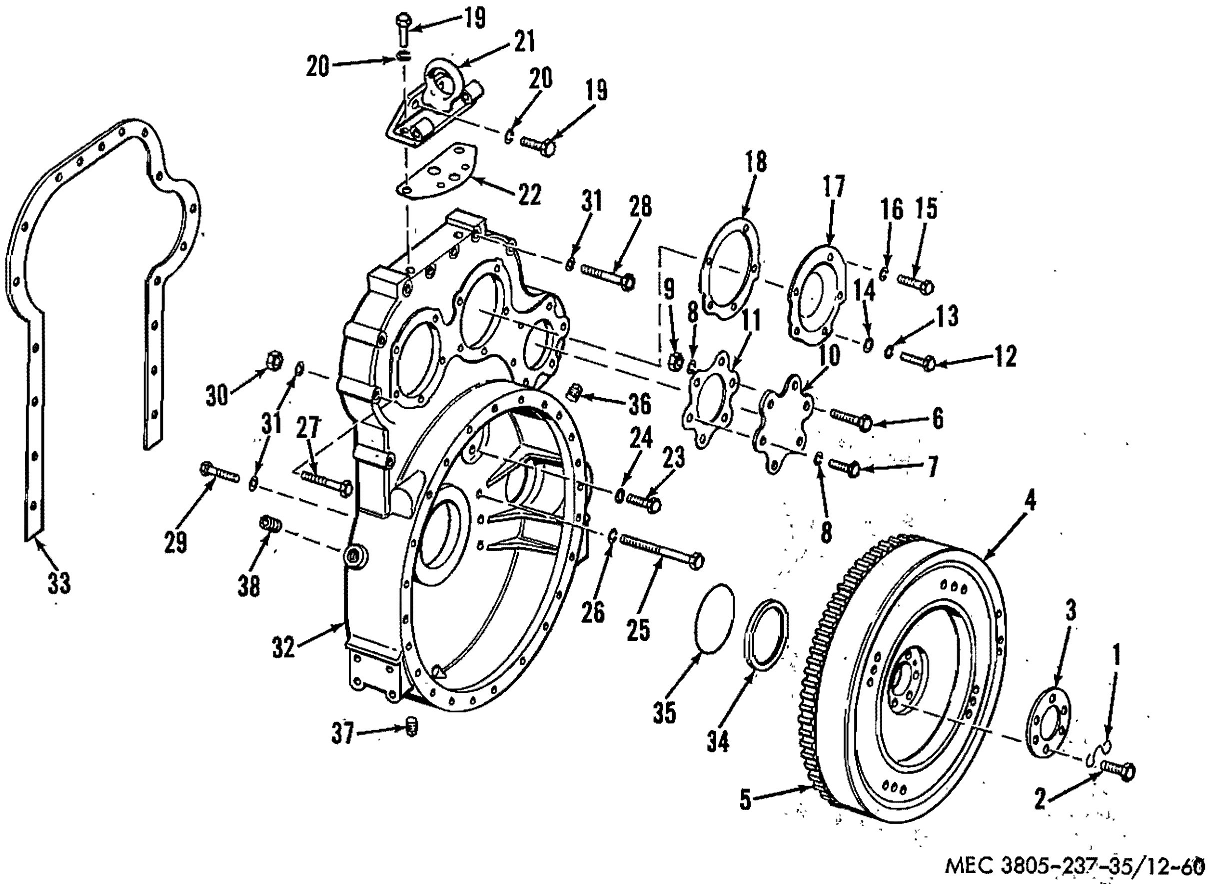
(1) Inspect flywheel housing for cracks and other damage. Replace a cracked or damaged flywheel housing.
(2) Inspect oil seal bore in housing for burs and damage. Remove burs with a fine stone if possible. Replace flywheel housing if bore is badly burred or damaged.
(3) Refer to figure 12-60 and install flywheel housing and new gasket on engine. Secure with screws (23, 25, 27, 28, and 30). Tighten screws in sequence as described in *g* below.
(4) Mount a dial indicator on crankshaft and check runout of oil seal bore. Runout must not exceed 0.008 inch total indicator reading.
(5) Remove screws and remove flywheel housing as described in *b* above.

*f. Reassembly.*

(1) Install spacer (35, fig. 12-60) in bore of flywheel housing.
(2) Using a suitable tool, drive oil seal (34) into bore of housing.
(3) Install lifting bracket (21) on flywheel housing and secure with two screws (19) and lockwashers (20).
(4) Attach a suitable hoist to lifting bracket and install a new gasket on flywheel housing.
(5) Install four pilot studs in holes in end plate.
(6) Install a suitable expander in oil seal to seat oil seal over crankshaft. Install flywheel housing on engine over pilots. Install screws to hold flywheel housing in place and remove pilots. Install remainder of attaching screws and tighten screws lightly.
(7) Refer to figure 12-61 and tighten screws in sequence illustrated. Tighten screws to a snug fit.

*Note.* Always tighten the idler gear hub screws (23, fig. 12-60) first. Rotate crankshaft by hand while tightening screws to prevent binding of roller bearings.

(8) Finish tightening the screws in the sequence illustrated on figure 12-62 to the following torques.




| | | | |
|---|---|---|---|
| 1 | Lock wire | 20 | Washer, lock, 7/16 in. (4) |
| 2 | Screw, cap, hex-head, 9/16-18 × 2 in. (6) | 21 | Lifting bracket |
| 3 | Retaining plate | 22 | Bracket gasket |
| 4 | Flywheel | 23 | Screw, cap, hex-head, 3/8-16 × 1 in. (6) |
| 5 | Flywheel ring gear | 24 | Washer, flat (6) |
| 6 | Screw, cap, hex-head, 3/8-24 × 5 in. (4) | 25 | Screw, cap, hex-head, 1/2-13 × 3 1/4 in. (6) |
| 7 | Screw, cap, hex-head, 3/8-16 × 7/8 in. (2) | 26 | Washer, lock, 1/2 in. |
| 8 | Washer, lock, 3/8 in (6) | 27 | Screw, cap, hex-head, 3/8-24 × 4 1/4 in. (4) |
| 9 | Nut, 3/8-24 (4) | 28 | Screw, cap, hex-head, 3/8-24 × 4 in. (4) |
| 10 | Housing small hole cover | 29 | Screw, cap, hex-head, 3/8-24 × 1 in. (2) |
| 11 | Cover gasket | 30 | Nut, 3/8-24 (4) |
| 12 | Screw, cap, hex-head, 7/16-14 × 7/8 in. (2) | 31 | Washer, lock, 3/8 in. (10) |
| 13 | Washer, lock, 7/16 in. (2) | 32 | Flywheel housing |
| 14 | Washer, copper, (2) | 33 | Housing gasket |
| 15 | Screw ,cap, hex-head, 1/2-13 × 1 in. (8) | 34 | Crankshaft rear oil seal |
| 16 | Washer, lock, 1/2 in. (8) | 35 | Spacer |
| 17 | Housing large hole cover (2) | 36 | Pipe plug |
| 18 | Cover gasket (2) | 37 | Pipe plug |
| 19 | Screw, cap, hex-head, 7/16-14 × 1 1/2 in. (4) | 38 | Pipe plug |

*Figure 12-60. Flywheel housing and flywheel, exploded view.*

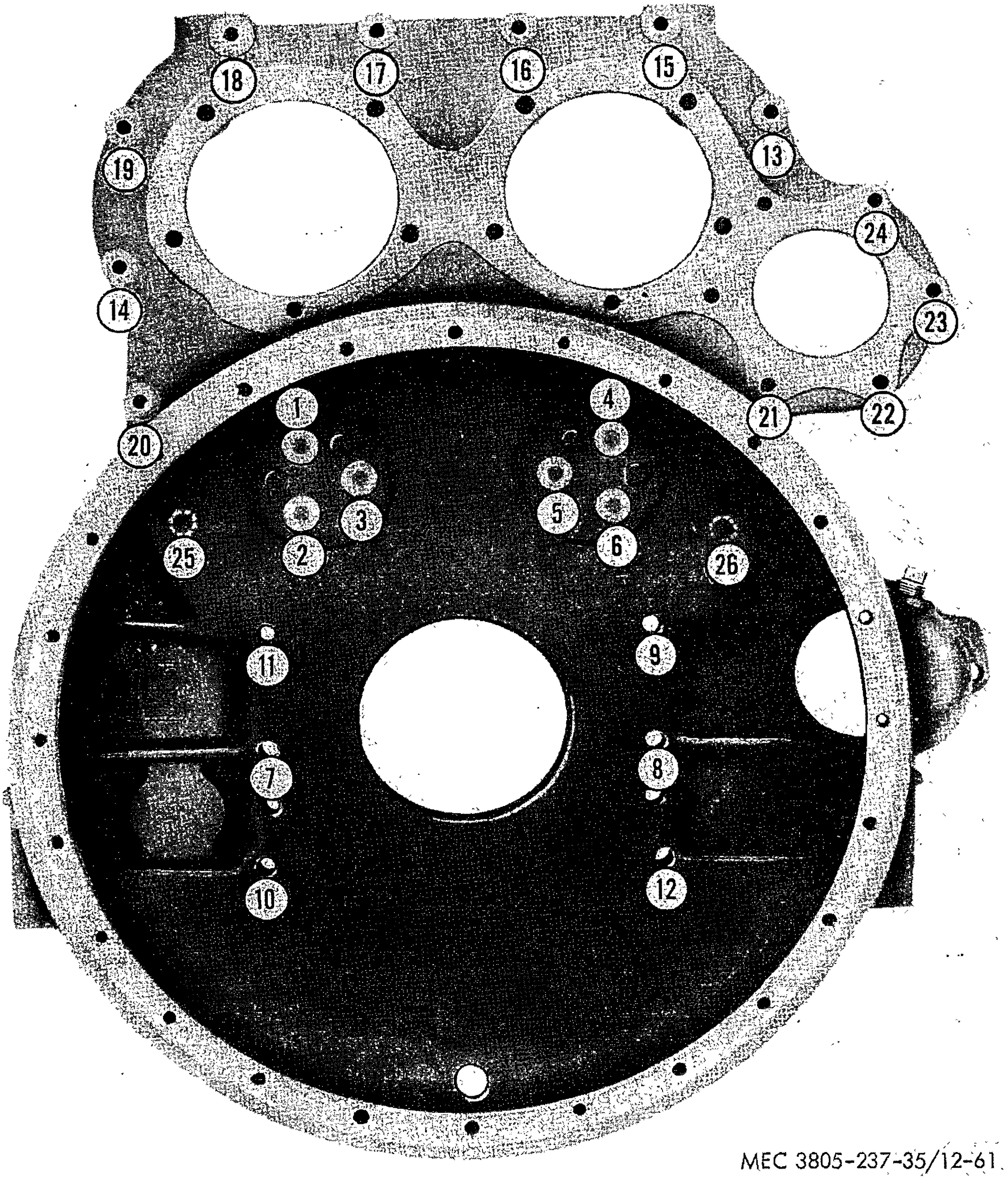



*Figure 12-61. Flywheel housing screw tightening sequence, first operation.*

(*a*) Tighten idler gear hub screws (3/8-16) to a torque of 40 to 50 foot pounds.

(*b*) Tighten remaining 3/8-16 and 3/8-24 screws to a torque of 24 to 30 foot pounds.

(*c*) Tighten 1/2-13 screws to a torque of 90 to 100 foot pounds.

(9) Refer to paragraph 2-28 and install the flywheel.

(10) Position dial indicators on flywheel housing to check concentricity of flywheel housing bore and bolting flange.

(11) Rotate crankshaft one full revolution. Take readings at 45° intervals (8 readings each of bore and flange). Maximum total indicator reading must not exceed 0.013 inch for both bore and flange.

(12) If reading exceeds maximum, remove flywheel housing (*b* above) and check for dirt, foreign material or gasket out of alinement.

(13) Clean housing and end plate, install new gasket, and install housing, and tighten screws as described above. Install flywheel (para 12-28).

(14) Recheck concentricity of housing as described above. If reading again exceeds maximum, replace flywheel housing.

(15) Refer to paragraph 12-27 and install the blower drive gear.

(16) Refer to paragraph 12-24 and install the oil pan.

(17) Refer to paragraph 12-15 and install the fuel filter and bracket.

(18) Refer to paragraph 12-18 and install the throttle linkage on engine rear lifting bracket.

(19) Refer to TM 5-3805-237-12 and install starter.

(20) Refer to paragraph 2-32 and install the clutch assembly and clutch brake housing on the engine.

(21) Refer to paragraph 2-31 and install the engine on the motor grader.

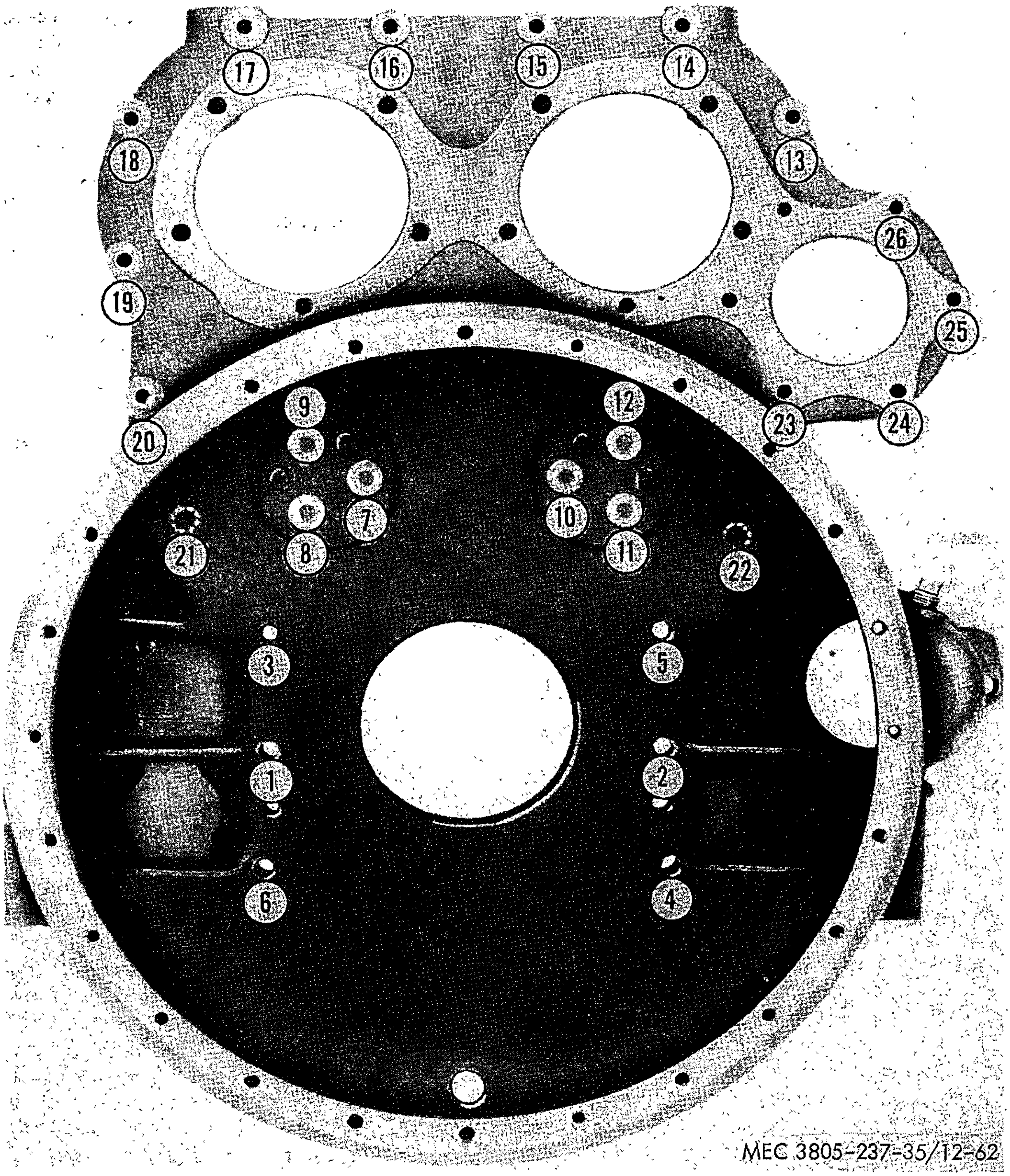



*Figure 12-62. Flywheel housing final screw tightening sequence.*

## Section VIII. CYLINDER HEAD

### 12-30. General

*a.* The cylinder head is a one piece casting mounted above the cylinder block. It is attached to the cylinder block with nuts, studs, and screws. Cam followers (fig. 12-63) and guides, push rods, rocker arms, exhaust valves and injectors and operating mechanism are contained in the cylinder head. The upper operating parts are protected by the valve rocker cover.

*b.* Valve seat inserts, pressed into the cylinder head, permit accurate seating of the valves under all conditions of temperature and prolong the life of the cylinder head. The inserts are ground to close tolerances and are quite free from warpage, reducing valve reconditioning to a minimum. The valves (fig. 12-63) and the valve seat inserts are ground to a seating angle of 30°.

*c.* To insure efficient cooling, each fuel injector is installed in a thin-walled copper tube which passes through the coolant space in the cast iron cylinder head. The tube is flared and seated against leaks.

*d.* Exhaust passages from the valves of each cylinder lead through a single port to the exhaust manifold. These passages are also completely surrounded by coolant. Nozzles incorporated into the coolant system of the head are so positioned to direct comparatively cool water against sections of the head which are subjected to the greatest heat. Two nozzles are located between each pair of cylinders and two single jet spray nozzles are installed at each end of the cylinder head.

*e.* Fuel inlet and outlet manifolds are cast as integral parts of the head. This permits a greater degree of flexibility in installation of fuel lines with inlet and outlet passages provided in the cylinder head opposite each cylinder position.

*f.* Separate laminated gaskets are provided at each cylinder to seal compression between the cylinder head and the block. Water passages are sealed with seal rings which fit into counterbored holes in the block. A synthetic rubber seal fits in a rectangular milled groove near the outer perimeter of the block. When the cylinder head is pulled down and torqued properly a positive leakproof, metal-to-metal contact is maintained between the head and block.

### 12-31. Rocker Arms

*a. General.* The rocker arms are operated by the push rods (fig. 12-63) and cam followers. Each set of three rocker arms pivots on a shaft supported by two brackets. A single screw secures each bracket to the top of the cylinder head.

*b. Removal.*

(1) Refer to paragraph 12-17 and remove the rocker cover.

(2) Refer to paragraph 12-17 and remove the fuel pipes from the injectors and from the cylinder head.

(3) Remove two screws (1, fig. 12-64) and brackets (2). Remove shaft (3) from rocker arms.

*Note.* When removing shaft, tip three rocker arms back only far enough to remove shaft. Forcing arms back too far could bend push rods.

(4) Loosen locknut (13) and remove rocker arm from push rod.

*Note.* Quantities shown in legend are for one cylinder only.

*c. Cleaning.* Clean all parts in fuel oil. Clean oil passages in rocker arms, bracket bolts, and rocker arm shaft with a small diameter wire. Dry parts with compressed air.

*d. Inspection and Repair.*

(1) Inspect bracket bolts for clogged oil passages. Clean with 1/16 inch drill if necessary. Clean all metal particles and burs from bolt after drilling.

(2) Inspect rocker arm shaft and bushings for wear. Check parts against tolerances listed in Table 1-1. Replace parts not conforming to repair and rebuild standards. Ream replacement bushings to size after installation.

(3) Inspect rocker arms for wear and galling on valve contact surfaces. If worn, reface surfaces up to a depth of 0.010 inch. Do not overheat when grinding surface. Replace badly worn rocker arms.

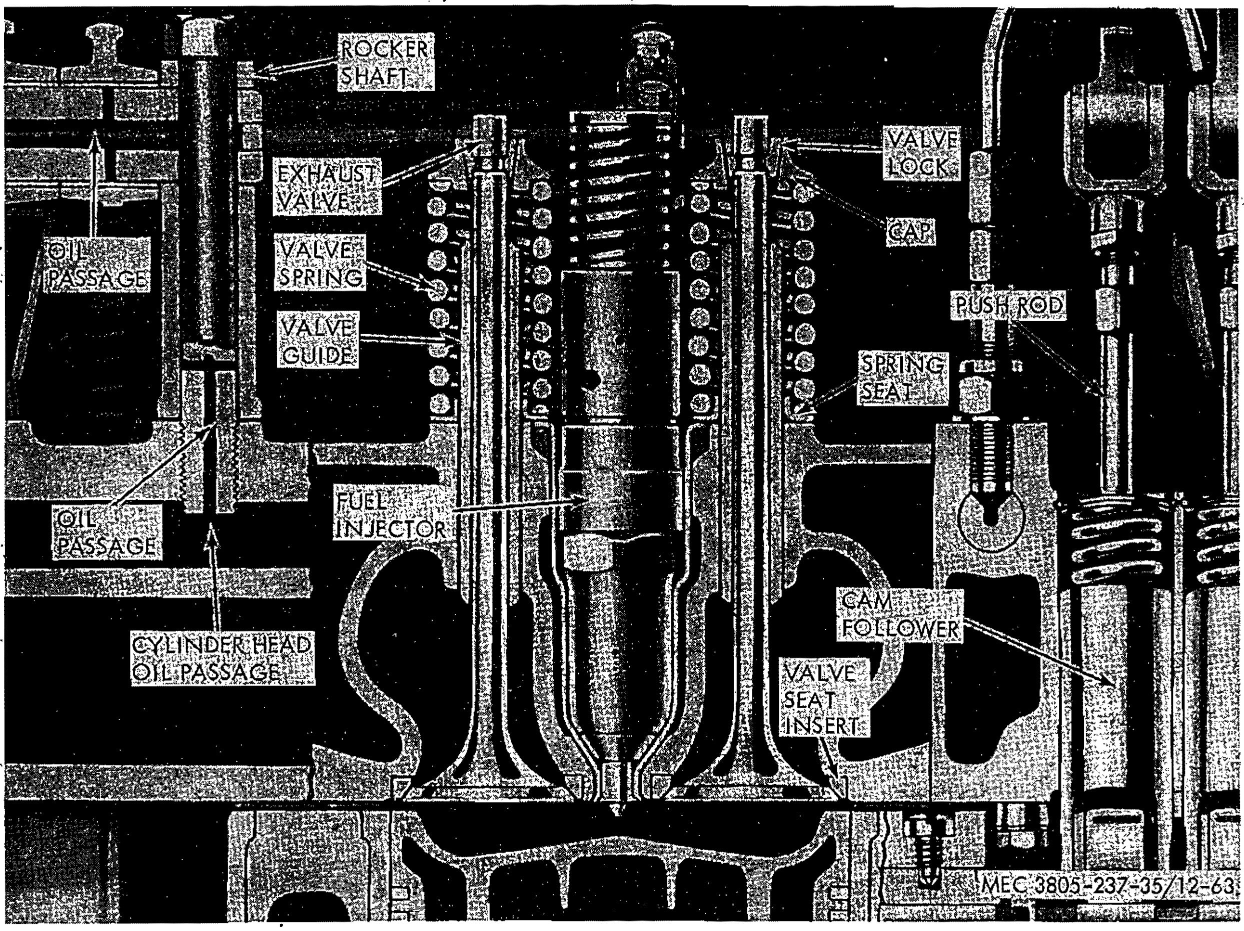



*Figure 12-63. Cylinder head, cutaway view.*

(4) Inspect clevis and pin for wear. Replace worn parts.

*e. Installation.*

(1) Lubricate rocker shaft (3, fig. 12-54) with engine oil (OE). Install shaft in rocker arms (5 and 6).

(2) Install brackets (2) on shaft with finished faces of brackets toward rocker arms.

(3) Position brackets in place in head and secure with two bracket screws (1). Tighten screws to a torque of 90 to 100 foot pounds.

(4) Refer to paragraph 12-17 and install the fuel pipes in cylinder head and injector.

(5) Adjust valve clearance and time injectors as described in paragraphs 12-48 and 12-49.

(6) Refer to paragraph 12-17 and install the rocker cover.

## 12-32. Cylinder Head

*a. General.* Some of the repair procedures required for parts installed on or in the cylinder head can be performed with the cylinder head on the engine. However, for ease of access and inspection of various parts, the cylinder head must be removed from the engine.

*b. Removal.*

(1) Refer to the following paragraphs and remove the following engine parts.

(*a*) Paragraph 12-8, exhaust manifold

(*b*) Paragraph 12-12, water manifold

(*c*) Paragraph 12-15, fuel filter and bracket

(*d*) Paragraph 12-17, fuel injectors

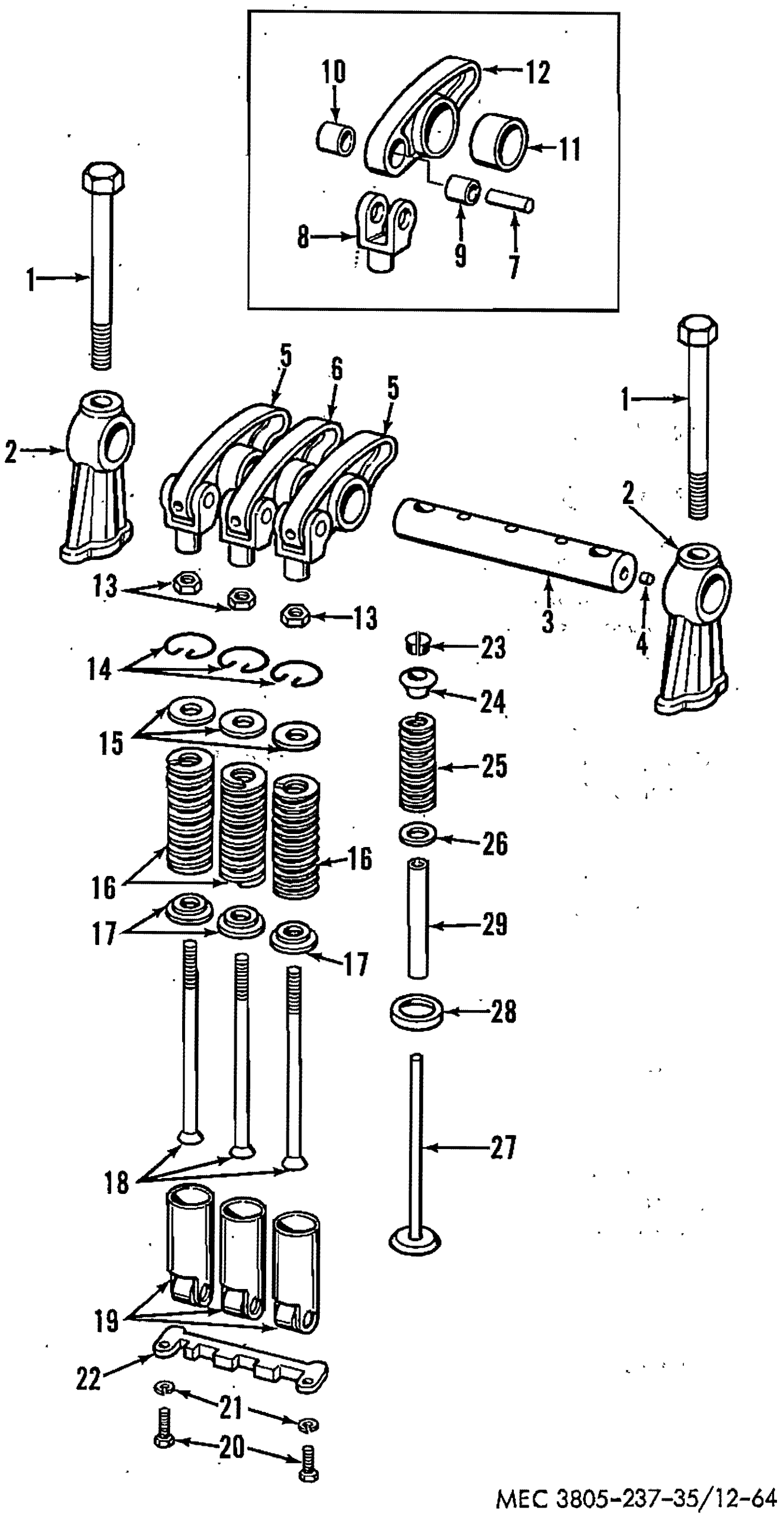



*Figure 12-64. Valve operating mechanism, exploded view.*

1 Screw, bracket (2)
2 Rocker arm bracket (2)
3 Rocker arm shaft
4 Plug
5 Exhaust valve rocker arm assembly (2)
6 Injector rocker arm assembly
7 Pin
8 Clevis(3)
9 Clevis bushing (3)
10 Bushing (3)
11 Shaft bushing (3)
12 Rocker arm
13 Lock nut (3)
14 Retaining ring (3)
15 Spring upper seat (3)
16 Push rod spring (3)
17 Spring lower seat (3)
18 Push rod (3)
19 Cam follower
20 Screw, cap, hex-head, 1/4-20 × 3 /4 in. (2)
21 Washer, lock 1/4 in. (2)
22 Cam follower guide
23 Tappered lock (4)
24 Cap (2)
25 Valve spring (2)
26 Spring seat (2)
27 Exhaust valve (2)
28 Valve seat insert (2)
29 Valve guide (2)

*Figure 12-64*—Continued.

(*e*) Paragraph 12-18, throttle linkage
(*f*) Paragraph 12-19, governor
(*g*) Paragraph 12-20, injector control tube
(*h*) Paragraph 12-31, rocker arms

(3) Loosen the two screws, below engine front lifting bracket, securing the balance weight cover to front end plate. Loosen two screws, below engine rear lifting bracket, securing flywheel housing to rear end plate.

*Note*. Screws must be loosened three or four turns to avoid interference when cylinder head is removed.

(4) Remove two screws (19, fig. 12-60) securing engine rear lifting bracket to flywheel housing.

(5) Remove two screws (1, fig. 12-65) securing engine front lifter bracket to balance weight cover.

(6) Remove four cylinder head nuts (5, fig. 12-65) and six screws (6, fig. 12-65).

(7) Attach a hoist to the lifting brackets and lift cylinder head uniformly from the studs. Place cylinder head on its side and remove engine rear lifting bracket (21, fig. 12-60) and front lifting bracket (3, fig. 12-65) from cylinder head. Install cylinder head on blocks to prevent damage to injector tubes and cam followers.

(8) Remove four cylinder head compression gaskets (8, fig. 12-65) and seal rings (9, 10, and 11) from block.

*c. Disassembly.*

(1) Remove eight screws (20, fig. 12-64) and lockwashers (21) and remove four cam follower guides (22) from bottom of cylinder head.

(2) Pull twelve cam followers (19, fig. 12-64) from bottom of cylinder head.

(3) Remove twelve push rods (18, fig. 12-64), locknuts (13), push rod springs (16) and spring seats (15 and 17) from cylinder head. Remove twelve retaining rings (14) from top of cylinder head.

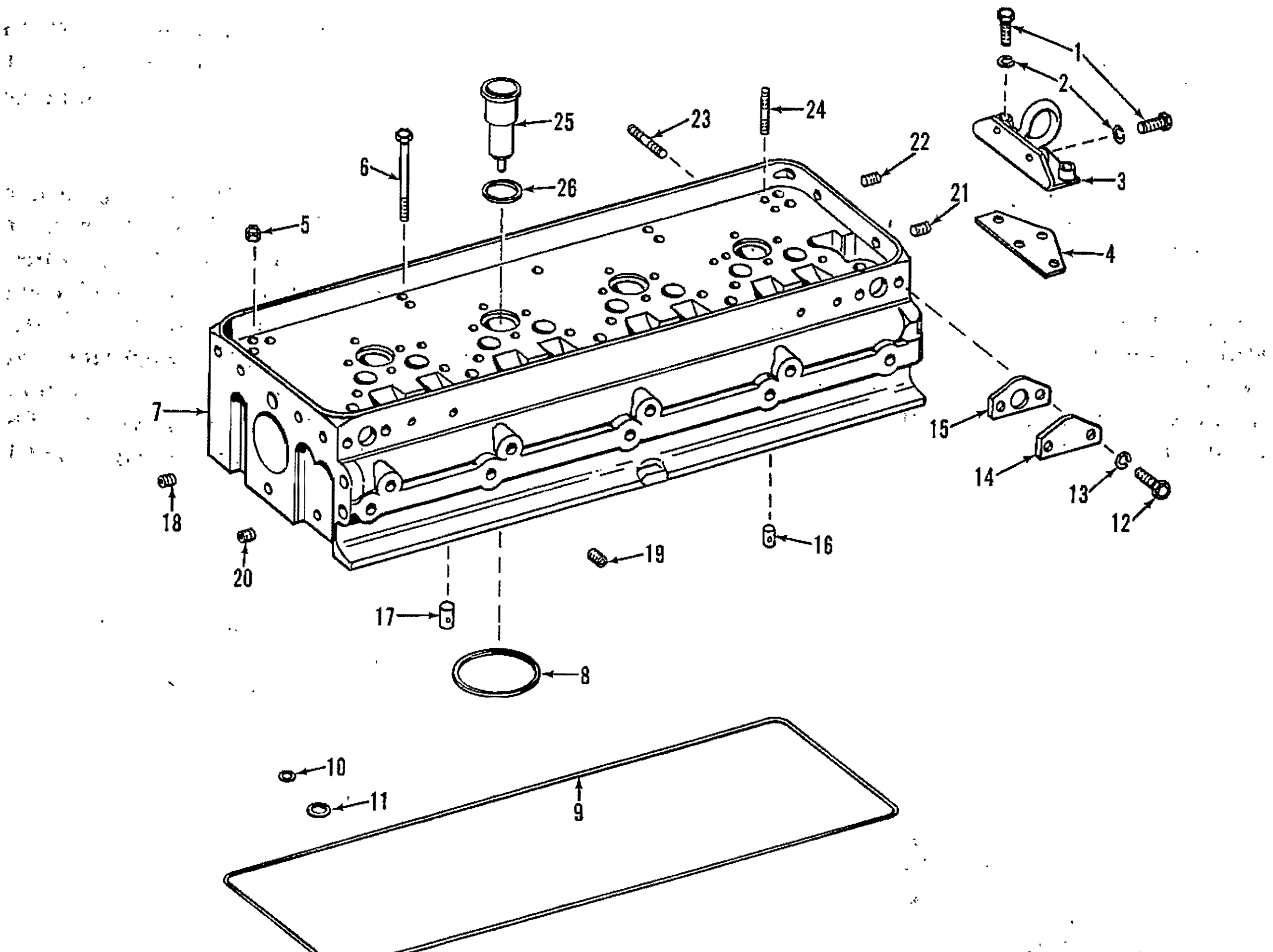
(4) Compress the valve springs and remove eight tapered locks (23, fig. 12-64) from exhaust valve stems. Remove eight spring caps (24), valve springs (25), spring seats (26), and exhaust valves (27) from cylinder head.

*Note*. Number each exhaust valve before removal to install valve in same place at reassembly.

(5) If valve guides (29, fig. 12-64) require replacement, drive valve guides from cylinder head, using a suitable tool.

(6) If valve seat inserts (28, fig. 12-64) require replacement, remove valve seat inserts in the manner illustrated on figure 12-66.

(*a*) Place collet (5, fig. 12-66) inside the valve seat insert (6, fig. 12-66) so that bottom of collet is flush with bottom of insert.




MEC 3805-237-35/12-65

Screw, cap, hex-head, 7/16-14 × 1 1/2 in. (4)
2 Washer, lock, 7/16 in. (4)
3 Engine front lifting bracket
4 Gasket
5 Nut (4)
6 Screw, cap, hex-head (6)
7 Cylinder head
8 Compression gasket (4)
9 Seal ring
10 Water hole seal ring (6)
11 End water hole seal ring (2)
12 Screw, 1/4-20 × 1/2 in. (2)
13 Washer, lock, 1/4 in. (2)
14 Cover
15 Gasket
16 Water nozzle (single outlet) (4)
17 Water nozzle (double outlet) (6)
18 Pipe plug
19 Pipe plug (9)
20 Pipe plug (5)
21 Pipe plug (3)
22 Pipe plug (4)
23 Exhaust manifold stud (8)
24 Water manifold stud (8)
25 Injector tube (4)
26 Seal ring (4)

*Figure 12-65. Cylinder head, exploded view.*

(*b*) Hold the collet handle and turn the handle (4, fig. 12-66) to expand the collet cone until the insert is held securely by the cone.

(*c*) Insert driver (2, fig. 12-66) through exhaust valve guide and in contact with collet.

(*d*) Tap driver sharply once or twice to move insert away from seat in cylinder head.

(*e*) Loosen collet with handle and move cone into insert slightly to place narrow flange on collet below insert.

(f) Tighten handle and continue to drive insert from cylinder head.

(7) If replacement of injector tube (25, fig. 12-65) is required, drive injector tube from cylinder head, using a suitable tool. Remove seal ring (26) from cylinder head.

*d. Cleaning.* Clean the cylinder head with steam. Clean all scale from water passages. Remove water nozzles (16 and 17) if they have scale accumulations. If possible, immerse cylinder head in a solution of inhibited commercial pickling acid to remove all scale. Rinse the head in clear hot water to remove the acid solution and place head in an alkaline bath to neutralize the acid. Wash head in clean hot water or steam clean head. Dry head throughly with compressed air.

*e. Inspection and Repair.*

(1) Using a straight edge and a feeler gage, check bottom face of cylinder head for warpage. Check for transverse (cross ways) warpage at each end and between cylinders. Check longitudinal warpage at each side and between each set of holes. Maximum allowable transverse warpage is 0.008 inch and longitudinal warpage, 0.004

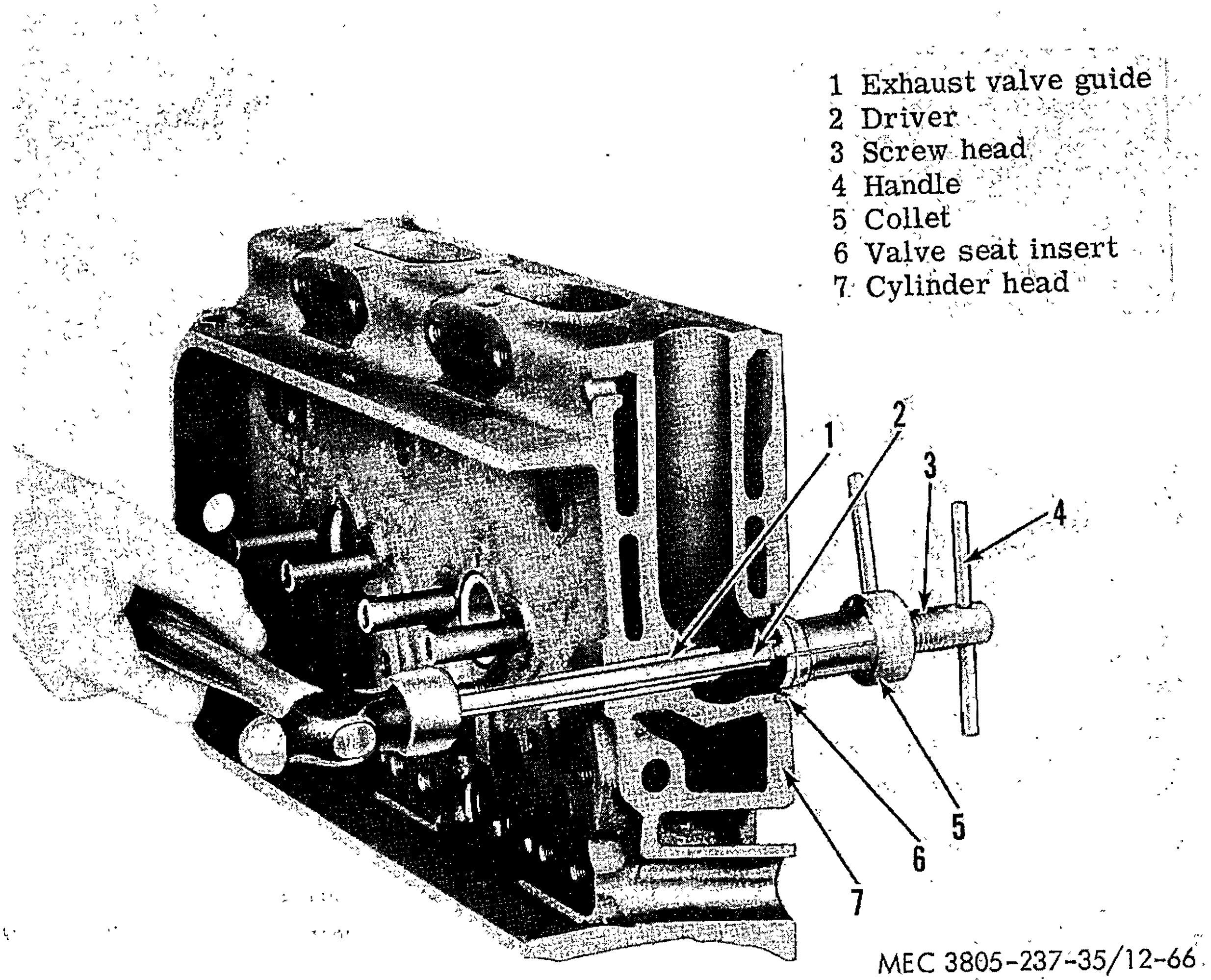



*Figure 12-66. Removing valve seat insert.*

inch. If cylinder head is warped beyond these limits, reface, cylinder head, if possible. Replace cylinder head if it can not be refaced.

(2) Check cylinder head for leaks by sealing all water holes with steel plates and rubber gaskets. Install dummy or scrap injectors in tubes to insure seating of tubes. Tighten injector clamp screws to 20 to 25 foot pounds. Drill and tap one of the water hole cover plates for an air hose connection and apply 80 to 100 psi air pressure. Immerse head in a tank of water heated to 180° to 200°F. Keep head in water for approximately fifteen minutes. Check for air bubbles at injector tubes, oil gallery, stud holes, and the head itself. Replace head if leaks are evident.

(3) Inspect cam follower bores for scoring and wear. Remove light scores with crocus cloth dipped in fuel oil. Inside diameter must be from a minimum of 1.062 inches to a maximum of 1.065 inches. If cam follower clearance exceeds 0.006 inch, replace cylinder head.

(4) Check valve seat insert counterbores in cylinder head. Diameter of counterbore should be 1.626 to 1.627 inches and depth of counterbore should be 0.3705 to 0.3845 inch. Counterbores must be concentric with valve guides within 0.003 inch total indicator reading.

(5) If cylinder head water nozzles are loose or plugged, replace nozzles.

(6) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.*

(1) *Injector tube.*

(*a*) If injector tubes were removed from head, install new seal ring (26, fig. 12-65) and injector tube (25) using a suitable tool as shown in figure 12-67, to drive tube in place. Flange on tube will seat on seal ring when properly positioned.

(*b*) Turn cylinder head bottom side up and upset or flare the lower end of the tube using a suitable flaring tool as illustrated in figure 12-68.

(*c*) After installing injector tube, ream injector tube with a suitable tool to receive the injector body nut and spray tip as illustrated in figure 12-69.

*Note.* Ream carefully. Do not use undue force. Rotate reamer in a clockwise direction only, both when inserting and withdrawing the reamer. Remove at intervals to remove chips. Use a light cutting oil (OL) to aid in reaming tube.

(*d*) After reaming a bore, clean out all chips. Remove excess stock from lower flared end of tube until tube is flush with or to 0.005 inch below surface of head.

(*e*) Ream the bevel seat in injector tube to provide a smooth and true seat for the injector nut as illustrated on figure 12-70.

(*f*) Before reaming as illustrated in figure 12-70, install injector in tube and tighten tube clamp screw to 20 to 25 foot pounds. Check bottom of cylinder head to find relationship between shoulder of spray tip and face of cylinder head as illustrated on figure 12-71. Numbered face and shoulder of tip should be flush to 0.015 inch recessed below surface of cylinder head. This will determine amount of stock to remove in reaming operation illustrated on figure 12-70. Remove reamer at intervals to check amount of stock removed.

(2) *Install exhaust valve guides and insert.*

(*a*) Place cylinder head, bottom side down, on blocks to protect face.

(*b*) Start valve guide (29, fig. 12-64) squarely in bore of cylinder head. Using a suitable tool, drive valve guide into cylinder head.

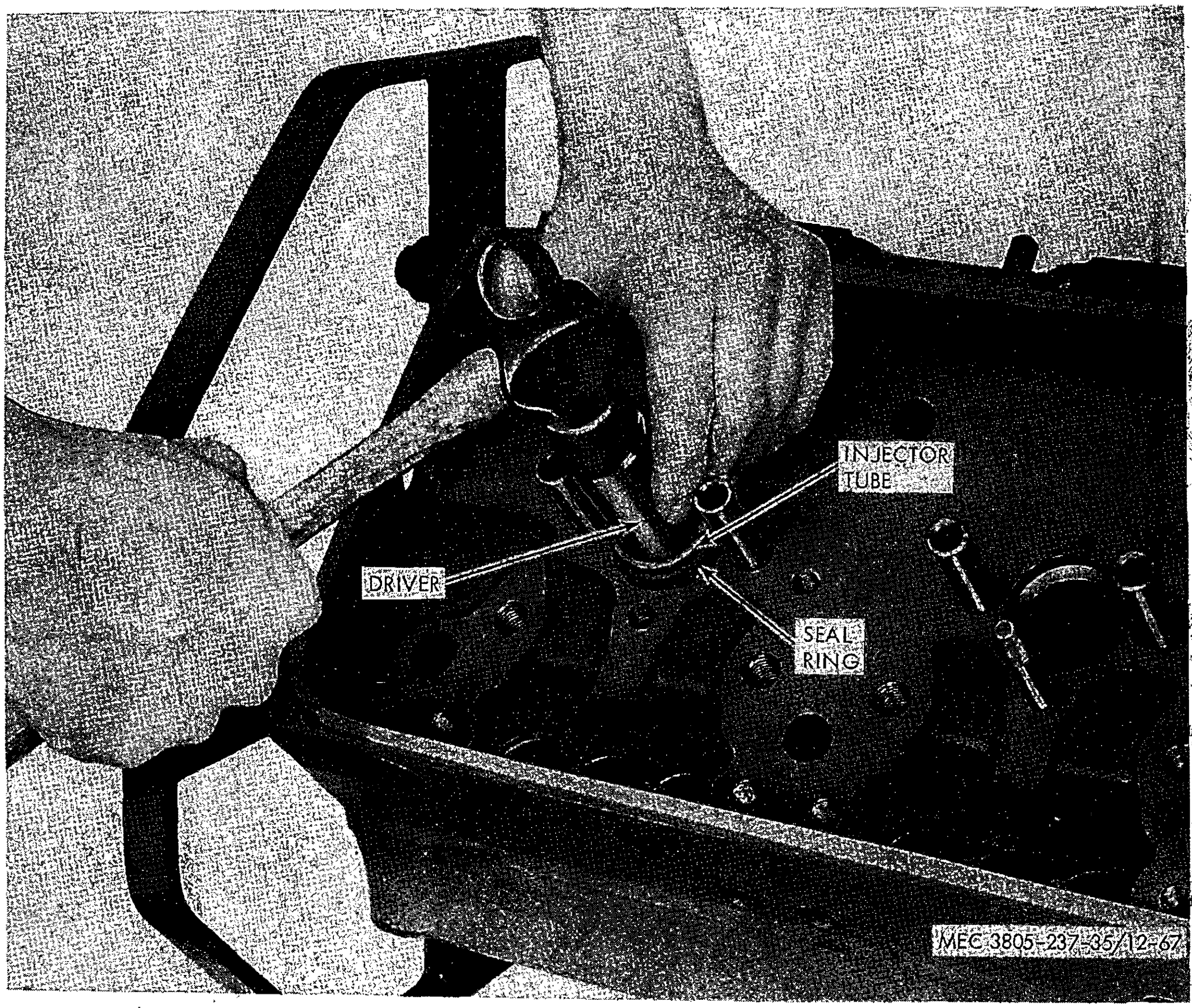



*Figure 12-67. Installing injector tube.*

(*c*) Drive guide into head until top of guide protrudes 1-19/32 inch above top of head.

(*d*) Refer to paragraph 12-33 to install and grind valve seat inserts.

(3) *Install valve operating mechanism.*

(*a*) Lubricate cam follower (19, fig. 12-64) with engine oil (OE).

(*b*) Install retaining ring (14) in cylinder head. Assemble lower spring seat (17), spring (16), upper spring seat (15), and locknut (13) on push rod (18). Slide assembly into position from bottom of head.

(*c*) Screw locknut down on push rod as far as possible. Screw push rod into rocker arm clevis until end of rod is flush with or above inner side of clevis.

(*d*) Point oil hole in cam follower away from exhaust valves and injectors and slide cam follower into cylinder head. Install all cam followers and push rods in this manner.

(*e*) Install cam follower guide (22, fig. 12-64) and secure with two screws (20) and lockwashers (21). Check cam follower to make

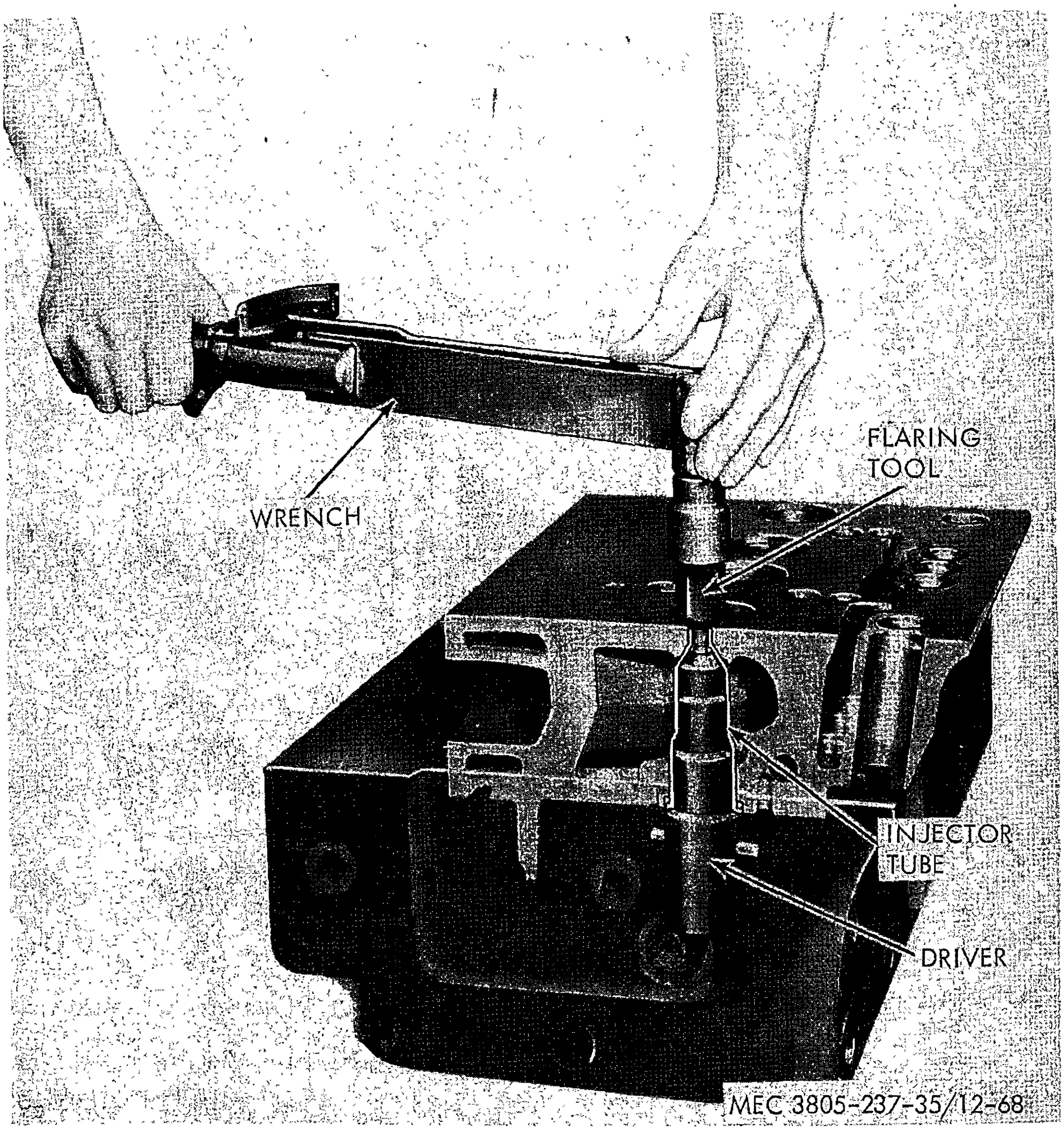



*Figure 12-68. Flaring end of injector tube.*

sure clearance exists and that follower moves freely in bore. Tighten guide screws to a torque of 12 to 15 foot pounds.

(4) *Install exhaust valve.*

(*a*) Install exhaust valves (27, fig. 12-64) in cylinder head from bottom and place a piece of tape over valve and head to hold valve in place.

(*b*) Set head on blocks to protect face, with top of cylinder head up.

(*c*) Install valve springs (25, fig. 12-64) and seats (26) on valve stem. Use a suitable valve spring com-

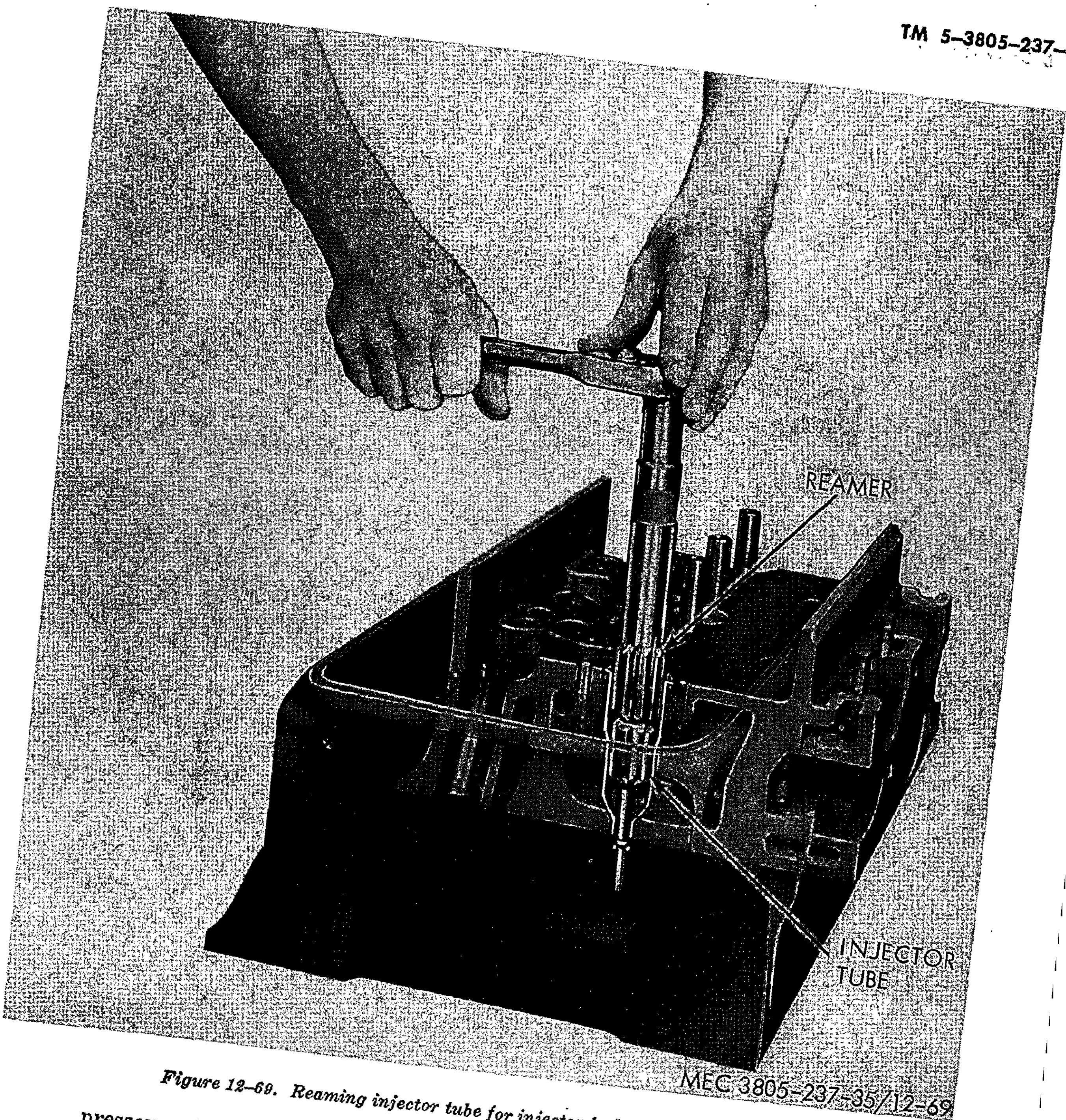



*Figure 12-69. Reaming injector tube for injector body nut and spray tip.*

pressor and compress valve spring. Install tapered lock (23) on stem of valve and remove tool.

(*d*) Refer to paragraph 12-33 and check valve and valve seat for proper relationship.

(5) *Install remaining parts.*

(*a*) Press water nozzles (16 and 17, fig. 12-65) in nozzle openings in bottom of head with nozzle openings parallel to longitudinal center of head, and opening in single nozzles toward center of engine.

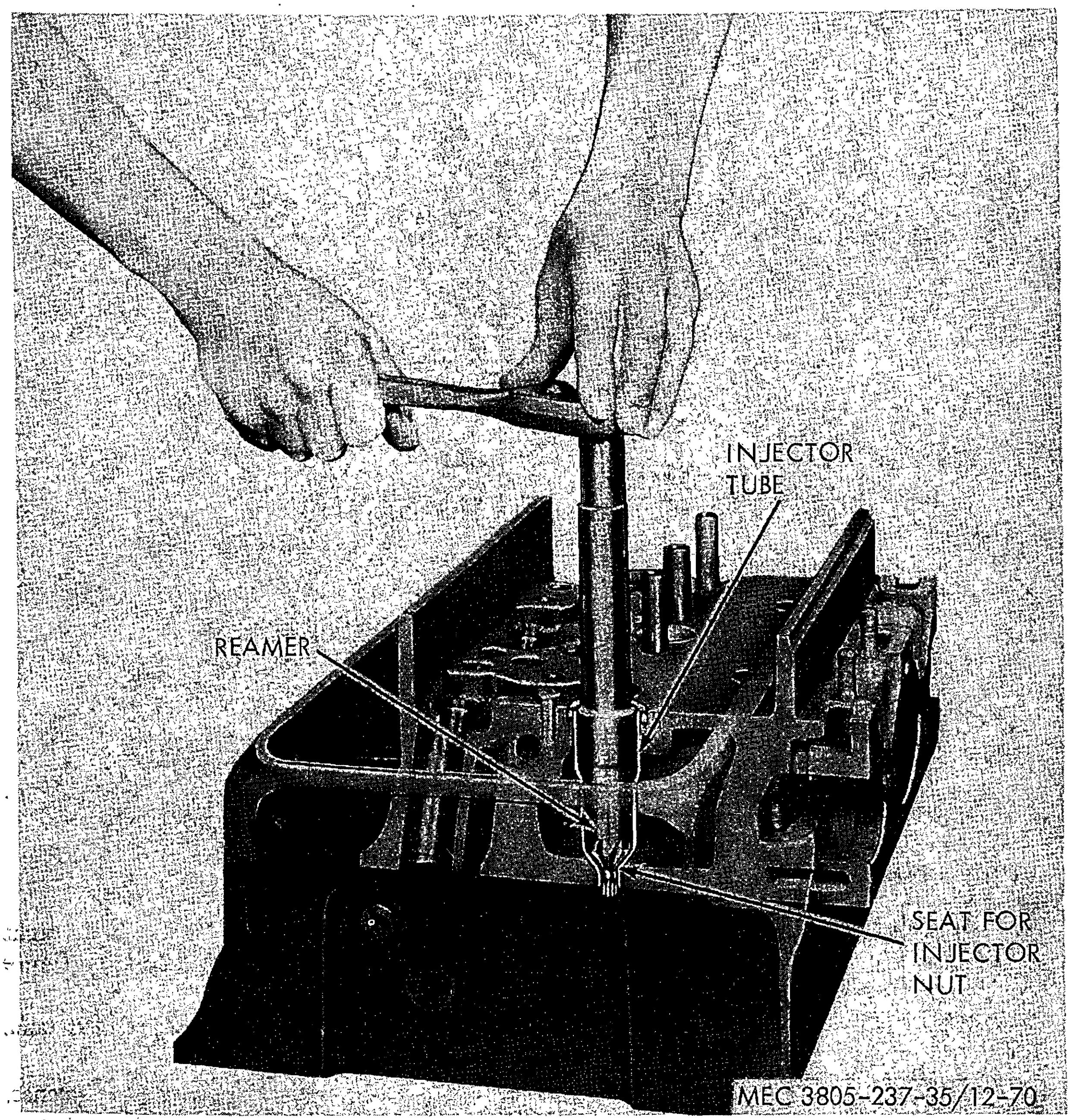



*Figure 12–70. Reaming injector tube to seat injector nut.*

(*b*) Install oil plugs and studs in cylinder head if necessary. Install lifting brackets on cylinder head.

*g. Installation.*

(1) Install new seal rings (10 and 11, fig. 12–65) in counterbores of oil holes in cylinder block.

(2) Install new compression gaskets (8) on each cylinder liner.

(3) Install new seal ring (9) in square groove around outer perimeter of cylinder block.

(4) Check all mating surfaces for dirt or foreign matter and clean if necessary.

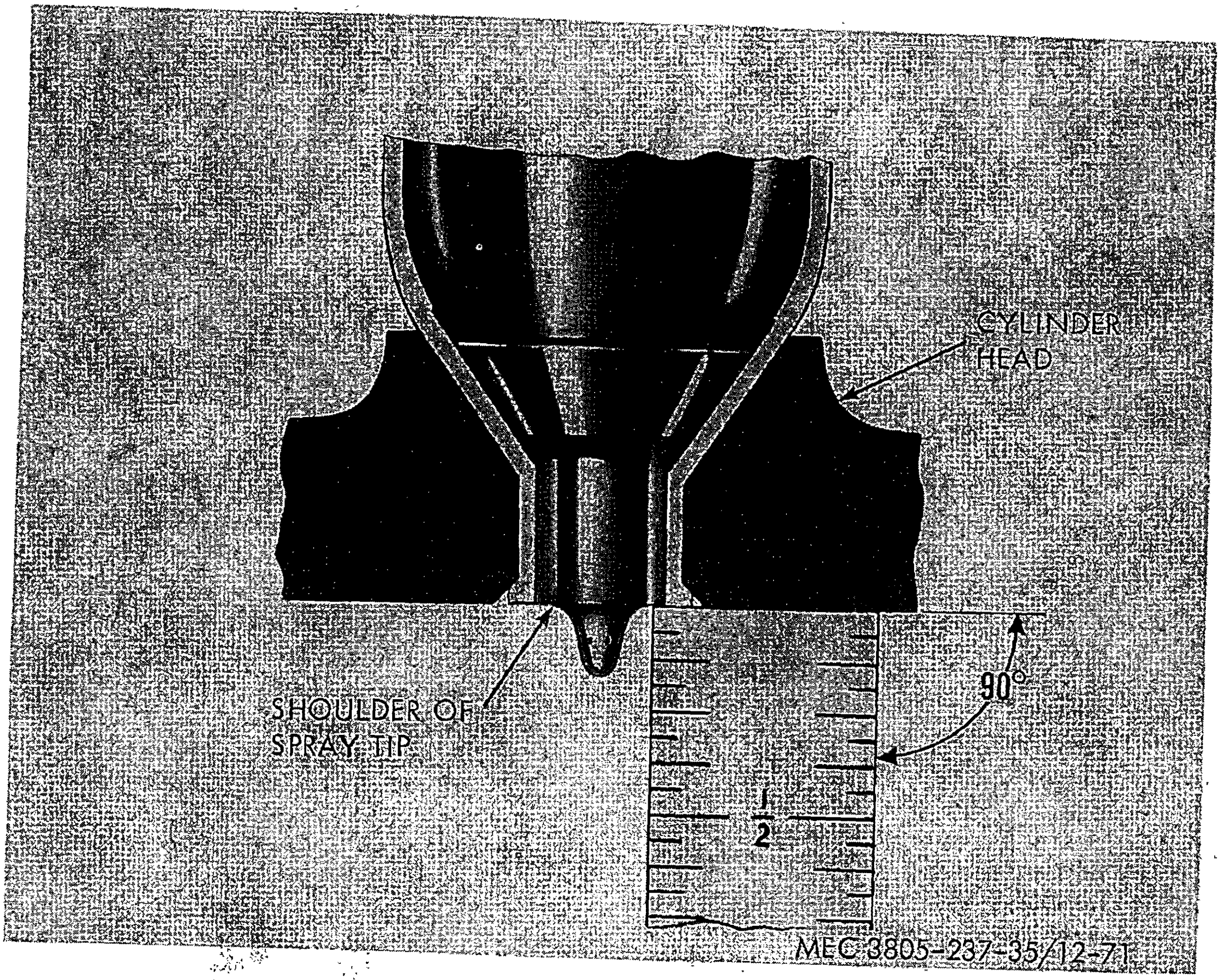



*Figure 12-71. Checking relationship between spray tip and face of cylinder head.*

(5) Lift cylinder head, using a suitable hoist and lower cylinder head in position to place on cylinder block.

(6) Check to be sure all gaskets and seals are in place and lower cylinder head over studs and on cylinder block.

(7) Loosen screws securing lifting brackets to cylinder head.

(8) Secure cylinder head to block with nuts (5, fig. 12-65) and screws (6). Lubricate threads of screws and studs with engine oil (OE) before installation.

(9) The cylinder head must be gradually drawn down against gaskets and seals to insure a good seal.

(10) Tighten nuts and screws hand tight in the sequence illustrated on figure 12-72.

(11) Tighten nuts and screws in the same sequence with a socket wrench.

(12) In the final tightening sequence, tighten nuts and screws with a torque wrench, one-half turn at a time, to insure uniform compression of the gaskets, in the same sequence.

(13) Tighten nuts to a torque of 175 to 185 foot pounds. Tighten the screws to a torque of 175 to 185 foot pounds. Tighten nuts and screws to the high side of the torque but do not exceed the limits.

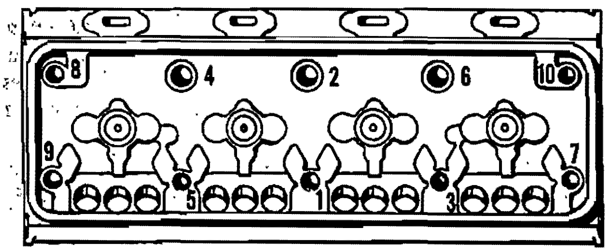



*Figure 12-72. Cylinder head nut and screw tightening sequence.*

(14) Tighten two flywheel housing screws below engine lifting bracket. Install a new gasket (22, fig. 12-60) and secure lifting bracket to cylinder head and flywheel housing. Tighten screws to a torque of 55 to 60 foot pounds. Tighten upper right screw into cylinder head first, then tighten lower left screw into flywheel housing. Tighten upper left screw and lower right screw in that order.

(15) Install a new gasket (4, fig. 12-65) and install front lifting bracket (3) on cylinder head and balance weight cover. Secure with four screws (1) and lockwashers (2). Tighten screws to a torque of 55 to 60 foot pounds.

(16) Refer to the following paragraphs and install the following parts.

- (*a*) Paragraph 12-20, injector control tube
- (*b*) Paragraph 12-31, rocker arms
- (*c*) Paragraph 12-17, fuel injectors and rocker cover
- (*d*) Paragraph 12-19, governor
- (*e*) Paragraph 12-18, throttle linkage
- (*f*) Paragraph 12-15, fuel filter and bracket
- (*g*) Paragraph 12-12, water manifold
- (*h*) Paragraph 12-8, exhaust manifold

## 12-33. Exhaust Valves

*a. General.* Two exhaust valves serve each cylinder. The valves are timed to open and allow the burned gases to be expelled from the cylinder. The heat treated valves are opened under pressure of the rocker arms and are closed by action of the valve springs when this pressure is released. Lubrication for the valve ends is supplied by excess oil from the rocker arms. The valves are cooled by the flow of air from the blower each time the air inlet ports are open.

*b. Removal.* Refer to paragraph 12-32 and remove exhaust valves and springs.

*c. Cleaning.* Scrape carbon from the valve stems and wash in clean fuel oil. Clean the exhaust valve guides with a wire brush to remove carbon deposits.

*d. Inspection and Repair.*

(1) Inspect valve guides (29, fig. 12-64) for fractures, scoring, or excessive wear. Replace valve guides (para 12-32) if worn, fractured, or scored.

(2) Inspect valves (27, fig. 12-64) for scratches and scuff marks on stems. Replace valves if badly scratched or scuffed.

(3) Inspect valve faces for pitting, ridges, or cracks and for carbon on face of valve. Reface or replace pitted and poor seating valves.

(4) Check valve heads to be sure they are square with the stem and not warped. Replace warped valves.

(5) Check valve stem clearance in valve guide. This clearance should not be less than 0.002 inch to 0.006 inch. If clearance exceeds these limits, replace valve guides (para 12-32).

(6) Inspect valve springs (25, fig. 12-64) for cracks or broken condition. Springs should have a free length of 2 3/8 inches and require a load of 142.5 to 150.5 pounds to compress spring to 14 9/64 inches. Replace spring when 135 pounds will compress spring to this length.

(7) Inspect spring seats (24 and 26, fig. 12-64) and locks (23) for wear and damage. Replace damaged parts.

(8) Inspect valve seat inserts (28, fig. 12-64) in cylinder head for excessive wear, pitting, cracking, and improper angle. Replace insert if badly worn,

pitted, or cracked. Reface valve seat inserts, if possible. Refer to paragraph 12-32 to remove inserts.

(9) If new valve seat is to be installed, proceed as follows.

(*a*) Place cylinder head in water heated to a temperature of 185° to 200°F for at least 30 minutes.

(*b*) Remove cylinder head and place on bench bottom side up. Locate insert squarely in counterbore, seating face up.

*Note.* Install inserts in head while head is still hot and inserts at room temperature. Inserts are to be installed at a press fit of 0.005 to 0.0025 tight in the cylinder head.

(*c*) Drive inserts into head with a suitable tool as shown in figure 12-73.

(*d*) Check angle of valve seat on insert, angle should be 30° as shown on figure 12-74.

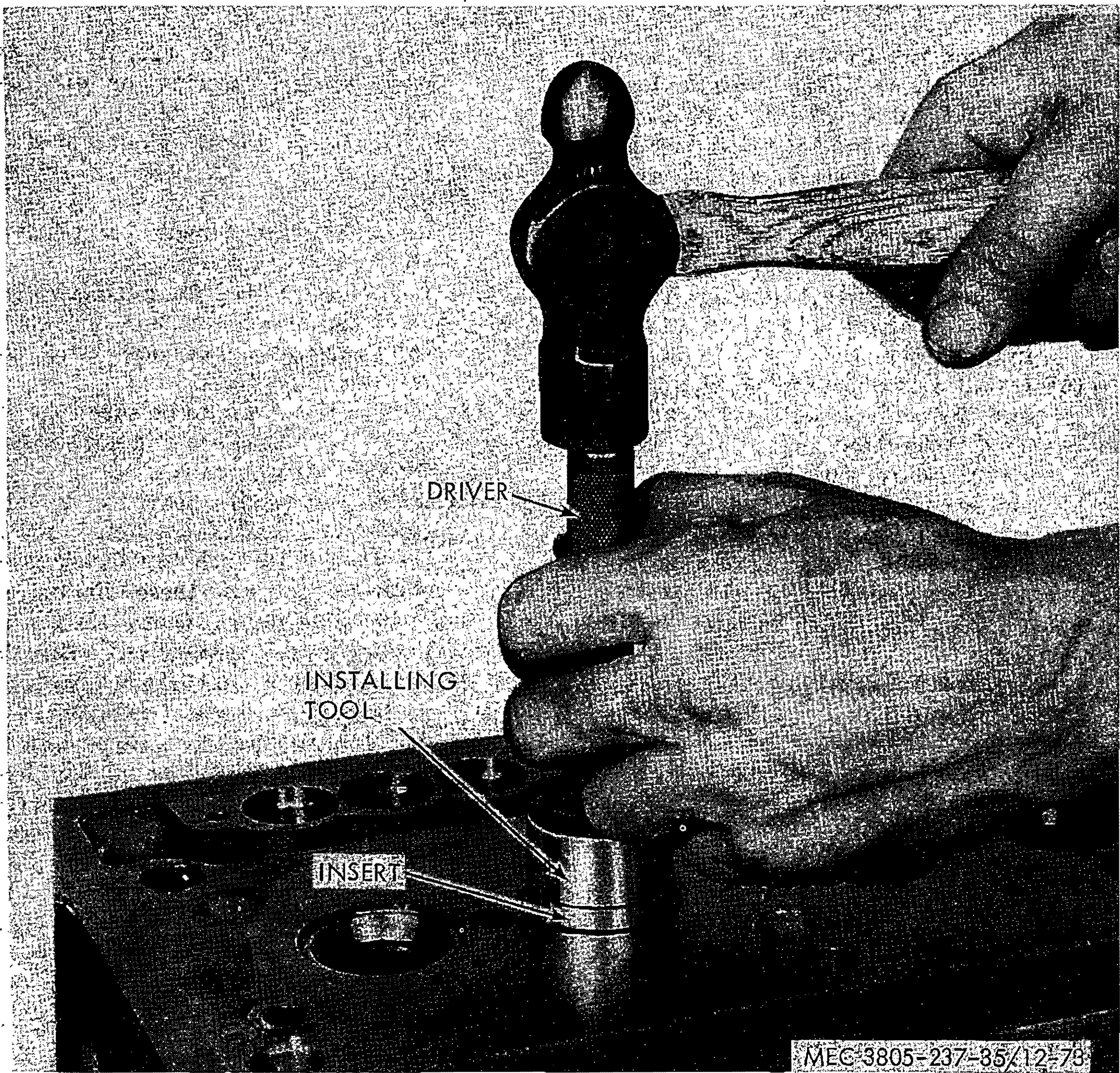



*Figure 12-73. Installing valve seat insert.*

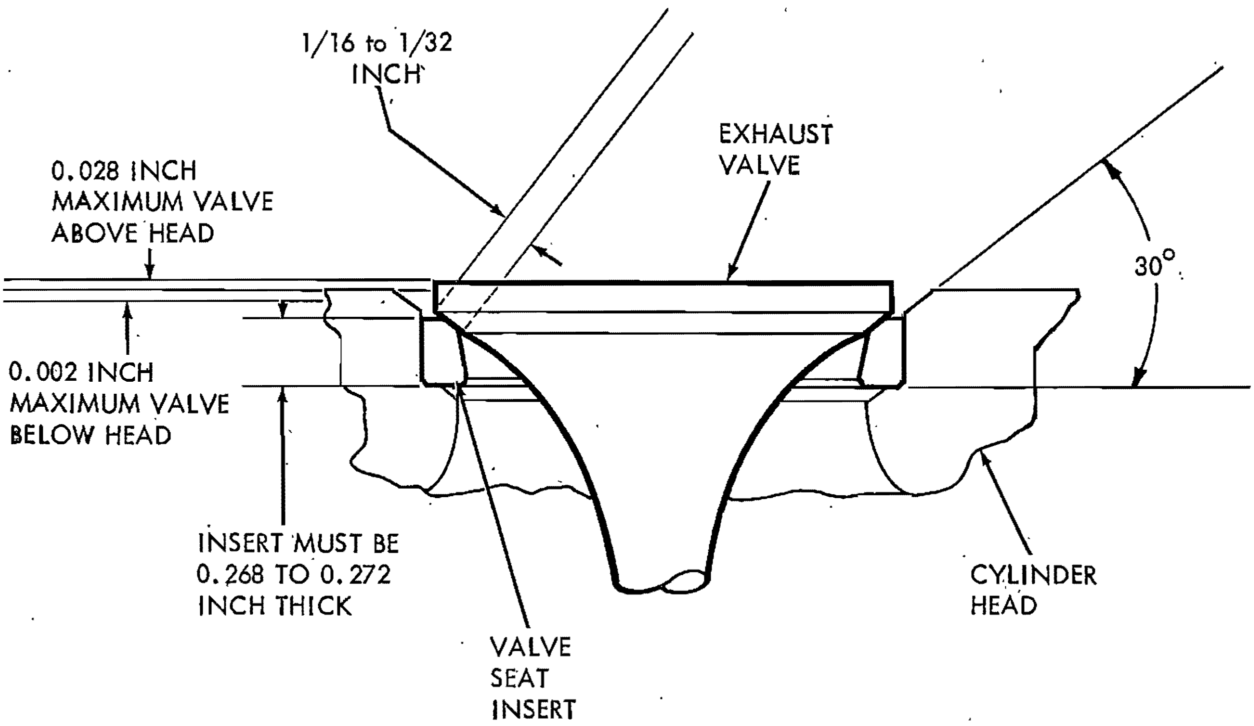



*Figure 12–74. Valve and valve seat angles and relationship to cylinder.*

(*e*) If angle is not correct, reface exhaust valve angle with an eccentric grinder. Angle must be correct, clean, and have no pit or score marks.

(*f*) Grind valve seat with a 30° grinding wheel. Open throat of insert with a 60° grinding wheel. Grind top surface of insert with a 15° grinding wheel to establish width of seat to 1/16 to 1/32 inch. Adjust 30° face of insert, relative to the center of the valve face, with 15° and 60° grinding wheels.

*Note.* Do not contact cylinder head with grinding wheels when grinding insert.

(*g*) Maximum allowable limits that the valve can protrude above and recede below cylinder head when valve is closed are shown on figure 12–74. If grinding operations reduce valve or valve seat insert thickness so that valve recedes beyond these limits, replace valve seat insert and/or valve.

(*h*) After grinding, clean insert thoroughly with fuel oil and blow dry with compressed air. Check concentricity with a dial indicator as illustrated on figure 12–75. Total runout should not exceed 0.002 inch. If runout exceeds this, check for bent valve guide before regrinding the insert. If valve seat insert is within desired limits check contact surface of valve.

(*i*) Apply a light coat of Prussian blue to valve seat insert. Lower stem of valve into valve guide and bounce, do not rotate, valve on the insert.

This will show area of contact between valve and insert. Most desirable contact area is in center of valve face.

(j) Dress valve and/or valve seat to obtain the proper seat angle as illustrated on figure 12-74.

(k) After grinding and checking, clean cylinder head thoroughly.

(10) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*e. Installation.*

(1) Refer to paragraph 12-32 and install the exhaust valves, springs, seats, and locks.

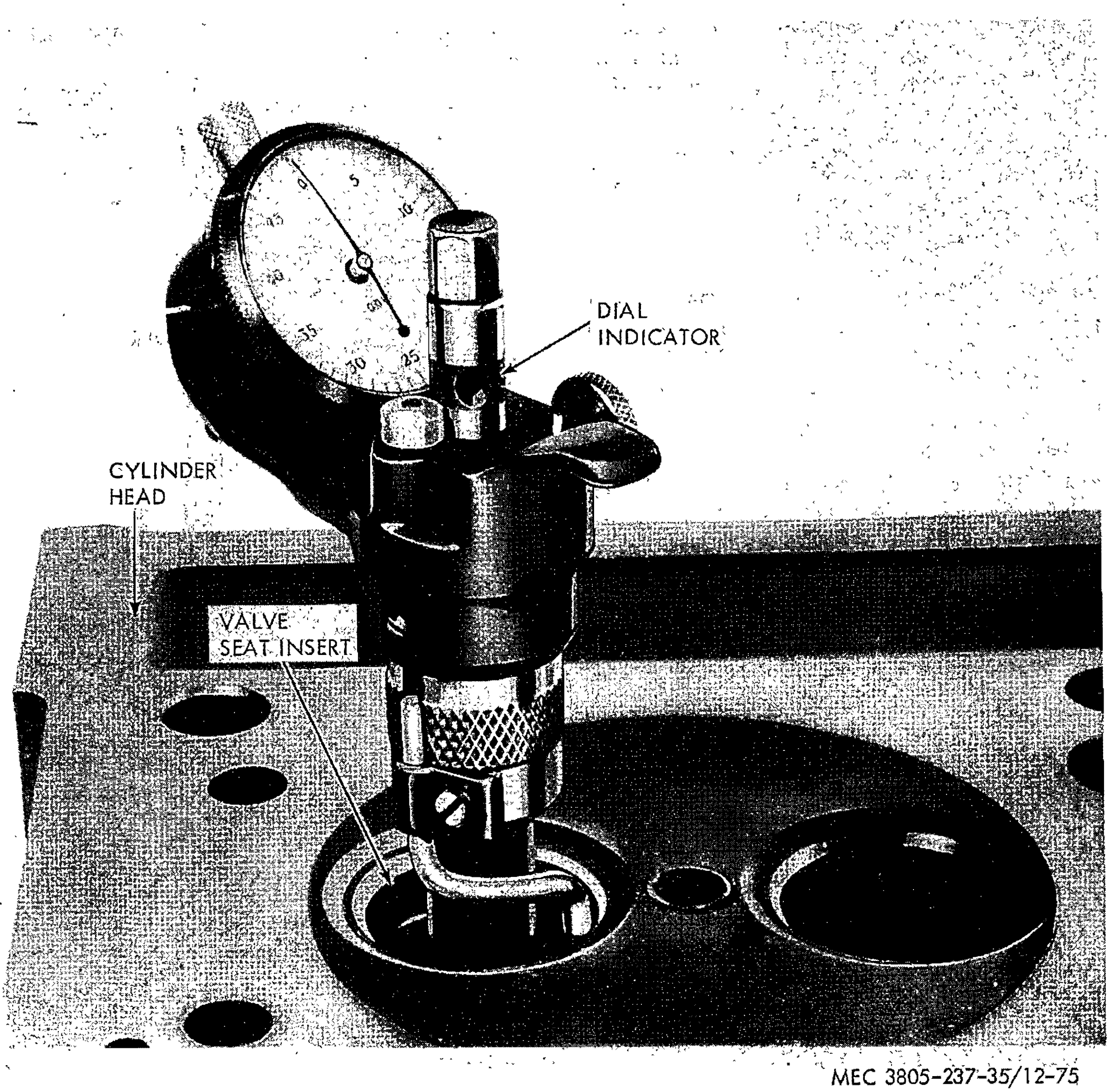



*Figure 12-75. Checking concentricity of valve seat insert.*

(2) Refer to paragraph 12-48 and perform the final engine tuneup procedures.

## 12-34. Cam Followers

*a. General.* The cam followers are operated by the camshaft lobes. As the lobes contact the followers and lift them, the push rods rise through the cylinder head. As the push rods rise they lift the outer end of the rocker arms. The rocker arms pivot on the rocker arm shaft and depress the exhaust valve stems or the injector follower. These motions open the exhaust valve ports to allow purging of the cylinder, or, when the injector follower is depressed, inject fuel into the cylinder. The followers incorporate a roller which is in contact with the camshaft to allow as little interference to camshaft and follower motion as possible.

*b. Removal.* Refer to paragraph 12-32 and remove cylinder head from the engine and remove cam followers from the cylinder head.

*c. Cleaning.* Clean all parts with fuel oil and dry with compressed air.

*d. Inspection and Repair.*

(1) Inspect push rods (18, fig. 12-64) and spring seats (15 and 17) for wear and damage. Replace rods and seats if worn or damaged.

(2) Inspect push rod springs (16, fig. 12-64) for cracked or weak condition. Springs should have a free length of 2 5/8 inches. Replace the spring when a load less than 172 pounds will compress spring to a length of 2 1/8 inches.

(3) Inspect body of cam follower (19, fig. 12-64) for scores, nicks, and damage. Replace cam follower if body is nicked or damaged.

(4) Check diameter of cam follower. Diameter should be 1.060 to 1.061 inches. Clearance between follower and cylinder head bore should be 0.001 to 0.006 inch. Replace cam follower if dimensions are not correct.

(5) Check cam rollers for free rotation on pins and for flat spots and scuff marks. If roller has scuff marks or flat spots replace roller. Check cam roller wear and clearance as illustrated on figure 12-76. Check diametric and total side clearance to dimensions shown. Replace roller if wear is evident.

(6) Remove and install cam follower roller as follows:

(*a*) Place cam follower in a device with soft jaws or a suitable fixture with a spring loaded plunger.

(*b*) Use a drift and drive roller pin (fig. 12-77) from cam follower body.

(*c*) Remove roller (fig. 12-77) from follower.

(*d*) Coat new roller bushing and pin with engine oil (OE). Install roller (fig. 12-77) in cam follower body.

(*e*) If fixture is used, install body on fixture with plunger centered in roller and body. Start roller pin (fig. 12-77) squarely in body and drive pin through body and roller until pin is centered in legs of body.

(*f*) Check side clearance of roller as in figure 12-76.

(7) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*e. Installation.* Refer to paragraph 12-32 and install cam follower, push rod, and springs in cylinder head and install cylinder head on engine.

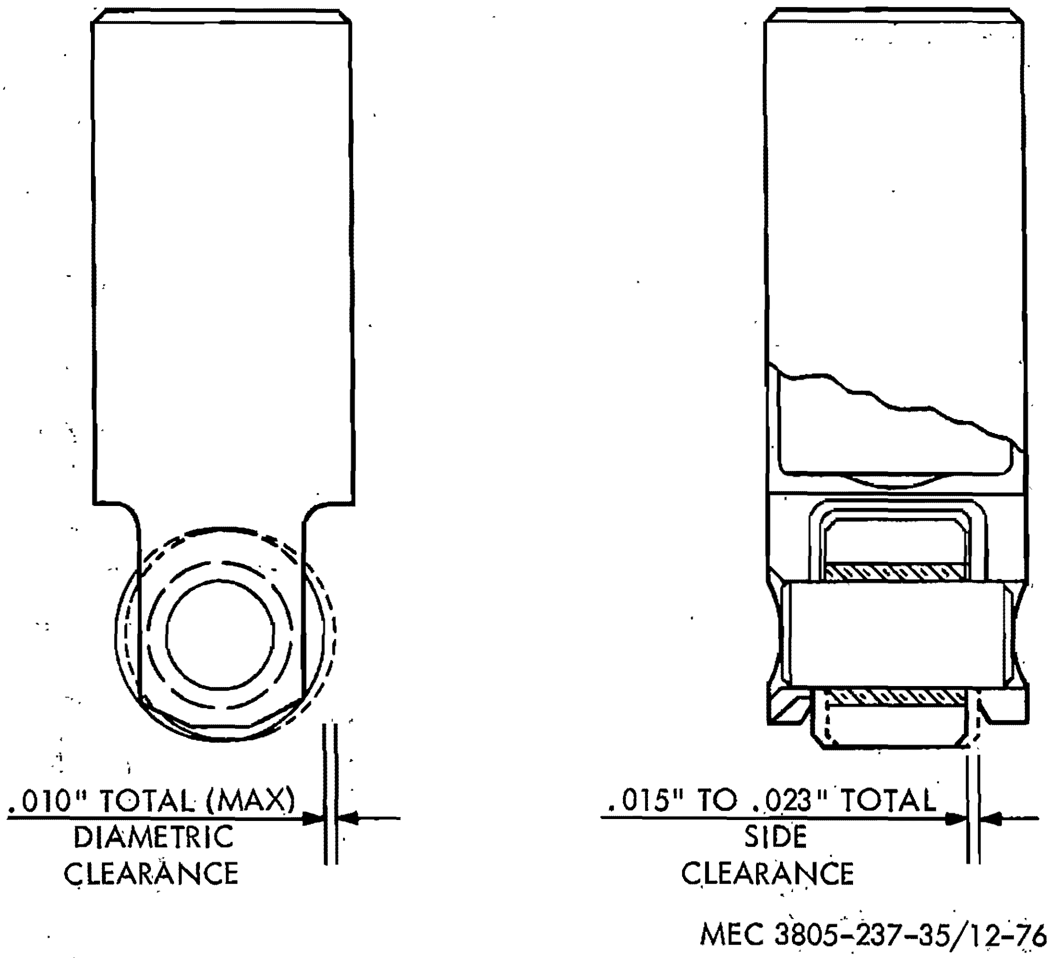



*Figure 12-76. Checking cam roller wear and clearance.*

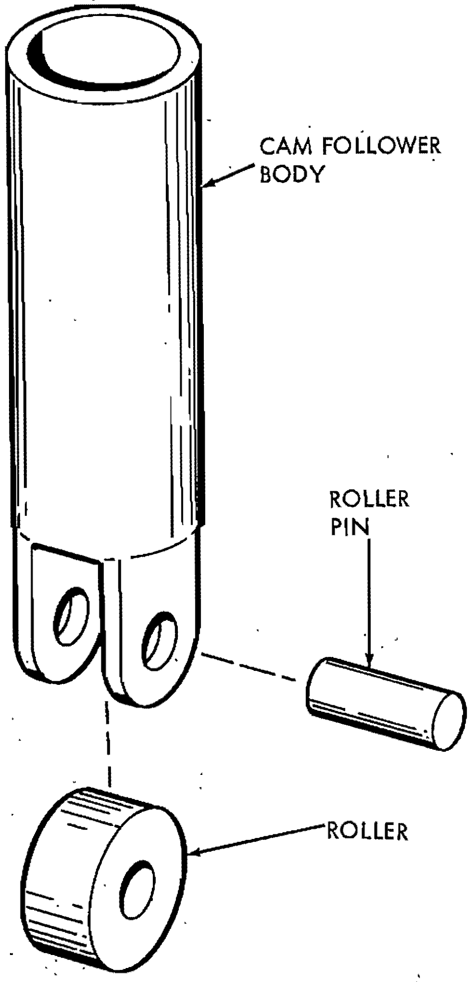



*Figure 12-77. Cam follower roller, removal and installation.*

## Section IX. CAMSHAFT, BALANCE SHAFT, AND GEAR TRAIN

### 12-35. General

*a.* The camshaft and the balance shaft are located near the top of the cylinder block. The camshaft actuates the valve and operating mechanism. The cams on the camshaft are accurately ground to insure efficient, quiet, cam follower action. Heat treatment of the cams provides a hard wear surface.

*b.* The ends of the camshaft and balance shaft are supported by bearing assemblies. Intermediate two piece bearings support the camshaft at intervals along its length. These bearings are secured to the camshaft by lock rings to allow installation with the camshaft. The bearings are secured in place, after installation of the camshaft, with lockscrews threaded into counterbored holes in the top of the cylinder block.

*c.* Both shafts have thrust washers to absorb the thrust load. Drive gears are secured to the shaft with keys, nuts, nut retainers, and screws. A solid weight is installed on the front end of each shaft for balance.

*d.* The shafts are lubricated with oil under pressure from the cylinder block oil passages. The intermediate bearings are lubricated with oil from end bearings which passes through a drilled passage in the shaft.

## 12-36. Balance Weight Cover and Balance Weights

*a. General.* The balance weight cover encloses the front balance weights and supports the fan bracket. The balance weight cover must be removed to service camshaft, balance shaft, or front balance weights.

*b. Removal*

(1) Refer to paragraphs 12-10 and 12-11 and remove the radiator and fan from the engine.

(2) Refer to figure 12-78 and remove the front balance weight cover and gasket. Discard gasket.

(3) Place a block of wood between the two balance weights as illustrated on figure 12-79 and remove nuts, lockwashers and balance weights.

*c. Cleaning.* Clean all parts with fuel oil and dry thoroughly.

*d. Inspection and Repair.*

(1) Inspect cover for cracks and other damage. Replace cover if cracked or damaged.

(2) Inspect balance weight for damage and wear on thrust surface (side facing shaft thrust washers). Replace balance weights if damaged or worn. Weights must be replaced as a set to maintain engine balance.

*e. Installation.*

(1) Apply a coating of grease (GAA) to thrust washers on shafts.

(2) Install weights and keys on shafts and install a block of wood between weights as illustrated on figure 12-79.

(3) Install lockwashers and nuts on shafts and tighten nuts to a torque of 300 to 325 foot pounds.

(4) Refer to figure 12-78 and install the balance weight cover. Tighten screws finger tight. Tighten all screws to a torque of 25 to 30 foot pounds. Tighten screws in a sequence starting at the screw marked A on figure 12-78 and continuing across the top in a clockwise direction, down the right side, across the bottom and up to the screw marked B. Tighten all screws snug, then tight, and then torque screws to the final torque.

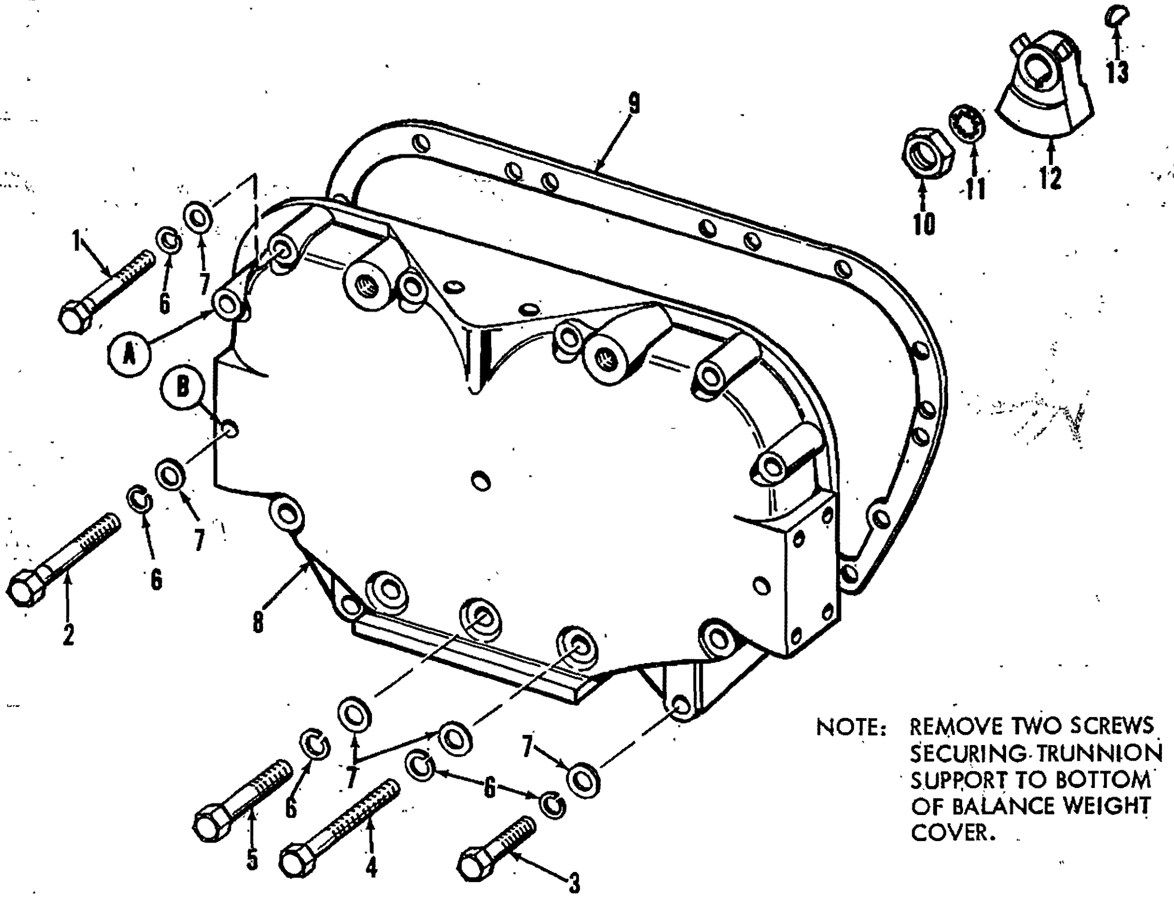
(5) Refer to paragraphs 12-10 and 12-11 and install the radiator and the fan on the engine.

## 12-37. Camshaft, Balance Shaft, and Gears

*a. General.*

(1) The camshaft and balance shaft gears, located on the flywheel end of the engine (fig. 12-80) are in mesh with each other and run at the same speed as the crankshaft. The two upper gears (fig. 12-80) are the camshaft gear and balance shaft gear. The balancer gear is driven by the idler gear (fig. 12-80) and, in turn, drives the camshaft gear.

(2) The idler gear also drives the blower drive gear (fig. 12-80) and is driven by the crankshaft gear. The camshaft and balance gears must be in time with each other, therefore they have marked teeth (0 markings, see fig. 12-80) which must mesh with each other. They must also be in time with the crankshaft gear (fig. 12-80). Timing marks (R and A, fig. 12-80) are placed on the crankshaft gear in two places, with a corresponding R on the idler gear (fig. 12-80). The R on each gear must be in mesh, as well as the teeth marked R on the idler gear and balance shaft gear. The A on the crankshaft gear alined with the R on the idler gear indicates advanced timing. Before disassembly, note whether standard or advanced timing is used.




1 Screw, cap, hex-head, 3/8-24 x 3 in. (9 rqr)
2 Screw, cap, hex-head, 3/8-24 x 3-1/4 in. (2 rqr)
3 Screw, cap, hex-head, 3/8-24 x 1-7/8 in. (3 rqr)
4 Screw, cap, hex-head, 3/8-24 x 3-1/2 in.
5 Screw, cap, hex-head, 3/8-24 x 2-1/4 in.
6 Washer, lock, 3/8 in. (15 rqr)
7 Washer, flat, 3/8 in. (15 rqr)
8 Balance weight cover
9 Cover gasket
10 Nut (2 rqr)
11 Washer, lock (2 rqr)
12 Balance weight (2 rqr)
13 Key (2 rqr)

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*Figure 12-78. Balance weight cover, removal and installation.*

(3) The camshaft and balance shaft gears are keyed to the shafts and are held against the shoulder on the shaft by a nut, secured by a retainer. A small balance weight is attached to the inner face of each gear. These weights are important in maintaining engine balance.

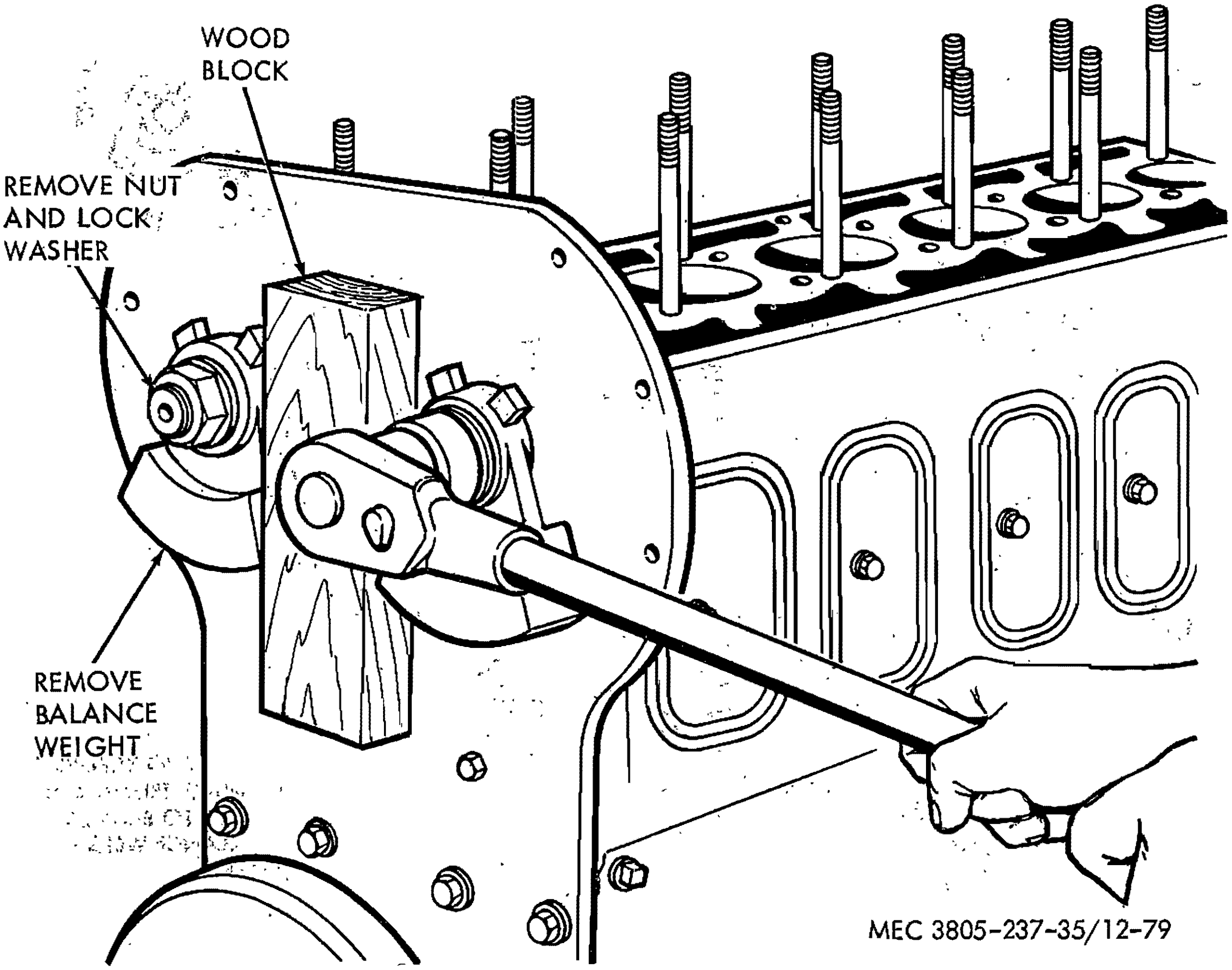



*Figure 12-79. Front balance weights, removal and installation.*

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 12-29 and remove the flywheel housing.

(3) Refer to paragraph 12-32 and remove the cylinder head.

(4) Refer to paragraph 12-36 and remove the front balance weight cover and balance weights. Remove thrust washers from behind weights.

(5) Remove three screws (2, fig. 12-81) securing camshaft bearings to cylinder block.

(6) Remove eight screws (3, fig. 12-81) and two retaining plates (4) from face of gears.

(7) Insert a socket wrench through the hole in the web of the camshaft gear and balancer gear and remove six screws (5, fig. 12-81) and lockwashers (6) securing two shaft bearings to the cylinder block.

(8) Pull the camshaft and balance shaft from the rear of the engine block.

(9) Remove idler gear (fig. 12-80) and spacer from end plate by removing screw (1, fig. 12-82) and lockwasher (2). Remove idler gear assembly from end plate. Remove screw (10) and remove idler gear spacer (fig. 12-80) from end plate.

*c. Disassembly.*

(1) Install shaft in vise with soft jaws.

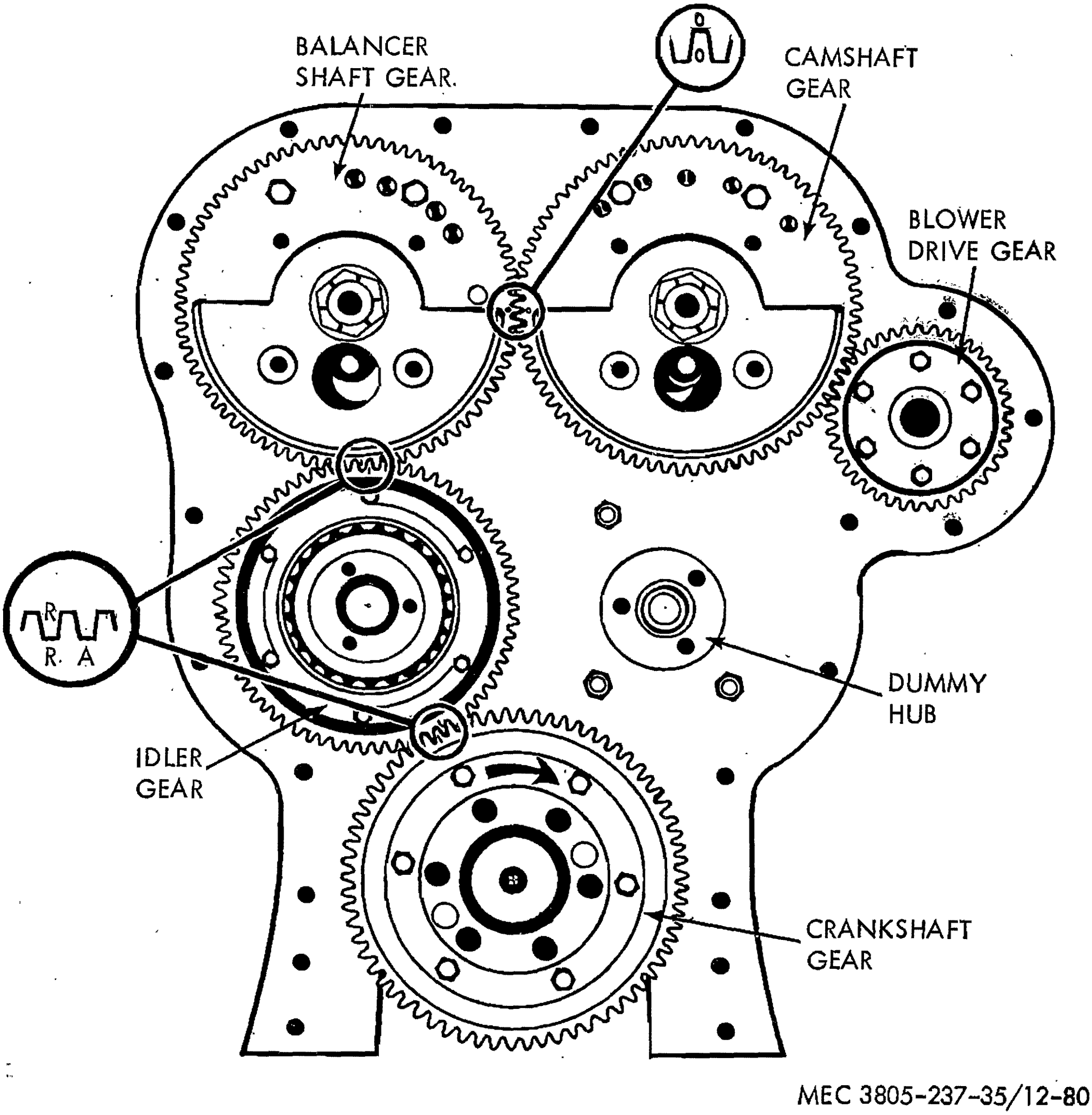
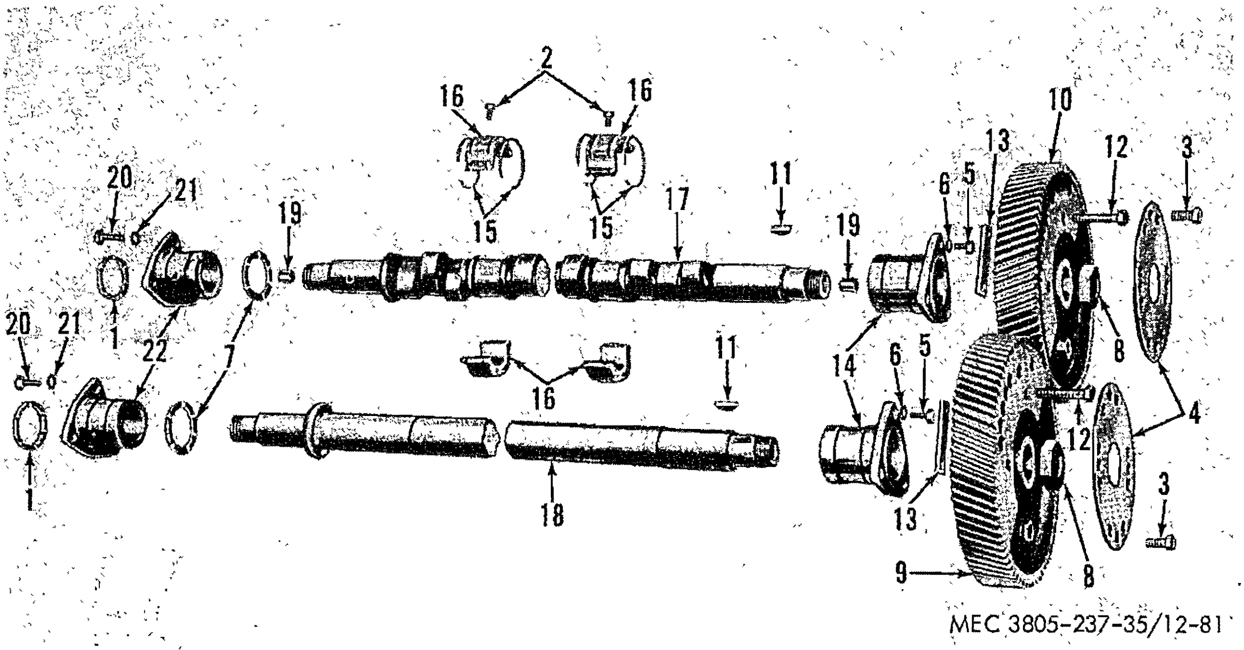



*Figure 12-80. Flywheel end gear train.*

(2) Remove nuts (8, fig. 12-81) from balance shaft and camshaft.

(3) Using a suitable gear puller similar to the puller illustrated in figure 12-83, remove gears (9 and 10) from the shafts. Remove two keys (11).

(4) Remove four screws (12) and two weights (13) from gears.




1 Thrust washer (2)
2 Screw, cap, hex-head, 1/4-28 × 45/64 in. (3)
3 Screw, cap, hex-head, 3/8-24 × 1 in. (8)
4 Retaining plate (2)
5 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (6)
6 Washer, lock, 3/8 in. (6)
7 Thrust washer (2)
8 Shaft nut (2)
9 Balance shaft gear
10 Camshaft gear
11 Key (2)
12 Screw, cap, hex-head, 3/8-24 × 1 3/8 in. (4)
13 Gear balance weight (2)
14 Shaft rear bearing (2)
15 Retaining ring (6)
16 Intermediate bearing (3)
17 Camshaft
18 Balance shaft
19 Plug (2)
20 Screw, cap, hex-head, 3/8-16 × 1 1/4 in. (6)
21 Washer, lock, 3/8 in. (6)
22 Shaft front bearing

*Figure 12-81. Camshaft and balance shaft, exploded view.*

(5) Remove six retaining rings (15) and remove six bearing halves (16) from camshaft.

(6) Remove two plugs (19) from camshaft by drilling and tapping the plugs and removing plugs with a suitable slide hammer.

(7) Remove six screws (20) and lockwashers (21) and remove two shaft front bearings (22) from cylinder block.

(8) Remove six screws (3, fig. 12-82) and locks (4, fig. 12-82) and remove retainer (5, fig. 12-82) from idler gear.

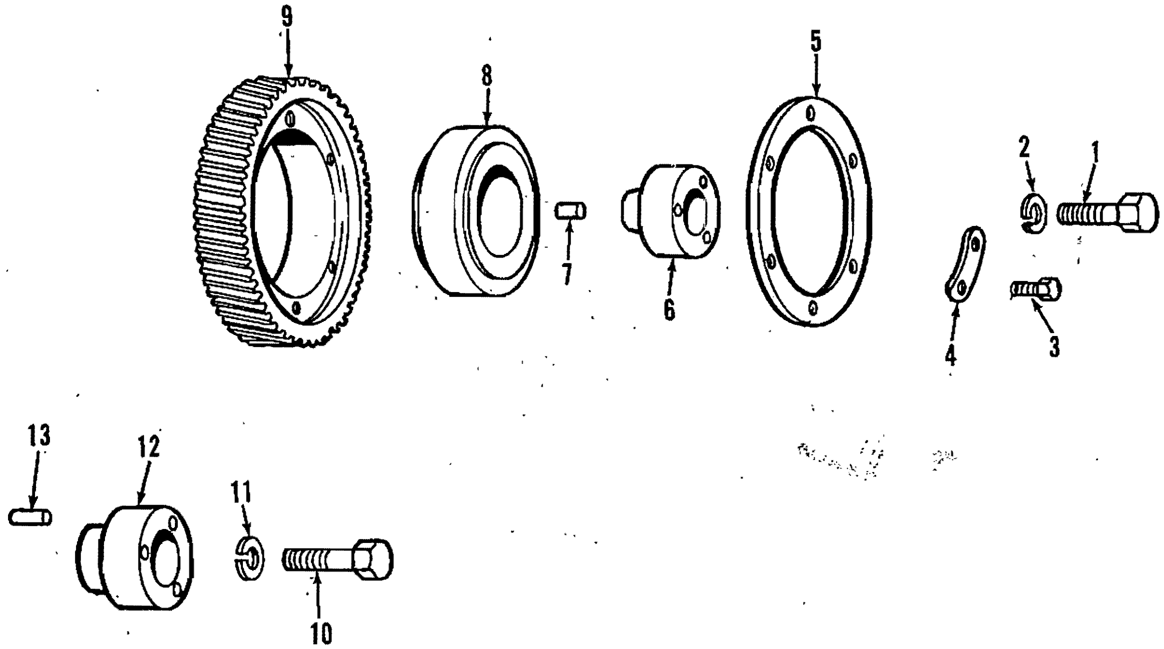
(9) Press hub (6, fig. 12-82) and bearing (8, fig. 12-82) from bore of idler gear (9, fig. 12-82).

*d. Cleaning.* Clean shafts and parts in fuel oil and dry thoroughly. Check and clean all foreign matter and carbon from camshaft oil passage.

*e. Inspection and Repair.*

(1) Inspect cams and journals on camshaft for wear and scoring. If cams or journals are badly scored or worn, replace camshaft.

(2) Inspect faces of thrust washers. Replace a badly scored or worn thrust washer. Clearance between thrust




1 Screw, cap, hex-head, 1/2-13 x 2-1/2 in.
2 Washer, lock, 1/2 in.
3 Screw, cap, hex-head, 5/16-24 x 1/2 in. (6 rqr)
4 Bolt lock (3 rqr)
5 Gear retainer
6 Gear hub
7 Dowel pin
8 Bearing
9 Idler gear
10 Screw, cap, hex-head, 1/2-13 x 2-1/2 in.
11 Washer, lock, 1/2 in.
12 Spacer
13 Dowel pin

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*Figure 12-82. Idler gear and spacer, exploded view.*

washers and shoulders on shaft should be 0.004 to 0.012 inch for new parts and a maximum of 0.018 inch for used parts. If required, grind thrust surface of shaft shoulders to provide clearance. Figure 12-84 illustrates fillet radius to be ground on the shafts.

(3) Inspect thrust faces of shaft end bearings for scoring and wear. Remove light scores and scratches with a fine stone. Replace bearings if faces are badly marred or worn.

(4) Inspect bushings in shaft end bearings for wear or evidence of looseness in bearing retainer. If bushings are worn or loose replace end bearings. Bushings must resist a 2000 pound end load without turning. Inside diameter of bushing must be square with rear face of bearing retainer within 0.0015 inch total indicator reading and concentric with outside of retainer within 0.002 inch total indicator reading. Bushings must project 0.045 to 0.0055 inch from each end of retainer. If dimensions are not correct, replace end bearings.

(5) Inspect intermediate bearings for wear and scoring. Replace bearings if badly worn or scored.

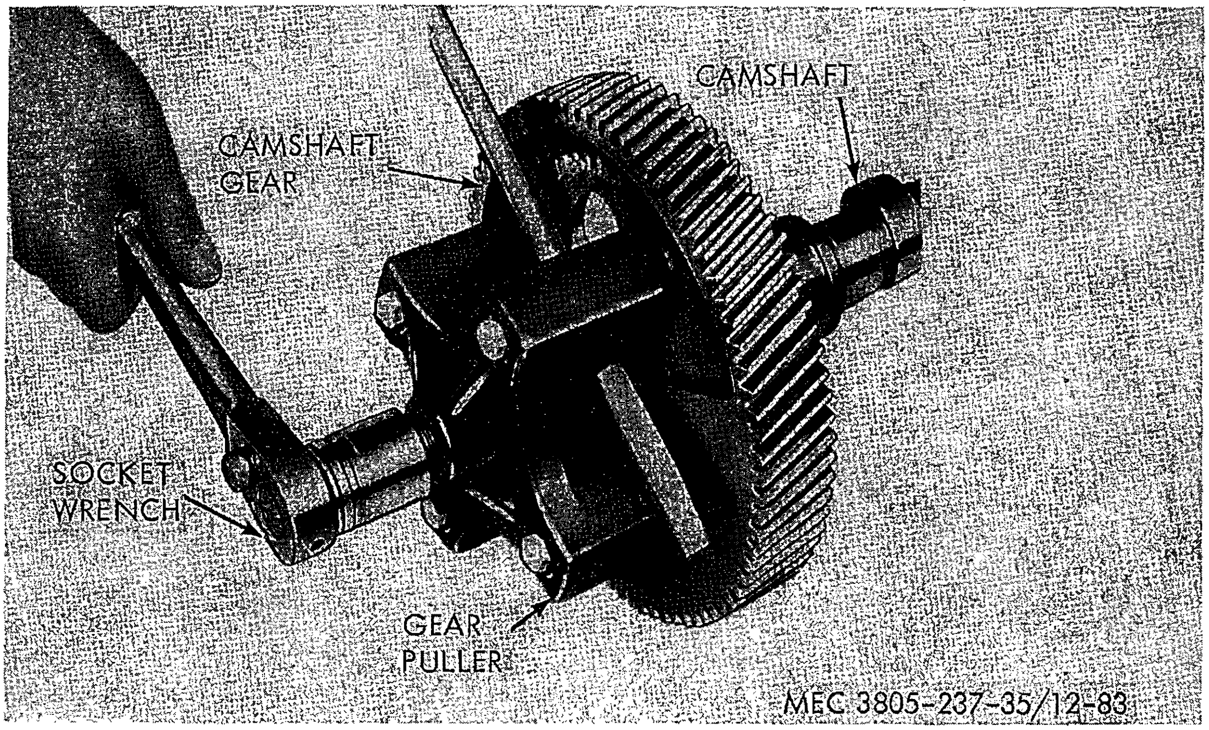



*Figure 12-83. Removing camshaft or balance shaft gear.*

(6) Inspect lockscrews and holes for screws for damaged threads. Plug holes and retap if necessary. Replace screws if threads are damaged.

(7) Inspect gear teeth on all gears for scoring, pitting, wear, and damage. Replace gears if teeth are pitted, worn or damaged.

(8) Inspect idler gear bearing (8, fig. 12-82) for wear, rough spots, flat spots on rollers, and damage. Replace bearing if any of these conditions exist.

(9) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.*

(1) Support idler gear (9, fig. 12-82), shoulder down on an arbor press. Place bearing (8) in bore and press bearing into gear.

(2) Install hub (6, fig. 12-82) in bore of bearing with oil hole in hub 180° from gap in bearing spacer ring. Press hub into bearing until face of hub which will contact bearing block is flush with face of bearing.

(3) Check preload of bearing as follows:

(*a*) Mount idler gear assembly on engine. Install screw (1, fig. 12-82) and lockwasher (2) to secure idler gear to end plate. Tighten bolt to a torque of 80 to 90 foot pounds.

(*b*) Place a steel plate, drilled to fit hub holes, over hub and bearing. Install three screws, 3/8-16 x 1 1/4, through plate and into hub. Tighten screws to a torque of 25 to 40 foot pounds.

(*c*) Tie a piece of 1/8 inch cord around a 1/8 inch round piece of wood. Place wood between teeth of idler gear and wrap cord around gear several times.

(*d*) Attach a spring scale to cord. Maintain a steady pull 90° to the axis

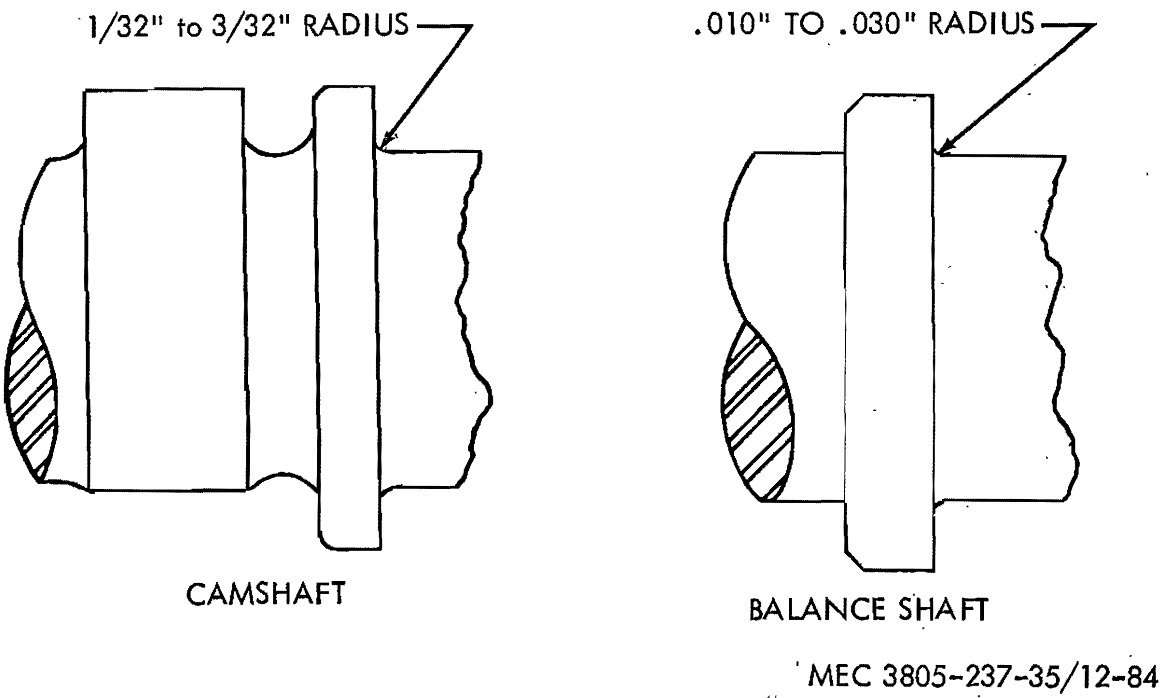



*Figure 12-84. Camshaft and balance shaft journal fillets.*

of hub and note pull, in pounds, required to start gear rotating. Make several checks to get average reading. Pull should register from 1/2 pound minimum to 6 pounds, 12 ounces maximum and should not fluctuate more than 2 pounds, 11 ounces between readings. If preload cannot be properly set, replace bearing.

(*e*) Remove plate from idler gear and remove screw (1, fig. 12-82) and remove idler gear from end plate.

(4) Apply grease (GAA) to thrust bearings (1, fig. 12-81) and install washers and two shaft front bearings (22, fig. 12-81) on block and secure with six screws (20) and lockwashers (21). Tighten screws to a torque of 35 to 40 foot pounds.

(5) Press plugs (19, fig. 12-81) into ends of camshaft.

(6) Lubricate six intermediate bearing halves (16, fig. 12-81) with engine oil (OE) and install bearings on camshaft journals. Secure bearings with six retaining rings (15, fig. 12-81). Install rings with gaps over upper bearing and ends of rings an equal distance above split line of bearing.

(7) Install weights (13, fig. 12-81) on gears (9 and 10) and secure with four screws (12).

(8) Lubricate shafts (18 and 19, fig. 12-81) with engine oil (OE) and place shaft rear bearings (14) on shafts, with bearing flanges toward gear end of shaft.

(9) Install woodruff keys (11, fig. 12-81) in shafts. Install gears (9 and 10) on shafts over keys.

*Note.* Balancer gear has right hand helical teeth and camshaft gear has left hand helical teeth.

(10) Support shafts and drive gears on shafts, using a suitable driver.

(11) Install nuts (8, fig. 12-81) on shafts but do not tighten.

*g. Installation.*

(1) Apply grease (GAA) to thrust washers (7, fig. 12-81) and install washers on ends of shafts with steel fans of washers towards end bearings.

(2) Install camshaft through flywheel end plate on blower side of engine. Use care to prevent damage to camshaft lobes. Turn crankshaft to aline holes in intermediate bearings with holes in block. Install three screws (1, fig. 12-81) and tighten screws to a torque of 15 to 20 foot pounds.

(3) Install balance shaft through end plate, aline timing marks (0 markings fig. 12-80) on gears and slide shafts into place.

(4) Secure shaft rear bearings (14, fig 12-81) with screws (5, fig. 12-81). Insert screws through gear openings and tighten screws to a torque of 35 to 40 foot pounds.

(5) Install front balance weights as described in paragraph 12-36.

(6) Wedge a clean cloth between camshaft and balance shaft gears and tighten shaft nuts (8, fig. 12-81) on shafts to a torque of 300 to 325 pounds.

(7) Install retaining plates (4, fig. 12-81) on gears and secure with screws (3). Tighten screws to a torque of 35 to 39 foot pounds.

(8) Check clearance between thrust washers (7, fig. 12-81) and thrust shoulders on shaft. Clearance should be 0.004 to 0.012 inch for new parts and a maximum of 0.018 inch for used parts

(9) Check backlash between camshaft gear and balance shaft gear. Backlash should be 0.003 to 0.008 inch.

(10) Install spacer (12, fig. 12-82) on end plate and secure with screw (10) and lockwasher (11). Tighten screw to a torque of 80 to 90 foot pounds.

(11) Install idler gear assembly on end plate and aline R marks on gear teeth with R marked teeth on balancer shaft gear and crankshaft gear. As gear is installed, rotate gear to aline hollow dowel pin in hub with hole in end plate.

(12) With hub tight against end plate secure idler gear assembly with screw (1, fig. 12-82) and lockwasher (2). Tighten screw to a torque of 80 to 90 foot pounds.

(13) Lubricate idler gear and bearing liberally with engine oil (OE).

(14) Check backlash between idler gear and balance shaft and crankshaft gears. Backlash should be 0.003 to 0.008 inch.

(15) Refer to paragraph 12-36 and install the balanced weight cover.

(16) Refer to paragraph 12-32 and install the cylinder head.

(17) Refer to paragraph 12-29 and install the flywheel housing.

(18) Refer to paragraph 12-31 and install the engine in the motor grader.

## Section X. CRANKSHAFT AND MAIN BEARINGS

### 12-38. General

*a.* The crankshaft is a one piece steel forging heat treated, and provided with complete static and dynamic balance through counterweights incorporated in the casting. Full pressure lubrication is provided by drilled passages within the crankshaft leading to lubricating oil holes (fig. 12-85) in the journals.

*b.* The crankshaft is supported by five main bearings retained by bearing caps secured to the engine block. Two oil seals, one in the flywheel housing and the other in the front cover, seal the crankshaft.

### 12-39. Crankshaft Front Cover

*a. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 12-11 and remove fan and pulley.

(3) Refer to figure 12-86 and remove the crankshaft pulley and front cover.

(*a*) Remove six screws (1, 2, and 3) and lockwashers (4 and 5) and remove trunnion support (6).

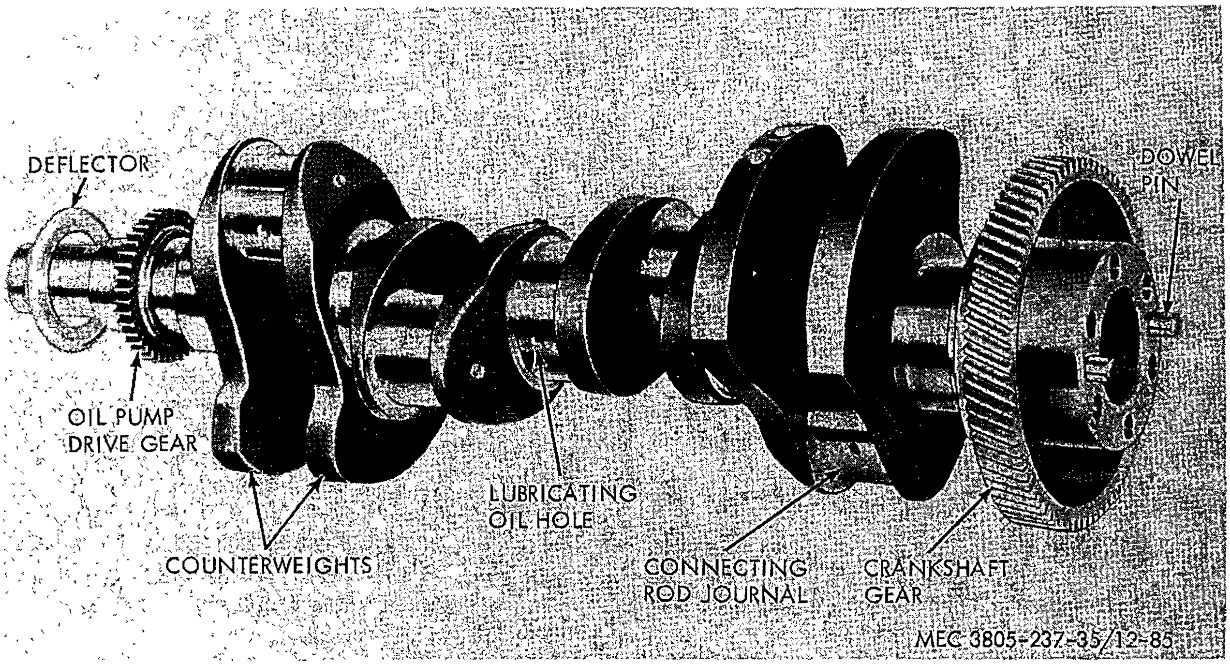



*Figure 12-85. Crankshaft and associated parts.*

(b) Remove screw (7) and retainer (8). Using a suitable puller, remove crankshaft pulley (9) from crankshaft.

(c) Remove three screws (11) and lockwashers (12). Remove four screws (13 and 14) and lockwashers (15).

(d) Strike front cover (16) with a soft hammer to free cover from dowels. Remove front cover. Remove and discard gasket (17).

(e) Using a suitable tool press oil seal (18) from front cover.

(f) Remove oil seal spacer (19) and oil deflector (20) from crankshaft.

b. *Cleaning.* Clean all parts in fuel oil and dry thoroughly. Clean all gasket material from front cover and block.

c. *Inspection and Repair.*

(1) Inspect oil seal for scored, cracked or charred surfaces. Inspect seal for evidence of leaking. Replace damaged or leaking seals.

(2) Inspect front cover for damage, especially to oil seal surfaces. Replace damaged cover.

(3) Inspect crankshaft pulley for damage, particularly in belt grooves. Replace pulley if damaged.

d. *Installation.*

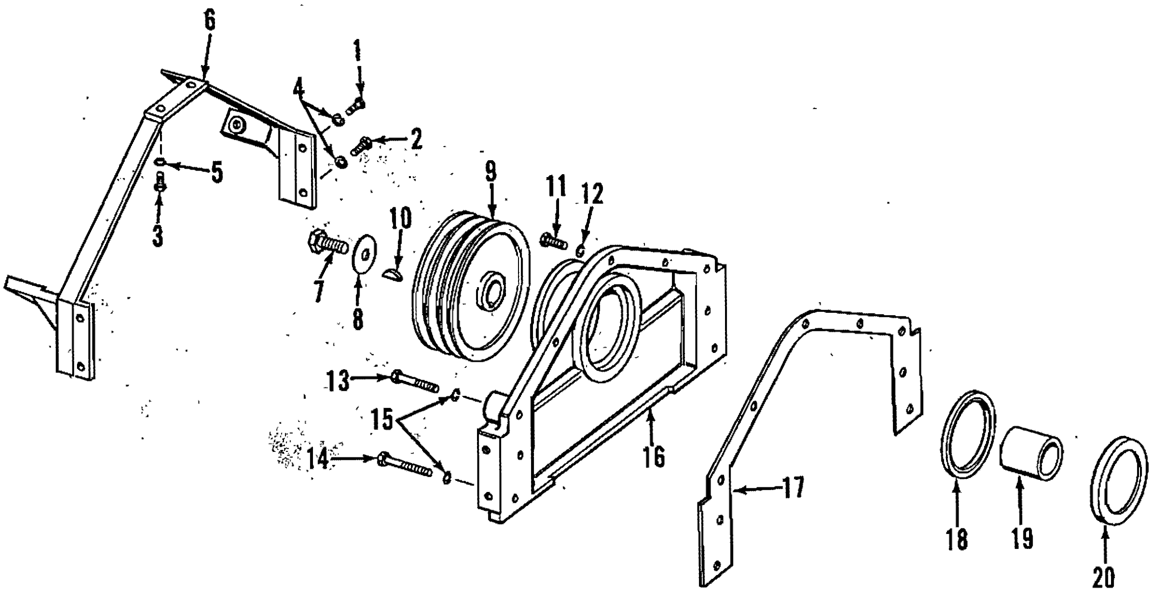
(1) Refer to figure 12-86 and install the crankshaft front cover.

(a) Install deflector (20) and spacer (19) on crankshaft.

(b) Using a suitable tool, press oil seal (18) into bore of front cover.

(c) Install new gasket (17) on block. Coat lip of oil seal with grease (GAA) and install front cover on engine. Tighten screws (11) to a torque of 25 to 30 foot pounds. Tighten screws (13 and 14) to a torque of 80 to 90 foot pounds. Tighten screws in sequence illustrated on figure 12-87.

(d) Install pulley (9, fig. 12-86) on crankshaft over two keys (10) and secure with retainer (8) and screw (7). Tighten screw to a torque of 290 to 310 foot pounds.




| | | | |
|---|---|---|---|
| 1 | Screw, cap, hex-head, 1/2-13 × 1 1/2 in. (2) | 11 | Screw, cap, hex-head, 3/8 × 24 × 3/4 in. (3) |
| 2 | Screw, cap, hex-head, 1/2-12 × 1 1/4 in. (2) | 12 | Washer, lock, 3/8 in. |
| 3 | Screw, cap, hex-head, 9/16 × 1 3/4 in. (2) | 13 | Screw, cap, hex-head, 1/2-13 × 2 1/4 in. (2) |
| 4 | Washer, lock, 1/2 in. (4) | 14 | Screw, cap, hex-head, 1/2-13 × 2 1/2 in. (2) |
| 5 | Washer, lock, 9/16 in. (2) | 15 | Washer, lock, 1/2 in. (4) |
| 6 | Trunnion support | 16 | Crankshaft front cover |
| 7 | Screw, cap, hex-head, 1-14 × 2 1/4 in. | 17 | Cover gasket |
| 8 | Pulley retainer | 18 | Oil seal |
| 9 | Crankshaft pulley | 19 | Oil seal spacer |
| 10 | Key, woodruff (2) | 20 | Oil deflector |

*Figure 12-86. Crankshaft front cover, exploded view.*

(*e*) Install trunnion support (6) and secure with screws (1, 2, and 3) and lockwashers (4 and 5).

(2) Refer to paragraph 12-11 and install fan and pulley.

(3) Refer to paragraph 2-31 and install engine in motor grader.

## 12-40. Crankshaft and Main Bearings

*a. General.* The crankshaft is supported by the main bearings and the two oil seals. The main bearing caps and lower shells and the connecting rods must be disconnected to remove the crankshaft.

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 12-29 and remove the flywheel housing.

(3) Refer to paragraph 12-25 and remove the oil pan and oil pump.

(4) Refer to paragraph 12-39 and remove the crankshaft front cover.

(5) Refer to figure 12-88 and remove main bearing caps and connecting rod caps from crankshaft.

(6) Remove thrust washers from rear main bearing.

(7) Using a suitable hoist and rope, lift crankshaft from engine.

*c. Disassembly.*

(1) Remove six screws (7, fig. 12-89) and lockwashers (8).

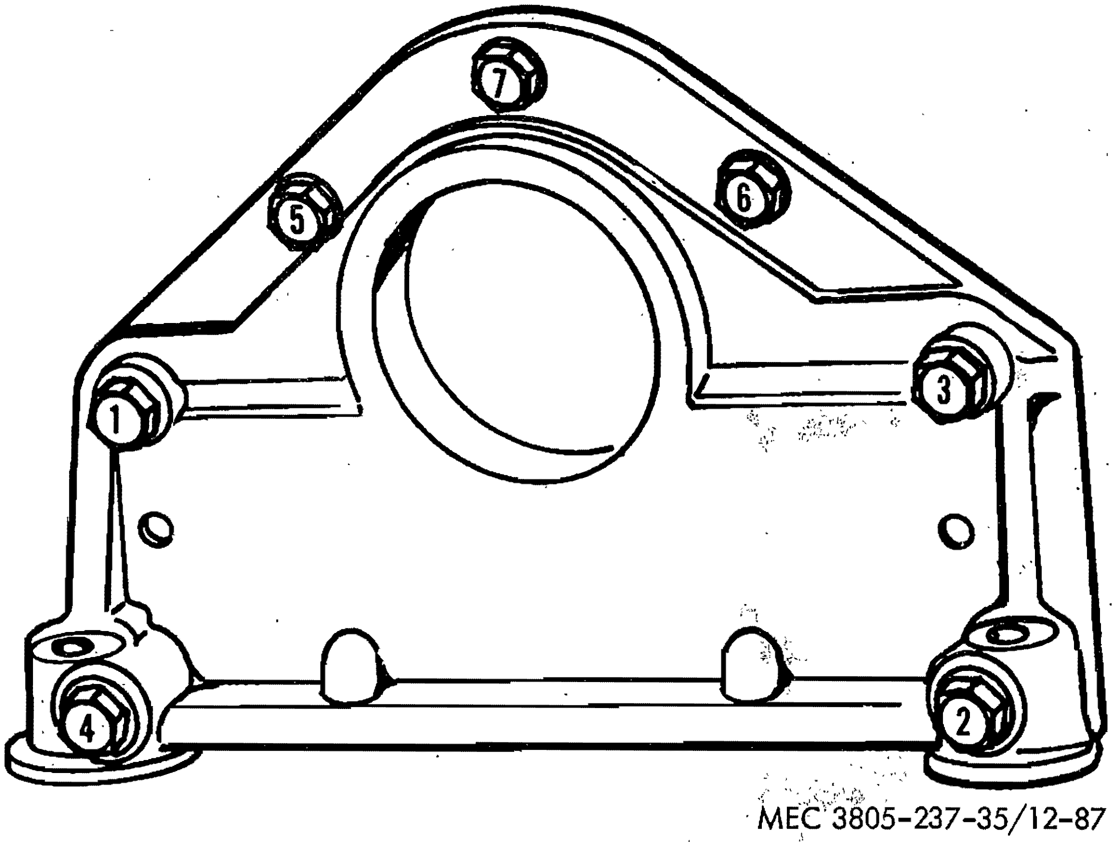



*Figure 12-87. Front cover screw tightening sequence.*

(2) Using a suitable gear puller, pull crankshaft gear (9) from crankshaft.

(3) Use a suitable puller and pull oil pump drive gear (10) from crankshaft. Remove key (11).

(4) Remove four pipe plugs (12) from crankshaft.

(5) If damaged, remove dowel pins (13) from crankshaft.

(6) Remove main bearings (4) from bearing cap and cylinder block.

*d. Cleaning.* Clean the crankshaft and oil passages in crankshaft with cleaning compound, solvent (Spec. P-S-661) and dry thoroughly.

***Warning:* The solvent is highly inflammable. Do not use solvent near an open flame.**

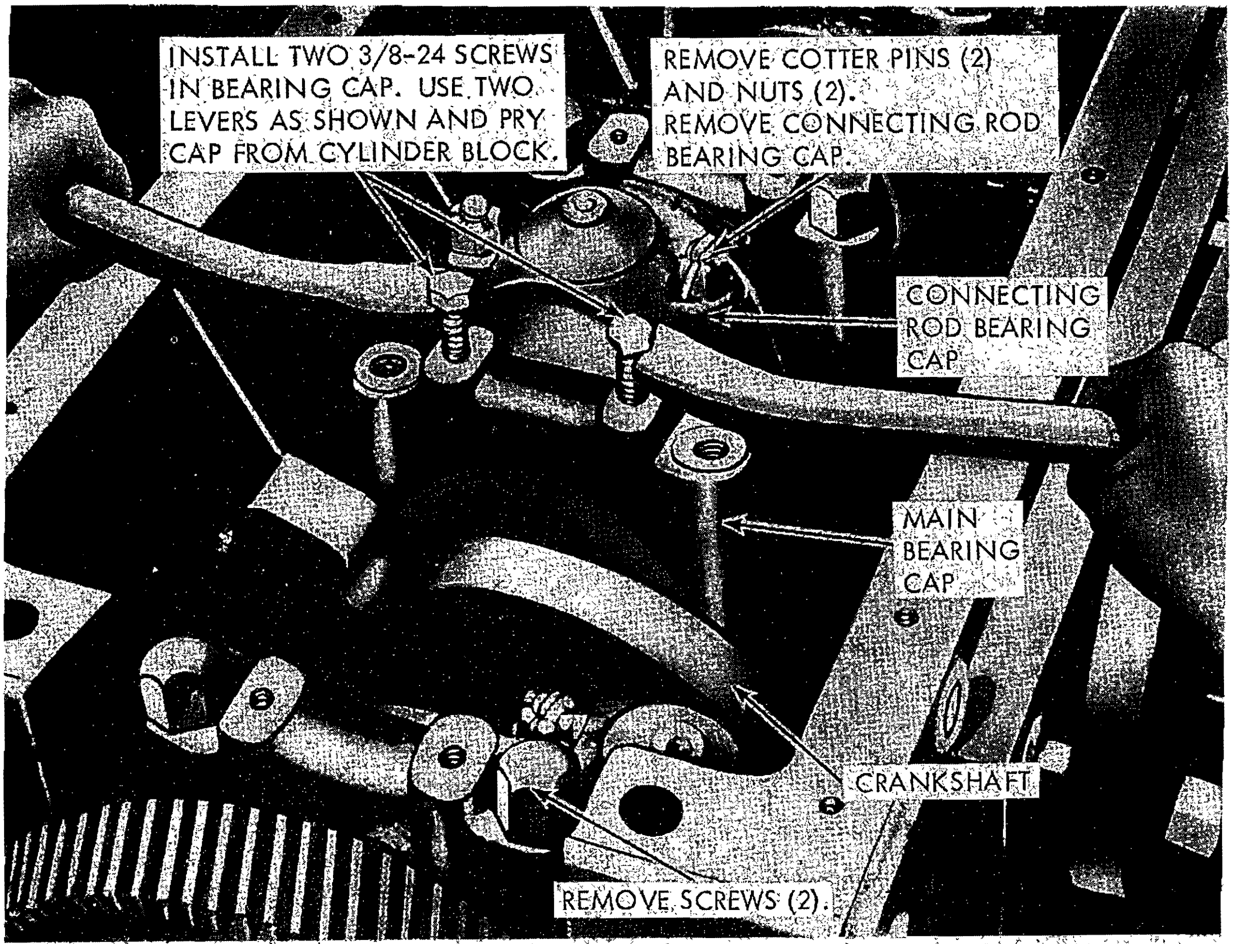
*e. Inspection and Repair.*

(1) Support crankshaft on front and rear journals in V blocks or in a lathe and check alinement of adjacent intermediate journals, using a dial indicator.

(*a*) When runout on adjacent journals is in the opposite direction, the sum of the runout must not exceed 0.003 inch total indicator reading.

(*b*) When runout on adjacent journals is the same direction the difference must not exceed 0.003 inch total indicator reading.

(*c*) Maximum runout (total indicator reading) at number 2 and number




STEP 1. REMOVE TWO SCREWS AND LOCK WASHERS SECURING MAIN BEARING CAP.
STEP 2. INSTALL TWO 3/8-24 SCREWS IN BEARING CAP.
STEP 3. USE TWO LEVERS AND PRY MAIN BEARING CAP FROM CYLINDER BLOCK.
STEP 4. REMOVE TWO COTTER PINS AND TWO NUTS SECURING CONNECTING ROD BEARING CAP.
STEP 5. REMOVE CONNECTING ROD BEARING CAP.
STEP 6. REMOVE ALL FIVE MAIN BEARING CAPS AND FOUR CONNECTING ROD CAPS IN THE SAME MANNER.

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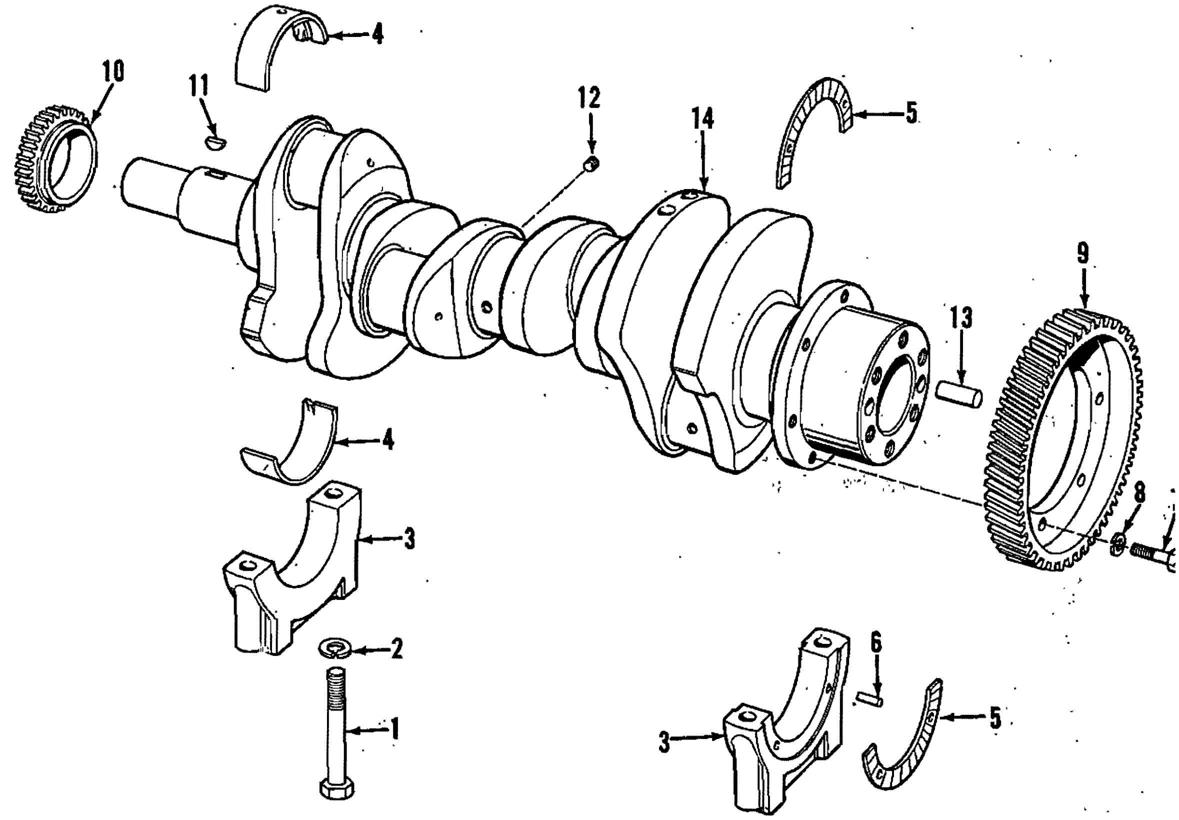
*Figure 12-88. Main bearing caps and connecting rod bearing caps, removal.*




1 Screw, cap, hex-head (10 rqr)
2 Washer, lock, 5/8 in. (10 rqr)
3 Main bearing cap (5 rqr)
4 Main bearing (5 rqr)
5 Washer, thrust (4 rqr)
6 Dowel pin (4 rqr)
7 Screw, cap, hex-head (6 rqr)
8 Washer, lock, 3/8 in. (6 rqr)
9 Crankshaft gear
10 Oil pump drive gear
11 Key
12 Pipe plug (4 rqr)
13 Dowel pin (2 rqr)
14 Crankshaft

MEC 3805-237-35/12-89

*Figure 12-89. Crankshaft and main bearings, exploded view.*

4 journals must not exceed 0.002 inch and at number 3 journal 0.004 inch.

(*d*) Replace crankshaft if runout exceeds limits listed above.

(2) Measure main and connecting rod bearing journals. Measure journals at several places to determine if journal is out-of-round.

(*a*) Taper on the journals of a used shaft should not exceed 0.003 inch and out-of-round should not exceed 0.003 inch. Maximum taper on a new shaft is 0.0005 and out of round is 0.00025.

(*b*) Replace crankshaft if taper and out-of-round exceeds these limits.

(3) Used chankshafts may have a ridge caused by groove in the upper main bearing shell. Check ridge and if ridge exceeds 0.0002 inch, remove ridge. Figure 12-90 shows a typical ridge.

(a) Remove ridges with crocus cloth dampened with fuel oil. Rotate crankshaft frequently to prevent out-of-round condition.

(b) If ridge exceeds 0.0005 inch, use 120 grit emery cloth and finish with 240 grit emery cloth.

(c) Ridges exceeding 0.001 inch may require regrinding the crankshaft.

(4) Inspect surfaces of crankshaft for evidence of cracks. Use a magnetic particle method or a magnaflux method if available. If neither method is available, use a strong light and a magnifying glass to check for cracks, especially at journal edges and oil holes. Replace crankshaft if cracked.

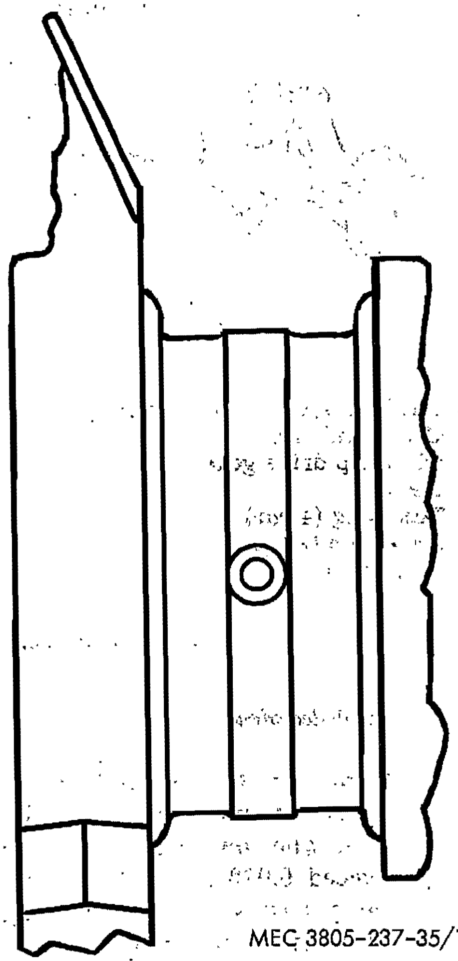



*Figure 12-90. Typical ridging of crankshaft.*

(5) Inspect thrust surfaces on crankshaft for wear and roughness. Dress surfaces with crocus cloth dipped in fuel oil to remove roughness, if possible. After installation, check end thrust clearance. Clearance should be 0.004 to 0.011 inch for new parts and a maximum of 0.018 inch for used parts.

(6) Inspect keyways for cracks and wear. Replace crankshaft if keyways are cracked or worn.

(7) Inspect oil seal contact surfaces for wear or roughness. If ridges or roughness are evident, remove with crocus cloth or fine emery cloth. If badly damaged, replace crankshaft. An oil seal spacer can be installed to bring oil seal in contact with new surface on crankshaft. If shaft is not to badly worn, install a sleeve on shaft to contact oil seal. Seal sleeve and crankshaft with shellac or a sealer and press sleeve on shaft. Remove excess sealer from shaft.

(8) Inspect oil pump drive gear and crankshaft gear for worn or chipped teeth and other damage. Replace gears if damaged.

(9) Inspect main bearing halves for scoring, flaking, pitting, chipping and signs of overheating. Replace bearings if any of the above signs are present.

*Note.* Replace all bearings if one or more require replacement.

(10) Inspect back of bearing halves for bright spots. If spots are present, it indicates halves are moving and must be replaced.

(11) Measure thickness of bearing halves as illustrated on figure 12-91.

(a) Use a micrometer with a steel ball attachment if possible.

(*b*) Minimum thickness should be 0.153 inch. If less than this, replace all bearing halves.

(*c*) New bearing halves should be 0.1548 to 0.1554 inch thick.

(12) Measure outside diameter of crankshaft journal. Install upper half of main bearing in cylinder block. Install lower half and main bearing cap on block. Install screws and tighten to torque of 180 to 190 foot pounds. Measure inside diameter of bearing halves. Clearance must not exceed 0.006 inch. If clearance is in excess of 0.006 inch on any one bearing, replace all bearings.

(13) Bearing halves, when in place, have a 0.001 inch larger diameter at the parting line than at 90° to the parting line as illustrated in figure 12-92. The halves do not form a true circle.

(14) The halves have a squeeze fit on the main bearing bore and must be tigh when cap is torqued on.

(15) Thrust washers, located at rear main bearing, consist of two pieces. Check thrust washers for wear, scoring, and damage. Replace washers if worn or damaged.

(16) Inspect main bearing caps for cracks, scoring or damage. Replace cap if cracked or damaged.

(17) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.*

(1) Install main bearing upper halves (4, fig. 12-89) in cylinder block.

*Note.* Upper halves are grooved and drilled for lubrication.

(2) Install crankshaft gear (9) on crankshaft and secure with six screws (7) and lockwashers (8). Tighten screws to a torque of 35 to 39 foot pounds.

(3) Install key (11) in crankshaft and press oil pump drive gear (10) on crankshaft. Install gear on crankshaft with chamfer on gear hub toward main bearing journal. Press gear tight against shoulder on shaft.

*g. Installation.*

(1) Using a suitable hoist if necessary and raise crankshaft and install in bearings in cylinder block. Aline timing marks on crankshaft gear with teeth on idler gear (fig. 12-80). Refer to note made at time of disassembly to determine if teeth are to be alined with R or A on crankshaft gear.

(2) Install main bearing caps (3) and install caps on cylinder block. Place thrust washers (5) in with rear main bearing and over dowels on bearing cap, and install cap as illustrated on figure 12-93.

*Note.* Main bearing caps are numbered. Install caps in correct position.

(3) Lubricate the threads on screws (1) (fig. 12-89) with engine oil (OE) and screw head contact areas on bearing caps and install screws and lockwashers. Tighten screws up snug. Rap bearing cap sharply to seat cap. Tighten screws to a torque of 180 to 190 foot pounds.

*Note.* If bearings have been installed properly, crankshaft will turn freely.

(4) Check crankshaft end play. Install a dial indicator on cylinder block and pry crankshaft toward the indicator. Keep constant pressure on tool and set indicator at zero. Force crankshaft in opposite direction and note reading on indicator. End play must be within 0.004 to 0.011 inch for new parts and not more than 0.018 inch with used parts. If end play exceed these dimensions, check alinement of rear main bearing. Loosen and retighten rear main bearing if necessary and check end play.

(5) Install connecting rod bearing (para 12-42) and tighten nuts to a torque of 65 to 75 foot pounds.

(6) Refer to paragraph 12-39 and install crankshaft front cover.

(7) Refer to paragraph 12-25 and install the oil pump.

(8) Aline teeth on oil pump drive gear on crankshaft with idler gear on pump. Check clearance between teeth with a feeler gage as illustrated on

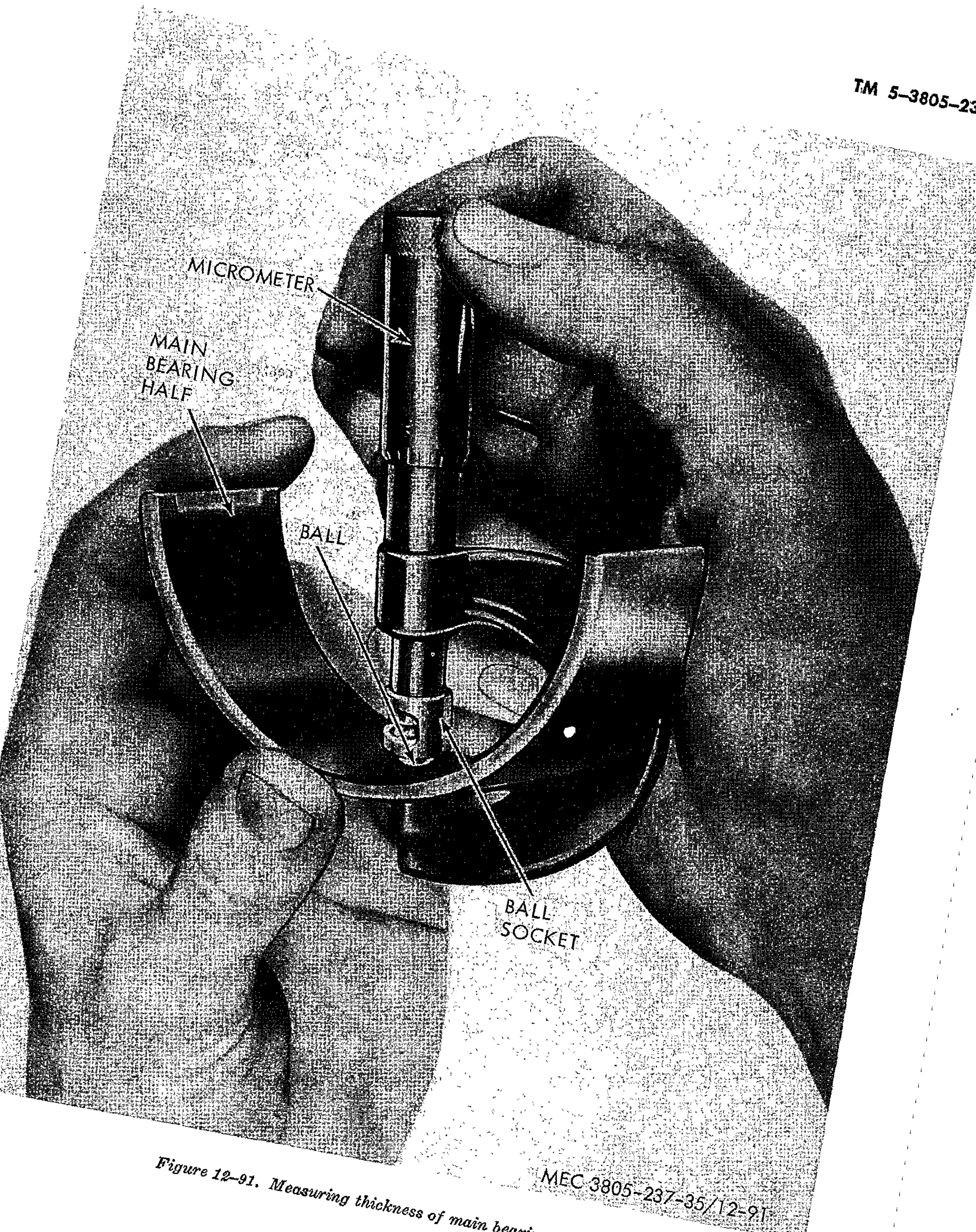


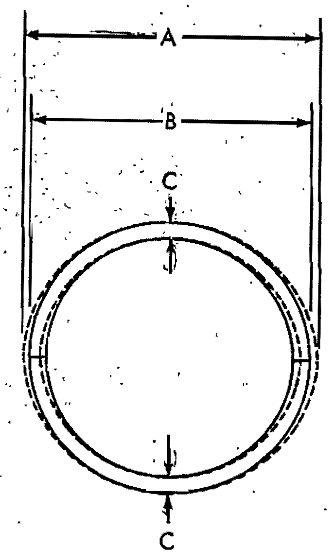

*Figure 12-91. Measuring thickness of main bearing half.*

figure 12-94. Proper clearance is 0.005 to 0.012 inch. Remove or replace shims under pump mounting pads to obtain this clearance. Always tighten pump mounting screws before checking clearance.

(9) Refer to paragraph 12-24 and install the oil pan.

(10) Refer to paragraph 12-29 and install the flywheel housing.

(11) Refer to paragraph 2-31 and install the engine on the motor grader.




A FREE DIAMETER
B INSTALLED DIAMETER
C BEARING THICKNESS

MEC 3805-237-35/12-92

*Figure 12-92. Diameters of main bearing halves.*

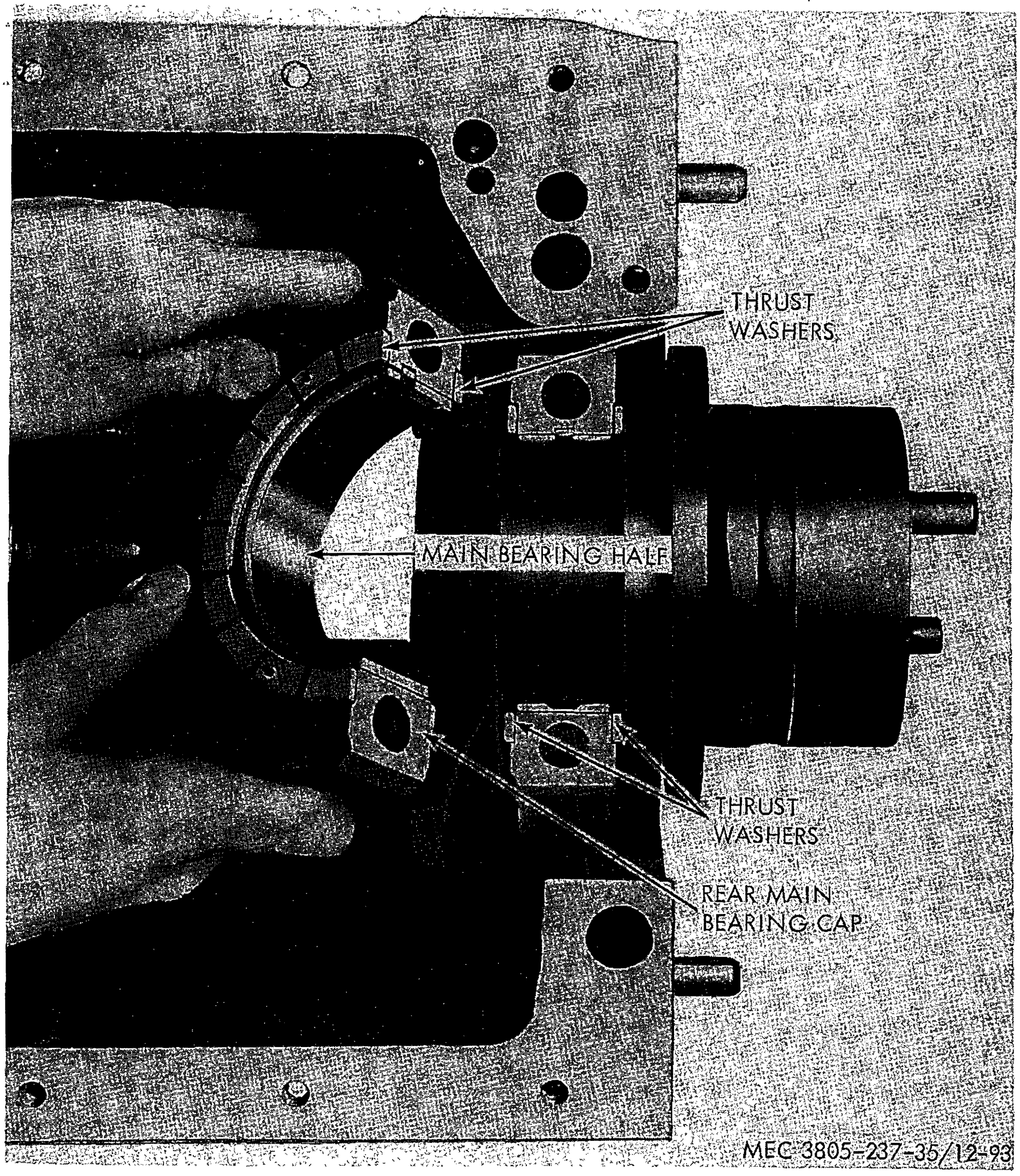



*Figure 12-93. Installing rear main bearing cap and thrust washers.*

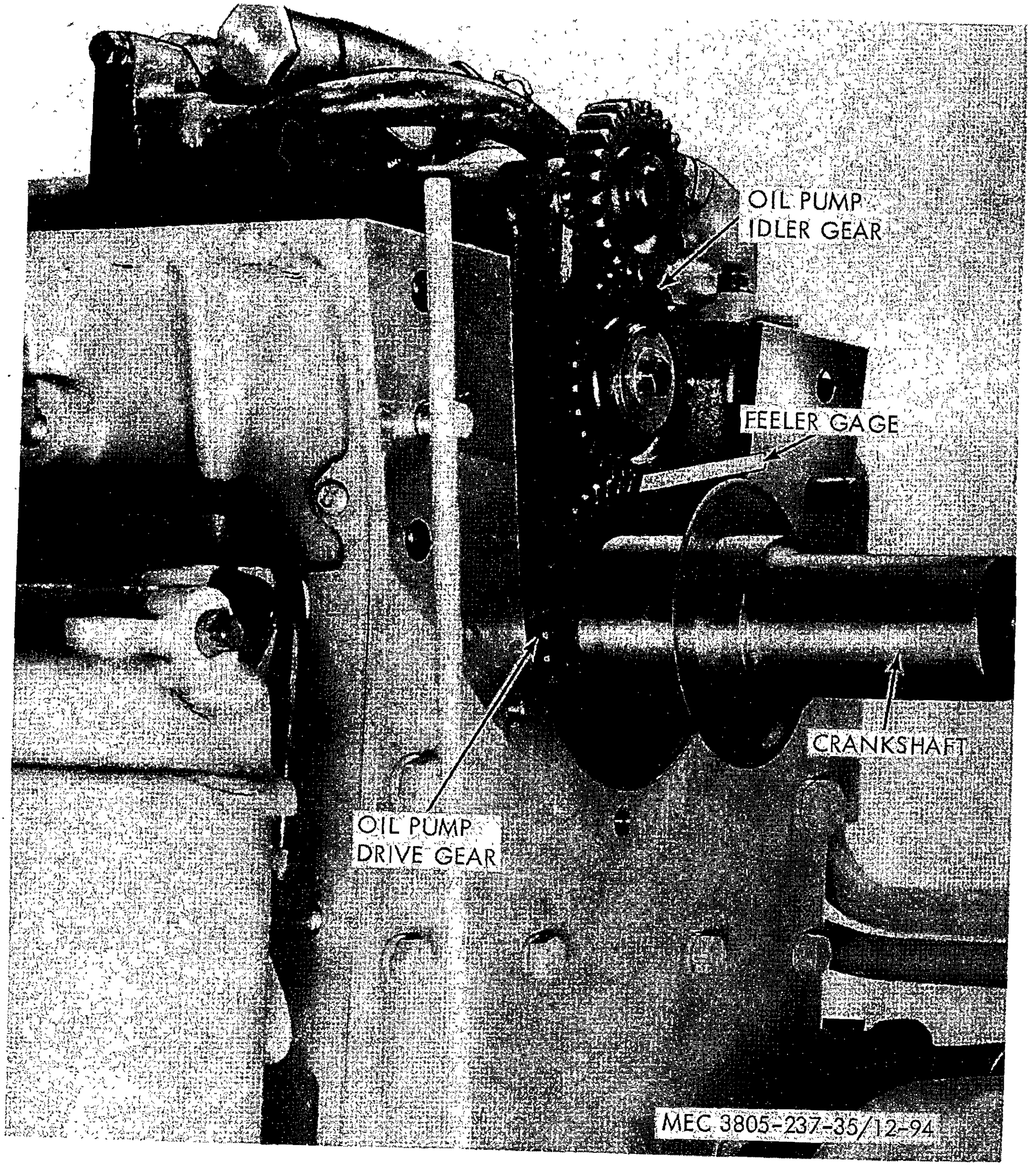



*Figure 12-94. Checking clearance between oil pump drive and idler gear.*

## Section XI. CONNECTING RODS AND PISTONS

### 12-41. General

*a.* The pistons are constructed of malleable iron and are plated with tin to reduce scuffing and prolong piston life. The top of the piston forms the combustion chamber and is so designed to compress the air into close proximity of the fuel spray. Cooling for the piston is supplied by a spray of oil directed at the underside of the piston head from a nozzle in the top of the connecting rod. Fresh air from the blower also serves to cool the piston as does the coolant in the jacket around the cylinder.

*b.* The piston pin rides in two bushings pressed into the piston bore. Steel retainers seal the pin bores preventing oil from the piston cooling from entering the cylinder. Each piston is equipped with four compression rings and two oil control rings.

*c.* The connecting rods are forged to an I section with a closed hub at the upper end and a bearing cap at the lower end. Helical grooved bushings are pressed in the connecting rod at the upper end. An opening between the bushings carries oil to the piston pin and to the nozzle at the top of the connecting rod.

### 12-42. Connecting Rods

*a. General.* The connecting rods provide the connection between the pistons and the crankshaft. Force of the explosion drives the piston down and with it the connecting rod. The rod is offset on the crankshaft journal and its force turns the crankshaft in a circular motion.

*b. Removal.*

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 12-32 and remove the cylinder head.

(3) Refer to paragraph 12-25 and remove the oil pan and oil pump.

(4) Remove carbon deposits from the upper inner surface of the cylinder liner.

(5) Use a ridge cutter to remove any ridge in the cylinder liner at the top of piston ring travel.

*Note.* Turn crankshaft to move piston to bottom limits of travel. Place a cloth on top of piston to collect cuttings. When ridge is removed, turn crankshaft to bring piston to top of travel and remove cloth and cuttings from cylinder.

(6) Refer to figure 12-88 and remove bearing cap from connecting rod.

(7) Push piston and connecting rod out through top of cylinder block.

*c. Disassembly.*

(1) Place connecting rod in a vice with soft jaws.

(2) Punch a hole in center of one of the piston pin retainers (7, fig. 12-95). Use a narrow chisel or sharp tool and pry retainer from piston.

(3) Remove piston pin (8) from piston and remove connecting rod (11).

(4) Clamp the upper end of the connecting rod in a vise or suitable fixture. Using a driver, drive two bushings (9) from connecting rod.

(5) Using a tool inserted inside of connecting rod and extending up to spray nozzle, press down on connecting rod and drive spray nozzle (10) from end of rod.

(6) Remove upper and lower bearing halves (6 and 5) from rod and cap.

*d. Cleaning.* Clean connecting rod parts in fuel oil and dry with compressed air.

*e. Inspection and Repair.*

(1) Inspect connecting rod for cracks using magnetic particle or magnaflux. If these are not available, use a strong light and a magnifying glass. If rod is cracked, replace rod.

(2) Inspect oil passage in rod for dirt or foreign material. Clean passage with a wire probe and blow out with compressed air.

(3) Clean holes in spray nozzle with a wire. Replace nozzle if damaged.

(4) Inspect bushings for wear and damage. Replace worn or damaged bushings, or bushings that have worked

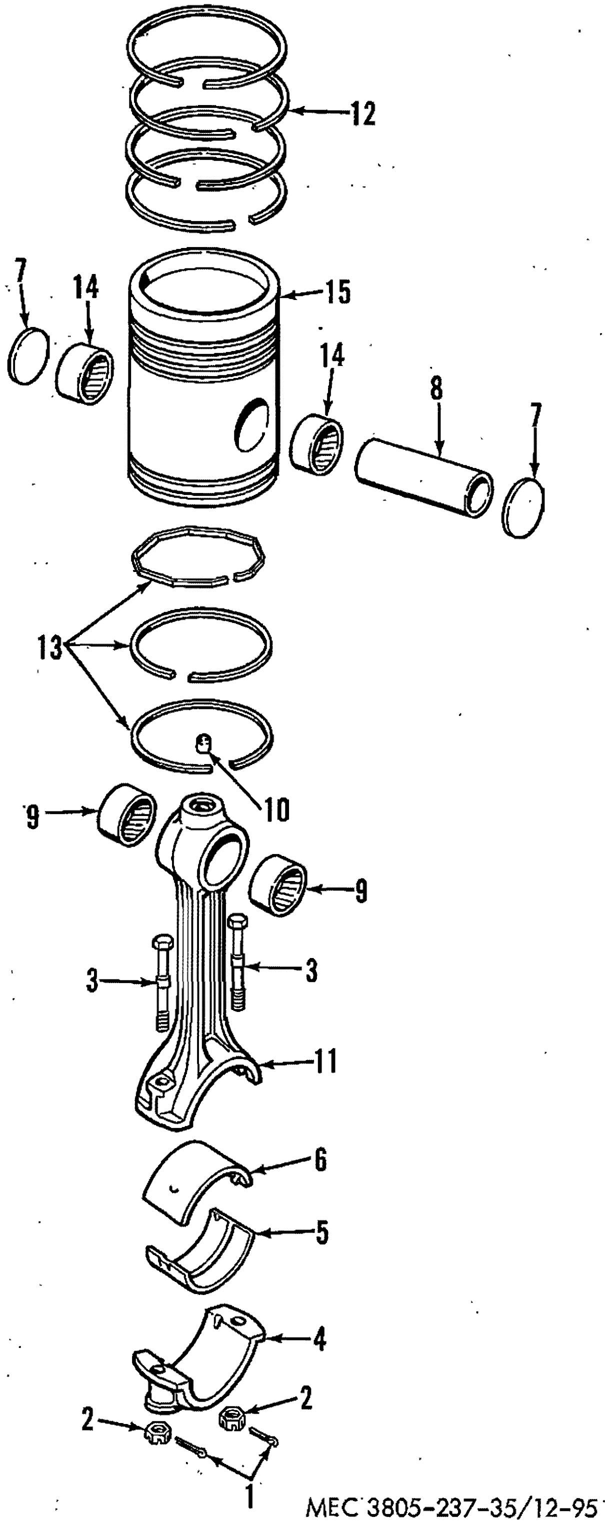



*Figure 12-95. Connecting rod and piston, exploded view.*

1 Pin, cotter, 3/32 × 3/4 in. (8)
2 Nut (8)
3 Screw, cap, hex-head, 7/16-20 × 3.32 in. (8)
4 Bearing cap (4)
5 Bearing half, lower (4)
6 Bearing half, upper (4)
7 Piston pin retainer (8)
8 Piston pin (4)
9 Bushing (8)
10 Spray nozzle (4)
11 Connecting rod (4)
12 Compression ring (16)
13 Oil ring (8)
14 Bushing (8)
15 Piston (4)

*Figure 12-95*—Continued.

loose in the rod. Bushings should have an inside diameter of 1.5015 to 1.5020 inches.

(5) Inspect piston pin for wear and damage. Measure diameter of pin. Pin should measure 1.4996 to 1.5000 inches in diameter. Replace worn or damaged pins.

(6) Clearance between pin and bushing should be 0.0015 to 0.0024 inch for new parts.

(7) Inspect bearing halves for cracks, chipping, and signs of overheating. Inspect backs for bright spots or evidence of shifting. Use a micrometer to measure thickness of bearing halves. Bearing halves should be a minimum of 0.153 inch thick. Replace bearing halves if any of these conditions exist. Replace both halves if one must be replaced.

(8) Inspect bearing cap for cracks and damage. Replace cap if cracked or damaged.

(9) Check all parts tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.*

(1) If remove, press spray nozzle (10, fig. 12-95) in top of rod. Use a 3/8 inch inside diameter sleeve over spray nozzle to press nozzle in. Set nozzle in with spray holes positioned as illustrated on figure 12-96.

(2) Press bushings (9) into end of connecting rod, one from each side. End of bushings should be flush with outside of connecting rod and division between bushings in line with spray nozzle.

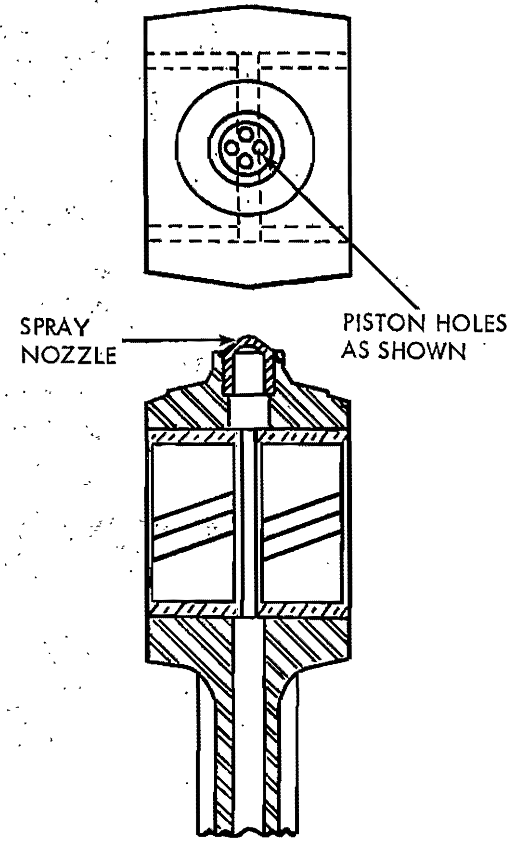



*Figure 12-96. Installing spray nozzle.*

*Note.* Bushing joint must be toward top of connecting rod.

(3) Ream bushings to an inside diameter of 1.5015 to 1.5020 inches to provide a clearance of 0.0015 to 0.0024 inch with a new piston pin.

(4) Install piston in a suitable fixture. Install a new piston pin retainer (7) on one side of piston pin hole and,

using a suitable tool, tap retainer in place in piston.

(5) Install connecting rod inside of piston with end of rod in line with holes. Install piston pin (8) through piston and rod. Install other piston pin retainer (7) in piston. Pin should be loose in bushings.

(6) Check retainers for leakage by placing piston and connecting rod upside down on bench.

(*a*) Fill interior of piston with fuel oil to level above, piston pin bosses. Wipe area around retainers dry of oil.

(*b*) Let piston set for fifteen minutes.

(*c*) Check area around retainers for evidence of oil seepage. If oil leaks, replace retainers.

(*d*) Empty fuel oil from piston and lubricate piston pin with engine oil (OE).

*g. Installation.*

(1) Rotate crankshaft to bring connecting rod journal for the cylinder to bottom of travel. Wipe journal clean and lubricate with engine oil (OE).

(2) Lower connecting rod through cylinder liner and down through the liner.

*Note.* Numbers on side of connecting rod and cap identify the cylinder and must face same side as match mark on liner. Number face blower side of engine.

(3) Stagger the piston ring gaps on piston and install piston ring compressor over piston and rings.

(4) Slide piston down into cylinder liner and remove ring compressor.

(5) Install upper bearing half (6, fig. 12-95) in connecting rod. Lubricate bearing half with engine oil (OE).

*Note.* Upper bearing half has a short oil groove at each parting line.

(6) Install lower bearing half (5, fig. 12-95) in connecting rod bearing cap (4). Lubricate bearing half with engine oil (OE).

(7) Install bearing cap on connecting rod with identifying numbers on same side of rod. Install two screws (3), and nuts (2). Tighten nuts to a torque of 65 to 75 foot pounds. Install cotter pins (1) to secure nuts.

(8) Check connecting rod side clearance on crankshaft. Clearance should be 0.006 to 0.0012 inch.

(9) Refer to paragraph 12-25 and install oil pump and oil pan.

(10) Refer to paragraph 12-32 and install the cylinder head.

(11) Refer to paragraph 2-31 and install the engine in the motor grader.

(12) If new parts were installed operate the engine on the run-in schedule (para 12-57).

## 12-43. Pistons

*a. General.* The pistons and piston rings work inside the cylinder liners. The four upper rings on the piston are the compression rings. The two lower rings are oil control or wiper rings. The lower rings wipe the oil from the sides of the liner when the piston is on the down stroke. Expanders, placed in the ring groove behind the rings, keep the rings in contact with the walls of the liner.

*b. Removal.* Refer to paragraph 12-42 and remove the piston and connecting rod from the engine and to remove the connecting rod from the piston.

*c. Disassembly.*

(1) Use a piston ring remover tool, remove four compression rings (12, fig. 12-95) from piston as illustrated on figure 12-97.

(2) Remove two oil control rings and expanders from piston with the tool in the same manner.

*Note.* Oil control rings are in two halves, an upper and lower half.

(3) If bushings (14) are worn or damaged and require replacement, install the piston in a suitable holding fixture.

(4) Drive the bushings from the piston, using a suitable driver.

*d. Cleaning.* Clean piston and parts in fuel oil and dry with compressed air. If fuel oil does not remove carbon deposits use a solvent (carbon removing compound, Spec. FED P-C-111). Dip piston and rings into solvent allow to set, and remove. Clean piston in water after immersion in solvent. Clean softened

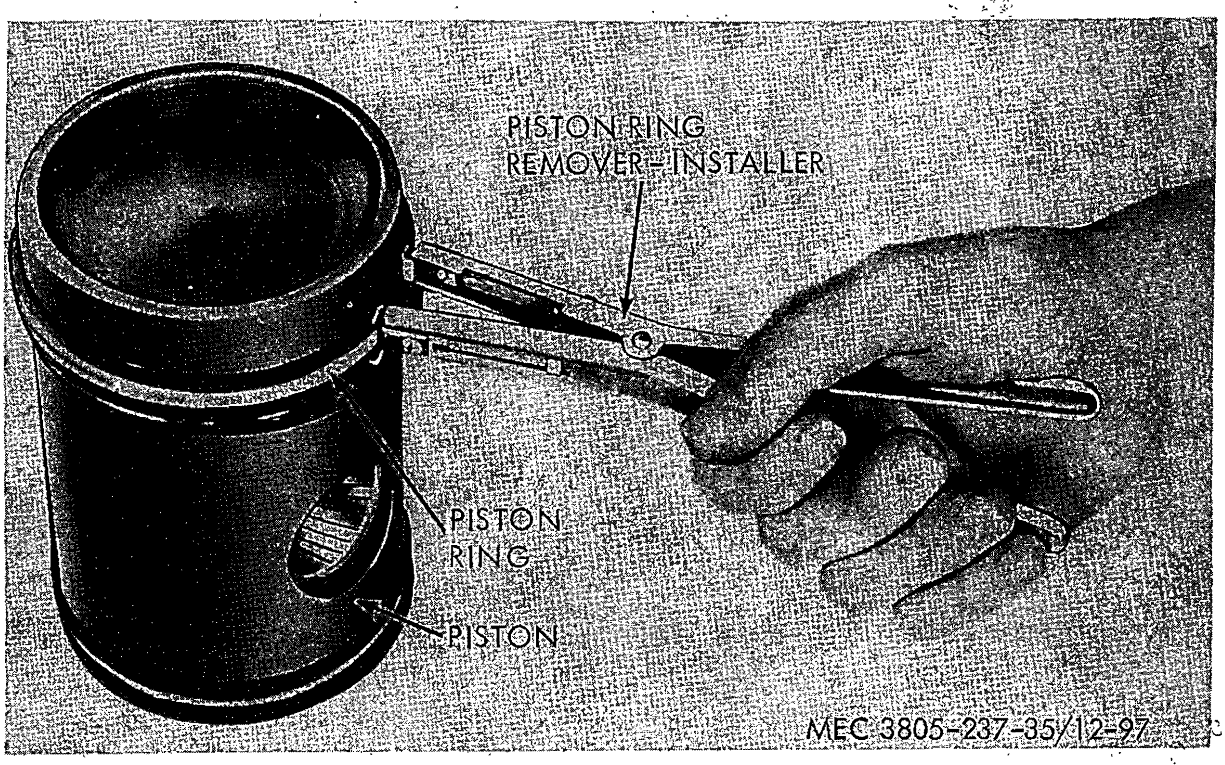



*Figure 12-97. Piston rings, removal and installation.*

carbon deposits from parts. Clean top of piston with a wire brush. Clean piston ring groove with a sharp tool. Clean oil holes with a soft probe.

***Warning:*** **Use goggles, rubber gloves and apron when using solvent. Provide adequate ventilation. If solvent is splashed on the skin, flush immediately with fresh water and wash with alcohol. Alcohol with two to three percent camphor is preferrable.**

*e. Inspection and Repair.*

(1) Inspect piston for wear and damage. If tin plate on piston and the original grooves in the rings are intact it indicates very little wear.

(2) Inspect piston for score marks, cracks, damaged ring groove lands, and indication of overheating. Clean up light score marks on piston with a fine stone. Replace piston if severely scored, cracked, or overheated. Check struts inside piston for cracks. Replace piston if cracked.

(3) Measure inside diameter of piston pin bushing. Diameter should be 1.5025 to 1.5030 inches. Clearance of piston pin (8, fig. 12-95) in bushing should be 0.0025 to 0.0034 inch for new parts. A clearance of 0.010 inch is allowable for used parts.

(4) Replace bushings if worn or damaged or beyond limits specified. Drive bushings from piston. Using a suitable fixture, install new bushings in piston, driving bushings in with a suitable tool.

(5) Bushing joints must be toward bottom of piston as illustrated on figure 12-98.

(6) Clamp the piston in a suitable fixture and ream inside diameter of bushings as shown in figure 12-99. Ream bushings, using a reamer with a pilot to aline bushings, to an inside diameter of 1.5025 to 1.5030 inches.

(7) Clean piston thoroughly after reaming.

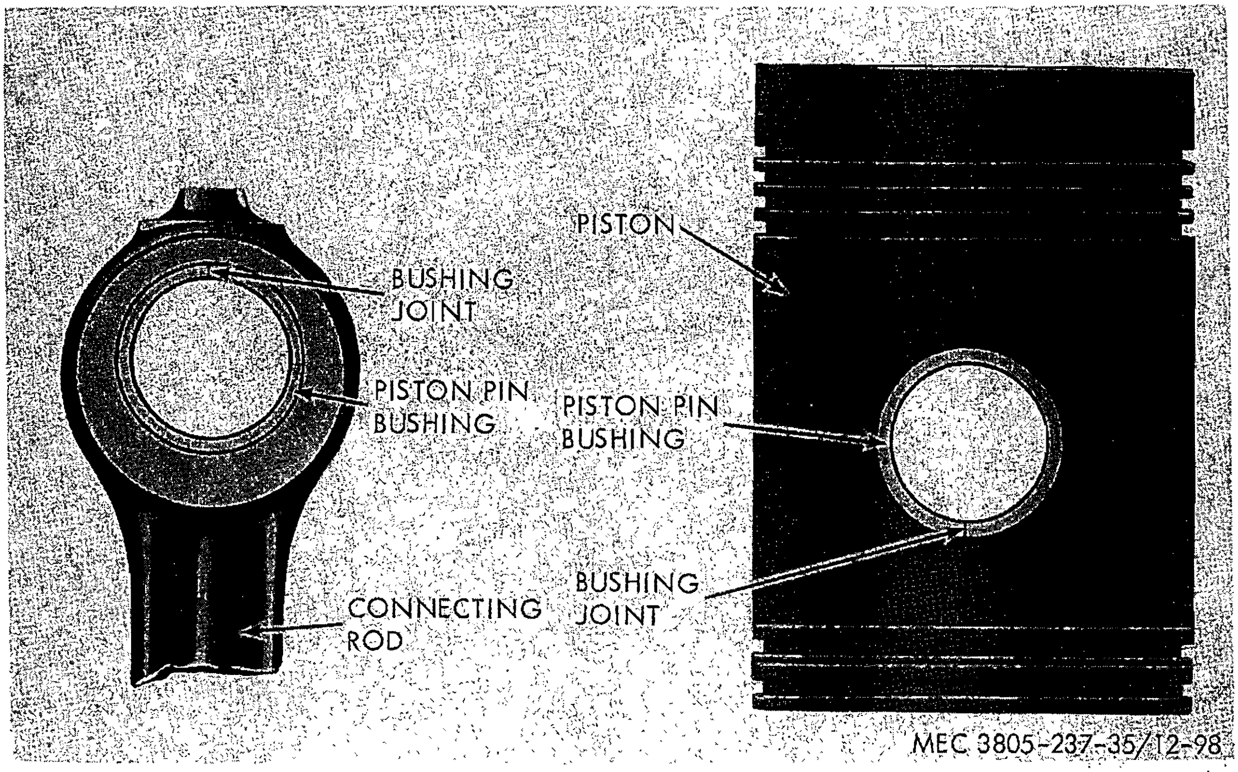



*Figure 12–98. Location of joint in piston and connecting rod bushings.*

(8) Measure piston diameter, at room temperature, as follows.

(*a*) Measure piston skirt lengthwise and crosswise of the piston pin bore.

(*b*) Diameter at top of piston should be 4.2190 to 4.2220 inches.

(*c*) Diameter at skirt below compression rings to bottom should be 4.2433 to 4.2455 inches.

(*d*) Maximum allowable out-of-round is 0.0005 inch.

(*e*) Maximum taper is 0.0005 inch.

(*f*) Replace piston if postion does not meet these tolerances.

(9) Check clearance of piston in cylinder liner. Inside diameter of liner should be 4.2495 to 4.2511 inches. Hold piston upside down in liner as illustrated on figure 12–100.

*Note.* Liner should be installed in cylinder block.

(10) Use a feeler gage attached to a spring scale as illustrated. Check clearance in four places 90° apart. Maximum allowable clearance is 0.012 inch.

(11) Select a feeler gage that, when placed between piston and liner, will require a six pound pull to remove. This will give a piston-to-liner clearance of 0.001 inch more than thickness of feeler gage. If gage measures 0.004 inch, actual clearance is 0.005 inch.

(12) If piston binds in liner, remove piston and check piston and liner for burs. Remove burs with a fine hone and check clearances as above.

(13) All new piston rings must be installed whenever a piston is removed. Check all rings for porper gap. Install rings, one at a time, in cylinder liner as illustrated on figure 12–101. Push ring down far enough to be within normal limits of travel and parallel with top of liner. Measure

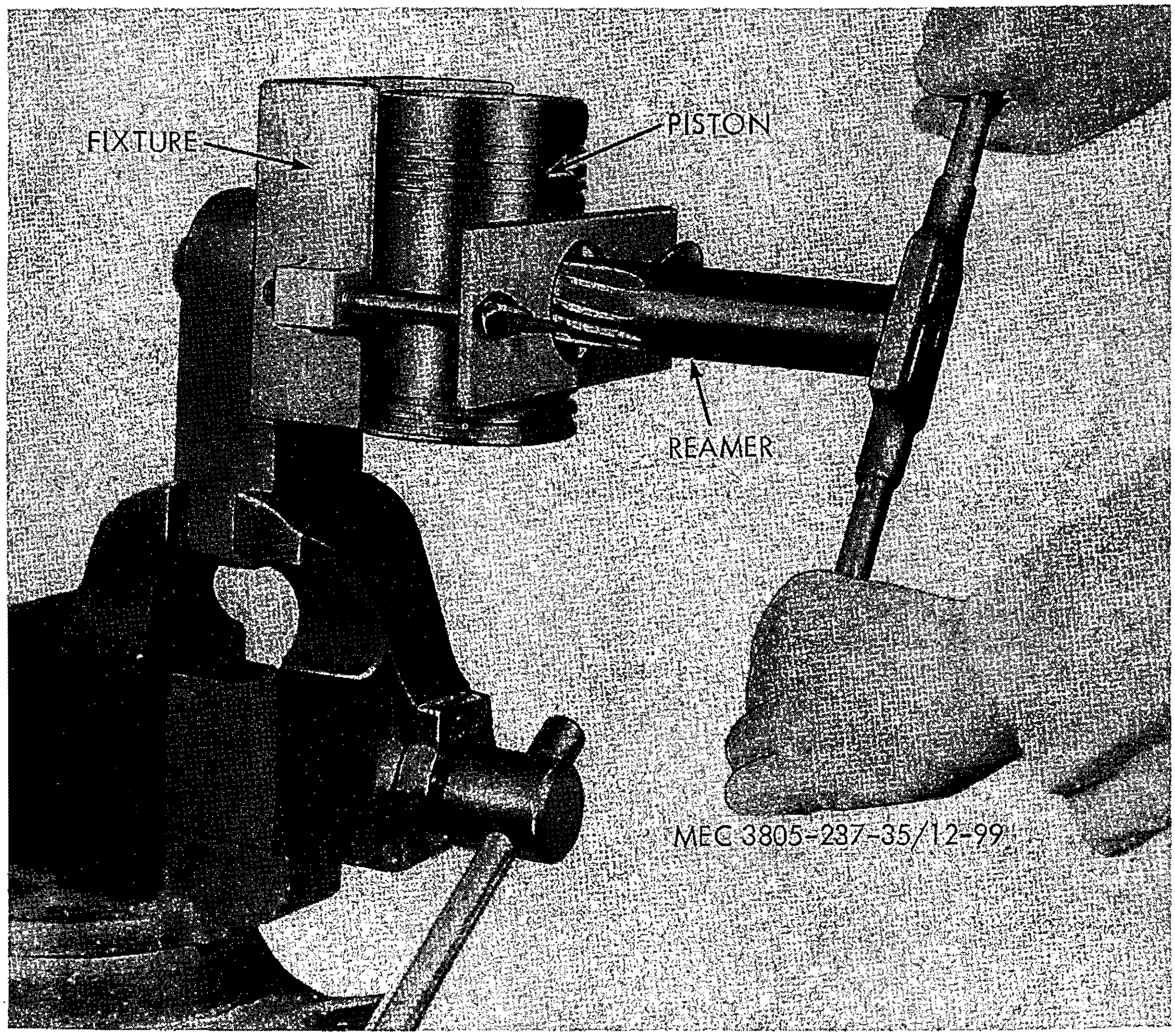



*Figure 12-99. Reaming piston bushings.*

gap as illustrated on figure 12-101. Compression ring gap should be 0.0180 to 0.0430 inch. In a used liner gap can be a maximum of 0.0600 inch. Oil ring gap should be 0.0080 to 0.0230 inch with a maximum for used liners of 0.0430 inch.

(14) If gap is less than indicated, file or stone ends of ring to increase gap. File or stone from the outer surface to the inner surface to prevent chipping chrome plate. Ends of rings must be square and the chamfer must be approximately 0.015 inch on the outer edge.

(15) After increasing gap, check gap again (fig. 12-101).

(16) Check piston ring side clearance. Install ring in ring groove and check clearance between ring and lands with a feeler gage. Clearances should be as listed below.

(*a*) Top ring - 0.0095 to 0.013 inch. Maximum of 0.0220 inch in used piston.

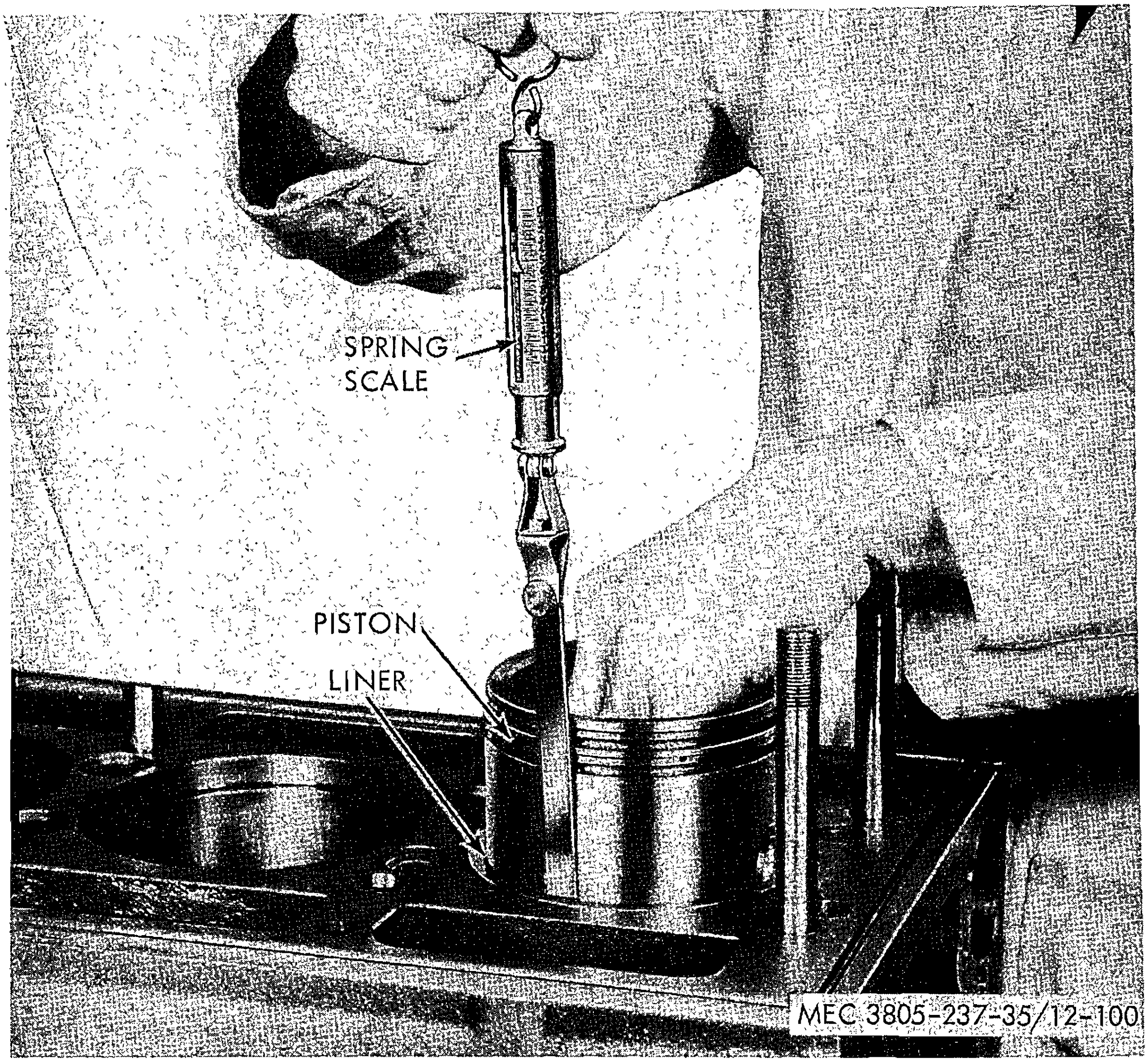



*Figure 12–100. Checking piston clearance.*

(*b*) Number 2 ring - 0.0075 to 0.0110 inch. Maximum of 0.0150 inch in used piston.

(*c*) Number 3 and number 4 ring - 0.0055 to 0.0090 inch. Maximum of 0.0130 inch in used piston.

(*d*) Oil rings - 0.0015 to 0.0055 inch. Maximum of 0.008 in used piston.

(*e*) If clearances are not as specified replace piston and/or rings.

(17) Check all parts against tolerances listed in Table 1–1. Replace all parts not conforming to repair and rebuild standards.

*f. Reassembly.*

(1) Refer to figure 12–97 and install compression rings using a piston ring expander.

*Note.* **Do not spread rings more than necessary to slip rings over piston.**

(2) Install oil control rings by hand. Scraping edges of rings must face toward bottom of piston.

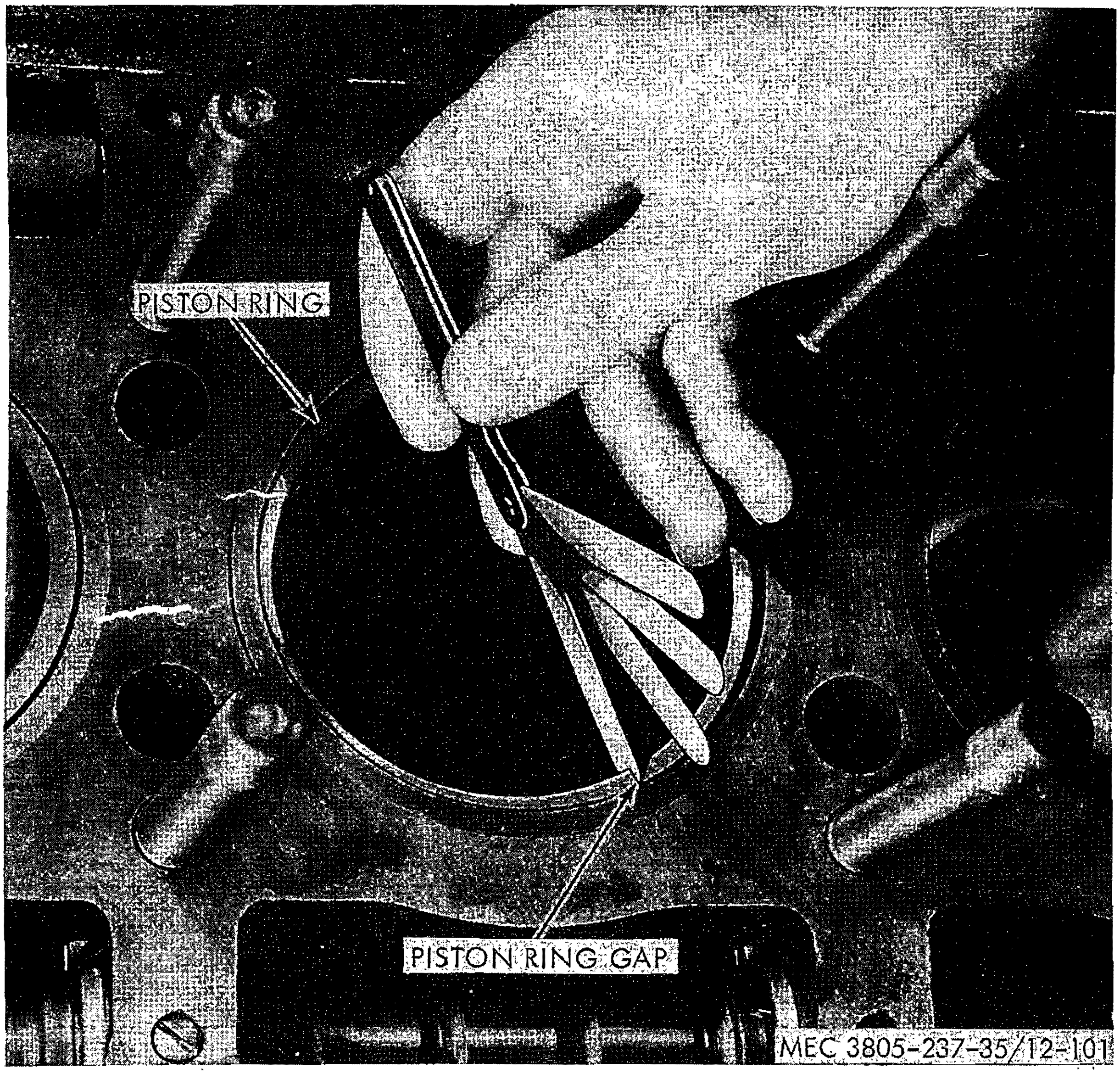



*Figure 12-101. Checking piston ring gap.*

(3) Install expander carefully in groove. Install top ring in groove with ring gap 180° from the gap in the expander. Install bottom ring in groove with gap 45° from gap in upper ring.

*Note.* Do not overlap ends of oil control ring expanders. Expanders must be correctly seated inside of grooves. Overlapped expanders will cause oil control ring to protrude beyond allowable limits.

*g. Installation.* Refer to paragraph 12-42 to attach connecting rod to piston and install connecting rod and piston in cylinder liner.

## Section XII. CYLINDER BLOCK

### 12-44. General

*a*. The cylider block is a cast iron integral casting forming the structural basis of the engine. The block is bored to receive the cylinder liners and has coolant jackets extending the full length of the bores. The jackets are divided into upper and lower sections which are connected by hollow struts. Coolant from the pump enters at the bottom of each jacket and leaves at the top of the block through holes connected to openings in the cylinder head.

*b*. An air box surrounds the coolant jacket and conducts air from the blower to all air inlet ports in the cylinder liners. Openings on the side opposite the blower provide access to the air box and permit inspection of pistons and compression rings through air inlet ports (fig. 12-102).

*c*. Camshaft and balance shaft bores are located on opposite sides near the top of the block. Upper halves of the main bearing supports are cast integrally in the block. The main bearing bores are linebored with the bearing caps in place to insure longitudinal alinement. Drilled passages in the block carry lubricating oil to all moving parts of the engine.

*d*. The top of the block is grooved to accommodate a head-to-block seal ring. Individual seal rings seal each water and oil passage between the block and the head. The cylinder liners are retained in the block by a flange on the upper end. The flange rests on an insert (fig. 12-103) located in a counterbore. Each cylinder has its own compression gasket. When the cylinder head is installed the individual gaskets and seal rings are compressed to form a tight metal-to-metal contact between the head and the block.

### 12-45. Cylinder Block

*a*. *Removal*.

(1) Refer to paragraph 2-31 and remove the engine from the motor grader.

(2) Refer to paragraph 2-32 and remove the clutch.

(3) Refer to TM 5-3805-237-12 and remove the starter and generator from the engine.

(4) Refer to the following paragraphs and remove the items from the engine.

(*a*) Paragraph 12-6, blower.

(*b*) Paragraph 12-8, exhaust system.

(*c*) Paragraph 12-10, radiator.

(*d*) Paragraph 12-11, fan and pulley.

(*e*) Paragraph 12-12, water pump, thermostat, and water manifold.

(*f*) Paragraph 12-15, fuel filters.

(*g*) Paragraph 12-16, fuel pump.

(*h*) Paragraph 12-17, fuel injectors.

(*i*) Paragraphs 12-18, throttle linkage.

(*j*) Paragraph 12-19, governor.

(*k*) Paragraph 12-20, injector control tube.

(*l*) Paragraph 12-22, oil filter.

(*m*) Paragraph 12-23, oil cooler.

(*n*) Paragraph 12-24, oil pan.

(*o*) Paragraph 12-25, oil pump.

(*p*) Paragraph 12-27, blower drive gear.

(*q*) Paragraph 12-29, flywheel housing.

(*r*) Paragraph 12-32, cylinder head.

(*s*) Paragraph 12-36, balance weight cover and weights.

(*t*) Paragraph 12-37, camshaft and balance shafts.

(*u*) Paragraph 12-40, crankshaft and main bearings.

(*v*) Paragraph 12-42, connecting rods.

(5) The above procedures should reduce the engine to the block.

*b*. *Disassembly*.

(1) Remove hourmeter switch (1, fig. 12-104) from cylinder block. Remove elbow and fitting.

(2) Refer to paragraph 12-46 and remove cylinder liners (4, fig. 12-104) from cylinder block. Remove inserts (31).

(3) Disassemble cylinder block in the numerical sequence as illustrated on figure 12-104.

*c*. *Cleaning*.

(1) Remove all pipe plugs from oil gallerys and core holes.

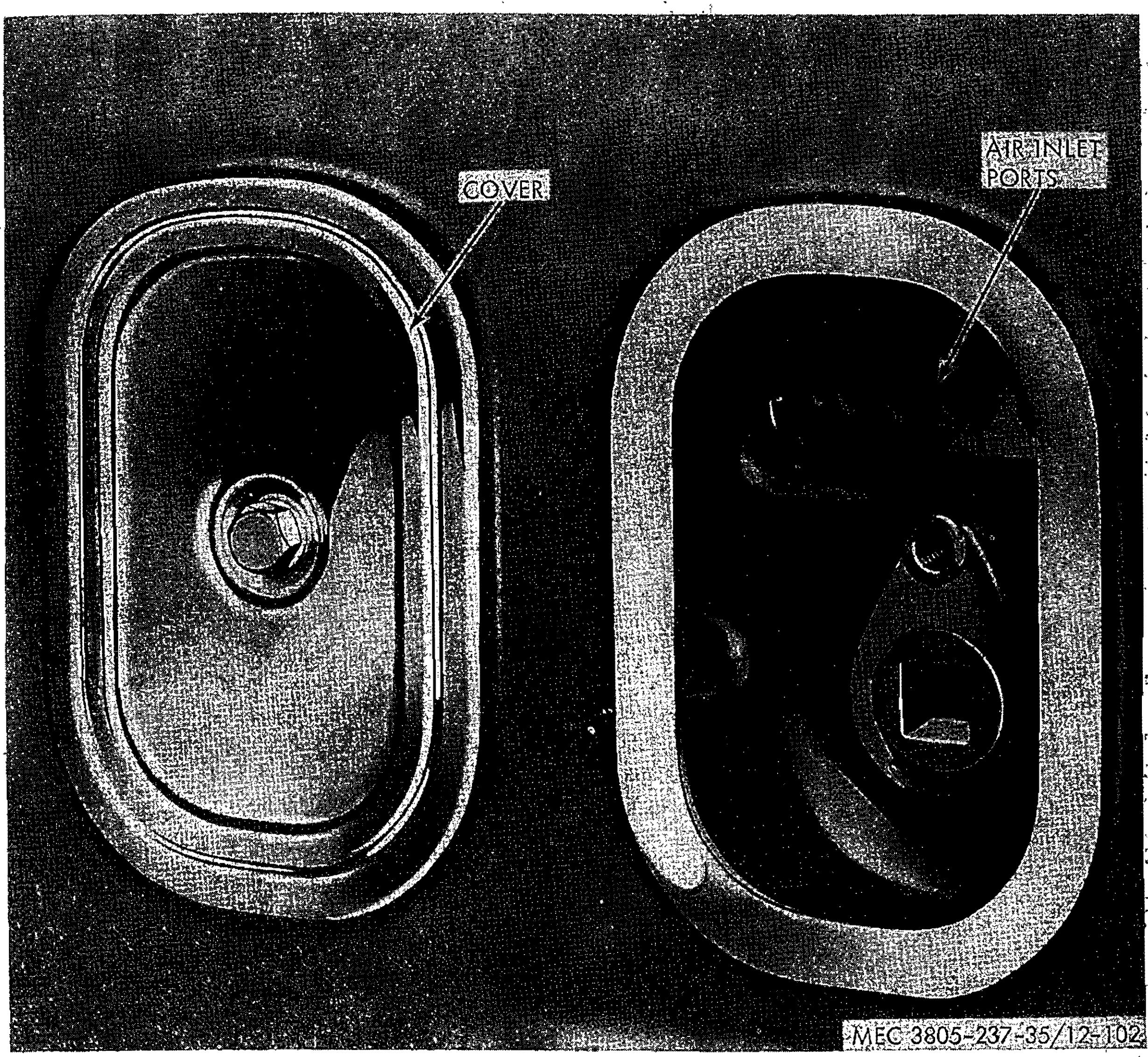



*Figure 12-102. Cover and air inlet ports.*

(2) If available, clean cylinder block by dipping and agitating it in a hot bath of an alkaline solution made up of 10 ounces of cleaning compound, alkali (FED P-C-436) to one gallon of water.

(3) Wash the block with hot water or steam clean it to remove alkaline solution.

(4) Make certain all water passages, oil galleries and air box drain holes are clean.

*d. Inspection and Repair.*

(1) Pressure test cylinder block.

(*a*) Install core hole plugs. Coat threads of plugs with sealant. Install end plugs (29, fig. 12-104) with new gaskets (30) and install plugs and tighten to a torque of 75 to 100 foot-pounds. Do not exceed torque limits.

(*b*) Fabricate plates to seal water openings in top and bottom of block.

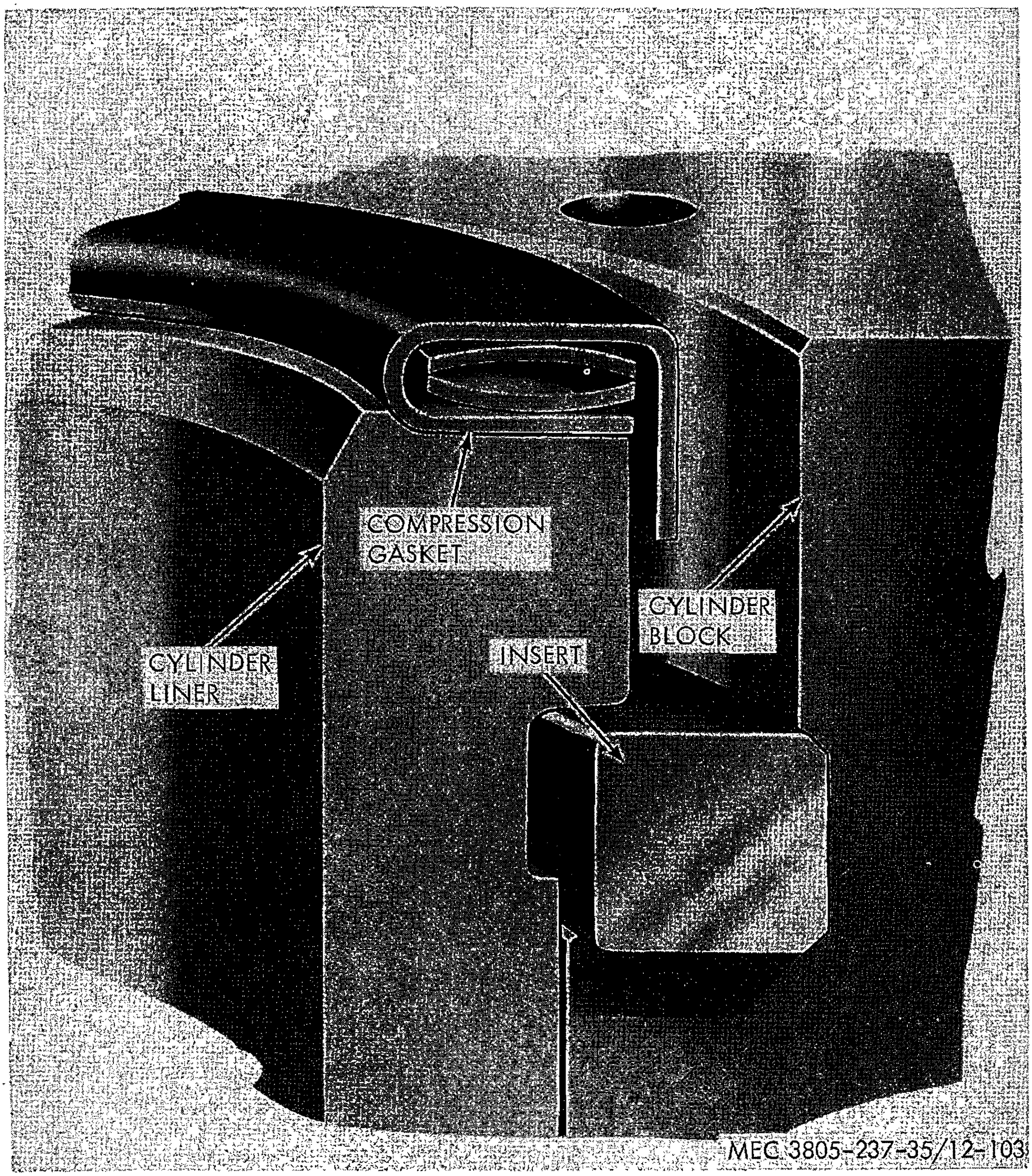
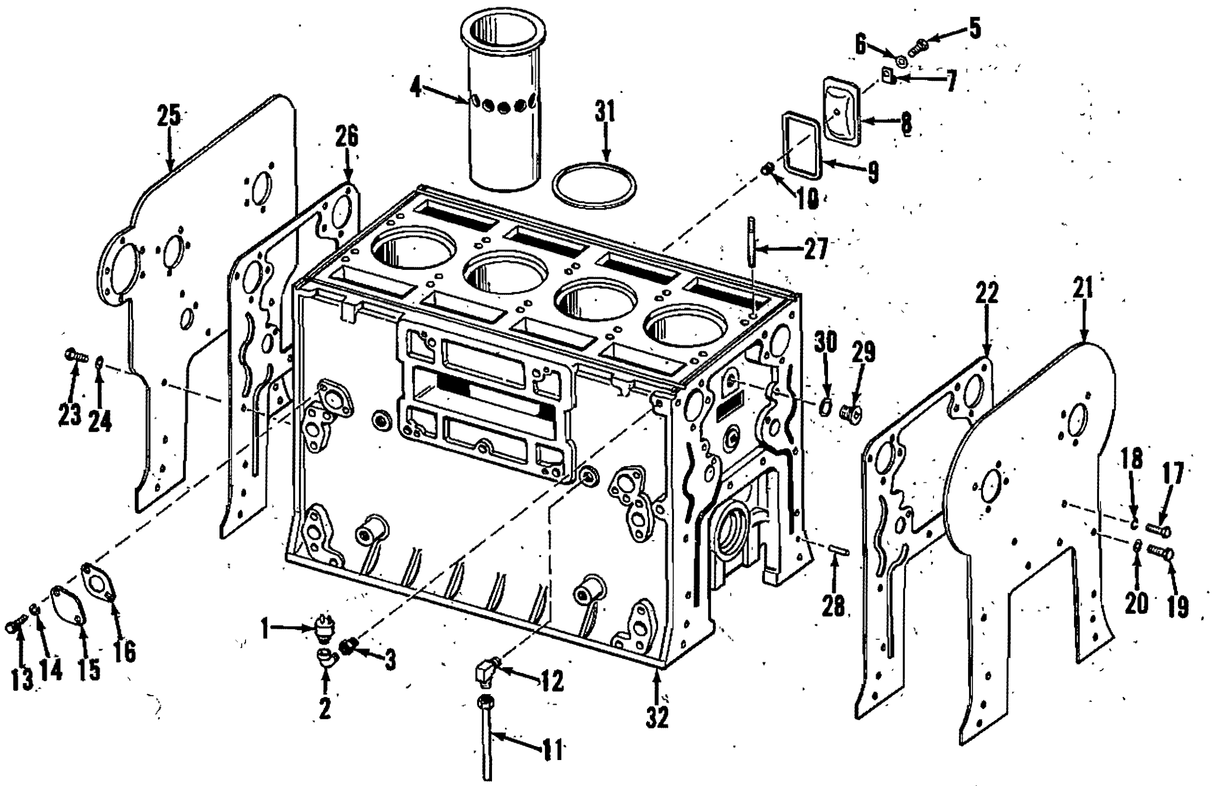



*Figure 12-103. Cylinder liner and insert, cutaway view.*

Install water hole cover (15) and gasket (16).

(c) Drill and tap one cover for a hose connection. Before attaching last sealing plate fill water jacket with a mixture of water and one gallon of permanent type anti-freeze (TM 5-3805-237-12).




MEC 3805-237-35/12-104

| | | | | |
|---|---|---|---|---|
| 1 | Hourmeter switch | | 17 | Screw, cap, hex-head, 3/8-16 × 1 in. (6) |
| 2 | Elbow | | 18 | Washer, lock, 3/8 in. (6) |
| 3 | Fitting | | 19 | Screw, cap, hex-head, 1/2-13 × 1 1/8 in. (2) |
| 4 | Cylinder liner (6) | | 20 | Washer, lock, 1/2 in. (2) |
| 5 | Screw, cap, hex-head, 3/8-16 × 2 1/8 in. (4) | | 21 | Front end plate |
| 6 | Washer, flat, 3/8 in. (4) | | 22 | End plate gasket |
| 7 | Clamp | | 23 | Screw, cap, hex-head, 3/8-16 × 1 in. (6) |
| 8 | Cover (4) | | 24 | Washer, lock, 3/8 in. (6) |
| 9 | Cover gasket (4) | | 25 | Rear end plate |
| 10 | Pipe plug (4) | | 26 | End plate gasket |
| 11 | Air box drain tube (2) | | 27 | Cylinder head stud (4) |
| 12 | Elbow (2) | | 28 | Dowel pin (4) |
| 13 | Screw, cap, hex-head, 5/16-18 × 7/8 in. (2) | | 29 | Pipe plug (4) |
| 14 | Washer, lock, 5/16 in. (2) | | 30 | Gasket (4) |
| 15 | Water hole cover | | 31 | Cylinder liner insert (4) |
| 16 | Cover gasket | | 32 | Cylinder block |

*Figure 12-104. Cylinder block, exploded view.*

(*d*) Install last sealing plate and secure.

(*e*) Apply 80 to 100 psi air pressure to cylinder block through hose connection. Maintain this pressure at least two hours.

(*f*) Examine cylinder bores, air box, oil passages, crankcase, and exterior of block for evidence of leakage.

(*g*) If any cracks are in evidence, replace cylinder block.

(2) Check drive pins (which plug oil galleries) in the corners of the block to be sure pins are flush or below top surface of block.

(3) Check top surface of block for flatness with an accurate straightedge and a feeler gage as illustrated on figure 12-105.

(*a*) Top surface must not vary more than 0.003 inch transversely or more than 0.006 and 0.007 inch longitudinally on number 3 and 4 cylinder blocks.

(*b*) If necessary to grind top surface to correct for the above, do not remove more than 0.008 inch of metal. Stamp amount of metal removed on face of block. Distance from centerline of crankshaft to top of block must not be less than 16.176 inches as illustrated on figure 12-106.

(*c*) If stock has been removed, check depth of seal ring grooves and counterbores. Seal strip grooves must be 0.092 to 0.107 inch deep. Large water hole counterbores must be 0.109 to 0.120 inch deep and combination water and oil counterbores and small water hole counterbores must be 0.087 to 0.098 inch deep. If necessary, deepen grooves or counterbores to retain proper set on the seal rings.

(3) Check blower mounting pad for flatness with a straightedge. Surface must not vary more than 0.004 inch.

(4) Replace damaged cylinder head studs. Drive studs in to a height of 4 3/8 $\pm$ 1/32 inches and a minimum torque of 75 foot pounds. Check cylinder head screw holes. Repair thread with a tap if necessary.

(5) Inspect cylinder liner bores in cylinder block.

(*a*) Before checking bores, hone bores through their entire length. Use a

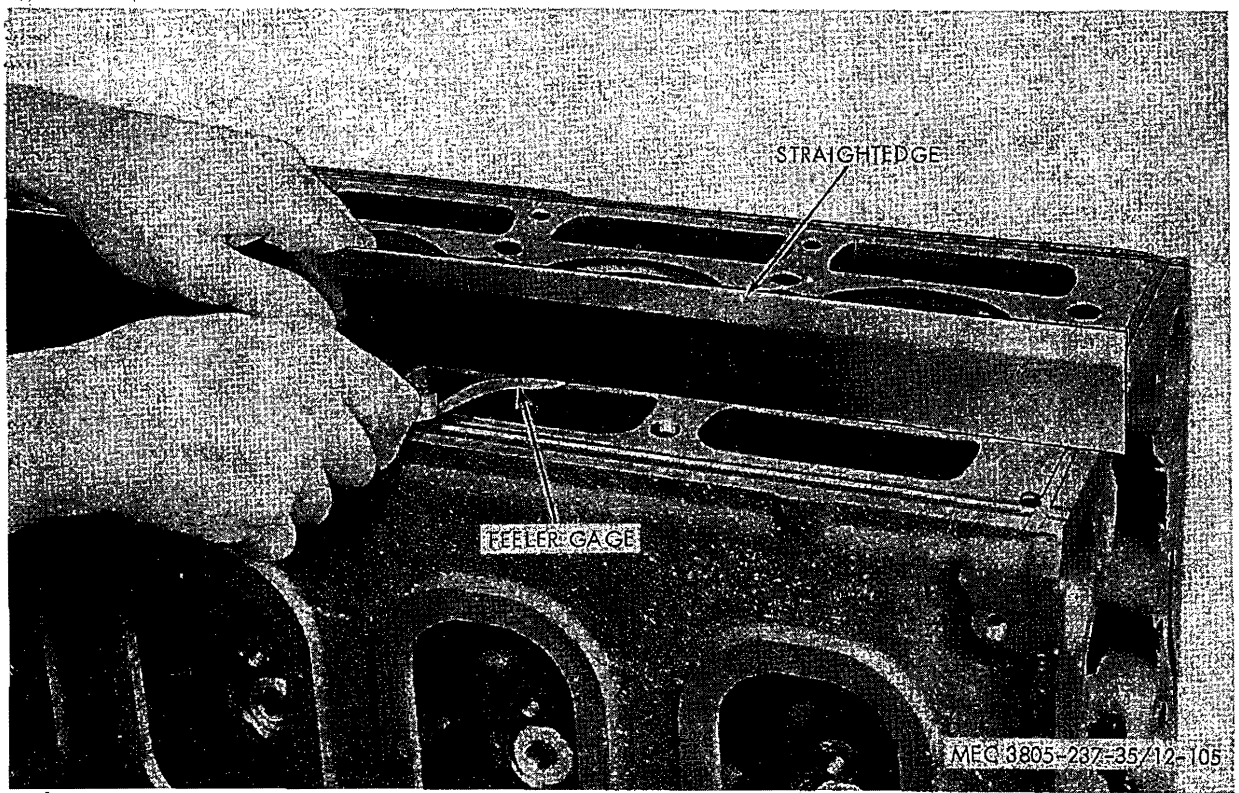



*Figure 12-105. Checking top surface of cylinder block.*

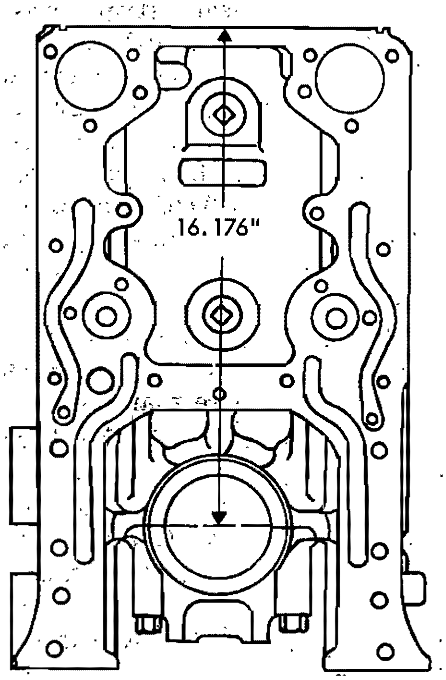



*Figure 12–106. Minimum distance, center of crankshaft to top of cylinder block.*

hone on which the cutting radius of the stones can be set at a fixed position to remove any irregularities which may exist. Use a hone with 120 grit stones.

(*b*) Insert hone in bore and adjust stones snugly to narrowest section. Hone should not shake in bore, but should drag freely up and down when hone is not running.

(*c*) Start hone and feel for high spots, which will cause increased drag on hone. Move hone up and down bore with short, overlapping strokes about one inch long. Concentrate on high spots on the first cut and drag on hone will become lighter and smoother. Do not hone air inlet port area as long as rest of bore. This area cuts away rapidly.

(*d*) Judge honing by feel. Do not cut too long in one spot. Use a light cut with frequent stone adjustments.

(*e*) Wash cylinder block thoroughly after honing operation is completed.

(*f*) Visually inspect honed surface. There must not be any low spot larger in area than 1 1/4 inches in diameter.

(*g*) Measure entire cylinder bore with a dial indicator gage as illustrated in figure 12–107. Place bore gage in master ring and set dial to zero. Take measurements at at least six positions in bore. Take measurements 90° apart. Standard size bore is 4.6265 to 4.6275 inches. The liner-to-block clearance, with a new liner is 0.0005 to 0.0025 inch, with used parts maximum clearance is 0.003 inch. Out-of-round of bore must not exceed 0.003 inch and the taper must not exceed 0.002 inch in each bore.

(*h*) If bores do not meet specifications for diameter, taper, and out-of-round, or if liner-to-block clearance is greater than 0.003 inch, bores must be increased to accommodate an oversize liner. Liners are furnished 0.005, 0.010, 0.020, and 0.030 inch oversize on the outside diameter. To accommodate oversize liners, bores must be enlarged. Bore out bore to size and hone to a smooth finish. Wash the bore thoroughly after boring.

(6) Inspect main bearing bores.

(*a*) Install main bearing caps (3, fig. 12–89) in their original positions. Check numbers on caps. Number 1 bearing is always on the end opposite the flywheel. Numbered side of bearing is always installed on blower side of engine.

(*b*) Tighten bearing cap mounting screws to a torque of 180 to 190 foot pounds.

(*c*) Measure bearing bores. Bores must be 3.812 to 3.813 inches in diameter. If bores are not within this tolerance, replace cylinder block and bearing caps.

(*d*) Check alinement of bores. If, after installation of standard bearing

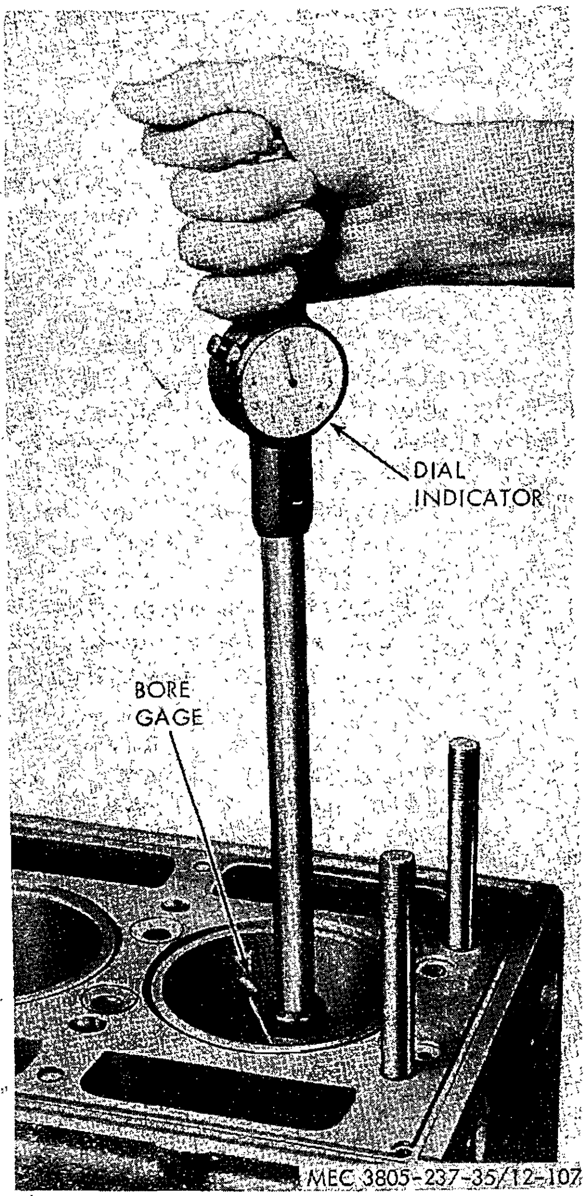



*Figure 12-107. Checking cylinder bore.*

halves and the crankshaft and with caps torqued porperly, the crankshaft can be turned freely by hand, the bores can be considered in line.

(*e*) If main bearing bore is 0.001 inch out of alinement, block must be line reamed or replaced. After reaming all bores must meet the 3.812 to 3.813 inches diameter dimension.

(7) Inspect cylinder liner counterbores.

(*a*) Counterbores at top of cylinder block must be clean and free of dirt.

(*b*) Each counterbore must be 5.0460 to 5.0485 inches in diameter and 0.4770 to 0.4795 inches deep, throughout the entire circumference. The bottom surface of the liner insert must contact the counterbore all the way around and both top and bottom surfaces of insert must be smooth and flat.

(8) Check all machined surfaces and threaded holes for damage. Remove nicks and burs with a fine mill file. Clean damaged threads with a tip, if possible.

(9) Replace loose or damaged dowel pins.

(10) Install all plugs. Use a good grade of sealing compound on threads of plugs.

(11) Inspect end plates for nicks, dents, cracks, and other damage. Check tapped holes for damage. Replace plates that are damaged on sealing surfaces or plates that are warped.

(12) Check all parts against tolerances listed in Table 1-1. Replace all parts not conforming to repair and rebuild standards.

*e. Reassembly.*

(1) Reassemble the cylinder block in reverse of the numerical sequence as illustrated on figure 12-104.

(2) Install elbow (2), fitting (3) and hourmeter switch (1) in cylinder block.

(3) Install cylinder liners (4) in cylinder block (para 12-46).

*f. Installation.*

(1) Refer to the following paragraphs and install the items on the engine.

(*a*) Paragraph 12-41, connecting rods.

(*b*) Paragraph 12-40, crankshaft and main bearings.

(*c*) Paragraph 12-37, camshaft and balance shafts.

(*d*) Paragraph 12-36, balance weight cover and weights.

(e) Paragraph 12-32, cylinder head.
(f) Paragraph 12-29, flywheel housing.
(g) Paragraph 12-27, blower drive gear.
(h) Paragraph 12-25, oil pump.
(i) Paragraph 12-24, oil pan.
(j) Paragraph 12-23, oil cooler.
(k) Paragraph 12-22, oil filter.
(l) Paragraph 12-20, injector control tube.
(m) Paragraph 12-29, governor.
(n) Paragraph 12-18, throttle linkage.
(o) Paragraph 12-27, fuel injectors.
(p) Paragraph 12-16, fuel pump.
(q) Paragraph 12-15, fuel filters.
(r) Paragraph 12-12, water pump, thermostat, and water manifold.
(s) Paragraph 12-11, fan and pulley.
(t) Paragraph 12-10, radiator.
(u) Paragraph 12-8, exhaust system.
(v) Paragraph 12-6, blower.

(2) Refer to TM 5-3805-237-12 and install the starter and generator on the engine.
(3) Refer to paragraph 2-32 and install the clutch on the engine.
(4) Refer to paragraph 2-31 and install the engine in the motor grader.

## 12-46. Cylinder Liners

*a. General.* The cylinder liners are a slip fit into the cylinder bores. The replaceable liners are accurately machined and heat treated to provide a long wearing surface. A flange at the top of the cylinder liner fits into a counterbore in the cylinder block and rests on an insert, permitting accurate alinement of the liner. The top of the liner is in contact with a compression gasket to seal each cylinder. Cooling for the liner is provided by the water jacket and by scavenging air entering through the air inlet ports. The ports are machined at an angle to produce a swirling motion to the air as it enters the cylinder.

*b. Inspection of Liner Air Inlet Ports.*

(1) Air inlet ports should be kept free of carbon formations for efficient engine operation.
(2) Remove cylinder block covers (8, fig. 12-104) and check air inlet ports (fig. 12-102).
(3) If ports have an accumulation of carbon or sludge which could restrict air flow, clean ports.
(a) Refer to paragraph 12-32 and remove the cylinder head.
(b) Install clamps as shown in figure 12-108.
(c) Rotate engine until piston in cylinder liner to be cleaned is at the bottom of its stroke.
(d) Clean all the ports with a suitable tool from inside the cylinder.
(e) Remove all carbon from top of piston and from air box outside of ports. Check air box drains to see they are clean.
(f) Examine inside of liner ports for burs. Remove burs by sanding with 250 grit emery paper. Clean liner and air box after sanding.
(g) Remove the clamps (fig. 12-108) from engine.
(h) Refer to paragraph 12-32 and install the cylinder head.

*c. Removal.*

(1) Refer to paragraph 12-42 and remove the pistons and connecting rods from the cylinder.
(2) Using a suitable puller tool such as illustrated on figure 12-109, remove the cylinder liner from the block.
(a) Slip lower clamp through liner and attach clamp to bottom of liner.
(b) Slide upper clamp (fig. 12-109) down to top of liner.
(c) Slide weight (fig. 12-109) up against top of rod, striking top a sharp blow to release cylinder liner.
(d) Remove puller and remove cylinder liner (4, fig. 12-104) from block.
(e) Remove cylinder liner insert (31, fig. 12-104) from block.

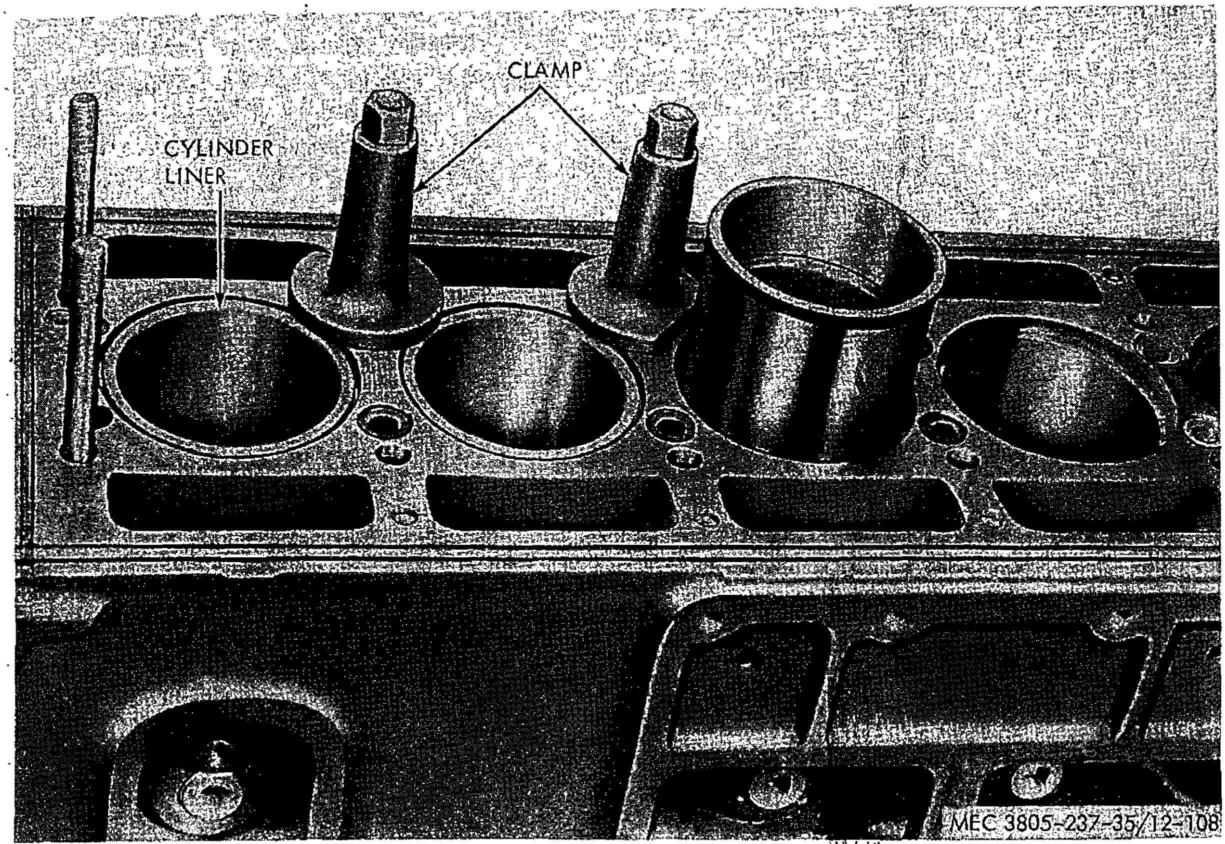



*Figure 12-108. Cylinder liner clamps.*

*d. Cleaning.* Clean all carbon and residue from cylinder liner. Use care in scraping liner to prevent damage to surface. Clean air inlet ports thoroughly.

*e. Inspection and Repair.*

(1) Inspect cylinder liner for cracks and scoring. Replace a cracked or badly scored liner.

(2) Inspect outside diameter of liner for material from bore clinging to surface. Remove material with a coarse, flat stone.

(3) Inspect liner flange. Flange must be smooth and flat on both top and bottom surfaces. Check flange for cracks. If flange is cracked or dented, replace cylinder liner.

(4) Measure inside diameter of liner at points indicated, using a bore gage having a dial indicator as illustrated on figure 12-110.

(5) Measurements should show the following tolerances.

(*a*) Taper must not exceed 0.002 inch.

(*b*) Out-of-round must not exceed 0.003 inch.

(*c*) If out-of-round exceeds 0.002 inch rotate the liner 90° in the cylinder block bore and check out-of-round again.

(*d*) Inside diameter od cylinder liner should be 4.2495 to 4.2511 inches.

(*e*) Ridge at top of piston ring travel must be removed from inside of liner.

(6) Used cylinder liners must be honed to remove glaze that forms in liner and to remove ridge at top of ring travel.

(*a*) Place cylinder liner in a suitable fixture to hold liner assembly.

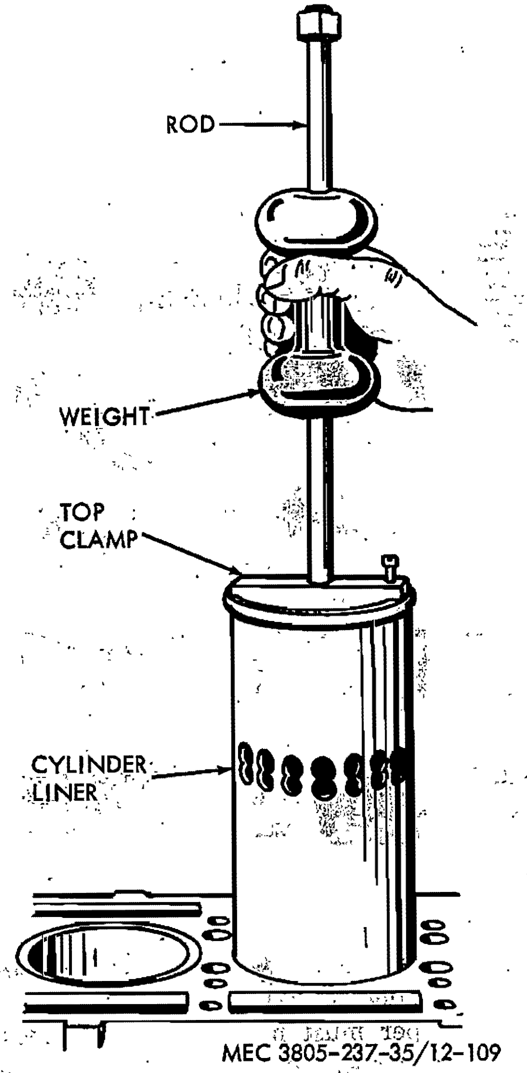



*Figure 12-109. Cylinder liner, removal.*

(*b*) Use 120 grit stones and hone liner in a crisscross pattern to produce hone marks at a 45° axis.

(*c*) After honing, clean cylinder liner thoroughly.

(*d*) Check taper, out-of-round, and inside diameter. Cylinder liner must conform to tolerances and piston-to-liner clearance must be within 0.0040 to 0.0120 inch limits.

(7) Inspect cylinder liner insert. Insert must be smooth and flat on both top and bottom surfaces. Replace insert if dented or if insert shows indication of flaking or brinelling.

(8) Wipe inside of liner clean, and check bore and counterbores in block to be sure they are clean.

(9) Install cylinder liner insert in counterbore as illustrated on figure 12-103.

(10) Push liner into block until liner flange rests on insert. Liner should slide smoothly into place. Do not force liner into place. If liner does not slide in smoothly, rotate liner 90° and insert liner.

(11) Clamp liner in place with clamps as illustrated in figure 12-108. Check distance from top of liner to top of cylinder block with a dail indicator.

(*a*) Liner flange must be 0.0465 to 0.050 inch below surface of block.

(*b*) Although liners meet the above tolerances, there must not be over 0.002 inch difference in depth between two adjacent liners.

(*c*) If the above distances are not met, install liner in another cylinder or replace the cylinder liner.

(*d*) Make a match mark with chalk or paint on the liner and block so liners can be installed in the same position if removed. Match marks should be toward blower side of engine.

(*e*) Remove the clamps.

*f. Installation.* Install all cylinder liners and measure them as described above.

(1) Refer to paragraph 12-42 and install the pistons and connecting rods.

(2) Refer to paragraph 12-42 and check piston clearance in cylinder liner.

(3) After complete assembly, operate the engine on run-in schedule (para 12-57).

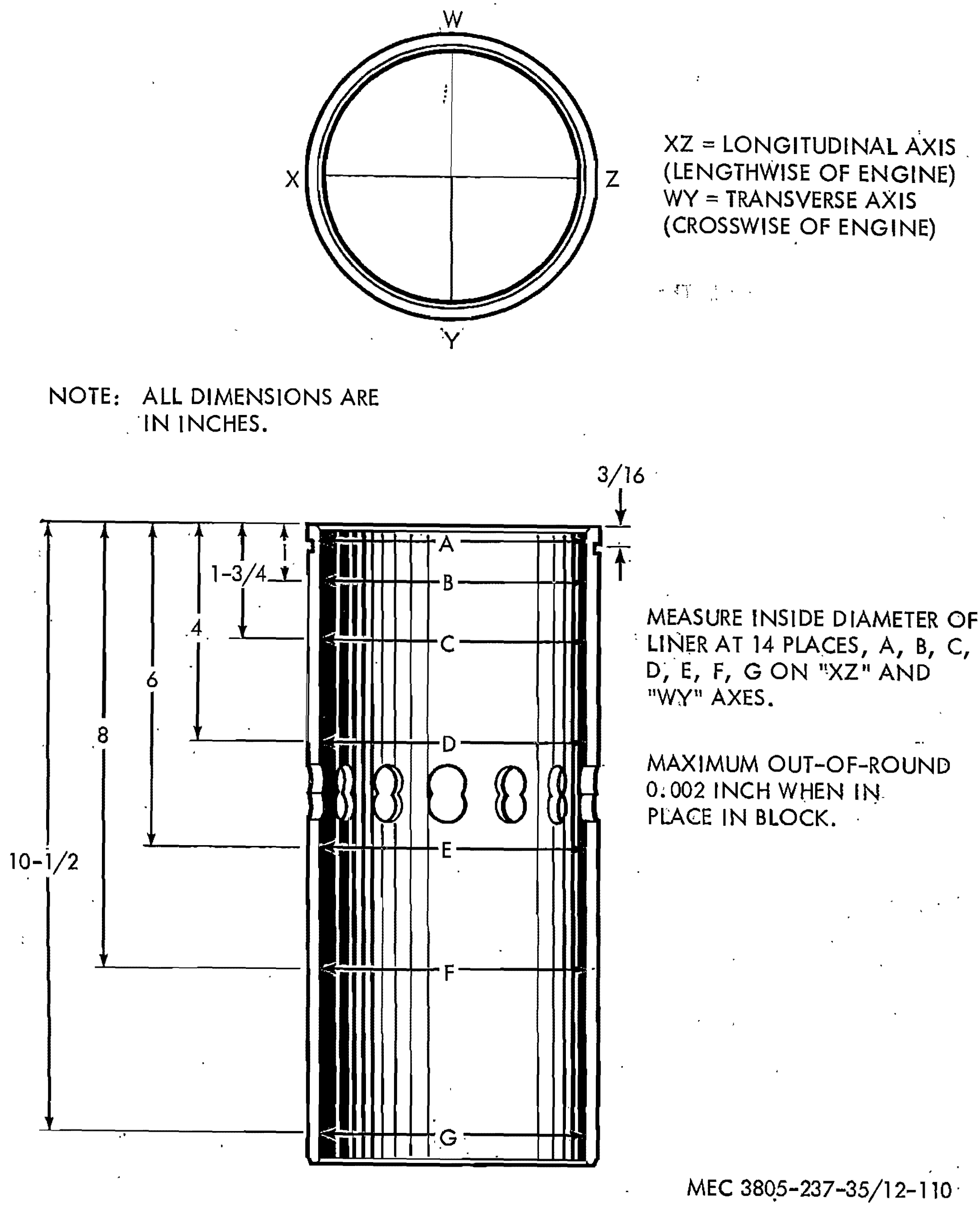



*Figure 12-110. Cylinder liner measurement diagram.*

## Section XIII. ENGINE ADJUSTMENTS

### 12-47. General

*a.* The adjustments required by the engine at intervals or after engine overhaul are described in this section. Adjustments to an engine that is in service are only those necessary to check that the various adjustments and settings have not changed during operation.

*b.* If the cylinder head, governor, or injectors have been replaced or overhauled, certain preliminary adjustments are required before the engine is started. The preliminary adjustments required are as follows:

(1) Exhaust valve clearance adjustment.
(2) Fuel injector timing.
(3) Governor gap adjustment.
(4) Injector rack control lever position adjustment.

*c.* To completely adjust an engine after overhaul has been performed the above four adjustments are required plus the following adjustments.

(1) Maximum no-load speed adjustment.
(2) Idle speed adjustment.
(3) Buffer screw adjustment.
(4) Throttle booster spring adjustment.

### 12-48. Exhaust Valve Clearance Adjustment

*a. General.* Exhaust valve clearance at normal engine operating temperature is important to smooth, efficient operation of the engine. Whenever the cylinder head is overhauled, exhaust valves are reconditioned, or replaced or the valve operating mechanism is replaced or disturbed, the valve clearance must be adjusted to the cold setting to allow for normal expansion as engine warms-up.

*b. Adjustment.*

(1) Refer to paragraph 12-17 and remove the rocker cover.
(2) Place the governor speed control lever (fig. 12-32) in the no-fuel position.
(3) Rotate the crankshaft until the injector follower on number 1 cylinder is fully depressed.
(4) Loosen the push rod locknut (fig. 12-111).
(5) Place an 0.013 inch feeler gage (fig. 12-111) between valve stem and rocker arm.
(6) Adjust the push rod to obtain a smooth pull on the feeler gage. Remove the feeler gage.
(7) Hold the push rod with a 5/16 inch wrench and tighten the lock nut with a 1/2 inch wrench.
(8) Check the clearance again. If the clearance is correct a 0.011 inch feeler gage will pass freely between the valve stem and the rocker arm, but a 0.013 inch feeler gage will not.
(9) Set remaining seven exhaust valve clearances in the same manner in firing order (1-3-4-2) sequence.
(10) Start engine (TM 5-3805-237-12) and operate engine until engine reaches operating temperature (160° to 185°F). Stop engine.
(11) With engine at operating temperature, rotate crankshaft until injector follower on number 1 cylinder is fully depressed.
(12) Check valve clearance as described above and illustrated on figure 12-111. If valve clearance is correct, a 0.008 inch feeler gage will pass freely between rocker arm and valve stem but a 0.010 inch gage will not pass through. Adjust push rod if necessary to obtain this clearance.

*Note.* In making this adjustment it is important that engine is within operating temperature limits. If engine cools off before adjustments are completed, bring engine to operating temperature before continuing with adjustments.

(13) Check all valves in the same manner in firing order sequence.
(14) Refer to paragraph 12-17 and install the rocker cover.

### 12-49. Injector Timing Adjustment

*a. General.* The injectors are timed properly when the injector follower is adjusted to a definite height in relation to the injector body. This height varies with the type of injectors incorporated in the engine. All of the

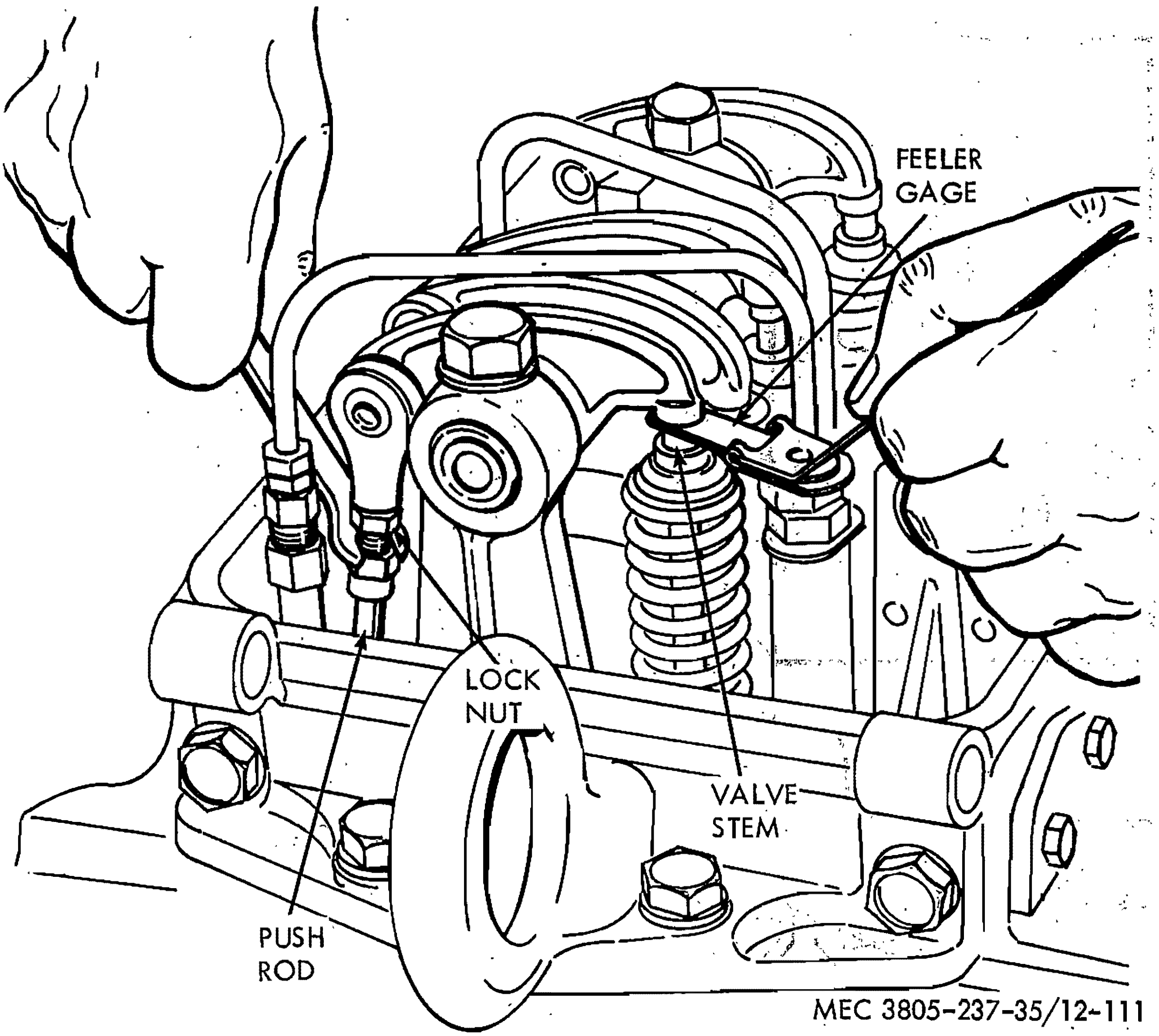



*Figure 12-111. Adjusting valve clearance.*

injectors should be timed in firing order sequence (1-3-4-2).

*b. Adjustment.*

(1) Place the governor speed control lever (fig. 12-32) in the no fuel position.

(2) Refer to paragraph 12-17 and remove the rocker cover.

(3) Rotate the crankshaft until the exhaust valves on number 1 cylinder are fully depressed.

(4) Place the small end of injector timing gage in the hole provided in top of injector body with the flat of the gage toward injector body as illustrated on figure 12-112.

*Note.* Inject timing gage has a timing dimension of 1.460 inches as shown in figure 12-112. The gage number is 72582-J1853, available from General Motors.

(5) Loosen the injector push rod lock nut (fig. 12-112). Turn the push rod and adjust the injector rocker arm until

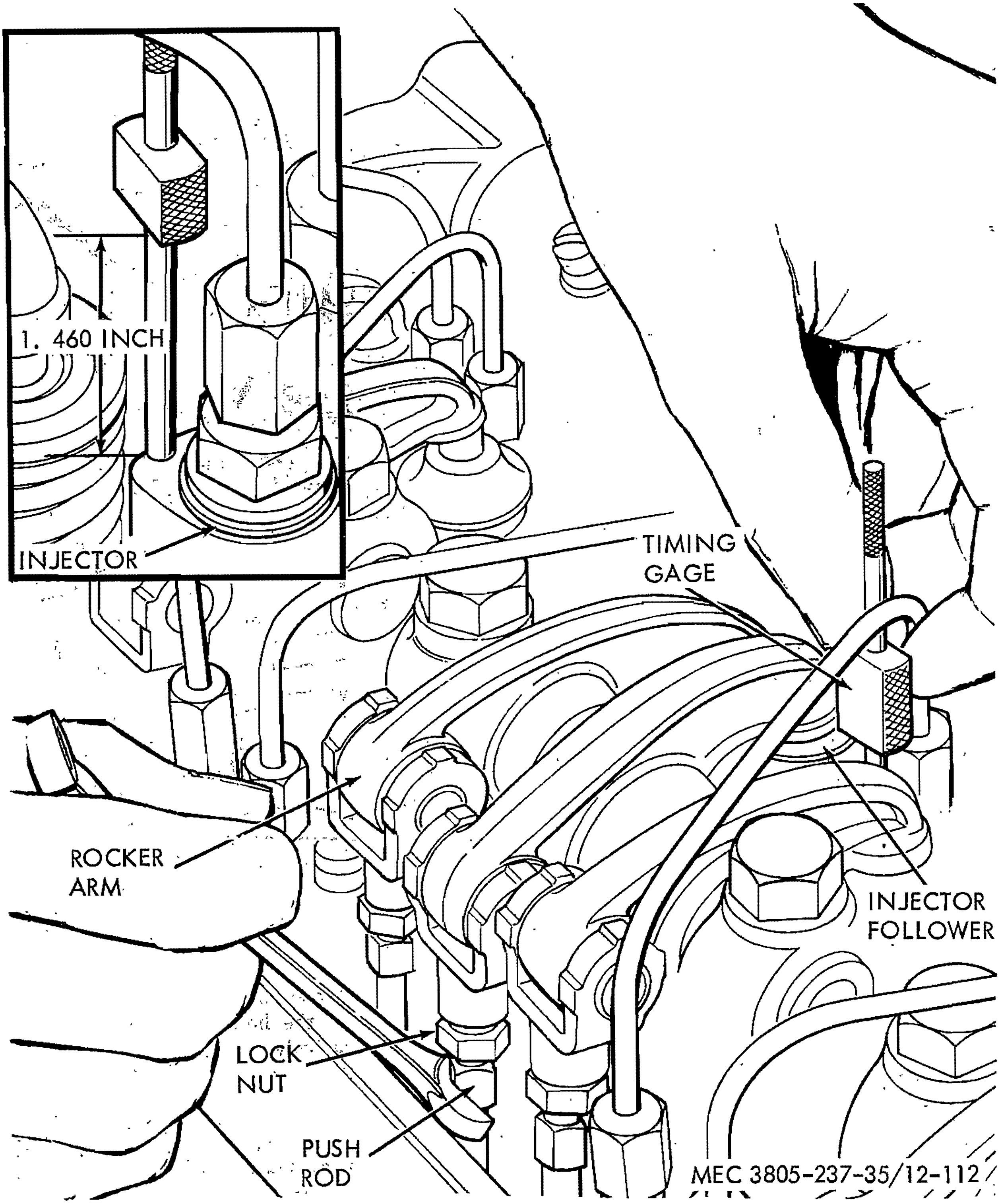



*Figure 12-112. Timing fuel injectors.*

the extended part of the follower will just pass over the top of the injector follower.

(6) Hold push rod and tighten locknut. Check the adjustment and, if necessary, readjust the push rod.

(7) Adjust the timing of the remaining three injectors in the same manner.

(8) Refer to paragraph 12-17 and install the rocker cover.

## 12-50. Injector Rack Control Adjustment

*a. General.* Properly positioned injector rack control levers determine the amount of fuel injected into each cylinder and equalizes distribution of the load. The control levers must be positioned with the governor at the full load setting.

*b. Adjustment.*

(1) Adjust governor gap (para 12-51).

(2) Refer to paragraph 12-17 and remove the rocker cover.

(3) Disconnect throttle linkage from governor stop lever (para 12-18).

(4) Loosen the locknut (fig. 12-114) and back out buffer screw (fig. 12-114) approximately 5/8 inch.

(5) Loosen all eight inner and outer control lever adjusting screws (fig. 12-113).

(6) Move the governor speed control lever (fig. 12-113) to the maximum speed position (all the way back).

(7) Move governor stop lever (fig. 12-113) to the run position (forward). Hold lever in run position with light finger pressure.

(8) Turn inner adjusting screw (fig. 12-113) on number 1 injector rack control lever down until a step up in effort to hold the stop lever in run position is noted. This places number 1 injector rack in the full fuel position.

(9) Turn down outer adjusting screw (fig. 12-113) until it bottoms lightly on injector control tube.

(10) Alternately tighten inner and outer adjusting screws to hold adjustment.

*Note.* The above step should result in placing governor linkage and control tube in the same positions they will attain when running at full load.

(11) Check adjustment as follows:

(*a*) Hold the stop lever (fig. 12-113) in the run position.

(*b*) Press down on the rack control lever (fig. 12-113) with a screw driver or finger tip, causing the injector control tube to rotate. When control lever is released, injector rack should return to its original position. If rack does not return to its original position, setting is too loose. To correct, back off outer adjusting screw (fig. 12-113) slightly and tighten inner adjusting screw slightly.

(*c*) Setting is too tight if, when moving governor stop lever (fig. 12-113) from the stop to the run position, the injector rack becomes tight before stop lever reaches the end of its travel. If this occurs back off inner adjusting screw slightly and tighten outer screw slightly.

(*d*) Continue adjustments above until injector control rack operates smoothly through its complete length of travel.

(*e*) Completion of these adjustments should establish number 1 injector control rack lever in full fuel position.

(12) With number 1 cylinder fuel injector adjusted as above, adjust remaining injectors as follows:

(*a*) Manually hold number 1 injector rack in the full fuel position (all the way in).

(*b*) Turn inner adjusting screw on number 2 control lever down until number 2 injector rack has moved into the full fuel position and adjusting screw is bottoming on injector control tube.

(*c*) Turn outer adjusting screw down until it bottoms lightly on control tube. Alternately tighten both

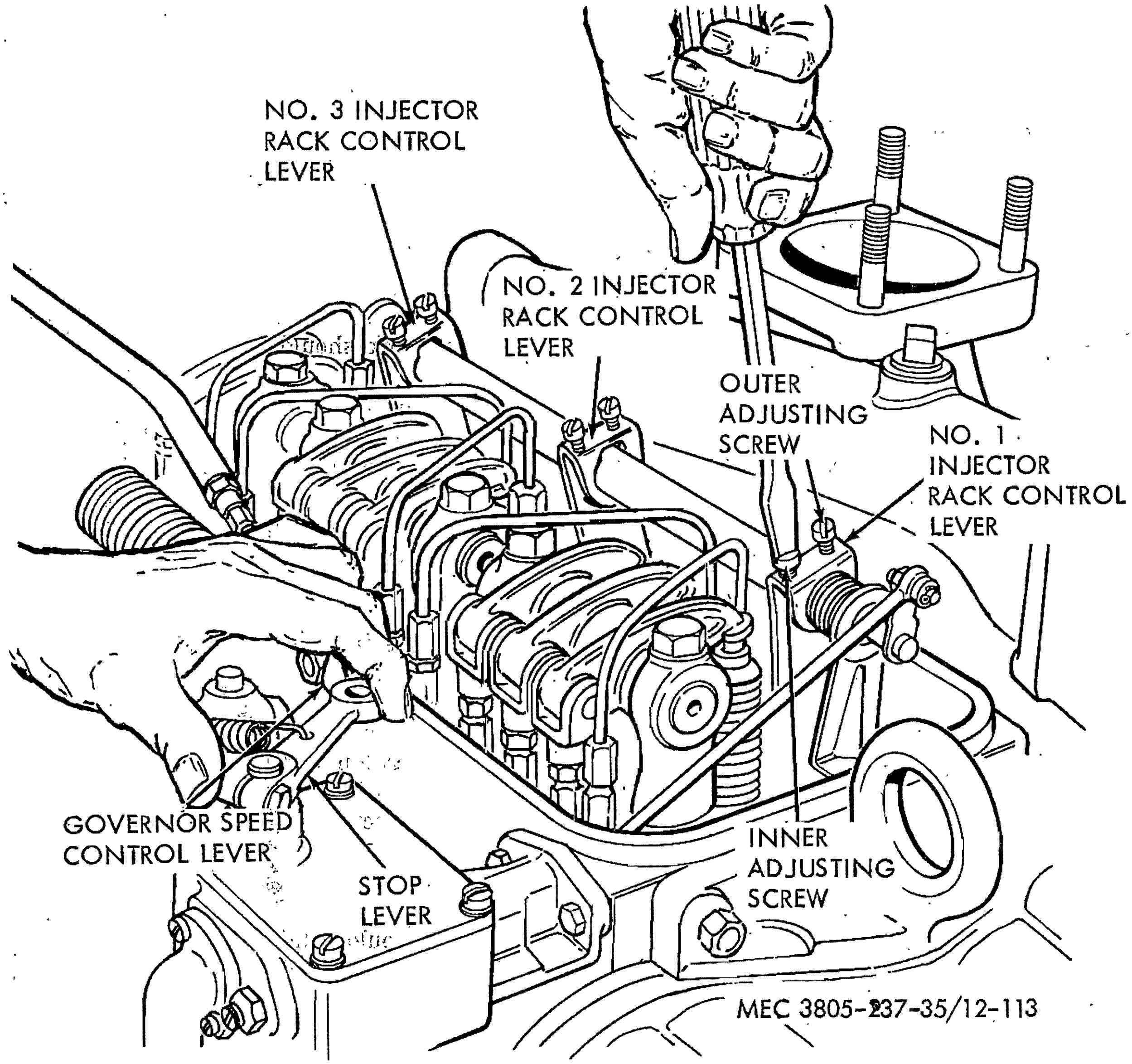



*Figure 12-113. Adjusting injector rack control lever.*

inner and outer adjusting screws until tight.

(*d*) Recheck number 1 injector rack to be sure it has remained snug on the ball end of the control levers while positioning number 2 rack. If rack on number 1 injector has become loose, back off inner adjusting screw on number 2 control lever slightly and tighten outer adjusting screw slightly.

*Note.* Do not change setting of number 1 injector control lever and rack while adjusting remaining control levers.

(*e*) Continue adjustments until number 2 injector rack functions in accordance with number 1 injector rack.

(13) Adjust two remaining injectors in the same manner.

(14) Refer to paragraph 12-17 and install the rocker cover.

(15) Refer to paragraph 12-18 and connect linkage to stop lever.

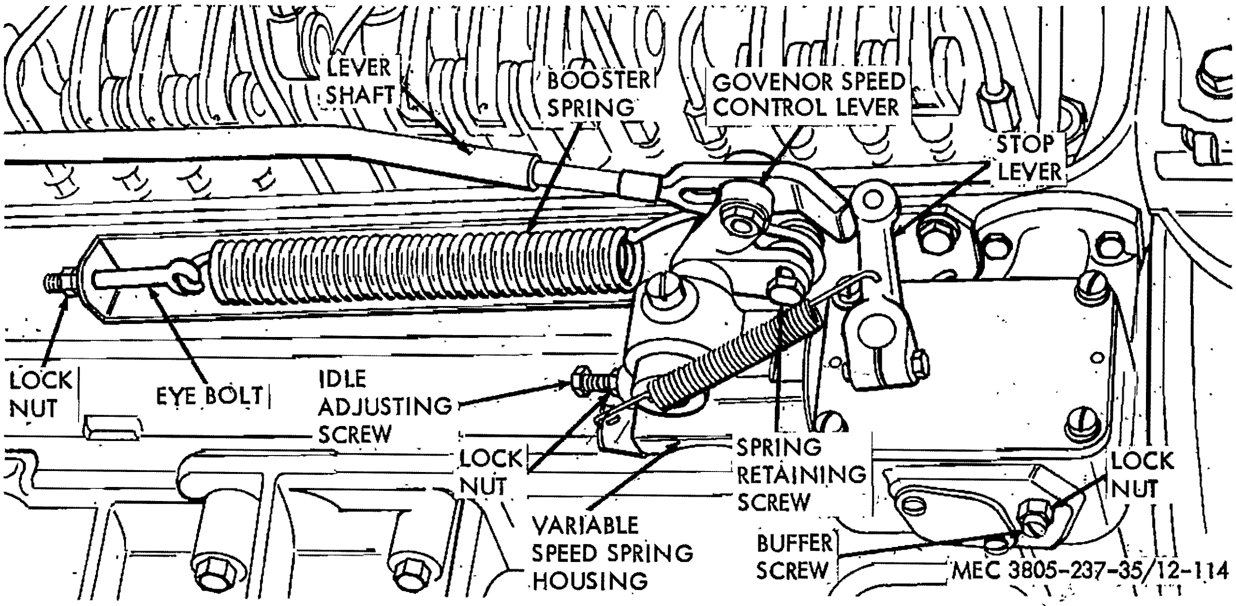



*Figure 12-114. Governor adjustment points.*

## 12-51. Governor Gap Adjustment

*a. General.* When the governor speed control lever is at full fuel position a gap must be maintained between the spring plunger and the plunger guide in the governor control housing.

*b. Adjustment.* With the engine stopped, adjust the governor gap as follows.

(1) Refer to paragraph 12-19 and remove the governor cover.

(2) Set the governor speed control lever (fig. 12-115) in the full fuel position (all the way back).

(3) Insert a 0.006 inch feeler gage between the spring plunger (fig. 12-115) and the plunger guide. Check pressure on feeler gage.

(4) If necessary, loosen locknut (fig. 12-115) and turn adjusting screw (fig. 12-115) in or out until a slight drag is felt on the feeler gage.

(5) Hold the adjusting screw and tighten locknut to secure adjustment. Check gap, after tightening nut, to be sure gap is correct. Readjust if necessary.

(6) Refer to paragraph 12-19 and install governor cover.

## 12-52. Maximum No-Load Speed Adjustment

*a. General.* Maximum no-load speed on engines equipped with variable speed governors must not be less than 125 rpm or more than 150 rpm above the recommended full load speed of 1975 rpm.

*b. Adjustment.*

(1) Operate engine (TM 5-3805-237-12) and allow engine to reach operating temperature (160° to 185° F).

(2) With a hand tachometer, determine the maximum no-load speed of the engine.

(3) If no-load speed is below 2100 rpm no adjustment is required.

(4) If no-load speed is above 2100 rpm adjust as follows:

(*a*) Disconnect the booster spring (fig. 12-114) and return spring.

(*b*) Refer to paragraph 12-19 and remove the variable speed spring housing (fig. 12-114) from the governor control housing.

(*c*) Disassemble the variable speed spring housing (fig. 12-42) and remove or install retainer stops (7

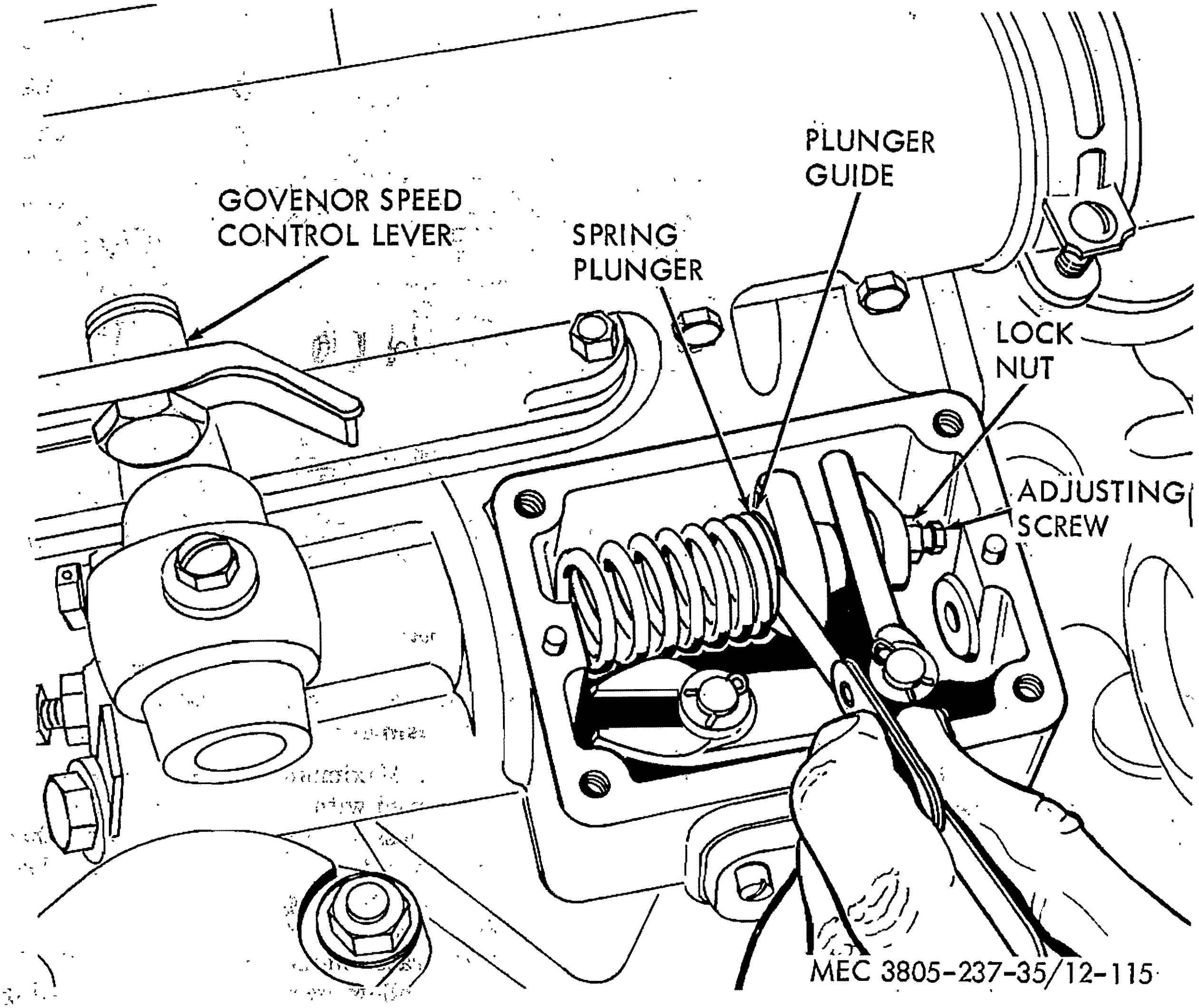



*Figure 12-115. Adjusting governor gap.*

and 8, fig. 12-42) or shims (9, fig. 12-42) to attain speed required.

*Note.* For each 0.001 inch shim thickness added the operating speed will increase one rpm. Shims are available in 0.010 inch and approximately 0.078 inch thicknesses.

(*d*) Install variable speed spring housing (para 12-19) and connect springs. Check maximum no-load speed. Readjust with shims and stops, if necessary, to obtain required speed.

*Note.* If no-load speed is raised or lowered more than 50 rpm by installation or removal of shims, check governor gap setting (para 12-51) and adjust if necessary. If governor gap required adjustment, check injector control lever settings (para 12-50).

### 12-53. Idle Speed Adjustment

*a. Genral.* After adjusting the maximum no-load speed, adjust the idle speed. The recommended idle speed is 500 to 600 rpm.

*b. Adjustment.*

(1) Start the engine (TM 5-3805-237-12) and run the engine until it reaches

operating temperature (160° to 185° F).

(2) Place governor speed control lever (fig. 12-114) in the idle position and the governor stop lever in the run position.

(3) Loosen locknut (fig. 12-114) and back out the buffer screw (fig. 12-114).

(4) Loosen locknut and back out idle speed adjusting screw (fig. 12-114) until engine is operating at approximately 15 rpm below desired idle speed.

(5) Hold locknut and tighten adjusting screw.

(6) Adjust buffer screw (para 12-54).

## 12-54. Buffer Screw Adjustment

*a. Genral.* After adjusting the idle speed the buffer screw must be adjusted to compensate for the 15 rpm required to bring idle speed to desired limits.

*b. Adjustment.*

(1) If not already loosened, loosen buffer screw locknut (fig. 12-114).

(2) Turn buffer screw (fig. 12-114) in until engine is operating at recommended idle speed.

*Note.* Do not raise idle speed more than 15 rpm with buffer screw.

(3) Hold buffer screw and tighten locknut.

## 12-55. Booster Spring Adjustment

*a. General.* With the idle speed and buffer screw adjusted, the booster spring must be adjusted. The booster spring (fig. 12-114) helps move the governor speed control lever.

*b. Adjustment.*

(1) Loosen booster spring retaining nut on the governor speed control lever.

(2) Loosen nut and locknut on the eyebolt (fig. 12-114) at the other end of the booster spring.

(3) Move spring retaining screw (fig. 12-114) up or down in slot in governor speed control lever until center of screw is on or slightly below an imaginary line through the center of the screw, the lever shaft (fig. 12-114) and the eye bolt. Hold the screw in position and tighten the locknut.

(4) Start the engine (TM 5-3805-237-12) and move the governor speed control lever (fig. 12-114) to maximum speed position (all the way back).

(5) Release the governor speed control lever. The lever should return to idle position. If lever does not return to idle position, reduce the spring tension by loosening nut on eye bolt.

(6) If lever does return to idle position, increase spring tension by tightening nut on eye bolt. Move governor speed control lever to full speed position and release. Keep increasing spring tension until a point is reached where governor control lever will not return to idle position.

(7) Loosen nut on eye bolt until lever will return to idle position. Tighten locknut on eye bolt.

(8) Adjusting booster spring in this manner will result in a minimum of force required to operate governor speed control lever.

# Section XIV. ENGINE RUN-IN INSTRUCTIONS

## 12-56. General

*a.* Whenever the engine has been completely overhauled or has had any major repair operation such as installation of piston rings, pistons, cylinder liners, or bearings, the engine should be run-in before being placed in service. The run-in operation will aid in uncovering any malfunctions which could crop up after repair and will break the engine in to be ready for service.

*b.* The run-in should be accomplished with the engine coupled to a dynamometer, if possible. If a dynamometer is not available use a driven mechanism as a load. For run-in purposes the engine could be installed in the motor grader and operated through the run-in schedule if necessary.

## 12-57. Engine Run-In Schedule

*a. General.* Peform the following operations before starting the engine after an overhaul.

(1) If not already performed, perform or check the following adjustments.
  (*a*) Exhaust valve clearance (cold engine) (para 12-48).
  (*b*) Injector timing (para 12-49).
  (*c*) Governor adjustments (para 12-51 through 12-55).

(2) Check drain plugs in cooling system to see that they are all installed and fill the cooling system with coolant (TM 5-3805-237-12).

(3) Remove the rocker cover (para 12-17) and pour approximately two quarts of engine oil (OE) over the rocker arms and push rods. Refer to current LO for correct grade of oil. Install rocker cover (para 12-17).

(4) Fill crankcase with correct grade of engine oil (OE) to the full mark on the dipstick. Refer to current LO.

(5) Prime the fuel filter (para 12-15) and fill the fuel tank with fuel oil.

(6) Refer to TM 5-3805-237-12 and check grader for maintenance that may have to be per formed before using grader to test engine.

*b. Preparation for Run-In.*

(1) Start the engine (TM 5-3805-237-12).

(2) Immediately after starting, check engine oil pressure. If there is no oil pressure, stop the engine. Check the lubricating system. Start engine and check oil pressure. Pressure should be 30 to 60 psi.

(3) Run the engine at approximately half throttle for five minutes or until engine reaches operating temperature.

*c. Run-In Schedule.*

(1) Run the engine for 15 minutes at a 15% of rated load. Speed should be 1200 rpm. Stop engine.
  (*a*) Check valve clearance (hot engine) as described in paragraph 12-48.
  (*b*) Check injector timing as described in paragraph 12-49.
  (*c*) Check governor adjustments as described in paragraphs 12-51 through 12-55.

(2) Start the engine and run at 50% of rated load for one hour at 1,400 rpm.

(3) Advance load to 75% of rated load and increase speed to 1,600 rpm and run engine for one hour.

(4) Place 100% of rated load on the engine and operate engine at 1800 rpm for 30 minutes. Stop engine.
  (*a*) Perform checks listed under (1) above on valves, injectors and governor.
  (*b*) Inspect engine for oil and water leaks. Correct any leaks that are in evidence.
  (*c*) Tighten all external screws on engine.

(5) Start engine and run at 100% of rated load at governed speed for 30 minutes.

(6) Maintain a close check on oil pressure and engine temperature during engine run-in.
  (*a*) A minimum engine temperature of 160°F should be maintained during run-in.
  (*b*) Engine oil pressure should be at least 18 psi at 1,200 rpm and 24 psi or over at 1,600 rpm. Normal pressure will be considerably higher.

*d. After Run-In Procedures.*

(1) Change lubricating oil and install new oil filter element (TM 5-3805-237-12) after run-in to remove any metallic or foreign material accumulated during this period.

(2) Check all accessories and applications for proper installation and operation.

(3) Check valve clearances (para 12-48), injector timing (para 12-49), and governor adjustments (para 12-51 through 12-55).

# APPENDIX A

# REFERENCES

## A-1. Operating Instructions

| | |
|---|---|
| TM 5-3805-237-12 | Operator and Organizational Maintenance. Grader, Road, Motorized: Diesel Engine Driven; 13,300 Lb Pressure at Blade: 6 Wheels, 4 Driving, 2 Steerable, Leaning Front Wheels: w/Scarifier (Le Tourneau—Westinghouse Model 440HA) FSN 3805-931-7881. |

## A-2. Maintenance

| | |
|---|---|
| TB ENG 347 | Winterization Techniques for Engineer Equipment. |
| TM 9-207 | Operation and Maintenance of Army Materiel in Extreme Cold Weather. |
| TM 9-6140-200-15 | Maintenance Storage Batteries—Lead Acid Type. |
| TM 38-750 | Army Equipment Record Procedures. |

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 TM 5-3805-237-35

By Order of the Secretary of the Army:

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*NG:* State AG (3).

*USAR:* Same as Active Army allowance is one (1) copy each.

For explanation of abbreviations used, see AR 320-50.

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