TM 9-1787B

RESTRICTED

WAR DEPARTMENT

U.S. Dept. of Army

TECHNICAL MANUAL

# ORDNANCE MAINTENANCE
# HEAVY TRACTOR M1
# (ALLIS-CHALMERS HD-10W)
# ENGINE ACCESSORIES

APRIL 3, 1943

FOR ORDNANCE PERSONNEL ONLY

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# HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W)
# ENGINE ACCESSORIES

Prepared under the direction of the
Chief of Ordnance

(with the cooperation of the Allis-Chalmers Manufacturing Company)

## CONTENTS

## ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

# CHAPTER 1

# INTRODUCTION

Paragraph



## 1. PURPOSE AND SCOPE.

**a.** The instructions contained in this manual are for the information and guidance of the personnel charged with the maintenance and repair of the Heavy Tractor M1 (Allis-Chalmers HD-10W). Information on the detailed construction of the unit, disassembly and assembly procedure, inspection, maintenance and repair is contained in four Technical Manuals of which this is the second. The first manual (TM 9-1787A) contains a description of and procedure for removing the engine from the tractor, removal of accessories from the engine, disassembly, inspection, trouble shooting, repair and assembly of subassemblies, installation of accessories and installation of the engine back in the tractor. This manual on the accessories for the engine contains a description of and procedure for the removal, disassembly, inspection, trouble shooting, repair, assembly and installation of the master clutch and the various units outlined in the fuel and air system, cooling system, electrical system, lubrication system, exhaust manifold and muffler, governor and controls, and engine and air heaters. The third manual (TM 9-1787C) contains a description of and procedure for the disassembly, inspection, trouble shooting, repair and assembly of the power train, frame assembly, seats and equipment listed for the Heavy Tractor M1.

## 2. CONTENT AND ARRANGEMENT OF MANUAL.

**a.** Chapter 2 defines the various maintenance terms used in this manual and allocates the various maintenance operations in the proper echelons. Chapter 3 contains description and trouble shooting of the master clutch, and outlines procedures for removal, disassembly, maintenance and repairs, assembly, installation, and clutch brake adjustment. Chapters 4 to 10 contain a general description, trouble shooting, removal, disassembly, inspection and repair, assembly, installation, and special tools of the various units outlined in the fuel and air system, cooling system, electrical system, lubrication system, exhaust manifold and muffler, governor and controls, and engine and air heaters respectively. In TM 9-1787A, the procedure for removal and installation of accessories with the engine removed from the tractor was outlined. In this manual the procedure for removing and installing the individual accessories with the engine in the tractor is explained. The specifications for fits and tolerances, if any, as well as special tools and equipment required for each assembly, are listed at the end of each section.

### 3. REFERENCES.

**a.** Chapter 11 at the end of this technical manual lists all Standard Nomenclature Lists, Technical Manuals and other publications for the materiel described herein.

# CHAPTER 2

## MAINTENANCE ALLOCATION



### 4. SCOPE.

**a.** The scope of maintenance and repair by the crew and other units of the using arms is determined by the availability of suitable tools, availability of necessary parts, capabilities of the mechanics, time available and the tactical situation. All of these are variable and no exact system of procedure can be prescribed.

### 5. ALLOCATION OF MAINTENANCE.

**a.** Indicated below are the maintenance duties for which tools and parts have been provided for the using arm personnel. Other replacements and repairs are the responsibility of ordnance maintenance personnel but may be performed by using arm personnel when circumstances permit, within the discretion of the commander concerned. Echelons and words as used in this list of maintenance allocations are defined as follows:

(1) SECOND ECHELON: Line organization regiments, battalions, companies, detachments, and separate companies.

(2) THIRD ECHELON: Ordnance light maintenance companies, ordnance medium maintenance companies, ordnance divisional maintenance battalions and post ordnance shops.

(3) FOURTH ECHELON: Ordnance heavy maintenance companies and service command shops.

(4) FIFTH ECHELON: Ordnance base regiments, ordnance bases, arsenals and manufacturers' plants.

(5) SERVICE (Including preventive maintenance) (Refer to AR 850-15, par. 23 **a** (1) and (2)): Consists of servicing, cleaning, lubricating, tightening bolts and nuts and making external adjustments of subassemblies or assemblies and controls.

(6) REPLACE (Refer to AR 850-15, par. 23 **a** (4)): Consists of removing the part, subassembly or assembly from the vehicles and replacing it with a new or reconditioned or rebuilt part, subassembly or assembly, whichever the case may be.

(7) REPAIR (Refer to AR 850-15, par. 23 **a** (3) and (5), in part): Consists of making repairs to, or replacement of the part, subassembly or

assembly that can be accomplished without completely disassembling the subassembly or assemblies, and does not require heavy welding, or riveting, machining, fitting and/or alining or balancing.

(8) REBUILD (Refer to AR 850-15, par. 23 a (5) in part and (6)): Consists of completely reconditioning and replacing in serviceable condition any unserviceable part, subassembly or assembly of the vehicle, including welding, riveting, machining, fitting, alining, balancing, assembling and testing.

| CLUTCH, MASTER, ASSEMBLY | ECHELONS 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Clutch assembly—service (adjust) | X | | | |
| Clutch assembly—replace | E | X | | |
| Clutch assembly—repair (reline) | | X | | |
| Clutch assembly—rebuild | | | E | X |
| Controls and linkage (external)—replace | X | | | |
| Controls and linkage (internal)—replace | | X | | |
| Controls and linkage (external and internal)—repair | | X | | |
| **COOLING SYSTEM** | | | | |
| Connections, radiator to engine—service and replace | X | | | |
| Cooler, oil, assembly—replace | X | | | |
| Cooler, oil, assembly—repair | | X | | |
| Cooler, oil, assembly—rebuild | | | E | X |
| Cooling system—service (flush) | X | | | |
| Radiator assembly—replace | X | | | |
| Radiator assembly—repair | | X | | |
| Radiator assembly—rebuild | | | E | X |
| Shutter and controls, radiator—replace | X | | | |
| Shutter and controls, radiator—repair | | X | | |
| **DRIVE, FINAL, ASSEMBLIES** | | | | |
| Drive, final, assemblies—replace | E | X | | |
| Drive, final, assemblies—repair | | X | | |
| Drive, final, assemblies—rebuild | | | E | X |
| Sprockets, final drive—replace | E | X | | |
| Sprockets, final drive—repair | | X | | |
| Sprockets, final drive—rebuild | | | E | X |

See explanatory notes on page 12.

# MAINTENANCE ALLOCATION

## ELECTRICAL SYSTEM

| | Echelons 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Batteries—service, recharge or replace | X | | | |
| Batteries—repair | | X | | |
| Batteries—rebuild | | | E | X |
| Box, apparatus (generator control)—replace | X | | | |
| Box, apparatus (generator control)—repair | | X | | |
| Cables, battery—replace | X | | | |
| Cables, battery—repair | E | X | | |
| Conduits, fuses and wiring, electrical—replace | X | | | |
| Conduits and wiring, electrical—repair | E | X | | |
| Harness, wiring (all)—replace | X | | | |
| Harness, wiring (all)—repair | E | X | | |
| Lamps (all)—service and replace | X | | | |
| Lamps (all)—repair | | X | | |
| Switches (all)—replace | X | | | |
| Switches (all)—repair | | X | | |

## ENGINE

(General Motors Diesel, 471)

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Bearings, connecting rod (inserts)—replace | | E | E | X |
| Bearings, crankshaft (inserts)—replace | | E | E | X |
| Belts—service (adjust) and replace | X | | | |
| Block assembly and cylinder sleeves—rebuild (recondition) | | | E | X |
| Blower assembly—replace | X | | | |
| Blower assembly—repair | | X | | |
| Blower assembly—rebuild | | | E | X |
| Controls and linkage—replace | X | | | |
| Controls and linkage—repair | | X | | |
| Crankshaft—rebuild (recondition) | | | E | X |
| *Engine assembly—replace | * | X | | |
| Engine assembly—repair | | X | | |
| Engine assembly—rebuild | | | E | X |
| Fan assembly—replace | X | | | |
| Fan assembly—repair | | X | | |
| Fan assembly—rebuild | | | X | |
| Filter, oil, assemblies—service (clean) and replace | X | | | |
| Filter, oil, assemblies—repair | | X | | |
| Flywheel assembly—replace or repair | | X | | |
| Flywheel assembly—rebuild (recondition) | | | E | X |

See explanatory notes on page 12.

| ENGINE (Continued) | ECHELONS 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Gaskets (handhole cover, lower pan, manifold and valve cover)—replace | X | | | |
| Gear, timing, train—replace | | X | | |
| Generator assembly—replace | X | | | |
| Generator assembly—repair | | X | | |
| Generator assembly—rebuild | | | X | |
| Governor assembly—service (adjust), replace or repair | | X | | |
| Governor assembly—rebuild | | | E | X |
| Head, cylinder, assembly—replace or repair | | X | | |
| Head, cylinder, assembly—rebuild (recondition) | | | E | X |
| Heater, air box, assembly—replace | X | | | |
| Heater, air box, assembly—repair | | X | | |
| Heater, air box, assembly—rebuild | | | E | X |
| Housing, flywheel, assembly—replace | | X | | |
| Housing, flywheel, assembly—rebuild (recondition) | | | E | X |
| Injector assembly—replace | X | | | |
| Injector assembly—repair | | X | | |
| Injector assembly—rebuild | | | E | X |
| Lines and connections, oil (external)—replace | X | | | |
| Lines and connections, oil (external)—repair | E | X | | |
| Lines and connections, oil (internal)—replace or repair | | X | | |
| Manifold, exhaust—replace | X | | | |
| Manifold, exhaust—repair | | X | | |
| Manifolds and connectors, fuel—replace | X | | | |
| Manifolds and connectors, fuel—repair | E | X | | |
| Motor, starting, assembly—replace | X | | | |
| Motor, starting, assembly—repair | | X | | |
| Motor, starting, assembly—rebuild | | | X | |
| Pan, oil (lower)—service (clean) and replace | X | | | |
| Pan, oil (upper)—replace | | X | | |
| Pan, oil (lower or upper)—repair | | X | | |
| Pistons and rings—replace | | E | E | X |
| Pump, fuel, assembly—replace | X | | | |
| Pump, fuel, assembly—repair | | X | | |
| Pump, fuel, assembly—rebuild | | | X | |
| Pump, oil, assembly—replace | E | X | | |
| Pump, oil, assembly—repair | | X | | |

See explanatory notes on page 12.

## MAINTENANCE ALLOCATION

### ENGINE (Continued)

| | ECHELONS 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Pump, oil, assembly—rebuild | | | X | |
| Pump, water, assembly—replace | X | | | |
| Pump, water, assembly—repair | | X | | |
| Pump, water, assembly—rebuild | | | X | |
| Rod, connecting, assembly—replace | | E | E | X |
| Sleeve, cylinder—replace | | E | E | X |
| Thermostat—replace | X | | | |
| Valve clearance—service (adjust) | X | | | |

### EXHAUST SYSTEM

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Muffler and pipes—replace | X | | | |

### EXTINGUISHER, FIRE

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Extinguisher, fire (carbon dioxide—$CO_2$)—replace | X | | | |
| Extinguisher, fire (carbon dioxide—$CO_2$) — service (recharge) and repair | | X | | |
| Extinguisher, fire (carbon dioxide—$CO_2$)—rebuild | | | E | X |
| Extinguisher, fire (carbon tetrachloride—$CCl_4$)—service (refill) and replace | X | | | |
| Extinguisher, fire (carbon tetrachloride—$CCl_4$)—repair | | X | | |
| Extinguisher, fire (carbon tetrachloride—$CCl_4$)—rebuild | | | E | X |

### FRAME, TRUCK

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Crank, stabilizer, assemblies—replace | X | | | |
| Crank, stabilizer, assemblies—repair | | X | | |
| Crank, stabilizer, assemblies—rebuild | | | E | X |
| Frame, truck, components—replace | X | | | |
| Frame, truck, components—repair | | X | | |
| Frame, truck, components—rebuild | | | E | X |
| Idler, track front, assemblies—replace | X | | | |
| Idler, track front, assemblies—repair | | X | | |
| Idler, track front, assemblies—rebuild | | | E | X |
| Mechanism, track adjusting—service (adjust) and replace | X | | | |
| Mechanism, track adjusting—repair | | X | | |
| Mechanism, track adjusting—rebuild | | | E | X |
| Roller, track support, assemblies—replace | X | | | |

See explanatory notes on page 12.

ORDNANCE MAINTENANCE — HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

| FRAME, TRUCK, (Continued) | Echelons 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Roller, track support, assemblies—repair |  | X |  |  |
| Roller, track support, assemblies—rebuild |  |  | E | X |
| Spring, stabilizer, assembly—replace | X |  |  |  |
| Spring, stabilizer, assembly—repair |  | X |  |  |
| Spring, stabilizer, assembly—rebuild |  |  | E | X |
| Track assemblies—replace or repair | X |  |  |  |
| Track assemblies—rebuild |  |  | E | X |
| Wheel, truck, assemblies—replace | X |  |  |  |
| Wheel, truck, assemblies—repair |  | X |  |  |
| Wheel, truck, assemblies—rebuild |  |  | E | X |
| **FUEL SYSTEM** |  |  |  |  |
| Cleaners and connections, air—service (clean) and replace | X |  |  |  |
| Cleaners and connections, air—repair |  | X |  |  |
| Filters, fuel—service and replace | X |  |  |  |
| Filters, fuel—repair |  | X |  |  |
| Lines and connections, fuel—service (clean) and replace | X |  |  |  |
| Lines and connections, fuel—repair | E | X |  |  |
| Pump, air box heater, assembly—replace | X |  |  |  |
| Pump, air box heater, assembly—repair |  | X |  |  |
| Tank, fuel, assembly—service (clean) and replace | X |  |  |  |
| Tank, fuel, assembly—repair |  | X |  |  |
| **GEAR TRAIN AND MAIN FRAME ASSEMBLY** |  |  |  |  |
| Bands, brake, steering clutch—service (adjust) | X |  |  |  |
| Bands, brake, steering clutch—replace or repair (reline) |  | X |  |  |
| Case, power take-off, assembly—replace | X |  |  |  |
| Case, power take-off, assembly—repair |  | X |  |  |
| Case, power take-off, assembly—rebuild |  |  | X |  |
| Clutch, steering, assemblies—service (adjust) | X |  |  |  |
| Clutch, steering, assemblies—replace or repair |  | X |  |  |
| Clutch, steering, assemblies—rebuild |  |  | E | X |
| Controls and linkage (external)—replace | X |  |  |  |
| Controls and linkage (internal)—replace |  | X |  |  |
| Controls and linkage (external or internal)—repair |  | X |  |  |

See explanatory notes on page 12.

## MAINTENANCE ALLOCATION

### GEAR TRAIN AND MAIN FRAME ASSEMBLY (Continued)

| | ECHELONS 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Draw-bar assembly—replace | X | | | |
| Draw-bar assembly—repair | | X | | |
| Gear, bevel, assembly—service (adjust) and replace | | X | | |
| Guard, crankcase—replace | X | | | |
| Guard, crankcase—repair | | X | | |
| Hook, towing—replace | X | | | |
| Hook, towing—repair | | X | | |
| Pintle assemblies—replace | X | | | |
| Pintle assemblies—repair | | X | | |
| Pintle assemblies—rebuild | | | E | X |
| Spacer, engine support, assembly—replace or repair | | X | | |
| Support, engine, assembly—replace or repair | | X | | |
| Support, pintle—replace | X | | | |
| Support, pintle—repair | | X | | |
| Transmission components—replace or repair | | X | | |
| Transmission components—rebuild | | | E | X |

### INSTRUMENTS AND GAGES

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Instruments and gages—replace | X | | | |
| Instruments and gages—repair | | X | | |
| Instruments and gages—rebuild | | | E | X |
| Meter, hour, assembly—replace | X | | | |
| Meter, hour, assembly—repair | | X | | |
| Meter, hour, assembly—rebuild | | | E | X |
| Odometer assembly—replace | X | | | |
| Odometer assembly—repair | | X | | |
| Odometer assembly—rebuild | | | E | X |

### METAL, SHEET

| | 2nd | 3rd | 4th | 5th |
|---|---|---|---|---|
| Boxes, street plate and tool—replace | X | | | |
| Boxes, street plate and tool—repair | | X | | |
| Fenders and support assemblies—replace | X | | | |
| Fenders and support assemblies—repair | | X | | |
| Hood, top plate and doors—replace | X | | | |
| Hood, top plate and doors—repair | | X | | |
| Panel, dash and instrument, assembly—replace | X | | | |
| Panel, dash and instrument, assembly—repair | | X | | |
| Rack, luggage—replace | X | | | |

See explanatory notes on page 12.

# ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

| | ECHELONS | | | |
|---|---|---|---|---|
| METAL, SHEET (Continued) | 2nd | 3rd | 4th | 5th |
| Rack, luggage—repair | | X | | |
| Seat and seat frame—replace | X | | | |
| Seat and seat frame—repair | | X | | |
| **VEHICLE ASSEMBLY** | | | | |
| Tractor, heavy, M1 (HD-10-W)—service | X | | | |
| Tractor, heavy, M1 (HD-10-W)—rebuild (with serviceable assemblies) | | | X | E |
| **AUXILIARY EQUIPMENT: ENGINE PREHEATER ASSEMBLY** | | | | |
| Preheater, engine, assembly—service (refill) and replace | X | | | |
| Preheater, engine, assembly—repair | | X | | |
| Preheater, engine, assembly—rebuild | | | E | X |
| **WINCH ASSEMBLY** | | | | |
| Band, worm shaft safety brake—service (adjust) | X | | | |
| Band, worm shaft safety brake—replace (reline) | | X | | |
| Bearings, drive shaft—replace | X | | | |
| Cable and hook assembly—replace | X | | | |
| Cable and hook assembly—repair | | X | | |
| Chain, winch drive—service and replace | X | | | |
| Chain, winch drive—repair | | X | | |
| Drum, worm shaft safety brake—replace | X | | | |
| Drum, worm shaft safety brake—repair | | X | | |
| Pin, shear—replace | X | | | |
| Shaft, drive, assemblies (front and rear)—replace | X | | | |
| Shaft, drive, assemblies (front and rear)—repair | | X | | |
| Shaft, drive, assemblies (front and rear)—rebuild | | | X | |
| Winch assembly—replace | X | | | |
| Winch assembly—repair | | X | | |
| Winch assembly—rebuild | | | E | X |

NOTE: Operations allocated will normally be performed in the echelon indicated by "X."

Operations allocated to the echelons as indicated by "E" may be accomplished by the respective echelons in emergencies only.

NOTE: *The second echelon is authorized to remove and reinstall engine and transmission assemblies, transfer units, controlled differential assembly and other items marked by an asterisk. However, when it is necessary to replace an item marked by an asterisk with a new or rebuilt part, subassembly or unit assembly, the assembly marked by an asterisk may be removed from the vehicle by the second echelon *only after authority has been obtained from a higher echelon of maintenance.*

# CHAPTER 3

# MASTER CLUTCH



## 6. DESCRIPTION.

**a.** The master clutch is an over-center, cam-locking, lever-engaging type. A screw-thread adjustment between the adjusting ring and back plate provides the necessary adjustment to assure proper clutch operation. A driven disk, with friction lining on both sides, is riveted to a splined hub carried on the master clutch shaft. All other parts of the clutch except the release mechanism and clutch brake are bolted to the engine flywheel.

**b.** To engage the clutch, the pressure plate is forced forward against the driven disk by means of the control lever and linkage. This tightly clamps the clutch driven disk between the pressure plate and flywheel, thus transferring power from flywheel to driven disk, which carries it to the transmission. As the control lever is pulled all the way back, the over-center levers snap in to hold the clutch engaged until pressure on the control lever snaps them out to release the clutch. A flexible lubricating tube extends from outside the clutch housing to the release bearing for lubrication of the bearing. The shafts on which the three cams are mounted have rollers on each end, making operation easier. These shafts are equipped with pressure gun fittings for lubrication purposes.

## 7. TROUBLE SHOOTING.

**a. Slipping.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Improper adjustment. | (1) Adjust clutch. |
| (2) Oily facings. | (2) Wash out clutch. Inspect rear main bearing seal and wick in crankshaft for excess oil loss. Replace drive disk assembly if necessary. |

| Probable Cause | Probable Remedy |
|---|---|
| (3) Worn or glazed facings. | (3) Replace drive disk assembly. |
| (4) Warped pressure plate. | (4) Machine face or replace. |

**b. Does Not Engage.**

| | |
|---|---|
| (1) Facing torn off. | (1) Install new drive disk assembly. |
| (2) Release bearing failure. | (2) Install new bearings. |
| (3) Adjusting lock worked loose. | (3) Adjust clutch and inspect locking lug. |
| (4) Clutch adjustment too tight. | (4) Adjust clutch. |

**c. Hard to Operate.**

| | |
|---|---|
| (1) Clutch cams dry. | (1) Lubricate pressure lubrication fittings on cam assemblies. |
| (2) Warped pressure plate. | (2) Machine face or replace. |
| (3) Throw-out bearing or clutch sleeve dry. | (3) Lubricate the bearing which also lubricates the sleeve and shaft. |
| (4) Linkage worn. | (4) Install new parts and lubricate with engine oil. |
| (5) Linkage binding. | (5) Clean and lubricate. |
| (6) Facing torn off. | (6) Replace drive disk assembly. |

**d. Clutch Disengages when in Operation.**

| | |
|---|---|
| (1) Pressure plate worn in cam guides. | (1) Install new pressure plate. |
| (2) Cam blocks worn. | (2) Install new cam blocks. |
| (3) Camshaft rollers and assemblies worn. | (3) Install new assemblies. |

**e. Noise, Rattles or Squeaks.**

| | |
|---|---|
| (1) Pilot bearing failure. | (1) Replace bearing and, if caused by lack of lubrication, replace wick in crankshaft. |
| (2) Release bearing failure. | (2) Replace bearing and inspect lubricating tube for breaks. |
| (3) Worn clutch shaft splines. | (3) Replace clutch shaft. |

**f. Clutch Will Not Disengage.**

| | |
|---|---|
| (1) Pilot bearing failure (bearing "seized"). | (1) Replace bearing and inspect wick in crankshaft. |

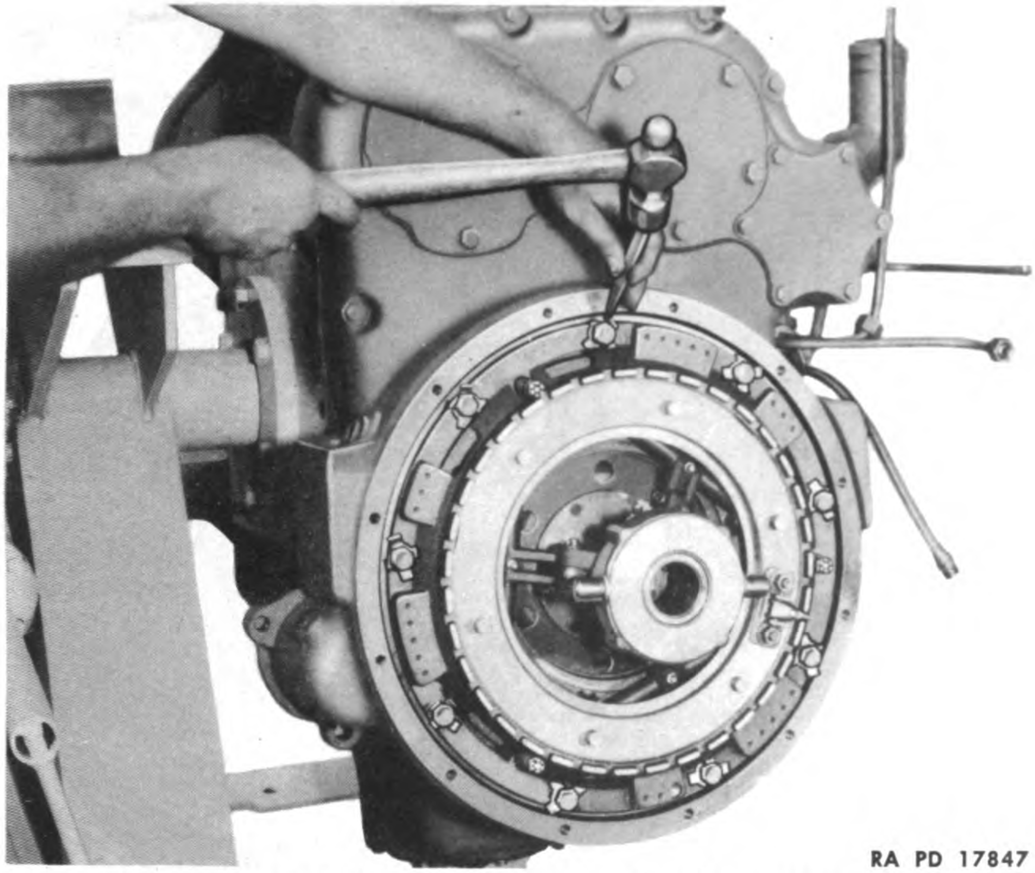

RA PD 17847

*Figure 1 — Straightening Screw Lock to Remove Clutch*

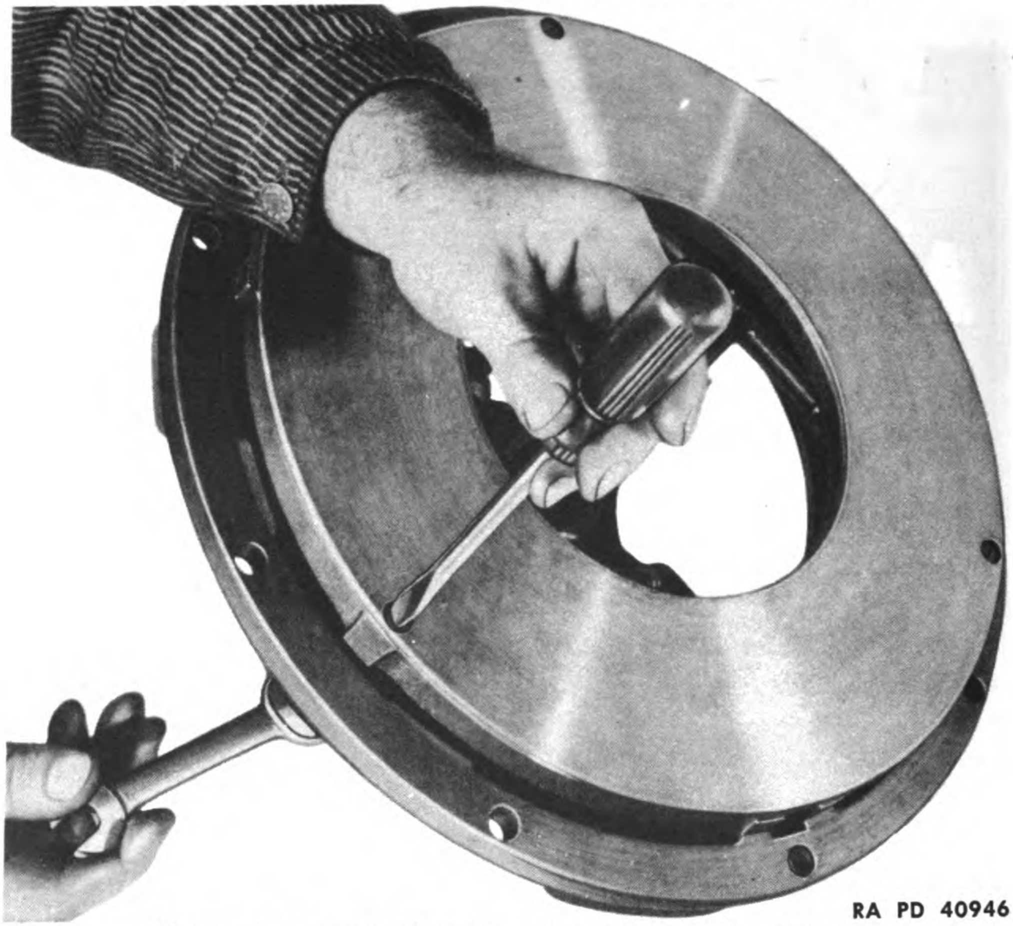
## 8. REMOVAL.

### a. Equipment.

CHISEL, ¾-in.
HAMMER, 2-lb.
HOIST, chain
PLIERS
PUNCH, 10-in.
ROPE, for lifting engine
SCREWDRIVER, 6-in.
WRENCH, box-socket, 9/16-in. with 90° offset
WRENCHES, two, 7/16-in.
WRENCHES, two, ¾-in.
WRENCH, 1-in.
WRENCH, open-end, ⅜-in.
WRENCH, open-end, ½-in.
WRENCH, open-end, 9/16-in.
WRENCH, open-end, ⅝-in.
WRENCH, open-end, 11/16-in.
WRENCH, open-end, ⅞-in.
WRENCH, open-end, 15/16-in.
WRENCH, socket, ½-in.
WRENCH, socket, 9/16-in.
WRENCH, socket, ⅝-in.
WRENCH, socket, ⅞-in.

### b. Procedure.

(1) Remove Engine from Tractor. It is necessary to remove the engine from tractor to remove master clutch. Refer to TM 9-1787A, section V, paragraph 10, for removal of engine.



RA PD 40946

*Figure 2 — Removing Pressure Plate Cap Screws*

(2) REMOVE CLUTCH ASSEMBLY FROM ENGINE.

CHISEL, ¾-in.
HAMMER, 2-lb.
WRENCH, ¾-in.

Straighten the screw locks (hammer and chisel) and remove the nine special cap screws holding clutch assembly to flywheel (¾-in. wrench). Lift master clutch assembly from flywheel.

**9. DISASSEMBLY.**

**a. Equipment.**

BLOCK, hardwood
HAMMER, 2-lb.
PLIERS
PUNCH, 10-in.
SCREWDRIVER, 6-in.
WRENCH, ½-in.

**b. Procedure.**

(1) REMOVE PRESSURE PLATE.

PLIERS
SCREWDRIVER, 6-in.
WRENCH, ½-in.

MASTER CLUTCH

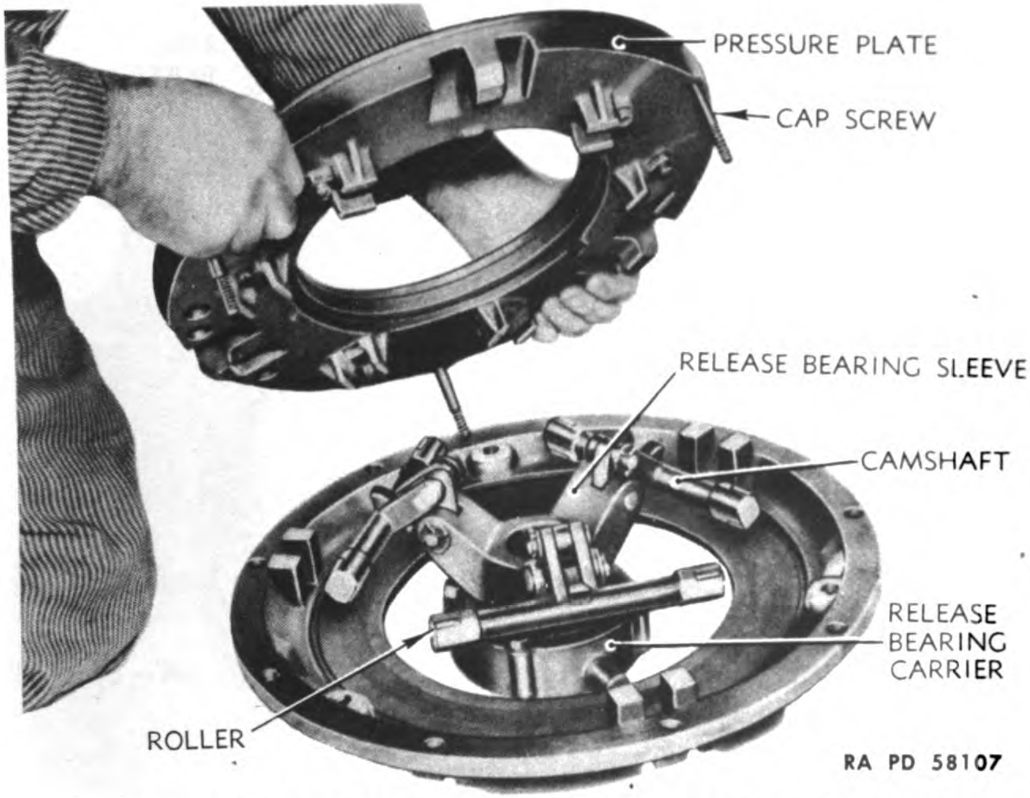



***Figure 3 — Removing Master Clutch Pressure Plate***

Remove three cotter pins (pliers) and castle nuts (½-in. wrench and screwdriver) from the three fillister head cap screws, remove cap screws and return springs. Remove pressure plate.

(2) REMOVE ADJUSTING RING ASSEMBLY. Hinge adjusting lock back and screw adjusting ring out of mounting plate.

(3) REMOVE CAMSHAFT ASSEMBLIES.

PLIERS

Lift release bearing carrier assembly from clutch assembly. Remove the three short link pins from connecting link camshaft levers and remove camshaft assemblies. Remove long link pins to separate connecting links from clutch sleeve assembly.

(4) REMOVE RELEASE BEARING CARRIER.

HAMMER, 2-lb. WRENCH, ½-in.
PUNCH, 10-in.

Remove four cap screws (½-in. wrench) to loosen release bearing carrier from release bearing plate. Tap release bearing and sleeve out of carrier (hammer and punch).

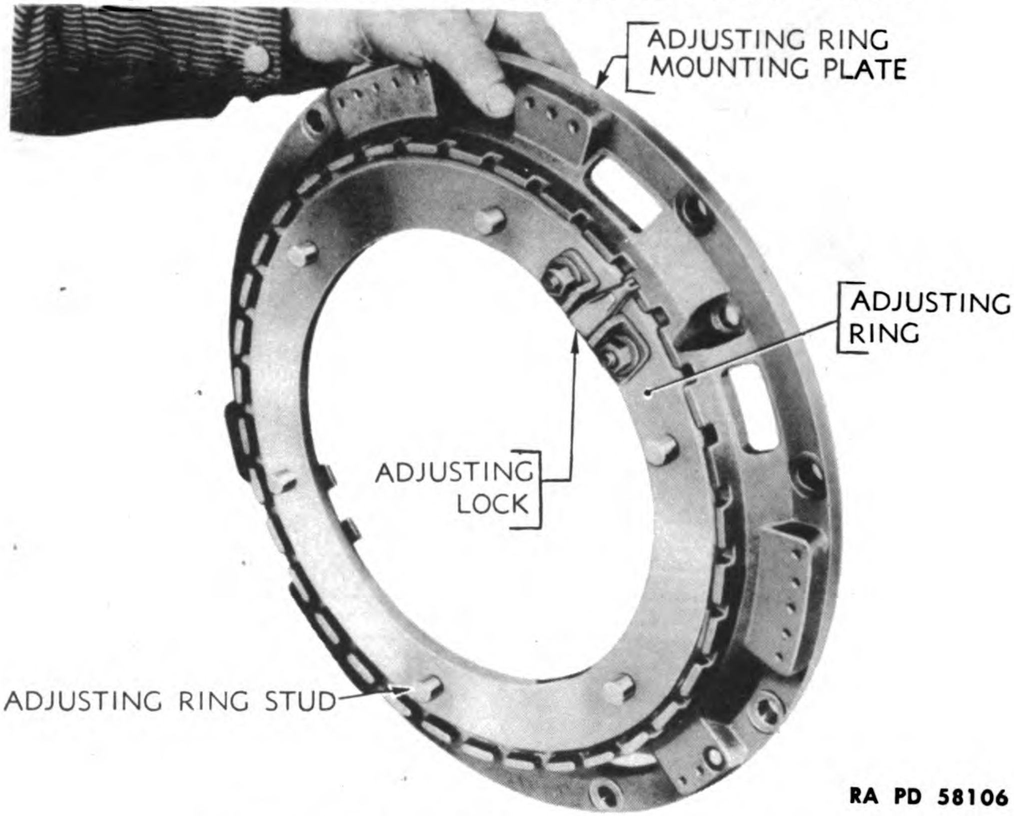



***Figure 4—Clutch Adjusting Mechanism***

(5) REMOVE RELEASE BEARING.

BLOCK, hardwood
HAMMER, 2-lb.
SCREWDRIVER, 6-in.

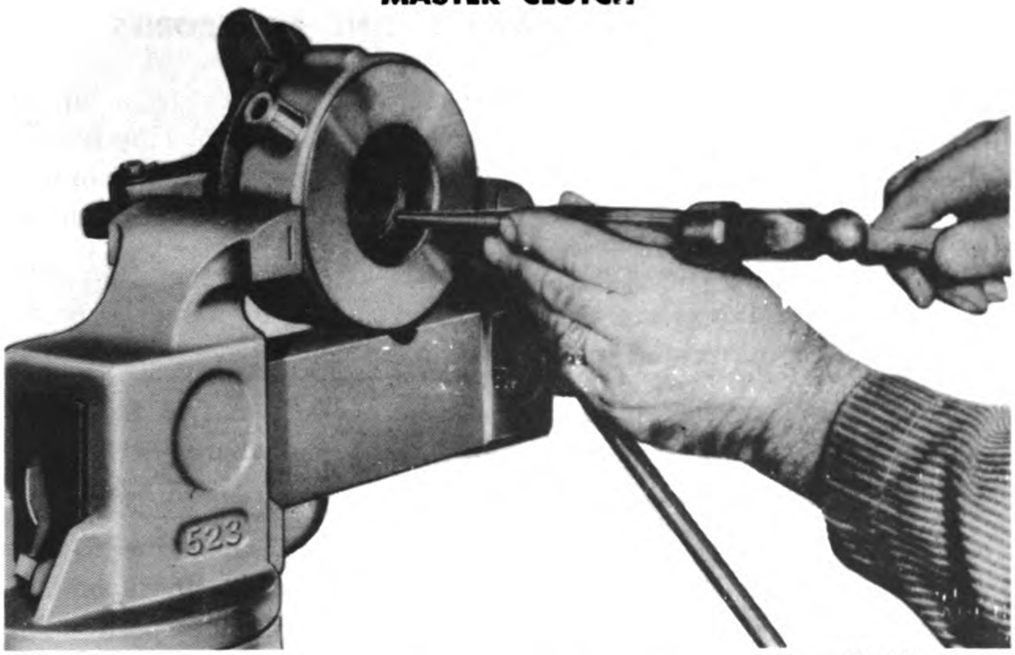
Remove snap ring holding bearing on release sleeve (screwdriver) and tap release bearing from sleeve (hammer and block). Remove bearing plate from sleeve.

## 10. MAINTENANCE AND REPAIR.

**a.** The clutch release bearing should be lubricated after every 8 hours of operation with GREASE, general purpose, seasonal grade. Do not over-lubricate, as excess grease may get on the clutch facings and cause the clutch to slip.

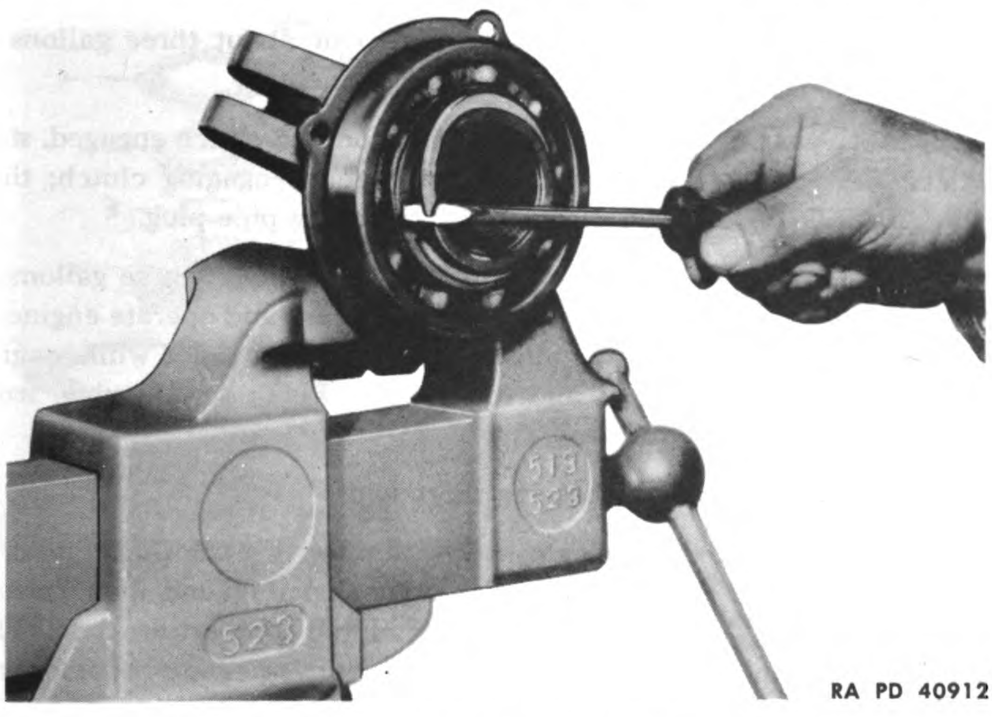
**b.** After clutch facings have worn to the point where all adjustment has been taken up and cannot be adjusted further, it will be necessary to replace the driven disk assembly. After clutch has been removed and disassembled, clean and inspect all parts.

(1) CHECK LINKAGE. Badly worn connecting links or link pins should be replaced.



RA PD 40964

***Figure 5 — Removing Release Bearing Carrier from Sleeve Assembly***



RA PD 40912

***Figure 6 — Removing Snap Ring from Sleeve***

(2) CHECK WEAR ON CLUTCH SLEEVE BUSHINGS. If bushings are worn, replace clutch sleeve. Replacement bushings are not available.

(3) CHECK CONDITION OF CAMSHAFTS AND ROLLERS. Replace camshaft assemblies if they are worn or rollers are stuck and out-of-round.

(4) INSPECT PRESSURE PLATE. Heat checks, caused from slipping clutch, may be observed, but will not be a cause for replacing pressure plate. If pressure plate is badly scored or warped, replace or machine the face of plate. Do not remove more than $\frac{1}{16}$ inch from plate in machining.

(5) REPLACE DRIVEN DISK ASSEMBLY. Do not attempt to reline driven disk. The linings are bonded to driven disk by a special process which cannot be duplicated in the field or shop.

(6) RELINE CLUTCH BRAKE. These linings are in two halves and held with rivets. It is always well to reline this brake whenever the driven disk assembly is replaced.

**c. Washing Master Clutch.** If master clutch slips, due to over-lubrication of release bearing or oil leaking from engine or transmission into clutch compartment, washing of the clutch and compartment will be necessary. Proceed as follows:

(1) Place ½-inch pipe plug in drain hole at left rear of clutch housing.

(2) Remove inspection hole cover and pour about three gallons of SOLVENT, dry-cleaning, into clutch compartment.

(3) With gear shift lever in neutral position and clutch engaged, start engine. Run engine for five minutes without disengaging clutch; then drain dirty SOLVENT, dry-cleaning, by removing pipe plug.

(4) Again place pipe plug in drain hole. Pour about three gallons of SOLVENT, dry-cleaning, into clutch compartment and operate engine as before. Disengage and engage master clutch several times while engine is running; then stop engine and drain SOLVENT, dry-cleaning, from compartment.

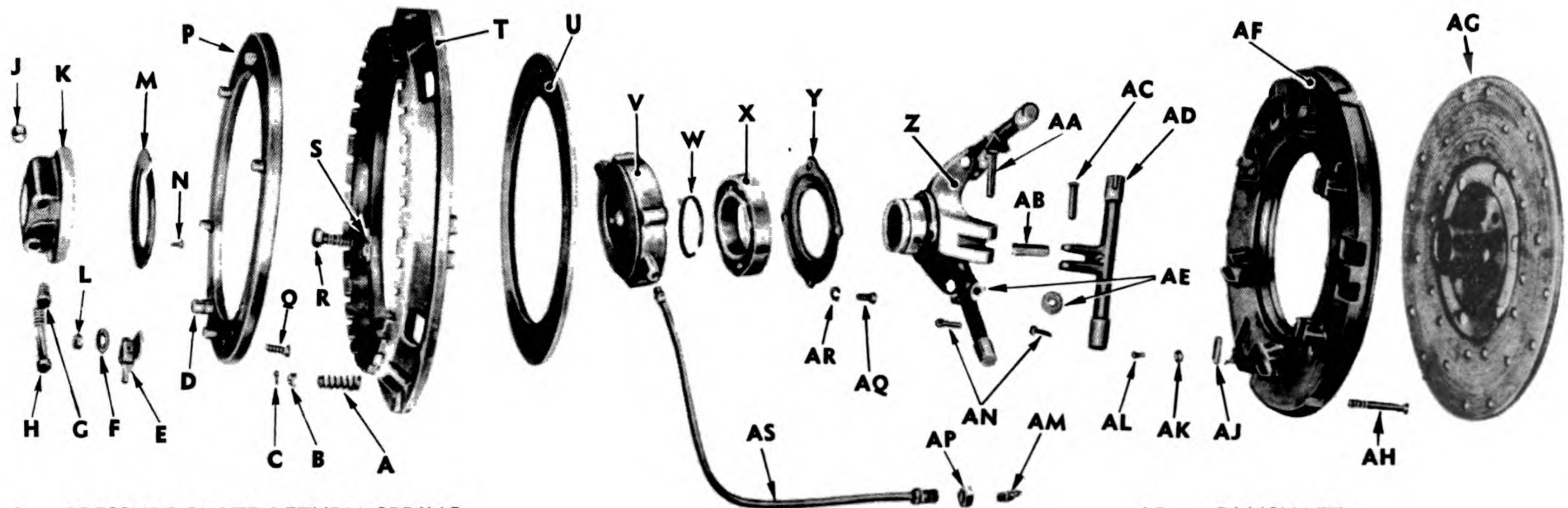
(5) Lubricate throw-out bearing thoroughly.

(6) Lubricate clutch mechanism and linkage by splashing about a quart of engine oil against back of clutch assembly and over release assembly linkage. Allow oil to drain from clutch compartment. NOTE: This must be done with clutch engaged. If clutch linkage becomes dry and binds, or is hard to operate, it may be lubricated in this manner.

## 11. ASSEMBLY.

**a. Equipment.**

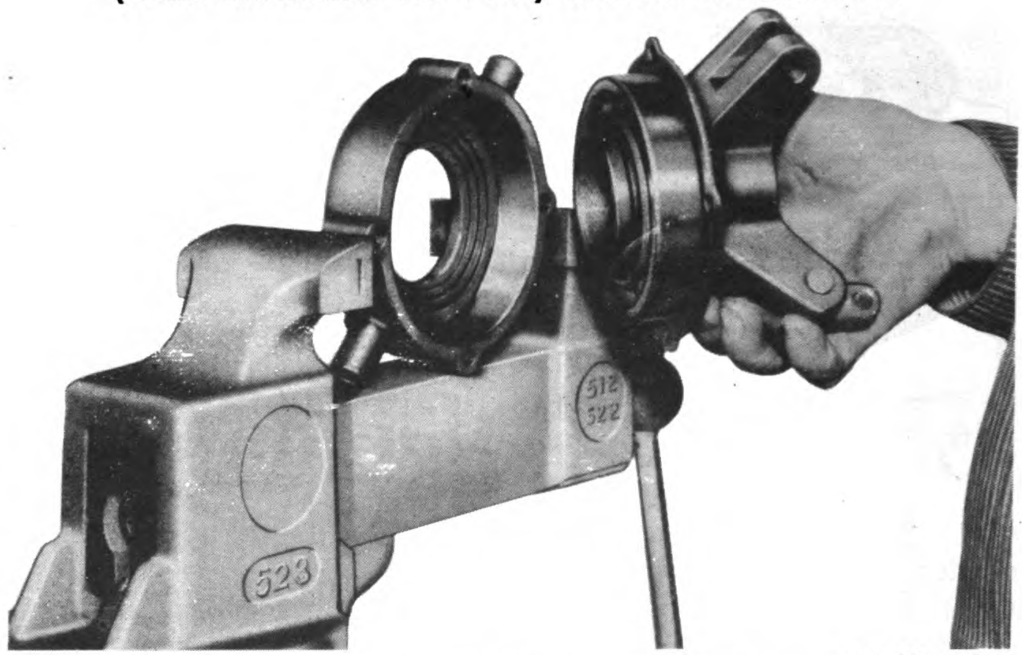
BAR, brass
HAMMER, 2-lb.
PLIERS
SCREWDRIVER, 6-in.
WRENCH, ½-in.




| | | |
|---|---|---|
| A — PRESSURE PLATE RETURN SPRING | R — BOLT | AD — CAMSHAFT |
| B — NUT | S — SCREW LOCK | AE — PLAIN WASHER |
| C — COTTER PIN | T — ADJUSTING RING MOUNTING PLATE | AF — PRESSURE PLATE, ASSEMBLY |
| D — ADJUSTING RING STUD | U — ADJUSTING RING PLATE | AG — DRIVEN DISK |
| E — ADJUSTING LOCK W/BASKET, ASSEMBLY | V — RELEASE BEARING CARRIER | AH — CAP SCREW |
| F — PLAIN WASHER | W — RELEASE BEARING SNAP RING | AJ — CAM BLOCK |
| G — SET SCREW | X — RELEASE BEARING | AK — CAM BLOCK SCREW LOCK |
| H — SCREW | Y — RELEASE BEARING PLATE | AL — CAP SCREW |
| J — NUT | Z — RELEASE BEARING SLEEVE W/BUSHING ASSEMBLY | AM — LUBRICATION FITTING |
| K — BRAKE ASSEMBLY | AA — LINK PIN | AN — COTTER PIN |
| L — NUT | AB — CONNECTING LINK | AP — NUT |
| M — BRAKE FACING | AC — LINK PIN | AQ — CAP SCREW |
| N — TUBULAR RIVET | | AR — LOCK WASHER |
| P — ADJUSTING RING, ASSEMBLY | | AS — LUBRICATION TUBE |
| Q — SCREW | | |

RA PD 58105

**Figure 7 — Exploded View of Master Clutch Assembly**




RA PD 40918

***Figure 8—Installing Release Bearing Carrier***

**b. Procedure** (fig. 7).

(1) ASSEMBLE RELEASE BEARING ASSEMBLY.

BAR, brass
SCREWDRIVER, 6-in.
HAMMER, 2-lb.

Slip bearing plate onto clutch sleeve. Tap bearing into place on clutch sleeve (hammer and brass bar) and install snap ring in groove in sleeve to hold bearing (screwdriver).

(2) INSTALL RELEASE BEARING CARRIER.

WRENCH, ½-in.

Slide carrier over bearing and secure bearing plate to bearing carrier using four 5⁄16- by ⅝-inch cap screws with lock washers.

(3) CONNECT LINKAGE.

PLIERS

Lay camshafts in cam blocks. Connect the clutch sleeve arms to arms on camshafts with the connecting links and pins. Use three long link pins to connect the links to the clutch sleeve arms, and three short ones to connect the links to the camshafts. Fasten pins with cotter pins.

(4) INSTALL ADJUSTING RING IN MOUNTING PLATE.

Install ring by screwing it into mounting plate. Lock by snapping adjusting lock into notch in mounting plate.

(5) INSTALL PRESSURE PLATE ON MOUNTING PLATE.

PLIERS
SCREWDRIVER, 6-in.
WRENCH, ½-in.

Place pressure plate in position against mounting plate and insert three fillister head cap screws. Slip return springs on these cap screws and install castle nuts (screwdriver and ½-in. wrench). Install cotter pins through nuts and cap screws (pliers).

## 12. INSTALLATION.

### a. Equipment.

BAR, pry, small
CHISEL, ¾-in.
HAMMER, 2-lb.
HOIST, chain
PLIERS
ROPE
or
CHAIN
SCALE
or
RULER
SCREWDRIVER, 8-in.
WRENCH, 1-in.
WRENCH, box-socket, 9/16-in. with 90° offset.
WRENCH, engine cranking
WRENCH, fan-adjusting
WRENCH, open-end, 5/16-in.
WRENCH, open-end, ⅜-in.
WRENCHES, open-end (two), 7/16-in.
WRENCH, open-end, ½-in.
WRENCHES, open-end, two, 9/16-in.
WRENCH, open-end, ⅝-in.
WRENCH, open-end, 11/16-in.
WRENCH, open-end, ¾-in.
WRENCH, open-end, ⅞-in.
WRENCH, open-end, 15/16-in.
WRENCH, socket, 9/16-in.
WRENCH, socket, ⅝-in. with 6-in. extension.
WRENCH, socket, ¾-in.

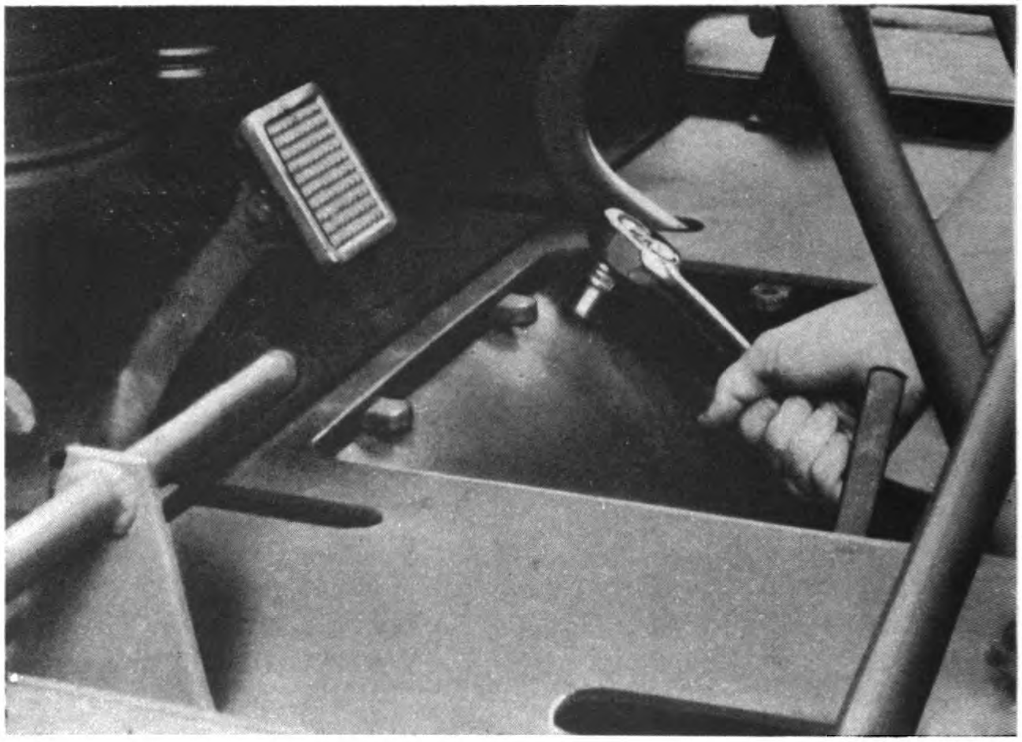
### b. Procedure.

(1) PLACE DRIVEN DISK ASSEMBLY IN POSITION. Place driven disk assembly against flywheel, with oil slinger on clutch facing flywheel. NOTE: Lubricating pilot bearing in flywheel at this time will facilitate connecting clutch shaft. Lubricate clutch camshafts through lubrication fittings provided before engine is installed in tractor.

(2) INSTALL MASTER CLUTCH ASSEMBLY.

CHISEL, ¾-in.
HAMMER, 2-lb.
WRENCH, ¾-in.

Place master clutch assembly in position against driven disk assembly. Attach to flywheel with nine special cap screws with screw locks. Tighten cap screws firmly and evenly (¾-in. wrench). Bend screw locks over cap screw heads with chisel and hammer.



RA PD 17638

*Figure 9—Removing Clutch Inspection Cover*

(3) ATTACH RELEASE BEARING LUBRICATING TUBE.

WRENCH, open-end, $^7/_{16}$-in.

Place sliding block over yoke pin on release bearing carrier. Connect lubricating tube to release bearing carrier.

(4) INSTALL ENGINE AND RADIATOR ASSEMBLY IN TRACTOR. Refer to TM 9-1787A, section XI, paragraphs 24 to 25, for installation instructions.

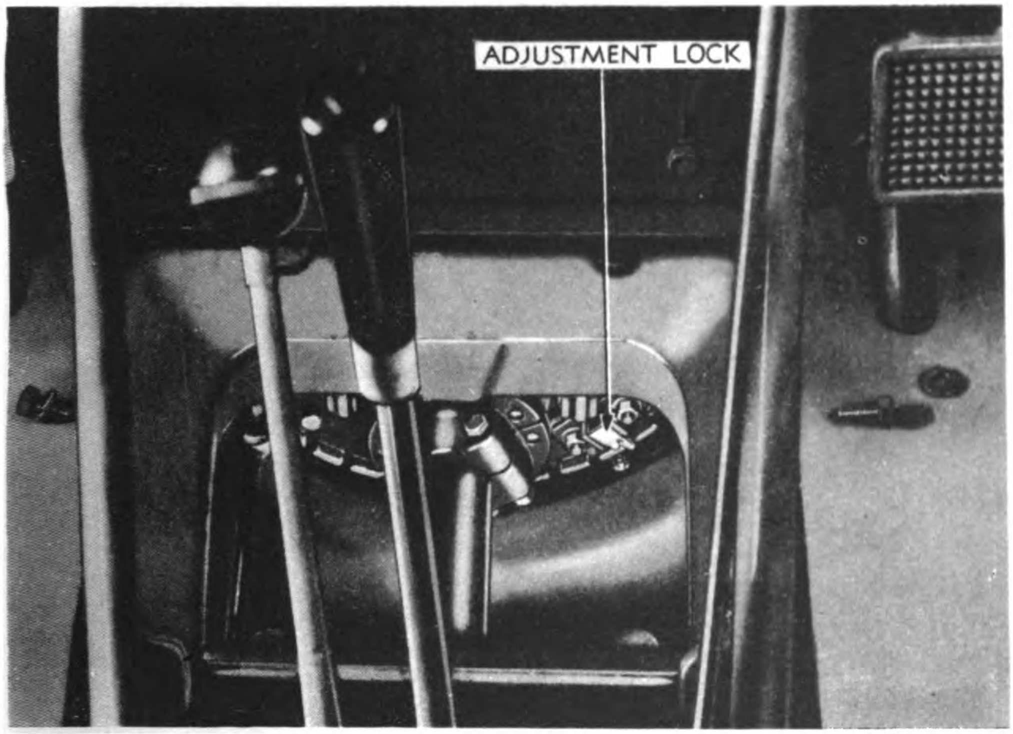
## 13. ADJUSTMENT.

**a.** Engagement of the master clutch when in proper adjustment requires a pull of from 50 to 55 pounds on the control lever when engine is idling, or from 60 to 65 pounds when engine is stopped. It should engage with a snap and lever will lock into position with an over-center action. These figures assume that there is no binding in any of the linkage. If the linkage is binding in any place, those parts or joints should be freed and lubricated before attempting to obtain the correct adjustment. Do not adjust the clutch too tightly, as that would result in faster wear on the linkage and make operation harder. Proceed as in the following steps for adjustment of master clutch.

**b. Equipment.**

BAR, pry, small

WRENCH, $^3/_4$-in.




RA PD 17228

*Figure 10—Master Clutch Adjusting Lock*

**c. Procedure.**

(1) Remove Clutch Inspection Hole Cover.
WRENCH, ¾-in.

Remove two cap screws and lift off floor plate over inspection hole cover (¾-in. wrench). Remove four cap screws from cover over master clutch inspection hole (¾-in. wrench) and remove cover.

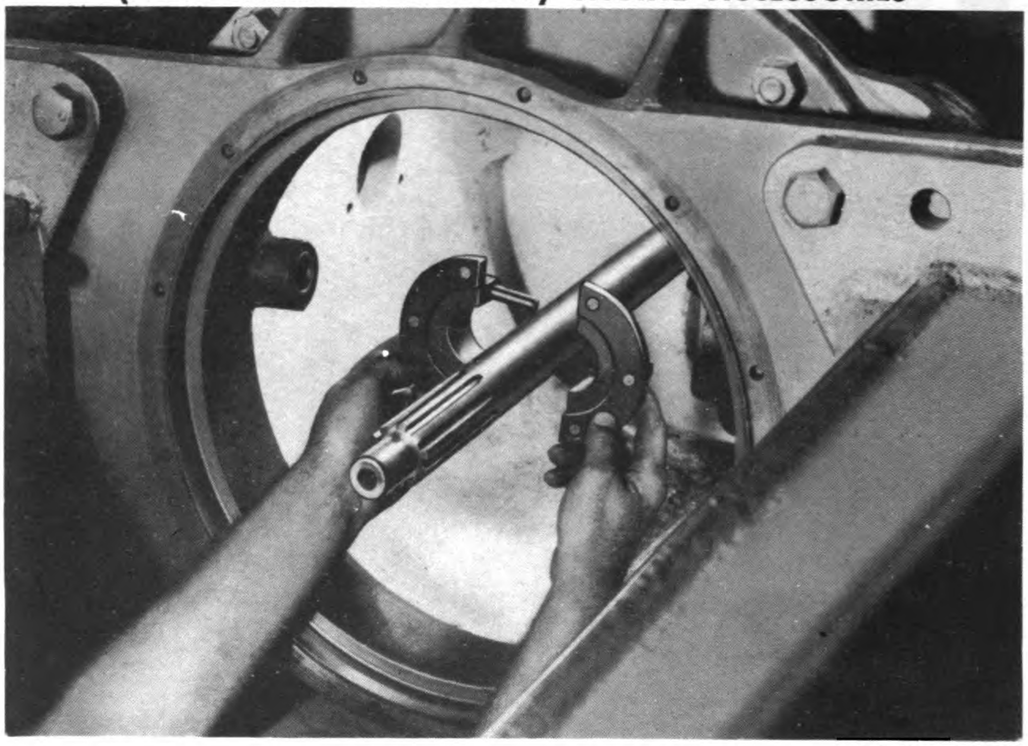
(2) Turn Clutch to Adjusting Position. Disengage clutch and revolve the clutch until the adjusting lock is located near the inspection hole (fig. 10).

(3) Disengage Adjusting Lock. Hinge adjusting lock (fig. 4) back out of slot in adjusting ring mounting plate.

(4) Turn Adjusting Ring.
BAR, pry, small

Pry on the studs of adjusting ring to turn ring. To tighten clutch, turn adjusting ring clockwise; to loosen, turn the ring counterclockwise. Turn ring in desired direction a notch at a time and test pull required on lever to engage clutch until desired pull is obtained. Snap lock into notch in mounting plate.

(5) Lock Ring in Place.
WRENCH, ¾-in.



RA PD 40577

*Figure 11—Removing Master Clutch Brake Assembly*

Engage adjusting lock in notch in mounting plate and install inspection covers.

(6) ADJUST CLUTCH BRAKE. For adjustment of the clutch brake see paragraph 15.

## 14. CLUTCH BRAKE ASSEMBLY.

**a.** The master clutch brake assembly is a two-piece casting which is bolted around the clutch shaft. The brake is faced on the flanged side with brake lining. When the master clutch lever is pushed forward, the clutch release bearing carrier is forced back against the clutch brake assembly, which stops the transmission gears and permits easy shifting. The throw-out mechanism should contact the brake before operator's hand can come in contact with the dash when pushing lever ahead to disengage clutch and engage clutch brake.

## 15. CLUTCH BRAKE ADJUSTMENT.

**a. Equipment.**

| | |
|---|---|
| PLIERS | WRENCH, $^9/_{16}$-in. |
| RULER | WRENCH, $^3/_4$-in. |
| or SCALE | |

## MASTER CLUTCH

**b. Procedure.**

(1) REMOVE LOCKING WIRE.

PLIERS

Cut wire running through head of lock screw and around the clutch shaft.

(2) LOOSEN CLAMP BOLTS.

WRENCH, 9/16-in. WRENCH, 3/4-in.

Loosen the lock screw (9/16-in. wrench) and loosen the two bolts that clamp the two halves of brake assembly to clutch shaft (3/4-in. wrench).

(3) ADJUST CLEARANCE.

RULER
or
SCALE

Engage master clutch. Move brake assembly ahead (or back) on shaft until space between clutch throw-out assembly and brake measures 1 1/16 to 1 1/8 inch (ruler or scale).

(4) TIGHTEN BOLTS, INSTALL WIRE.

PLIERS WRENCH, 3/4-in.
WRENCH, 9/16-in.

Tighten bolts clamping brake assembly to shaft (3/4-in. wrench). Then tighten lock screw (9/16-in. wrench) and install lock wire through head of lock screw and around shaft (pliers).

# CHAPTER 4

# FUEL AND AIR SYSTEM

## Section I

## DESCRIPTION OF SYSTEM



### 16. DESCRIPTION OF SYSTEM.

**a. Fuel System.**

(1) The fuel system consists of a 160-gallon fuel supply tank, fuel pump, fuel filters and injectors. The first stage fuel filter assembly consists of two filters, exactly alike, mounted on a bracket bolted to the transmission case. There are also two other filters—the second stage fuel filter, fastened on the front of the cowl, and the third stage fuel filter, bolted to the engine. The fuel pump is bolted to the rear of the blower and is driven by the lower blower rotor shaft. The injectors, one for each cylinder, are located in the cylinder head directly over the center of each combustion chamber.

(2) The fuel is drawn from the bottom of the fuel tank and through the first stage fuel filters by the fuel pump. The fuel is then forced—under about 25 pounds pressure—through the second and third stage fuel filters to the lower fuel manifold on the side of the cylinder head. From

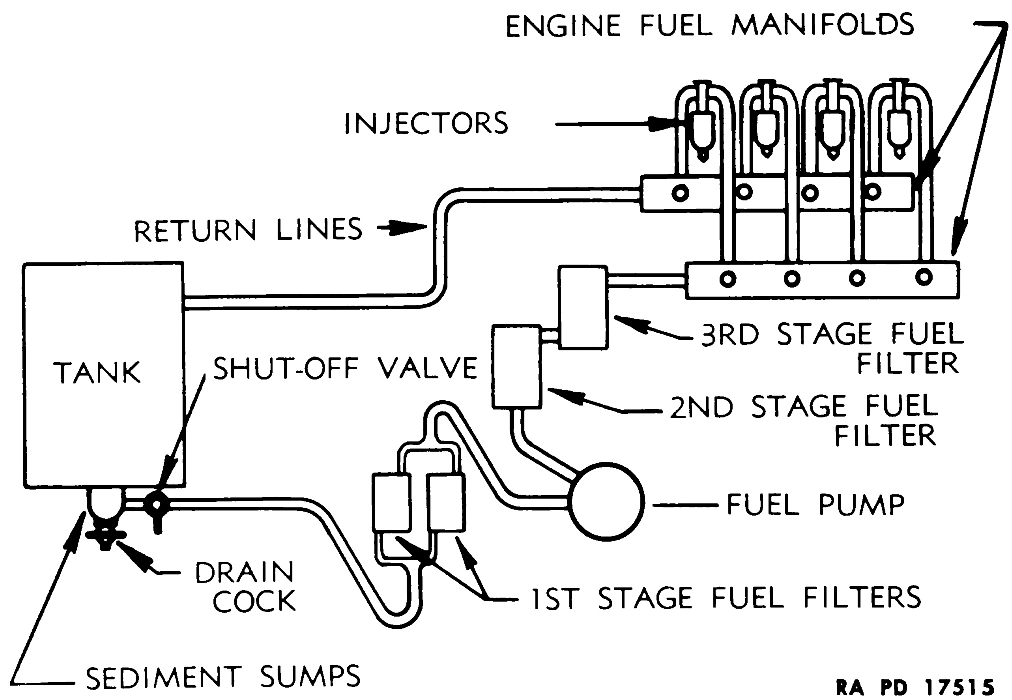



*Figure 12—Fuel System Diagram*

this manifold the fuel flows—under pressure—to the injectors through a porous bronze filter located in the injector. The surplus fuel leaves the injector—through a similar porous bronze filter—and returns through the return or upper fuel manifold and fuel return line to the fuel tank. This continual circulation of Diesel fuel helps to cool the injectors, warms up the fuel and eliminates air pockets in the fuel system. It also helps to lubricate parts of the unit injector.

**b. Air Supply.**

(1) Air for combustion and scavenging is supplied by a blower mounted on the right side of the engine, and driven by the blower drive shaft from a gear in the gear train. The blower draws the air from the atmosphere through the air pre-cleaners, and through oil bath air cleaners, and delivers the clean air to the cylinders through air intake ports in the cylinder sleeves. The blower maintains from seven to eight pounds of air pressure in the air box. The scavenging air (fig. 60) is forced into the cylinders by the blower while air intake ports are uncovered by the piston. It thoroughly sweeps out all of the burnt gases through the exhaust valve ports, helps cool the internal engine parts—particularly the exhaust valves—and leaves each cylinder filled with fresh, clean air ready for the compression stroke.

(2) Combustion is secured by mixing an accurately metered quantity of finely atomized fuel, at the end of the compression stroke, with the charge of air which has been forced into the cylinder by the blower. This is accomplished by the injector, explained in section IV.

## Section II

# PREVENTIVE MAINTENANCE



## 17. CHECKS FOR FUEL SUPPLY SYSTEM.

**a. Low Fuel Pressure.** Normal fuel pressure is from 20 to 30 pounds on the gage at operating engine speed. DO NOT OPERATE when the fuel pressure is not within this range. When pressure drops to below 20, proceed as follows:

(1) Drain sediment sumps under fuel tank of all water and sediment.

(2) Remove both first stage fuel filter elements and test fuel line from the tank to these filters to be absolutely sure that it is free and open. If necessary, replace the first stage fuel filter elements with new ones. When installing new elements, make certain that the filter cap gaskets are in their proper places to prevent leakage. When starting engine after replacing these filter elements, it may be necessary to open drains at bottom of filters to allow air to escape before fuel will start to circulate through fuel system.

(3) Start engine and check to see whether fuel oil pressure comes up to normal. If not, stop the engine and replace element in second stage fuel filter. Check fuel lines for obstructions and leaks and again start engine to determine whether fuel pressure comes up to normal.

(4) If fuel pressure is still below normal, replace element in third stage fuel filter. If all fuel line connections are tight, eliminating all possibility of air leaks, and pressure still does not come up to normal after above procedure, the fuel pump will have to be removed for cleaning, repair, rebuilding, or a new pump installed.

**b. Insufficient Fuel with Fuel Pressure Normal.** If the fuel pressure is within the normal range and the operation of engine indicates that insufficient fuel is being supplied to the injectors, proceed as follows to locate the trouble:

(1) Check for obstructions in fuel lines and fuel manifold carrying fuel to the injectors. Also see that return fuel manifold and return fuel line to tank are not restricted in any way. To check the return flow, remove fuel tank cover and look into tank. When the engine is running at fast idle, there should be an ample flow of fuel into the tank from the return line.

(2) If no restriction is found in any part of the fuel system as outlined in the preceding paragraphs, it is likely that the porous bronze filters in the injector are clogged and the injectors will have to be removed for cleaning. See section IV.

## 18. CHECKS FOR AIR SUPPLY SYSTEM.

a. **Insufficient Air Supply.** Lack of sufficient air for combustion is usually indicated by black smoke issuing from the exhaust stack. As explained in section I, the blower maintains approximately eight pounds air pressure in the air box of the engine, which is sufficient to effect clean combustion and burning of fuel. If indications point to lack of air, inspect as follows:

(1) Inspect pre-cleaners to see that air intake openings are not clogged with grass, leaves or other trash.

(2) Check lower end of central air passage tube in oil bath air cleaners. Dust mixed with oil from the air cleaners will sometimes collect in this passage and restrict air flow through this tube.

b. **Air Box Drain Tube.** With engine running, hold hand below end of tube. If this tube is clogged, no air will be felt coming from the tube. The tube and elbow should be removed and cleaned out if clogged. This tube allows unburned fuel which collects in the air box to drain out if a leak should develop in the air heater fuel pump line or if engine is allowed to run at idling speed for an extended period. A blast of air will be felt coming from tube if it is not clogged.

## Section III
# TROUBLE SHOOTING



## 19. TROUBLE SHOOTING FOR SYSTEM.

**a. Engine Fails to Start.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Fuel and air shut-off controls out of adjustment. | (1) Correct control rod adjustment. |
| (2) Insufficient fuel to injectors. | (2) Inspect fuel supply, fuel shut-off valve, fuel filters, fuel pump and lines. |
| (3) Cold weather. | (3) Use air heater. |
| (4) Fuel shut-off lever on governor loose on shaft. | (4) Adjust lever and tighten clamp bolt. |

**b. Lack of Power.**

| | |
|---|---|
| (1) Injectors out of time. | (1) Time injectors. |
| (2) Injectors not equalized. | (2) Equalize injectors. |
| (3) Improper fuel. | (3) Obtain proper fuel. |
| (4) Fuel filters clogged. | (4) Replace filter elements. |
| (5) Defective fuel pump. | (5) Repair or replace. |
| (6) Air cleaners clogged. | (6) Remove cup; clean and refill cup, and clean out air inlet pipe. |
| (7) Pre-cleaners clogged. | (7) Service pre-cleaners. |
| (8) Fuel lines clogged. | (8) Inspect fuel lines. |

**c. Excessive Black Smoke from Exhaust.**

| | |
|---|---|
| (1) Air box handhole cover gaskets leaking. | (1) Tighten or install new gaskets. |
| (2) Insufficient air supply. | (2) Inspect air supply system. |
| (3) Air box drain clogged. | (3) Open drain. |
| (4) Injectors out of time. | (4) Time injectors. |
| (5) Injectors not equalized. | (5) Equalize injectors. |
| (6) Defective injector. | (6) Repair or replace injector. |

**d. Excessive Blue Smoke.**

| | |
|---|---|
| (1) Insufficient fuel to injectors. | (1) Inspect fuel supply to injectors. |
| (2) Injectors not equalized. | (2) Equalize injectors. |
| (3) Defective injectors. | (3) Repair or replace. |

## Section IV

# FUEL INJECTORS



### 20. DESCRIPTION.

**a. Mounting.** The injectors are mounted in the cylinder head, with their spray tips projecting slightly below the top of the inside surface of the combustion chambers. A clamp—bolted to the cylinder head and fitting into machined recesses on each side of the injector body—holds the injector in place in a water-cooled copper tube which passes through the cylinder head. A dowel pin in the injector body registers with a hole in the cylinder head for accurately locating the injector assembly. A taper seat on the lower end of the injector forms a tight seal between the injector and the copper tube to withstand the high pressure inside the combustion chamber.

**b. Construction and Operation.**

(1) The cut-away view of the model 71 fuel injector (fig. 13) shows the various injector parts. Fuel is supplied to the injector at a pressure of about 20 to 30 pounds per square inch and enters the drop-forged steel body at the top through the filter cap. It passes through the fine grained filter element in the inlet passage and fills the supply chamber which is the cylindrical space around the bushing, between it and the spill deflector. The bore of this bushing is connected to the supply chamber by two funnel-shaped ports, and the plunger which forces fuel into the combustion chamber operates up and down in the bushing bore.

(2) This up and down motion is transmitted to the plunger by the follower which is given its upward motion by the return spring and forced down on the injection stroke by the rocker arm (fig. 14). The plunger

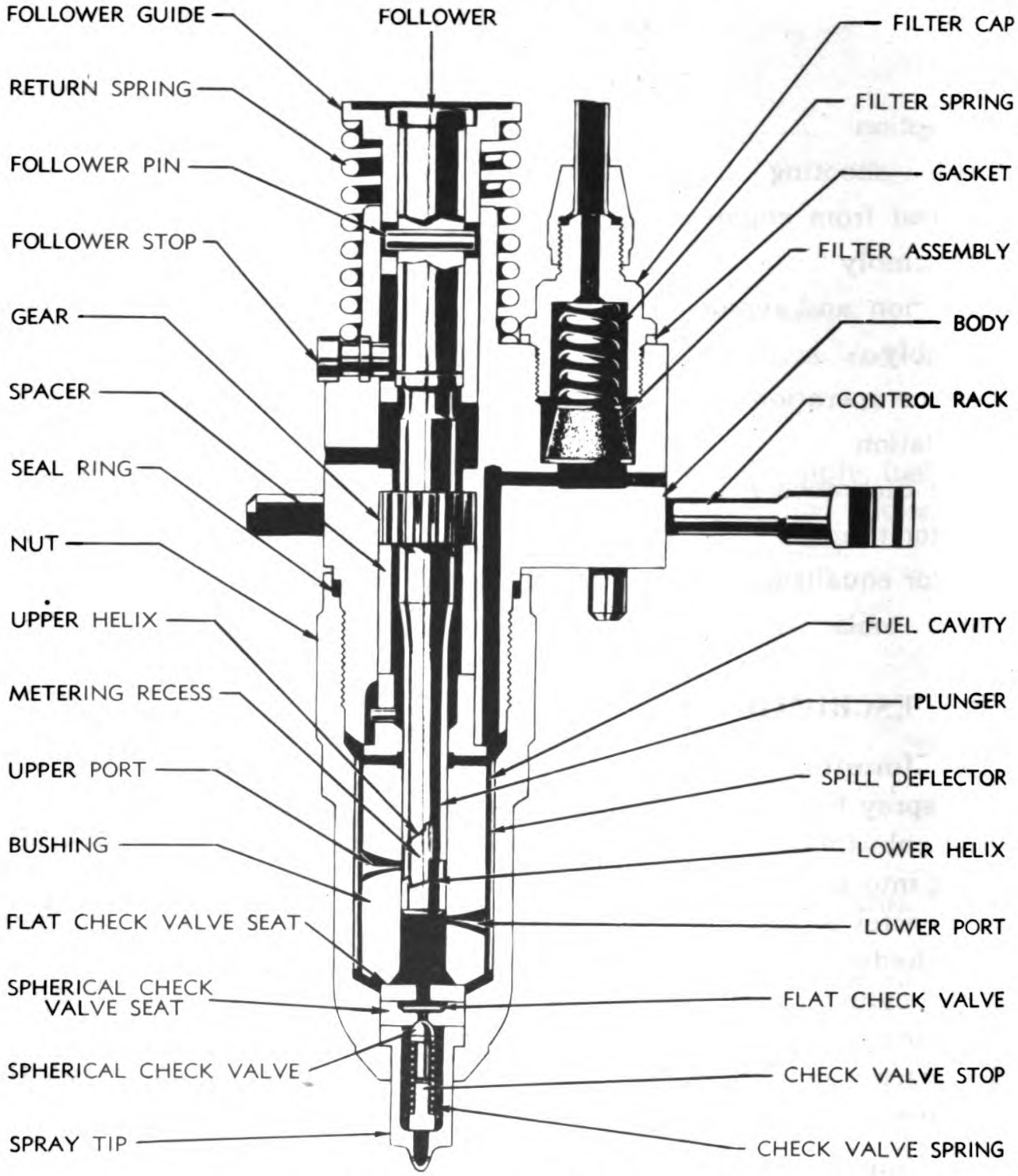



***Figure 13—Cross-section of Injector*** RA PD 17255

can also be rotated by means of the control rack and gear, and it is this rotary motion which makes it possible to vary the amount of fuel injected and the time of its injection to suit the operating load on the engine. The way in which this rotary motion of the plunger controls the injection of fuel is shown in step (4) below.

(3) An upper helix and a lower helix are machined into the lower end of the plunger and the space between the two helices is called the metering recess (fig. 15). A drilled hole in the center of the plunger connects this metering recess with the fuel chamber below the plunger. This fuel chamber fills with fuel from the supply chamber through the upper and lower ports while the injector is at the top of its stroke (fuel from the

FUEL INJECTORS

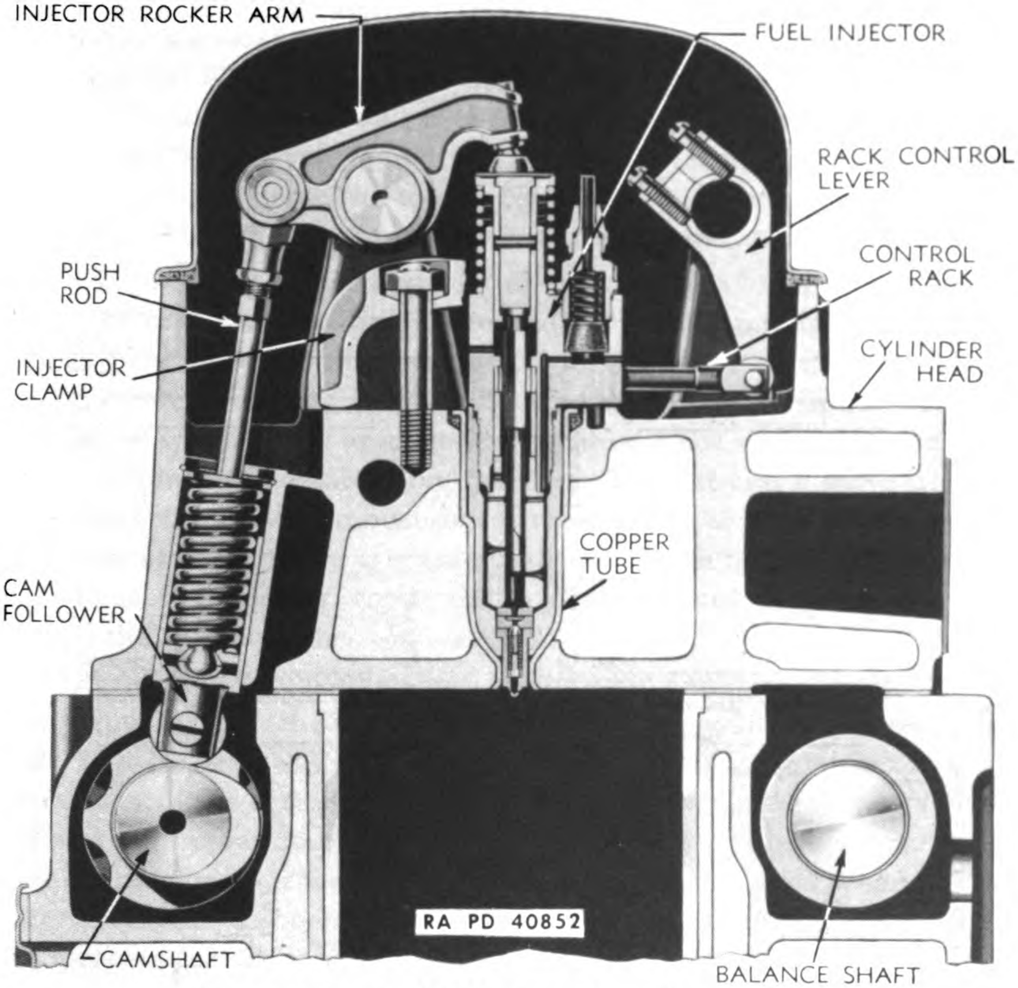



***Figure 14 — Fuel Injector Mounting Details***

upper port passes into the metering recess and down through the drilled hole). As the plunger comes down on its injection stroke, it first covers the lower port as at A, figure 15. As it continues downward, fuel in the chamber below the plunger bypasses up through the drilled passage and out the upper port until the upper port is closed by the upper helix as at B, figure 15. Fuel below the plunger is now trapped and is forced out through the spray tip into the combustion chamber. Injection continues, as the plunger moves on down, until the lower helix uncovers the lower port as at C, figure 15. This permits the fuel to bypass up through the drilled hole and out the lower port (D, fig. 15).

(4) Thus it is seen that the upper helix controls the start of injection and the lower helix controls the end of injection. For each different position, as the plunger is rotated, a different portion of each helix acts to cover the upper or lower ports. This is clearly shown in E, F, G and H, figure 15. When the fuel rack is pulled all the way out (fuel shut off) no fuel is injected because the upper helix covers the upper port to start

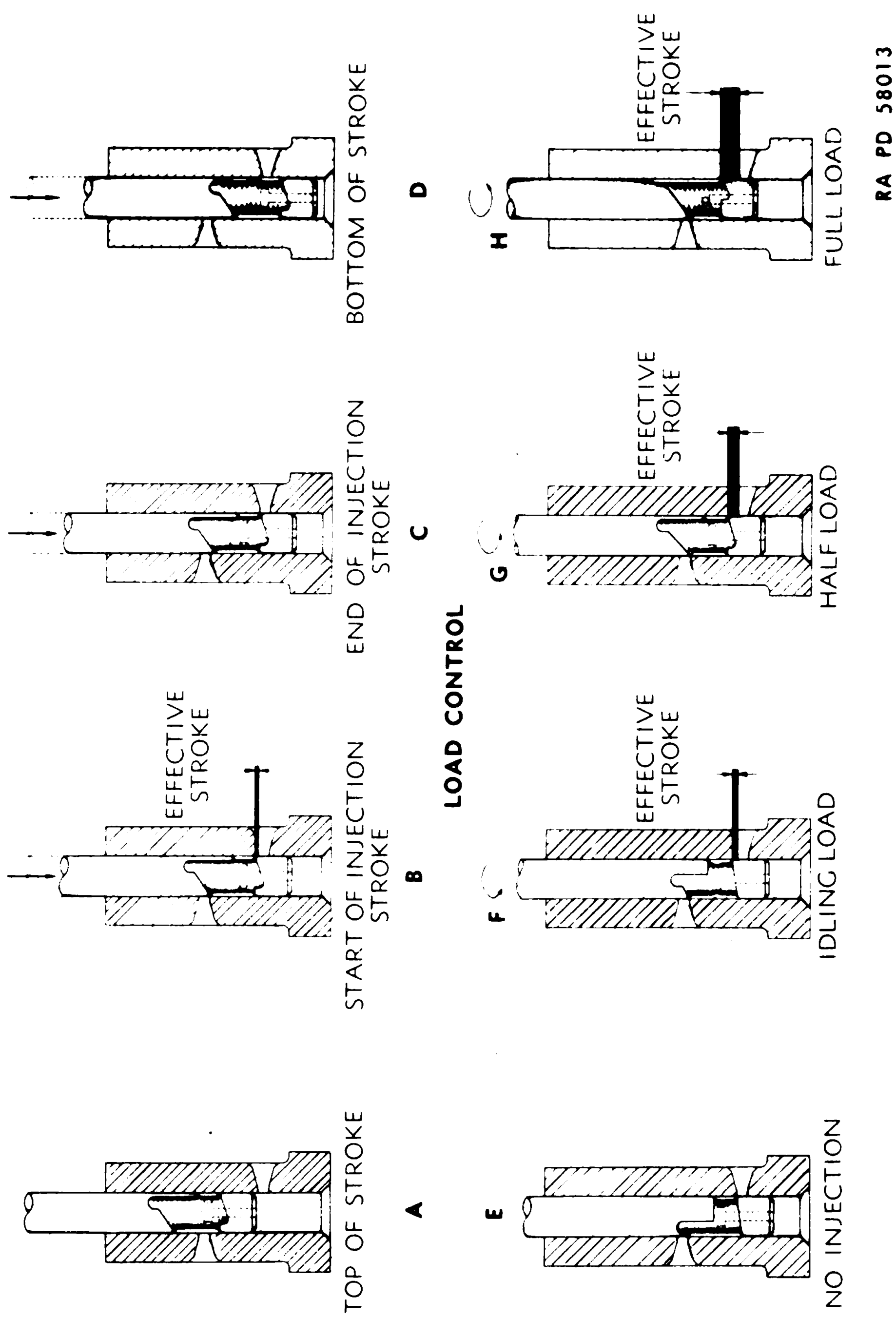



*Figure 15—Injector Plunger Positions*

injection at the same time that the lower helix uncovers the lower port to end injection (E, fig. 15). F and G, figure 15, show the plunger rotated to idling load and half load, and H shows the plunger position with the control rack all the way in and the injector delivering its maximum fuel charge to the cylinders (full load). Note that the timing of both the start of injection and the end of injection is varied to meet the load conditions.

(5) During the effective stroke of the plunger, when both ports are closed, the downward motion of the plunger builds up pressure in the fuel trapped below it until that pressure is high enough to lift the spherical check valve (fig. 13) off its seat. This permits the fuel, under very high pressure, to spray out in atomized form through the six small holes in the injector tip into the combustion chamber. The flat check valve prevents air leakage from the combustion chamber into the fuel system in case the spherical check valve is accidentally held open by a small particle of dirt. Thus the injector continues to operate until the particle works through the spherical check valve.

(6) Fresh, cool fuel is always in constant circulation from the fuel tank through the fuel filters, through the injectors and back to the fuel tank. This carries away heat from the injectors and any air which might accumulate in the system and interfere with the accurate metering of the fuel and the operation of the engine. *No venting or bleeding of the fuel lines or injectors is, therefore, required at any time, even when starting after the system has been empty.* The fuel injector outlet opening through which excess fuel, supplied by the fuel transfer pump, returns to the tank is located beside the inlet opening and is protected against dirt or other foreign matter by a fine-grained filter element exactly like the one on the inlet side.

c. **Injector Control.** Each injector control rack is connected by a detachable joint to a lever on a common control shaft which, in turn, is linked to the governor and throttle. These levers can be rotated independently on the control shaft by the adjustment of two screws which permit a uniform setting of all injector racks. (See fig. 152 for governor to injector linkage.)

d. **Injector Service.**

(1) The injector is one of the most important and carefully constructed parts of the engine. It must inject exactly the right amount of fuel into the combustion chamber at exactly the right time. The injector works against high compression in the combustion chamber, and all injector parts must be maintained in clean, first-class condition at all times for efficient operation. The same care and cleanliness must be exercised when servicing the injector as was given it when originally manufactured.

ORDNANCE MAINTENANCE — HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

(2) No service operation should be attempted on the injector unless the mechanic has first acquired a complete understanding of its construction and operation. This text thoroughly describes the working principle, shows the construction and explains how to service the unit. While a skilled mechanic may intelligently service the injectors, using the instructions in this section as a guide, time and expense may be saved by changing the unit rather than attempting repairs, especially in dirty surroundings.

## 21. TROUBLE SHOOTING.

### a. Engine Detonates (Knocks).

| Probable Cause | Probable Remedy |
|---|---|
| (1) Injector out of time. | (1) Time injector. |
| (2) Injector not equalized. | (2) Equalize injector. |

### b. Black Exhaust Smoke.

| | |
|---|---|
| (1) Spray tip burned off. | (1) Replace tip. |
| (2) Spherical valve inoperative. | (2) Replace valve and seat. |

### c. Engine Misses on One Cylinder.

| | |
|---|---|
| (1) Insufficient fuel to injector. | (1) Check injector filters. |
| (2) Spray tip clogged. | (2) Clean spray tip. |
| (3) Plunger stuck. | (3) Replace plunger and bushing. |

### d. Lubricating Oil Diluted.

| | |
|---|---|
| (1) Worn plunger and bushing (fuel bypassing plunger). | (1) Replace plunger and bushing. |
| (2) Injector fuel line fittings leaking. | (2) Repair or tighten. |

## 22. REMOVAL FROM ENGINE.

### a. Equipment.

TOOL, injector remover
WRENCHES, two, 7/16-in.
WRENCH, 3/4-in.
WRENCH, open-end, 1/2-in.
WRENCH, open-end, 11/16-in.
WRENCH, socket, 9/16-in.

### b. Procedure.

(1) REMOVE PRE-CLEANERS.

WRENCHES, two, 7/16-in.

## FUEL INJECTORS

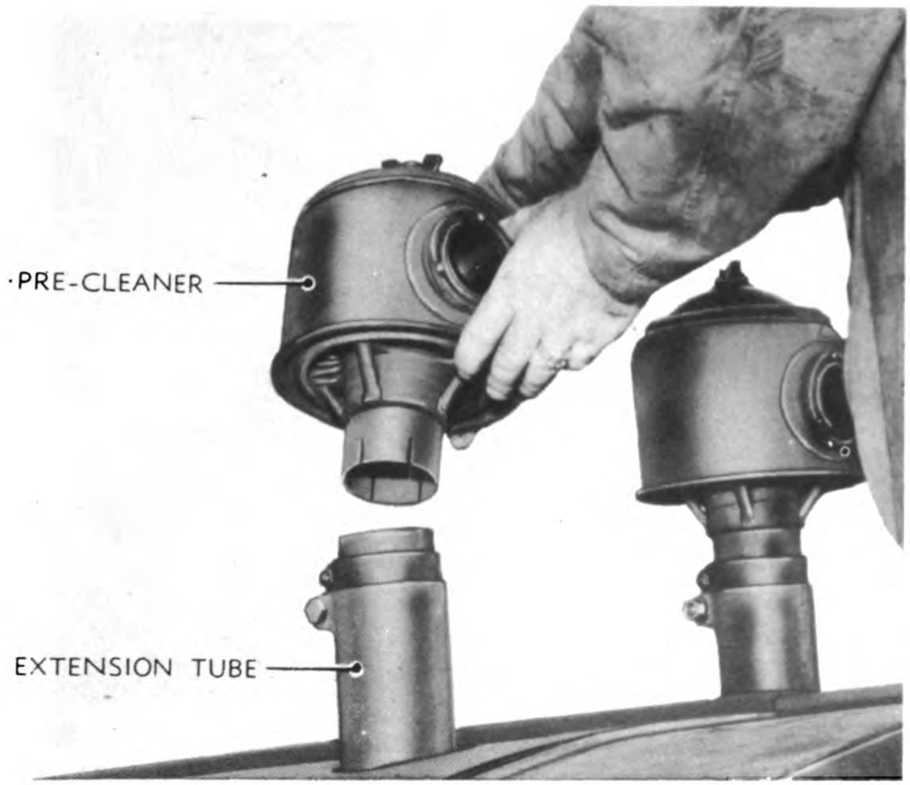



***Figure 16—Removing Pre-Cleaners***

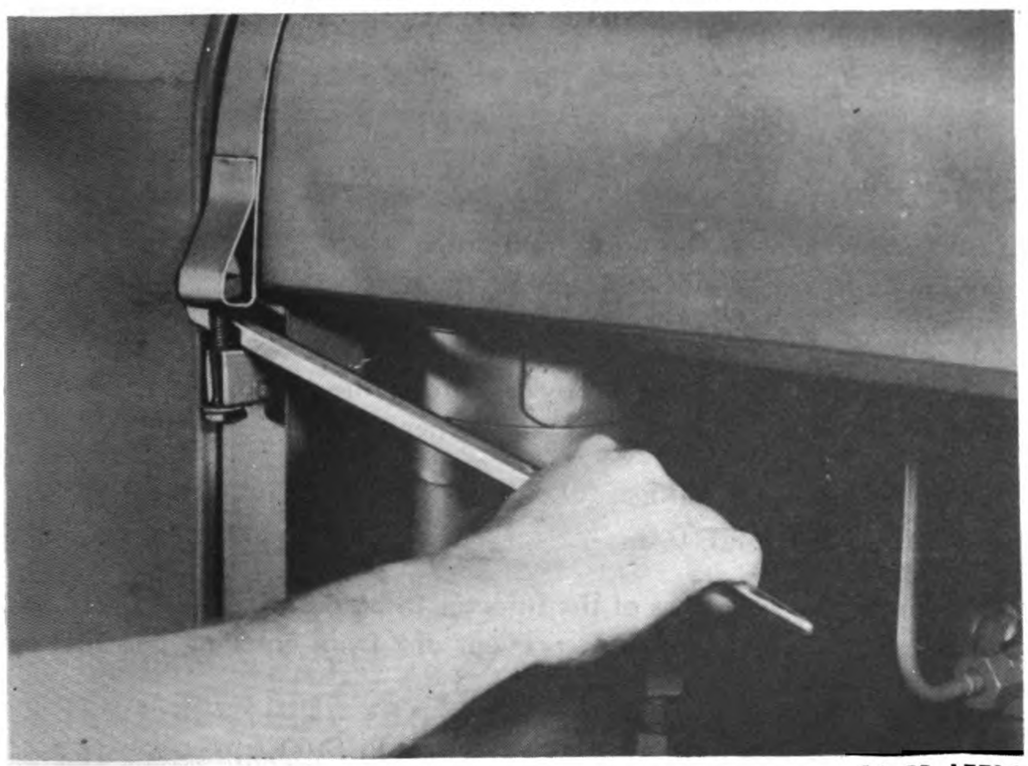
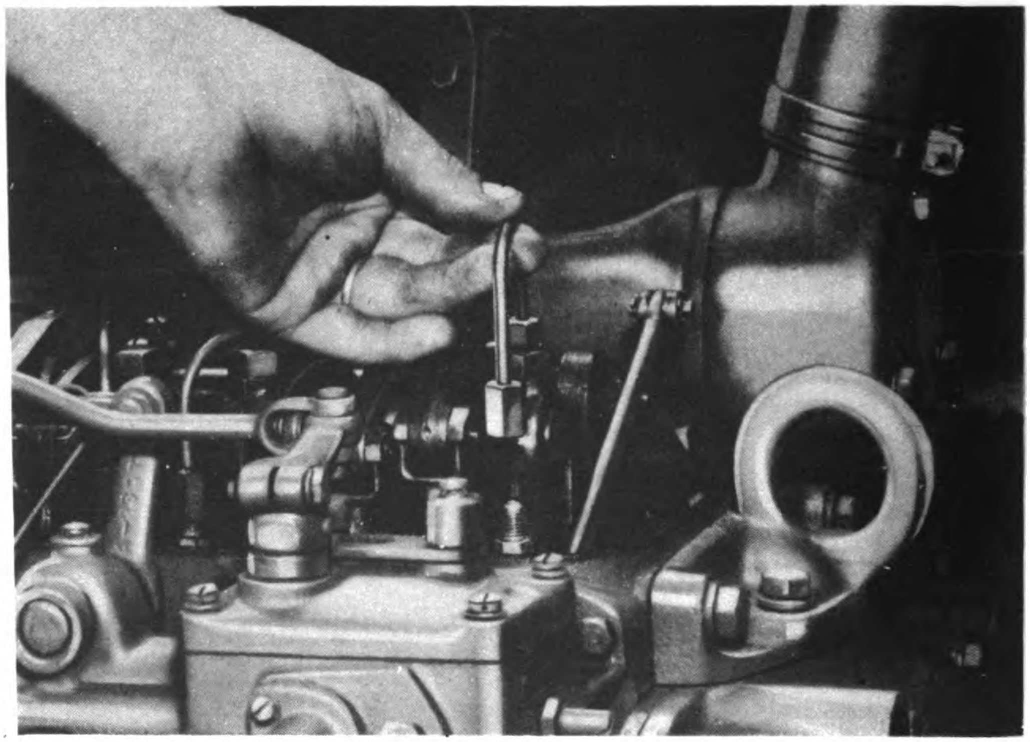



***Figure 17—Removing Hood Clamp***



RA PD 17606

***Figure 18—Injector Fuel Line Removed***

Loosen clamps holding pre-cleaners to air cleaner extension tubes and remove pre-cleaners.

(2) REMOVE HOOD.

BAR, pry WRENCH, $^9/_{16}$-in.

Loosen the nuts on the hood hold-down straps at each corner of the hood; pry bolts out of slot and remove the hood.

(3) REMOVE ROCKER ARM COVER. Clean the rocker arm cover thoroughly, and remove the cover by loosening the two hand screws that hold the rocker arm cover to the cylinder head.

(4) REMOVE FUEL LINES.

Wrench, open-end, ½-in.

Disconnect the fuel lines of the injector to be removed and place shipping caps on the fuel fittings to prevent dirt from entering the fuel system (see fig. 18).

(5) REMOVE ROCKER ARM BRACKETS AND SHAFT.

WRENCH, ¾-in. WRENCH, open-end, ½-in.

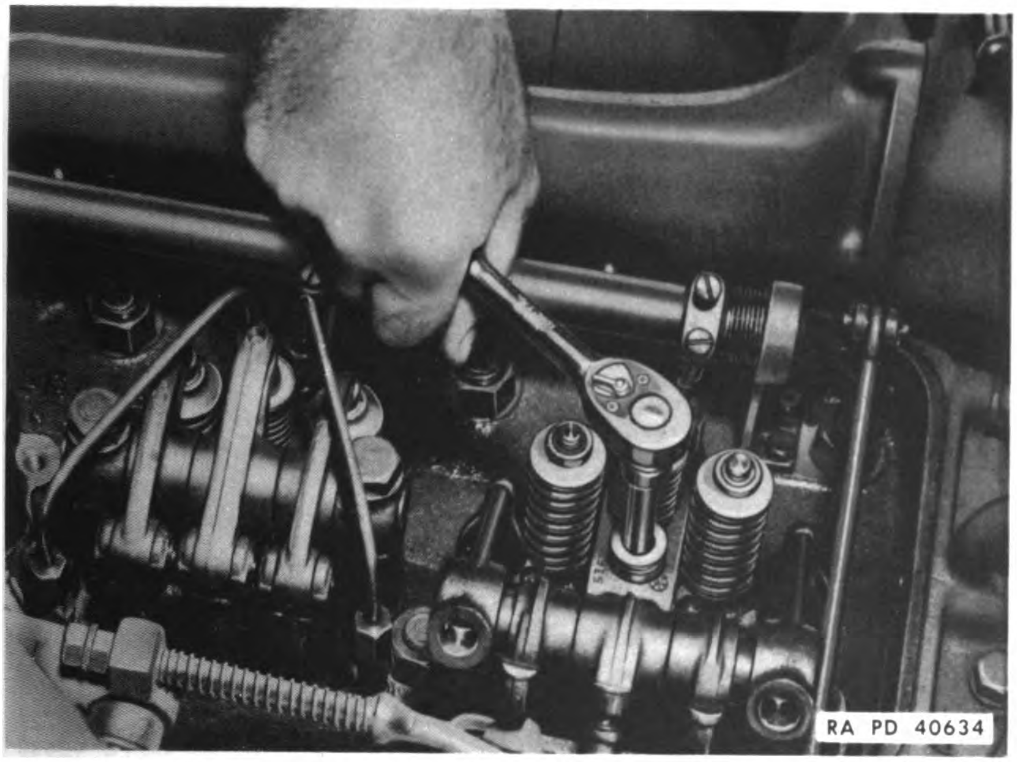



*Figure 19—Removing Injector Clamp Nut*

Loosen push rod lock nuts (½-in. wrench). Remove the two bolts holding the rocker arm shaft brackets (¾-in. wrench) to the cylinder head and remove the brackets from the shaft. Slide the shaft from the rocker arms and fold the arms back. Unscrew rocker arms from push rods. CAUTION: When removing the rocker arm shaft, fold back the three rocker arms and shaft just far enough so shaft can be pulled endwise. Do not force the rocker arms back with shaft in place and impose a load on the rocker arm push rod.

(6) REMOVE INJECTOR.

TOOL, injector remover | WRENCH, socket, 9/16-in.

Remove the nut holding injector clamp (9/16-in. wrench) and lift off clamp washer and clamp. Place square end of injector remover tool under shoulder of injector body and pry injector from its seat; at the same time disengage the control rack linkage.

## 23. DISASSEMBLY.

**a. Equipment.**

JAWS, vise, injector body
LIFTER, injector spring
PANS, containing clean fuel oil (two)
WRENCH, injector nut

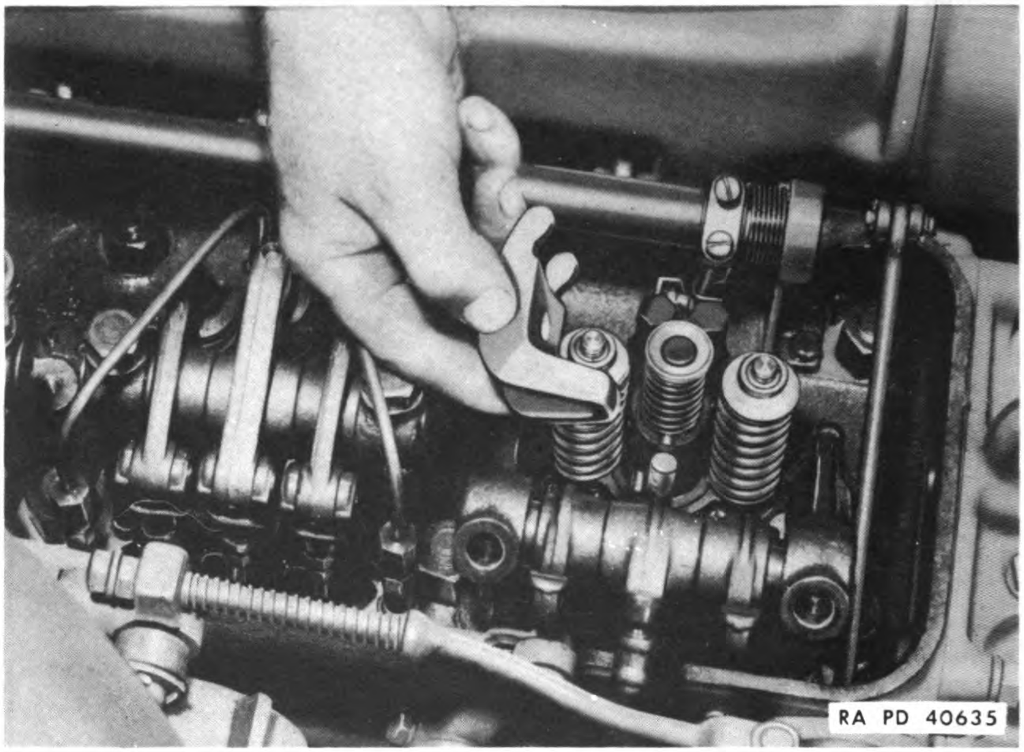



***Figure 20—Lifting Out Injector Clamp***

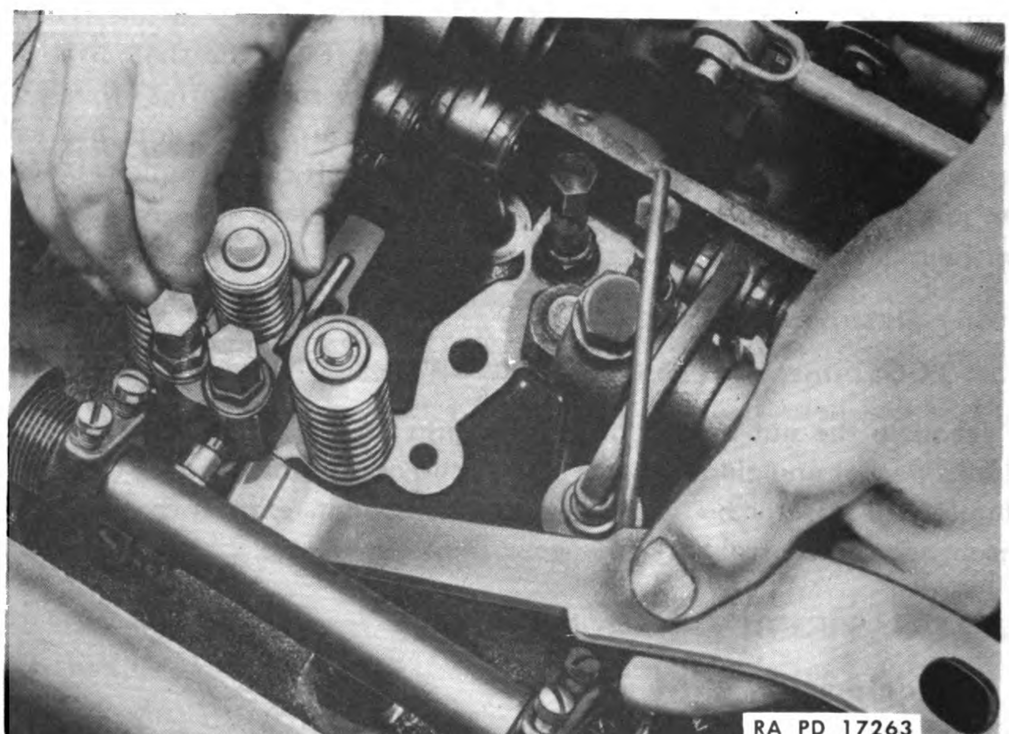
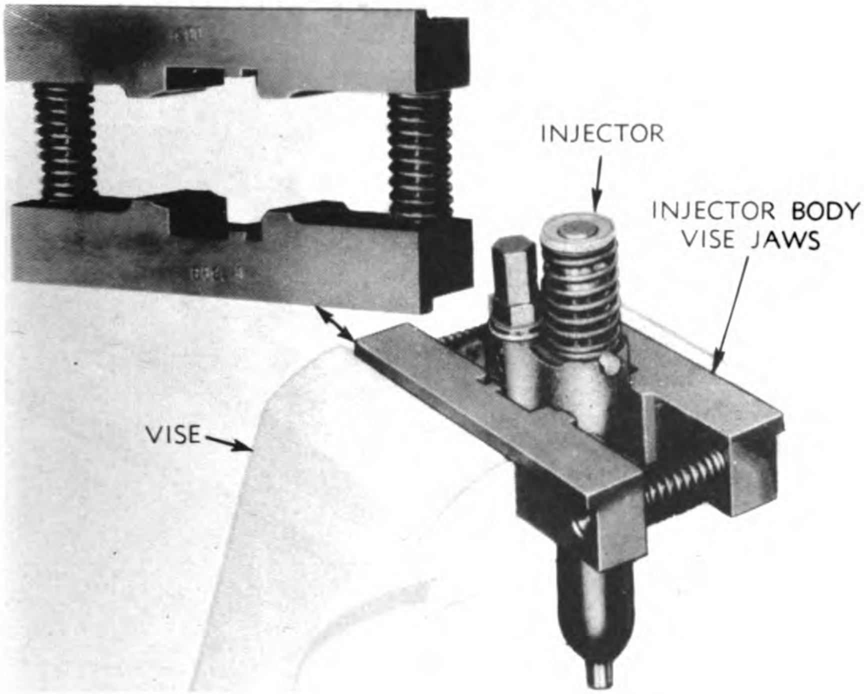



***Figure 21—Injector Removal***

FUEL INJECTORS




RA PD 56428

***Figure 22—Injector Mounted in Vise Jaws***

**b. Procedure.**

(1) Before starting to dismantle an injector, it is absolutely necessary to have an extremely clean work bench in a clean room on which to work. *Cleanliness* for the injector is emphasized because practically all injector service troubles are directly traceable to dirt, grit or other foreign matter. Use clean paper on the bench and lay (not drop) the parts in a clean pan of SOLVENT, dry-cleaning, as they are removed. If more than one injector is to be disassembled, *keep the parts for each injector separate.* The plunger must *always* go with the same bushing. The spherical valve and seat are also individual sets.

(2) CLAMP INJECTOR IN VISE.

JAWS, vise, injector body WRENCH, socket, $\frac{9}{16}$-in.

Support injector right side up in vise with the injector body vise jaws and loosen (not remove) the two fuel connections ($\frac{9}{16}$-in. wrench).

(3) REMOVE FOLLOWER STOP PIN.

LIFTER, injector spring

Insert the lifter beneath the spring (fig. 23) and lift spring away from stop pin. Hold lifter up with fingers and press down on follower with palm of same hand. Remove stop pin with other hand. Let spring go up slowly.

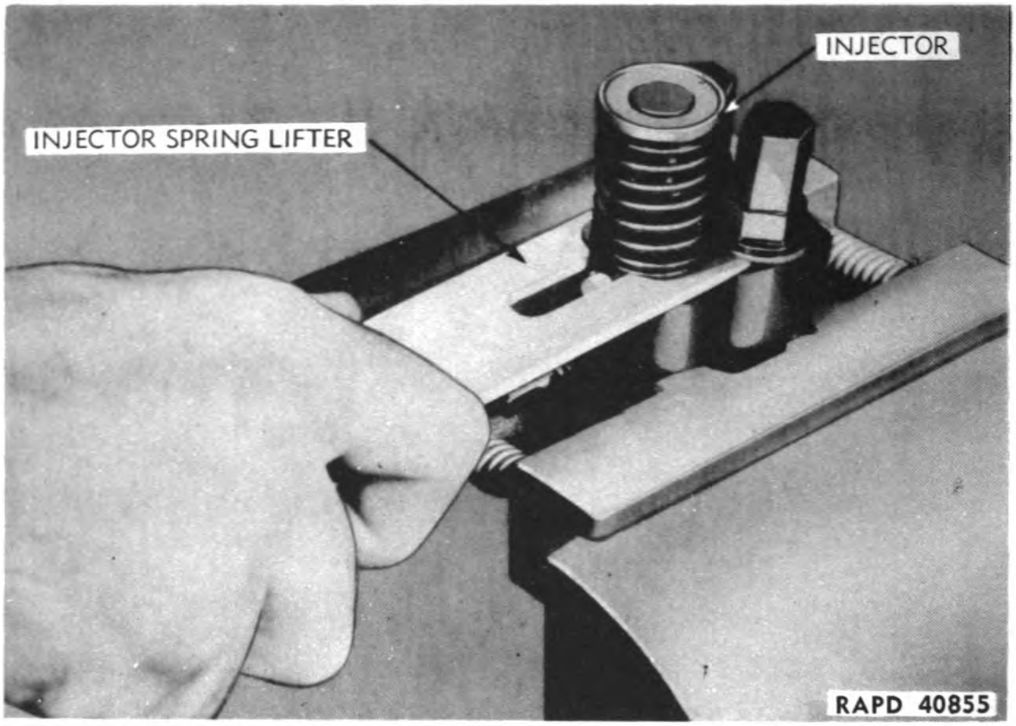



***Figure 23—Injector Spring Lifter Installed***

(4) REMOVE PLUNGER, FOLLOWER GUIDE AND PIN. Lift out the plunger, follower guide, follower and follower pin from the injector body. Remove follower pin and separate these parts, and clean with SOLVENT, dry-cleaning (see fig. 31).

(5) REMOVE INJECTOR NUT.

WRENCH, injector nut

Loosen vise, remove injector and reinstall in vise with spray tip end up. Loosen (not remove) injector nut with wrench. Remove nut with hand and lift away from the injector body, being careful not to dislodge the spray tip and the other small parts resting on the end of the plunger bushing.

(6) REMOVE SPRAY TIP AND VALVES. Carefully lift the spray tip, spherical check valve, spherical valve spring, spring stop, flat check valve, check valve seat and spherical valve seat away from the plunger bushing (fig. 30).

(7) REMOVE SPILL DEFLECTOR AND PLUNGER BUSHING. Jar the spill deflector and remove seal ring from the nut. In some cases these two parts may not come off with nut. Lift plunger bushing from injector body.

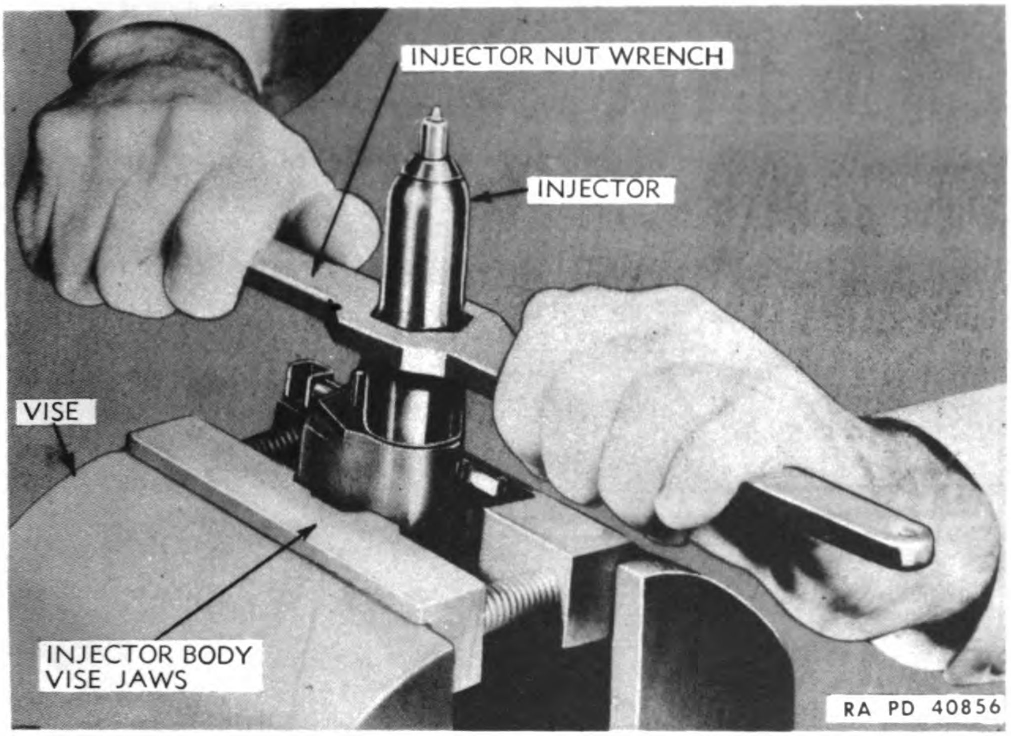



***Figure 24 — Removing Injector Nut***

(8) REMOVE GEAR, SPACER AND CONTROL RACK. Remove injector body from injector body vise jaws and hold over pan of clean fuel oil and turn body right side up. Spacer and gear will fall out of body if shaken slightly. Pull rack from injector body.

(9) REMOVE FUEL CAPS AND FILTERS. Remove the two filter caps, copper washers, filter springs and filters from injector body.

## 24. INSPECTION AND REPAIR.

**a. Inspect Injector Parts.** Many of the close-fitting parts in the injector are carefully lapped. If, therefore, any of the internal working parts of the injector become scored or damaged, these parts are unfit for further use and should be replaced. After the injector has been disassembled and all parts carefully cleaned in SOLVENT, dry-cleaning, they should be protected from dirt by storing in clean fuel until replaced in the injector.

**b. Clean Injector Bushing.** First clean the injector plunger bushing with large brush from injector service kit by immersing in a tank containing SOLVENT, dry-cleaning, and working brush through bushing; then blow out with compressed air and again wash. For final cleaning, wrap cleaning tissue around injector bushing cleaner and rotate in and out through bushing as illustrated in figure 25.

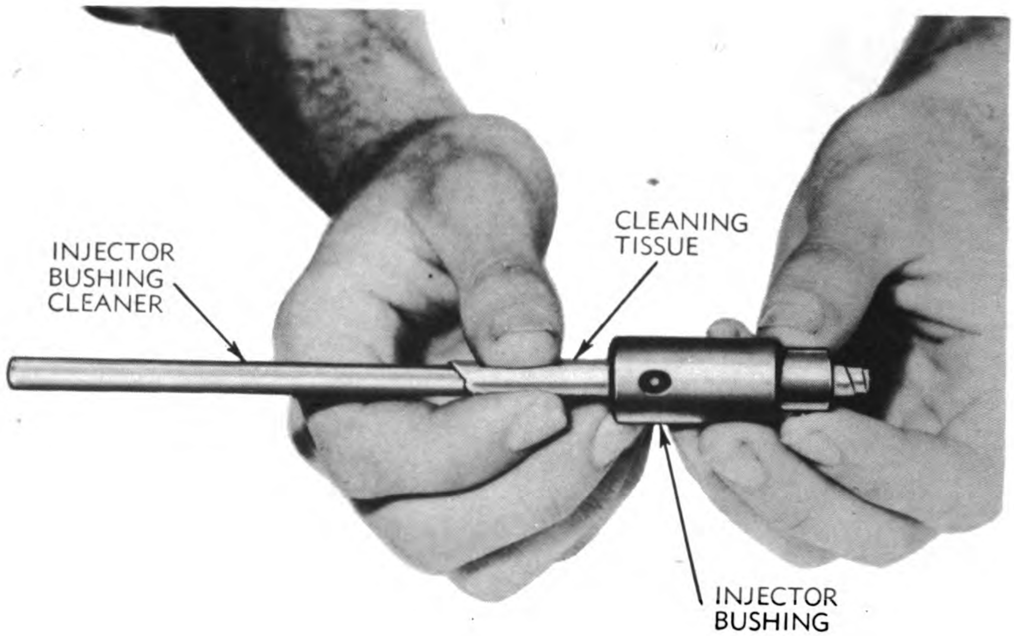



***Figure 25—Cleaning Injector Bushing***

**c. Recondition Valves and Seats.**

(1) Thoroughly wash and inspect the small flat check valve for flat smooth surfaces, the flat check valve seats for smoothness and chips, the spherical valve seat (conical surface on lower side of the thick disk) for smoothness and chips and the spherical valve and check valve stop for smoothness. CAUTION: Do not attempt to reseat the check valves by grinding the seat or valves. If the valves or seats are damaged, replace the valve assembly. If the adjoining surfaces of the flat check valve seats and the spherical check valve seats show discoloration, they should be lapped by using a "figure eight" movement after a small spot of valve grinding compound has been sprinkled on the lapping block (fig. 26).

(2) Original injectors in engines having the number 4716652 and above contain a spray tip assembly which is different from that described above. These injectors have a colored identification disk pressed into the injector body and contain a flat valve and seal assembly, shorter valve spring and differently shaped valve stop. Also the counterbore in the spray tip for the valve assembly is only half as deep. Individual parts for the second type valve and spray tip assembly *are not interchangeable*

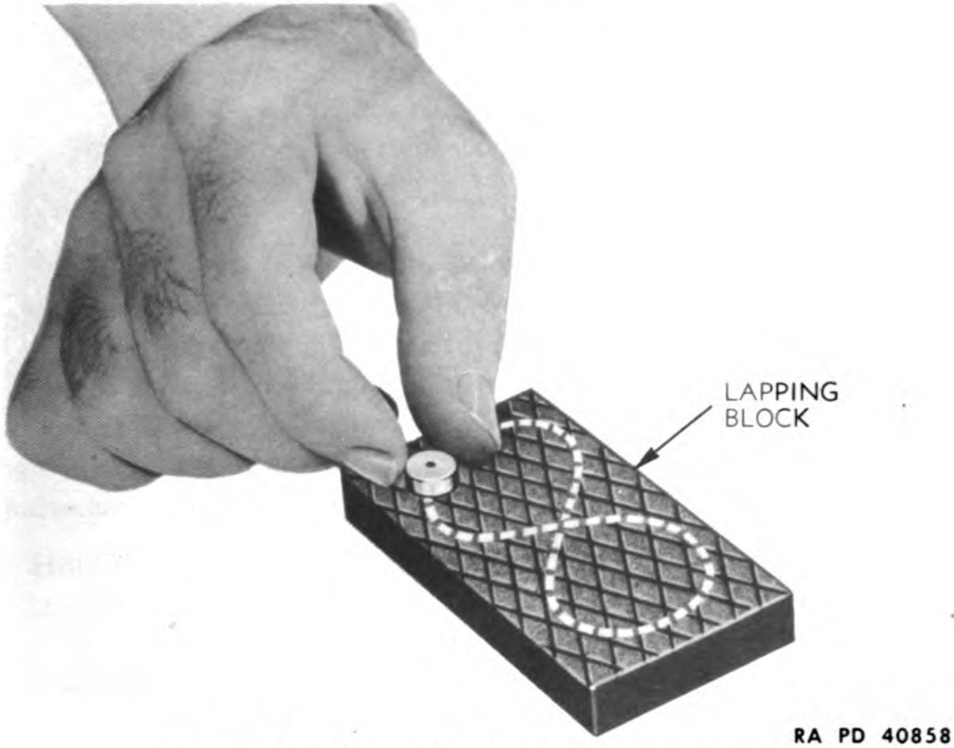



*Figure 26 — Lapping Injector Valve Seat*

with parts in the first type. In the event, therefore, that parts for the first type, as shown in figure 27, are not available, the entire spray tip assembly must be replaced with an assembly of the later type. Parts required for the new assembly are: flat valve and seat assembly, flat valve spring, flat valve stop and spray tip. Relation of parts in assembling is the same for both types of spray tip assemblies.

(3) The new valve has a flat surface contact with the valve seat, whereas the first type valve was spherical and fitted in a spherical recess in the seat. The flat valve will allow lapping—using certain precautions—whereas the spherical valve, if defective, could not be serviced, only replaced. Because of its size, the flat valve requires extreme care in lapping to insure a perfectly flat surface which is necessary for proper operation. Either a cast iron lapping block or a piece of first grade plate glass (4 in. long, minimum) may be used. CAUTION: Ordinary or double strength glass is not satisfactory—use first grade plate glass. Use the check valve lapping fixture for holding the valve when lapping to insure a flat surface on the valve and proceed as follows:

*(a)* Put a small spot of valve grinding compound on lapping block, and place valve in lapping fixture.

*(b)* With fixture held between thumb and middle finger, apply a light pressure on the sleeve of fixture with the index finger (first finger), while drawing across the lapping block in a straight line.

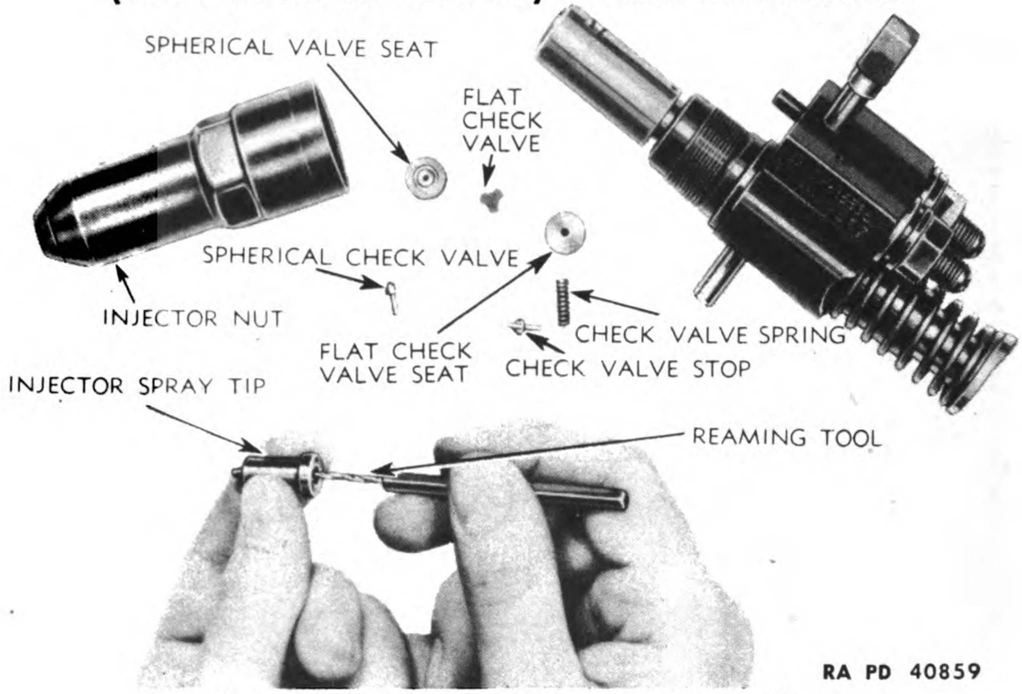



**Figure 27 — Reaming Injector Spray Tip**

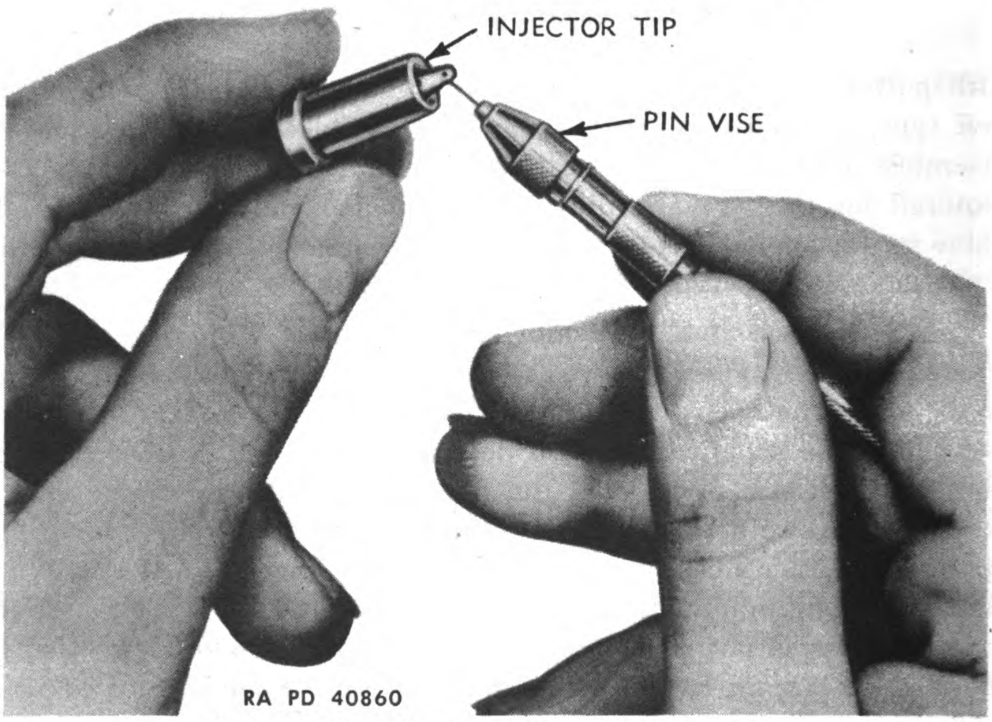



**Figure 28 — Cleaning Spray Tip Orifices**

*(c)* After each stroke, thoroughly clean the valve and inspect by holding to the light to observe differences of light reflection as an indication of valve flatness. If valve is perfectly flat, it will present a uniform appearance when held to the light and rotated.

## FUEL INJECTORS

*(d)* Lap surface of the valve seat, using same lapping block and cream, and using same care in lapping as for valve.

*(e)* The "chirping" sound heard when "popping" an injector (par. 26 **c** (2)) equipped with a spherical valve is not produced by an injector with the new flat valve.

**d. Recondition Spray Tip.**

(1) Hold injector spray tip in the fingers as illustrated in figure 27. Ream tip with the small injector drill from injector service kit. While reaming, hold spray tip in fingers, insert drill down into tip, press lightly and turn with fingers to remove any carbon or foreign matter. After thoroughly reaming, blow tip out with compressed air to remove any loose particles.

(2) Hold spray tip in fingers as illustrated in figure 28. Clean the six spray tip orifices with pin vise and the 0.006-inch probing wire. Before using the tool, the sharp burs should be removed from the wire on a honing stone furnished with the cleaning set. Blow out with compressed air and puream the tip. Again clean the holes. Then wash with SOLVENT, dry-cleaning, and again blow out with compressed air.

### 25. ASSEMBLY.

**a. Equipment.**

JAWS, vise, injector body
LIFTER, injector spring
TUBING, copper, ½- x 6-in.
WRENCH, injector nut
WRENCH, socket, $^{9}/_{16}$-in.

**b. Procedure.**

(1) When assembling an injector, the room in which the work is being done must be clean and free from flying dust. The mechanic's clothes and hands, the work bench and the tools used must all be clean. The cleaned injector parts should remain in a pan of clean fuel until reassembly is begun; then each part should be picked from the pan and assembled in the injector. Care must be taken when assembling to place the various parts in their proper relative positions. The various figures accompanying the build-up of the injector, therefore, should be thoroughly studied before attempting the assembly.

(2) INSTALL FILTER ASSEMBLIES.

WRENCH, socket, $^{9}/_{16}$-in.

Hold the injector body right side up and place one of the filters (washer end down) in each fuel cavity in the top of injector body. NOTE: Always

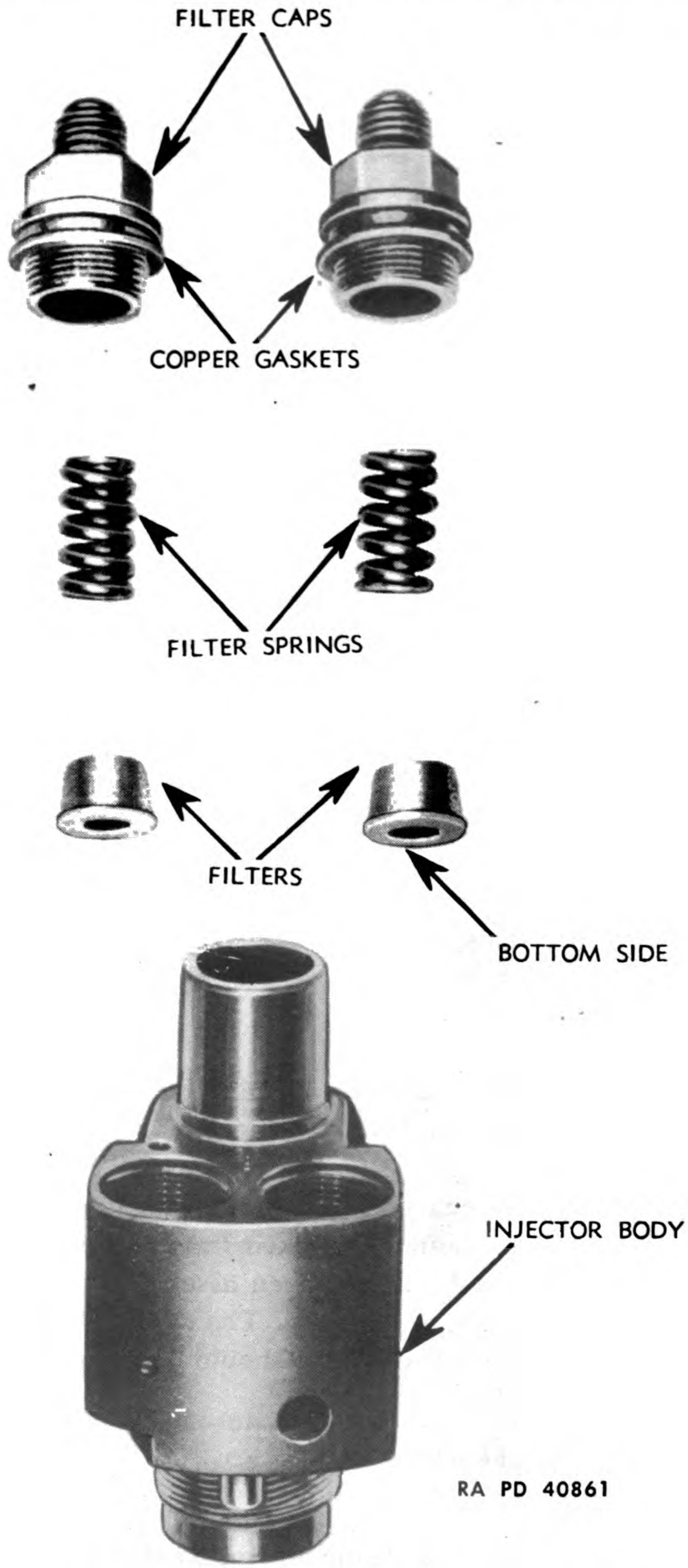



**Figure 29—Injector Filters, Springs and Nuts**

FUEL INJECTORS

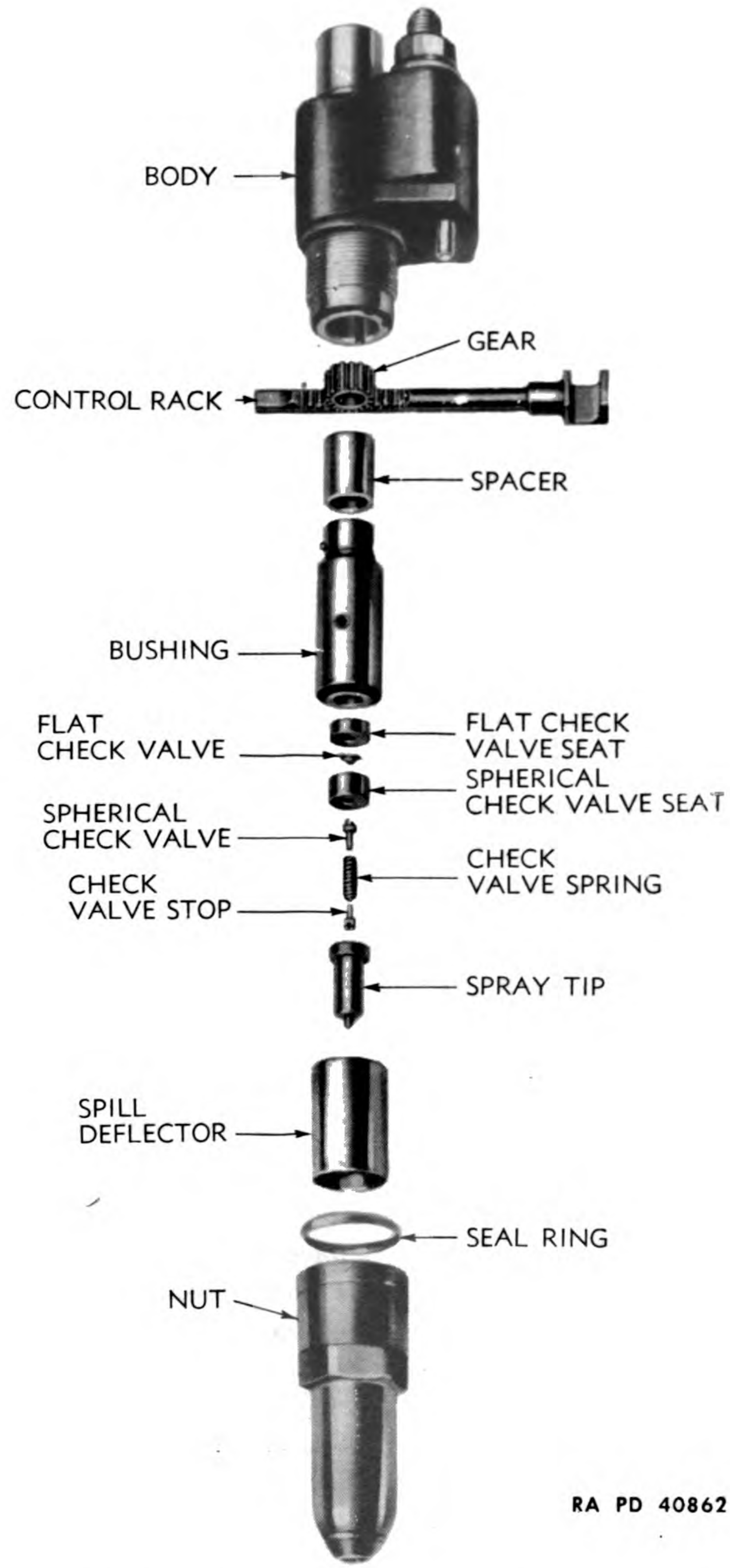



***Figure 30 — Relative Location of Parts in Lower Part of Injector***

use new filters if possible. In emergency, when new filters are not available and it is necessary to use the filters that were removed from the injector, be sure to install the filters in the same side from which they were removed. If the filter that was removed from the outlet side is placed in the inlet side, dirt lodged on the lower surface of the filter will be washed into the injector when the injector is put into operation. Place a spring above each filter and a *new* copper gasket up against the shoulder of each filter cap. Lubricate the threads and screw the caps into the body. Tighten firmly.

(3) INSTALL RACK AND GEAR. Two of the teeth of the injector rack have a drill spot mark on the one end; also one tooth of the mating gear is similarly marked. When the rack and gear are assembled, the marked tooth of the gear engages between the two marked teeth on the rack. This relation of rack and gear must be maintained for proper timing of the injector. Hold the injector body bottom end up and slide the rack through hole in side of body toward filters so the two marked teeth can be seen through opening in bottom of injector body. Now hold the rack in position so the teeth marks show and slide the gear into the proper engagement with the rack.

(4) INSTALL SPACER AND PLUNGER BUSHING. Slide spacer down on top of gear. Insert plunger bushing down onto spacer with locating pin in bushing guided into slot in injector body.

(5) INSTALL SPILL DEFLECTOR AND SEAL RING.

JAWS, vise, injector body

Place injector in vise jaws and insert in vise with bottom end up. Clamp vise jaws, taking care not to bind or bend rack in injector body. Drop spill deflector on over bushing. Slip *new* rubber seal ring over bushing and threads against shoulder of injector body.

(6) ASSEMBLE SPRAY TIP ASSEMBLY. Place flat check valve seat flat down on clean piece of paper; place flat check valve on seat and spherical check valve seat cupped side down over check valve. Holding the spray tip point down, drop the check valve stop, small end down, into injector tip. Drop spring over end of stop and drop spherical check valve down into spring with spherical end up. Place tip assembly on check valves and place check valves and tip assembly on the end of the plunger bushing.

(7) INSTALL INJECTOR NUT.

TUBING, copper, ¼ x 6-in. WRENCH, injector nut

Lubricate threads in injector nut. Insert copper tubing through nut.

FUEL INJECTORS

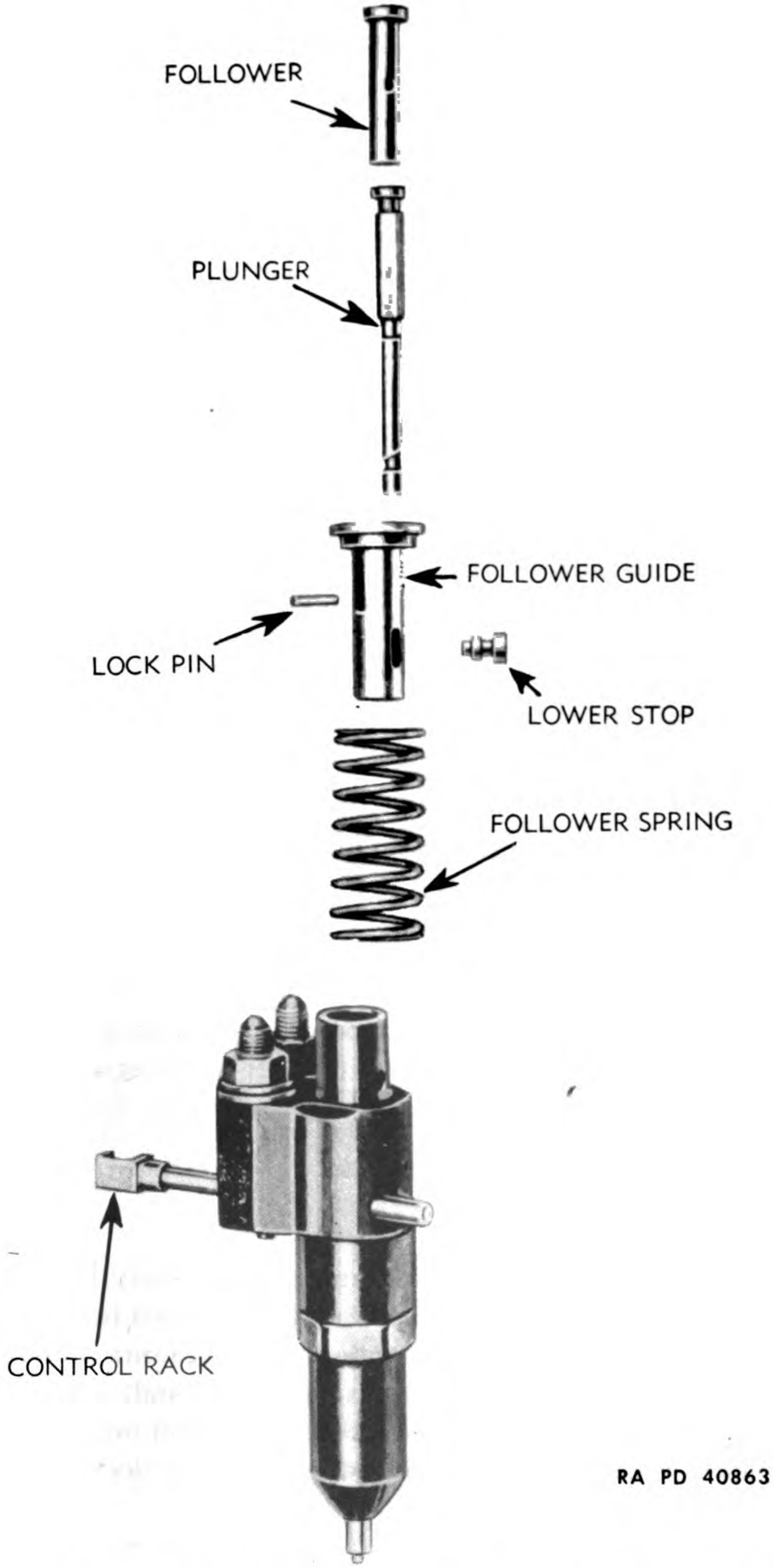



***Figure 31 — View Showing Relative Location of Parts in Plunger and Follower Assembly***

Hold nut and copper tubing in one hand; hold valves and tip assembly with other hand. Place end of tube over point of spray tip to hold these parts in place while nut is lowered over them. Retaining hold on top of copper tube with one hand, screw nut down into position with other. Move spray tip slightly to help guide valve seats up into recess in nut. Screw nut down by hand until tip seats tightly. The nut should now be within $\frac{1}{16}$ inch of touching shoulder. *Do not force nut* even by hand while screwing it down. It can be turned down with thumb and finger if valves are in line. If shoulders inside nut strike edges of valves and the nut does not screw down easily as outlined, it will have to be removed and valves again centrally located on end of bushing. Tighten nut firmly (injector nut wrench).

(8) INVERT INJECTOR IN VISE. Turn injector in vise and clamp injector in vise with spray tip end down. Push control rack all the way in.

(9) ASSEMBLE PLUNGER AND FOLLOWER ASSEMBLY. Insert plunger with large end up into follower guide. Install follower, large end up, into top of follower guide. Line up holes through follower and guide and insert lock pin.

(10) INSTALL SPRING ON FOLLOWER ASSEMBLY. Drop follower assembly into spring, plunger end first. Head of follower must seat into counterbored head of follower guide.

(11) INSTALL FOLLOWER ASSEMBLY AND SPRING. Lower follower assembly and spring into top of injector. Plunger must pass through gear and into bushing. NOTE: Flat side of plunger must register with flat side of bore of gear in order for plunger to enter gear (fig. 31).

(12) INSTALL FOLLOWER STOP PIN.

LIFTER, injector spring

Aline holes in the follower guide and injector body for the stop pin beneath the return spring; then insert spring lifter tool beneath the lower end of spring; push down on top of follower and at same time raise spring with one hand and insert stop pin with the other hand. The stop pin will slip into place as soon as holes in follower guide and injector body come in alinement. When lifter is removed, pin will be locked in place by spring.

(13) TEST FOR BINDING. Remove injector from vise. Hold injector flat and turn from one side to the other. Control rack should fall back and forth by its own weight if injector has been properly assembled.

FUEL INJECTORS

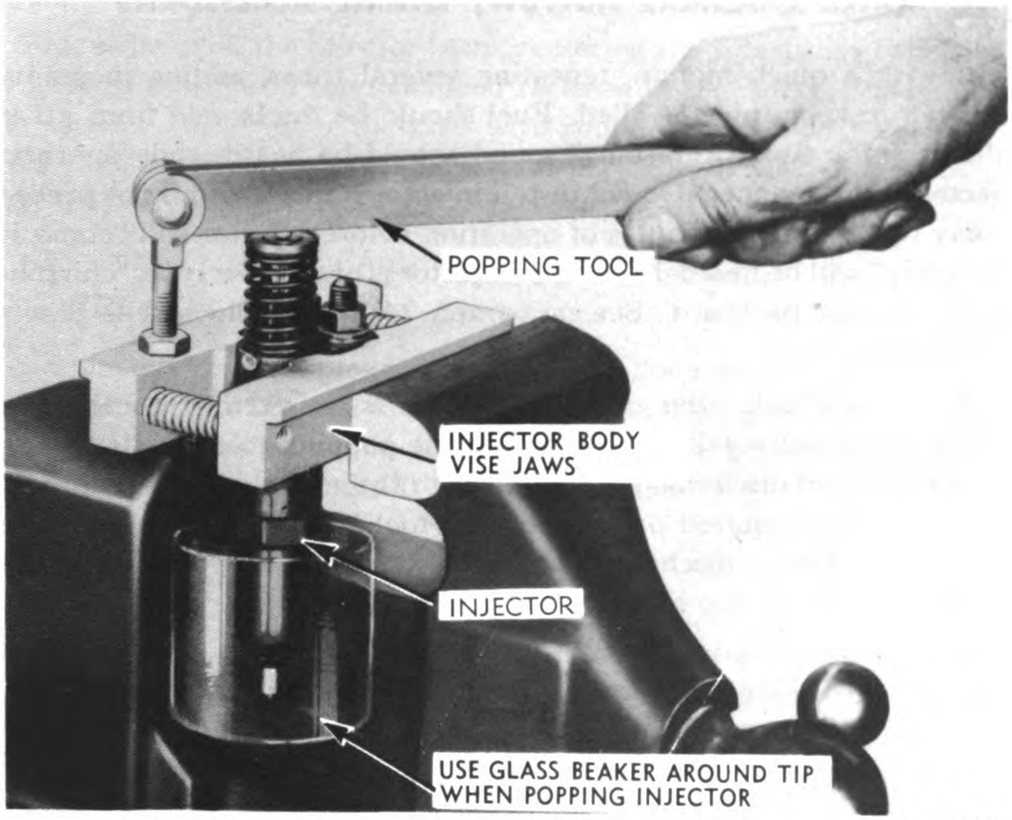



***Figure 32—Testing Injector***

## 26. TEST FOR OPERATION.

**a.** After an injector has been rebuilt, it should be tested before it is installed in the engine. This test is known as "popping the injector" and is accomplished with tool as shown in figure 32.

**b. Equipment.**

BEAKER, glass
JAWS, vise, injector body with popping tool
OILCAN, filled with clean fuel

**c. Procedure.**

(1) Place the injector in the injector body vise, and by means of an oilcan introduce *clean* fuel into one of the injector openings until fuel flows from the other opening. Set a beaker under and surrounding injector spray tip so fuel injected from tip hits inside of beaker. CAUTION: Always use beaker and keep hands away from spray tip when "popping" injector. The finely atomized fuel from spray tip travels with such force it will penetrate the skin and may cause blood poisoning.

(2) To determine if all six holes in spray tip are open, push injector rack into full fuel position and press test handle down on plunger fol-

lower with a quick motion, repeating several times, adding more fuel from can to keep injector filled. Fuel should be discharged from all six holes in spray tip. A "chirping" sound should be heard while operating injector in this manner. Do not install injector if this sound is not present. It may require a few minutes of operation before injector will "come in" and "chirp" will be heard. NOTE: If injector is of the new type, "chirping" sound will not be heard. See paragraph 24 c (2), which tells how to identify new type.

(3) If the check valve opening pressure is satisfactory, considerable downward pressure will be required on the popping tool handle to open check valve and discharge the fuel through the six holes. If considerable pressure is not required on the popping tool handle to open the check valve so the fuel is discharged in a "fog" from the spray tip, the valve opening pressure is too low.

(4) To test for a check valve leak or dribble, wipe or blow all fuel from spray tip and press down firmly on popping tool handle to the point where check valve is about to open. (Do not force valve open.) Continue to hold handle down against check valve pressure. No "dribble" should take place at spray tip. If "dribble" occurs, check valve is not seating properly. If the injector does not pass the above three tests satisfactorily, it should be disassembled, carefully and thoroughly cleaned, and any worn or corroded parts replaced. NOTE: Never remove filters from injector unless unit is entirely disassembled because there is a possibility of dirt entering injector when filters are removed.

(5) After tests are completed, place shipping caps on injector filter cap fittings and place injector in box provided or wrap in clean oiled paper and seal against dirt until ready to install in engine.

## 27. INSTALLATION.

### a. Equipment.

WRENCH, open-end, ½-in.
WRENCH, socket, ¾-in.
WRENCH, socket, 9⁄16-in.

### b. Procedure.

(1) PLACE THE INJECTOR IN THE INJECTOR TUBE. A dowel, provided on the injector body, registers with a hole in the cylinder head so that the injector can be located in only one position in the head. As injector is slipped in place, engage the control rack with the control lever.

(2) INSTALL THE INJECTOR CLAMP.

WRENCH, socket, 9⁄16-in.

Place clamp on the injector body, centering the side arms of the clamp as well as possible in the machined recesses in the injector body. Drop the special washer over the stud with rounded side down. Put nut on stud and draw clamp down firmly, using wrench with 8-inch handle (fig. 19).

(3) INSTALL ROCKER ARM SHAFT AND BRACKETS.

WRENCH, 3/4-in.

Slide shaft through rocker arms and place a bracket on each end of shaft, with the smooth side of brackets toward rocker arms. Draw brackets down firmly at the same time holding rocker arm brackets loosely against rocker arms, allowing about 0.006-inch clearance.

(4) CONNECT FUEL LINES.

WRENCH, open-end, 1/2-in.

Remove the shipping caps from fuel fittings in head and on injectors and connect fuel lines. After engine has been started, check for leaks before installing rocker arm cover. NOTE: The injector must be timed and equalized and the valve clearance adjusted for 0.010-inch clearance before engine is started and the rocker arm cover, hood and pre-cleaners are installed. See paragraphs 29 and 30 for injector timing and equalizing, and refer to paragraph 28 for adjustment of valve clearance.

## 28. VALVE CLEARANCE ADJUSTMENT (fig. 33).

**a. General.** Correct valve clearance is important because of high compression pressure developed in a Diesel engine. Too little clearance causes a loss of compression, "missing", and eventual burning of the valves and valve seats. Too much clearance results in noisy engine operation. The correct valve clearance is 0.010-inch at operating temperature. The valve clearance is adjusted by turning the push rod in the rocker arm clevis, which changes the length of the rod. Turn the push rod to the left to decrease valve clearance (lengthen rod), and to the right to increase clearance (shorten rod). The following procedure should be used to adjust the valve clearance correctly.

**b. Equipment.**

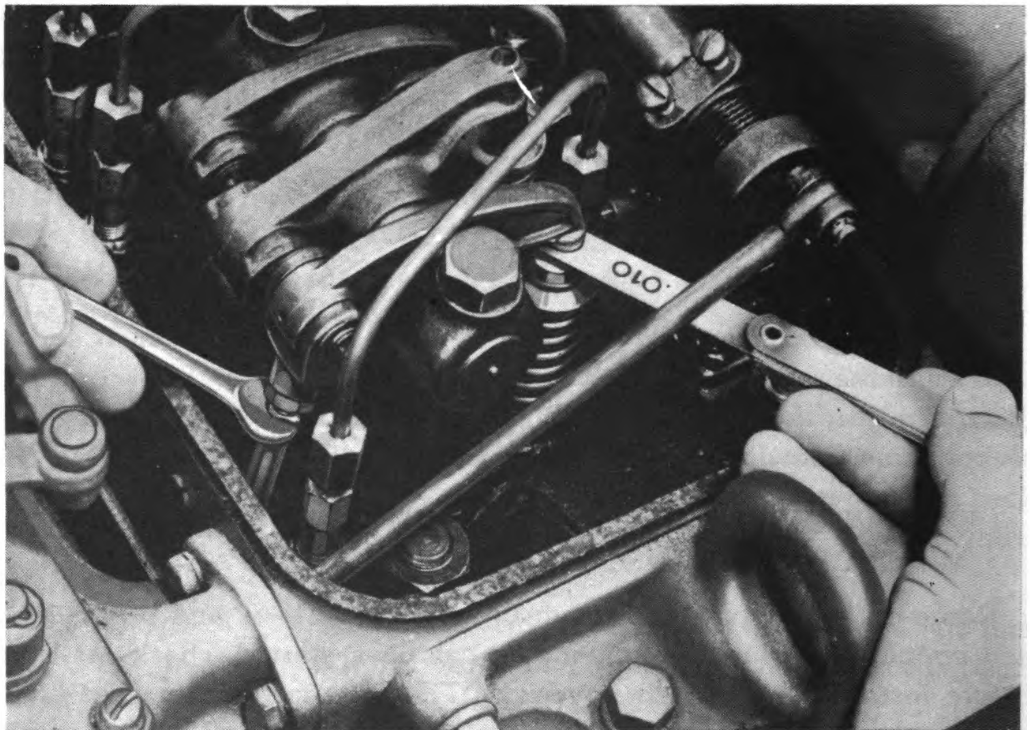
GAGE, feeler

WRENCH, open-end, 5/16-in.

WRENCH, open-end, 1/2-in.

**c. Procedure.**

(1) ROTATE ENGINE UNTIL INJECTOR IS AT BOTTOM OF STROKE. Rotate the engine with the starting motor until the injector plunger is fully depressed (injector rocker arm down).



RA PD 17491

***Figure 33 — Valve Clearance Adjustment***

(2) ADJUST CLEARANCE BETWEEN ROCKER ARM AND PUSH ROD.

GAGE, feeler
WRENCH, open-end, ½-in.
WRENCH, open-end, 5/16-in.

Use the 0.010-inch feeler gage and adjust each push rod until the gage will just pass between the valve stem and the rocker arm.

(3) TIGHTEN LOCK NUT.

WRENCH, open-end, 5/16-in.
WRENCH, open-end, ½-in.

Hold push rod and tighten lock nut. Check again to see if 0.010-inch feeler gage can be inserted between the valve stem and rocker arm. A slight drag should be felt on feeler gage.

(4) Repeat above steps for each cylinder.

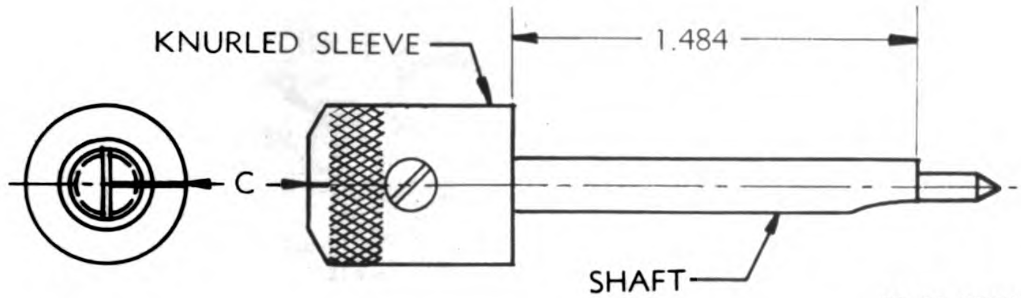
## 29. INJECTOR TIMING (fig. 35).

**a.** The timing of an injector consists of properly locating the top of the injector plunger follower in relation to the injector body when it is at the top of its stroke. This distance is 1.484 inches, and a special tool called a timing gage (fig. 34) (in the injector service kit) is used to make the proper adjustment.

**b. Equipment.**

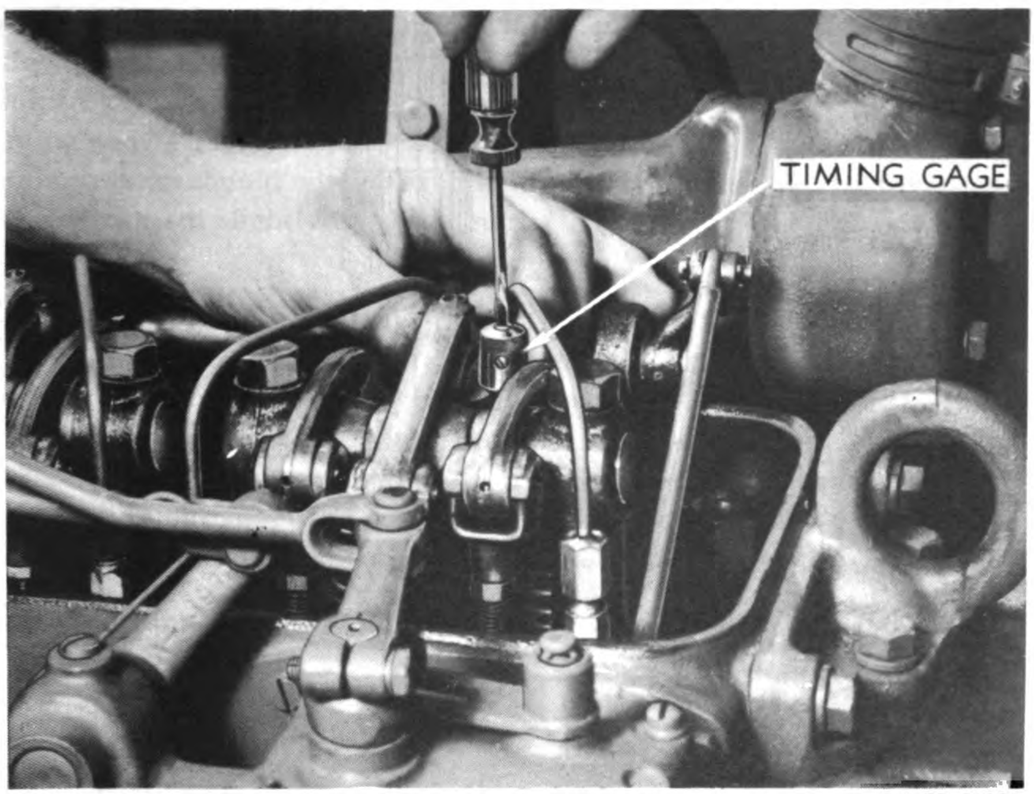
GAGE, injector timing
WRENCH, open-end, 5/16-in.
SCREWDRIVER, ⅛-in.
WRENCH, open-end, ½-in.

## FUEL INJECTORS




RA PD 53980

*Figure 34 — Injector Timing Gage*




RA PD 56386

*Figure 35 — Injector Timing*

**c. Procedure.**

(1) Pull Fuel Shut-off to "OFF" Position. Do not allow the engine to start. Crank engine with the starting motor until the exhaust valves of the cylinder on which the injector is to be timed are fully opened. When the rocker arms have fully depressed the exhaust valves, the injector may be timed.

(2) Set Timing Gage in Position.

| | |
|---|---|
| GAGE, injector timing | SCREWDRIVER, 1/8-in. |

Place the timing gage in the timing hole in the injector body. The knurled head or sleeve should be turned to the left as far as possible.

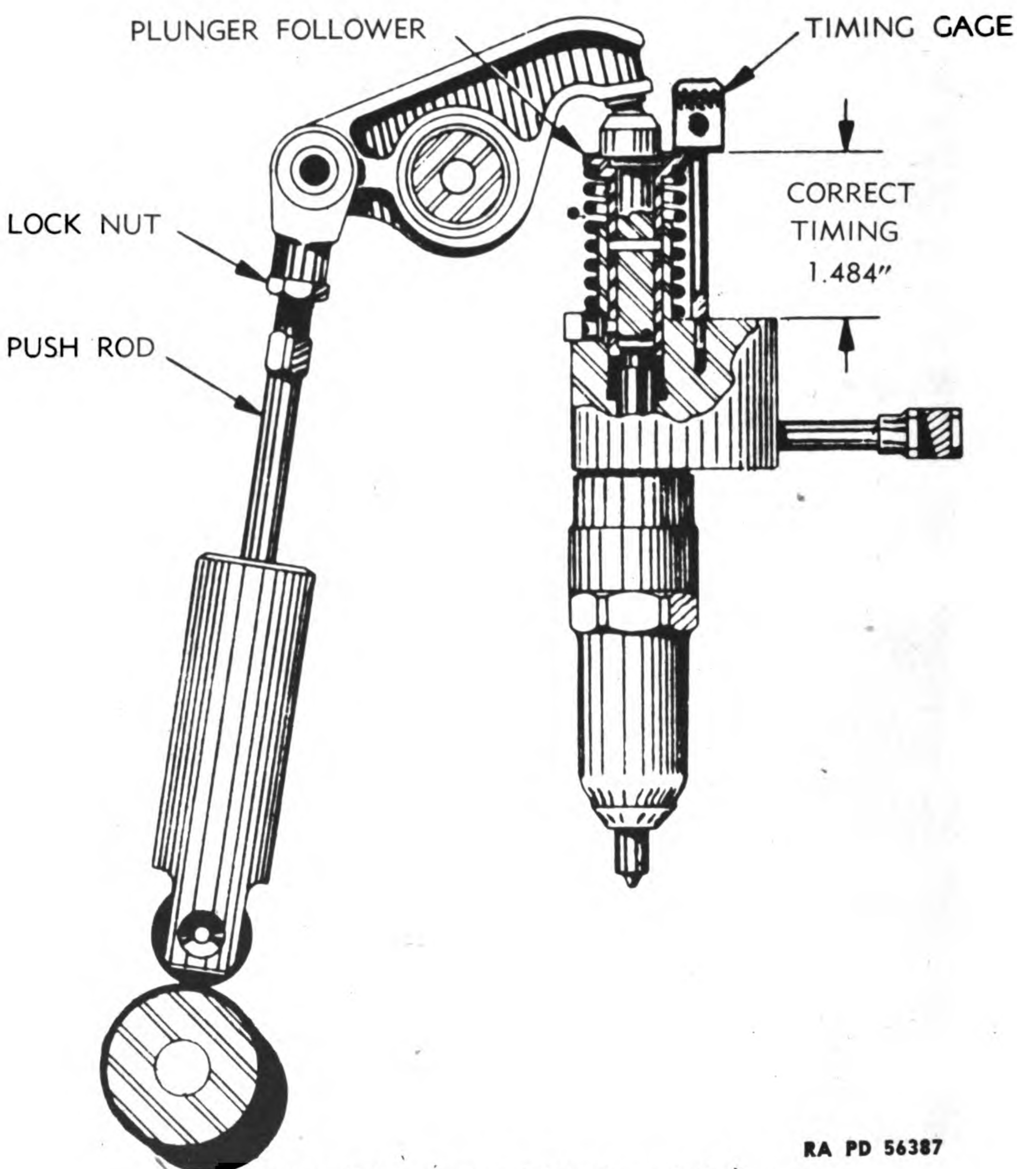



***Figure 36 — Correct Timing of Injector***

Hold the gage vertical with a firm downward pressure on a small screwdriver engaged in the slot in the top of the timing gage shaft. Make certain that the shoulder at the lower end of the timing gage shaft rests squarely on the injector body and is not resting on the copper gasket under the fuel line fitting in the injector.

(3) CHECK PRESENT SETTING.

GAGE, injector timing

Rotate the knurled sleeve to the right until the lower shoulder of the sleeve rests squarely on the edge of the follower guide. If the top of the shaft and the sleeve are not flush, and the marks "C" on the sleeve and shaft are not in line, the injector push rod must be lengthened or shortened to obtain the proper adjustment.

(4) ADJUST PUSH ROD.

WRENCH, open-end, 5/16-in. WRENCH, open-end, ½-in.

Loosen the lock nut on the push rod (½-in. wrench). Adjust the rocker arm by turning the push rod to the right to shorten it, which will allow the injector plunger follower to come up (5/16-in. wrench). Turning the push rod to the left will lengthen the push rod and will push the plunger follower guide down. When the timing marks line up (a small allowance must be made for the slight change which occurs when the lock nut is tightened), the sleeve should also be flush with the top of the timing shaft. Tighten the lock nut on the push rod (½-in. wrench). The timing marks should now be exactly in line. If they are not in line, change the adjustment slightly until the marks line up when the lock nut is tight.

## 30. INJECTOR EQUALIZING.

**a.** This operation consists of properly adjusting all injector control racks to obtain an equal fuel injection from each injector. Accurate timing of the injectors is essential before they can be equalized. The injector must be timed and equalized every time any part of the engine is worked on which might affect the position of the injector or rocker arm assembly. Equalizing is accomplished by the procedure mentioned in step c.

**b. Equipment.**

PLIERS SCREWDRIVER, 6-in.

**c. Procedure.**

(1) PUSH FUEL SHUT-OFF FORWARD (OPEN). Push fuel shut-off all the way forward and pull throttle back (open) as far as possible.

(2) LOOSEN ADJUSTING SCREWS.

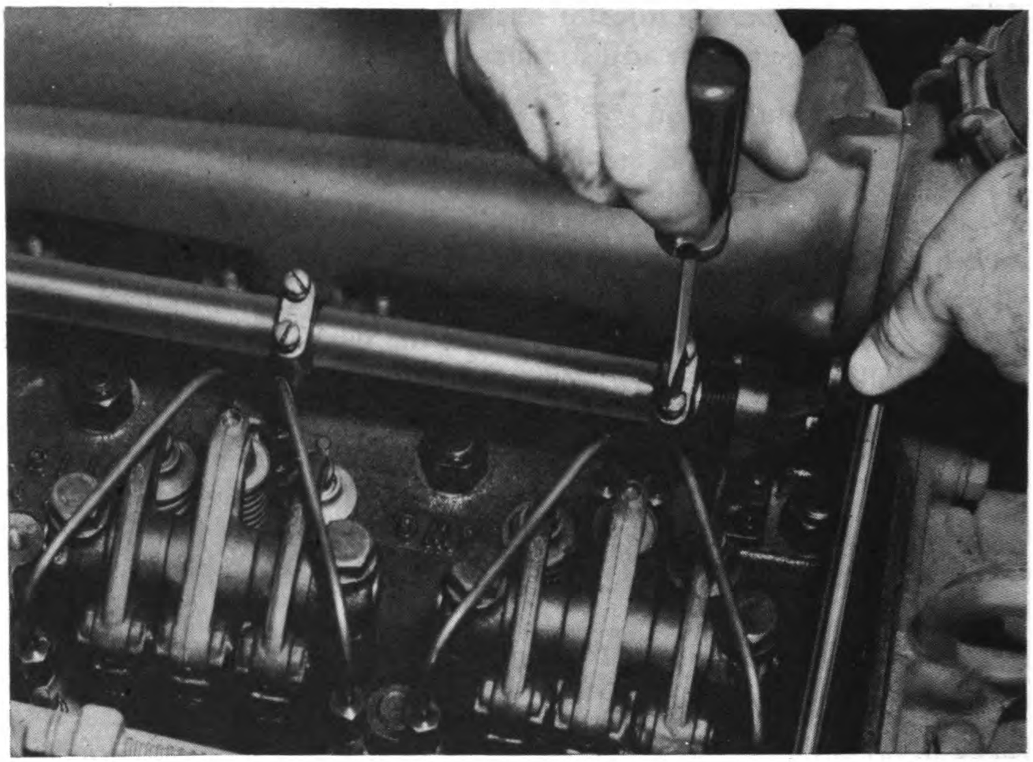
SCREWDRIVER, 6-in.

Loosen all adjusting screws on the rack control levers and be sure the levers are free on the control tube and that the control tube rotates freely in the bearings.

(3) DISCONNECT GOVERNOR CONTROL LINK.

PLIERS

Remove link pin from governor control link and control tube lever. All injector control racks should move freely and the injector control



RA PD 17664

*Figure 37 — No. 1 Control Rack Adjustment*

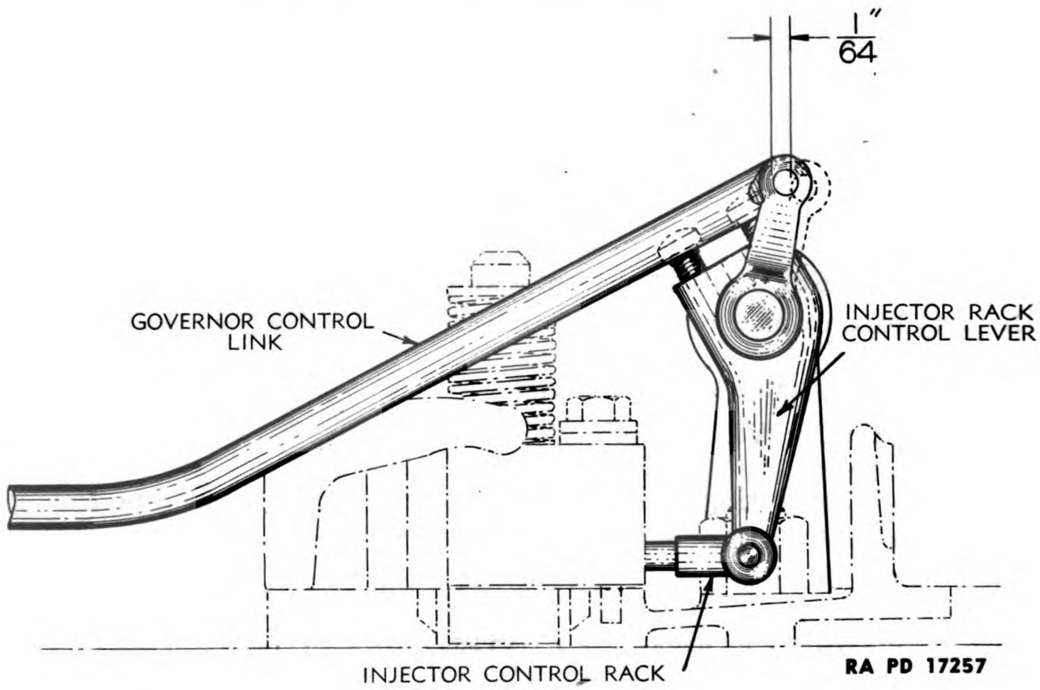



*Figure 38 — Clearance for Control Rack and Gear*

tube assembly should return to the "no injection" position when the governor control link is disconnected.

(4) ADJUST FOR CONTROL RACK AND GEAR CLEARANCE.

SCREWDRIVER, 6-in.

Hold the throttle lever on the top of the governor in full load position, and turn the lower adjusting screw for No. 1 injector in, until the hole for the pin in the control tube lever is 1/64-inch out of line with the hole in the governor control link (fig. 37). Turn the upper adjusting screw down and tighten both screws lightly so the 1/64-inch spacing is maintained.

(5) ADJUST REMAINING RACK CONTROL LEVERS. Hold No. 1 rack control lever against No. 1 injector control rack in its "IN" position and adjust the remaining rack control levers until the lugs on all rack control levers just contact the inner faces of the slots in the injector control racks. CAUTION: The adjusting screws will be damaged if drawn too tightly. If they are just screwed down firmly, they will not loosen.

(6) CONNECT GOVERNOR CONTROL LINK.

PLIERS

Install link pin in governor control link and control tube lever and secure with cotter pin. Install rocker arm cover, start engine and test for proper operation.

(7) TEST FOR PROPER OPERATION. Engine should run smoothly at both idling and full speed. If one injector is adjusted too rich, a "knock" will be heard. In this case repeat equalizing procedure. If engine still knocks after equalizing has been checked, one of the injectors is not operating properly and should be replaced.

## 31. SPECIAL TOOLS.

**a.** Special tools required for working on injectors are as follows:

BEAKER, glass
BLACK, lapping, injector valve
CLEANER, injector bushing
JAWS, vise, injector body, with popping tool
KIT, service, injector; includes:
  BRUSH, small
  BRUSH, large
  GAGE, timing, injector
  REAMER, spray tip
  STONE, emery
  VISE, pin, with 0.006-inch probing wire
LIFTER, injector spring
TOOL, remover, injector
WRENCH, injector nut

ORDNANCE MAINTENANCE — HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

## Section V

## FUEL PUMP



### 32. DESCRIPTION.

a. The fuel pump is of the positive displacement vane type. It is bolted to the rear end of the blower housing and driven from the lower blower rotor shaft through a U-shaped steel stamping which acts as a universal joint. The steel rotor is formed as part of the shaft and is supported at each end of the pump. This rotor revolves in a housing, the bore of which is eccentric to the shaft. Two spring-loaded vanes, carried in the rotor, revolve inside the eccentric housing, thus displacing the liquid from the inlet to the outlet port. Two oil seals are used inside the flange at the inner end of the rotor shaft. One seal retains the fuel, under pressure; the other prevents the lubricating oil in the blower timing gear compartment from creeping along the pump shaft. The seals are located approximately $^{1}/_{16}$ inch apart. The feather edge of the leather on the inner seal faces the blower, and that on the outer seal faces the pump body. A drain hole is located between the two seal vents to the outside.

b. A spring-loaded, horizontal relief valve is provided in the cover of the pump, connecting the inlet and outlet ports. This valve opens at a pressure of approximately 60 pounds per square inch, and therefore does not open under ordinary conditions, but serves to relieve excessive pump pressure in case any of the fuel lines or filters become plugged. The relief valve and its seat always face the discharge opening in the pump cover so that when valve opens, the fuel flow will be back to the suction side of the pump.

### 33. TROUBLE SHOOTING.

a. **Fluctuating Fuel Pressure.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Dirt in relief valve. | (1) Remove and clean relief valve. |
| (2) Insufficient fuel supply. | (2) Obtain fuel. |

## FUEL PUMP

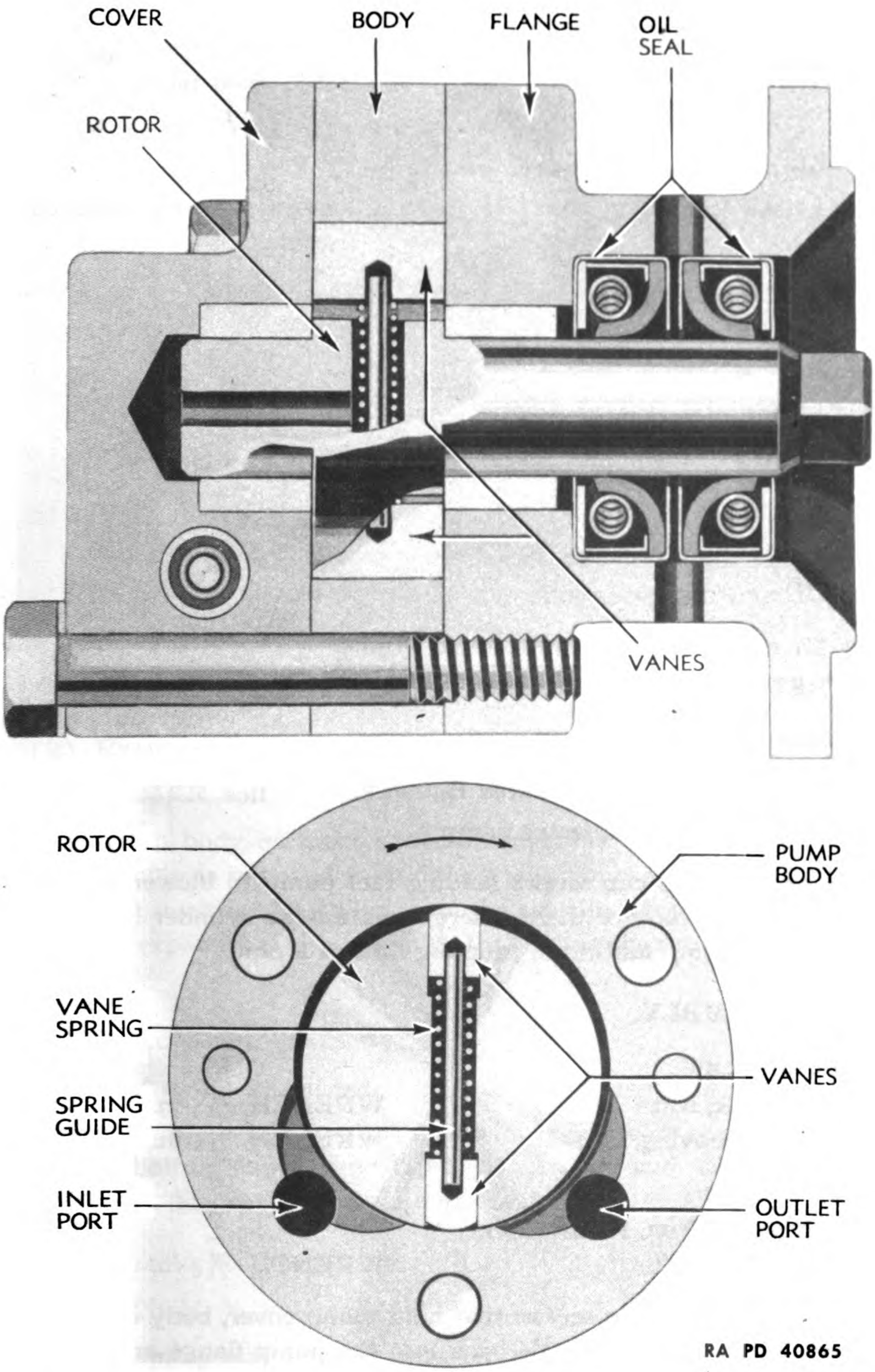



***Figure 39—Fuel Pump Assembly Showing Position of Rotor, Vanes and Oil Seals***

| Probable Cause | Probable Remedy |
|---|---|
| (3) Worn body, rotor or vanes. | (3) Replace worn parts. |

b. **Low or No Fuel Pressure.**

| | |
|---|---|
| (1) Air leaks in system. | (1) Inspect system for loose connections. |

c. For other contributing causes, refer to Paragraph 19.

## 34. REMOVAL OF PUMP.

a. **Equipment.**

WRENCH, fuel and water pump — WRENCH, open-end, 7/8-in.

b. **Procedure.**

(1) CLOSE FUEL SHUT-OFF.

(2) DISCONNECT FUEL LINES FROM PUMP.
WRENCH, open-end, 7/8-in.

Disconnect inlet and outlet lines from pump.

(3) REMOVE FUEL PUMP FROM BLOWER.
WRENCH, fuel and water pump

Remove the three cap screws holding fuel pump to blower. Use the special wrench to remove the cap screw nearest the cylinder block. Remove the fuel pump and drive coupling fork as a unit.

## 35. DISASSEMBLY.

a. **Equipment.**

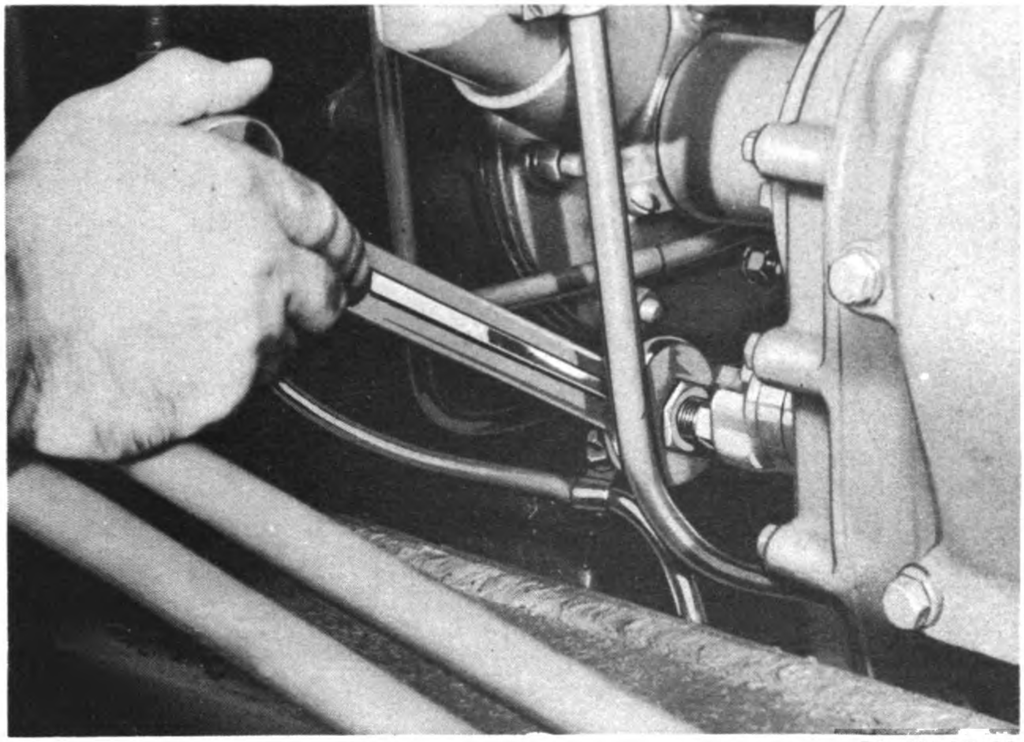
HAMMER, soft — WRENCH, 7/16-in.
TOOL, removing, oil seal — WRENCH, 9/16-in.

b. **Procedure.**

(1) REMOVE FUEL PUMP COVER.
HAMMER, soft — WRENCH, 7/16-in.

Remove the three cap screws that hold pump cover, body and flange together. Drive the two dowels back into the pump flange and remove the cover and gasket. NOTE: Be careful not to destroy gaskets at each side of pump body, as gaskets of the same thickness must be used when assembling pump.

FUEL PUMP



RA PD 17611

***Figure 40 — Disconnecting Fuel Lines from Fuel Pump***

(2) REMOVE BODY.

HAMMER, soft

Tap pump body off dowels. Rotor assembly can be withdrawn. As rotor assembly is removed from flange, hold vanes with fingers. **NOTE**: Rotor shaft must not be pulled from the seals in the pump flange unless an oil seal expander tool is available for guiding the rotor shaft back into the seals.

(3) REMOVE OIL SEALS.

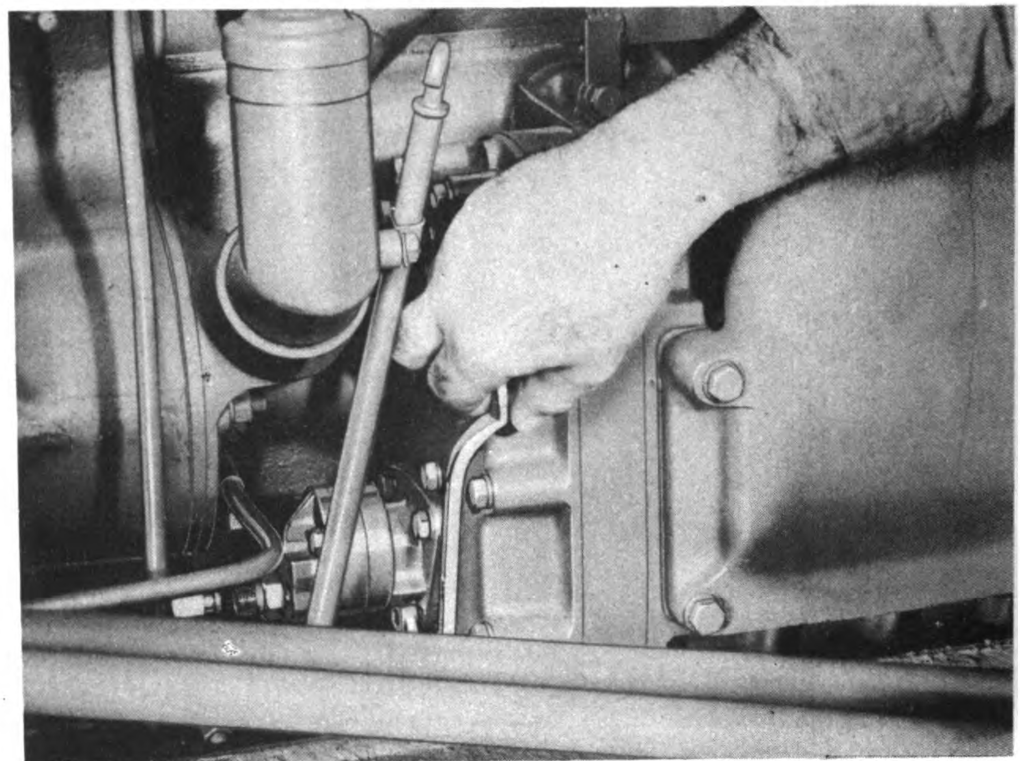
TOOL, removing, oil seal

Screw threaded end of tool shaft into inner oil seal of pump flange (seal closest to bolting flange) and tap head on shaft with sliding weight to remove seal. Repeat to remove outer seal.

(4) REMOVE RELIEF VALVE.

WRENCH, $^9/_{16}$-in.

This assembly may be removed from the pump cover—without disassembling the other parts of the pump—by backing out the retaining screw and jarring out the relief valve retaining spring, valve and seat, small spring, and cage.



RA PD 17613

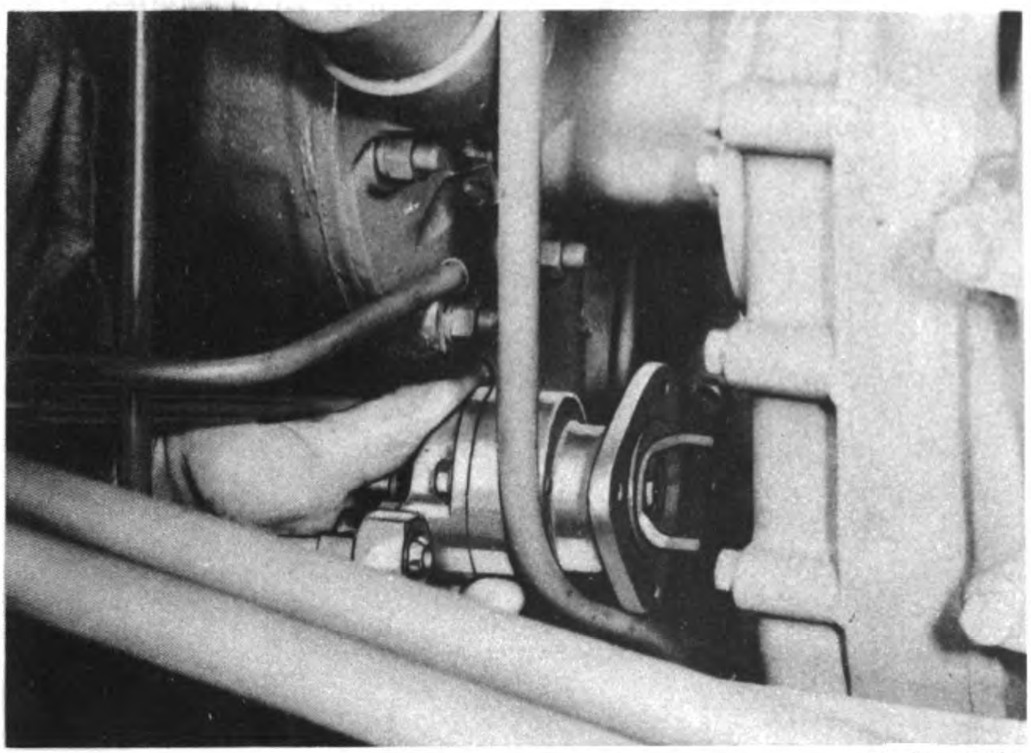
*Figure 41 — Removing Cap Screws from Pump with Special Wrench*

## 36. INSPECTION AND REPAIR.

**a.** All pump parts should be washed in fuel and carefully inspected before reassembly. The oil seals, once pulled from the flange, should not be used again. If the feather edges of the leather seals are damaged in any way so they do not form a perfect seal around the shaft, either a fuel or lubricating oil leak will result.

**b.** The paper gaskets used on either side of the pump body are of the proper thickness to produce the correct clearance for the rotor and vanes between the pump cover and flange. If these gaskets are not usable, replace with new gaskets of the same thickness. The rotor shaft and vanes should be inspected before replacement and changed if necessary. This is particularly true of the wiping surface of the vanes and the inside surface of the pump body.

**c.** The rotor shaft bears directly on the cast iron flange and cover. The bearing surfaces of the flange, cover and rotor shaft should be inspected for scores, scratches or burs. The clearance of the shaft in its bearings is 0.0015-inch. If clearance is increased above this figure, by reaming or honing, the pump will not operate. Complete pump replacement is therefore necessary when shaft or bearing surfaces are damaged.



RA PD 17616

*Figure 42 — Removing Fuel Pump*

d. If the relief valve does not form a tight seal with its seat, no attempt should be made to lap the valve or the seat. Use new parts.

## 37. ASSEMBLY.

### a. Equipment.

| | |
|---|---|
| HAMMER, soft | TOOLS, oil seal |
| TOOLS, guide pin | WRENCH, 7/16-in. |
| TOOL, pump holding fixture | WRENCH, 9/16-in. |

### b. Procedure.

(1) INSTALL OIL SEALS.

| | |
|---|---|
| HAMMER, soft | TOOLS, oil seal |

With leather of seal pointing toward pump body, start outer seal into pump flange. Set driven head of oil seal replacing tool onto seal, with long portion of head toward outer seal. (Short portion of head is placed toward inner seal when it is installed as in fig. 46.) Then slide handle through driven head and drive seal into place down tight into counterbore of flange (soft hammer and oil seal tools). Position inner oil seal with leather pointed away from pump body, as shown in figure 39; then place driven head on seal and drive seal into position as shown in figure

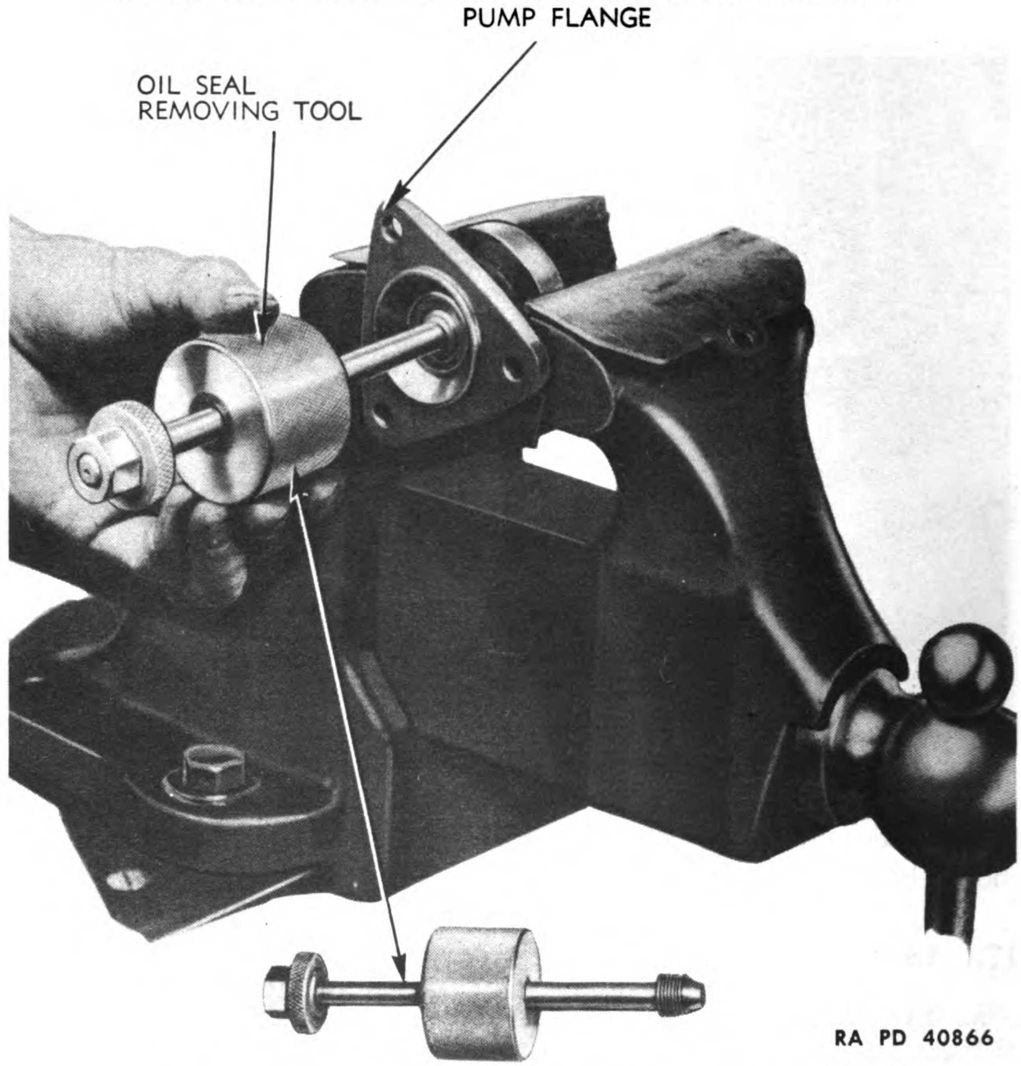



***Figure 43 — Removing Oil Seals from Fuel Pump***

46. The short end of the driven head will locate this seal the proper distance from the outer seal, which was first driven into the flange.

(2) INSTALL PUMP BODY.

TOOL, pump holding fixture    TOOLS, guide pin

Support holding fixture vertically in bench vise. Set pump flange on the three pins of the tool as shown in figure 48 and place the two guide pins in the dowel pin holes. Place a paper gasket in position on the face of the pump flange; then place the pump body in position over the guide pins as shown in figure 48.

(3) INSTALL ROTOR ASSEMBLY.

PILOT, oil seal

Assemble the vane guide, vane spring and vanes in the rotor and hold them in place with fingers. Place the oil seal pilot over the square end

## FUEL PUMP

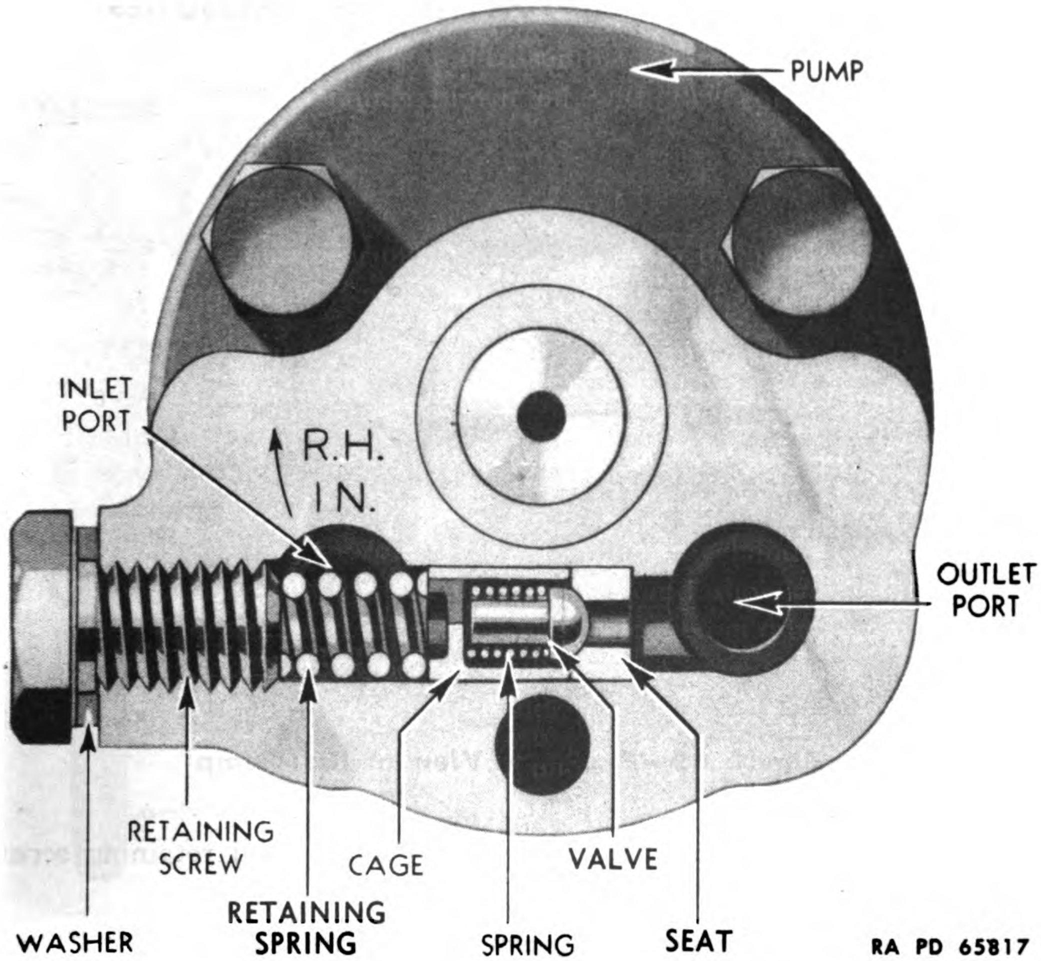



***Figure 44—Cut-Away View of Fuel Pump Relief Valve Assembly***

of pump shaft, as shown in figure 47. Lubricate pilot tool with clean engine oil and, while holding the pump vanes in position on the rotor, insert the rotor into place in the pump body.

(4) INSTALL PUMP COVER.

**WRENCH, 7/16-in.**

Install a new paper gasket. Then place the pump cover over the guide pins. Install the cover to body bolts, and draw tight with fingers only. Remove the special guide pins, and drive the two dowels shown in figure 45 into place as shown in figure 49. Tighten the cover to body bolts. Turn the pump shaft by hand and test for bind. The rotor should turn smoothly, with a slight drag, but should not bind or have tight spots.

(5) INSTALL RELIEF VALVE ASSEMBLY.

**WRENCH, 9/16-in.**

Install the relief valve parts, including cage, spring, valve, seat and retainer spring, being sure that the valve points away from the retainer

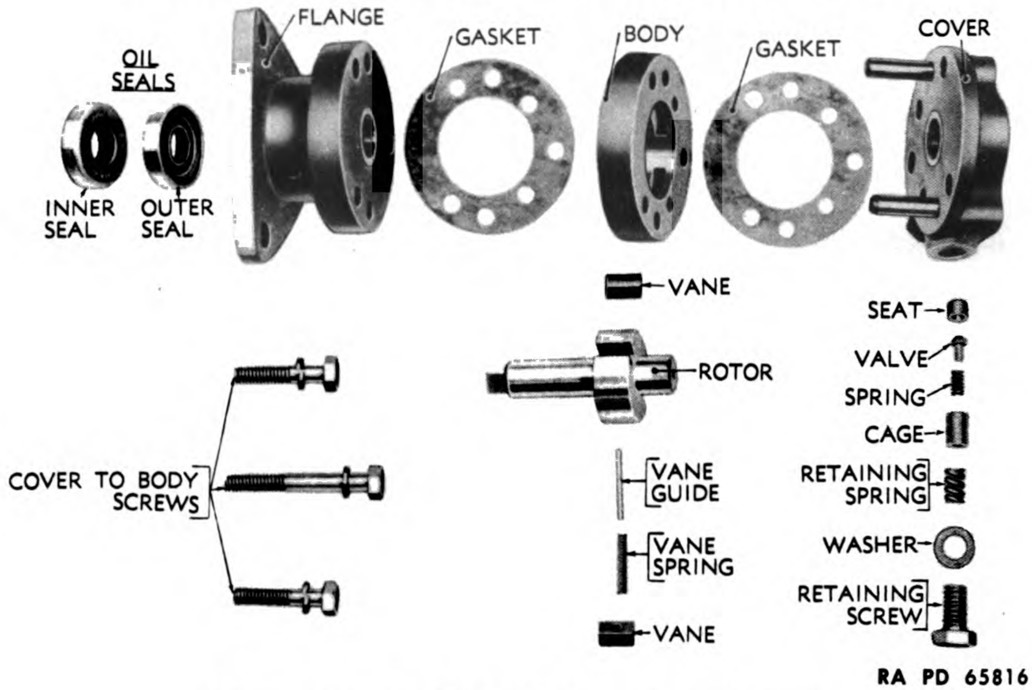



***Figure 45—Exploded View of Fuel Pump***

screw. Place washer over retaining screw and install retaining screw. (See fig. 44.)

## 38. INSTALLATION.

**a. Equipment.**

WRENCH, fuel pump WRENCH, open-end, 7/8-in.

**b. Procedure.**

(1) INSTALL COUPLING FORK ON PUMP.

Put drive coupling fork (arms out) on the squared outer end of the pump shaft. Use a new paper gasket on the pump support flange.

(2) INSTALL PUMP.

WRENCH, fuel pump

Install pump assembly on the blower end housing, engaging the drive fork in the slots of the driving plate on the lower blower rotor shaft. NOTE: The "IN" marking on the pump body should be on the cylinder block side. Secure pump to blower end housing with three cap screws with lock washers.

FUEL PUMP

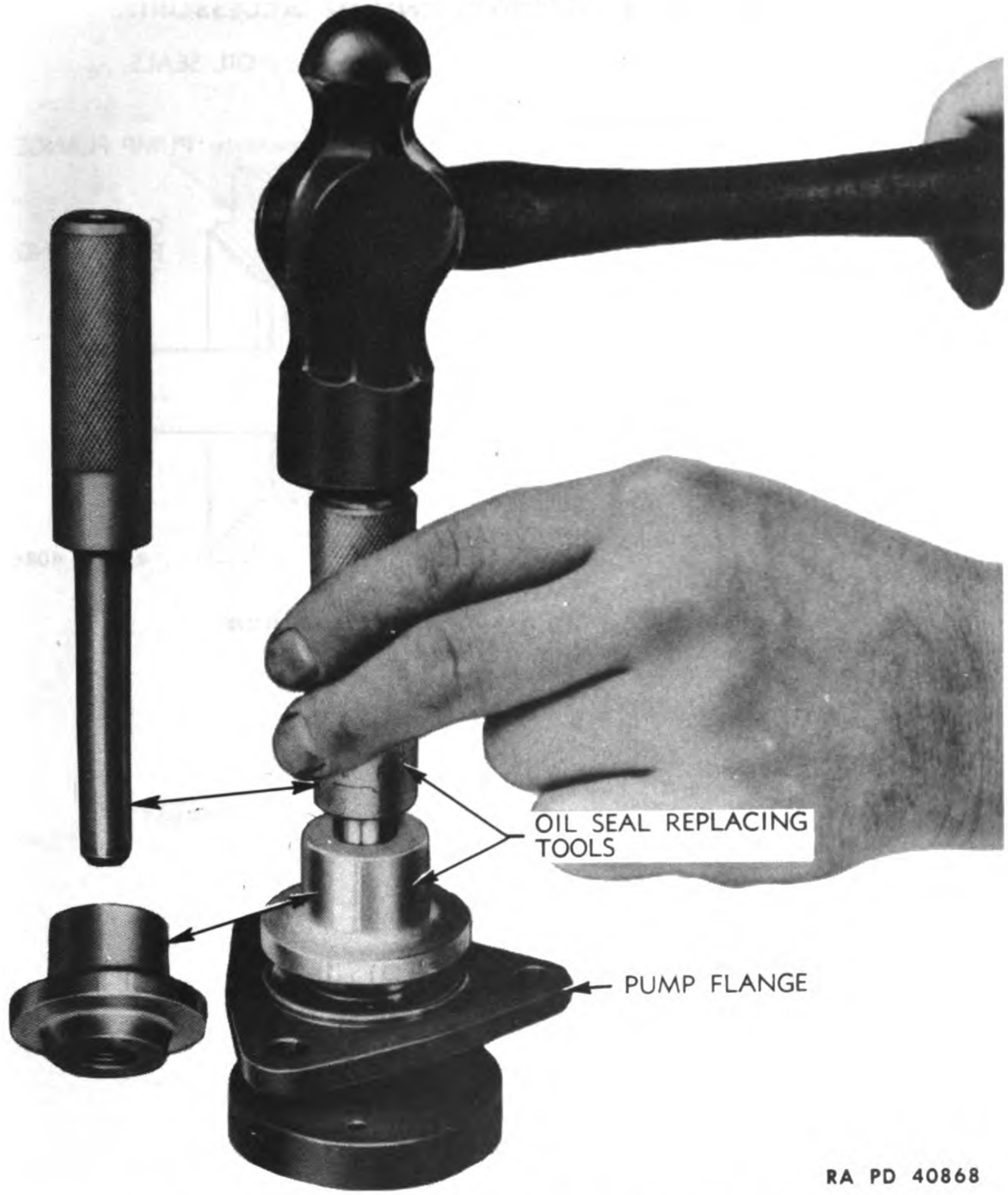



***Figure 46—Installing Inner Oil Seal in Fuel Pump***

(3) **Connect Fuel Lines to Pump.**

**WRENCH**, open-end, ⅞-in.

Connect fuel line from the fuel supply tank to the fitting on "IN" side of pump, and the second line to the other fitting.

(4) **Test for Operation.**

Start engine and check for fuel or air leaks. Air leaks are indicated by foaming of the fuel or by air bubbles in the fuel that comes from the return line.

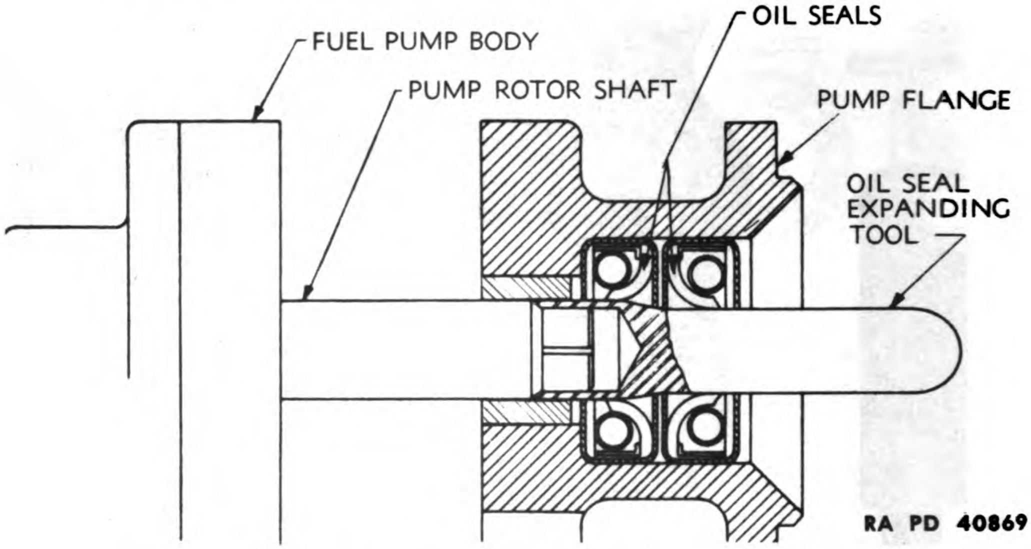



*Figure 47 — Oil Seal Pilot in Position*

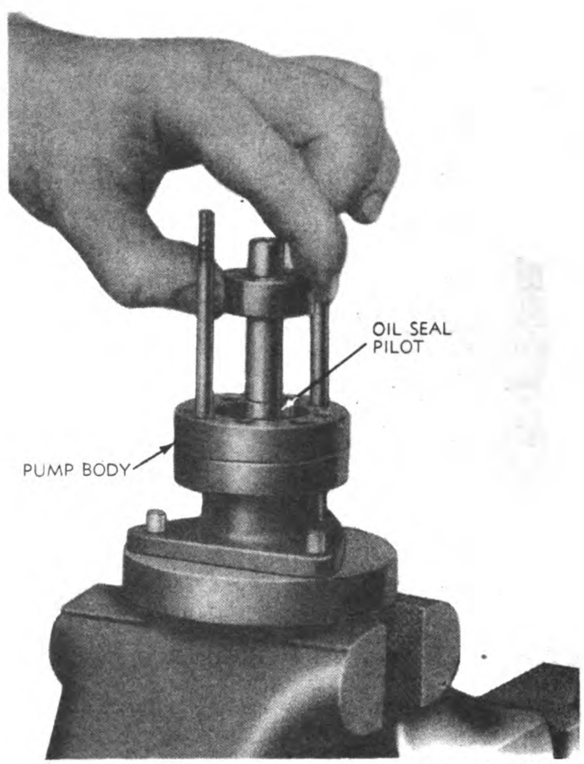


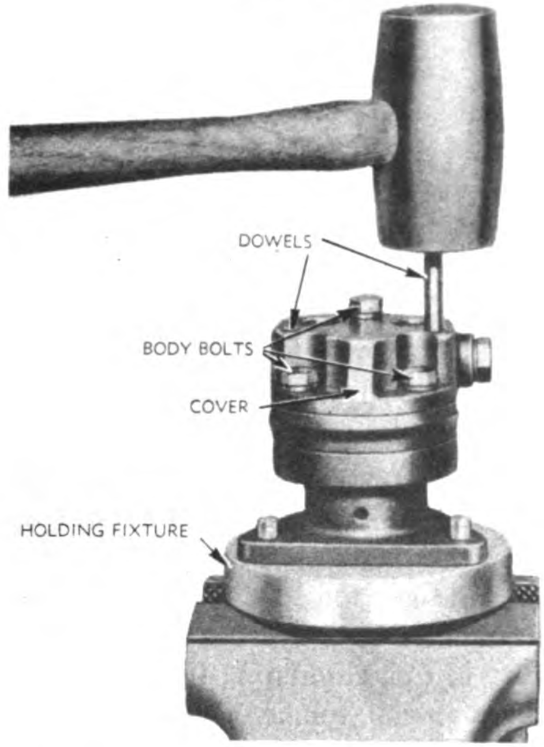

*Figure 48 — Installing Rotor Shaft Through Oil Seals*

## 39. SPECIAL TOOLS.

a. Special tools required for working on the fuel pump are as follows:

FIXTURE, holding, pump
TOOLS, guide pin
TOOLS, removing and replacing, oil seal

## FUEL PUMP




RA PD 40871

**Figure 49 — Installing Fuel Pump Body and Cover**

## Section VI

# FUEL FILTERS



## 40. GENERAL.

**a.** In this engine the circulation of fuel through the injectors helps keep the injectors cool. The fuel pump circulates approximately 25 gallons of fuel per hour through the injection system. If this quantity is allowed to decrease and get too low, there is a possibility of serious damage to the injectors because of overheating. As the fuel filters begin to plug up, the quantity of fuel circulating through the injectors becomes less. It may be reduced to the point where the injectors are becoming dangerously overheated, even though this flow may be sufficient to keep the engine operating normally. Therefore, proper performance of the engine does not necessarily mean that enough fuel is being circulated. For this reason the fuel filtering system should be checked and the filter elements replaced at the first indication of any deviation from normal fuel oil pressure. All fuel filters are of the replaceable element type.

## 41. FIRST STAGE FUEL FILTER ASSEMBLY.

**a. Description.** The first stage fuel filter assembly consists of two individual filters suspended on a bracket bolted to the transmission case under the seat. A fuel line from the supply tank leads to this assembly and another leads from the assembly to the fuel pump. Cotton wound elements are used in these filters.

**b. Removal.**

(1) EQUIPMENT.

WRENCHES, two, 9/16-in. WRENCH, open-end, 7/8-in.

(2) PROCEDURE.

*(a) Disconnect Fuel Lines.*

WRENCHES, two, 9/16-in. WRENCH, open-end, 7/8-in.

Close fuel shut-off valve at tank and disconnect the fuel lines from both inlet and outlet side of filter assembly (7/8-in. wrench). Remove bolt that holds fuel line clip to filter bracket (two 9/16-in. wrenches).

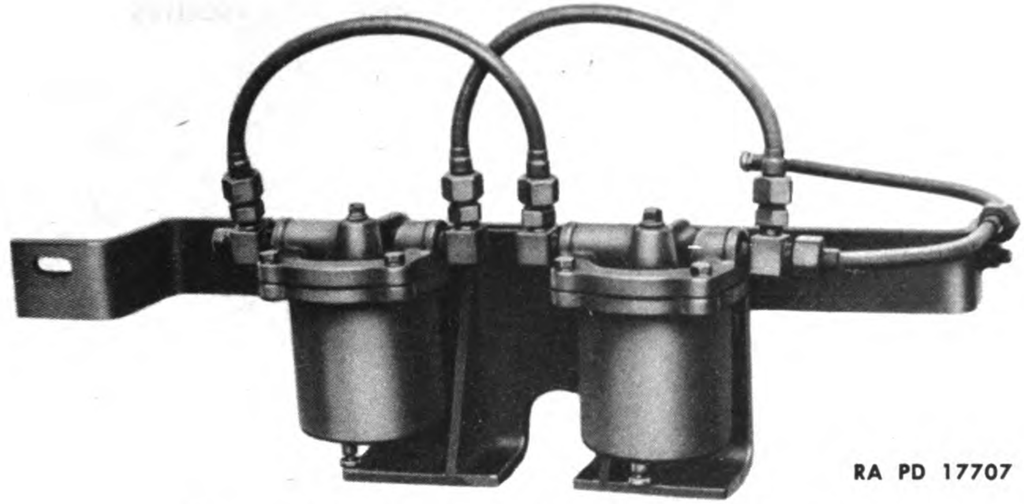



***Figure 50 — First Stage Fuel Filter Assembly***

*(b) Remove Assembly from Tractor.*

WRENCH, open-end, 7/8-in.

Remove the two cap screws that hold bracket to tractor transmission case and remove filter assembly.

**c. Disassembly.**

(1) EQUIPMENT.

WRENCH, 7/16-in.
WRENCHES, two, 9/16-in.
WRENCH, open-end, 7/8-in.

(2) PROCEDURE.

*(a) Remove Fuel Filters from Bracket.*

WRENCHES, two, 9/16-in.
WRENCH, open-end, 7/8-in.

Disconnect flexible fuel lines from filters (7/8-in. wrench) and remove the two bolts that hold each filter to bracket (two 9/16-in. wrenches) and remove fuel filters.

*(b) Remove Filter Shells.*

WRENCH, 7/16-in.

Remove the four cap screws from each filter clamp ring and remove shells.

**d. Maintenance.** Remove the dirty or clogged element and clean shell thoroughly with clean fuel. Replace old element with new one. NOTE: Do not attempt to clean dirty or clogged elements. It is not neces-

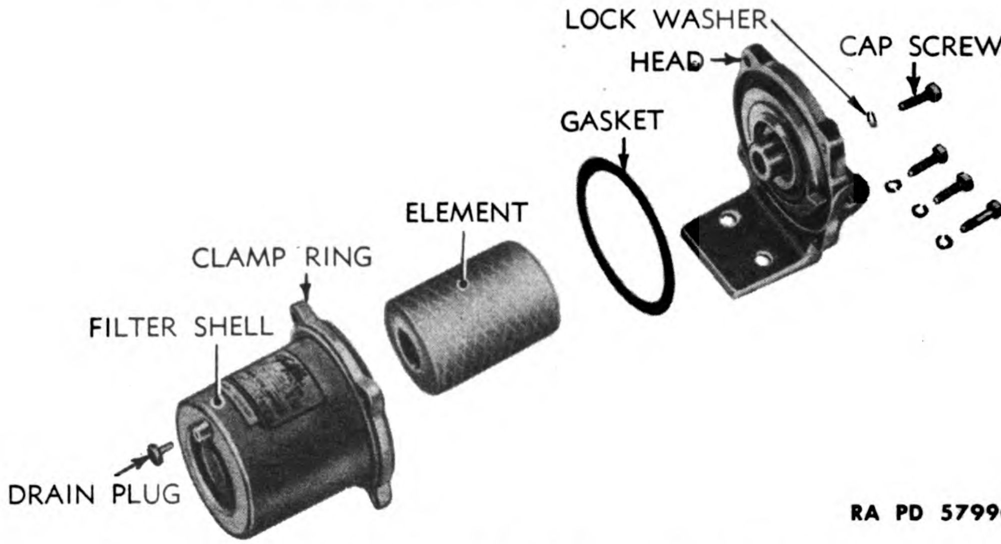



*Figure 51 — Exploded View of First Stage Fuel Filter Assembly*

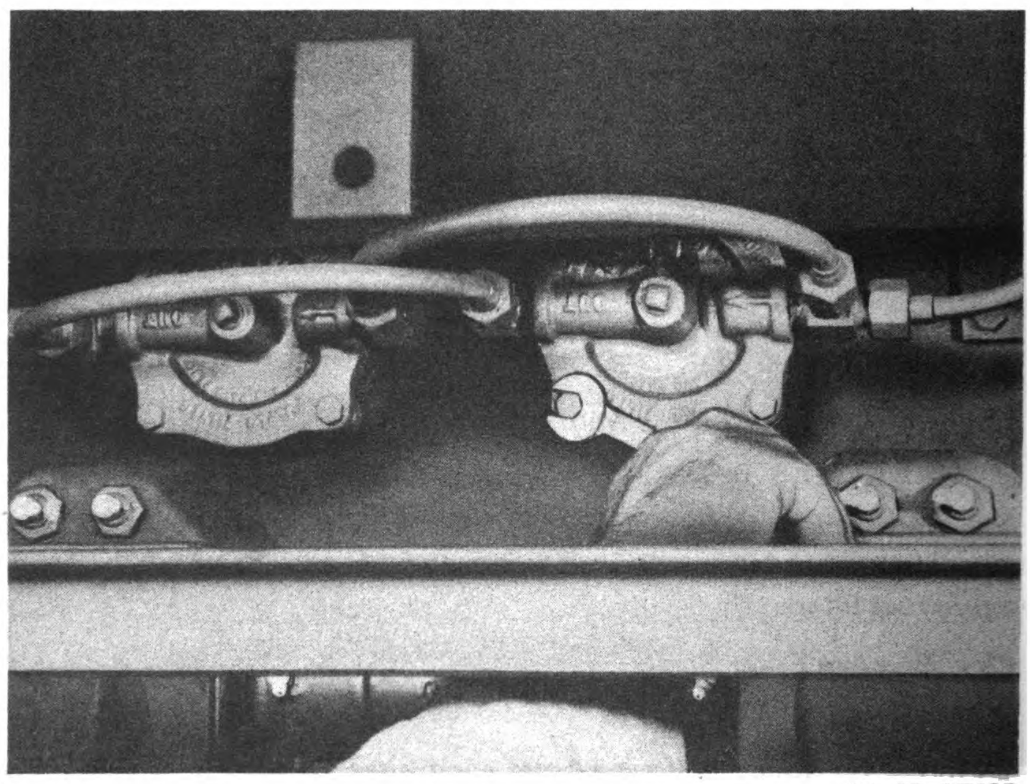
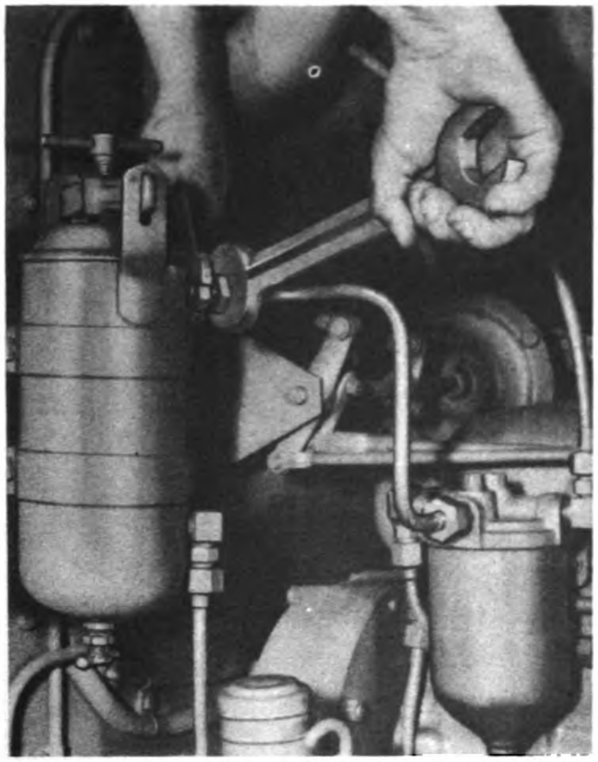



*Figure 52 — Removing First Stage Fuel Filter Shell*

sary to remove the entire assembly to replace filter elements. The element can be changed by merely removing the filter shells from the two filter clamp rings.

## FUEL FILTERS



RA PD 17633

**Figure 53—Disconnecting Fuel Line from Second Stage Fuel Filter**

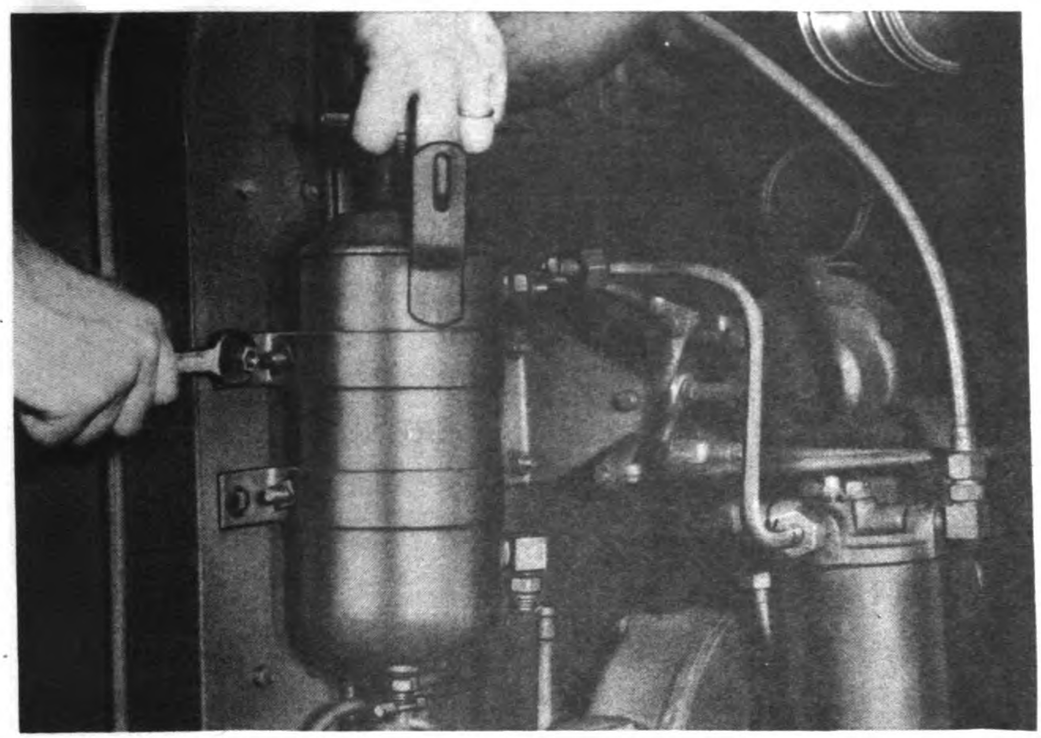


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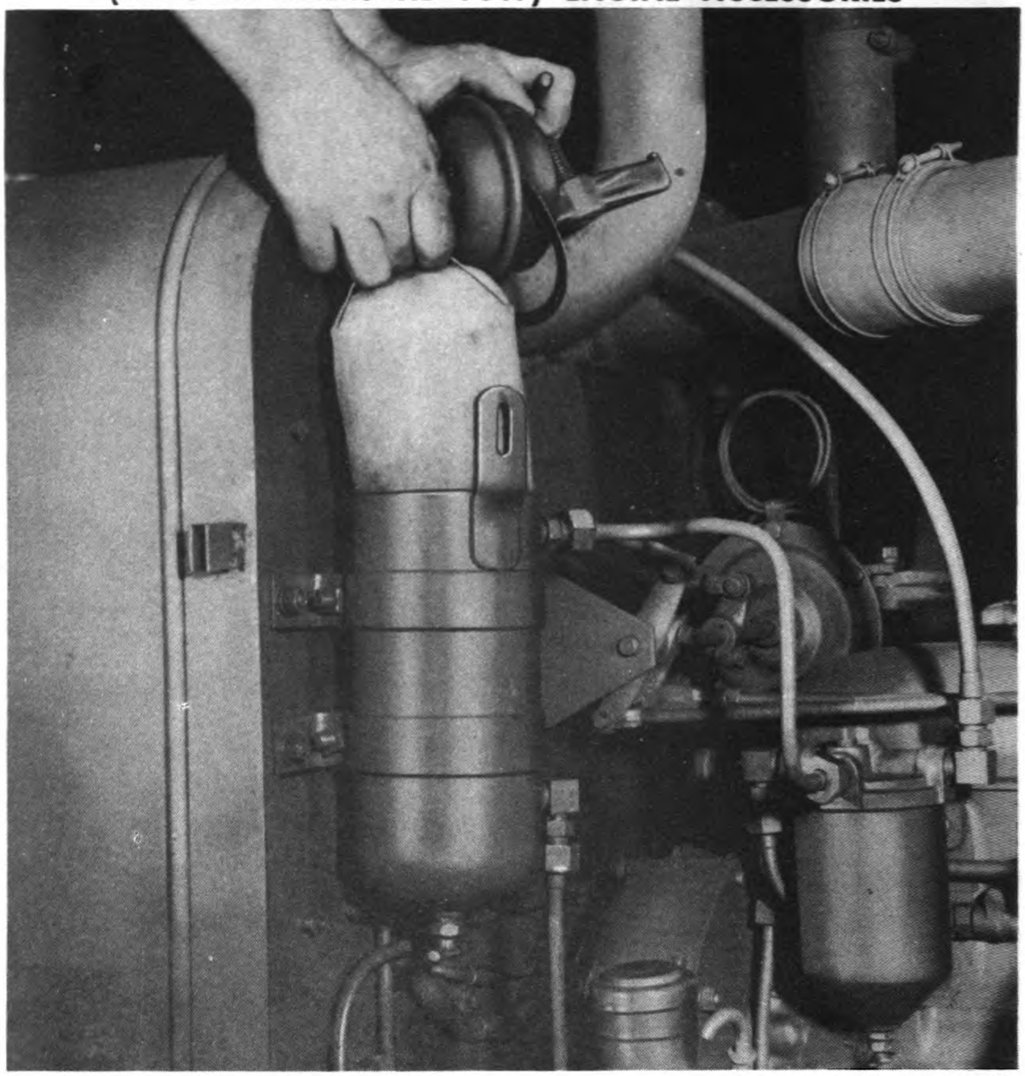
**Figure 54—Removing Second Stage Fuel Filter Assembly**



RA PD 17642
*Figure 55—Removing Second Stage Fuel Filter Assembly Element*

**e. Assembly.**

(1) Equipment.

WRENCH, 7/16-in.
WRENCHES, two, 9/16-in.
WRENCH, 7/8-in.

*(a) Install Filter Clamp Rings.*

WRENCHES, two, 9/16-in.

Clamp bracket in vise, if vise is available, and install filter heads to bracket with two bolts each with lock washers.

*(b) Install Filter Shells.*

WRENCH, 7/16-in.

FUEL FILTERS

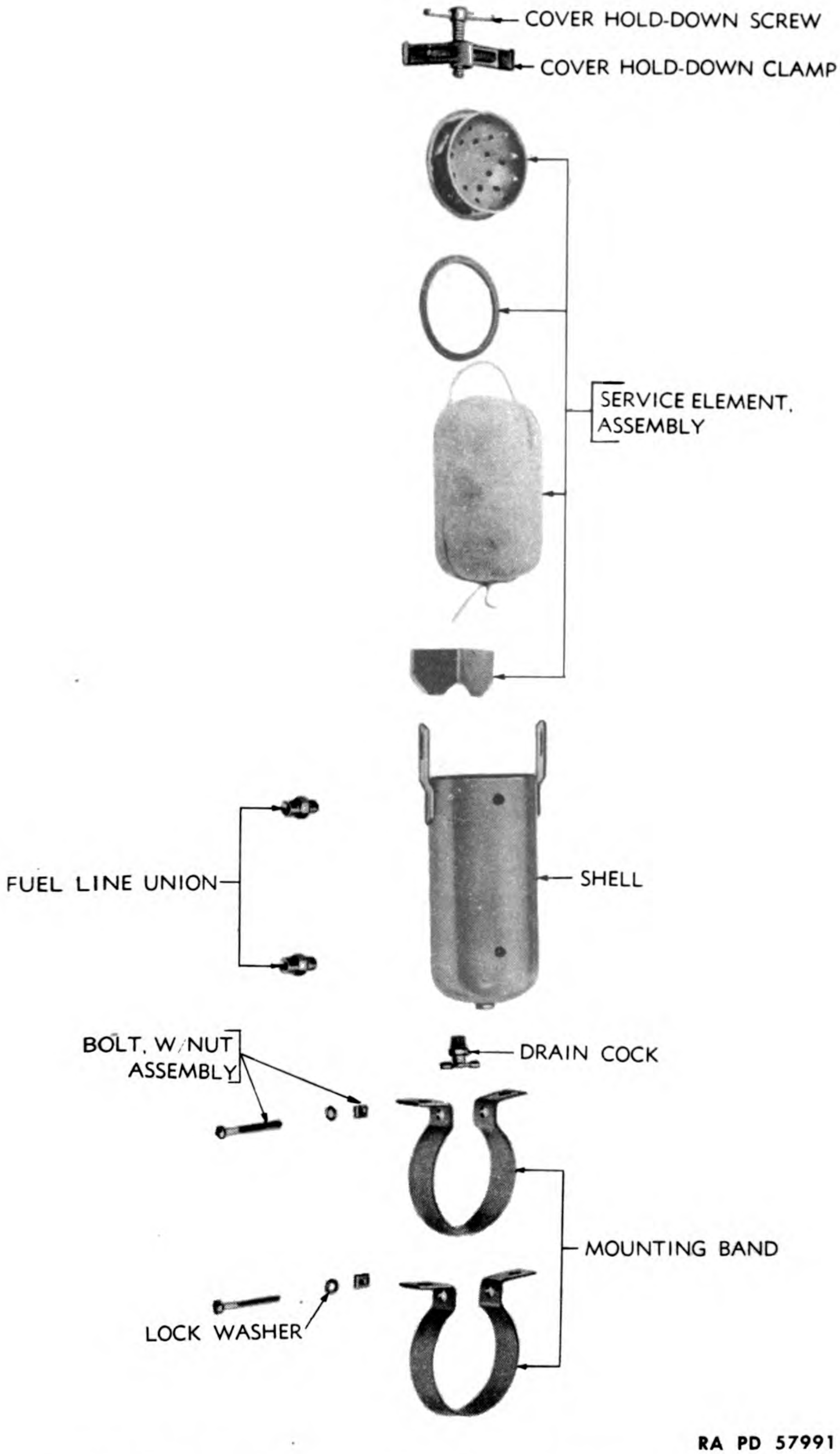



***Figure 56—Exploded View of Second Stage Fuel Filter Assembly***

Bolt the shells to the filter heads by inserting four cap screws with lock washers through filter heads and into clamp rings. Use new gaskets and shellac both sides of gaskets.

*(c) Connect Fuel Lines Between Filters.*

WRENCH, open-end, ⅞-in.

Place connectors of the flexible fuel lines on fittings and tighten them firmly.

**f. Installation.**

(1) EQUIPMENT.

WRENCHES, two, 9⁄16-in. WRENCH, open-end, ⅞-in.

(2) PROCEDURE.

*(a) Install Assembly on Tractor.*

WRENCH, open-end, ⅞-in.

Install the assembly on the transmission case with two cap screws with lock washers.

*(b) Connect Fuel Lines to Filter Assembly.*

WRENCHES, two, 9⁄16-in. WRENCH, open-end, ⅞-in.

Connect the fuel lines to each end fitting of fuel filter assembly (⅞-in. wrench); open fuel shut-off valve under fuel supply tank and inspect for leaks. Install bolt through fuel line clip on intake line and into bracket (two 9⁄16-in. wrenches).

## 42. SECOND STAGE FUEL FILTER ASSEMBLY.

**a. Description.** This filter is of the replaceable cartridge type bolted to the front of the cowl. The element consists of a replaceable waste-filled sack.

**b. Removal.**

(1) EQUIPMENT.

WRENCHES, two, 9⁄16-in. WRENCH, open-end, ⅞-in.

(2) PROCEDURE.

*(a) Disconnect Fuel Lines.*

WRENCH, open-end, ⅞-in.

Disconnect both inlet and outlet fuel lines.

FUEL FILTERS

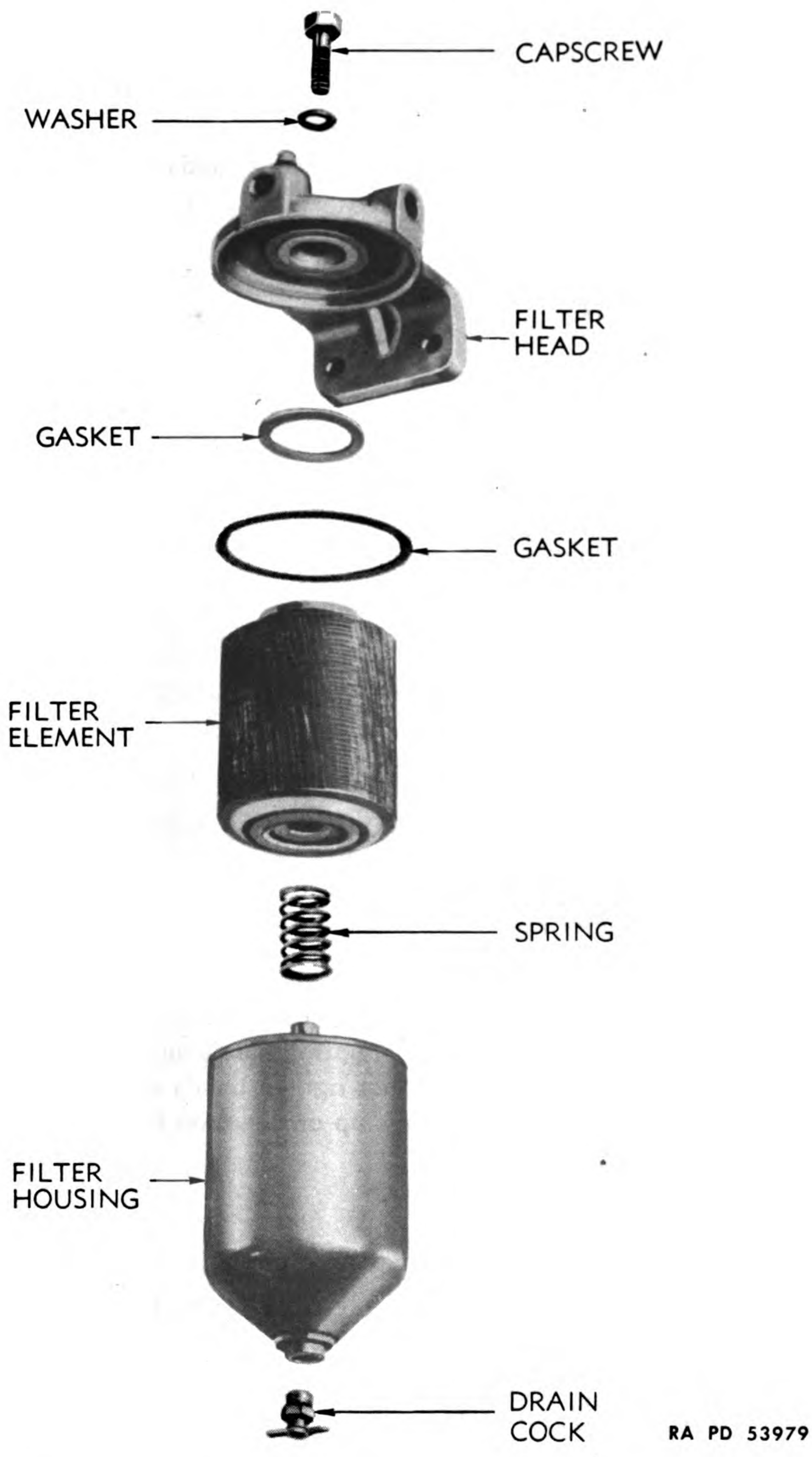



***Figure 57 — Exploded View of Third Stage Fuel Filter Assembly***

*(b) Remove Fuel Filter from Cowl.*

WRENCHES, two, 9⁄16-in.

Remove the four bolts that hold mounting bands to cowl and remove filter assembly.

**c. Disassembly.**

(1) EQUIPMENT.

WRENCH, ½-in.

(2) PROCEDURE.

*(a) Remove Mounting Band Bolts.*

WRENCH, ½-in.

Remove the bolts through mounting bands and slide bands off filter body.

*(b) Remove Filter Element.*

Loosen and remove cover hold-down screw, clamp, and cover; and lift element from filter case.

**d. Maintenance.** Wash filter shell out with clean fuel before installing new element. See that drain cock is not clogged. This drain cock should be opened every day to drain sediment and water out of filter. NOTE: To replace element only, the filter assembly should be left installed on the tractor and only the hold-down clamp and cover removed.

**e. Assembly.** Install element in filter shell. Place cover and new gasket on filter, install cover hold-down clamp in slots, and tighten cover in place with hand screw. Place mounting bands on filter and install the two bolts through bands, but do not tighten bands around filter case, as it may be necessary to slide bands up or down on filter when mounting it on cowl.

**f. Installation.**

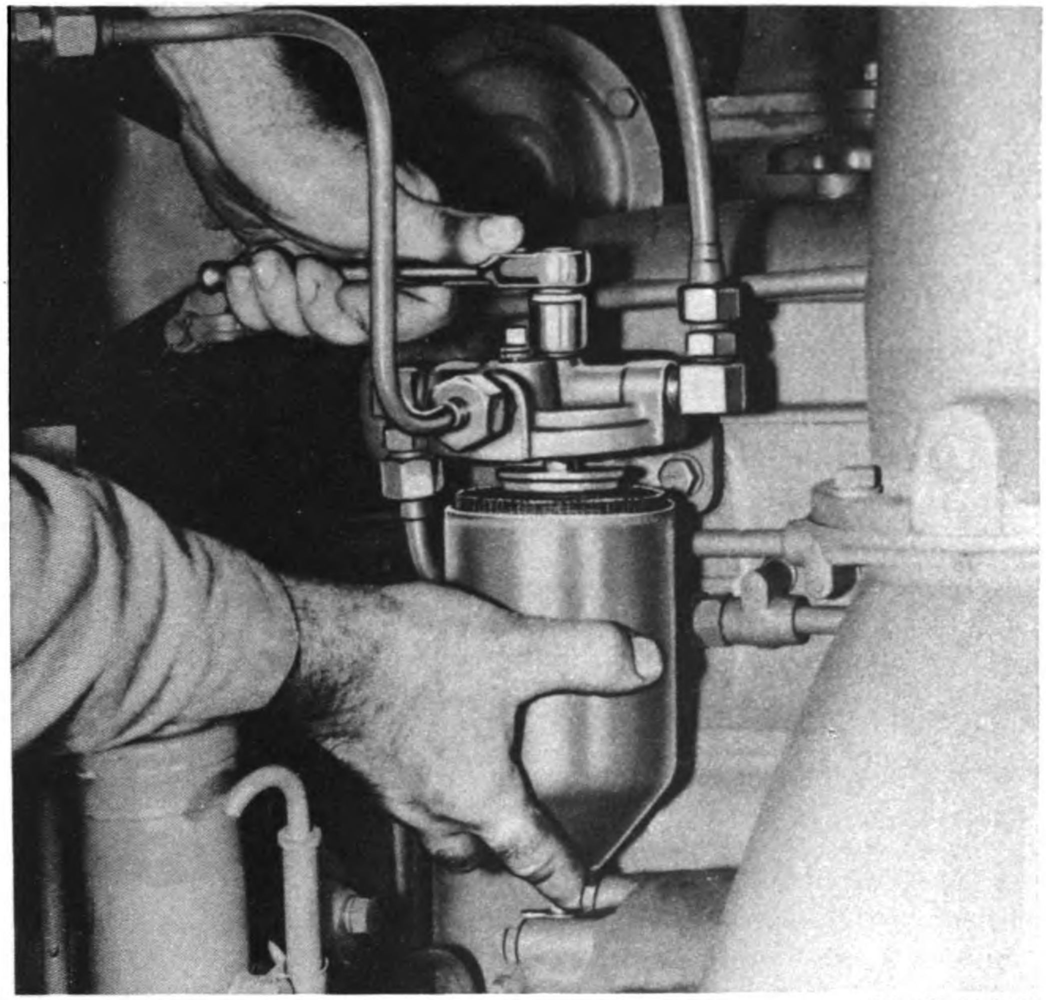
(1) EQUIPMENT.

WRENCH, ½-in.
WRENCHES, two, 9⁄16-in.
WRENCH, open-end, ⅞-in.

(2) PROCEDURE.

*(a) Install Filter Assembly on Cowl.*

WRENCH, ½-in.
WRENCHES, two, 9⁄16-in.



RA PD 17637

***Figure 58 — Removing Third Stage Fuel Filter Case***

Install bolts through mounting bands and cowl, install lock washers, and start nuts on bolts. Tighten bolts through mounting bands (½-in. wrench) and then tighten bolts through cowl (two 9/16-in. wrenches).

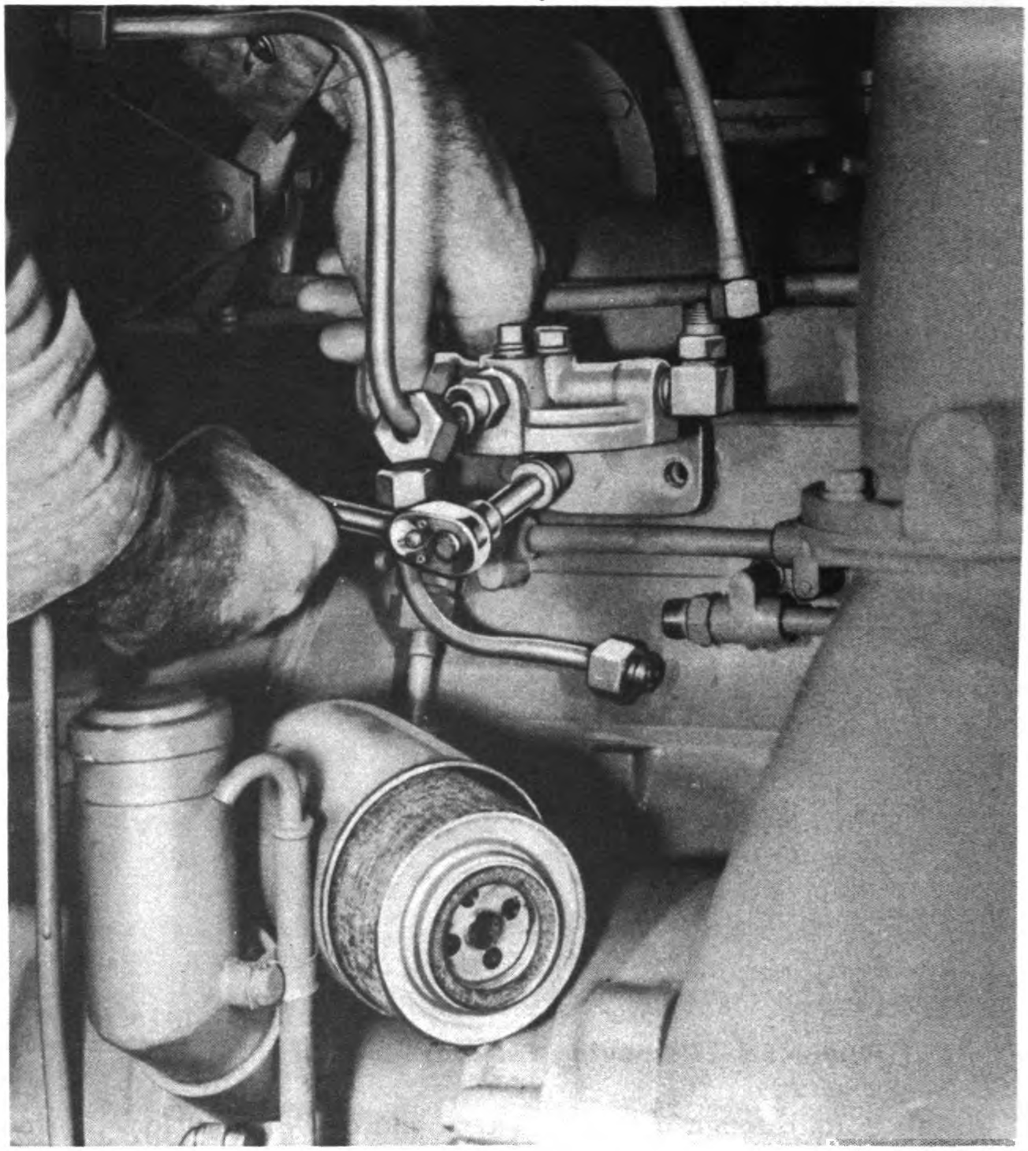
*(b) Connect Fuel Lines.*

WRENCH, open-end, ⅞-in.

Connect lower fuel line, fill the filter with fuel (this will save cranking engine with starter to pump fuel to fill filter) and connect upper fuel line. Start engine and check for leaks.

## 43. THIRD STAGE FUEL FILTER ASSEMBLY.

**a. Description.** This filter is mounted to the cylinder head. It is also of the replaceable cartridge type. The fuel line running to the fuel pressure gage connects to the top of this filter. Fuel leaving this filter passes into the intake fuel manifold and to the injectors.



RA PD 17607

*Figure 59 — Removing Third Stage Fuel Filter Head*

**b. Removal.**

(1) EQUIPMENT.

WRENCH, 9/16-in.
WRENCH, 5/8-in.
WRENCH, open-end, 7/8-in.

(2) PROCEDURE.

*(a) Disconnect Fuel Lines.*

WRENCH, open-end, 7/8-in.

Disconnect the fuel lines from the fittings on filter head.

*(b) Remove Fuel Filter Case.*

WRENCH, 5/8-in.

## FUEL FILTERS

Drain filter by opening drain cock at bottom of filter. Remove retaining cap screw that holds filter case to filter head and remove filter case. Lift element from case.

*(c) Remove Fuel Filter Head.*

WRENCH, 9/16-in.

Remove two cap screws that hold head to cylinder head and remove head of filter.

c. **Maintenance.** Clean filter case with clean fuel after removing the element. The element may be replaced without removing the filter assembly from tractor. Remove retaining screw and the case will drop down and out (fig. 58). Use new gasket supplied with each new element. Fill case with fuel before installing case on filter head. Open drain cock daily to drain sediment and water from filter.

d. **Installation.**

(1) EQUIPMENT.

WRENCH, 9/16-in.
WRENCH, 5/8-in.
WRENCH, open-end, 7/8-in.

(2) PROCEDURE.

*(a) Install Filter Head.*

WRENCH, 9/16-in.

Install head to cylinder head with two cap screws and lock washers.

*(b) Install Element in Case.* Install the spring and new element in the case, with the end marked "TOP" up, and fill the case with fuel. NOTE: Two interchangeable types of filter elements are supplied for use in the third stage fuel filter. One is a cotton-wound type similar to the filter elements used in the filters located under the seat. A steel washer is supplied with each of these elements, and when this type filter element is used, the washer should be placed on the hollow stud inside the filter case before the gasket and filter are installed.

*(c) Install Case.*

WRENCH, 5/8-in.

Install new gaskets in filter head and on top of element; install retaining screw and draw case up to head (fig. 58).

*(d) Connect Fuel Lines.*

WRENCH, open-end, 7/8-in.

Connect fuel line from second stage fuel filter to front fitting of third stage fuel filter and line from intake fuel manifold to rear fitting. Connect pressure gage line to fitting on top of filter.

## Section VII

# BLOWER



## 44. DESCRIPTION.

### a. General Description.

(1) The blower, designed especially for efficient Diesel operation, supplies the fresh air needed for combustion and for sweeping the cylinders clear of exhaust gases. Its operation is similar to that of a gear-type oil pump. Two hollow rotors, each with three lobes, revolve with very close clearances in a housing bolted to the side of the engine. To provide continuous and uniform displacement of air, the rotor lobes are made with a twisted or helical form (fig. 73).

(2) Air entering the blower inlet from the air cleaner is picked up by the lobes and carried to the discharge side of the blower as indicated by the arrows (fig. 60). The continuous discharge of fresh air from the blower creates an air pressure of about eight pounds per square inch in the air chamber of the cylinder block when the engine is operating at maximum speed. As the intake ports at the bottom of the cylinder start to open at 48 degrees before bottom dead center, this air sweeps through into the cylinder. These ports close at 48 degrees after bottom dead center. The angle of the ports in the cylinder liners imparts a rotary motion to the intake air as it enters the cylinder. This rotation persists throughout the compression stroke and improves combustion.

(3) Two timing gears on the drive end of the rotor shafts space the rotor lobes with a slight clearance. Thus, because the rotors do not touch

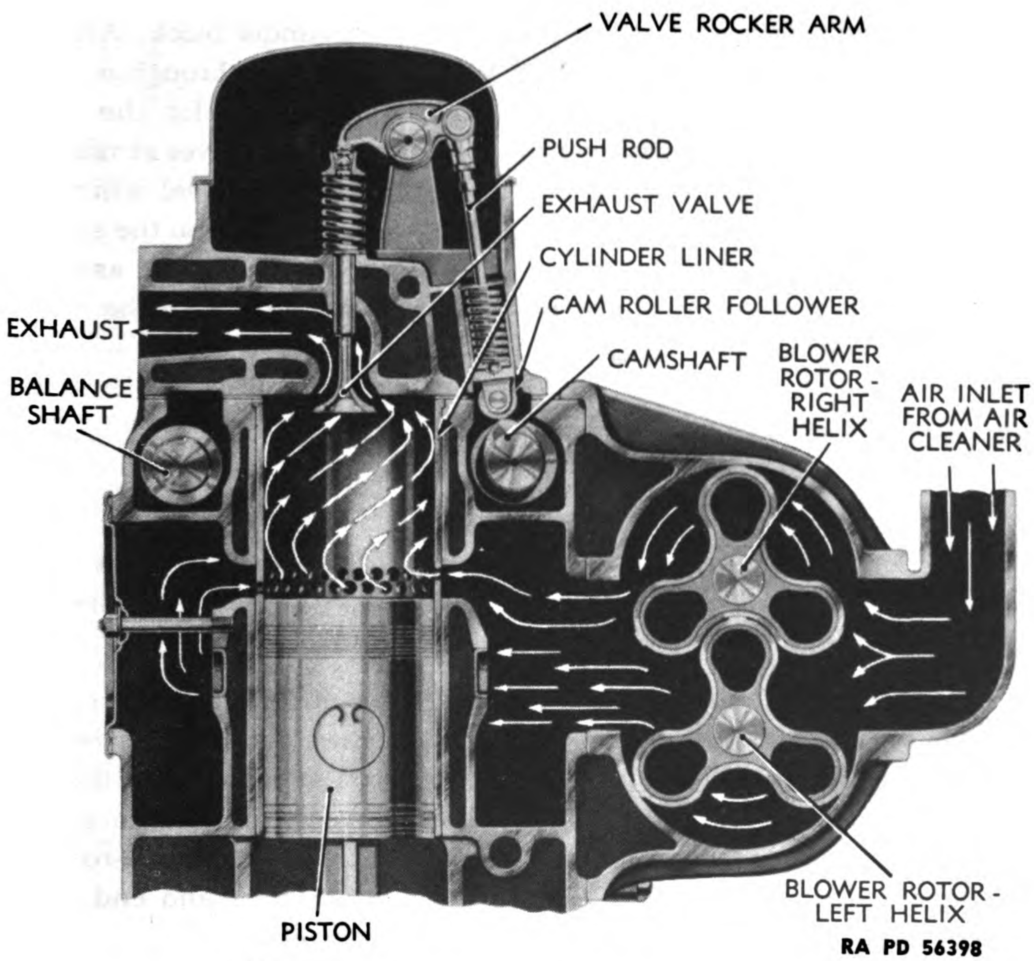



***Figure 60 — Cross-Section of Engine Showing Circulation of Air***

each other at any time, they require no lubrication. Highly effective seals prevent air leakage at the ends of the lobes, and also keep the oil used for lubricating the timing gears and rotor shaft bearings from entering the rotor compartment. The upper rotor is driven at 1.95 times engine speed by the blower drive shaft, and the lower rotor is driven from the upper rotor through the blower timing gears. The flexible coupling attached to the blower drive gear prevents the transmission of torque fluctuations to the blower. It is formed by an elliptical cam driven by two bundles of leaf springs which ride on four semicylindrical supports. Each rotor is supported on the doweled end plates of the blower housing by a single-row, radial ball bearing at the front, and a two-row, preloaded, radial and thrust ball bearing at the rear or gear end.

**b. Blower Lubrication.** The blower gears and bearings are lubricated from the oil which drains from the valve operating mechanism in the cylinder head into the camshaft pockets in the cylinder block. After this oil reaches a certain level in the pockets, it overflows through a hole at each end of the blower housing, providing lubrication for the blower drive gears at rear end and governor and water pump drives at the front. A dam in the blower housing cover maintains an oil level which submerges the teeth of the lower rotor timing gears. A slinger on the opposite end of the lower rotor throws oil into the governor weight assembly. Surplus oil passes from a hole in the end of the blower to the oil pan through drilled holes in the cylinder block.

## 45. PREVENTIVE MAINTENANCE.

**a. Service.**

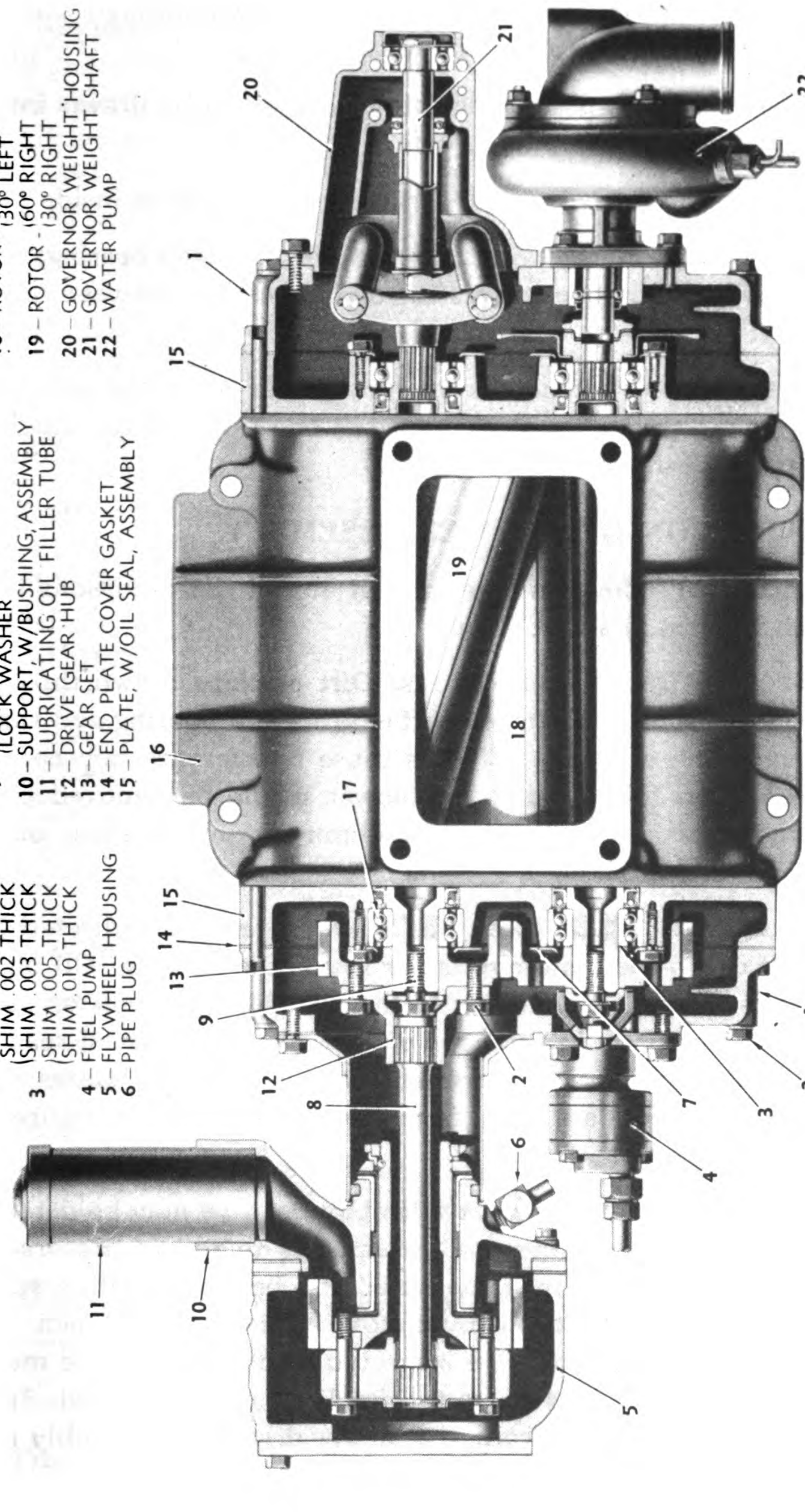
(1) The blower is not a delicate device. Nevertheless, great care is taken when the unit is assembled at the factory. The same care must be exercised when the blower is serviced in the field.

(2) As pointed out in the foregoing description, the blower rotors revolve with a slight clearance between the lobes, and also between the lobes and the blower housing. Bearings are used at each end of the rotor shafts and suitable oil seals are used back of each bearing to prevent engine oil entering the rotor compartment. Selected double-row ball bearings provide proper end clearance between rotors and end plates. The blower rotors are "timed" by the two gears at the rear end of the rotor shafts. This timing or spacing must be correct; otherwise the required clearance between rotor lobes will not be maintained.

(3) Normal gear wear causes a decrease of rotor-to-rotor clearance between the leading flanks of the upper rotor lobes and the trailing flanks of the lower rotor lobes. Clearance between the opposite sides of the rotor lobes is increased correspondingly. While rotor lobe clearance may be corrected by adjustment, gear backlash cannot. Therefore, when gears have worn to the point where the backlash exceeds 0.004 inch, the gears should be changed. The procedure for timing blower rotors for proper clearance between lobes is outlined under Blower Timing, paragraph 51, step b (9).

(4) Because of the important part the blower plays in the efficient operation of the Diesel engine, an inspection of the unit should be made every 1,000 engine hours. If this practice is followed, minor irregularities can usually be detected and corrected before more serious difficulties develop. A blower may fail to function properly because of any one or a combination of the following reasons:

## BLOWER



1 — END PLATE COVER
2 — {CAP SCREW
{LOCK WASHER
3 — {SHIM .002 THICK
{SHIM .003 THICK
{SHIM .005 THICK
{SHIM .010 THICK
4 — FUEL PUMP
5 — FLYWHEEL HOUSING
6 — PIPE PLUG
7 — RETAINER
8 — DRIVE SHAFT
9 — {BOLT
{LOCK WASHER
10 — SUPPORT, W/BUSHING, ASSEMBLY
11 — LUBRICATING OIL FILLER TUBE
12 — DRIVE GEAR HUB
13 — GEAR SET
14 — END PLATE COVER GASKET
15 — PLATE, W/OIL SEAL, ASSEMBLY
16 — BLOWER HOUSING
17 — BALL BEARING
18 — ROTOR - {60° LEFT
{30° LEFT
19 — ROTOR - {60° RIGHT
{30° RIGHT
20 — GOVERNOR WEIGHT HOUSING
21 — GOVERNOR WEIGHT SHAFT
22 — WATER PUMP

RA PD 58005

***Figure 61 — Cut-Away View of Blower Assembly***

*(a)* Dirt or foreign matter having been drawn through the blower, thereby scoring the rotor lobes and housing.

*(b)* Worn oil seals, permitting lubricating oil to be drawn into rotor compartment.

*(c)* Worn blower drive coupling, causing rattling noise inside blower.

*(d)* Loose rotor shafts, worn gear teeth or damaged bearings, causing contact between rotor lobes, rotors and end plates, and between rotors and housing.

*(e)* Out of time—that is, due to timing gear wear, the mating rotor lobes may not have sufficient clearance at one side and too much clearance on the opposite side. (See fig. 80.)

## 46. INSPECTION OF BLOWER ASSEMBLY.

**a.** Proceed as follows to determine if any of the conditions listed in paragraph 45 exist in a used blower:

(1) SCORED HOUSING OR ROTORS. Dirt or chips drawn through the blower will cause deep scratches in the rotors and housing and throw up burs around such abrasions. If burs cause interference between rotors, or between rotors and housing, the blower should be removed from the engine and parts dressed down to eliminate interference, or rotors changed if too badly scored.

(2) LEAKY OIL SEALS. Leaky oil seals are usually indicated by the presence of oil on the blower rotors or inside the housing. Oil on rotors is sometimes a result of pull-over from overfilled air cleaners; therefore the two conditions should not be confused. To check for oil seal, direct a strong light into rotor compartment and observe end plates for thin oil film which will radiate away from a leaky oil seal. See figure 72 for location of blower oil seals.

(3) WORN BLOWER DRIVE. A worn blower drive may be detected by grasping the top rotor firmly and attempting to rotate. Rotors should move from 3/8 inch to 5/8 inch, measured at lobe crown, with a springing action. When released, rotors should move back at least 1/4 inch. Blower flexible drive coupling should be inspected if rotors cannot be moved as directed above or if rotors move too freely or can be rattled. If check shows drive coupling to be worn, the blower drive gear assembly may be withdrawn from the front of the cylinder block end plate after the blower has been removed from the engine and the drive gear housing-to-cylinder block end plate cap screws are removed.

(4) LOOSE ROTOR SHAFTS OR DAMAGED BEARINGS. If loose rotor shafts or damaged bearings are causing blower difficulties, such conditions will be indicated by rubbing and scoring between crowns of rotor lobes and mating rotor roots, between rotors and end plates, or between rotors and housing. Generally a combination of these conditions exists. A loose shaft usually causes rubbing between rotors and end plates. Worn or damaged bearings will cause rubbing between mating rotor lobes at some point or perhaps allow rotor assemblies to touch blower housing. This condition will usually show up at end of rotors at which bearings have failed. Excessive backlash in blower timing gears usually results in rotor lobes rubbing throughout their entire length. To correct any of the conditions cited in above paragraph, the blower must be removed from the engine and either repaired or replaced.

## 47. REMOVAL FROM TRACTOR.

**a. Equipment.**

BAR, pry
HAMMER, soft
PLIERS
SCREWDRIVER, 8-in.
WRENCHES, two, 7/16-in.
WRENCH, 9/16-in.
WRENCH, fuel pump
WRENCH, open-end, 1/2-in.
WRENCH, open-end, 5/8-in.
WRENCH, open-end, 11/16-in.
WRENCH, open-end, 3/4-in.
WRENCH, open-end, 7/8-in.
WRENCH, socket, 1/2-in. with extension
WRENCH, socket, 5/8-in.
WRENCH, socket, 3/4-in.

**b. Procedure.**

(1) REMOVE PRE-CLEANERS AND HOOD.

BAR, pry
WRENCHES, two, 7/16-in.
WRENCH, 9/16-in.

Loosen clamps holding pre-cleaners to extension tubes (7/16-in. wrenches) and remove pre-cleaners (see fig. 16). Loosen the nuts on the hood hold-down straps at each corner of the hood (9/16-in. wrench); pry bolts out of slot, and remove the hood (see fig. 17).

(2) REMOVE RIGHT FRONT FENDER.

WRENCHES, two, 3/4-in.

Remove one bolt and three cap screws and lift off fender.

(3) DISCONNECT WATER AND FUEL LINES.

WRENCH, open-end, 5/8-in.
WRENCH, open-end, 3/4-in.
WRENCH, open-end, 7/8-in.

**ORDNANCE MAINTENANCE — HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES**

Drain radiator and water pump. Clean all dirt and grease from rocker arm cover, blower and blower drive assembly, governor assembly, and right side of engine. Disconnect air compressor water line from water pump (5/8-in. wrench). Disconnect fuel lines from fuel pump (3/4-in. and 7/8-in. wrenches).

(4) REMOVE ROCKER ARM COVER AND GOVERNOR CONTROL HOUSING COVER.

PLIERS | SCREWDRIVER, 8-in.

Remove pins to disconnect governor control rods (pliers). Remove spring from rod. Remove rocker arm cover. Remove four screws and lift off governor control housing cover (screwdriver).

(5) REMOVE GOVERNOR CONTROL LINK.

PLIERS

Remove pin connecting link to injector control tube lever. Remove clip and lift outer end of link from differential lever on governor and remove link from cylinder head (fig. 152).

(6) REMOVE GOVERNOR CONTROL HOUSING ASSEMBLY.

SCREWDRIVER, 8-in. | WRENCH, 7/16-in.

Remove two screws from top of governor breather tube (screwdriver) and lift tube out of clip at bottom of tube. Remove two cap screws holding top of control housing to cylinder head and four cap screws holding control housing to governor weight housing (7/16-in. wrench). Lift out governor control housing assembly (fig. 153).

(7) REMOVE AIR INTAKE INLET AND AIR INLET HOUSING.

SCREWDRIVER, 8-in. | WRENCH, 9/16-in.

Disconnect hose at rear end of air inlet elbow (screwdriver). Remove four cap screws holding air inlet housing to blower (9/16-in. wrench) and remove the elbow and housing assembly, together with screen located between inlet housing and blower.

(8) DISCONNECT WATER PUMP.

SCREWDRIVER, 8-in. | WRENCH, socket, 1/2-in., with extension

Remove two cap screws from water pump discharge packing flange (1/2-in. wrench). Loosen hose clamp at connection between water pump and oil cooler (screwdriver), and slip hose connector up onto water pump inlet.

## BLOWER

(9) REMOVE BLOWER ASSEMBLY (WITH GOVERNOR WEIGHT HOUSING, WATER PUMP, AND FUEL PUMP ATTACHED).

WRENCH, socket, ⅝-in.

Remove four cap screws holding blower to cylinder block; raise front end of blower slightly to clear water pump to oil cooler connection. Pull blower assembly forward and away from engine, withdrawing blower drive shaft cover from grommet on drive gear support and drive shaft from drive hub attached to blower upper rotor timing gear, using caution not to bind blower drive shaft while removing assembly. NOTE: If engine is removed from tractor, it is better first to remove blower drive shaft cover on flywheel housing and pull blower drive shaft out through opening before blower is moved forward.

(10) REMOVE BLOWER DRIVE ASSEMBLY.

WRENCH, ½-in.
WRENCHES, two, 9/16-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, ¾-in.
WRENCH, open-end, ⅞-in.

Remove oil line leading from cylinder block to blower drive bearing (7/16-in. wrench). Remove cap screw that holds top of oil gage rod tube to filler pipe (½-in. wrench), disconnect tube at lower end (¾-in. and ⅞-in. wrenches), and remove oil gage rod and tube assembly. Remove two cap screws and four bolts that hold blower drive assembly to rear cylinder block end plate (two 9/16-in. wrenches), and pull assembly forward out of flywheel housing and cylinder block and plate.

(11) REMOVE ACCESSORIES FROM BLOWER.

*(a) Remove Fuel Pump.*

WRENCH, ½-in.

Remove three cap screws that attach fuel pump to blower rear end cover plate and remove fuel pump and coupling.

*(b) Remove Water Pump.*

HAMMER, soft
WRENCH, open-end, ½-in.

Remove three cap screws that hold pump to blower front cover plate (½-in. wrench). Tap pump lightly with hammer to loosen it and remove the pump from blower.

*(c) Remove Governor Weight Housing.*

WRENCH, ½-in.

Remove six cap screws that attach housing to blower front cover plate and withdraw governor drive shaft from blower rotor shaft as housing is removed.

## 48. DISASSEMBLY OF BLOWER.

**a. Equipment.**

BLOCKS, wooden, two
HAMMER, soft
HAMMER, 2-lb.
SCREWDRIVER, 8-in.
SET, service tool, blower
WRENCH, 7/16-in.
WRENCH, ½-in.
WRENCH, 9/16-in.
WRENCH, ¾-in.
WRENCH, hexagon, 3/16-in.

**b. Procedure** (fig. 70).

(1) REMOVE END COVERS.

HAMMER, soft
WRENCH, 9/16-in.

Remove 10 cap screws in each end cover (9/16-in. wrench) and remove both end covers. NOTE: Do not pry between cover and end plate, as gasket surfaces will be damaged. Tap loose with soft hammer.

(2) REMOVE WATER PUMP COUPLING.

WRENCH, hexagon, 3/16-in.

Loosen expander screw at center and front end of blower lower rotor shaft at water pump coupling and remove water pump coupling from shaft.

(3) REMOVE DRIVE SHAFT FLANGE.

HAMMER, soft
WRENCH, ½-in.

Remove six cap screws that attach blower drive shaft flange to rear face of upper rotor timing gear (½-in. wrench) and tap flange free from gear (hammer).

(4) REMOVE CAP SCREWS FROM CENTER OF BLOWER TIMING GEARS.

WRENCH, ¾-in.

Remove the cap screws at center of blower timing gears that lock the gears in place. Remove the retaining washers.

(5) REMOVE TIMING GEARS.

ASSEMBLY, puller

The two timing gears must be pulled from the rotor shafts at the same time. Back out puller studs in puller plates as far as possible. Install two anchor bolts in diametrically opposite holes so faces of plates are parallel with face of blower. Turn the two puller studs uniformly clockwise and withdraw gears from rotor shafts (fig. 62). Note number and thickness of shims on each rotor shaft, if any are used behind gears. Remove shims from shafts and keep in order for reassembly.

BLOWER

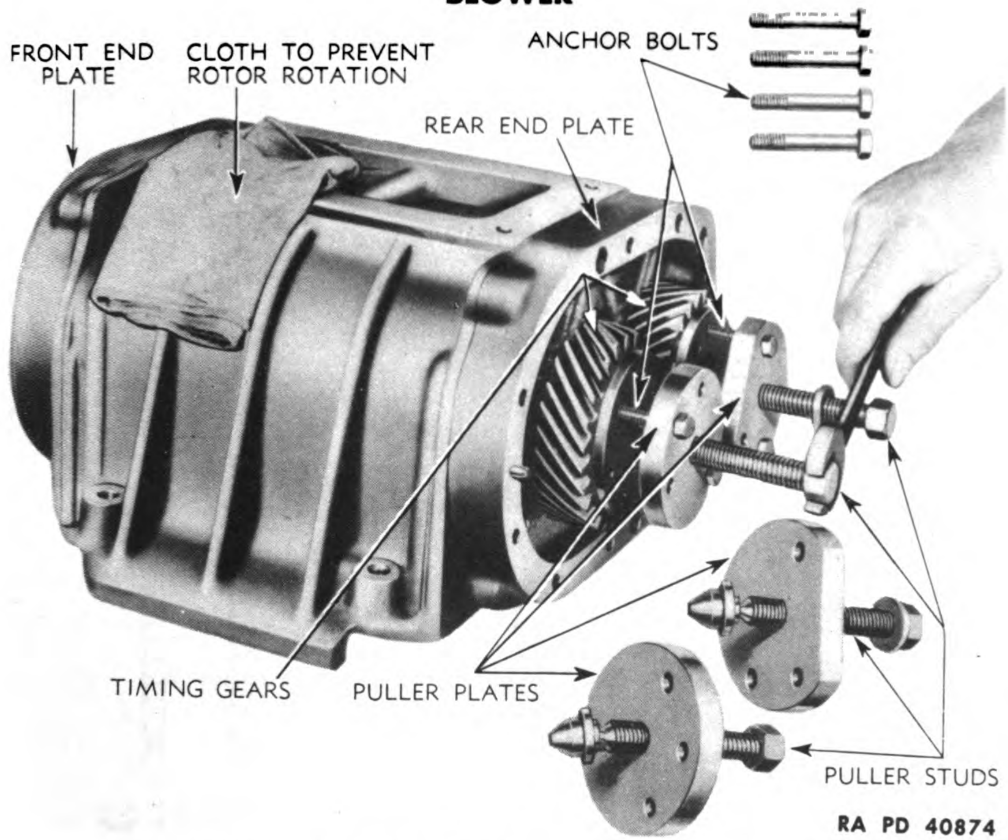



***Figure 62 — Removing Blower Rotor Timing Gears***

(6) REMOVE ROTOR SHAFT BEARING RETAINER.

WRENCH, 7/16-in.

Remove three cap screws at each bearing and remove rotor shaft bearing retainers at both ends of blower.

(7) REMOVE END PLATES AND ROTORS.

| | |
|---|---|
| ASSEMBLY, puller | WRENCH, ½-in. |
| SCREWDRIVER, 8-in. | WRENCH, ⅝-in. |

*(a)* Remove two countersunk fillister head screws from front end plate, and loosen the two countersunk fillister head screws in rear end plate about three turns (screwdriver).

*(b)* Back out puller studs in puller plate as far as possible.

*(c)* Install the three anchor bolts in the three equally spaced holes of each puller plate and screw anchor bolts in holes from which bearing retainer cap screws were removed on rear end plate, and screw in until faces of plates are parallel with face of blower (½-in. wrench).

*(d)* Turn the two puller studs uniformly clockwise and push rotor shafts from bearings in rear end plate (⅝-in. wrench). Front plate, with rotor shafts still assembled in bearings, will be pushed away from blower housing at same time.

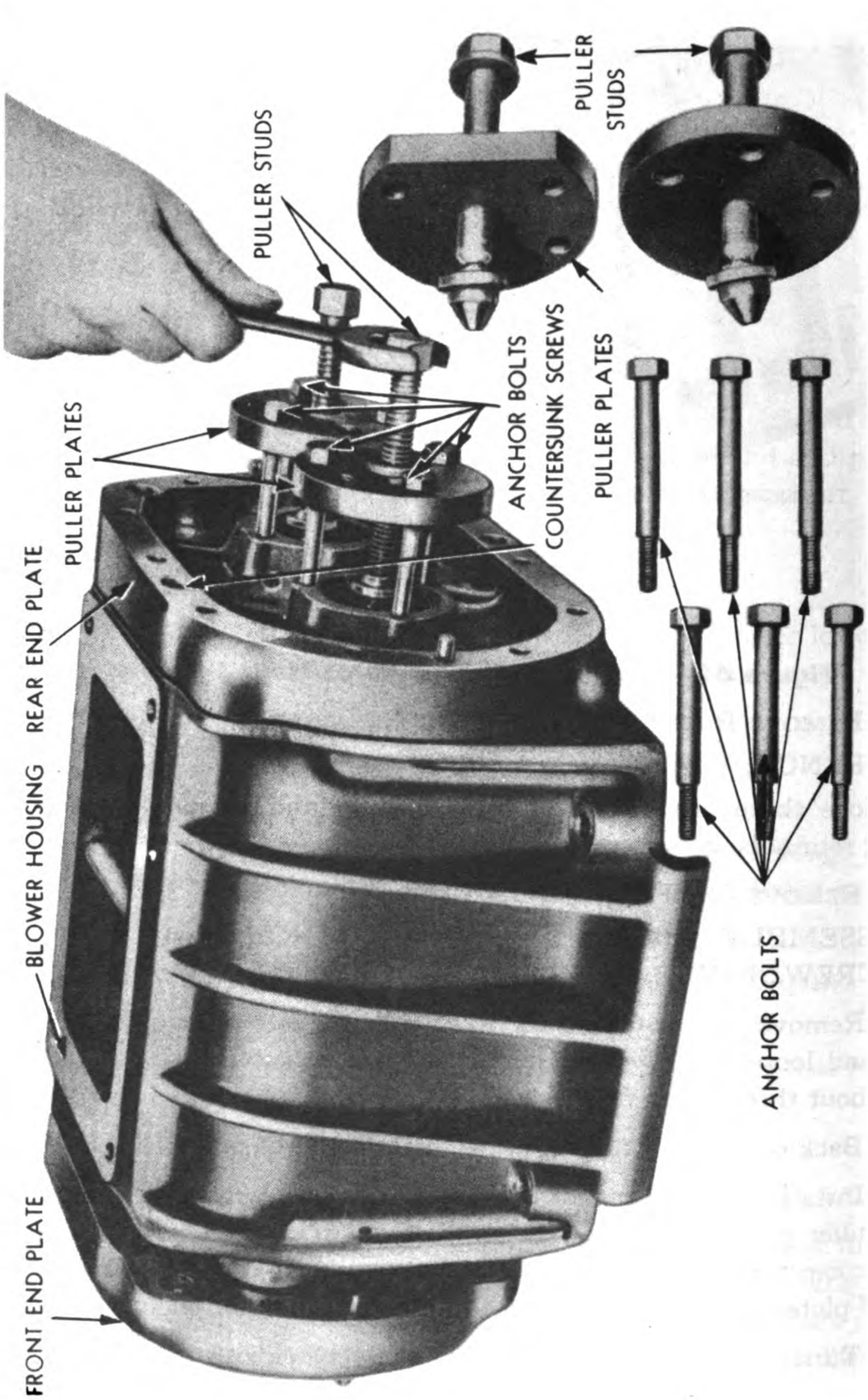



**Figure 63—Removing Front End Plate and Rotor Shafts from Rear Bearings and Housing**

BLOWER

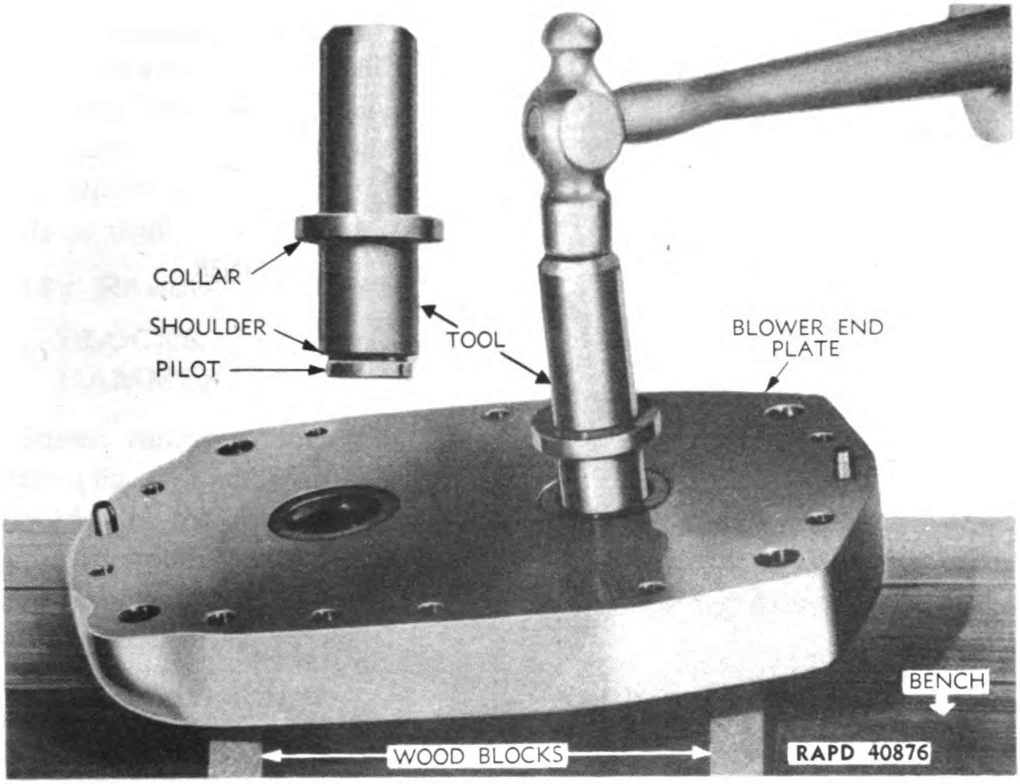



*Figure 64 — Removing Blower Rotor Shaft Bearings*

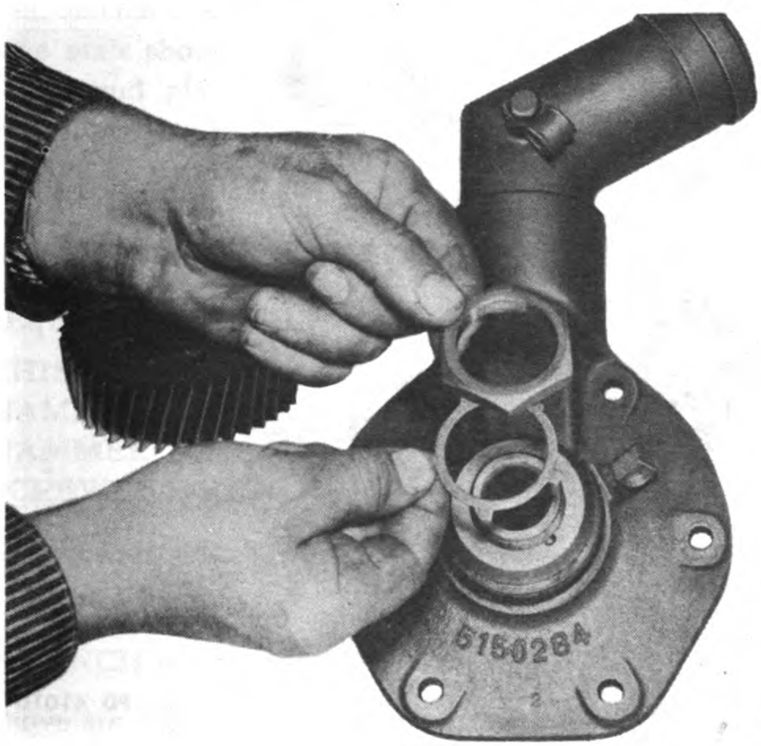



*Figure 65 — Nut and Lock Washer Removed from Blower Drive Hub*

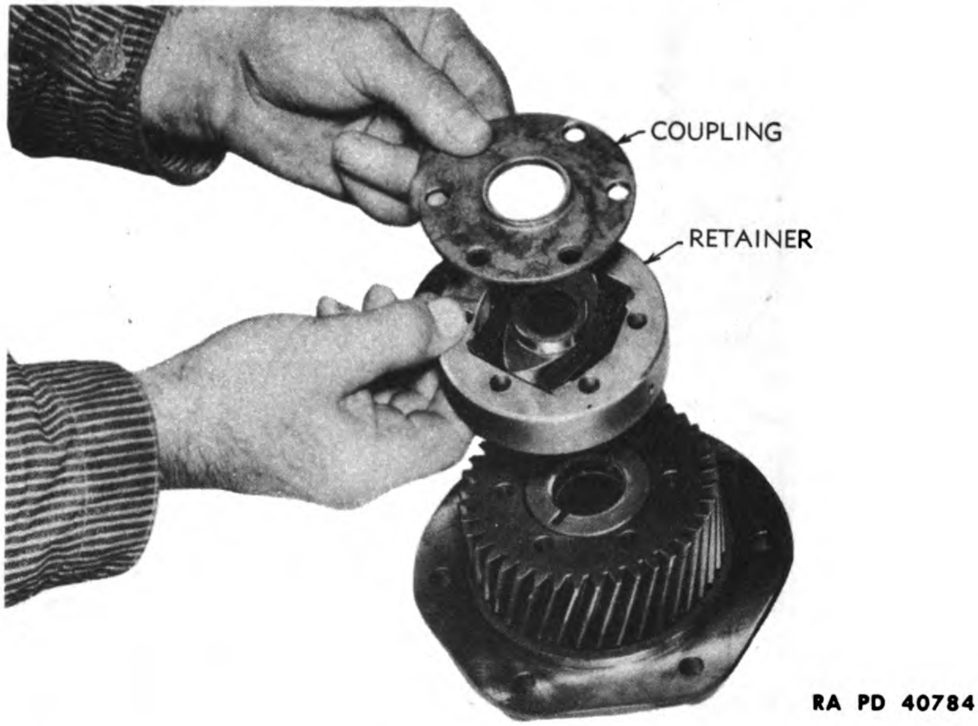



*Figure 66—Removing Blower Drive Coupling and Gear*

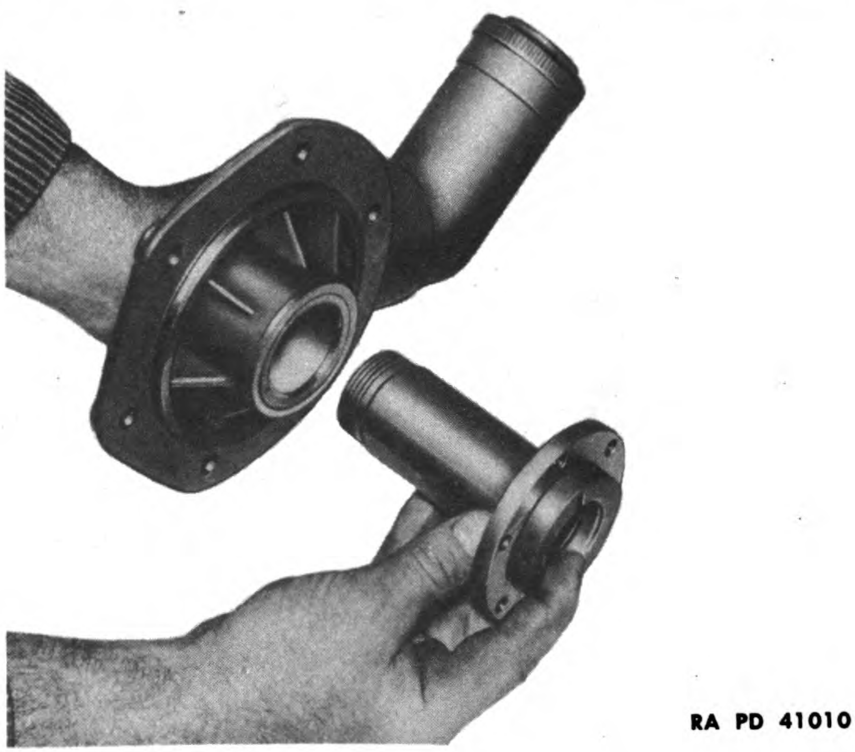



*Figure 67—Removing Blower Hub from Support*

*(e)* Remove puller from rear end plate. Remove the two countersunk screws (screwdriver), then pull plate from position by hand. Withdraw rotors and front end plate assembly from blower housing, *if rotors are not scored.* If rotors are scored, remove front end plate from rotor bearings before withdrawing rotors in the same manner, and with the same tools as used for removing rear end plate.

(8) REMOVE ROTOR SHAFT BEARINGS FROM BLOWER END PLATES.

| | |
|---|---|
| BLOCKS, wooden, two | TOOL, remover, bearing and seal |
| HAMMER, 2-lb. | |

Insert remover tool through oil seal from inner face of blower end plate (fig. 64) so pilot of tool enters bore in inner race of bearing and shoulder of tool rests against face of bearing inner race. Support end plate on wooden blocks about two inches off bench and, using hammer, drive bearing from position. (Read step 9 below.) Follow this method on all four bearings.

(9) REMOVE BEARING OIL SEALS FROM BLOWER END PLATES.

| | |
|---|---|
| BLOCKS, wooden, two | TOOL, remover, bearing and seal |
| HAMMER, 2-lb. | |

Inspect oil seals at this time. If the leather has been scored so that a tight seal on shafts is impossible or the leathers have become charred and hard, the seals should be replaced. If change is necessary, remove the seals from end plates at the same time the individual bearings are removed. This is done by continuing to drive down on the tool shown in figure 64 until collar on tool rests on and forces seal down and out of plate.

## 49. DISASSEMBLY OF BLOWER DRIVE ASSEMBLY.

**a. Equipment.**

| | |
|---|---|
| CHISEL, ½-in. | TOOL, spreader, spring |
| HAMMER, ½-lb. | VISE |
| HAMMER, 2-lb. | WRENCH, ½-in. |
| SCREWDRIVER, 10-in. | WRENCH, open-end, 1⅞-in. |

**b. Procedure** (fig. 82).

(1) REMOVE BLOWER DRIVE GEAR.

WRENCH, ½-in.

Remove six cap screws that hold blower drive coupling retainer and hub to blower drive gear. Remove blower drive coupling and gear from hub.

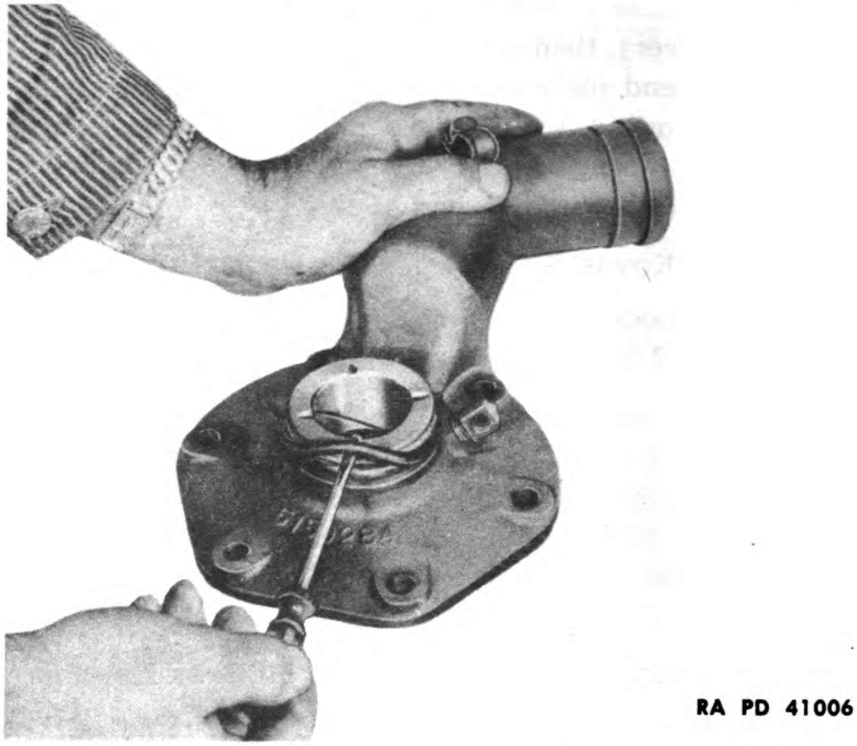
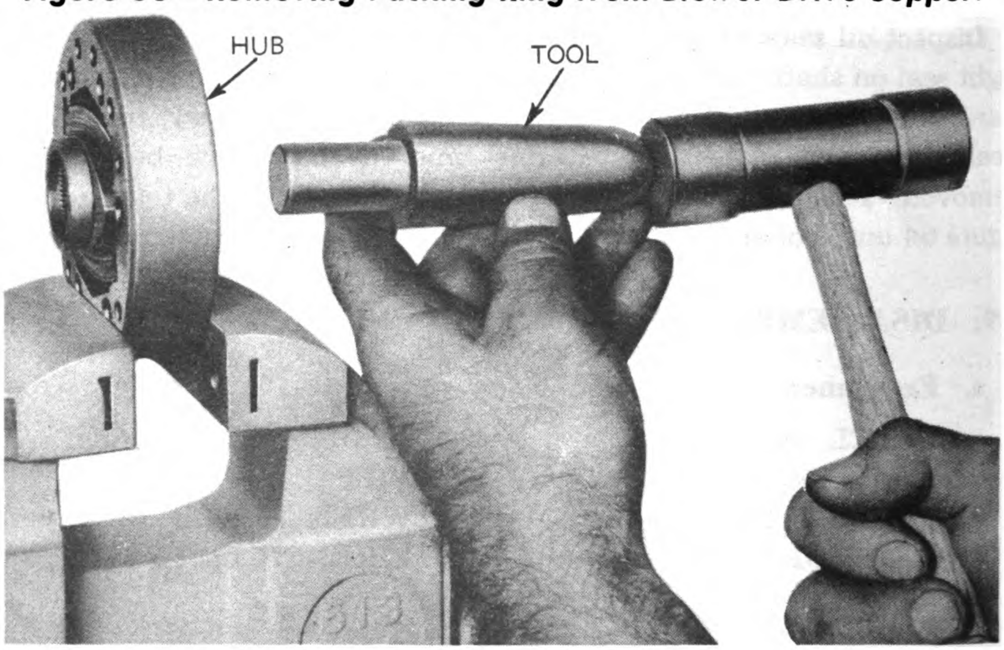



*Figure 68—Removing Packing Ring from Blower Drive Support*




RA PD 41015
*Figure 69—Preparing to Remove Blower Drive Coupling Cam*

(2) REMOVE HUB FROM SUPPORT.

| | |
|---|---|
| CHISEL, ½-in. | SCREWDRIVER, 10-in. |
| HAMMER, ½-lb. | WRENCH, open-end, 1⅞-in. |

Straighten lock washer (hammer and chisel) and remove nut ($1\frac{7}{8}$-in. wrench), lock washer, thrust washer and $\frac{7}{32}$-inch steel ball from blower hub. Remove hub from support. Remove packing ring from outside of support (screwdriver).

(3) REMOVE BLOWER DRIVE CAM AND SPRINGS.

HAMMER, 2-lb. VISE
TOOL, spreader, spring

Place assembly in vise. Drive blower drive coupling cam from springs with spring spreader and hammer. Remove the 42 blower drive coupling springs. Remove the four spring seats.

## 50. INSPECTION OF BLOWER PARTS.

**a.** After the blower has been disassembled, all parts should be washed in SOLVENT, dry-cleaning, blown off with dry compressed air, and inspected before assembly.

(1) BALL BEARINGS.

*(a)* Wash the ball bearings by rotating them by hand in SOLVENT, dry-cleaning, until free from grease and foreign substances.

*(b)* Clean the balls and races by directing air through the bearing as the bearing is rotated by hand. *Do not spin the bearing with air pressure.*

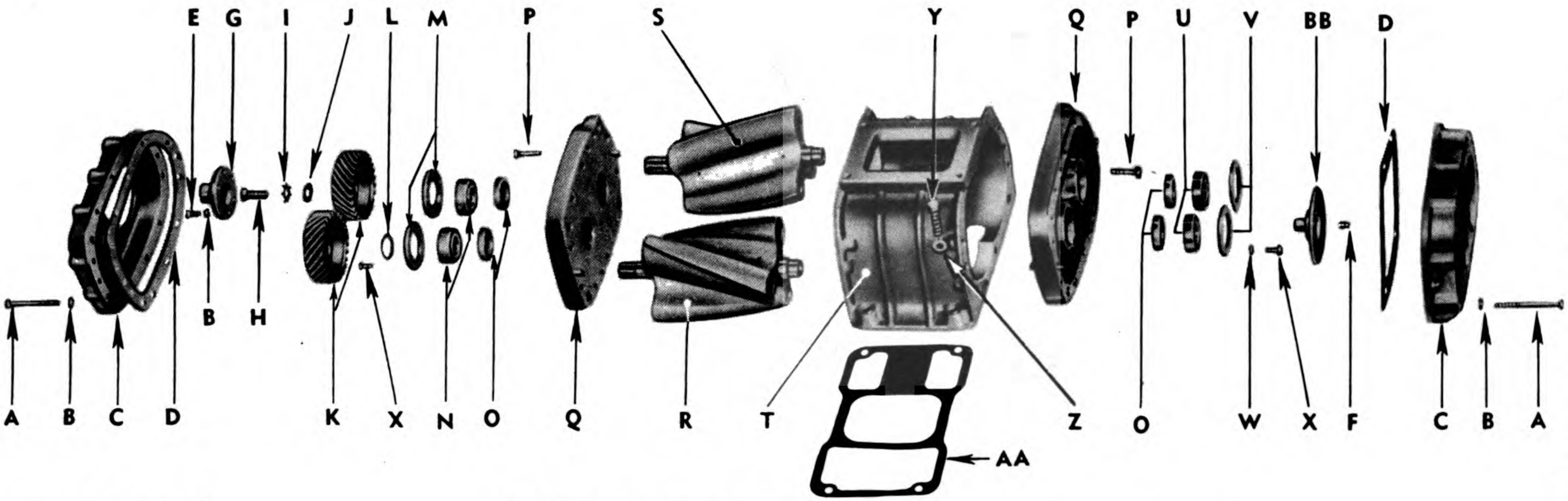
*(c)* If necessary, repeat cleaning operation to be sure all foreign substance is removed.

*(d)* After cleaning thoroughly, again rotate by hand and inspect for rough spots. The bearing should run free and show no indication of roughness. The double-row bearings are preloaded and have no end play. In fact, a new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

(2) OIL SEALS. Check oil seals in end plates and replace if necessary. Oil seals that have been used should be lubricated with clean engine oil at time of assembling blower. New oil seals should be soaked for at least 60 minutes in clean OIL, engine, SAE 10, before assembling.

(3) ROTOR LOBES. Inspect blower rotor lobes for smoothness. Inspect shaft serrations and bearing surfaces for wear or burs.

(4) END PLATES. See that end plate finished faces are smooth and flat. See that finished ends of blower housing, which receive the end plates, are flat and free from burs. The end plates must set flat against the blower housing.




A — CAP SCREW
B — LOCK WASHER
C — END PLATE COVER
D — END PLATE COVER GASKET
E — CAP SCREW
F — SET SCREW
G — ROTOR GEAR HUB
H — BOLT
I — LOCK WASHER
J — RETAINING WASHER
K — GEAR SET
L — SHIM .002 THICK; SHIM .003 THICK; SHIM .005 THICK; SHIM .010 THICK
M — FRONT BEARING RETAINER
N — BEARING
O — OIL SEAL
P — CAP SCREW
Q — PLATE, W OIL SEAL, ASSEMBLY
R — ROTOR, 60° RIGHT; ROTOR, 30° RIGHT
S — ROTOR, 60° LEFT; ROTOR, 30° LEFT
T — BLOWER HOUSING
U — BALL BEARING
V — REAR BEARING RETAINER
W — LOCK WASHER
X — SCREW
Y — CAP SCREW
Z — PLAIN WASHER
AA — BLOWER HOUSING GASKET
BB — COUPLING, W SHAFT, ASSEMBLY

RA PD 57993

**Figure 70 — Exploded View of Blower Assembly**

(5) GEARS. Check blower gears for wear.

(6) HOUSING. The rotors must revolve inside the blower housing with a specified clearance between the housing and rotor lobes. Inspect the inside of the housing to see that the surfaces are smooth. Inspect rotor lobes to see that lobes have not been in contact.

(7) Read paragraph 45 for further inspection.

## 51. ASSEMBLY OF BLOWER.

**a. Equipment.**

HAMMER, ½-lb.
HAMMER, soft
FEELER RIBBONS, as follows:
- 0.002-in. (two)
- 0.003-in. (two)
- 0.004-in. (two)
- 0.005-in. (two)

SCREWDRIVER, 8-in.
SET, service tool, blower
SHELLAC
WRENCH, hexagon, $\frac{3}{16}$-in.
WRENCH, $\frac{7}{16}$-in.
WRENCH, ⅝-in.
WRENCH, ¾-in.
WRENCH, open-end, ½-in.
WRENCH, socket, ½-in.

**b. Procedure.** Refer to figure 70 for relative position of parts.

(1) INSTALL OIL SEALS IN BLOWER END PLATES.

COLLAR, gear puller and seal assembly
WRENCH, ⅝-in.

The oil seals should be assembled into the end plates with the flat face of seals flush with inner, finished face of plates. The sealing edge of leather must point toward rotor bearings. Proceed as follows:

*(a)* Support end plate between soft jaws in bench vise. Back out puller stud as far as possible and push stud through bore for bearing in end plate from the outer face, resting puller plate against outer face of blower end plate.

*(b)* With sealing edge of leather toward bearings, slide seal over head of stud and start into bearing bore by hand.

*(c)* Slip pressure plate over body next to head of puller stud. Turn puller stud clockwise (⅝-in. wrench), forcing oil seal into seat until pressure plate sets tight against inner face of blower end plate. Remove tool and install remainder of seals in same manner.

(2) INSTALL BLOWER FRONT END PLATE.

HAMMER, soft
SCREWDRIVER, 8-in.

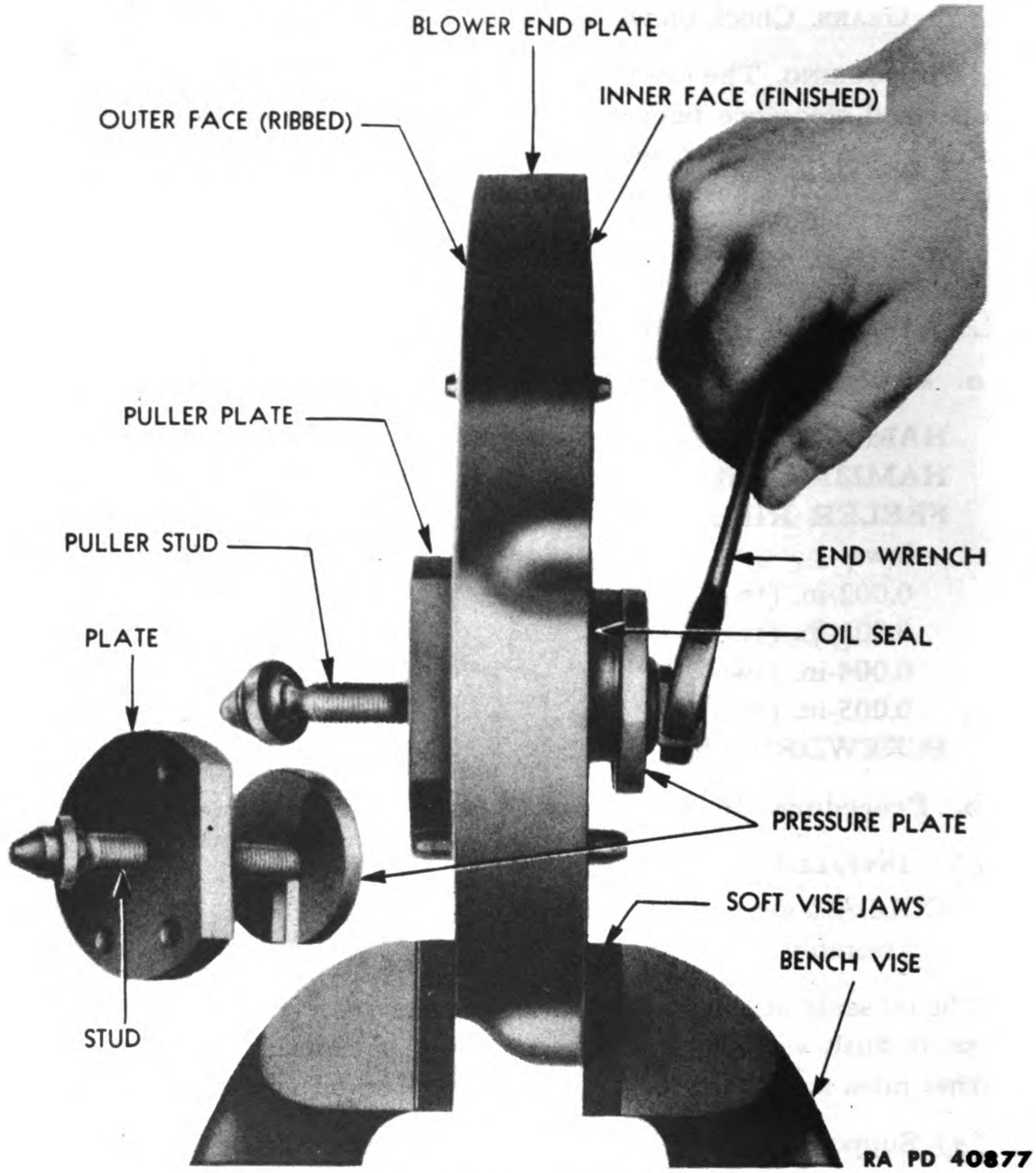



***Figure 71 — Installing Blower Oil Seals***

The top of the blower may be identified by the flange which extends the entire length of the housing and provides a rest on top of the cylinder block. The end plate is semicircular at the top as shown in figure 72, and is also marked "TOP" on outer ribbed side. Blower end plates are interchangeable, front and rear, but the plate at the front end of the blower should be assembled to the blower housing first. The rear plate should be assembled after the rotors are in place. When viewing blower housing from inlet side, the end plate for the front will be assembled to the right-hand end of housing. With these identifications clearly in mind, attach end plate to front end of blower housing as follows:

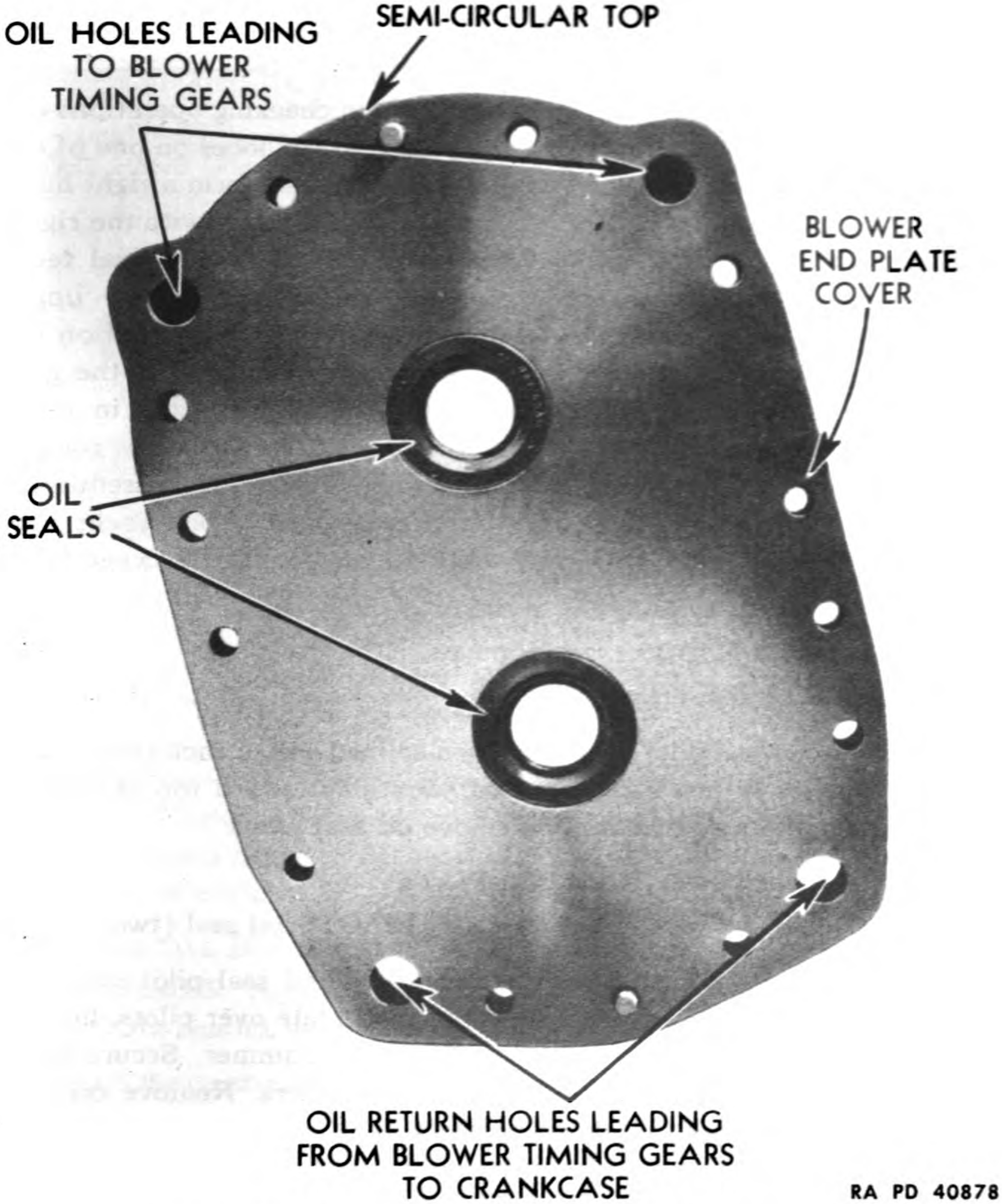



***Figure 72 — Blower End Plate and Oil Seal Locations***

*(a)* Start end plate dowels in dowel holes of blower housing. Tap end plate and dowels lightly with a soft hammer to fit end plate to housing. **NOTE**: No gaskets are used between end plates and housing; therefore mating surfaces must be perfectly flat and smooth.

*(b)* Secure end plate to housing with two fillister head screws (screw-driver). No lock washers. Inspect and see that dowels project ⅜ inch beyond outer face of end plate.

(3) CHECK RELATION OF PARTS.

Before further assembly of the blower, certain checking operations are necessary to insure the proper relation of parts. The lobes on one of the blower rotors and the teeth on one of the timing gears form a right-hand helix, and on the mating parts a left-hand helix. The rotor with the right-hand helix must be used with the gear having right-hand helical teeth and vice-versa. Rotor and gear with *right-hand* helices are the *upper units.* For convenience in blower timing, one serration is omitted on the drive end of each blower shaft with corresponding omissions in the gear hubs. Gears must be placed on the shafts with the serrations in registration. *Rotors must be assembled with the omitted serrations toward top on both rotor shafts* (fig. 73). To avoid confusion when assembling, place the right-hand rotor and right-hand gear together on bench; likewise the left-hand rotor and gear. With above in mind, proceed with assembly.

(4) ASSEMBLE ROTORS INTO HOUSING.

PILOTS, oil seal (two)

Install one oil seal pilot over short, non-splined end of each rotor shaft, and with rotors in mesh and omitted serrations toward top of blower housing, slip rotors into housing. Remove oil seal pilots.

(5) INSTALL BLOWER REAR END PLATE.

HAMMER, soft PILOTS, oil seal (two)

With rotors installed into housing, install one oil seal pilot over serrated end of each rotor shaft. Install rear end plate over pilots, line up dowels with holes, and tap into place with soft hammer. Secure plate with two fillister head cap screws. *No lock washers.* Remove oil seal pilots. Inspect and see that dowels project 3/8 inch beyond outer face of end plate to accommodate end cover.

(6) INSTALL ROTOR SHAFT FRONT BEARINGS.

HAMMER, 1/2-lb. WRENCH, 7/16-in.
TOOL, bearing assembly

Single-row ball bearings are used at the front end of the blower rotor shafts, and double-row ball bearings at the rear end. The bearing number is stamped at one end of the ball race only. *When assembled, the bearing markings are toward the outside face of the end plates.* Start the single-row bearings onto front end of rotor shafts. Using special bearing installing tool and hammer (fig. 75), tap bearings into end plate. **NOTE:** Bearing retainers for single-row (front) bearings have 1 13/16-inch inside

BLOWER

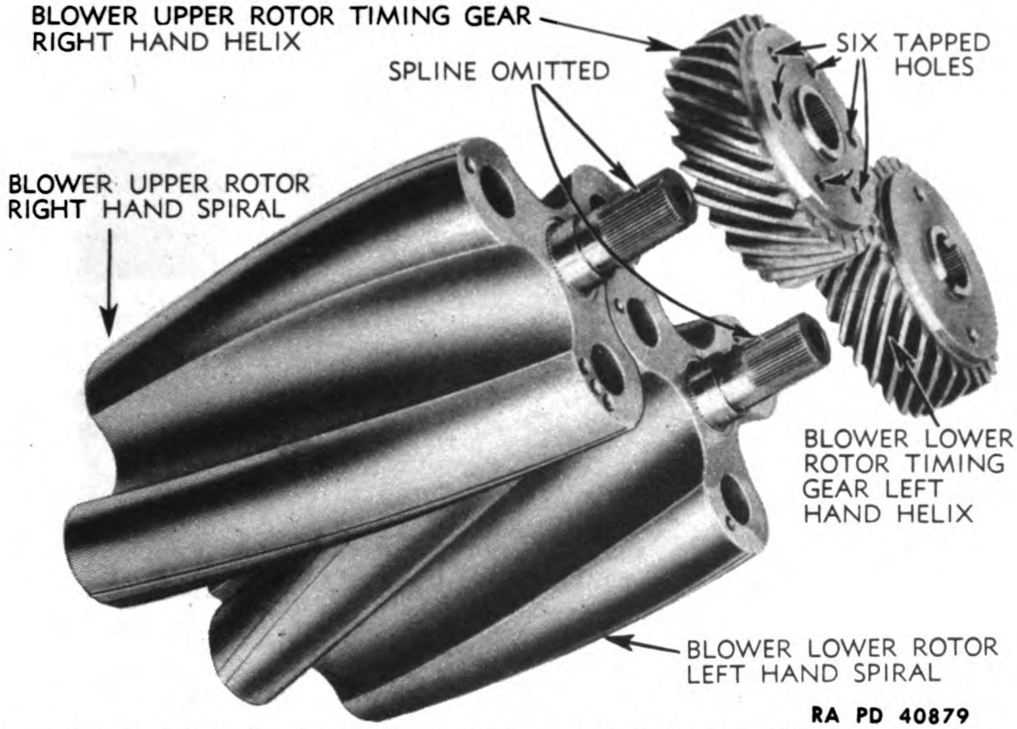



***Figure 73—Identification of Upper and Lower Blower Rotors and Gears***

diameter; and for double-row (rear) bearings, 1 9/16-inch inside diameter. Install front bearing retainers with flange at inner diameter of retainer directed toward bearing. Secure with three cap screws with lock washers (7/16-in. wrench).

(7) INSTALL ROTOR SHAFT REAR BEARINGS.

HAMMER, ½-lb. WRENCH, 7/16-in.
TOOL, bearing assembly

Install the rear rotor shaft bearings the same way the fronts were installed, except that flange at inner diameter of retainer is directed away from bearing. Secure retainers with three cap screws with lock washers in each retainer (7/16-in. wrench). NOTE: Rotor-to-end plate clearances should be checked at this time as explained in step (10) of this paragraph.

(8) INSTALL TIMING GEARS.

WRENCH, ¾-in.

NOTE: If blower once used is being reassembled, shims were no doubt used back of one or perhaps both blower timing gears. They should be installed in their original positions before pressing gears onto shaft. If new gears and shafts are used, install without shims, and use shims later, if necessary, when timing rotors. Being sure that both rotor shafts with the omitted serrations point toward top of blower as shown

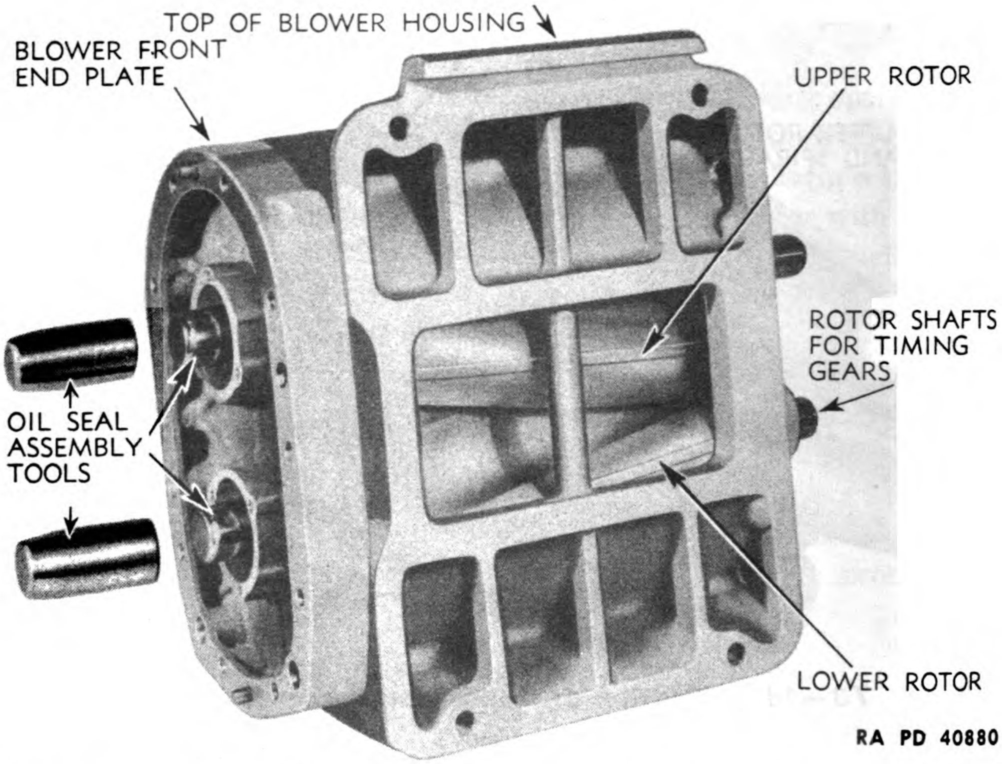



***Figure 74 — Assembling Blower Rotors into Housing Front End Plate***

in figure 73, that the drive timing gear with six tapped holes in hub is located on the upper rotor shaft, and that original shims are placed on their respective shaft, start both gears onto shaft with omitted serrations on shafts and gears registering. NOTE: A center punch mark is indented into end of shaft at omitted serration to assist in locating gears properly. Apply some engine oil at shaft serrations and proceed to press gears onto shafts as follows:

*(a)* Install puller studs and washers into ends of shafts, and press the gears (keeping one gear even with the other) into position, tight against bearing races.

*(b)* Remove studs used to pull gears into place, and install special lock washer next to head of each retainer bolt. Be sure that retainer washer at upper gear has pierced lugs to engage slots in gear hub; then the ears of the lock washer will engage the slots in the retaining washer. Draw retaining bolt tight. For lower gear lock, install special lock washer and fuel pump coupling disk on retainer bolt so lock tangs of disk engage slot in gear hub and lock washer ear engages slot in coupling disk. Draw retainer bolt reasonably tight, but not enough to bend fuel pump coupling disk.

BLOWER

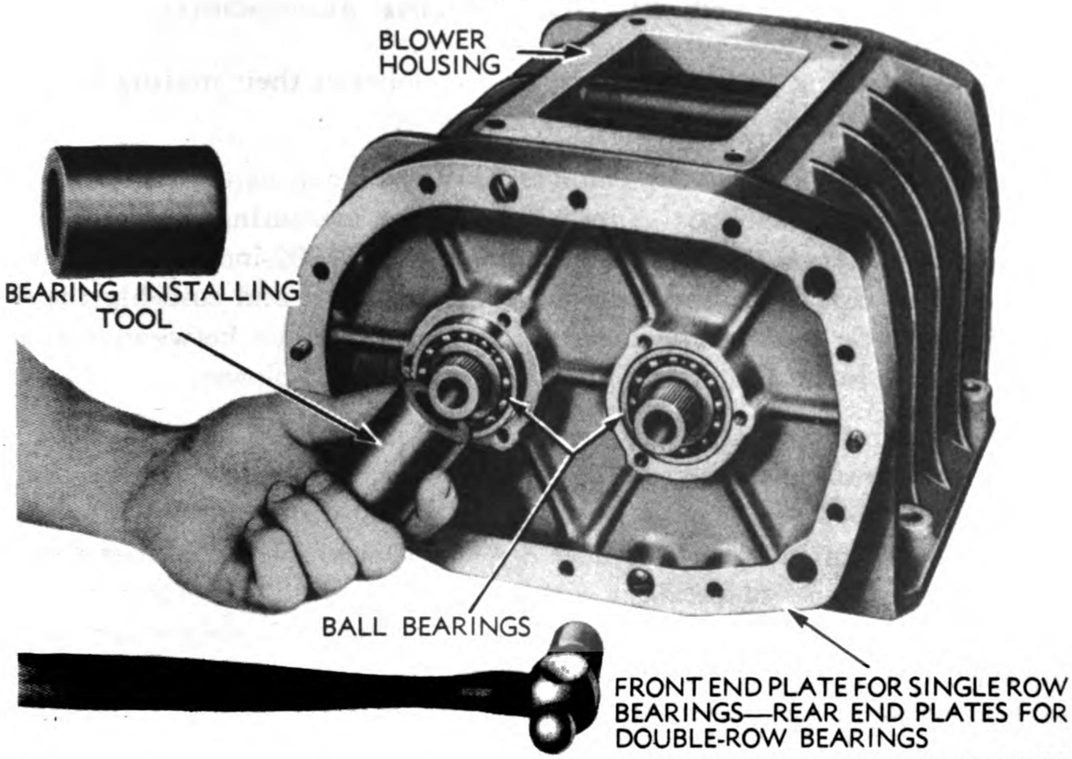



***Figure 75 — Installing Blower Rotor Shaft Bearings***

(9) TIME BLOWER ROTORS.

**FEELER RIBBONS**, as follows:

0.002-in. (two)
0.003-in. (two)
0.004-in. (two)
0.005-in. (two)

**PULLEY**, gear assembly
**WRENCH**, ¾-in.

**NOTE**: The three lobes on each blower rotor are located spirally with respect to the center line of the rotor shaft. The teeth on the timing gears are also helical, as previously stated. The rotor with the right-hand helical lobe is driven with a gear having right-hand helical teeth. The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear. If the *upper* gear is moved *out*, the upper rotor will turn counterclockwise when viewed from the gear end. If the *lower* gear is moved *out*, the lower rotor will turn *clockwise* when viewed from gear end. This positioning of the gear to obtain proper clearance between the rotor lobes is known as "blower timing". Moving the gears *out* or *in* on the rotors is accomplished by adding or removing shims between the gear hub and the bearing back of the gears. The clearance should be the same between the leading and trailing sides of individual rotor lobes as their mating lobes. Proceed as follows to check rotor lobe clearance:

*(a)* The clearance between rotor lobes may be checked with various thicknesses of feeler ribbons ½ inch wide. When measuring clearance of more than 0.005 inch, laminated feelers made up of 0.002-inch, 0.003-inch, 0.004-inch or 0.005-inch thickness are more practical and suitable than one single thick feeler. The measurement of clearance between rotor lobes must be taken from both inlet and outlet side of blower.

*(b)* Time rotors are to have from 0.004-inch to 0.006-inch clearance between the *trailing side* of the *upper* rotor and the *leading side* of the *lower* rotor, "CC"—measured from both the inlet and outlet sides of blower, as shown in figures 77 and 79. Then check clearance between leading side of upper and trailing side of lower rotors, "C", for a minimum of 0.012-inch as shown in figures 77 and 78. The 0.012-inch clearance should be held as an absolute minimum, and this should be closely adhered to when using new rotors. Measure clearance close to each end and at center of rotors.

*(c)* A 0.001-inch shim back of either gear will revolve that rotor 0.001 inch. Having determined the amount one rotor must be revolved to produce the proper clearance (same as thickness of shims required), add shims back of either the upper or lower gear to produce the desired result. When a change in shims is required, both gears must be pulled from the rotors, as directed in step (5) under Disassembly of Blower, paragraph 48. Install the required thickness of shims back of the proper gear, next to the bearing inner race, and again press gears tightly into place. Recheck clearances between rotor lobes.

(10) CHECK ROTOR END CLEARANCE.

FEELER RIBBONS, as follows:

| | |
|---|---|
| 0.002-in. (two) | 0.004-in. (two) |
| 0.003-in. (two) | 0.005-in. (two) |

Insert feeler ribbons between ends of rotors and end plates. This operation must be performed at the ends of each lobe, making 12 measurements in all. Refer to clearances listed in paragraph 55.

(11) INSTALL BLOWER GEAR DRIVE HUB.

WRENCH, ½-in.

Attach hub to upper blower timing gear with six cap screws with lock washers.

BLOWER

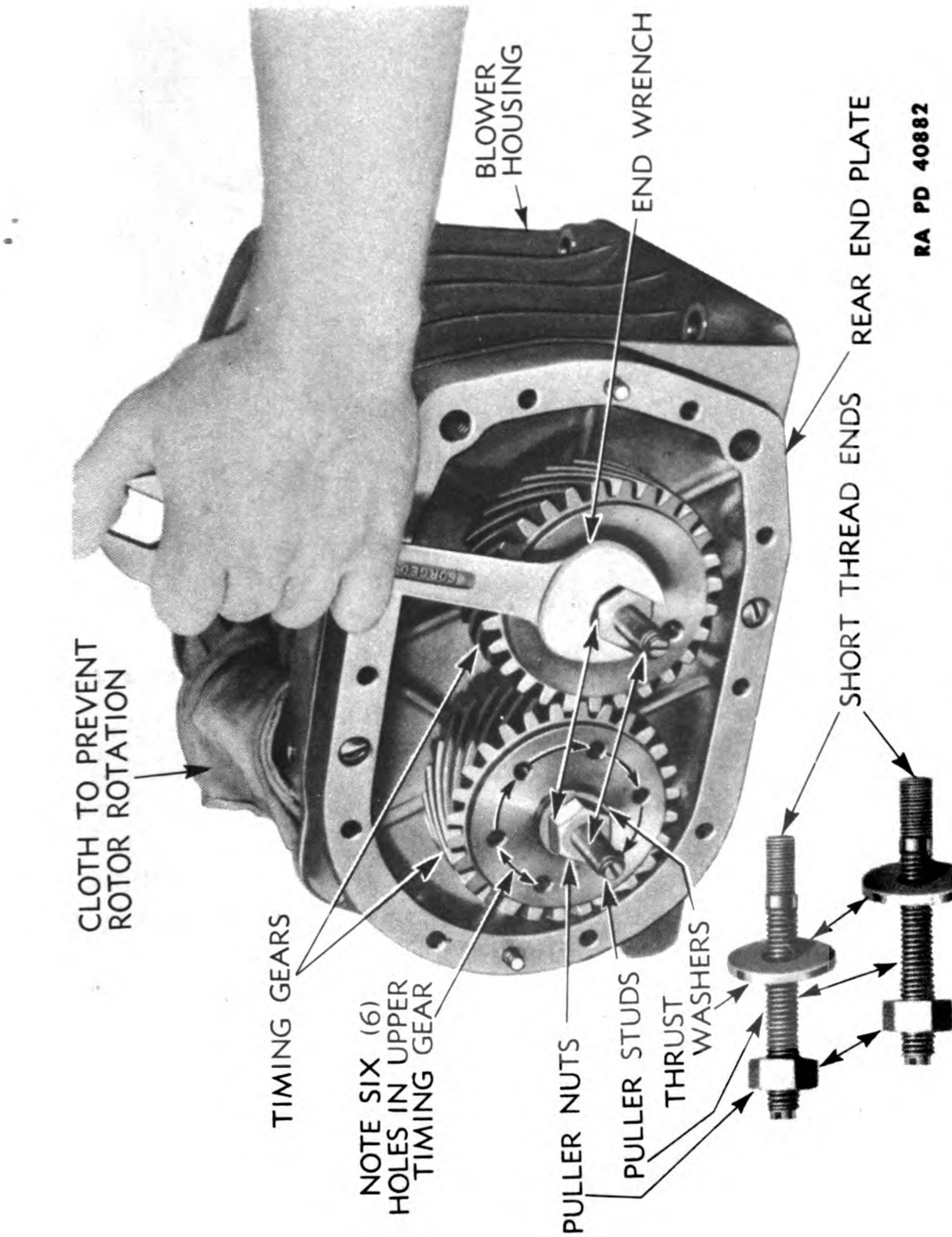
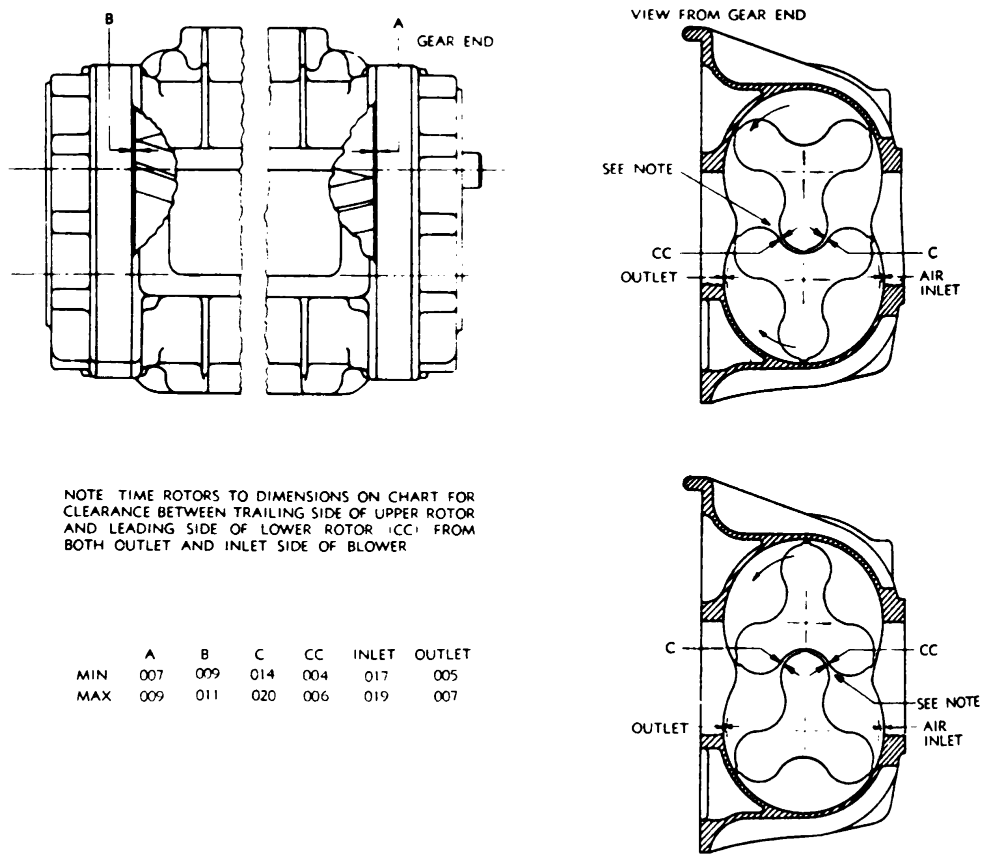



*Figure 76—Pressing Timing Gears onto Rotor Shafts*

## ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES




NOTE TIME ROTORS TO DIMENSIONS 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

| | A | B | C | CC | INLET | OUTLET |
|---|---|---|---|---|---|---|
| MIN | 007 | 009 | 014 | 004 | 017 | 005 |
| MAX | 009 | 011 | 020 | 006 | 019 | 007 |

RA PD 41436

***Figure 77—Diagram of Rotor Clearances***

(12) INSTALL WATER PUMP DRIVE.
WRENCH, hexagon, 3/16-in.

Insert splined end of water pump intermediate shaft and coupling into front end of lower rotor shaft. Hold coupling tight against end of shaft and tighten expander screw securely.

(13) INSTALL END PLATE COVERS.
WRENCH, ½-in.

Shellac gaskets to end plate covers and attach each end plate to blower end plates with ten cap screws with lock washers.

(14) INSTALL FUEL PUMP ON BLOWER.
WRENCH, 7/16-in.

Install a new gasket on pump supporting flange. Set pump assembly up against the blower rear end cover, being sure that the drive fork engages the slots in the driving plate. The lugs will engage the plate when the pump body sets tight up against the end of the blower end cover.

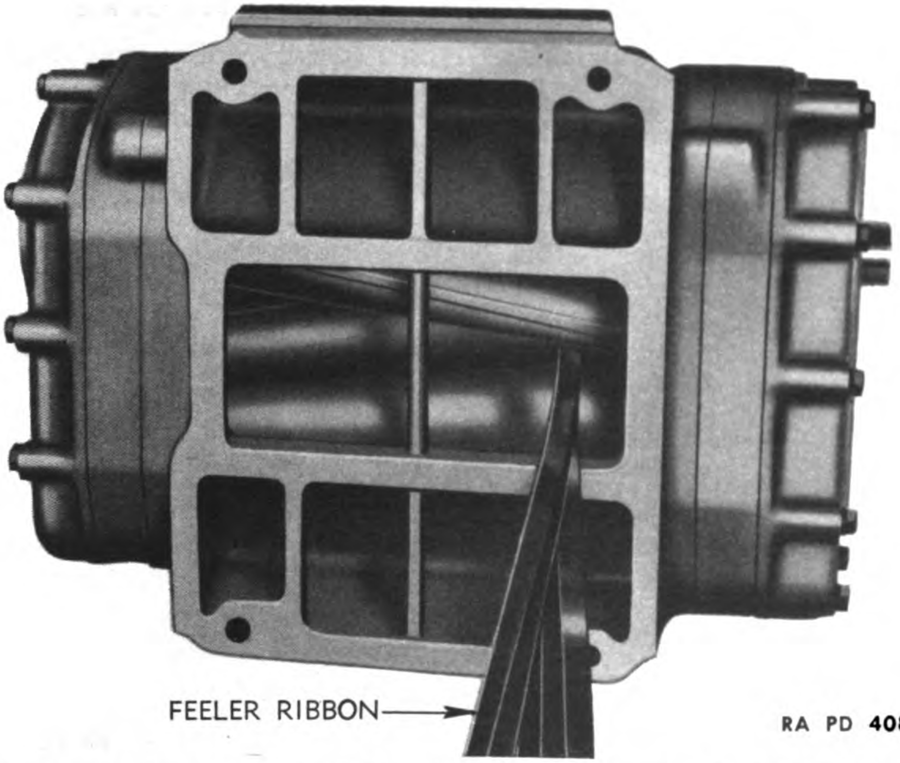



*Figure 78 — Method of Checking Clearance "C" Between Rotor Lobes*

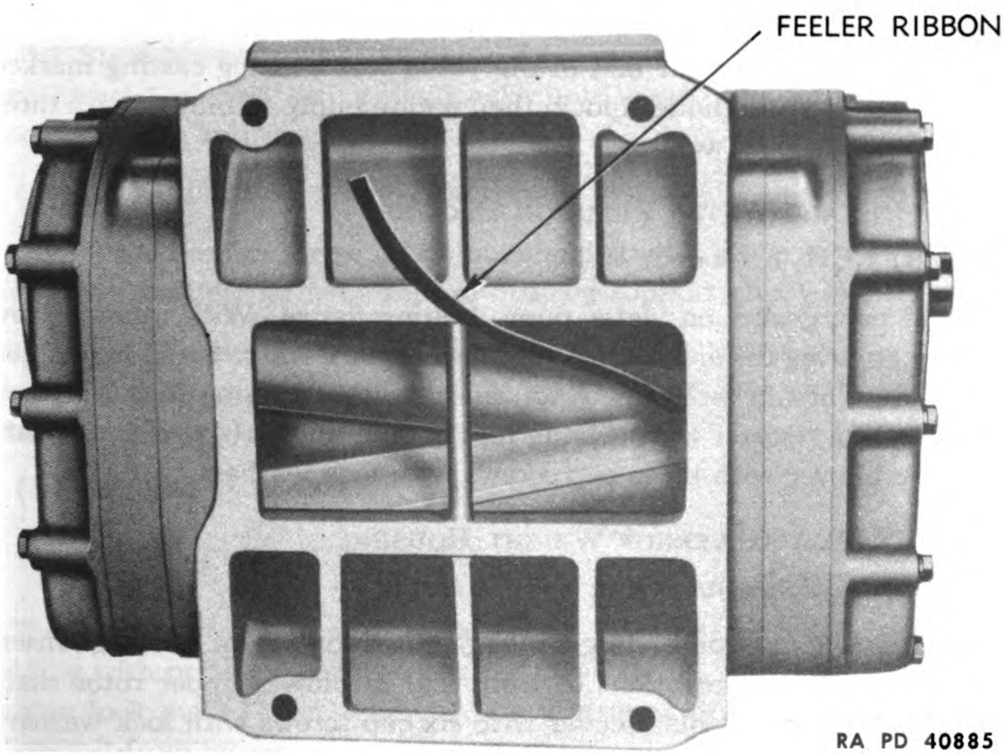



*Figure 79 — Method of Checking Clearance "CC" Between Rotor Lobes*

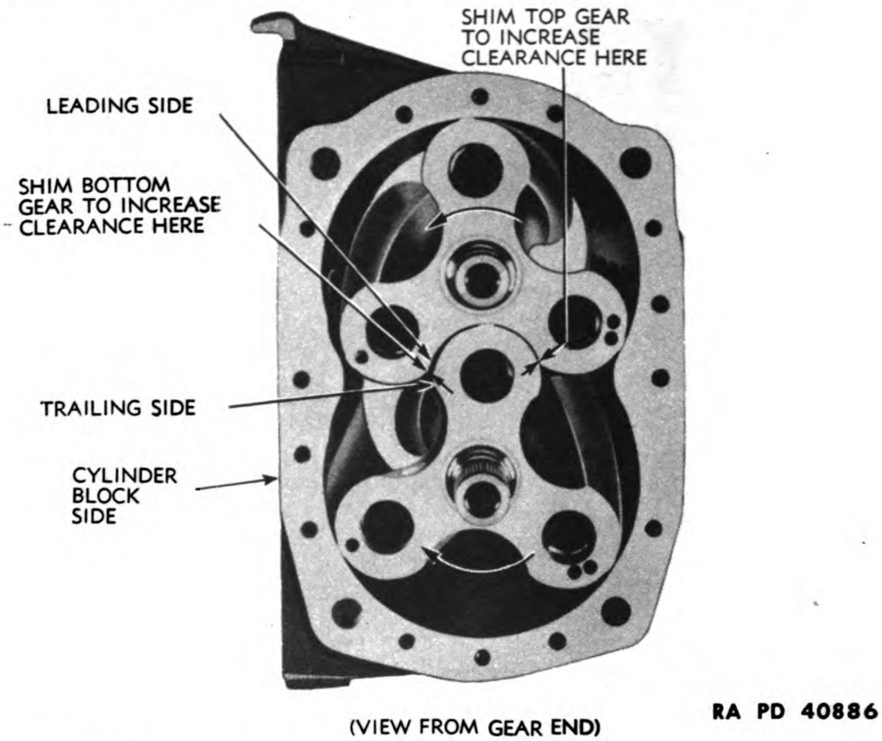



***Figure 80—Diagram Showing Proper Location of Shims to Correct Rotor Clearance***

Check to be sure that the end of the valve seat housing casting marked "IN" is nearest the cylinder block; then secure pump to blower with three cap screws with lock washers.

(15) INSTALL WATER PUMP ON BLOWER.

WRENCH, open-end, ½-in.

Install new gasket on water pump bolting flange. With intake elbow of pump pointing towards bottom of blower, place water pump in position at front end of blower lower rotor shaft, so that driving lugs on pump shaft coupling register with driving lugs of coupling on blower rotor shaft. Secure to blower with three cap screws with lock washers.

(16) INSTALL GOVERNOR WEIGHT HOUSING.

WRENCH, ½-in.

Install new gasket on bolting flange of governor weight housing. Insert governor shaft into serrations at front end of blower upper rotor shaft. Secure to blower and plate cover with six cap screws with lock washers. NOTE: After blower has been inspected and repaired, cover all openings with oil paper and fasten paper on to keep any dirt out until installation. The blower *must be clean* and free of dirt when installed.

## 52. ASSEMBLY OF BLOWER DRIVE ASSEMBLY.

**a. Equipment.**

BAR, pry
FEELER RIBBONS,
as follows:
0.002-in.
0.003-in.
0.004-in.
0.005-in.
HAMMER, ½-lb.
HAMMER, soft
PLIERS, long-nosed
SHELLAC
TOOL, spreader, spring
WRENCH, ½-in.
WRENCH, 1⅞-in.

**b. Procedure** (fig. 82).

(1) ASSEMBLE FLEXIBLE COUPLING DRIVE SPRINGS AND CAM.

*(a)* Place drive spring support on two blocks of wood, as shown in figure 83. Grease springs to hold the leaves together, and slide two spring packs, consisting of twenty-one springs each, into spring support with a drive spring seat at both ends of each spring pack. Locate spring seats so that rounded surface will set in corresponding curve in spring support.

*(b)* Slide blower drive coupling cam over end of spring spreader tool; then insert tool between spring packs until lower edge of cam rests on blocks beneath spring support.

(2) INSTALL DRIVE GEAR HUB.

*(a)* Spread some engine oil on outside diameter of drive gear hub and slide hub into bearing from rear of bearing support (fig. 67).

*(b)* Install locking ball into gear hub, and slide thrust washer in place over ball, with large diameter flat face of washer next to thrust face of bearing.

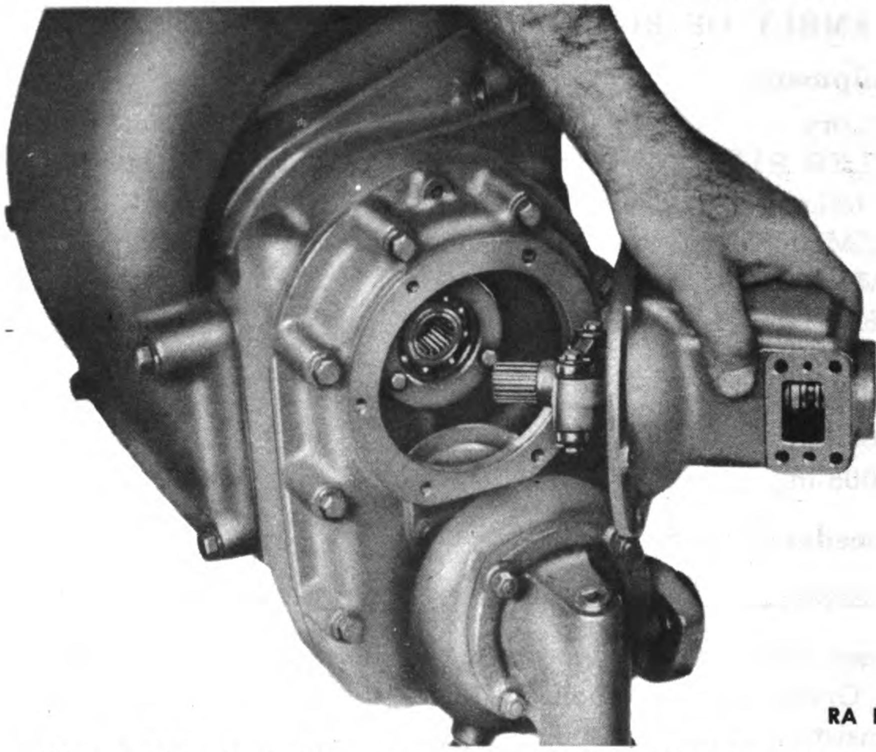
(3) INSTALL NUT ON HUB.

BAR, pry
HAMMER, ½-lb.
WRENCH, 1⅞-in.

Prevent hub from turning by inserting bolts in two holes in hub and holding with pry bar. Install a new lock washer next to thrust washer and tighten lock nut (1⅞-in. wrench). Bend ears of lock washer over nut to prevent it from loosening (hammer).

(4) INSTALL DRIVE GEAR AND COUPLING RETAINER.

HAMMER, soft
WRENCH, ½-in.



RA PD 40783

*Figure 81 — Installing Governor Weight Housing on Blower*

Tap gear into place on hub (soft hammer) with flat finished face of gear away from bearing support. The outer end of the cam is counterbored about ¼ inch on the inside diameter. With this counterbore away from face of gear, place the coupling retainer against the outer face of spring support, with flange at center of retainer pointing away from spring support. Secure retainer in place with six cap screws with lock washers (½-in. wrench).

(5) INSTALL DRIVE COVER PACKING AND GASKET.

Install blower drive cover packing into groove provided at front end of bearing support. Affix gasket to finished face of bolting flange on bearing support (fig. 68).

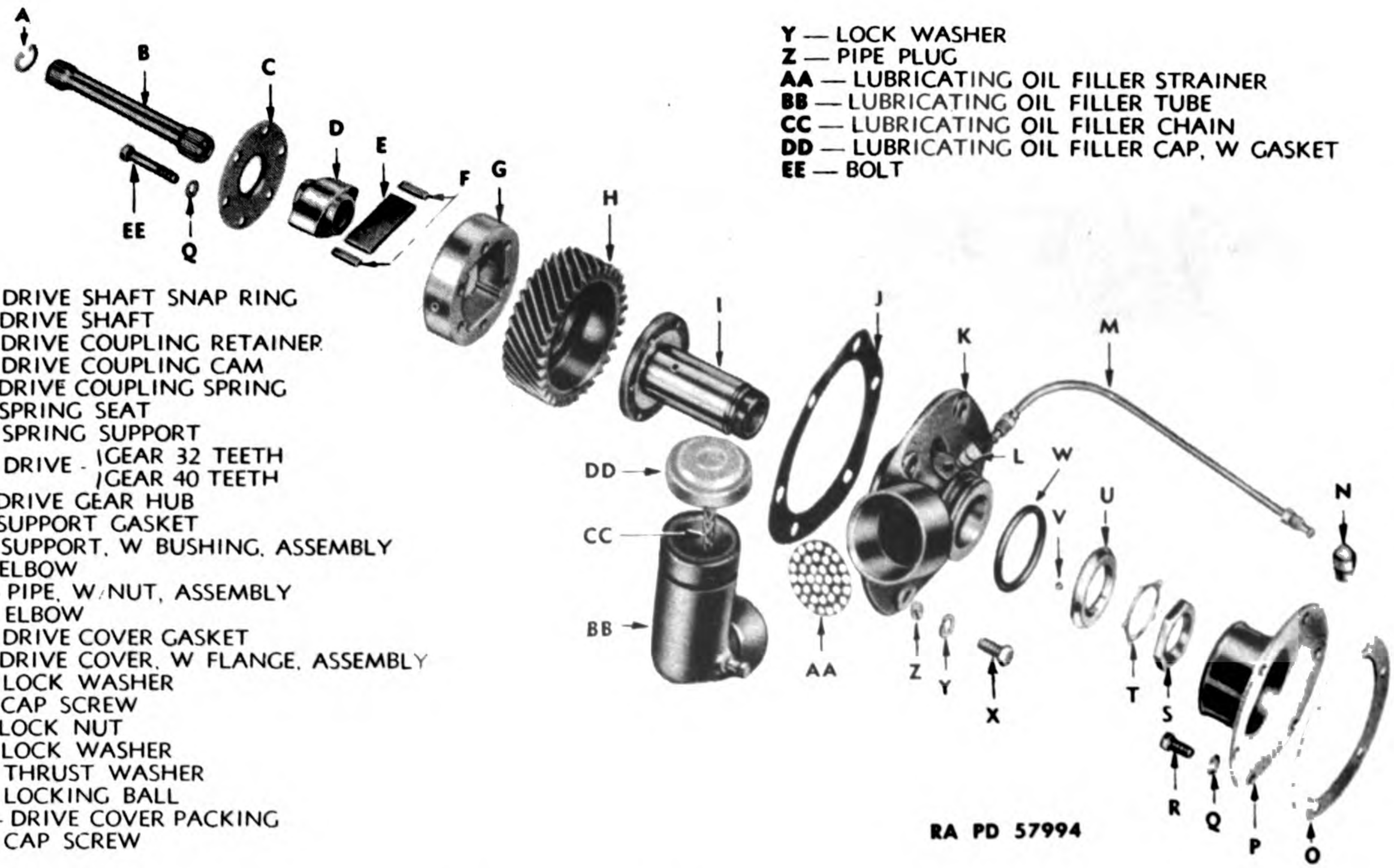
(6) CHECK END CLEARANCE AND INSTALL SNAP RING.

FEELER RIBBONS, as follows:
0.002-in.
0.003-in.
0.004-in.
0.005-in.

PLIERS, long-nosed

*(a)* Apply some engine oil at each thrust shoulder of hub bearing and insert feeler ribbons between gear hub and thrust shoulder of hub bearing (fig. 84). This clearance should be from 0.003-inch to 0.006-inch.

## BLOWER




A — DRIVE SHAFT SNAP RING
B — DRIVE SHAFT
C — DRIVE COUPLING RETAINER
D — DRIVE COUPLING CAM
E — DRIVE COUPLING SPRING
F — SPRING SEAT
G — SPRING SUPPORT
H — DRIVE - GEAR 32 TEETH / GEAR 40 TEETH
I — DRIVE GEAR HUB
J — SUPPORT GASKET
K — SUPPORT, W BUSHING, ASSEMBLY
L — ELBOW
M — PIPE, W/NUT, ASSEMBLY
N — ELBOW
O — DRIVE COVER GASKET
P — DRIVE COVER, W FLANGE, ASSEMBLY
Q — LOCK WASHER
R — CAP SCREW
S — LOCK NUT
T — LOCK WASHER
U — THRUST WASHER
V — LOCKING BALL
W — DRIVE COVER PACKING
X — CAP SCREW
Y — LOCK WASHER
Z — PIPE PLUG
AA — LUBRICATING OIL FILLER STRAINER
BB — LUBRICATING OIL FILLER TUBE
CC — LUBRICATING OIL FILLER CHAIN
DD — LUBRICATING OIL FILLER CAP, W GASKET
EE — BOLT

**Figure 82 — Exploded View of Blower Drive Assembly**

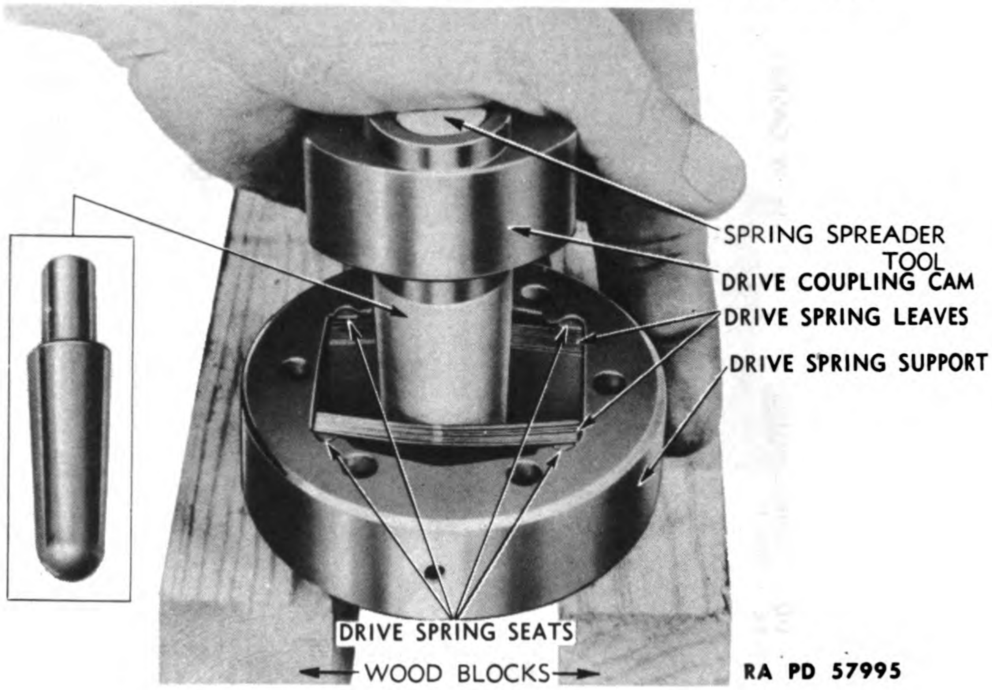



***Figure 83—Installing Blower Drive Coupling Cam***

*(b)* Install snap ring in groove in cam of flexible coupling where it will contact rear end of blower drive shaft when shaft is installed (pliers).

## 53. INSTALLATION OF BLOWER DRIVE ASSEMBLY.

**a. Equipment.**

WRENCH, 9/16-in.

**b. Procedure.**

(1) INSTALL BLOWER DRIVE ASSEMBLY IN HOUSING.

WRENCH, 9/16-in.

Place assembly in position in rear cylinder end plate and flywheel housing so that oil filler pipe points up. Install two cap screws with lock washers in the two tapped holes in cylinder block end plate to secure blower drive support to end plate. Partially tighten cap screws.

(2) INSTALL BLOWER DRIVE SHAFT.

Insert end of shaft with shortest splined end through drive gear hub and into splines in cam of flexible coupling so end contacts snap ring in cam. Do not install cover at rear of flywheel housing until blower has been installed.

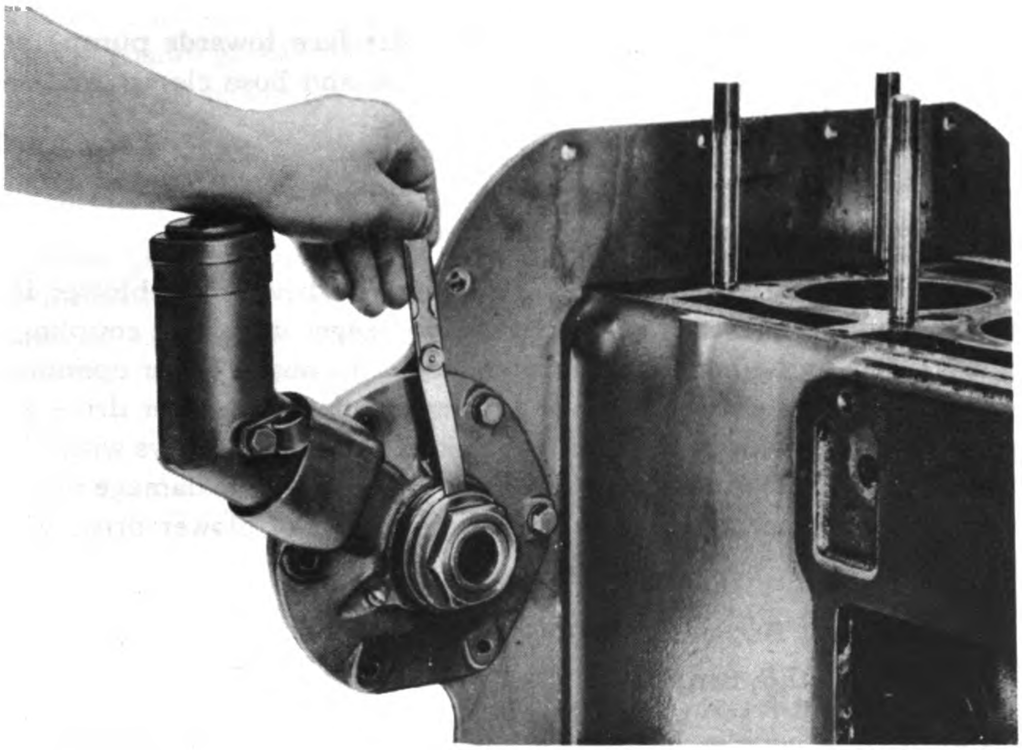

RA PD 17824

*Figure 84 — Measuring Clearance of Blower Drive Assembly*

## 54. INSTALLATION OF BLOWER.

**a. Equipment.**

COMPOUND, joint and thread
PLIERS
SCREWDRIVER, 8-in.
SOAP
VARNISH, shellac, orange, type 11
WRENCHES, two, open-end, 7/16-in.
WRENCH, open-end, 5/8-in.
WRENCHES, two, open-end, 3/4-in.
WRENCH, open-end, 7/8-in.
WRENCH, socket, 7/16-in.
WRENCH, socket, 1/2-in. with extension
WRENCH, socket, 5/8-in. with extension
WRENCHES, two, 9/16-in.

**b. Procedure.**

(1) PREPARE TO INSTALL BLOWER ON ENGINE.

Before attaching to engine, cement a new gasket to cylinder block, using COMPOUND, joint and thread, on block side only. Apply some soap to the rubber grommet in groove of blower drive gear support. Slip water pump outlet packing flange (with flat face towards pump) and new packing ring onto pump discharge pipe and hose clamp, and seal over pump inlet.

(2) ATTACH BLOWER ASSEMBLY TO ENGINE.

WRENCH, socket, ⅝-in., with extension

With blower drive shaft in place in blower drive, slide blower into place so splined end of blower drive shaft engages in splined coupling in blower—it may be necessary to rotate rotors through blower opening—and blower drive cover slips over rubber grommet in blower drive gear support. Attach blower to cylinder block with four cap screws with plain washers. CAUTION: Extreme care must be taken not to damage blower-to-engine gasket or to dislodge snap ring at rear of blower drive while installing blower.

(3) INSTALL BLOWER DRIVE COVER.

WRENCHES, two, 9/16-in.

Install cover at rear of flywheel housing with four bolts and two cap screws with lock washers.

(4) INSTALL OIL LINE AND OIL GAGE TUBE AND ROD.

WRENCH, open-end, 7/16-in.
WRENCH, open-end, ⅞-in.
WRENCH, open-end, ¾-in.

Connect blower drive bearing oil pipe to fittings on blower drive and in cylinder block (7/16-in. wrench). Insert upper end of oil gage rod tube through clip on oil filler pipe and connect lower end to fitting in base of cylinder block.

(5) CONNECT WATER PUMP.

SCREWDRIVER, 8-in.
WRENCH, open-end, ⅝-in.
WRENCH, socket, ½-in., with extension

Connect water pump discharge packing flange to cylinder block with two cap screws with lock washers (½-in. wrench). Slip seal and hose clamp down to connect water pump to oil cooler and tighten clamp (screwdriver). Connect water line from compressor to water pump (⅝-in. wrench).

(6) INSTALL AIR INLET HOUSING.

WRENCH, 9/16-in.

BLOWER

Insert four cap screws with lock washers through holes in air inlet housing. Install gasket and screen assembly on these bolts, place housing in position and secure it to blower over blower opening.

(7) INSTALL AIR INLET ELBOW.

SCREWDRIVER, 8-in. WRENCH, 9/16-in.

Shellac gasket to flange of air inlet elbow. Set elbow on blower air inlet housing with end of elbow pointing toward connecting tube to air cleaner. Secure to housing with four cap screws with lock washers. Connect hose and tighten clamp (screwdriver).

(8) CONNECT FUEL PUMP LINES.

WRENCH, open-end, 3/4-in. WRENCH, open-end, 7/8-in.

Connect fuel line leading from first stage fuel filter assembly to inlet fitting (closest to cylinder block) on fuel pump and connect discharge line to second stage fuel filter to discharge side of pump (3/4-in. and 7/8-in. wrenches).

(9) INSTALL GOVERNOR CONTROL HOUSING AND CONNECT CONTROLS.

See Installation of Governor, paragraph 187, for installation of this unit and connection of controls.

(10) INSTALL RIGHT FRONT FENDER.

WRENCHES, two, 3/4-in.

Place fender on tractor and insert one bolt and three cap screws and tighten.

(11) INSTALL HOOD AND PRE-CLEANERS.

WRENCHES, two, open-end, 7/16-in. WRENCH, open-end, 9/16-in.

Set hood in position. Force hold-down strap bolts into clips and tighten (9/16-in. wrench). Set pre-cleaners on tubes at top of air cleaners and tighten clamps at base (two 7/16-in. wrenches).

## 55. FITS AND TOLERANCES.

**a.** Specifications for blower and blower drive assembly are as follows:

(1) BLOWER DRIVE GEAR ASSEMBLY.

| | |
|---|---|
| *(a)* Diameter—inside—support bushings | 1.6260 to 1.6265-in. |
| Diameter—outside—hub | 1.6250 to 1.6245-in. |
| Clearance—annual—bushings with hub | 0.001 to 0.002-in. |
| Maximum clearance allowable | 0.005-in. |

(*b*) Clearance—end bushings with hub........................0.003 to 0.006-in.
Maximum clearance allowable..........................................................0.010-in.

(2) BLOWER ROTORS.

(*a*) Clearance "CC" between rotor lobes.....................0.004 to 0.006-in.
Clearance "C" between rotor lobes....................................0.014 to 0.020-in.

(*b*) Clearance "A" between gear end of rotors and end plate ..........................................................0.007 to 0.009-in.

Clearance "B" between front end of rotors and end plate...................................................................0.009 to 0.011-in.

(*c*) Clearance between rotors and housing—inlet side...........................................................0.017 to 0.019-in.
Clearance between rotors and housing—outlet side........0.005 to 0.007-in.

(3) BLOWER TIMING GEARS.

Maximum allowable backlash on timing gears...............................0.004-in.

## 56. SPECIAL TOOLS.

**a.** Special tools required for repair work on blower are as follows:

SET, tool, service, blower; includes:

- COLLAR, oil seal assembly
- PILOTS, oil seal
- PULLER, assembly, gear
- REMOVER, bearing and oil seal
- SPREADER, blower drive gear flexible coupling spring
- STUDS, rotor gear assembly
- TOOL, bearing assembly

## Section VIII

# AIR PRE-CLEANERS



## 57. DESCRIPTION.

**a.** The pre-cleaners are of the cyclone type. Approximately 85 percent of the dirt entering with the air is removed by them before the air reaches the oil bath air cleaners. Glass inspection ports make it easy for the operator to observe the quantity of dirt and dust in the dirt compartments so they can be emptied at the proper time. Air is drawn through the pre-cleaners by the blower. Fins where the air enters the pre-cleaners give it a swirling motion which throws the heavy particles of dust and dirt out of the air and deposits them in the dirt compartment. A rubber gasket under the cover seals against entrance of air except through the fins. *Do not operate the tractor without the pre-cleaners in place.*

## 58. REMOVAL FROM TRACTOR.

**a. Equipment.**

WRENCHES, two, 7/16-in.

**b. Procedure.**

Loosen clamp bolts at base of pre-cleaners and lift assemblies off air cleaner tubes (fig. 85).

## 59. PREVENTIVE MAINTENANCE.

**a.** The pre-cleaners must be emptied daily, or oftener if necessary. Dirt must not be allowed to become level with top of glass.

(1) Remove wing nut from the top of pre-cleaners and remove bowl.

(2) Shake dust from dirt compartment.

(3) Wipe gasket and reassemble. Replace rubber gasket if present one is not in good condition.

(4) Tighten wing nut with fingers. CAUTION: Do not use a wrench.

## 60. INSTALLATION.

**a. Equipment.**

WRENCHES, two, 7/16-in.

**b. Procedure.**

Place pre-cleaner assemblies in position over tubes, pushing them down as far as possible. Tighten clamp bolts.

## Section IX

# AIR CLEANERS (OIL BATH)



## 61. DESCRIPTION.

**a.** A United air cleaner assembly, Model CT 85 9665, is used on this tractor and is mounted under the tractor cowl. It consists of two oil bath air cleaners connected to one bracket which brings the air together into one outlet pipe. Oil cups with baffle plates at the lower end of the air cleaner assemblies are filled to a specified level with engine oil. As the air is drawn through the cleaners, a portion of this oil is whipped up into screen mats in the main body of the cleaners. Dust in the air collects on these oily screen mats as the air is drawn through them, and the oil, dripping back into the cups from the screen mats, carries this dirt with it to deposit it in the cups. Thus only clean air reaches the engine. The cups are removable and must be removed periodically and cleaned to remove this dirt. A broken hose, loose clamps, or a leak of any kind between the air cleaners and the blower will defeat the purpose of the cleaners. Therefore, care should be taken to see that all connections are tight.

## 62. PREVENTIVE MAINTENANCE.

**a.** The life of the engine depends largely on the care given the oil bath cleaners. Daily attention is necessary, and in extremely dusty or sandy operating conditions, more frequent attention is often necessary. The oil level must be maintained and the dirt cleaned from the cups at regular intervals. If not serviced regularly, the dirt builds up in the cup and on the baffle plate in the cup until the openings in the baffle plate for return of oil and dirt to the cup are closed and the efficiency of the cleaner is impaired. Dirt passing through into the blower and engine will result in rapid wear on blower, cylinder liners and other operating parts. It is good practice to swab out the lower end of the central air passage in the cleaner each time the cup is removed and cleaned. Oil-mixed dust which sometimes collects in this pipe will restrict the air supply to the cylinders for combustion if not removed. Use engine oil (not Diesel oil) in the air cleaner. Use viscosity shown on Lubrication Guide for prevailing temperature. *This is important.* If air cleaner is damaged, replace it *immediately.* See TM 9-787A for servicing air cleaner.

## 63. REMOVAL FROM TRACTOR.

**a. Equipment.**

PLIERS
SCREWDRIVER, 8-in.
WRENCHES, two, 7/16-in.
WRENCH, 3/4-in.
WRENCH, open-end, 9/16-in.
WRENCH, socket, 9/16-in.

**b. Procedure** (fig. 85).

(1) REMOVE PRE-CLEANERS AND HOOD.

WRENCHES, two, 7/16-in.
WRENCH, open-end, 9/16-in.

Loosen clamp bolts at base of pre-cleaners (two 7/16-in. wrenches) and lift off pre-cleaners. Loosen bolts at each corner of hood (9/16-in. wrench) and lift hood off over air inlet elbows and exhaust stack.

(2) REMOVE PRE-CLEANER ELBOW.

WRENCH, 9/16-in.

Remove four cap screws holding each pre-cleaner elbow to the cowl and remove elbows.

(3) REMOVE AIR CLEANER TUBE.

SCREWDRIVER, 8-in.
WRENCH, 3/4-in.

Loosen hose clamps connecting tube to air cleaner outlet elbow (screwdriver). Remove three cap screws holding air cleaner tube to cowl (3/4-in. wrench) and lift off tube.

(4) DISCONNECT AIR CLEANER STRAPS AND BRACKETS.

WRENCHES, two, 9/16-in.
WRENCH, 3/4-in.

Remove four cap screws holding air cleaner bracket inside and underneath top of cowl (3/4-in. wrench). Remove three bolts and nuts holding each air cleaner strap to air cleaner bracket (two 9/16-in. wrenches).

(5) REMOVE CONTROL RODS.

PLIERS

Pull cotter pins and remove pins connecting throttle rod and fuel shut-off rod at bottom of throttle lever and at rear of engine. Pull rods out from between air cleaner bodies.

(6) LIFT OUT AIR CLEANERS AND AIR CLEANER BRACKET.

Maneuver air cleaners and air cleaner bracket out from underneath cowl.

(7) REMOVE CLEANER BODIES FROM BRACKET.

WRENCH, 9/16-in.

Remove six cap screws holding each cleaner body to bracket and separate bodies and bracket.

## 64. CLEANING.

**a.** Screens cannot be removed from bodies of cleaners but if cleaners are removed, and are to be put back on, the screens should be rinsed by dipping in clean fuel. This will loosen and remove dirt lodged in screens.

## 65. INSTALLATION.

**a. Equipment.**

PLIERS
SCREWDRIVER, 8-in.
WRENCHES, two, 7/16-in.
WRENCH, 3/4-in.
WRENCH, open-end, 9/16-in.

**b. Procedure** (fig. 85).

(1) CONNECT CLEANER BODIES AND BRACKET.

WRENCH, 9/16-in.

Shellac new gaskets to bracket and install air cleaner bodies to bracket with six cap screws with lock washers in each. Shellac new gasket to surface of bracket that contacts cowl unless old one is in good condition.

(2) PUT AIR CLEANER ASSEMBLY IN PLACE.

PLIERS

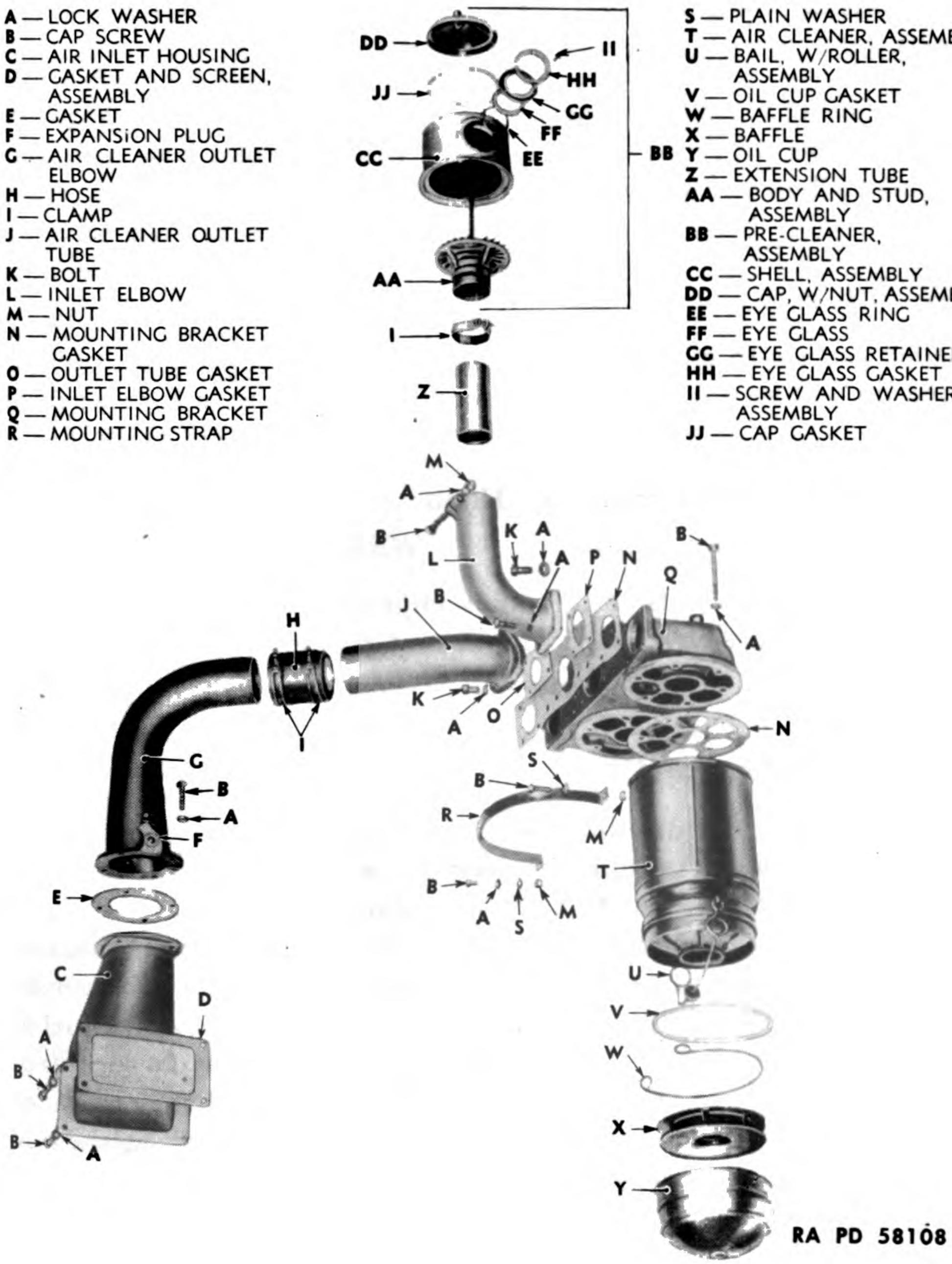
Maneuver air cleaner assembly into position under cowl and slide throttle rod between cleaners. Connect throttle rod to throttle lever and lever on throttle shaft; install and connect fuel shut-off rod to fuel shut-off lever on throttle shaft. Secure pins with cotter pins.

(3) ATTACH AIR CLEANER STRAPS AND BRACKET.

WRENCHES, two, 9/16-in. WRENCH, 3/4-in.

Install straps on cleaner bodies with three bolts with lock washers (two 9/16-in. wrenches). Attach bracket to cowl with four cap screws with lock washers (3/4-in. wrench). Fill cups to specified level with oil (see TM 9-787A).

## AIR CLEANERS (OIL BATH)




A — LOCK WASHER
B — CAP SCREW
C — AIR INLET HOUSING
D — GASKET AND SCREEN, ASSEMBLY
E — GASKET
F — EXPANSION PLUG
G — AIR CLEANER OUTLET ELBOW
H — HOSE
I — CLAMP
J — AIR CLEANER OUTLET TUBE
K — BOLT
L — INLET ELBOW
M — NUT
N — MOUNTING BRACKET GASKET
O — OUTLET TUBE GASKET
P — INLET ELBOW GASKET
Q — MOUNTING BRACKET
R — MOUNTING STRAP
S — PLAIN WASHER
T — AIR CLEANER, ASSEMBLY
U — BAIL, W/ROLLER, ASSEMBLY
V — OIL CUP GASKET
W — BAFFLE RING
X — BAFFLE
Y — OIL CUP
Z — EXTENSION TUBE
AA — BODY AND STUD, ASSEMBLY
BB — PRE-CLEANER, ASSEMBLY
CC — SHELL, ASSEMBLY
DD — CAP, W/NUT, ASSEMBLY
EE — EYE GLASS RING
FF — EYE GLASS
GG — EYE GLASS RETAINER
HH — EYE GLASS GASKET
II — SCREW AND WASHER, ASSEMBLY
JJ — CAP GASKET

***Figure 85 — Exploded View of Air Cleaner and Pre-cleaner Assembly***

(4) INSTALL AIR CLEANER TUBE.

SCREWDRIVER, 8-in. WRENCH, ¾-in.

Shellac gasket to tube and install to cowl and air cleaner bracket with three cap screws with lock washers (¾-in. wrench). Slip hose over end of air outlet elbow and tighten hose clamps (screwdriver).

(5) INSTALL PRE-CLEANER ELBOWS.

WRENCH, 9/16-in.

Shellac gaskets to elbows. Place in position against cowl with elbow pointing up and secure to cowl with four cap screws with lock washers in each.

(6) INSTALL PRE-CLEANERS AND HOOD.

WRENCHES, two, 7/16-in. WRENCH, open-end, 9/16-in.

Install hood, press bolts into holding clips and tighten bolts (9/16-in. wrench). Install pre-cleaners on tubes and tighten clamp bolts (two 7/16-in. wrenches).

## 66. AIR OUTLET ELBOW.

**a. Description.** Air leaving the oil bath air cleaner passes through the air outlet elbow and air inlet housing to the blower. A large butterfly air valve with beveled edges to fit tightly against the sides of the elbow is located at the lower end of the elbow and is controlled by the fuel and air shut-off lever and linkage. When the fuel and air shut-off lever on dash is pulled out, the air valve in the outlet elbow is closed as the fuel to the injectors is shut off. This air valve acts as a safety valve if a surplus of fuel collects in the engine. Closing the air valve shuts off the supply of air and thus causes the engine to stop. A spring and ball arrangement is located in the lever assembly to hold the valve in either open or closed position.

**b. Removal.**

(1) EQUIPMENT.

PLIERS
SCREWDRIVER, 8-in.
WRENCH, 9/16-in.

(2) PROCEDURE.

*(a) Disconnect Control Rods.*

PLIERS

## AIR CLEANERS (OIL BATH)

Pull cotter pins and remove pins from outer ends of control rods connected to air valve lever on elbow.

(b) *Remove Air Cleaner Outlet Elbow.*

SCREWDRIVER, 8-in. WRENCH, $^{9}/_{16}$-in.

Loosen hose clamp on hose at the upper end of the elbow connecting elbow to the connector tube of the air cleaner (screwdriver). Remove the four cap screws holding elbow to blower air inlet housing. Lift off air outlet elbow assembly ($^{9}/_{16}$-in. wrench).

c. **Disassembly.**

(1) EQUIPMENT.

BAR, pry, small
HAMMER, 2-lb.
PLIERS
PUNCH, small
SCREWDRIVER, 6-in.
WRENCHES, two, $^{9}/_{16}$-in.

(2) PROCEDURE.

(a) *Remove Air Valve Lever Assembly* (fig. 88).

BAR, pry
PLIERS
WRENCHES, two, $^{9}/_{16}$-in.

Remove cotter pin and washer from pivot pin holding lever assembly and fuel and air shut-off rods (pliers) (fig. 88). Remove bolt clamping lever on air valve shaft (two $^{9}/_{16}$-in. wrenches) and pry lever from shaft (pry bar). Take care not to lose the ball and spring when removing the lever assembly, as spring will throw ball if released.

(b) *Remove Air Valve Assembly.*

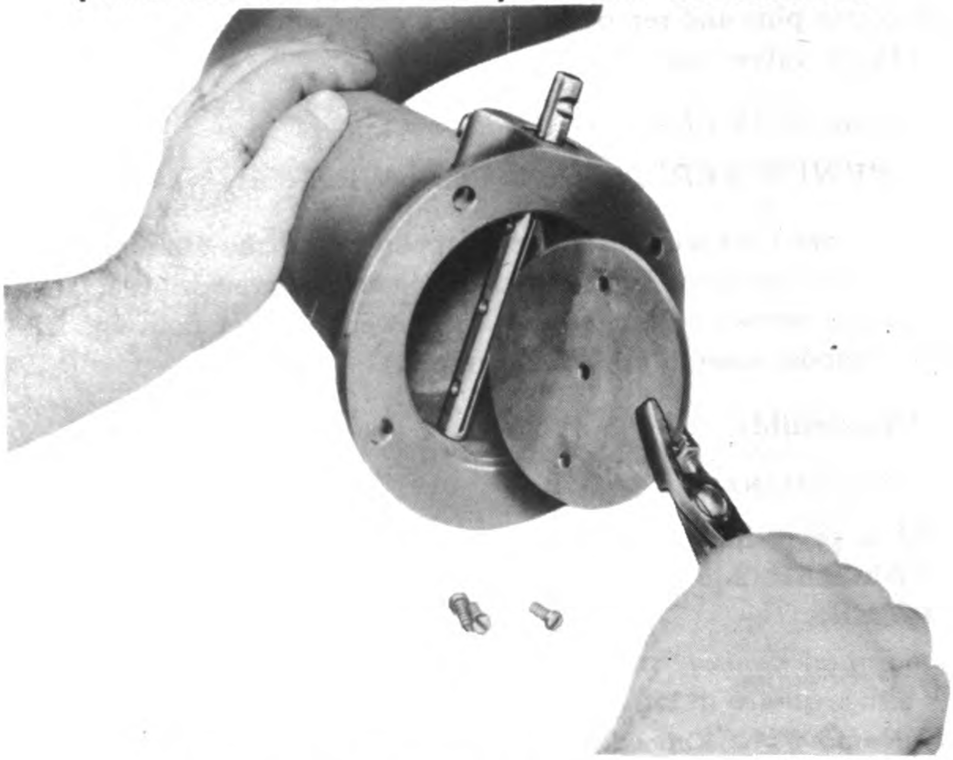
HAMMER, 2-lb.
PLIERS
PUNCH, small
SCREWDRIVER, 6-in.

Remove lock wire threaded through cap screws in air valve shaft and air valve (pliers), and remove these three cap screws (screwdriver). Slide air valve out of slot in shaft and pull shaft out of elbow from lever side of elbow. If necessary to replace seal, remove seal with punch and hammer.

d. **Assembly.**

(1) EQUIPMENT.

HAMMER, soft
PLIERS
SCREWDRIVER, 6-in.
WIRE, soft
WRENCHES, two, $^{9}/_{16}$-in.



RA PD 17944

*Figure 86—Removing Air Valve from Shaft*

(2) PROCEDURE.

*(a) Assemble Valve and Shaft.*

| | |
|---|---|
| HAMMER, soft | SCREWDRIVER, 6-in. |
| PLIERS | WIRE, soft |

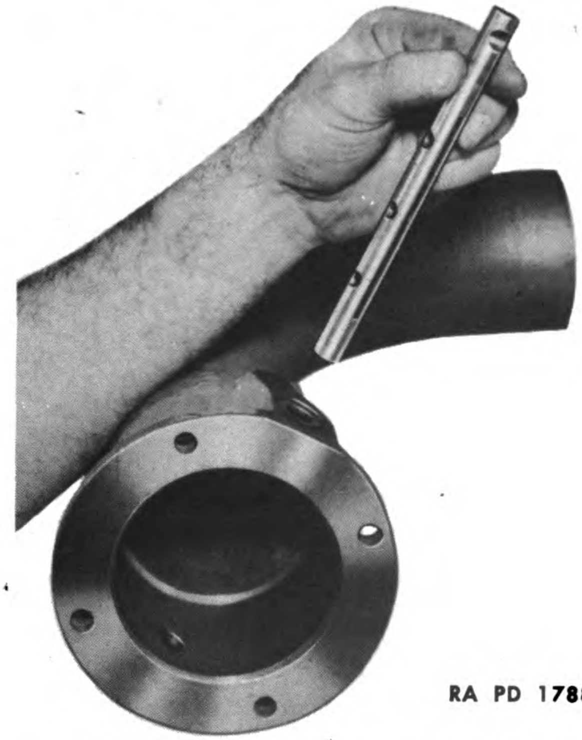
If seal was removed, drive new seal into place with soft hammer. Then slide air valve shaft into elbow from lever side and insert valve through slot in shaft. NOTE: Valve must be installed so beveled edges will fit against sides of elbow when closed. To test, have notch in outer end of shaft down, insert valve in shaft, and twist shaft counterclockwise. If beveled edges fit against elbow, the valve is in correct position and screws may be inserted in shaft and valve. Tighten screws with screwdriver, and lock with wire threaded through heads (pliers) (see fig. 87).

*(b) Install Lever on Shaft.*

WRENCHES, two, $^9/_{16}$-in.

Insert spring in recess in boss on elbow. Place ball on end of spring, compress spring and hold while lever is placed on shaft (fig. 88). Install bolt in lever so bolt registers with notch in shaft and tighten (two $^9/_{16}$-in. wrenches). Test lever by moving it back and forth to see if ball engages in holes in each end of flange on lever.

AIR CLEANERS (OIL BATH)



RA PD 17884

*Figure 87 — Installing Air Valve Shaft*

*(c) Install Control Rod Assembly.*

PLIERS

Insert pin on lever assembly through hole in air valve lever. Place flat washer on pin on inside of lever and secure with cotter pin.

**e. Installation.**

(1) EQUIPMENT.

PLIERS
WRENCH, open-end, $\frac{9}{16}$-in.
SCREWDRIVER, 8-in.

(2) PROCEDURE.

*(a) Install Elbow on Air Inlet Housing.*

WRENCH, $\frac{9}{16}$-in.

Shellac gasket to air inlet housing. Set elbow on air inlet housing, inserting upper end into hose on connecting tube to air cleaner. Secure elbow to inlet housing with four cap screws with lock washers.

*(b) Connect Tubes and Controls.*

PLIERS
SCREWDRIVER, 8-in.

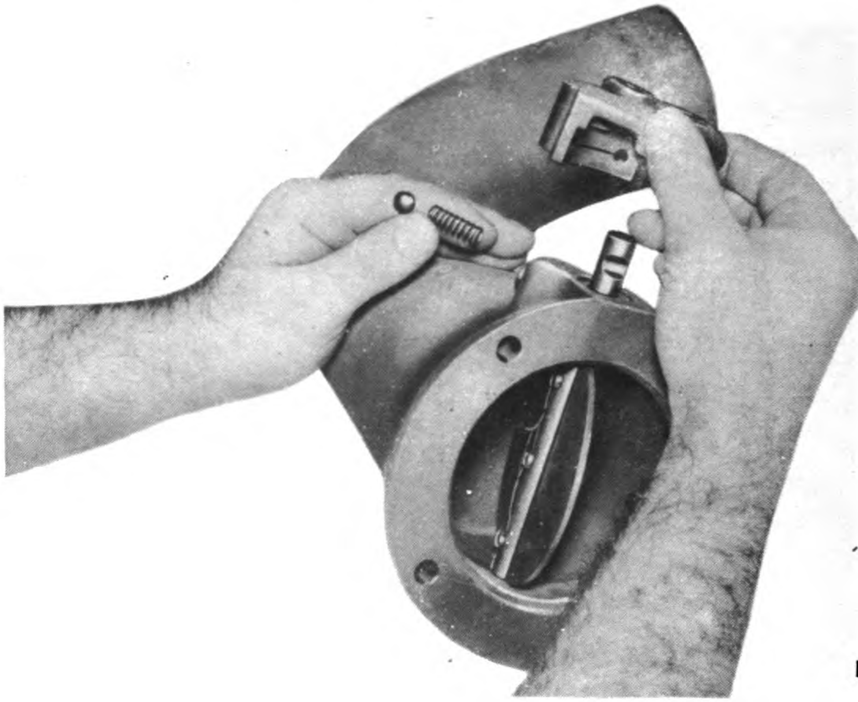



**Figure 88—Installing Lever on Air Valve Shaft**

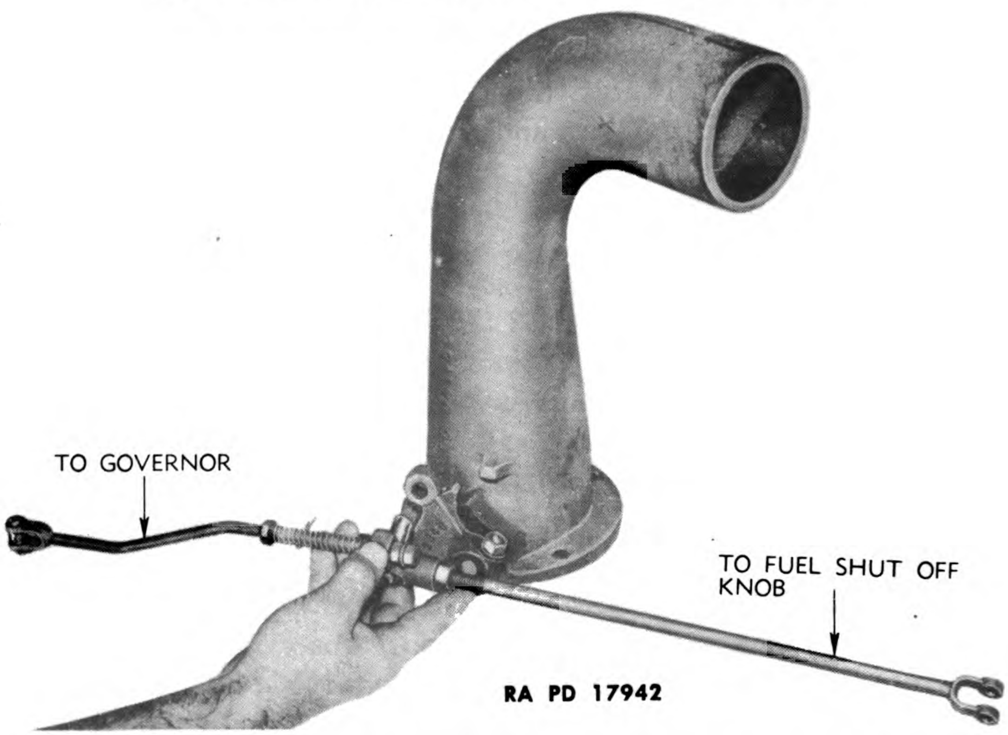



**Figure 89—Installing Air Valve Control Rod Assembly**

## AIR CLEANERS (OIL BATH)

Tighten hose clamp (screwdriver). Connect outer ends of control rods to lever on top of governor control housing and lever on throttle shaft (pliers).

(c) *Adjust Rods if Necessary.*

WRENCH, $^9/_{16}$-in.

When fuel shut-off is pushed in against dash, shut-off lever on governor should move forward until pin on lever is against rear end of slot, and ball in air valve lever assembly should engage in rear notch in lever flange. When fuel shut-off lever is pulled out, the pin on shut-off lever of governor should be against front end of notch; and ball in air valve lever assembly should engage in front notch in lever flange. Adjustment of air valve is made by shortening or lengthening rod controlling lever. See paragraph 187 for adjustment of governor control.

# CHAPTER 5

# COOLING SYSTEM

## Section I

## DESCRIPTION OF SYSTEM



### 67. DESCRIPTION OF SYSTEM.

**a.** The desired operating temperature of the engine is from 160 F to 180 F. It is very important to maintain this temperature in a Diesel engine to prevent the formation of sludge and insure efficient engine operation. Most Diesel fuels contain a certain amount of gum, shellac, varnish and other sticky substances which deposit on fuel filters, injector parts and other parts of the engine and cause these parts to stick unless kept in suspension by proper engine temperature. This heat is maintained by a thermostat in a housing on the front end of the water manifold. In very cold weather it is sometimes necessary to partially close the radiator shutter to help maintain proper engine operating temperature. It is also important to keep the engine from overheating.

**b.** Cooling of the engine is accomplished by means of the radiator, water pump and fan. Water is circulated through the cylinder block and cylinder head by a centrifugal water pump mounted on the front end of the blower and driven by the lower blower rotor shaft. This pump delivers the heated water to the top of the radiator core. The cooling fan—driven by belts from a pulley on crankshaft—draws air through the radiator core, thus dissipating the heat and lowering the water temperature while it passes from the top to the bottom of the radiator.

## Section II
# TROUBLE SHOOTING



## 68. TROUBLE SHOOTING FOR SYSTEM.

**a. Overheating.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Lack of water. | (1) Fill radiator. |
| (2) Fan belt loose. | (2) Adjust belts for 1¼-in. deflection. |
| (3) Thermostat stuck in closed position. | (3) Replace. |
| (4) Cooling system clogged. | (4) Clean and flush system. |
| (5) Water pump not functioning. | (5) Check pump drive shaft and impeller. |
| (6) Lime coated system. | (6) Clean and flush system. |
| (7) Dirt or insects in radiator air passages. | (7) Blow out with compressed air. |
| (8) Rotted hoses. | (8) Replace. |

**b. Loss of Cooling Water.**

| | |
|---|---|
| (1) Water pump packing defective. | (1) Replace. |
| (2) Leaking gaskets. | (2) Replace gaskets. |
| (3) Leaks in radiator core. | (3) Repair. |
| (4) Defective hose connections. | (4) Tighten or replace. |
| (5) Radiator tubes clogged so that water builds up in top tank and is lost through overflow pipe. | (5) Clean system. If condition not corrected, remove radiator and clean it by boiling in cleaning solution. |
| (6) Cracked cylinder head or block. | (6) Replace. |

ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

## Section III

# WATER PUMP



## 69. DESCRIPTION.

**a.** The pump is of the centrifugal type. A bronze impeller with straight blades is pressed onto one end of the case hardened steel shaft which rotates in a cast housing. A pump drive coupling with an oil slinger is pressed onto the opposite end of the shaft. The oil slinger shrouds the inner end of the pump body flange to prevent oil from creeping along the shaft and through the shaft bearing. Water is prevented from creeping along the shaft from the impeller end by means of a spring loaded Neoprene seal, retained in the impeller by a steel stamping. The shaft is supported at the drive end on a sealed, double-row, combination radial thrust ball bearing. A wire slinger is fitted on the shaft between the pump housing and ball bearing to prevent moisture from creeping along the shaft to the bearing. The pump shaft and bearing constitute one assembly and are serviced as such, because the shaft serves as the inner race of the ball bearing. The shielded bearing is filled with lubricant when assembled. No further lubrication is necessary. The drive coupling fits on the shaft with a light press fit. If the pump becomes frozen or otherwise bound, the coupling will turn on the shaft and thus damage to the pump is prevented.

## 70. TROUBLE SHOOTING.

**a. Overheating.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Pump drive shaft coupling turning on shaft. | (1) Replace coupling. |
| (2) Impeller turning on shaft. | (2) Replace pump. |

WATER PUMP

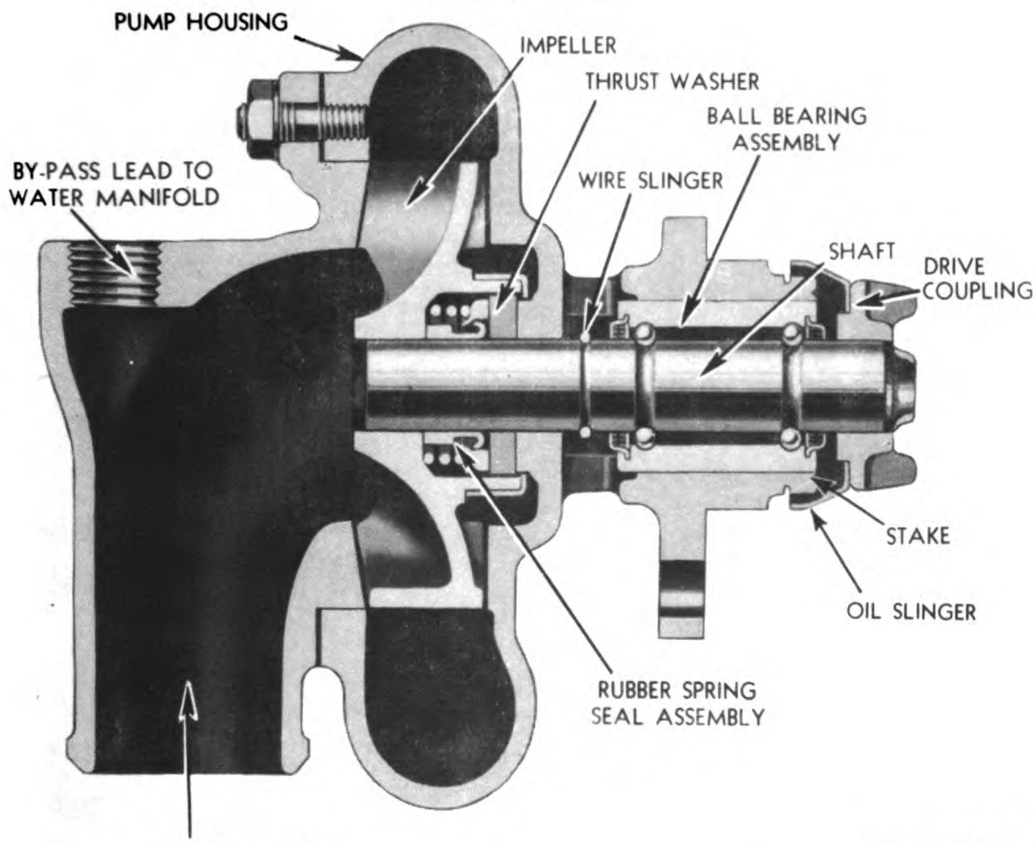



***Figure 90 — Cut-Away View of Water Pump***

**b. Noisy Pump.**

| | |
|---|---|
| (1) Bearing defective. | (1) Replace pump. |
| (2) Impeller defective. | (2) Replace pump. |

**c. Loss of Water.**

| | |
|---|---|
| (1) Water pump seal faulty. | (1) Replace pump. |

**71. REMOVAL.**

**a. Equipment.**

SCREWDRIVER, 6-in.
TOOL, drain, water pump
WRENCH, fuel pump
WRENCH, ½-in.
WRENCH, $^9/_{16}$-in.
WRENCHES, two, ¾-in.
WRENCH, open-end, ⅝-in.

**b. Procedure.**

(1) DRAIN COOLING SYSTEM.

TOOL, drain, water pump


RA PD 17807

*Figure 91 — Removing Right Front Fender*

Open both water pump and radiator drain cocks. If anti-freeze solution is in cooling system, drain into clean containers to save for refilling radiator.

(2) Remove Right Front Fender.

WRENCHES, two, ¾-in.

Remove one bolt and three cap screws holding fender and remove fender.

(3) Remove Governor Breather Tube.

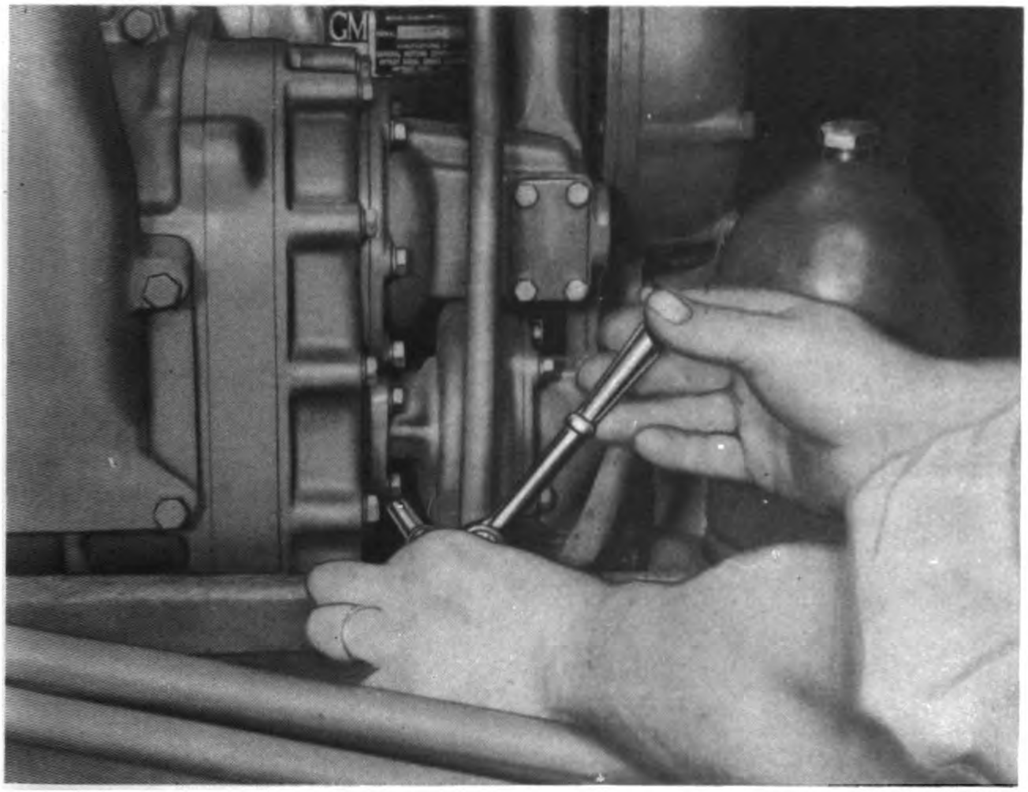
SCREWDRIVER, 6-in.

Remove two screws holding top of tube to governor housing and lift tube out of clip at bottom.

(4) Disconnect Hose and Water Line.

SCREWDRIVER, 6-in. WRENCH, open-end, ⅝-in.

Loosen hose clamp on hose connection between water pump and oil cooler (screwdriver). Disconnect pump-to-air compressor line from pump (⅝-in. wrench).



RA PD 17618

***Figure 92 — Removing Cap Screws from Packing Flange***

(5) Disconnect Pump Outlet Packing Flange.

WRENCH, ½-in.

Remove the two cap screws holding pump outlet packing flange to cylinder block.

(6) Remove Pump Assembly.

WRENCH, fuel pump

Remove the three cap screws holding water pump to front end of blower and remove pump assembly and coupling.

## 72. DISASSEMBLY.

**a. Equipment.**

HAMMER, 2-lb.
PRESS, arbor
TOOL, removing, water pump drive and oil slinger assembly
WRENCH, 7⁄16-in.

**b. Procedure** (fig. 96).

(1) Remove Water Pump Cover.

WRENCH, 7⁄16-in.

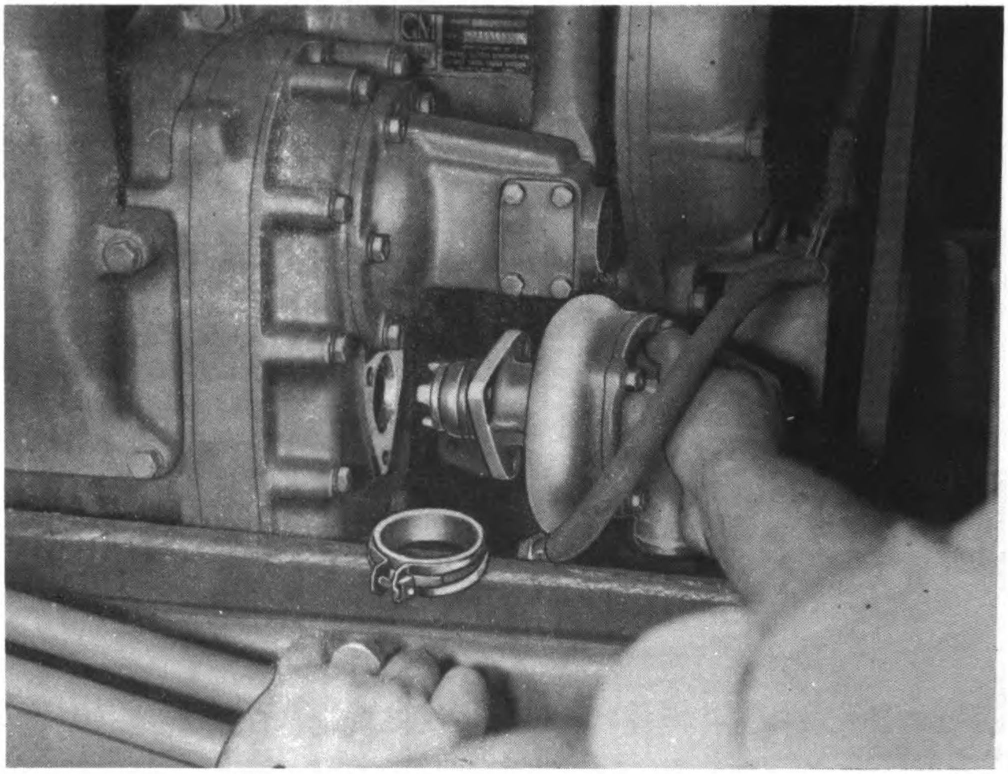


***Figure 93—Removing Water Pump*** RA PD 17617

Remove four nuts from water pump cover studs and remove cover.

(2) REMOVE BEARING AND SHAFT.

PRESS, arbor

Support the water pump in an arbor press, flange down, and press the shaft through the impeller. This removes shaft and bearing assembly. Lift impeller from pump housing. If the water seal only is to be inspected or changed, no further disassembly is necessary. The new seal may be installed and pump reassembled. If further disassembly is necessary, proceed as in following step (3).

(3) REMOVE PUMP DRIVE COUPLING.

HAMMER, 2-lb.

TOOL, removing, water pump drive coupling and oil slinger assembly

Using tool shown in figure 95, force pump drive coupling from shaft as illustrated.

## 73. INSPECTION AND REPAIR.

**a.** After the pump has been disassembled, carefully inspect all parts. Any worn or defective parts should be replaced with new ones. The

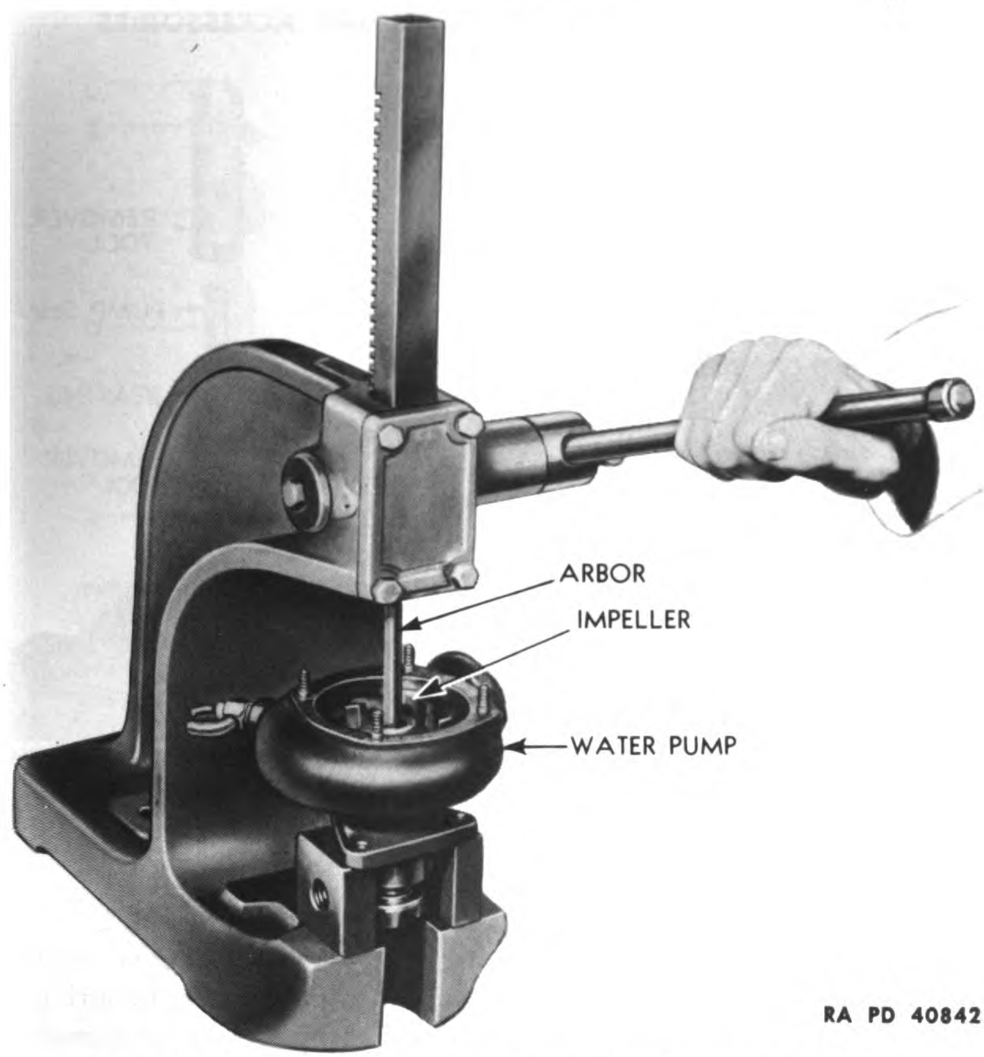



***Figure 94 — Pressing Water Pump Shaft from Impeller***

impeller and drive coupling cannot always be successfully used the second time as they are held on the shaft solely by press fits, and removal and installation are apt to stretch the metal.

## 74. ASSEMBLY.

**a. Equipment.**

| | |
|---|---|
| HAMMER, soft | SHELLAC |
| PRESS, arbor | WRENCH, 7/16-in. |

**b. Procedure.**

(1) INSTALL SHAFT AND BEARING.

PRESS, arbor

NOTE: Before starting to assemble pump, study figure 96 which shows the relative location of all parts. Press shaft and bearing assembly into pump housing until bearing seats against shoulder (arbor press).

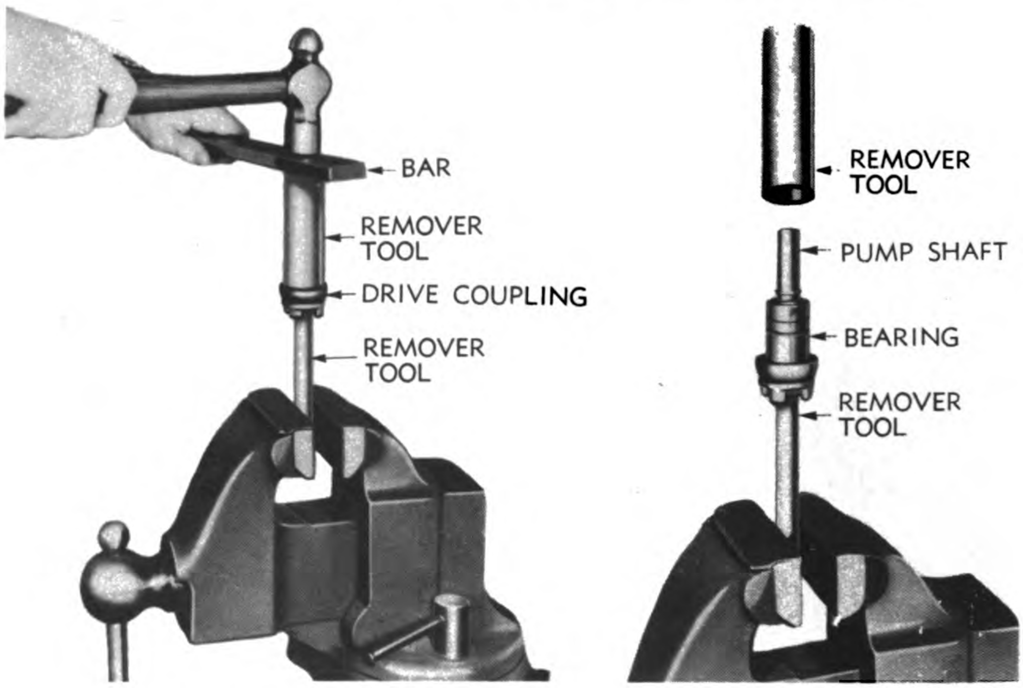



***Figure 95—Removing Water Pump Drive Coupling***

(2) Install Seal Assembly.
**HAMMER**, soft

Assemble spring guide, seal, clamp ring and seal washer together. Insert spring into impeller hub; then set seal assembly next to spring and lock the assembly in the impeller by driving retainer cup down over hub of impeller.

(3) Install Seal and Impeller.
**PRESS**, arbor

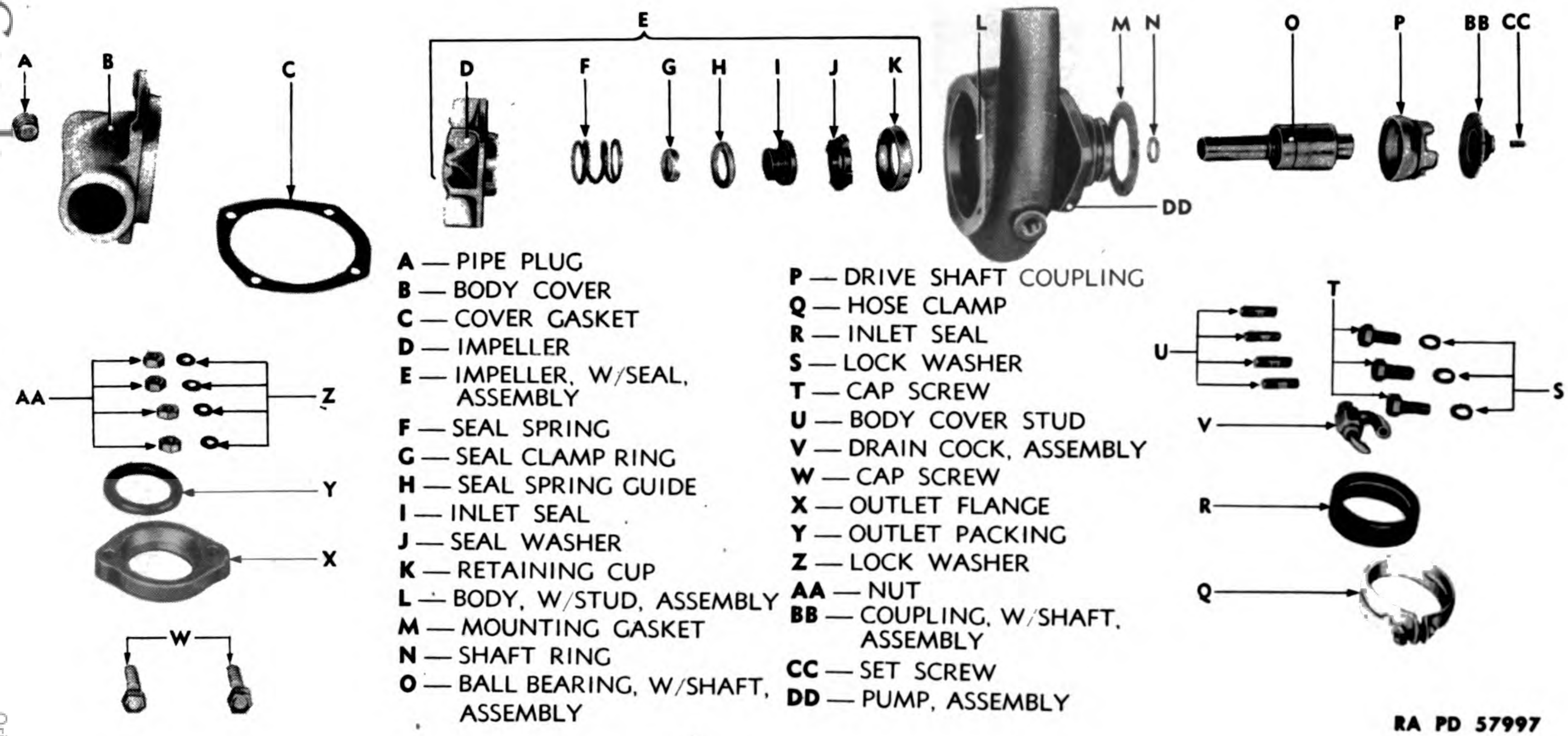
Start impeller and seal assembly onto outer end of shaft; then press impeller on flush with outer end of shaft.

(4) Install Drive Coupling.
**PRESS**, arbor

Support impeller end of shaft on arbor and press drive coupling onto inner end of shaft. Rotate shaft by hand to test for clearance between impeller and pump body. A clearance of 0.005-inch to 0.045-inch is satisfactory.

(5) Install Cover.
**WRENCH**, 7/16-in.

Shellac gasket to cover and set cover over studs and against pump body so that elbow points down when pump outlet can be attached to cylinder




A — PIPE PLUG
B — BODY COVER
C — COVER GASKET
D — IMPELLER
E — IMPELLER, W/SEAL, ASSEMBLY
F — SEAL SPRING
G — SEAL CLAMP RING
H — SEAL SPRING GUIDE
I — INLET SEAL
J — SEAL WASHER
K — RETAINING CUP
L — BODY, W/STUD, ASSEMBLY
M — MOUNTING GASKET
N — SHAFT RING
O — BALL BEARING, W/SHAFT, ASSEMBLY
P — DRIVE SHAFT COUPLING
Q — HOSE CLAMP
R — INLET SEAL
S — LOCK WASHER
T — CAP SCREW
U — BODY COVER STUD
V — DRAIN COCK, ASSEMBLY
W — CAP SCREW
X — OUTLET FLANGE
Y — OUTLET PACKING
Z — LOCK WASHER
AA — NUT
BB — COUPLING, W/SHAFT, ASSEMBLY
CC — SET SCREW
DD — PUMP, ASSEMBLY

***Figure 96 — Exploded View of Water Pump Assembly***

block. Install four nuts and lock washers on studs and tighten nuts. Rotate pump shaft again to make sure shaft turns freely and there is no bind between pump and cover.

## 75. INSTALLATION.

**a. Equipment.**

SCREWDRIVER, 6-in.
TOOL, drain, water pump
WRENCH, ½-in.
WRENCH, 9/16-in.
WRENCHES, two, ¾-in.
WRENCH, fuel pump
WRENCH, open-end, ⅝-in.

**b. Procedure.**

(1) INSTALL NEW COUPLING ON PUMP SHAFT.

Place coupling on pump shaft with jaws pointing toward blower. See that packing flange and packing ring are in position on the discharge tube, and that the hose connection from the pump to the oil cooler is in place. Use new gasket, if necessary.

(2) INSTALL PUMP ASSEMBLY.

WRENCH, fuel pump.

Install the pump assembly on the front end cover of the blower with three cap screws with lock washers, taking care that the driving jaws of the coupling engage the driving assembly on the blower rotor shaft.

(3) CONNECT PUMP OUTLET PACKING FLANGE.

SCREWDRIVER, 6-in. WRENCH, ½-in.

Connect flange to cylinder block with two cap screws with lock washers (½-in. wrench). Tighten hose connections (screwdriver).

(4) INSTALL GOVERNOR BREATHER TUBE AND CONNECT WATER LINE.

SCREWDRIVER, 6-in. WRENCH, open-end, ⅝-in.

Insert lower end of tube through clip on oil cooler and install screws with lock washers holding tube to governor housing (screwdriver). Connect water line from air compressor to water pump (⅝-in. wrench). Close drain cocks, fill cooling system. Start engine and check for leaks.

(5) INSTALL RIGHT FRONT FENDER.

WRENCHES, two, ¾-in.

Install front fender with three bolts and one cap screw removed from it.

## 76. SPECIAL TOOLS.

a. Special tools and equipment required for repair of water pump are:

PRESS, arbor
TOOL, removing, water pump drive coupling and oil slinger assembly

## Section IV

## FAN AND BELTS



### 77. DESCRIPTION.

a. The fan draws air through the radiator to speed cooling of the water as it circulates from top to bottom of the radiator. The fan assembly is mounted on a bracket supported on the front of the balance weight cover. The suction-type fan has four blades and is bolted to the fan pulley hub, which rotates on two ball bearings. It is driven by two V-belts from a pulley on engine crankshaft. A slotted bracket supports the fan shaft at the inner end. This construction permits raising or lowering of the fan assembly by means of an adjusting screw for belt adjustment purposes.

b. **Lubrication.** The fan bearings should be lubricated every 200 hours. A lubrication fitting is provided in the fan hub for this purpose. Use only a hand grease gun when lubricating the fan to prevent damage to the oil seals from too much pressure.

### 78. TROUBLE SHOOTING.

a. **Engine Overheating.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Drive belts loose. | (1) Adjust to 1¼-inch slack. |
| (2) Drive belts broken. | (2) Replace belts. |

b. **Fan Noisy.**

| | |
|---|---|
| (1) Bearing defective. | (1) Rebuild fan assembly. |
| (2) Fan loose on hub. | (2) Tighten fan assembly. |
| (3) Blades bent. | (3) Replace fan blade assembly. |

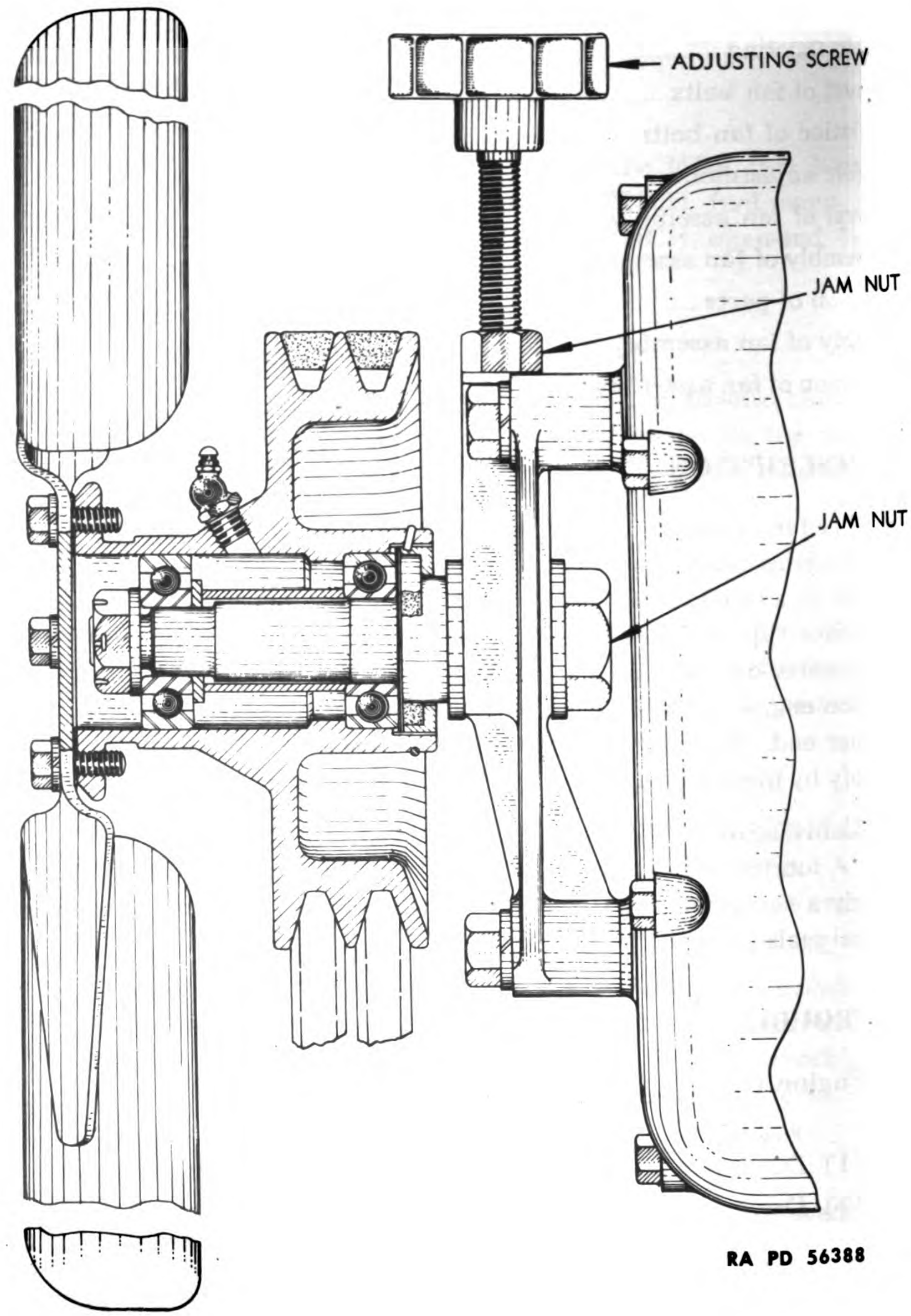



Figure 97—Fan Belt Adjustment

RA PD 40938

*Figure 98 — Removing Nut from Fan Pulley Spindle*

## 79. REMOVAL OF FAN BELTS.

**a. Equipment.**

WRENCH, adjusting, fan — WRENCH, open-end, ¾-in.

**b. Procedure.**

(1) LOOSEN JAM NUT ON FAN SPINDLE.

WRENCH, adjusting, fan

Loosen the large nut in back of bracket on end of fan spindle.

(2) LOOSEN FAN BELTS.

WRENCH, open-end, ¾-in.

Loosen jam nut on adjusting screw and turn screw counterclockwise to loosen belts enough to remove them from belt pulley grooves.

(3) REMOVE BELTS.

Remove one belt at a time. After removing belt from fan pulley, remove belt from lower crankshaft pulley and work belt off over fan. Remove second belt in same manner.

## 80. INSTALLATION OF FAN BELTS.

**a. Equipment.**

WRENCH, adjusting, fan — WRENCH, open-end, ¾-in

RA PD 40922

***Figure 99—Removing Cork Retainer from Pulley***

**b. Procedure.**

(1) INSTALL BELTS.

Work belts over fan. Place first belt in rear groove of lower crankshaft pulley first; then work belt onto fan pulley into rear groove. It may be necessary to turn fan by turning motor with engine cranking wrench to run belt onto fan pulley. Install second belt in front pulley grooves in same manner.

(2) ADJUST BELTS.

Adjust belts as described under paragraph 81, Fan Belt Adjustment.

## 81. FAN BELT ADJUSTMENT.

**a. Equipment.**

WRENCH, adjusting, fan
WRENCH, open-end, ¾-in.

**b. Procedure.**

With jam nuts on adjusting screw and fan spindle loosened, turn adjusting screw clockwise to tighten belts. The V-type fan belt should

FAN AND BELTS

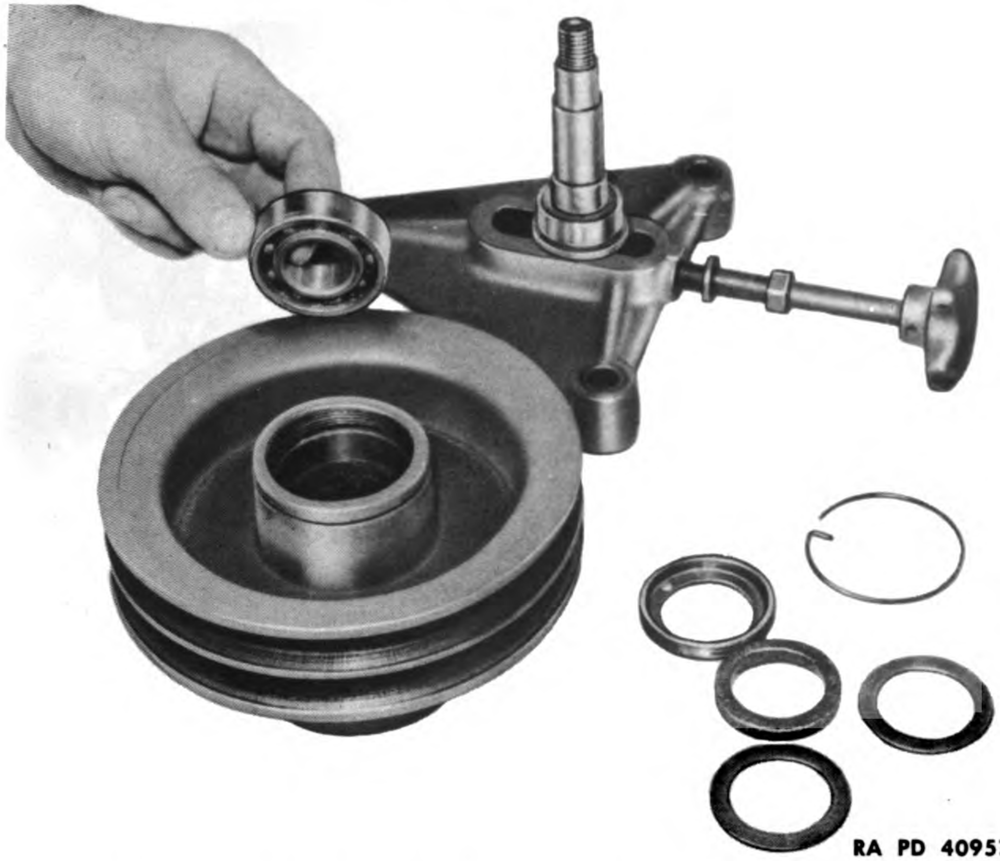

RA PD 40957

***Figure 100—Bearing Removed from Fan Pulley***

be neither too tight nor too loose. Too tight a belt imposes undue load on the fan bearings and shortens the life of the belt. Too loose a belt allows slippage and reduces the speed of the fan. Belts are correctly adjusted when one side of belt can be pressed towards the other side about 1¼-inch at point halfway between the pulleys. Tighten adjusting screw jam nut (¾-in. wrench) and fan spindle jam nut (fan adjusting wrench).

## 82. REMOVAL OF FAN ASSEMBLY.

**a. Equipment.**

WRENCH, ¾-in.

**b. Procedure.** Entire assembly may be removed as one unit. Remove the three cap screws holding bracket to balance weight cover. Lower assembly and remove fan belts from crankshaft pulley. Lift fan assembly and belts from tractor, taking care not to bend radiator fins.

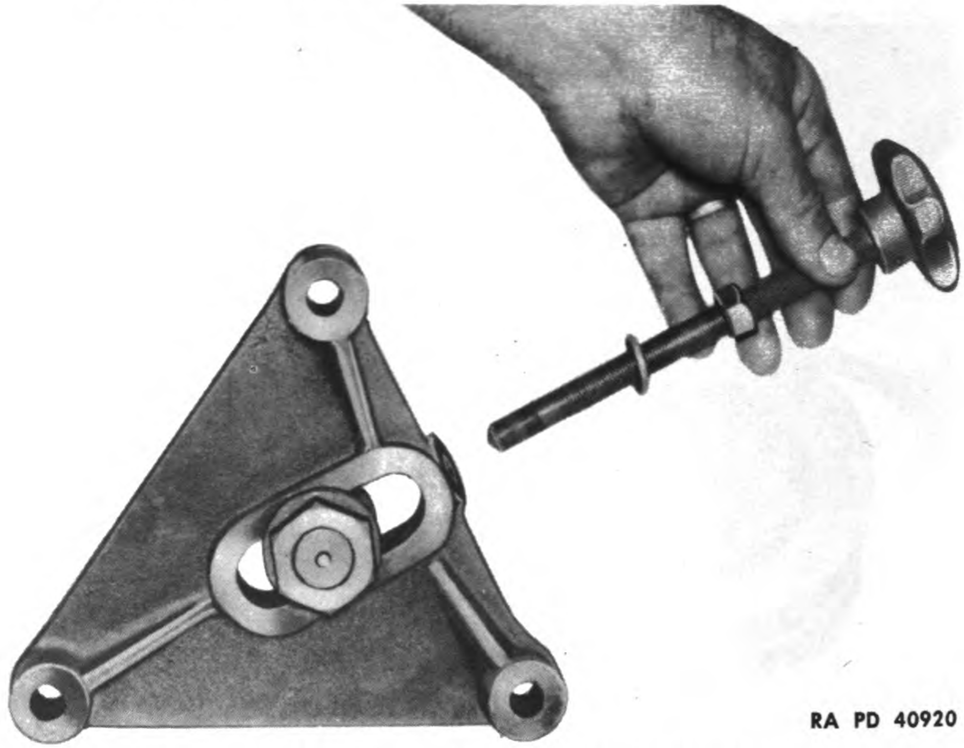



*Figure 101—Removing Fan Adjusting Screw*

## 83. DISASSEMBLY OF FAN ASSEMBLY.

**a. Equipment.**

| | |
|---|---|
| HAMMER, ½-lb. | WRENCH, ½-in. |
| PLIERS | WRENCH, adjusting, fan |
| PUNCH, small | WRENCH, open-end, ¾-in. |
| SCREWDRIVER, 6-in. | WRENCH, socket, 15⁄16-in. |

(1) REMOVE FAN BLADE ASSEMBLY.

Remove four cap screws and remove fan blade assembly from fan pulley.

(2) REMOVE FAN PULLEY FROM SPINDLE.

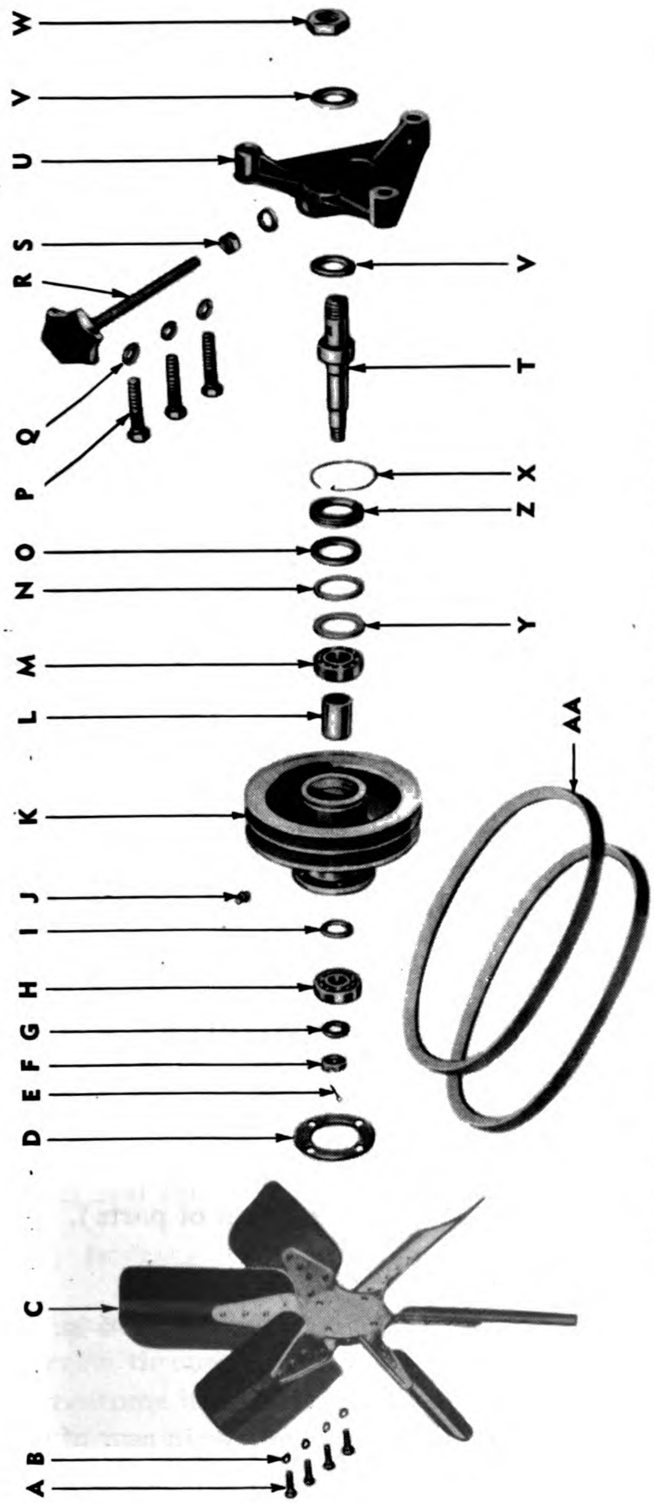
| | |
|---|---|
| HAMMER, ½-lb. | WRENCH, socket, 15⁄16-in. |
| PLIERS | |

Remove cotter pin from slotted nut on front end of fan spindle (pliers). Remove nut (fig. 98) and end washer (15⁄16-in. wrench) and, holding assembly off bench, tap shaft out of pulley (hammer).

(3) REMOVE CORK RETAINER.

| | |
|---|---|
| HAMMER, ½-lb. | SCREWDRIVER, 6-in. |
| PUNCH, small | |

## FAN AND BELTS




A — BOLT
B — LOCK WASHER
C — FAN BLADE
D — GASKET
E — COTTER PIN
F — NUT
G — PLAIN WASHER
H — FRONT BALL BEARING
I — PLAIN WASHER
J — LUBRICATION FITTING
K — FAN DRIVEN PULLEY
L — BEARING SPACER
M — REAR BALL BEARING
N — PLAIN WASHER
O — CORK WASHER
P — BOLT
Q — LOCK WASHER
R — SCREW, ASSEMBLY
S — NUT
T — FAN SPINDLE
U — MOUNTING BRACKET
V — PLAIN WASHER
W — NUT
X — SNAP RING
Y — REAR BEARING GASKET
Z — REAR BEARING RETAINER
AA — FAN DRIVE BELT

RA PD 57998

***Figure 102—Exploded View of Fan Assembly***

Remove lock wire snap ring from rear of fan pulley (screwdriver). Insert punch in hole in retainer and, by tapping on punch with hammer, unscrew retainer and retaining washer from pulley (fig. 99).

(4) REMOVE FAN PULLEY BEARINGS.

| | |
|---|---|
| HAMMER, ½-lb. | PUNCH, small |

Remove spacer and clamp washer from inside pulley and drive front and rear ball bearings from pulley (hammer and punch).

(5) REMOVE FAN SPINDLE FROM BRACKET.

| | |
|---|---|
| WRENCH, fan | WRENCH, open-end, ¾-in. |

Loosen jam nut on adjusting screw (¾-in. wrench). Screw adjusting screw out of spindle and bracket. Remove the hexagon jam nut from rear end of spindle (fan wrench) and remove spindle from bracket.

## 84. INSPECTION OF PARTS.

**a.** Clean and inspect all parts. Replace bearings if rough or if they show signs of wear or if colored from heat. Always install new cork seal when reassembling. Inspect fan spindle for signs of wear. Check to see that bearings fit snugly on spindle.

## 85. ASSEMBLY OF FAN ASSEMBLY.

**a. Equipment.**

| | |
|---|---|
| HAMMER, ½-lb. | SCREWDRIVER, 6-in. |
| PLIERS | WRENCH, ½-in. |
| PRESS, arbor | WRENCH, socket, 15/16-in. |
| PUNCH, small | |

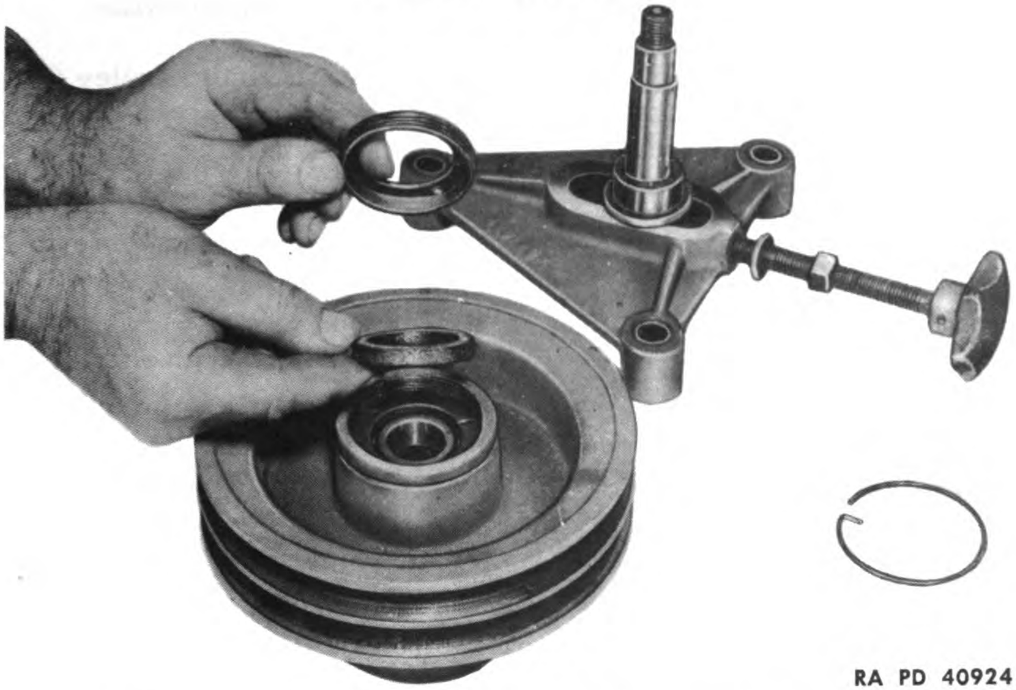
**b. Procedure** (refer to fig. 102 for relative location of parts).

(1) INSTALL REAR BEARING AND CORK RETAINER.

| | |
|---|---|
| HAMMER, ½-lb. | SCREWDRIVER, 6-in. |
| PUNCH, small | |

Tap rear ball bearing into recess and against shoulder in rear of pulley (hammer). Install gasket and cork retaining washer next to bearing (fig. 103). Install new cork washer in cork retainer and screw retainer into pulley (hammer and punch). Install lock wire snap ring (screwdriver).

FAN AND BELTS



RA PD 40924

***Figure 103—Installing Cork Washer and Retainer***

(2) INSTALL PULLEY ON SPINDLE.

| | |
|---|---|
| **HAMMER**, ½-lb. | **PRESS**, arbor |
| **PLIERS** | **WRENCH**, socket, $1\frac{5}{16}$-in. |

Press pulley onto fan spindle (arbor press). Install the bearing spacer and spacer washer and then tap front ball bearing onto front end of spindle and into pulley hub (hammer). Install the end washer and slotted nut, tighten nut ($1\frac{5}{16}$-in. wrench), and install cotter pin (pliers).

(3) INSTALL SPINDLE IN BRACKET.

Place one of the clamp washers on spindle and insert end of spindle through bracket. Install the second clamp washer on spindle behind bracket and start large jam nut, tightening with fingers.

(4) INSTALL ADJUSTING SCREW.

Place lock washer on adjusting screw below hexagon nut, insert adjusting screw through hole in top of bracket, and screw it through spindle so it bottoms in lower end of slot in bracket (fig. 101). Do not tighten large jam nut or hexagon nut on adjusting screw until fan assembly is installed and belts adjusted.

(5) INSTALL FAN BLADE ASSEMBLY.

**WRENCH**, ½-in.

Coat a new fan blade gasket with grease and stick it to pulley flange. Install fan blade assembly to pulley with four cap screws with lock washers.

## 86. INSTALLATION OF FAN ASSEMBLY.

**a. Equipment.**

WRENCH, fan — WRENCH, open-end, ¾-in.

**b. Procedure.**

(1) INSTALL FAN ASSEMBLY ON ENGINE.

WRENCH, open-end, ¾-in.

Place fan belts in fan pulley grooves and maneuver fan assembly into place, using care not to damage radiator with fan blades. Lower fan assembly as far as possible and install lower end of belts on crankshaft pulley. Then raise assembly so three cap screws with lock washers can be inserted through bracket and into balance weight cover. Tighten these cap screws securely.

(2) ADJUST BELTS.

See Fan Belt Adjustment, paragraph 81.

## Section V

## THERMOSTAT

Paragraph



### 87. DESCRIPTION.

a. The poppet valve thermostat, located in a housing on the front of the water manifold, automatically maintains correct water temperature in the engine except in extremely cold weather when it may be necessary to close or partially close the radiator shutter. Before the thermostat opens, water is circulated through the oil cooler, cylinder block and cylinder head, but does not pass through the radiator. Instead it passes through a bypass opening in the thermostat and down through a bypass tube to the water pump inlet. When temperature of water reaches approximately 158 F, the thermostat begins to open. As the thermostat opens, the water begins to circulate through the radiator and circulation through the bypass tube is automatically reduced. At 180 F, when the thermostat is fully opened, all of the cooling water circulates through the radiator. Thus cooling water is bypassed around the radiator during the warm-up period to provide a rapid, uniform temperature increase throughout the engine as well as lubricating oil, regardless of external temperature conditions.

### 88. TROUBLE SHOOTING.

**a. Engine Temperature Too Low.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Thermostat stuck in open position. | (1) Replace thermostat. |
| (2) Thermostat gasket defective. | (2) Replace gasket. |

**b. Engine Overheats.**

| | |
|---|---|
| (1) Thermostat stuck in closed position. | (1) Replace thermostat. |

## 89. REMOVAL.

**a. Equipment.**

SCREWDRIVER, 6-in. WRENCH, ½-in.

**b. Procedure.**

(1) DRAIN COOLING SYSTEM.

(2) DISCONNECT RADIATOR HOSE AND BYPASS TUBE.

SCREWDRIVER, 6-in. WRENCH, ½-in.

Loosen clamp on hose connection (screwdriver). Remove the two cap screws holding the bypass tube to the thermostat housing (½-in. wrench).

(3) REMOVE THERMOSTAT HOUSING.

WRENCH, ½-in.

Remove the three cap screws holding the housing to the water manifold (fig. 104). Thermostat can now be slipped out of the thermostat housing.

## 90. TESTING.

**a.** No attempt should be made to repair a defective thermostat. It can be tested for operation by removing and putting it in a pan of water, then heating the water to see if it opens at the right temperature, approximately 158 F, and closes again when the water cools.

## 91. INSTALLATION.

**a. Equipment.**

SCREWDRIVER, 6-in. WRENCH, ½-in.

**b. Procedure.**

(1) INSTALL THERMOSTAT IN HOUSING.

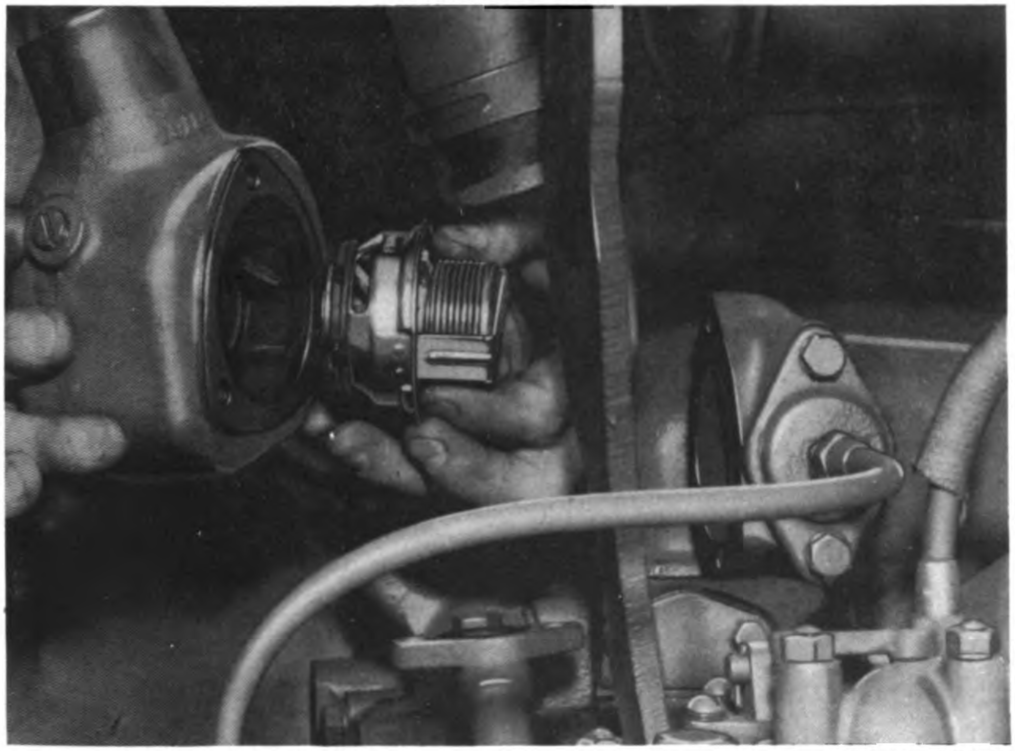
Place gasket over thermostat. Place thermostat in housing, taking care to keep gasket in place. Shellac new gasket to thermostat housing and coat other side of gasket with Chassis grease.

(2) CONNECT ASSEMBLY TO WATER MANIFOLD.

WRENCH, ½-in.

Hold assembly in place against water manifold and install three cap screws with lock washers.

THERMOSTAT



RA PD 17635

*Figure 104 — Installing Thermostat Assembly*

(3) CONNECT RADIATOR HOSE AND WATER BYPASS TUBE.

SCREWDRIVER, 6-in. WRENCH, ½-in.

Shellac inside of hose, install hose on thermostat housing, and tighten clamp (screwdriver). Install two $\frac{5}{16}$- x 1-inch cap screws with lock washers connecting bypass tube to thermostat housing (½-in. wrench).

## Section VI

## RADIATOR



### 92. DESCRIPTION.

**a.** A fin-and-tube type radiator with a capacity of 9¾ gallons is used in the cooling system. It is mounted in a shell, directly in front of the engine, close to the fan. A grill in front of the radiator protects it from being damaged by tree limbs and other foreign objects. The shutter on the front of the radiator is manually operated by a lever under the cowl. A quicker warm-up of engine is effected if this shutter is closed when the engine is started. The shutter also aids in maintaining correct engine temperature in extremely cold weather.

### 93. TROUBLE SHOOTING.

**a. Overheating.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Lack of water. | (1) Fill radiator. |
| (2) Radiator clogged. | (2) Clean and flush. |
| (3) Dirt, trash, or insects in radiator air passages. | (3) Blow out with compressed air. |
| (4) Rotted hoses. | (4) Replace hoses. |

**b. Loss of Water.**

| | |
|---|---|
| (1) Leaks in radiator core. | (1) Repair or replace. |
| (2) Radiator clogged so that water builds up on top tank and is lost through overflow. | (2) Clean and flush. |

## RADIATOR

### 94. REMOVAL.

**a. Equipment.**

BAR, pry
HAMMER, 2-lb.
HOIST, chain
PUNCH, 10-in.
ROPE
SCREWDRIVER, 6-in.
WRENCH, 7/8-in.
WRENCH, 1-in.
WRENCHES, two, 7/16-in.
WRENCHES, two, 3/4-in.
WRENCH, open-end, 9/16-in.
WRENCH, socket, 1/2-in.
WRENCH, socket, 9/16-in.
WRENCH, socket, 5/8-in. with extension

**b. Procedure.**

(1) DRAIN COOLING SYSTEM.

Open drain cocks in lower hose connector elbow and water pump.

(2) REMOVE PRE-CLEANERS AND HOOD.

BAR, pry
WRENCHES, two, 7/16-in.
WRENCH, open-end, 9/16-in.

Loosen clamp bolts (7/16-in. wrenches) and lift pre-cleaners off extension tubes. Loosen bolts at each corner of hood (9/16-in. wrench), pry bolts out of clips, and lift hood off over exhaust stack and pre-cleaner extension tubes (figs. 16 and 17).

(3) REMOVE BOTH FRONT FENDERS.

WRENCHES, two, 3/4-in.

Remove three bolts and one cap screw in left fender and one bolt and three cap screws in right fender and remove fenders.

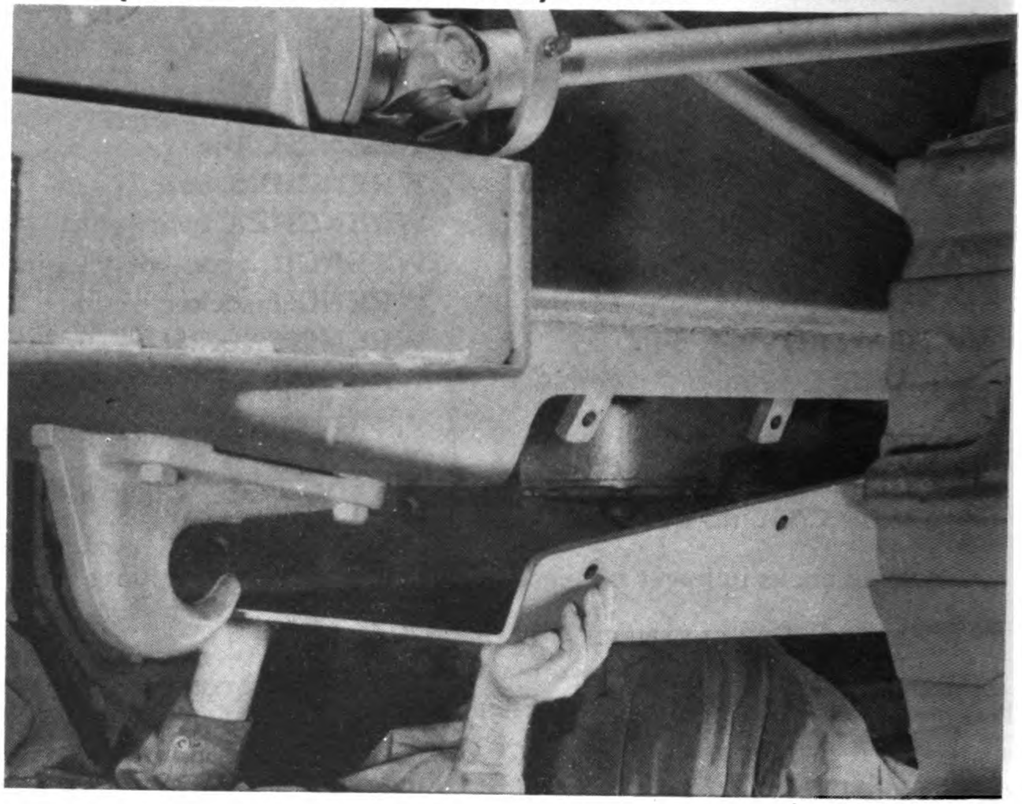
(4) REMOVE WINCH DRIVE SHAFT GUARD AND GUARD SUPPORT BRACKET.

WRENCHES, two, 9/16-in.
WRENCHES, two, 3/4-in.
WRENCH, 1-in.

Remove winch drive shaft guard by removing the three bolts at rear of guard and three cap screws at front (9/16-in. and 3/4-in. wrenches). Remove the two cap screws holding bracket to radiator shell and remove bracket (1-in. wrench). Remove the two corresponding cap screws on right side that hold radiator shell to engine support. Loosen the two remaining cap screws.

(5) DISCONNECT WIRES AND UPPER RADIATOR HOSE.

SCREWDRIVER, 6-in.



RA PD 17626
*Figure 105—Removing Engine Support Bottom Cover*

Disconnect headlight wires at connectors. These connectors can be found near generator. Loosen lower clamp of top radiator hose and remove hose from thermostat housing.

(6) REMOVE ENGINE SUPPORT BOTTOM COVER.

WRENCH, ⅞-in.

Remove the six cap screws holding cover to engine support. It may be necessary to pry cover from support.

(7) DISCONNECT LOWER WATER CONNECTION.

WRENCH, socket, ½-in.

Remove the two cap screws that hold connection to oil cooler inlet.

(8) REMOVE RADIATOR GRILL.

HAMMER, 2-lb.
HOIST, chain
PUNCH, 10-in.
ROPE
WRENCH, socket, ⅝-in., with extension

Remove the four nuts on each side from bolts that hold grill to radiator (⅝-in. wrench). Drive out the T-head bolts from which nuts were

RADIATOR

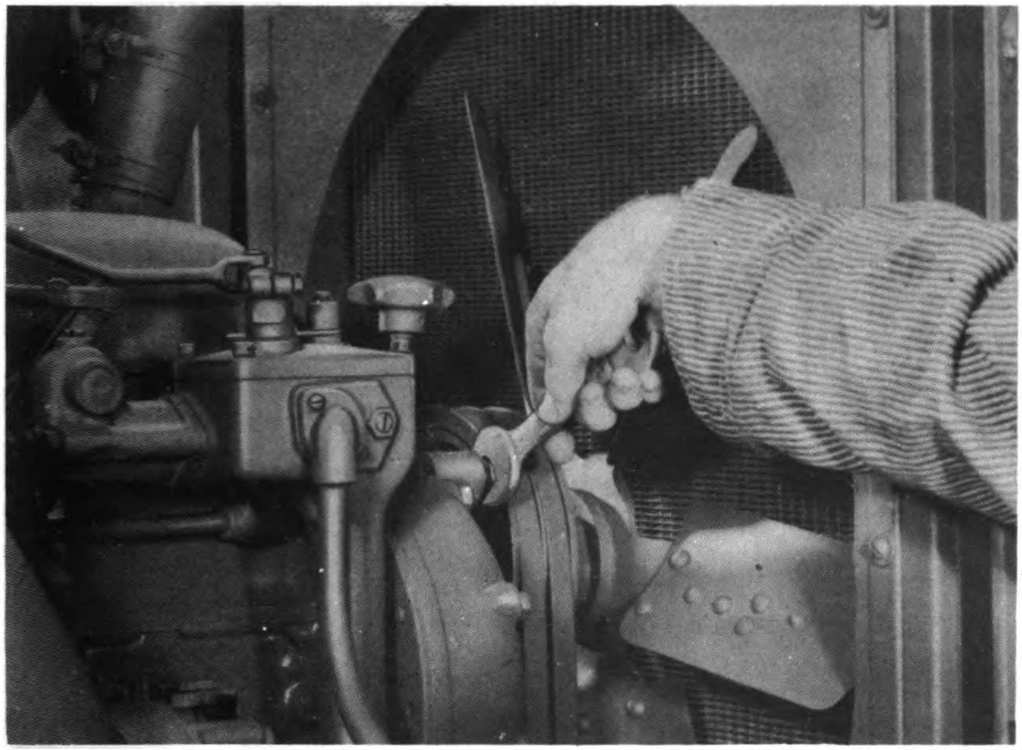


*Figure 106 — Removing Fan Assembly* RA PD 17715

removed (hammer, punch), taking care not to damage threads. NOTE: The lower bolt on left-hand side should be removed last, as grill will have to be shifted to the left to allow this bolt to pass under flange on winch drum. Tilt top of radiator assembly back until radiator touches fan, and lift out grill (chain hoist and rope).

(9) REMOVE FAN ASSEMBLY.

PLIERS WRENCH, ¾-in.

Remove pin from radiator shutter control rod (pliers) and pull top of radiator as far forward as possible. Remove the three cap screws that hold bracket of fan assembly to balance weight cover of engine (¾-in. wrench). Remove belts from pulley and lift out fan assembly.

(10) LIFT OUT RADIATOR ASSEMBLY.

HOIST, chain ROPE

Remove the two cap screws previously loosened on each side at bottom of radiator shell. Place rope around radiator under headlights and hook rope into chain hoist. Lift out radiator assembly. Disengage shutter control rod as radiator is lifted out.

## 95. DISASSEMBLY.

**a. Equipment.**

WRENCH, $\frac{9}{16}$-in.

ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

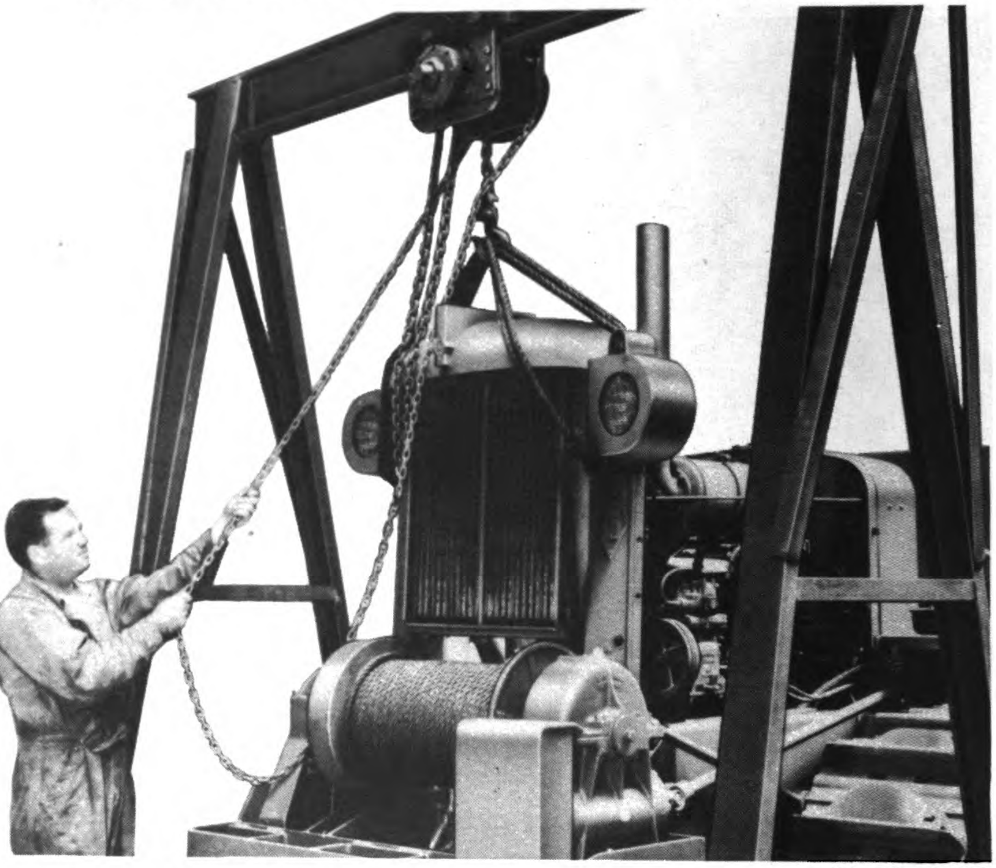

RA PD 17645

*Figure 107—Lifting Out Radiator Assembly*

**b. Procedure.**

(1) REMOVE RADIATOR FROM SHELL.

WRENCH, 9/16-in.

Remove eight cap screws that hold radiator in shell and lift out radiator.

(2) REMOVE SHUTTER ASSEMBLY.

WRENCH, 9/16-in.

Remove the eight cap screws that hold shutter assembly to shell and lift out shutter assembly.

## 96. MAINTENANCE AND REPAIRS.

**a.** Keep cooling system filled with clean water that is free from lime or alkalines. Use ETHYLENE GLYCOL in the cooling system in winter weather. The solution should be tested daily and kept to the proper strength for prevailing temperatures.

RADIATOR

RA PD 17892

***Figure 108 — Radiator Removed from Shell***

**b.** The cooling system has two drain cocks, and both of these should be opened when the cooling system is drained or when the unit is stored. One drain cock is in the bottom of the water pump housing, and the other is in the bottom of the elbow that connects the radiator to the lubricating oil cooler assembly. CAUTION: When refilling cooling system, remove the ¼-inch pipe plug in the thermostat housing. This will permit air to escape from the head and block. As soon as water runs out of the hole freely, the plug should be replaced and the system filled to its specified capacity.

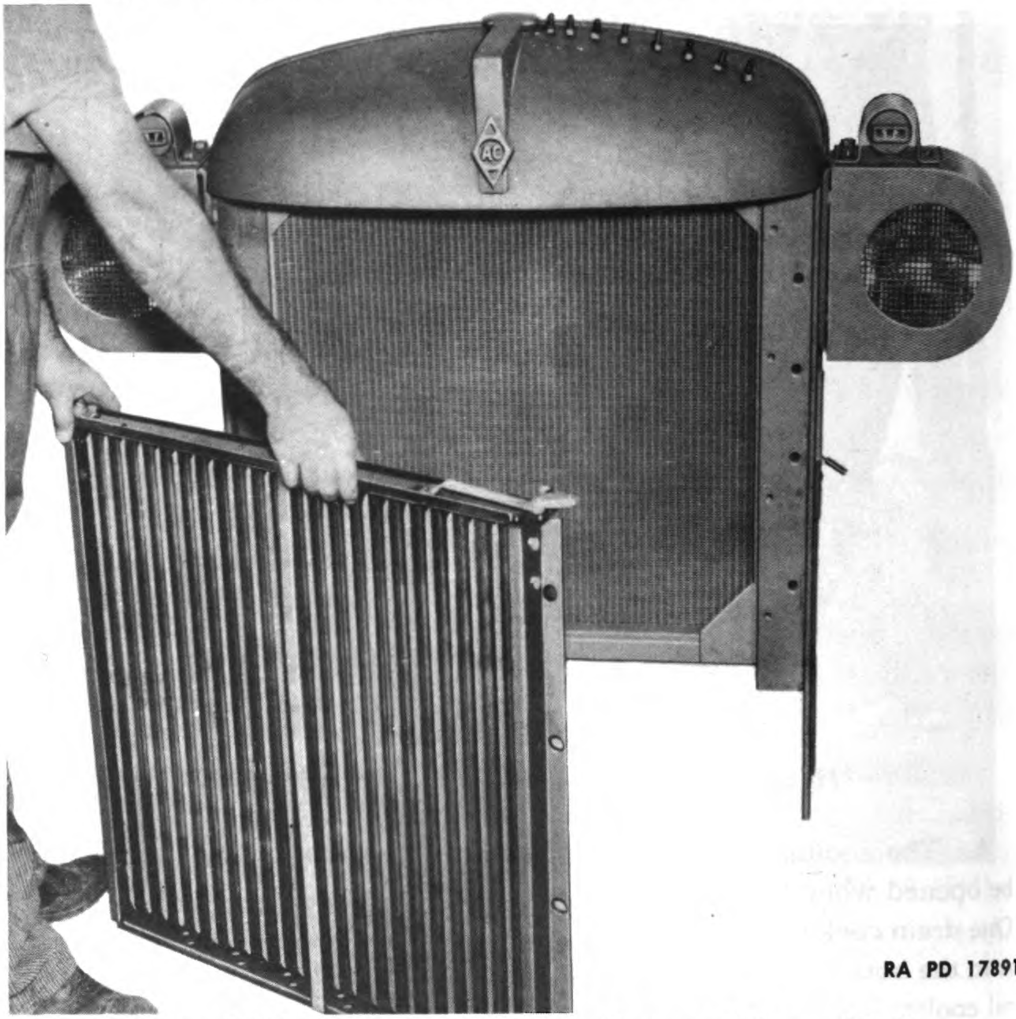
**c.** The cooling system should be flushed out periodically to remove accumulated loose rust or foreign material. This may be done with clean water or, if necessary, with a cleaning solvent which is not injurious to steel, cast iron, or copper. Follow directions for flushing as given below:

(1) For flushing with clean water, proceed as follows:

*(a)* Drain the cooling system and disconnect the water bypass tube at the thermostat housing.

*(b)* Remove the thermostat.

*(c)* After the thermostat has been removed, bolt housing back to the water manifold, and reconnect the water bypass tube.



RA PD 17891

***Figure 109—Shutter Assembly Removed from Shell***

*(d)* System may now be flushed. Fill the cooling system, start the engine, then open both drain cocks and, using a hose, keep the radiator filled as the water runs through the system and drains out.

*(e)* When all the rust, etc., has been flushed from the system, stop the engine, install the thermostat, close the drains, and refill the system.

(2) If a solvent solution is used to clean the cooling system, a different procedure should be followed.

*(a)* Drain the cooling system.

*(b)* Close the drains and fill the system with cleaning solution.

*(c)* Start the engine and run it for about an hour, regulating the raditor shutter to hold the engine temperature at 190 F.

*(d)* Drain the solution, flush radiator thoroughly, and refill.

## RADIATOR

(3) If trash or foreign material has gathered at the top of the tubes in the radiator core, back-flushing of the radiator is necessary.

*(a)* Drain the cooling system and remove radiator cap.

*(b)* Disconnect the hose from the elbow in which the main drain cock is located.

*(c)* Insert a water hose inside this hose, and stuff a cloth around it if an adapter is not available for connections.

*(d)* Let water run slowly into radiator through hose until water runs out the top of radiator; then increase the water pressure.

*(e)* Run water through the radiator in this way long enough to force the obstructions off the top of the tubes and out the radiator filler pipe.

*(f)* Reconnect the lower hose and refill the cooling system.

(4) If radiator is filled with trash or lime that cannot be removed by the above operations, it will be necessary to place radiator in a tank filled with a solvent solution and boil it to loosen accumulations of rust, lime, grease, etc. It should then be flushed thoroughly.

(5) If radiator leaks, the holes should be closed by soldering. Radiator should then be placed in a tank of water and tested for stoppage of all leaks. Proper adapters should be used to close filler pipe and inlet, and five pounds air pressure introduced through one of the adapters. If there are any leaks, the air will cause bubbles to appear and indicate where the leaks are.

### 97. ASSEMBLY.

**a. Equipment.**

WRENCH, 9/16-in.

**b. Procedure.**

(1) INSTALL SHUTTER ASSEMBLY.

WRENCH, 9/16-in.

Place shutter assembly in radiator shell. Attach to shell with eight cap screws with lock washers. See figure 109.

(2) INSTALL RADIATOR IN SHELL.

WRENCH, 9/16-in.

Place radiator in shell and attach with eight cap screws with lock washers. Insert headlight and blackout light wire clips under top and bottom cap screws on each side as they are installed.

## 98. INSTALLATION.

### a. Equipment.

HAMMER, 2-lb.
HOIST, chain
PLIERS
PUNCH, 10-in.
ROPE
SCREWDRIVER, 6-in.
SCREWDRIVER, 8-in.
WRENCHES, two, 7/16-in.
WRENCH, 1/2-in.
WRENCHES, two, 3/4-in.
WRENCH, 7/8-in.
WRENCH, 1-in.
WRENCH, adjusting, fan
WRENCH, open-end, 9/16-in.
WRENCH, socket, 9/16-in.
WRENCH, socket, 5/8-in. with extension

### b. Procedure.

(1) LOWER RADIATOR INTO POSITION.

HOIST, chain
ROPE
WRENCH, 1-in.

Lower radiator assembly into position on front of engine support (hoist). Start the two front lower cap screws with lock washers that hold radiator to engine support (1-in. wrench), but do not tighten these cap screws. Remove rope.

(2) INSTALL FAN ASSEMBLY.

WRENCH, open-end, 3/4-in.
WRENCH, adjusting, fan

Tilt top of radiator forward, lay belts in fan pulley, and install fan assembly on balance weight cover with three cap screws with lock washers (3/4-in. wrench). Adjust belts as outlined in paragraph 81 (fan adjusting wrench and 3/4-in. wrench).

(3) INSTALL RADIATOR GRILL.

HAMMER, 2-lb.
PLIERS
PUNCH, 10-in.
WRENCH, socket, 5/8-in., with extension

Tilt radiator back until it touches fan. Install pin that connects shutter control rod to lever on shutter and secure with cotter pin (pliers). Set grill in position and install the eight T-head bolts with lock washers through grill and shell (punch, hammer and 5/8-in. wrench). Install lower left-hand bolt first, as grill will have to be shifted to left so this bolt will pass flange of winch drum.

## RADIATOR

(4) Install Winch Guard Bracket and Connect Radiator Hose.

SCREWDRIVER, 6-in. WRENCH, 1-in.

Coat inside of top radiator hose with shellac and tilt radiator back so hose goes over outlet of thermostat housing. Then install the two remaining cap screws with lock washers in lower right side of radiator shell and engine support. Do not tighten. Hold winch drive shaft guard bracket in position and install two cap screws with lock washers through bracket and lower left side of radiator shell and into engine support. Now tighten the bolts on both sides (1-in. wrench). Tighten upper radiator hose clamp (screwdriver).

(5) Connect Lower Water Connection to Oil Cooler Inlet.

WRENCH, ½-in.

Shellac new gasket to oil cooler inlet and connect elbow to oil cooler inlet.

(6) Install Engine Support Bottom Cover.

WRENCH, ⅞-in.

Install engine support bottom cover and secure with six cap screws with lock washers.

(7) Fill Cooling System and Install Fenders.

SCREWDRIVER, 8-in. WRENCHES, two, ¾-in.

Close drain cocks and remove pipe plug in thermostat housing. Pour cooling solution in radiator until water runs out hole where pipe plug was removed. Then install plug and finish filling radiator. Install fenders (two ¾-in. wrenches).

(8) Install Winch Drive Shaft Guard.

WRENCHES, two, 9/16-in. WRENCHES, two, ¾-in.

Place guard over shaft. Install three cap screws with lock washers to hold guard to front bracket (two 9/16-in. wrenches). Install three bolts (two 9/16-in. wrenches) with lock washers (two ¾-in. wrenches) to hold rear end of guard to left rear fender.

(9) Install Hood and Pre-cleaners.

WRENCHES, two, 7/16-in. WRENCH, open-end, 9/16-in.

Lower hood into place over exhaust stack and air-cleaner extension tubes, press bolts at each corner of hood into clips, and tighten (9/16-in. wrench). Place pre-cleaners on extension tubes and tighten clamps at base of each cleaner (two 7/16-in. wrenches).

ORDNANCE MAINTENANCE—HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

# CHAPTER 6
# ELECTRICAL SYSTEM
## Section I
## GENERATOR

Paragraph



### 99. DESCRIPTION OF GENERATOR.

**a. General Description.** The generator is a machine for converting mechanical energy into electrical energy. The unit used on this tractor is a Delco-Remy Model 5888. It is a $5\frac{1}{16}$-in. frame diameter, 2-pole, third-brush, sealed-type unit, with ball bearings in both ends to support the armature. The generator is driven by means of a drive pulley mounted on the armature shaft, is hinge-mounted to the air compressor bracket, and is driven by a V-belt from the air compressor drive pulley, which is in turn driven by a V-belt from the engine crankshaft pulley. The generator makes use of a generator-regulator unit that is mounted directly on top of the air compressor bracket (see section II) to provide control of the generator output.

## GENERATOR

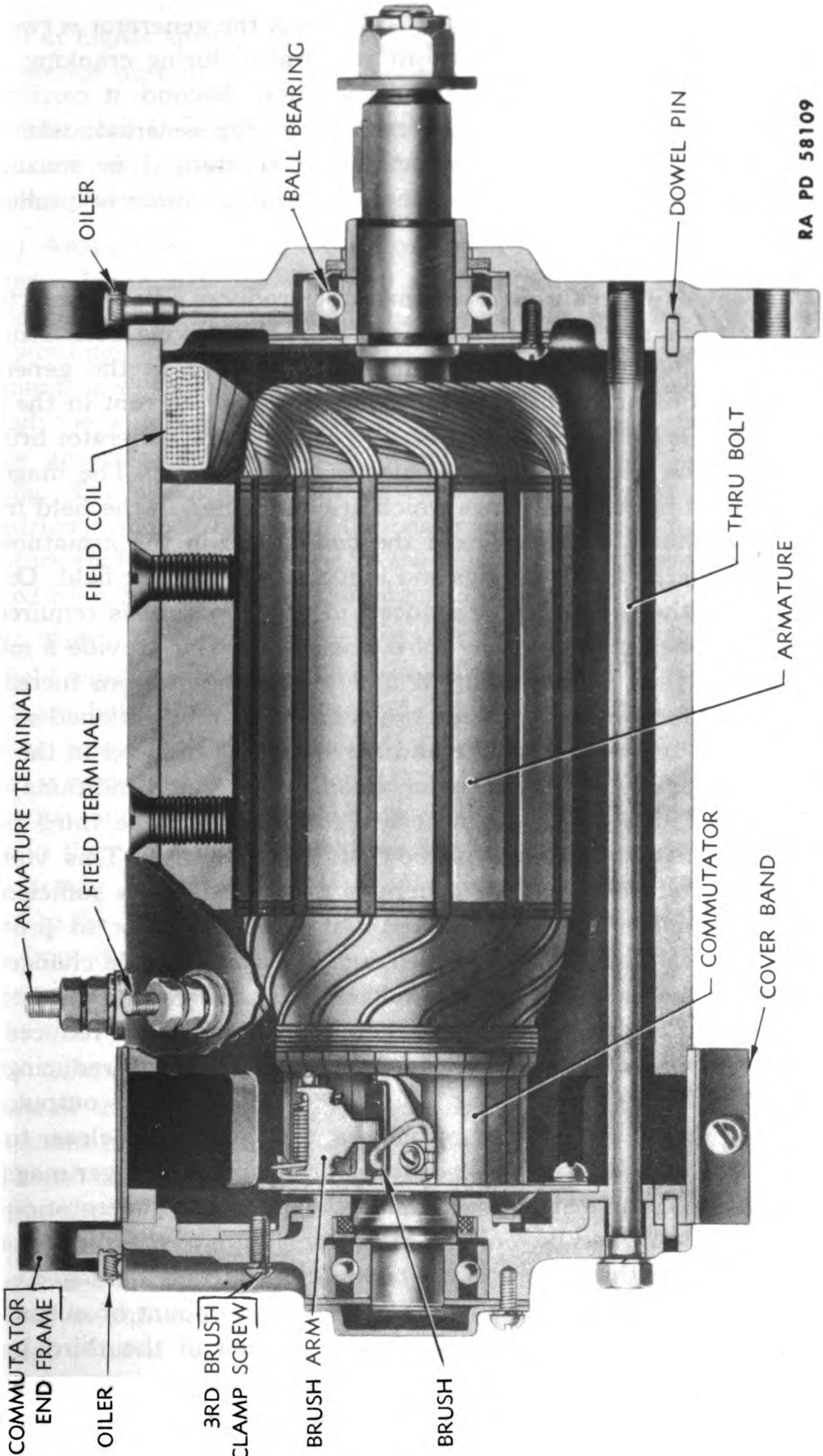



**Figure 110—Cut-Away View of Generator**

**b. Function of Generator.** The function of the generator is twofold. It restores to the battery the current withdrawn during cranking, thus maintaining the battery in a charged condition. Second, it carries the connected electrical load up to the capacity of the generator when the generator is operating at speeds at which substantial or maximum generator output can be obtained, thus preventing undue or prolonged draining of the battery.

**c. Theory of Operation.** The generator produces a flow of electrical current by using mechanical energy (through the driving belt from the engine) to rotate a series of conductors, assembled in the generator armature, in a magnetic field. This causes a flow of current in the conductors, which is led through the armature commutator, generator brushes and leads to the battery and other electrical accessories. The magnetic field is created by field windings which are assembled in the field frame around pole shoes. Current (from the conductors in the armature) is passed through the field windings and induces the magnetic field. Only a small part of the total current induced in the armature is required to produce the magnetic field. The third brush is used to provide a means of controlling the generator output and preventing it from increasing excessively. The two main brushes are connected and positioned so that the maximum amount of voltage and current being induced in the generator armature (which depends on speed and circuit conditions) can be "tapped off" the generator armature commutator. The third brush is so placed that it receives a somewhat lower voltage. This voltage, which is the voltage across the generator field windings, is sufficient to create a "normal" magnetic field and cause the generator to produce "normal" generator output. The third brush position can be changed to change the generator output. If a lower output is desired, the third brush may be moved away from the adjacent main brush. This reduces the amount of voltage on the generator field windings, thereby reducing the strength of the generator magnetic field and the generator output. Increased output can be obtained by moving the third brush closer to the main brush so it picks up a higher voltage, producing a stronger magnetic field and thus causing a higher output. CAUTION: The generator output must never be adjusted beyond the rated maximum of the generator, as this would cause the generator to be overloaded and damaged. The second function of the third brush is to limit the amount of output the generator can produce for any particular position of the third brush. This is accomplished by means of the third brush characteristic—or armature reactance—a subject beyond the scope of the present manual. The effect of this characteristic is to cause the generator output to reach a maximum at some intermediate speed and then to taper off to a lower output at higher speed, thus providing some degree of automatic control of generator output.

d. **Detailed Description.** The generator consists of an armature, field frame assembly, drive end assembly and commutator end assembly. Detailed descriptions of each are given below:

(1) ARMATURE. The armature consists of a steel shaft onto which is pressed a laminated iron core and a commutator. The core has longitudinal slots which are insulated and into which are assembled the armature windings. These windings are connected to the segments of the commutator so that current which is induced in the windings can pass through the windings to the segments of the commutator and from there to the generator brushes under which the commutator segments are passing. The armature is carefully balanced so that it will not show eccentricity when it rotates in the bearings. A pulley is mounted on the armature shaft at the drive end of the generator so the armature may be rotated by a belt driven by the engine.

(2) FIELD FRAME ASSEMBLY. The field frame assembly consists of two field windings, connected in series, assembled around iron pole shoes which are held in the frame by pole shoe screws. One end of the field winding assembly (which consists of the two windings connected in series) is connected to an insulated "F" or field terminal in the field frame. The other end of the field winding assembly is connected to the third brush in the commutator end frame and is supplied current through the third brush. The other insulated terminal is marked "A" and is connected to the insulated main brush in the commutator end frame. Current flows from the main insulated brush, through the "A" terminal, through the external circuit and back through the grounded side of the system to the generator.

(3) COMMUTATOR END ASSEMBLY. The commutator end assembly consists of the commutator end frame, ball bearing with oiling arrangement, main brush ring with the two main brush holders and brushes, the third brush ring, on which mounts the third brush holder and third brush. The positions of the two main brushes are fixed. The third brush ring is held against the commutator by pressure from a third brush tension spring and a clamp. When the clamp screw is loosened, the third brush ring may be shifted so as to shift the third brush position with respect to the main brushes. All brushes are held by brush spring tension against the commutator with the correct pressure to assure good contact. One main brush is connected by a lead to the "A" terminal, which is on the generator field frame assembly. The other main brush is connected to

ground through the grounded brush holder. The third brush is insulated and is connected to the field winding assembly.

(4) DRIVE END ASSEMBLY. The drive end assembly consists of the drive end frame and a ball bearing, together with the necessary oiling arrangement.

## 100. TABULATED DATA.

**a.** Generator specifications for the generators are as follows:

| | |
|---|---|
| Rotation | Clockwise viewed from drive end |
| Brush spring tension | 22 to 26 ounces for main brushes and 16 to 20 ounces for third brush |
| Cold output | 16 to 18 amperes at 16.1 to 16.5 volts at 2,400 revolutions per minute |
| Hot output | 11 to 13 amperes at 15.1 to 15.5 volts at 2,400 revolutions per minute |
| Field current | 1.35 to 1.55 amperes at 12 volts |

## 101. PREVENTIVE MAINTENANCE.

**a. Operational Maintenance Checks.** Operational maintenance checks may be defined as the checks which may be made during the operation of the vehicle. These checks give the operator some idea as to the condition of the generator so that if some abnormal condition of operation is noted, correction can be made before complete failure of the generator and the vehicle takes place. During starting, and after the vehicle is in operation, the position of the ammeter hand should be noted. After the engine is electrically cranked and started, the generator, if operating normally, will immediately begin to return to the battery the current used in starting. Consequently, the ammeter reading should be fairly high. Then, if the battery was originally in a good state of charge, the generator output will be reduced a substantial amount after some length of time of operation. The length of time will depend on the original state of battery charge and the amount of drain on the battery during cranking. This reduction of output is accomplished by operation of the generator regulator, which functions to cut the charging rate as the battery approaches a charged condition, and thus prevents battery overcharge. This action is indicated by a dropping back of the ammeter needle toward zero. Failure of the equipment to function in this manner requires further consideration as outlined in section II.

**b. Inspection Checks.** Routine inspection checks of generator brushes, commutator and leads should be made after every 100 hours of operation.

GENERATOR

(1) GENERATOR BRUSHES. The generator brushes should not be shorter than $\frac{7}{16}$-inch (original length $\frac{13}{16}$-in., third brush $\frac{23}{32}$-in.). If worn down to—or almost to—this length, they must be replaced. Brush spring tension must be sufficient to give good clean contact of the brushes on the commutator, and the brushes must be free to slide in their brush holders. The pig tail leads in the brushes must be tight and the lead clips fastened well to the brush holders.

(2) COMMUTATOR. The commutator must be smooth, round, without excessive roughness, dirt, gum or burned areas. The slots between the segments must be open and not filled with brush or copper dust. The armature leads must be properly soldered to the commutator segments. If the commutator does not meet with the above, the generator must be removed, disassembled, and the commutator serviced as outlined in paragraphs 103 to 109.

(3) DRIVE BELT. The drive belt must be tightened to the correct tension (see Adjustment of Generator Belt, par. 118). Excessive belt tension causes rapid belt and bearing wear, while low belt tension causes belt slippage, rapid belt wear and possible failure of the generator to charge in a normal manner.

(4) CONNECTIONS. The connections at the terminals should be checked to make sure they are all tight and in good condition. If abnormal operation of the generator or generator regulator system is noted, it is first necessary to determine whether it is the generator, the generator regulator unit or some other component of the electrical system which is at fault. The procedure for making this determination is covered in section II, paragraph 123.

## 102. TROUBLE SHOOTING.

### a. No Generator Output.

| Probable Cause | Probable Remedy |
|---|---|
| (1) Brushes sticking. | (1) Clean brush holders and brush arms. Replace if bent. |
| (2) Burned commutator bars. | (2) Recut commutator. |
| (3) Worn brushes. | (3) Replace brushes. |
| (4) Commutator gummed. | (4) Clean commutator. |
| (5) Open circuits in field or armature. | (5) Replace unit. |
| (6) Short circuits in field or armature. | (6) Replace unit. |
| (7) Weak brush springs. | (7) Replace springs. |

**b. Low or Unsteady Generator Output.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Low brush spring tension. | (1) Adjust or replace brush springs. |
| (2) Brushes worn or sticking. | (2) Clean or replace brushes. |
| (3) Rough, dirty or greasy commutator bars. | (3) Clean commutator bars. |
| (4) High mica on commutator. | (4) Undercut mica. |
| (5) Commutator out-of-round. | (5) Recut commutator. |
| (6) Burned commutator bars. | (6) Recut commutator. |
| (7) Loose drive belt. | (7) Adjust belt. |

**c. Noisy Generator.**

| | |
|---|---|
| (1) Loose mounting. | (1) Tighten mounting bolts. |
| (2) Worn gear. | (2) Replace gear. |
| (3) Loose gear. | (3) Tighten gear. |
| (4) Worn bearings. | (4) Replace bearings. |

**d. Excessive Generator Output.**

| | |
|---|---|
| (1) Generator field grounded. | (1) Locate for external ground, correct. |
| (2) Excessively advanced third brush setting. | (2) Adjust third brush. |

## 103. REMOVAL OF GENERATOR FROM ENGINE.

**a. Equipment.**

WRENCHES, two, ¾-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, ½-in.
WRENCH, open-end, 9/16-in.
WRENCH, open-end, ⅝-in.
WRENCH, socket, 9/16-in. with extension

**b. Procedure.**

(1) REMOVE WINCH DRIVE SHAFT GUARD.

WRENCHES, two, 9/16-in.
WRENCHES, two, ¾-in.

Remove three cap screws from front end of guard (9/16-in. wrench) and three bolts from rear end of guard (two ¾-in. and 9/16-in. wrenches) and lift off guard.

## GENERATOR

(2) REMOVE LEFT FRONT FENDER.

WRENCHES, two, ¾-in.

Remove three bolts and one cap screw and remove left front fender.

(3) REMOVE PRE-HEATER INLET ELBOW.

WRENCH, socket, 9/16-in. with extension

Loosen wing nuts and open cover. Remove cap screw holding elbow to cylinder block and remove inlet elbow.

(4) REMOVE ADJUSTING SCREW.

WRENCH, open-end, ½-in.

Remove cap screw in adjusting link.

(5) REMOVE WIRES FROM GENERATOR TERMINALS.

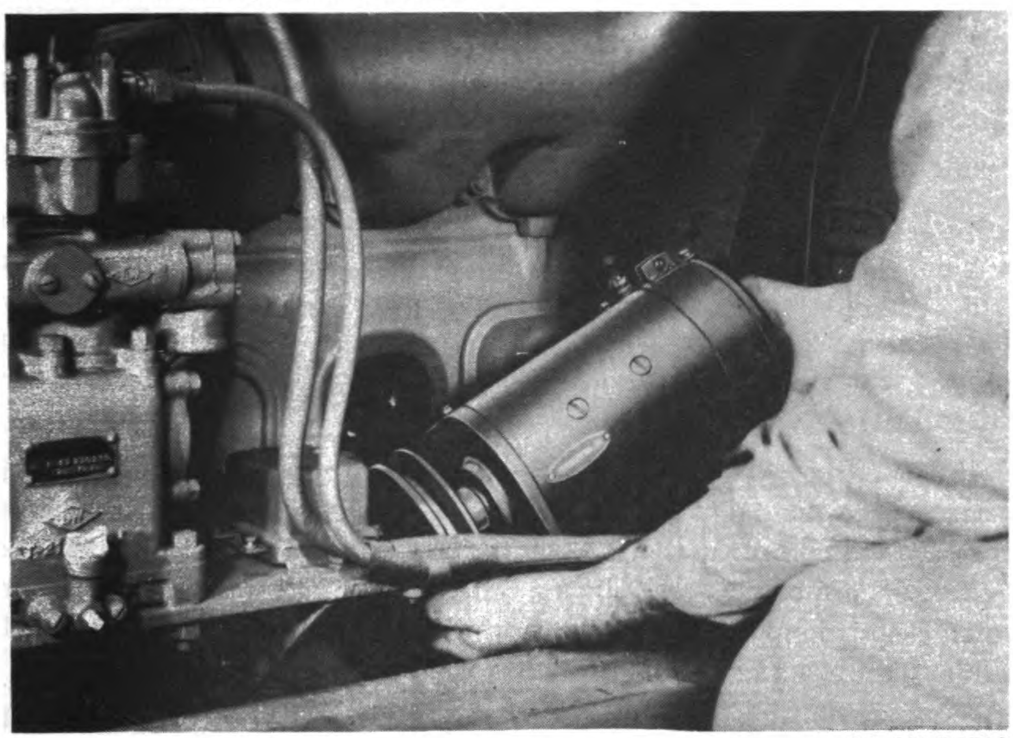
WRENCH, open-end, 7/16-in.

Swing generator down and remove the two nuts from the two generator terminals. Lift wires from terminals and replace washers and nuts on terminals.

(6) REMOVE GENERATOR.

WRENCH, open-end, ⅝-in.

Remove the two cap screws holding generator to air compressor bracket and lift generator out of belt. Generator can now be taken out from under air compressor bracket.



RA PD 17709

*Figure 111 — Removing Generator*

## 104. INSPECTION BEFORE DISASSEMBLING.

**a.** Disassembly should be carried only so far as is necessary to adequately inspect and clean the parts. For example, it will not be necessary to disassemble the commutator end assembly except as required to replace defective parts. Likewise, the field windings and terminal studs need not be removed from the field frame except for replacement. Indiscriminate disassembly and assembly of such parts may actually damage them, since it tends to weaken leads and connections by stressing and bending them and may damage insulation so that a short or ground will develop. Before disassembling the generator, if the trouble is not readily apparent, use a test lamp and test points to determine the cause of failure and which subassemblies are in need of inspection and repair. A test lamp and test points can be used to detect short circuits, grounds and open circuits. The test points are connected in series with the test lamp and a source of electricity (110-volt circuit, for example). When the test points are held together, the lamp lights. Thus a short circuit in an electrical circuit is indicated by lighting of the test lamp when the points are placed across the circuit. Likewise, an open circuit is indicated by failure of the lamp to light when the points are placed across the circuit. Check as in following step **b.**

**b. Test for Grounded Generator.** Raise and insulate grounded brush from the commutator and check with test points from the "A" terminal (fig. 117) to the frame. If test lamp lights—indicating ground—raise third brush from commutator and check the "A" terminal and the "F" terminal separately to determine whether the armature or field circuit is grounded.

**c. Test for Open Field Circuit.** Check for open field circuit with test points from the "F" terminal to the third brush holder. If lamp does not light, field is open. Leads which have broken or connections which have come loose to produce this condition may be resoldered (rosin-flux solder). But if open is inside a field winding, it must be replaced (pars. 108 to 110).

**d. Test for Shorted Field.** Connect a battery and an ammeter in series with the field circuit to determine how much current the field draws. Normal field current with a 12-volt battery is 1.35 to 1.55 amperes. Proceed with care on this test, since a shorted field will draw a high current which might damage the ammeter or other equipment. If a shorted field is found, replace the field (pars. 108 to 110).

**e. Open Circuited Armature.** An open circuited armature is usually readily apparent, since this condition causes burned commutator bars.

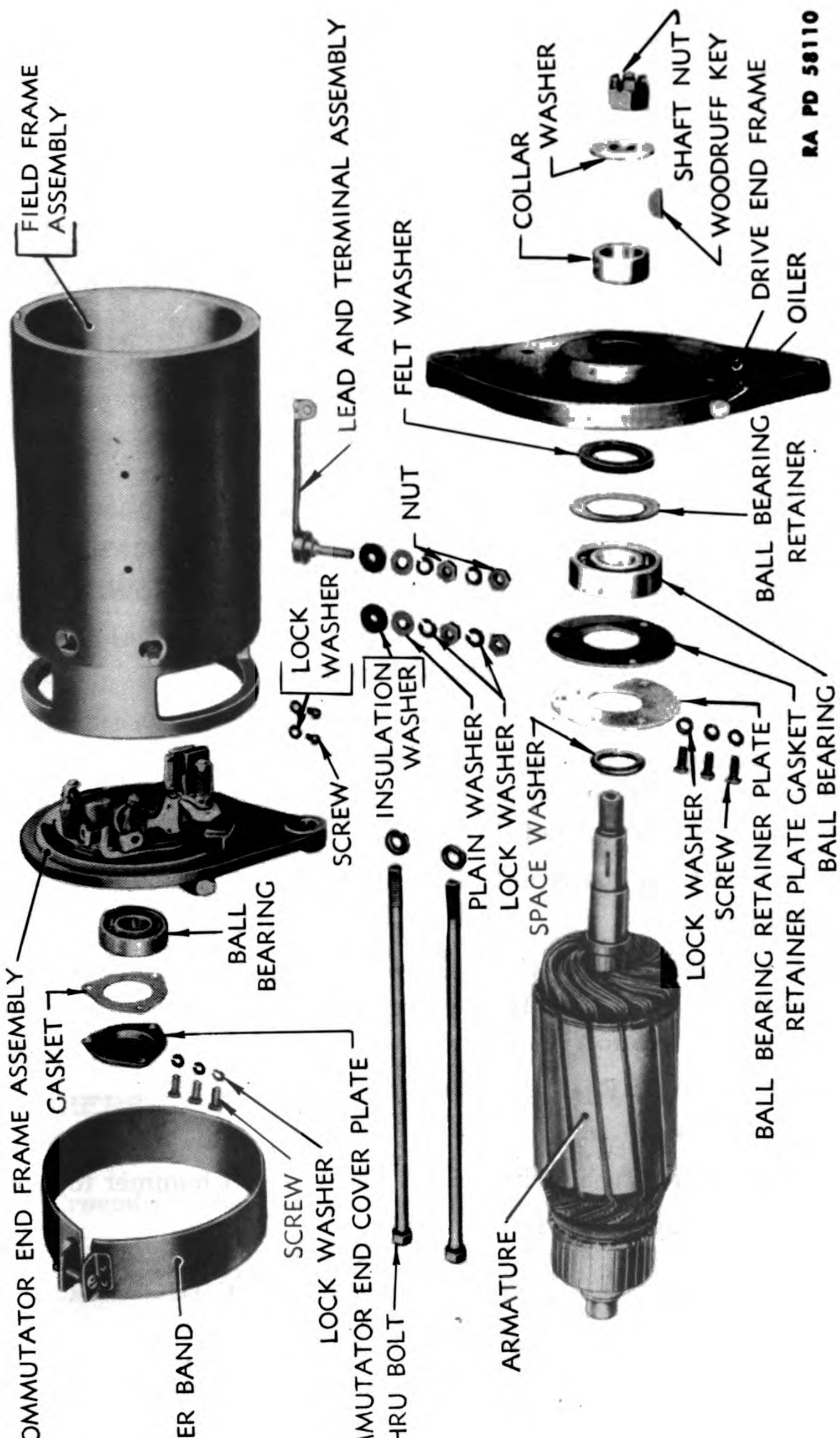



**Figure 112—Exploded View of Generator**

**f. Test Armature for Short Circuits.** Check the armature on a growler for short circuits. See paragraph 109 for explanation of the growler and its operation.

## 105. DISASSEMBLING INTO MAIN SUBASSEMBLIES.

**a. Equipment.**

| | |
|---|---|
| HAMMER, soft | SCREWDRIVER, 6-in. |
| PLIERS | VISE, soft-jaw |
| PRESS, arbor | WRENCH, 7/16-in. |
| PULLER | WRENCH, 3/4-in. |

**b. Procedure** (fig. 112).

(1) REMOVE COVER BAND.

SCREWDRIVER, 6-in.

Loosen screw and remove cover band. Note relationship of leads and brushes.

(2) DISCONNECT INSULATED AND THIRD BRUSH LEADS.

SCREWDRIVER, 6-in.

Remove screws from insulated and third brush holders. This disconnects lead from "A" terminal stud and lead from field winding. It also disconnects the two brush lead clips.

(3) REMOVE COMMUTATOR END.

HAMMER, soft WRENCH, 7/16-in.

Remove two through bolts (7/16-in. wrench) and detach commutator end frame from field frame. It may be necessary to loosen the commutator end frame with a soft hammer.

(4) DETACH FIELD FRAME.

HAMMER, soft

Detach field frame from drive end frame. Use soft hammer to loosen.

(5) REMOVE PULLEY NUT.

PLIERS WRENCH, 3/4-in.
VISE, soft-jaw

Place armature in soft jaws of vise, remove cotter pin (pliers) and using 3/4-inch wrench, remove pulley nut and washer.

(6) REMOVE PULLEY.

PLIERS VISE, soft-jaw
PULLER

With armature in jaws of vise, use puller to remove pulley. Remove half-moon key with pliers.

(7) REMOVE DRIVE END FRAME.

PRESS, arbor

Remove drive end frame from armature. While it normally slips off fairly easily, it may have to be pressed off in an arbor press. Remove collar from pulley side of frame. Remove washer from armature shaft.

## 106. DISASSEMBLY OF DRIVE END FRAME ASSEMBLY.

a. **Equipment.**

PRESS, arbor
SCREWDRIVER, 6-in.

b. **Procedure** (fig. 112).

(1) DETACH BEARING RETAINER PLATE.

SCREWDRIVER, 6-in.

Remove three screws so that bearing retainer plate and gasket may be removed.

(2) REMOVE BALL BEARING.

PRESS, arbor

Remove bearing from frame. While this may normally be done with a few light taps, it may have to be pressed out in an arbor press. Remove retainer and felt washer.

## 107. DISASSEMBLY OF COMMUTATOR END FRAME ASSEMBLY.

a. **Equipment.**

PLIERS
PRESS, arbor
SCREWDRIVER, 6-in.

b. **Procedure** (figs. 112 and 113).

(1) REMOVE BEARING COVER PLATE.

SCREWDRIVER, 6-in.

Remove bearing cover plate by detaching three screws. Remove gasket.

(2) REMOVE BEARING.

PRESS, arbor

If bearing does not come out readily, use arbor press.

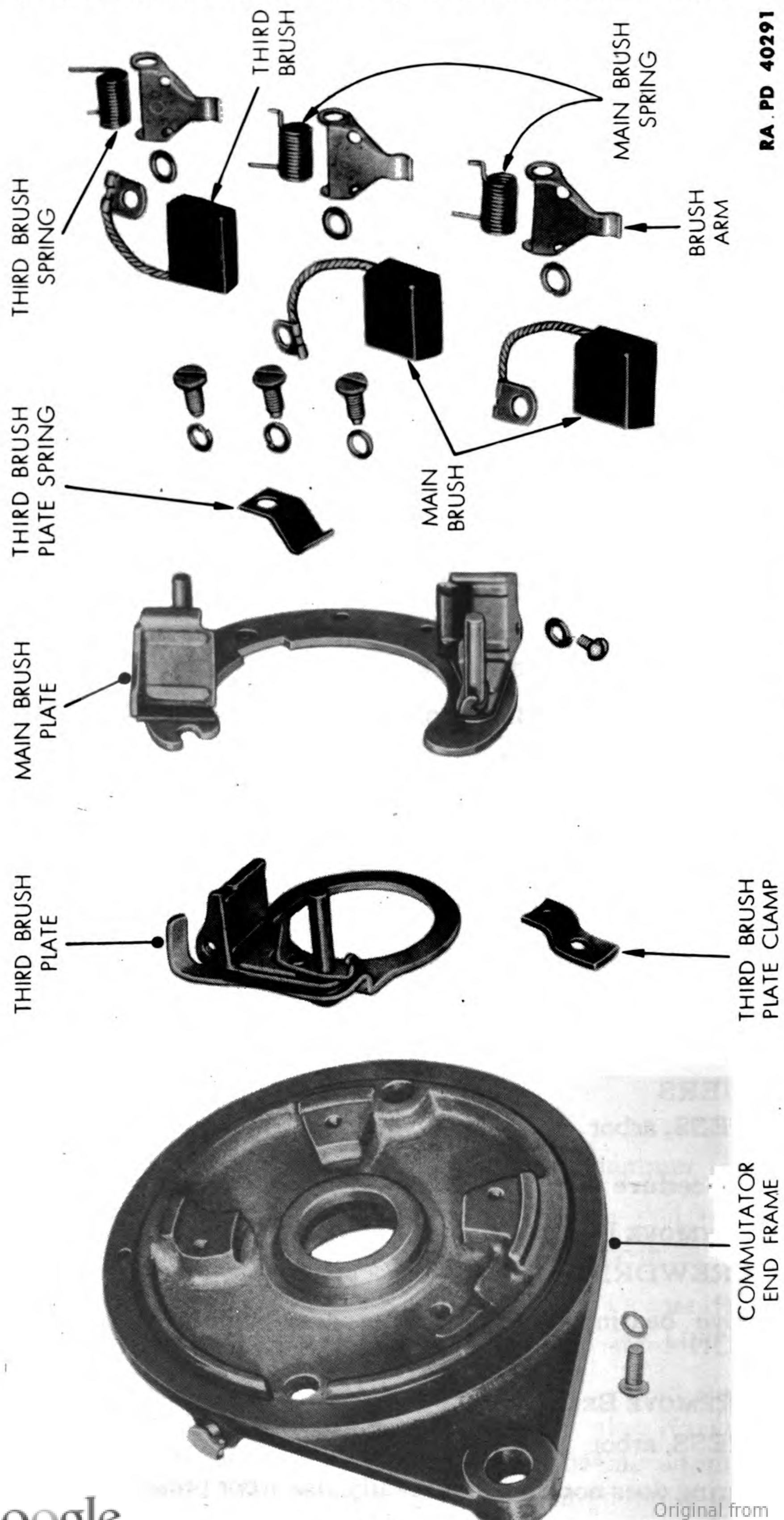



**Figure 113—Exploded View of Commutator End Frame**

GENERATOR

(3) REMOVE GROUNDED BRUSH LEAD SCREW.

SCREWDRIVER, 6-in.

Remove grounded brush lead screw connecting brush lead to brush holder.

(4) LIFT OFF BRUSHES, SPRINGS, ARMS AND WASHERS.

PLIERS

Pull back brush arms and lift brushes out of holders. Using pliers, catch lower end of spring and lift up over spring stop. Arm, spring and washer will slide off pin.

(5) DETACH MAIN BRUSH PLATE.

SCREWDRIVER, 6-in.

Detach main brush plate by removing three screws. One screw also attaches third brush ring tension spring, so spring will also come off.

(6) DETACH THIRD BRUSH PLATE.

SCREWDRIVER, 6-in.

Unscrew third brush locking screw from outside of frame so clamp and third brush plate may be detached from frame.

## 108. DISASSEMBLY OF FIELD FRAME ASSEMBLY.

**a. Equipment.**

IRON, soldering
SCREWDRIVER, pole shoe
WRENCH, 7/16-in.

**b. Procedure** (fig. 114).

(1) DETACH TERMINAL STUDS.

WRENCH, 7/16-in.

Remove one nut, lock washer, flat washer and insulator from each terminal stud ("A" and "F"). The "A" terminal stud may be removed from frame. The "F" terminal stud is soldered to the field winding lead.

(2) REMOVE FIELD WINDINGS.

IRON, soldering
SCREWDRIVER, pole shoe

Remove field windings by removing four pole shoe screws (pole shoe screwdriver), pole shoes and windings. Stud and clip on field winding leads may be unsoldered and replaced, if required (soldering iron). Be careful in handling field windings to avoid damaging leads or insulation.

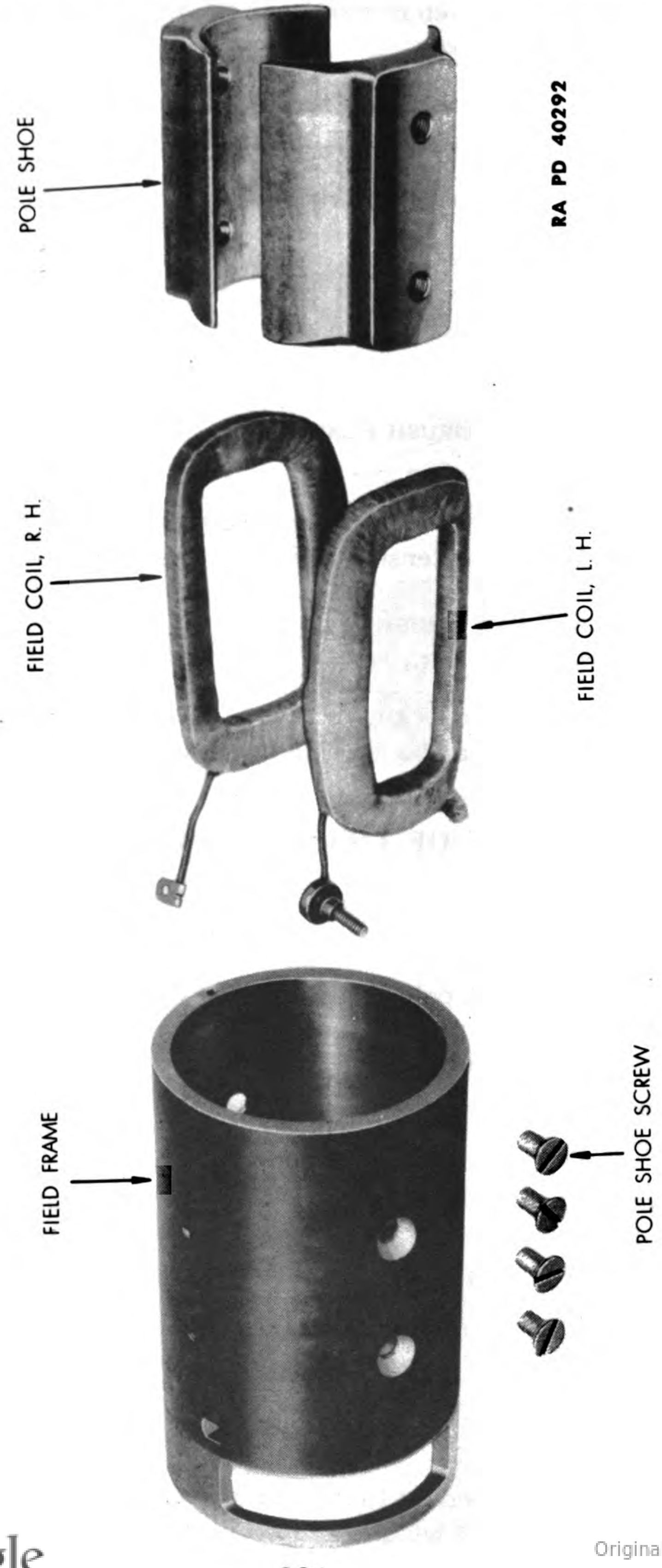



*Figure 114—Exploded View of Field Frame*

GENERATOR

## 109. INSPECTION AND REPAIR.

**a. General.** After disassembly, all parts should be cleaned, examined and defective parts replaced. The procedure for cleaning, inspecting and repairing parts is given in following paragraphs.

**b. Armature.**

(1) Do not clean the armature by any degreasing method, since this would damage the insulation and might ruin the armature. Wipe with a clean cloth slightly dampened with SOLVENT, dry-cleaning. If commutator is rough, out-of-round, worn, has high mica, filled slots, or is burned, it may be turned down in a lathe and the mica undercut (fig. 115). Armature may be checked for ground, open or short circuit, as follows:

*(a) Ground.* Check with test lamp and test points from the commutator to the armature shaft or lamination. If the lamp lights—indicating ground—and if the ground is not readily apparent and repairable, the armature must be replaced.

*(b) Open.* An open circuited armature is easily detectable, since this condition produces badly burned commutator bars. Some bars badly burned—with other bars fairly clean—indicates an open circuited armature. The bars connected to the open coils in the armature soon burn, since every time they pass under the brushes they interrupt a flow of current so that heavy arcing occurs. The open circuit will usually be found at the commutator riser bars and is often a result of generator overload—the consequence of an excessively high generator output resulting from a too advanced third brush adjustment. If the bars are not too badly burned, the armature may sometimes be saved by resoldering the leads in the riser bars with rosin flux, turning the commutator down and undercutting the mica. Make sure the third brush is adjusted according to specifications.

*(c) Commutator Worn, Dirty, etc.* If the commutator is rough, worn, out-of-round, has high mica, filled slots and burned spots, place the armature in a lathe and turn down the commutator. Make cut no deeper than necessary. Minimum diameter of commutator should be two inches. If it is necessary to turn the commutator below this diameter, discard the armature. Undercut mica $1/32$ inch (fig. 115).

*(d) Short.* A shorted armature may be detected on a growler. The growler is a strong electromagnet connected to a source of alternating current. When shorted armature is placed on the growler, and a hacksaw blade held above the shorted coils in the armature, the blade will be alternately attracted to, and repelled from, the armature, causing the blade to buzz against the armature. Before discarding an armature

GENERATOR

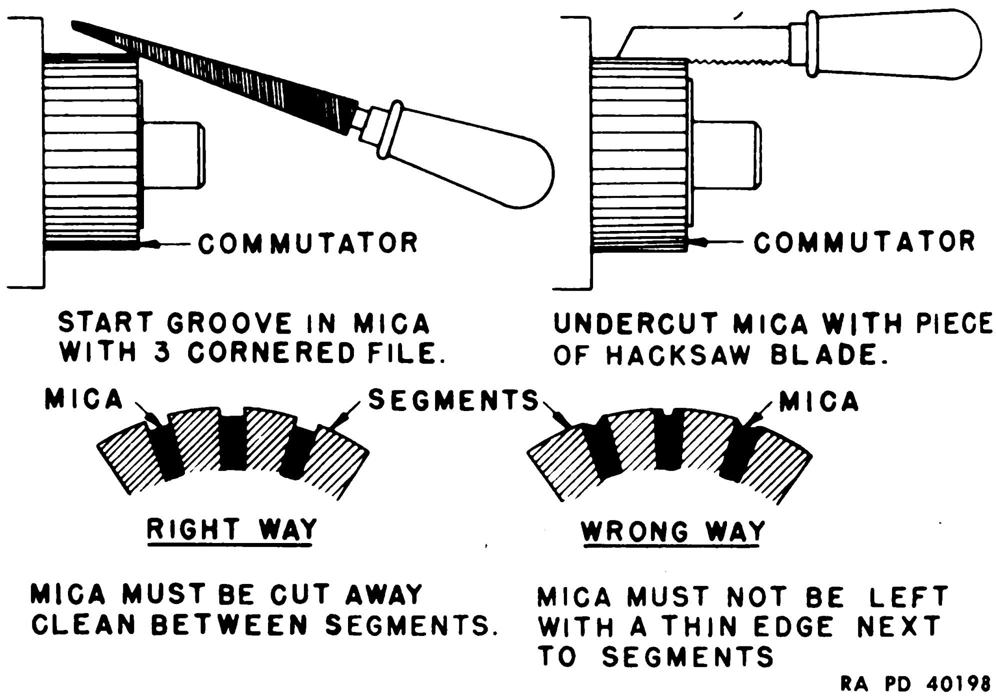



***Figure 115 — Undercutting Mica on Commutator***

testing shorted, inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars.

**c, Fields.**

(1) The fields should not be cleaned by a degreasing method, since this would damage the insulation and might ruin the windings. Clean by wiping with a clean, dry cloth. Be careful in handling the winding assembly to avoid breaking or weakening the connecting lead between the two windings. Test the field current draw by connecting a 12-volt battery and an ammeter in series with the two field leads. The current draw should be 1.35 to 1.55 amperes at 12 volts. Replace windings if they do not meet specifications. The field insulation should be in good condition. If it is charred or worn away so that the wire is exposed, it is sometimes possible to rewrap the windings with insulating tape and paint them with insulating compound. All soldered connections should be made with rosin-flux solder. If the terminal stud or clip is damaged, replace.

(2) FIELD INSULATION DEFECTIVE. If the field insulation is defective, charred or worn away, so the field circuit is—or could become—grounded, it may sometimes be repaired by rewrapping the field windings with insulating tape. This operation must be executed with care and neatness, since excessive bulkiness of the tape will prevent reassem-

bling the windings under the pole shoes in the proper manner. All soldered connections should be made with rosin-flux solder.

d. **Brushes.** If the brushes are worn down to $\frac{7}{16}$ inch (original length $1\frac{3}{16}$-in., third brush $2\frac{3}{32}$-in.), replace. Make sure that the pig tail leads are firmly in place in the brushes and that the clip is properly soldered to the lead. New brushes may be seated with a brush seating stone. The brush seating stone is an abrasive material which, held against a revolving commutator, disintegrates, carries under the brushes and seats them in a second or two.

e. **Brush Springs.** The brush springs should have sufficient tension to provide the proper pressure between the brushes and commutator after the unit is assembled. This may be checked by assembling the brushes, brush springs and arms to the commutator end frame (see Assembly of Generator, par. 113), placing the commutator in position in the end frame and then checking with a spring gage the amount of pull required to raise the brush arms from the brushes. Replace springs if tension is not correct.

f. **Bearings.** If the bearings appear to roll roughly, or sloppily, replace them. Otherwise the bearings may be cleaned by rotating them in SOLVENT, dry-cleaning, drying them with air, and immediately re-lubricating with ball bearing grease.

g. **Brush Rings.** If the brush rings, brush arm pins, brush holders and spring stop pins are damaged (bent, warped, cracked, insulation burned, etc.), replace brush ring. The rings are of a riveted construction so that they must be serviced as units.

h. **Miscellaneous.** Any defective insulator, screw, washer, lead, stud, retainer, plate, etc., should be replaced. Cracked, bent, battered, worn, burned insulators and washers are defective. Screws or studs which are bent, battered, broken, or which have crossed or damaged threads, are defective. Leads which have broken strands or badly frayed insulation are defective.

i. **Bearing Fits.** The bearing measurements and measurements of parts into which bearings are assembled, or which are assembled into the bearings, are as follows:

| | |
|---|---|
| Drive end bearings: | Armature shaft: |
| ID. 0.7870 to 0.7874 | 0.7865 to 0.7871 |
| OD. 1.8499 to 1.8504 | Drive end frame: |
| | 1.8508 to 1.8513 |
| Commutator end bearings: | Armature shaft: |
| ID. 0.6690 to 0.6693 | 0.6684 to 0.6690 |
| OD. 1.5743 to 1.5748 | Commutator end frame: |
| | 1.575 to 1.576 |

## 110. ASSEMBLY OF FIELD FRAME ASSEMBLY.

**a. Equipment.**

SCREWDRIVER, pole shoe
SPREADER, pole shoe
WRENCH, 7/16-in.

**b. Procedure** (fig. 114).

(1) ASSEMBLE FIELD WINDINGS.

SCREWDRIVER, pole shoe
SPREADER, pole shoe

Place field winding assembly, with pole shoes, in field frame. Insert pole shoe spreader and tighten shoes against frame. Install and tighten four pole shoe screws with pole shoe screwdriver. Winding with stud soldered to lead must be so placed that stud can be inserted through hole in frame.

(2) ATTACH TERMINAL STUDS.

WRENCH, 7/16-in.

Insert stud on winding lead through "F" terminal hole in frame and secure with insulator, flat washer, lock washer and nut. Place stud with lead attached through "A" terminal hole and secure with insulator, flat washer, lock washer and nut.

## 111. ASSEMBLY OF COMMUTATOR END FRAME ASSEMBLY.

**a. Equipment.**

PLIERS
PRESS, arbor
SCREWDRIVER, 6-in.

**b. Procedure** (fig. 113).

(1) MOUNT THIRD BRUSH PLATE.

SCREWDRIVER, 6-in.

Note relationship of third brush plate and frame, and attach third brush plate with clamp, screw and lock washer.

(2) MOUNT MAIN BRUSH PLATE.

SCREWDRIVER, 6-in.

Attach main brush plate to frame with three screws and lock washers. Under one screw and lock washer place the third brush ring tension spring, with spring resting on third brush. Spring fits into notch in main brush ring.

(3) REASSEMBLE BRUSHES, SPRINGS, ARMS AND WASHERS.

PLIERS
SCREWDRIVER, 6-in.

Assemble brush springs, arms and washers to hinge pins on brush plates. Washers go on first. Straight end of spring protrudes through hole in brush arm, while bent end of spring should be caught with pliers and hooked over spring stop. Brushes should be placed in holders. Fasten clip of brush in grounded holder to holder with screw and lock washer.

(4) INSTALL BEARING.

PRESS, arbor | SCREWDRIVER, 6-in.

If bearing does not slip easily into frame, press in with arbor press. Fasten with gasket, retainer plate, three screws and lock washers (screwdriver).

## 112. ASSEMBLY OF DRIVE END FRAME ASSEMBLY.

**a. Equipment.**

PRESS, arbor | SCREWDRIVER, 6-in.

**b. Procedure** (fig. 112).

(1) INSTALL BALL BEARING.

PRESS, arbor | SCREWDRIVER, 6-in.

Install felt washer, retainer and bearing in frame. Cupped side of retainer is away from bearing so it does not touch inner race of bearing. If ball bearing does not slip into frame easily, it may be pressed in with an arbor press. Secure bearing in place with gasket retainer plate, three lock washers and screws (screwdriver).

## 113. ASSEMBLY OF GENERATOR.

**a. Equipment.**

HAMMER, ½-lb. | VISE, soft-jaw
PLIERS | WRENCH, 7⁄16-in.
PRESS, arbor | WRENCH, ¾-in.
SCREWDRIVER, 6-in.

**b. Procedure** (fig. 112).

(1) INSTALL ARMATURE IN DRIVE END FRAME.

PRESS, arbor

Place washer on armature shaft. Insert shaft through bearing in drive end frame. It may have to be pressed in with an arbor press. Place collar on shaft.

(2) INSTALL PULLEY ON SHAFT.

HAMMER, ½-lb. | VISE, soft-jaw
PLIERS | WRENCH, ¾-in.
PRESS, arbor

Place key in keyway (hammer); press pulley on shaft in arbor press. Place armature in soft jaws of vise, install washer and pulley nut (3/4-in. wrench) and secure with cotter pin (pliers).

(3) ATTACH FIELD FRAME.

Aline dowel and holes and place field frame in position on drive end frame.

(4) ATTACH COMMUTATOR END FRAME.

| | |
|---|---|
| PRESS, arbor | WRENCH, 7/16-in. |
| SCREWDRIVER, 6-in. | |

Aline dowel and holes and place commutator end frame in position on drive end frame. The three brushes may be cocked in their holders so they will be out of the way of the commutator during this assembly procedure. If the shaft does not slip into the bearing in a normal manner, remove the retainer plate and gasket (three screws and lock washers) (screwdriver) so the bearing can be pressed on the shaft in an arbor press. Secure commutator end frame to field frame with two through bolts and lock washers.

(5) ATTACH INSULATED AND THIRD BRUSH LEADS.

SCREWDRIVER, 6-in.

Attach insulated and third brush leads to insulated and third brush holders with one each screw and lock washer. The screws also connect the brush leads to the holders. Clips go *under* lock washers. Drop brushes down on commutator with arms resting on brushes in operating position.

(6) INSTALL COVER BAND.

SCREWDRIVER, 6-in.

Install cover band and secure with screw.

## 114. TESTING AND ADJUSTING GENERATOR.

**a. Equipment.**

| | |
|---|---|
| RESISTANCE, 1/4-ohm variable | SCREWDRIVER, 6-in. |
| | STAND, test, generator |

**b. Procedure.**

(1) Mount generator on test stand, connect to test stand ammeter and voltmeter in accordance with test stand instruction pamphlet. Connect ammeter lead to generator "A" terminal and ground generator "F" terminal with a jumper lead. Operate generator at speed at which maximum output is obtained. If output exceeds 16 to 18 amperes with generator

cold, immediately remove cover band (screwdriver), loosen third brush ring locking screw in commutator end frame (screwdriver) and move third brush away from main brush to obtain 16 to 18 amperes. Generator output at specified voltage must be checked. If specified voltage cannot be attained, ¼-ohm variable resistance of sufficient current carrying capacity should be inserted into the charging circuit and resistance cut in until the specified voltage is attained. Operate until generator reaches operating temperature (about 30 minutes). At operating temperature, the generator should produce 11 to 13 amperes at 15.1 to 15.5 volts, at 2,400 revolutions per minute (read speed if an indicator is available). Adjust by moving the third brush toward the main brush to increase output, or move third brush away from main brush to lower output. After adjustment is complete, tighten the locking screw and replace cover band (screwdriver).

(2) Always check the generator output at the specified voltage. Never set the output beyond the specified value. Failure to observe these rules may cause a high setting which will damage the generator.

## 115. INSTALLATION OF GENERATOR ON ENGINE.

**a. Equipment.**

WRENCH, ⅝-in.
WRENCHES, (two), ¾-in.
WRENCH, open-end, 7⁄16-in.
WRENCH, open-end, ½-in.
WRENCH, open-end, 9⁄16-in.
WRENCH, socket, 9⁄16-in. with extension

**b. Procedure.**

(1) INSTALL GENERATOR ON BRACKET.

WRENCH, ⅝-in.

Hold generator in place and install on air compressor bracket with two cap screws with lock washers.

(2) CONNECT WIRES FROM VOLTAGE CONTROL UNIT.

WRENCH, open-end, 7⁄16-in.

Attach short lead wires from generator regulator to terminals of generator. Lead wire from "F" terminal on generator regulator unit goes to "F" terminal on generator. Round clip goes under second lock washer and second nut on generator "F" terminal stud. Attach other lead from "GEN" terminal on generator regulator unit to "A" terminal on generator in same manner.

(3) INSTALL AND ADJUST BELT IN PULLEY.

WRENCH, ½-in.

Swing generator up and place drive belt in generator pulley. Install cap screws through washer and adjusting link into generator. Adjust belt to have from ¾-inch to 1-inch slack measured halfway between pulleys and tighten cap screw in adjusting link. After the generator or regulator unit is reinstalled on the engine and reconnected, or at any time after leads have been disconnected and then reconnected, a jumper lead should be connected MOMENTARILY between the battery and generator terminals of the generator regulator *before starting the engine.* This allows a momentary surge of current from the battery to flow into the generator which correctly polarizes the generator with respect to the battery it is to charge. CAUTION: Never operate the generator with the field circuit connected and the charging circuit open (open circuit operation), since this will allow a high voltage to build up within the generator which will damage the field and armature.

(4) INSTALL PRE-HEATER ADAPTER.

WRENCH, socket, $^9/_{16}$-in. with extension

Install new gasket on adapter if old one is damaged. Place assembly in its proper position. Install cap screw with lock washer and close cover. Tighten wing nuts.

(5) INSTALL LEFT FRONT FENDER.

WRENCHES, two, ¾-in.

Install the fender with the three bolts and one cap screw with lock washer.

(6) INSTALL WINCH DRIVE SHAFT GUARD.

WRENCHES, two, ¾-in. WRENCH, open-end, $^9/_{16}$-in.

Install guard with three cap screws with lock washers in front end $^9/_{16}$-in. wrench) and three bolts with lock washers in rear end ($^9/_{16}$-in. and ¾-in. wrenches).

## 116. REMOVAL OF GENERATOR BELT.

**a. Equipment.**

BAR, pry
PLIERS
WRENCH, ½-in.
WRENCH, $^9/_{16}$-in.
WRENCHES, two, ¾-in.

**b. Procedure.**

(1) REMOVE WINCH DRIVE SHAFT GUARD.

WRENCH, $^9/_{16}$-in. WRENCHES, two, ¾-in.

Remove three cap screws from front of guard (9/16-in. wrench) and the rear of guard (3/4-in. and 9/16-in. wrenches) and lift off guard.

(2) REMOVE LEFT FRONT FENDER.

WRENCHES, two, 3/4-in.

Remove three bolts and one cap screw to remove fender.

(3) LOOSEN GENERATOR BELT.

WRENCH, 1/2-in.

Loosen belt by loosening adjusting cap screw in adjusting link.

(4) REMOVE AIR COMPRESSOR PULLEY.

BAR, pry
PLIERS
WRENCH, 3/4-in.

Remove cotter pin (pliers) and castellated nut (wrench, 3/4-in.) holding drive pulley on compressor crankshaft. Pry pulley from shaft. Generator belt may now be removed.

## 117. INSTALLATION OF GENERATOR BELT.

**a. Equipment.**

PLIERS
WRENCH, 1/2-in.
WRENCH, 9/16-in.
WRENCHES, two, 3/4-in.

**b. Procedure.**

(1) INSTALL BELTS.

Place generator belt in inside groove of air compressor drive pulley. Install air compressor drive belt in outside groove of compressor pulley.

(2) INSTALL AIR COMPRESSOR PULLEY.

PLIERS
WRENCH, 3/4-in.

With drive belts in place, slide pulley on shaft with slot in shaft in line with key in shaft. Install castellated nut (3/4-in. wrench) and cotter pin (pliers).

(3) ADJUST GENERATOR BELT.

WRENCH, 1/2-in.

Adjust belt for 3/4-inch to 1-inch slack and tighten cap screw in adjusting link.

(4) INSTALL LEFT FRONT FENDER.

WRENCHES, two, 3/4-in.

Install the fender with the three bolts and one cap screw with lock washer.

(5) Install Winch Drive Shaft Guard.

WRENCH, 9/16-in. WRENCHES, two, 3/4-in.

Install guard with three cap screws with lock washers in front end (9/16-in. wrench) and three bolts with lock washers in rear end (two 3/4-in. wrenches).

## 118. ADJUSTMENT OF GENERATOR BELT.

**a. Equipment.**

BAR, pry
WRENCH, 9/16-in.
WRENCH, 1/2-in.
WRENCHES, two, 3/4-in.

**b. Procedure.**

(1) Remove Winch Drive Shaft Guard.

WRENCH, 9/16-in. WRENCHES, two, 3/4-in.

Remove three bolts from rear of guard (two 3/4-in. wrenches) and three cap screws from front end (9/16-in. wrench) and lift off guard.

(2) Remove Left Front Fender.

WRENCHES, two, 3/4-in.

Remove three bolts and one cap screw to remove fender.

(3) Adjust Belt.

BAR, pry WRENCH, 1/2-in.

Loosen cap screw in adjusting link (1/2-in. wrench) and pry down on generator (pry bar) to tighten belt. Adjust so one side of belt can be depressed inward from 3/4 inch to 1 inch between pulleys. Too loose a belt will cause slippage and excessive belt wear, and too tight a belt will result in strain and wear on generator bearings. When adjusted correctly as above, tighten cap screw in adjusting link (1/2-in. wrench).

(4) Install Fender and Winch Drive Shaft Guard.

WRENCH, 9/16-in. WRENCHES, two, 3/4-in.

Install fender with the bolts removed in step (2) above (two 3/4-in. wrenches) and winch drive shaft guard with bolts and cap screws removed in step (1) above (9/16-in. and 3/4-in. wrenches).

## 119. SPECIAL TOOLS FOR GENERATOR.

a. Special tools required are:

GROWLER
SCREWDRIVER, pole shoe
SEATING or BEDDING, stone, brush
SPREADER, pole shoe

## Section II

# GENERATOR REGULATOR



### 120. DESCRIPTION.

**a. General Description.** This assembly is a Delco-Remy Model 5888, mounted on the air compressor support bracket, and consists of a voltage regulating mechanism and a cut-out relay, both mounted on the same metal base and under the same cover.

**b. Function of Generator Regulator.** The functions of the two units in the generator regulator are as follows:

(1) CUT-OUT RELAY. The cut-out relay closes the circuit between the generator and battery when the generator voltage has built up to a value sufficient to force a charge into the battery. The cut-out relay opens the circuit when the generator slows or stops and current begins to flow back from the battery into the generator.

(2) VOLTAGE REGULATOR UNIT. The voltage regulator unit is a magnetic switch which magnetically inserts or removes resistance in the generator field circuit. When the battery is in a low state of charge, the voltage regulator keeps the resistance out of the generator field circuit, so that the generator can produce full output (as determined by third brush setting) and thus recharge the battery. When the battery comes up to charge, the voltage regulator inserts resistance into the generator field circuit, causing the generator output to be cut down to a low value, so that battery overcharge and high voltage are avoided.

**c. Theory of Operation.**

(1) THE CUT-OUT RELAY. The cut-out relay consists of two windings —a shunt winding and a series winding—assembled on a single core, above which is positioned an armature. The shunt winding consists of

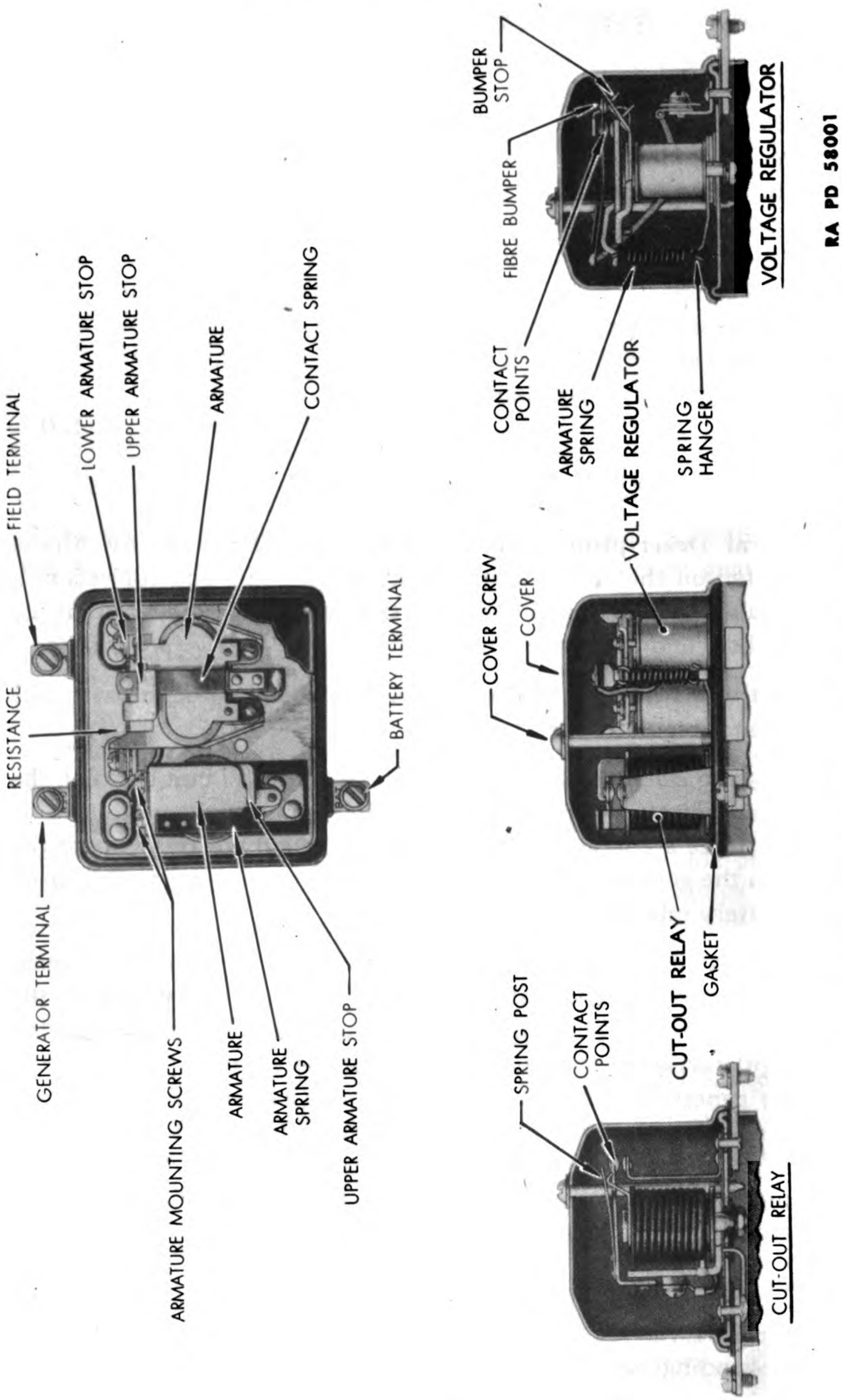



***Figure 116—Cut-Away Views of Generator Regulator***

GENERATOR REGULATOR

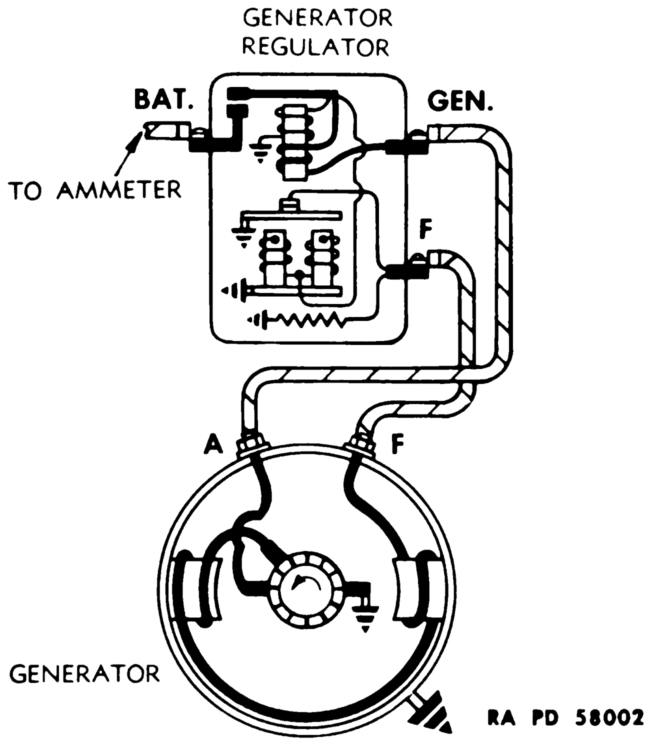



*Figure 117 — Wiring Diagram of Generator and Generator Regulator*

many turns of fine wire and is connected across the generator. The series winding consists of a few turns of heavy wire designed to carry full generator output and it is connected into the charging circuit. The armature carries a point which is positioned above a stationary matching point. When the generator is not operating, the armature is held away from the winding core by spring tension and the points are separated. As soon as the generator begins to operate at a speed sufficient to produce enough voltage to charge the battery, this voltage, which is impressed on the relay windings, creates enough magnetism to overcome the armature spring tension and close the points. So long as the generator charges the battery, the points are held closed. But when the generator slows or stops, so that current flows from the battery to the generator, the points open. They open because the series winding magnetic field reverses as the current in it reverses so that the two windings no longer help each other, but the magnetic fields buck, causing a reduction of the total magnetic field to a point where it can no longer hold the armature down and the points closed. The spring tension pulls the armature up and opens the points.

(2) VOLTAGE REGULATOR UNIT. The voltage regulator unit consists of two windings assembled on two cores—connected in series and, together, shunted across the generator—and an armature with a pair of contact points held closed by spring tension. In this position the generator

field circuit is conducted directly to ground through the points. Full generator output is thus available. As the battery approaches a charged condition, its charging voltage increases. This increasing voltage, energizing the two windings, becomes great enough, when the battery is sufficiently charged, to cause the voltage regulator unit to operate. At this point, the voltage is great enough to create sufficient magnetic strength in the winding cores to overcome the armature spring tension, pulling the armature toward the core so that the contact points open. With the points open, the generator field current must go to ground through a resistance. Generator field current and output are consequently reduced. So long as the battery remains in a charged condition and line voltage is high, then the resistance will remain in the generator field circuit and the generator continues to operate on low output. But when the battery becomes partly discharged, or when electrical accessories are turned on so that the line voltage is reduced, then the lowered voltage becomes insufficient to hold the points open; they close, directly grounding the field so that the generator output comes up on the high side. There are, in effect, two generators—a standard output unit when the battery and line voltage is low, and a reduced output generator when the battery is up to charge and less generator output is required.

## 121. TABULATED DATA.

**a.** Generator regulator specifications are:

(1) CUT-OUT RELAY.

| | |
|---|---|
| Air gap (inch) | 0.015 |
| Point opening (inch) | 0.020 |
| Points close (volts) | 12.9 to 13.9 |

(2) VOLTAGE REGULATOR UNIT.

| | |
|---|---|
| Air gap (inch) | 0.045 |
| Point opening (inch) | 0.015 |
| Contact spring tension (ounce) | 0.7 to 1.4 |
| Armature travel (inch) | 0.045 |
| Points open (volts at 180 F) | 14.1 to 14.7 |
| Points close (volts at 180 F) | 12.0 Max. |

## 122. PREVENTIVE MAINTENANCE.

**a. Operational Maintenance Checks.** Operational maintenance checks may be defined as the checks which may be made during the operation of the vehicle. These checks give the operator some idea as to the condition of the generator and generator regulator, so that if some abnormal condition of operation is noted, correction may be made before complete failure of the equipment takes place. During starting and after the vehicle is in operation, the position of the ammeter hand should be noted. After the engine is electrically cranked and started, the generator, if operating normally, will immediately begin to return to the battery the current used in starting. Consequently, the ammeter reading will be fairly high. Then, if the battery was originally in a good state of charge, the generator output will be reduced a substantial amount as the generator regulator operates when the battery approaches a charged condition. The length of time after starting will depend on the original state of battery charge and the amount of drain on the battery during starting. Failure of the equipment to operate in this manner requires further consideration as outlined in paragraph 123.

**b. Inspection Checks.** Inspection checks would normally include checking the electrical settings of the cut-out relay and voltage regulator. But without the proper instruments—which include a voltmeter and an ammeter—these checks cannot be made. Tampering with the unit by unauthorized or unequipped personnel can lead only to damage to the electrical units. Increasing the voltage regulator settings beyond their rated value may cause overcharged and damaged batteries, early failure of the electrical units, and damage to the generator. Reducing the voltage regulator settings below their rated minimum may result in undercharged batteries and inefficient operation of the electrical units. Adjusting procedures are outlined in paragraph 128.

**c. Periodic Generator Regulator Replacement.** At the same time that the generator is removed from the vehicle, the generator regulator should also be removed. The mechanical and electrical settings of the generator regulator may be noted and corrections made when necessary (see par. 128).

## 123. TROUBLE SHOOTING.

**a. General.** As outlined in paragraph 122, the dash ammeter should show a fairly high reading immediately after starting and then, after some period of operation, the ammeter reading should drop back to a lower value as the generator regulator operates. If the ammeter shows little or no charge although the battery is known to be in a low state of charge—as indicated by slow starting motor operation, dim lights, or weak operation of other electrical equipment—then further checking to locate the trouble is required. Likewise, if the ammeter continues to read high even though the battery is known to be in a charged condition—as indicated by fast, snappy cranking or bright lights—then further checking should be made. These conditions are analyzed in following steps **b** and **c**.

**b. Low Battery with Low Charging Rate.** The most accurate way to determine the state of battery charge is to use a hydrometer. (Refer to TM 9-787A, sec. XV, par. 86.) Some indication of the actual condition of the battery may, however, be gathered by noting the manner in which the electrical equipment is functioning, as detailed in previous paragraph. With a low battery and a low or no charging rate, check the equipment by momentarily grounding the "F" terminal of the generator with a jumper lead, while the generator is operating at medium speed. If the generator is capable of producing normal output, the output will come up. If the output does not come up, then the generator should be checked further as outlined in paragraph 114. If the output does come up, the generator regulator can be considered to be reducing the generator output even though the battery is in a low state of charge and it should be checked for a low voltage setting or for burned or oxidized contact points (par. 126). Loose connections, defective wiring, or other causes of excessive resistance in the charging circuit may cause the voltage regulator to operate as though the battery were fully charged, even though it is in a discharged condition, so the circuit must also be checked where this condition is found.

**c. Charged Battery with High Charging Rate.** With this condition, it is necessary to determine whether the generator regulator has operated to insert resistance in the generator field circuit. Remove the voltage regulator cover and check to see if the points are open. If they are not, open them by hand. If the output now falls off, then the voltage regulator must be readjusted. If the output does not drop off as the points are opened by hand, disconnect the lead from the "F" terminal of the generator. If the output still does not drop off, the generator field circuit is grounded. If the output does drop off, then there is a ground in the voltage regulator. It must be remembered that even after the generator regulator has operated and inserted its resistance into the generator field circuit, it may still be possible for the generator to overcharge the battery, even though the generator is operating on low output. Under such conditions, the generator output should be adjusted by adjusting the third brush as outlined in paragraph 114.

## 124. REMOVAL OF GENERATOR REGULATOR.

**a. Equipment.**

SCREWDRIVER, 6-in. WRENCH, $^{7}/_{16}$-in.

GENERATOR REGULATOR

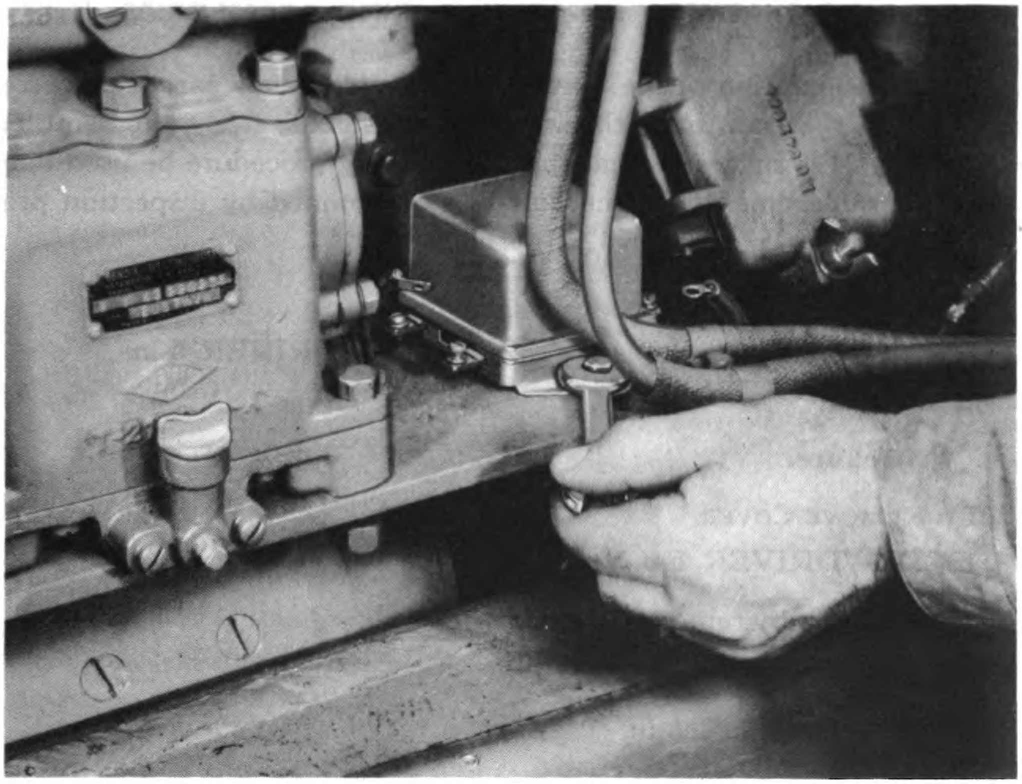


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***Figure 118 — Removing Generator Regulator Unit***

**b. Procedure.**

(1) DISCONNECT WIRES.

SCREWDRIVER, 6-in.

Remove the three screws that hold the three wires to the generator regulator unit terminals. Care should be taken not to short across terminals or ground terminals with screwdriver. Tape the lead disconnected from the "BAT" terminal to avoid grounding it, since it is connected to the battery and a high current would flow if the clip touched any metal.

(2) REMOVE GENERATOR REGULATOR.

WRENCH, $\frac{7}{16}$-in.

Remove two cap screws holding generator regulator to air compressor bracket and lift off generator regulator.

## 125. DISASSEMBLY OF GENERATOR REGULATOR.

**a.** As a rule, the generator regulator should *not* be disassembled. The only exception is where some part—such as the cut-out relay or voltage regulator armature—requires replacement. The adjustments of the unit are very delicate and must be made with great precision in order to obtain normal operation of the unit. Actually, only a few parts can be removed from the unit, since the windings, terminals, etc., are assembled by riveting. It is suggested that this disassembly procedure be used only where the replacement of some part—as determined by inspection procedure outlined in paragraph 126—is necessary.

**b. Equipment.**

IRON, soldering
SCREWDRIVER, 4-in.
SCREWDRIVER, 6-in.

**c. Procedure.**

(1) REMOVE COVER.

SCREWDRIVER, 6-in.

Remove cover by removing screw and washer.

(2) REMOVE RESISTANCE.

SCREWDRIVER, 6-in.

Remove resistance by unscrewing two screws. This also disconnects lead soldered to voltage regulator armature.

(3) DETACH VOLTAGE REGULATOR ARMATURE.

IRON, soldering
SCREWDRIVER, 4-in.

Detach voltage regulator armature by removing spring, two screws, lock washers and washers (screwdriver). Lead may be unsoldered from armature.

(4) DETACH CUT-OUT RELAY ARMATURE.

SCREWDRIVER, 6-in.

Remove two screws and remove cut-out relay armature and flat two-hole thick washer that goes under relay armature. It is not necessary to unsolder lead from thin two-hole clip washer that goes over armature.

## 126. INSPECTION AND REPAIR.

**a. Inspection of Parts.** All parts should be examined, with particular emphasis on the contact points in both the cut-out relay and the voltage regulator unit. Points which are dirty, burned or oxidized should be cleaned. The point and fiber bumper on the flat spring on the voltage regulator armature and the point on the cut-out relay armature should be assembled tightly. Leads, windings, insulators, screws and washers, must all be in good condition. If the windings, stationary cut-out relay

## GENERATOR REGULATOR

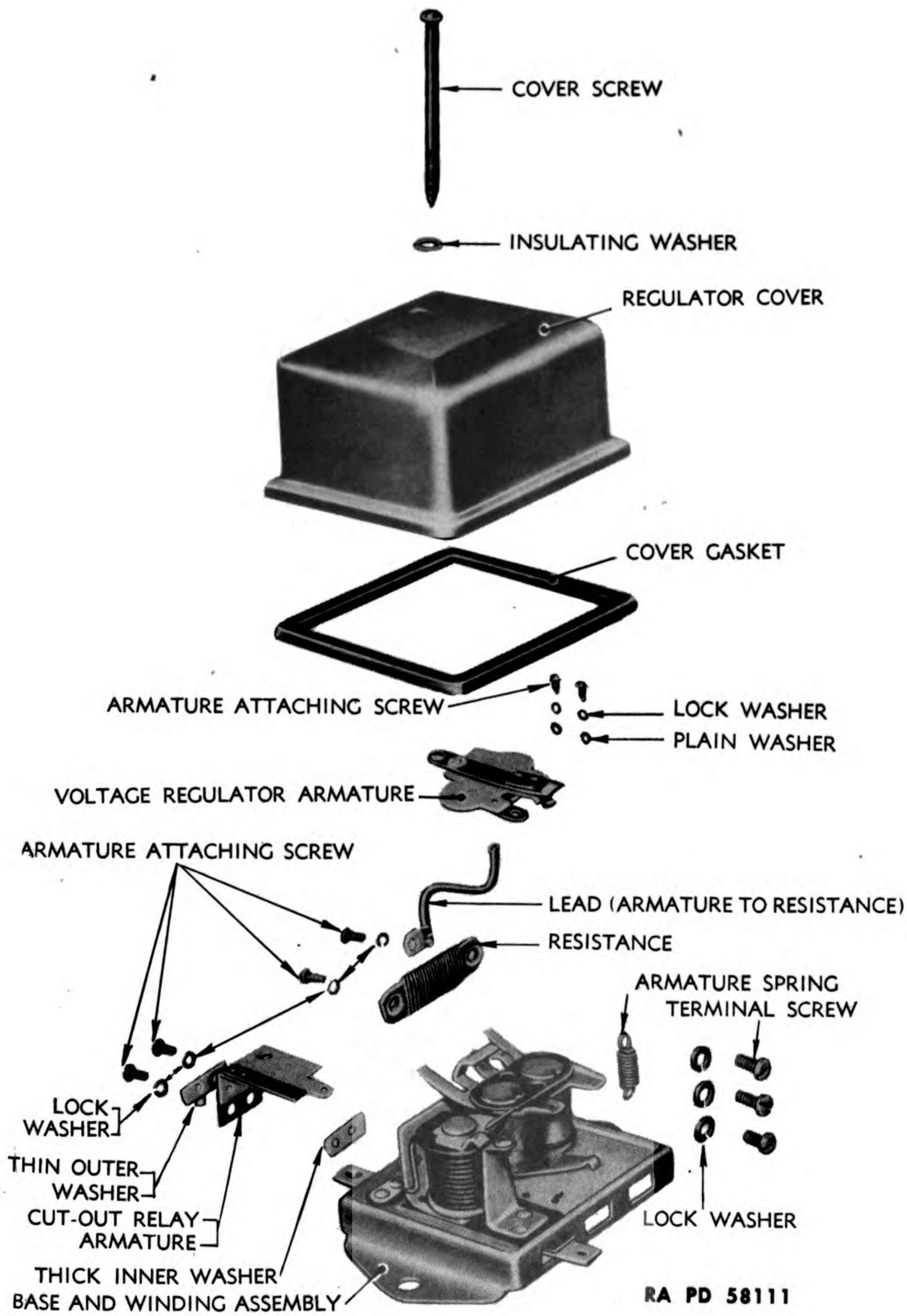


***Figure 119—Exploded View of Generator Regulator***

contact point or insulators, are burned or otherwise defective, replace the complete generator regulator. The voltage regulator is a riveted construction and only the parts shown disassembled in figure 119 are serviceable items.

**b. Repair of Parts.** Contact points which are pitted, rough, dirty or burned may be cleaned with a stroke or two of a clean, fine-cut contact file. Blow out all dust. Be careful in cleaning the voltage regulator unit contact points to avoid bending or distorting the flat armature spring. The spring should retain the two points in contact with the proper spring tension. Never use emery cloth or sandpaper to clean the points, since small particles of emery or sand might embed in the point surfaces and prevent good contact. Do not touch the point surfaces after cleaning them, since any trace of oil or grease may cause the points to burn.

## 127. ASSEMBLY OF GENERATOR REGULATOR.

**a. Equipment.**

IRON, soldering
SCREWDRIVER, 4-in.
SCREWDRIVER, 6-in.

**b. Procedure** (fig. 119).

(1) ATTACH CUT-OUT RELAY ARMATURE.

SCREWDRIVER, 6-in.

Attach cut-out relay armature with two screws and lock washers. Thick two-hole washer goes under relay armature, while thin two-hole clip washer goes over armature.

(2) ATTACH VOLTAGE REGULATOR ARMATURE.

IRON, soldering
SCREWDRIVER, 4-in.

Attach voltage regulator armature with two screws (screwdriver) lock washer and washers. Solder lead to armature, if it has been unsoldered, and hook spiral spring between armature and lower spring support.

(3) ATTACH RESISTANCE.

SCREWDRIVER, 6-in.

Attach resistance with two screws and lock washers. This also attaches other end of lead from voltage regulator armature. Lead should be attached under screw and lock washer nearest voltage regulator unit.

(4) ATTACH COVER WITH SCREW AND WASHER.

SCREWDRIVER, 6-in.

## GENERATOR REGULATOR

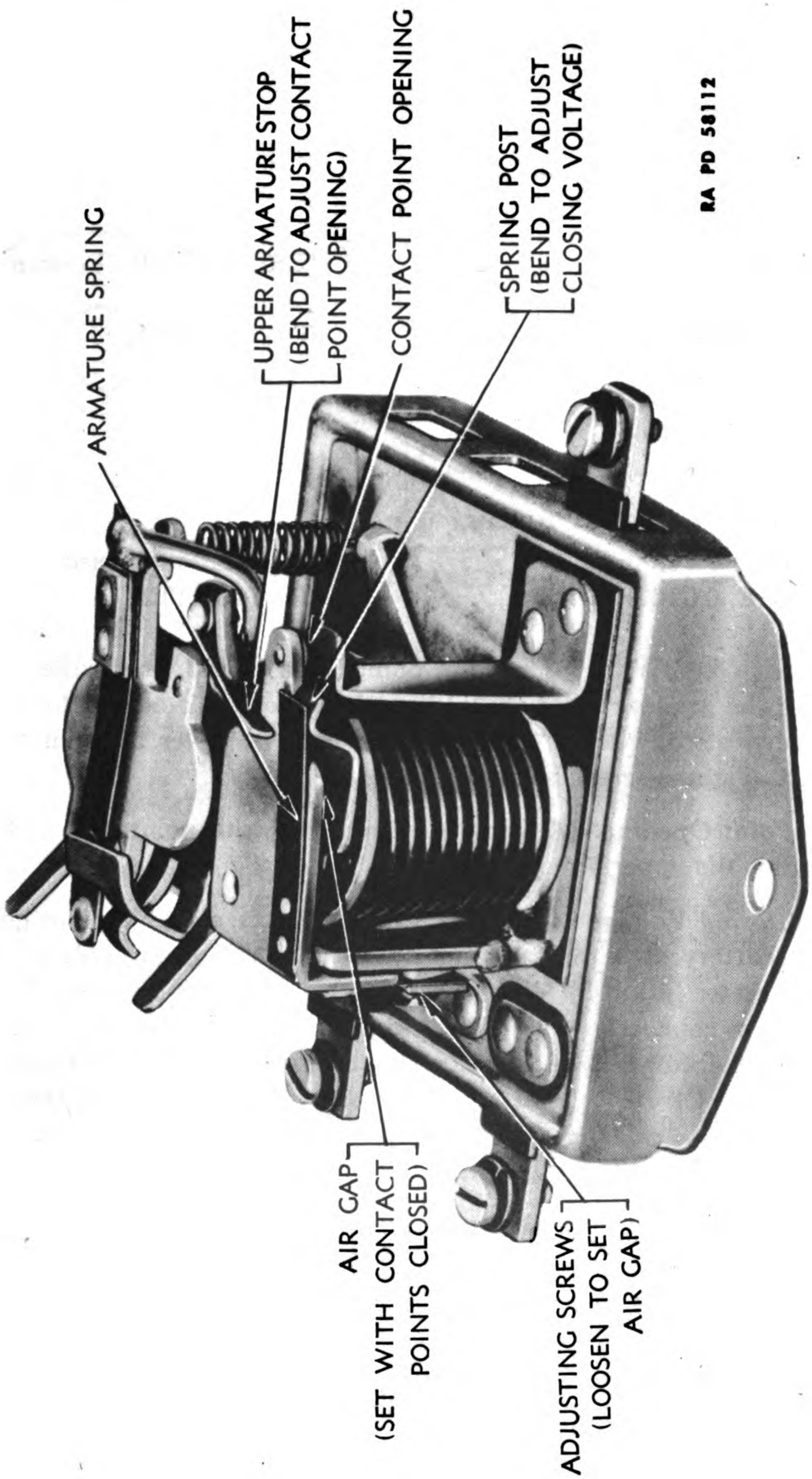


*Figure 120—Cut-Out Relay Adjustments*

## 128. ADJUSTMENT OF GENERATOR REGULATOR.

(Refer to paragraph 121 for specifications.)

**a. Equipment.**

AMMETER
GAGES, as follows:
0.010-in.
0.015-in.
0.020-in.
0.030-in.
0.035-in.
0.045-in.
GAGE, spring, measuring in tenths of an ounce
PLIERS, long-nosed
RESISTANCE, ½-ohm variable
VOLTMETER

**b. Procedure.**

(1) ADJUST CUT-OUT RELAY.

GAGE, 0.015-in.
GAGE, 0.020-in.
PLIERS, long-nosed
VOLTMETER

*(a) Air Gap.* With the contact points held closed, check the air gap between the armature and the center of the core. To adjust, loosen the two screws at the back of the relay and raise or lower the armature as required. Tighten screws securely after adjustment.

*(b) Point Opening.* Measure point opening with points open. Adjust by bending the upper armature stop.

*(c) Closing Voltage* (fig. 127). Connect voltage regulator to generator and battery in normal manner to check relay closing voltage. Connect voltmeter from "GEN" terminal to voltage regulator base. It is not necessary to connect ammeter into circuit as shown unless it is desired to measure generator output. Gradually increase generator speed and note voltage at which relay points close. Adjust by bending up on the spring post to increase the spring tension and raise the closing voltage. Bend down to lower closing voltage.

(2) ADJUST VOLTAGE REGULATOR.

AMMETER
GAGES, as follows:
0.010-in.
0.015-in.
0.030-in.
0.035-in.
0.045-in.
GAGE, spring, measuring in tenths of an ounce
PLIERS, long-nosed
RESISTANCE, ¼-ohm variable
VOLTMETER

## GENERATOR REGULATOR

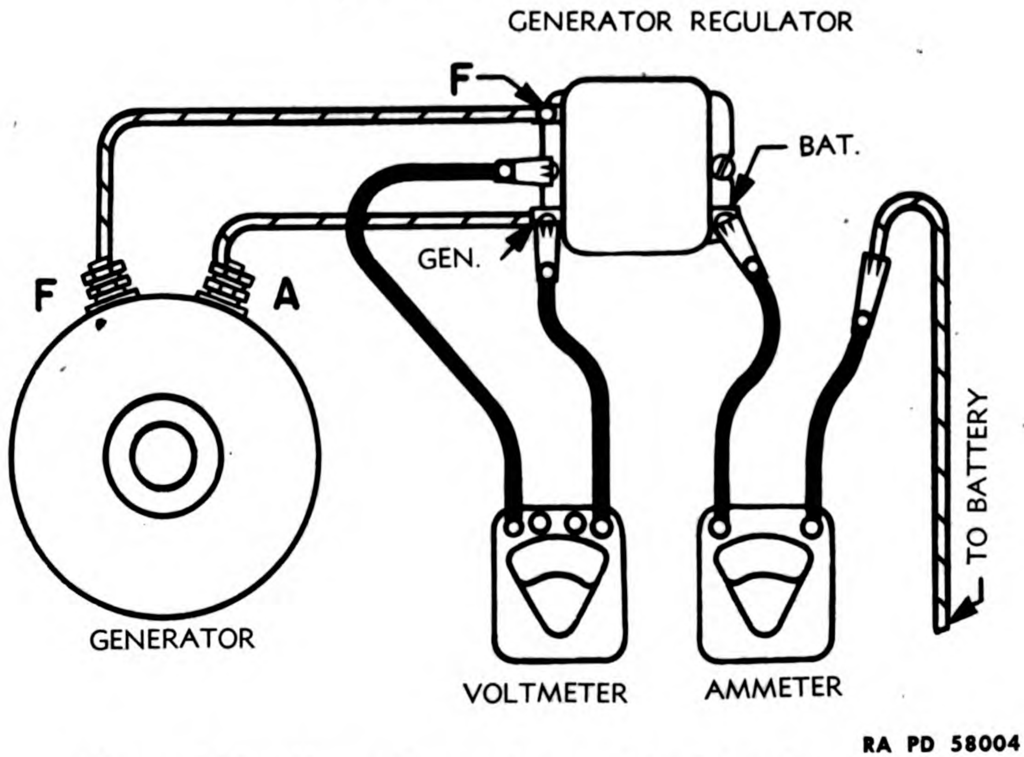


*Figure 121 — Meter Connections to Check Cut-Out Relay*

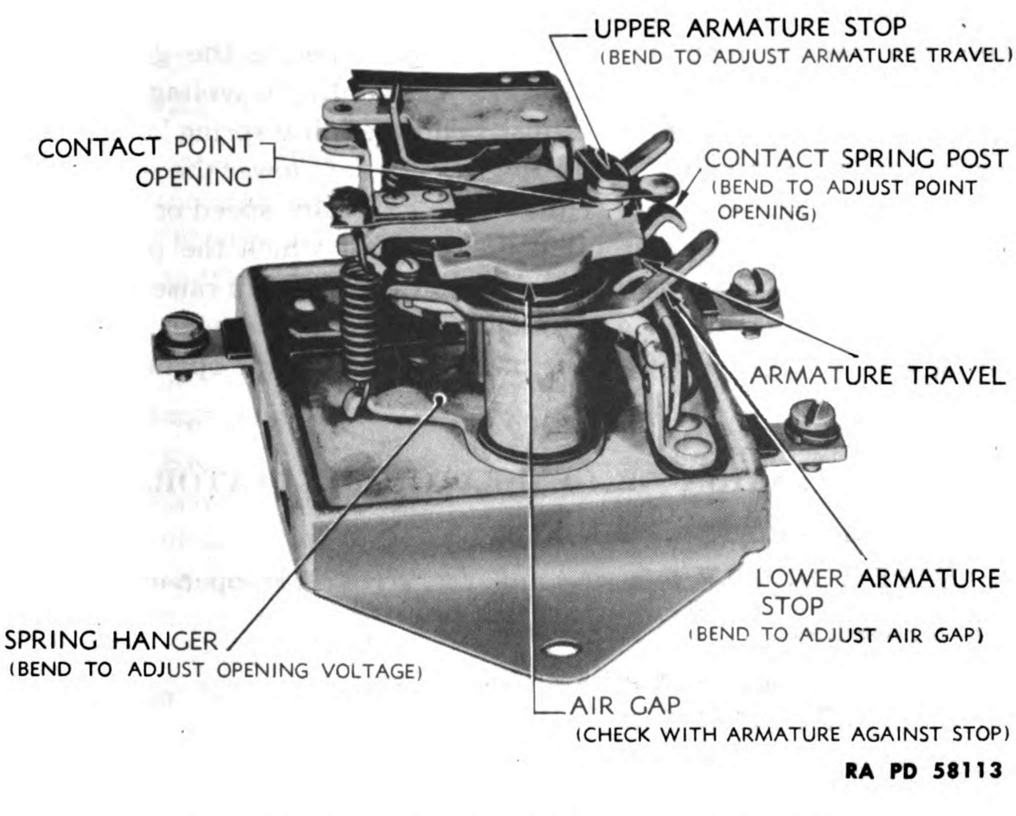


*Figure 122 — Voltage Regulator Adjustments*

*(a) Contact Spring Tension.* The flat contact spring tension is measured at the contacts with the armature up. The pull required to separate the points should be carefully measured. Adjust by slightly bending the flat spring.

*(b) Air Gap.* The air gap is measured with the armature held down against the lower armature stop, between the center of the core and the armature. Bend the lower armature stop to adjust.

*(c) Armature Travel.* Release the armature and gage the travel between the armature and the lower armature stop. Adjust by bending the upper armature stop.

*(d) Point Opening.* With the armature held down against the lower armature stop, measure the contact point opening. Adjust by bending the contact spring post.

*(e) Voltage Setting* (fig. 123). The *opening voltage* of the contact points is checked by connecting the meters and ¼-ohm variable resistance, as illustrated, to the voltage regulator generator and battery. Increase generator speed slowly and note the voltage at which the contact points of the voltage regulator unit open. *Voltage regulator must be at operating temperature and cover must be in place.* If the battery is low, the voltage regulator may not operate. To obtain sufficient voltage to cause the voltage regulator points to open, operate the generator at medium speed and slowly cut in resistance until the voltage regulator points open. Note voltage. To adjust, bend the spiral spring hanger down to increase the opening voltage setting. Bend up to lower the setting. The *closing voltage* is checked by reducing the generator speed or cutting out resistance so the voltage drops to the value at which the points close. Adjust by adjusting the *air gap*. Increase the air gap to raise the closing voltage or decrease the air gap to lower the closing voltage. After readjusting the air gap, readjustment of the contact point opening may be required.

## 129. INSTALLATION OF GENERATOR REGULATOR.

**a. Equipment.**

SCREWDRIVER, 6-in. WRENCH, open-end, 7/16-in.

**b. Procedure.**

(1) INSTALL GENERATOR REGULATOR UNIT.

SCREWDRIVER, 6-in.

Set regulator unit in place on air compressor bracket and insert the two cap screws and tighten. Care should be taken not to short across terminals or ground terminals with screwdriver.

**GENERATOR REGULATOR**

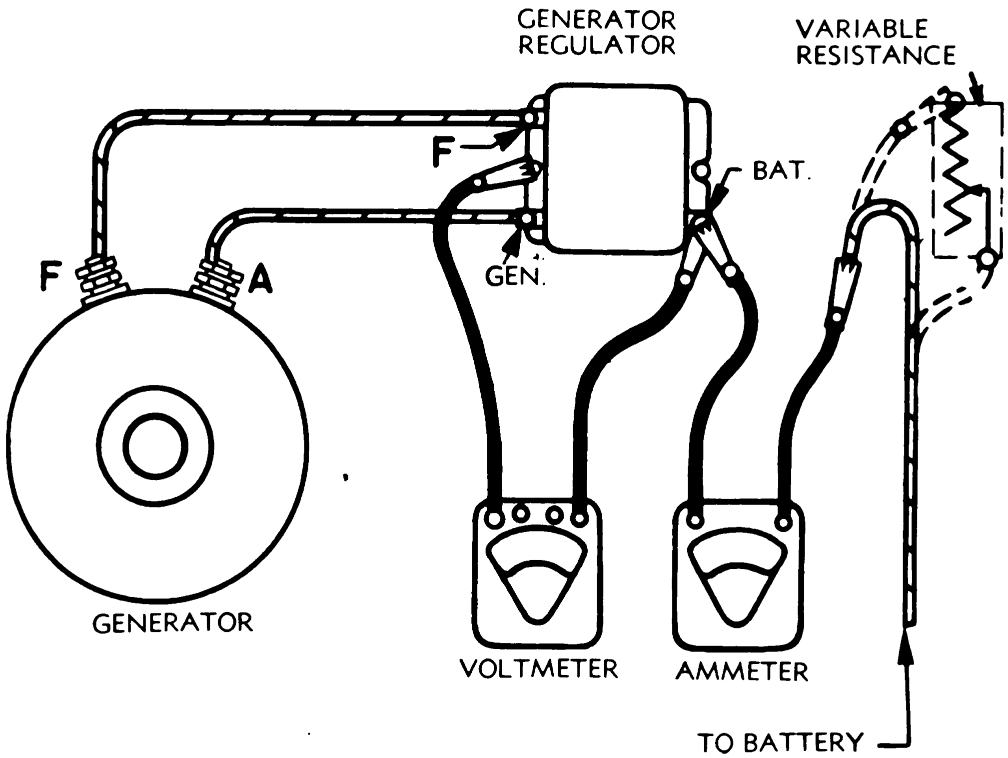


***Figure 123 — Meter Connections to Check Generator Regulator***

(2) CONNECT WIRES.

SCREWDRIVER, 6-in.

Connect wires as follows: Lead from ammeter goes to terminal on voltage regulator unit marked "BAT." Lead from "F" terminal of generator goes to "F" terminal on regulator unit. Lead from "A" terminal of generator goes to "GEN" terminal of regulator unit.

## 130. SPECIAL TOOLS.

**a.** Special tools required are:

AMMETER
GAGE, spring, measuring in tenths of an ounce
GAGES; as follows:
- 0.010-in.
- 0.015-in.
- 0.020-in.
- 0.030-in.
- 0.035-in.
- 0.045-in.

RESISTANCE, ¼-ohm variable
VOLTMETER

## Section II

# STARTING MOTOR



## 131. DESCRIPTION.

**a. General Description.** The starting motor, Delco-Remy #1108714, is an eight-brush, four-pole, heavy-duty unit, with the armature supported by three bushings at the drive end, center and commutator end. The unit has a heavy-duty starting motor switch mounted on it and employs a Dyer drive to mesh the drive pinion with the flywheel for cranking the engine and to demesh the drive pinion when the engine begins to operate. A shift lever in the drive housing is connected to the starting motor rod and pedal which projects through floor plate of cowl. Operation of the shift lever first shifts the drive pinion into mesh and completion of the shift lever movement closes the starting motor switch, so current can flow from the battery to the starting motor, thus enabling cranking of the engine to take place. As soon as the engine operates, the engine drives the pinion back out of mesh so that excessive speeds cannot be transmitted back to the starting motor armature.

## STARTING MOTOR

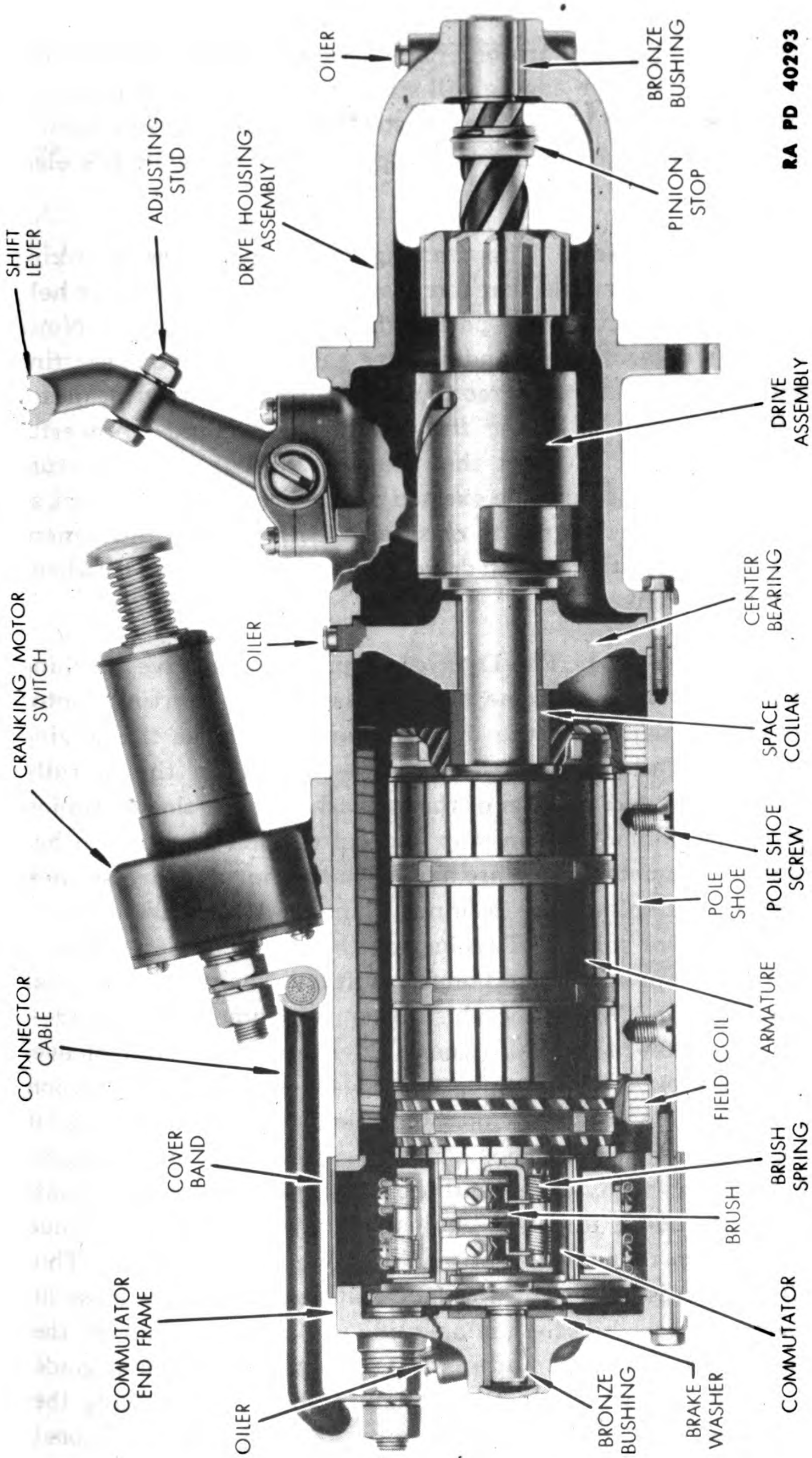


**Figure 124—Cut-Away View of Starting Motor**

**b. Function of Starting Motor.** The starting motor electrically cranks the engine so that the engine will start and run. Current from the vehicle batteries is utilized to operate the starting motor. This current is subsequently replaced in the batteries by operation of the vehicle's electric generator.

**c. Theory of Operation.** The starting motor produces cranking torque by utilizing the principle that force is exerted on a conductor held in a magnetic field when current is passed through the conductor. Numbers of conductors or armature windings are assembled in the starting motor armature. The armature is free to rotate within the starting motor field coils. When current is passed through the field coils, a powerful magnetic field is created. Current then flowing through the armature windings causes a strong force to be exerted on the armature windings, so that the armature is forced to rotate or spin. This rotational movement is transmitted by the starting motor drive pinion to the engine flywheel, so that the engine is cranked.

**d. Dyer Drive** (fig. 125). The Dyer drive provides positive meshing of the drive pinion with the engine flywheel before the starting motor switch is closed and demeshes the drive pinion as soon as the engine begins to operate. The complete drive is assembled on the spirally splined armature shaft and consists of thrust washers, shift sleeve, pinion guide, pinion spring, pinion, pinion stop and cotter pin. The pinion has splines on its inner diameter which are a loose fit on the armature splines. The pinion guide has splines on its inner diameter which are a fairly snug fit on the armature splines. Two lugs on the pinion guide engage in two lateral slots in the pinion. A stud on the shift lever engages in a spiral slot in the shift sleeve. When the shift lever is operated, the stud—resting on a flat portion of the shift sleeve slot—forces the shift sleeve, pinion guide and pinion, endwise, along the armature shaft. If the pinion and flywheel teeth aline, meshing takes place and further movement of the shift lever closes the starting motor switch so that cranking is accomplished. If the pinion and flywheel teeth do not aline and the teeth butt, the drive pinion is caused to rotate against the flywheel teeth without forward movement so that alinement and meshing do take place. This rotation of the pinion is caused by the fact that the pinion is a loose fit on the armature splines, while the pinion guide is a fairly snug fit. As the shift lever movement continues (after the teeth butt) the pinion guide continues to move endwise along the armature shaft, compressing the pinion spring. The pinion guide rotates and transmits this rotational movement—through the pinion guide lugs and slots in the pinion—to the

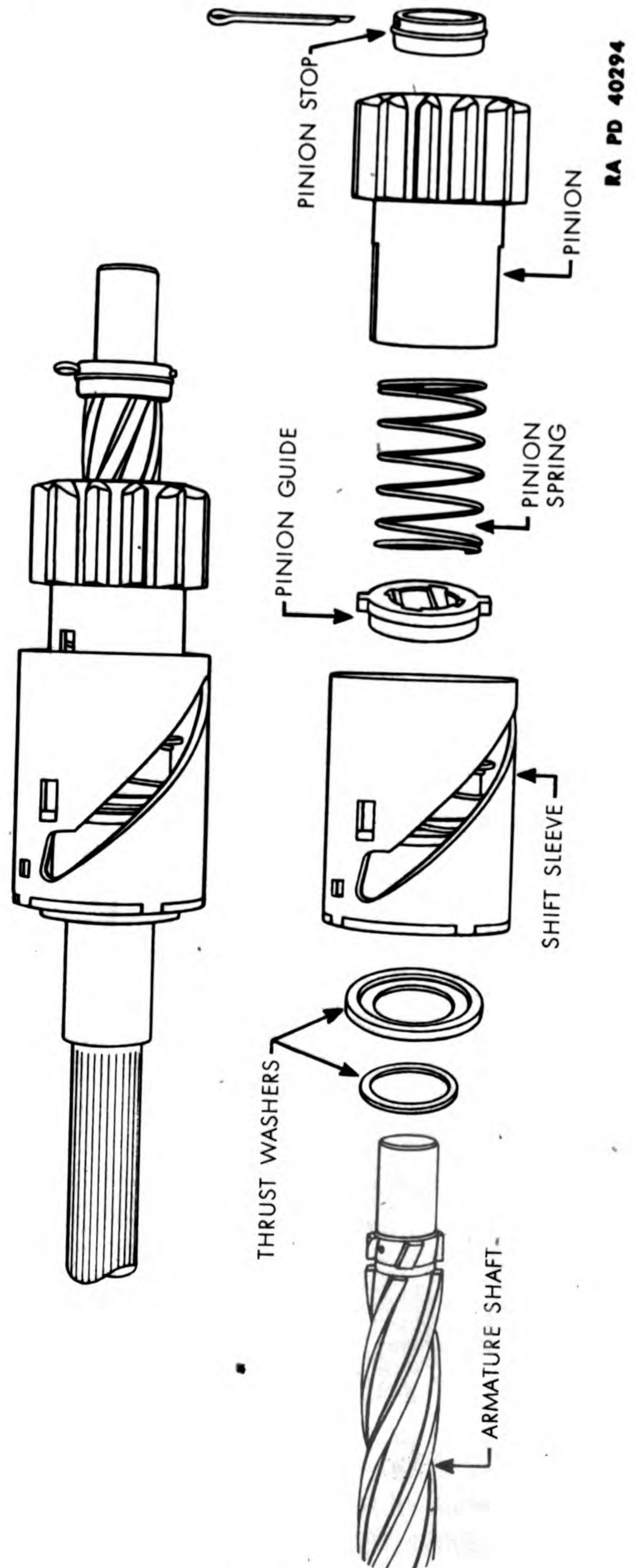


**Figure 125—Details of Dyer Drive Assembly**

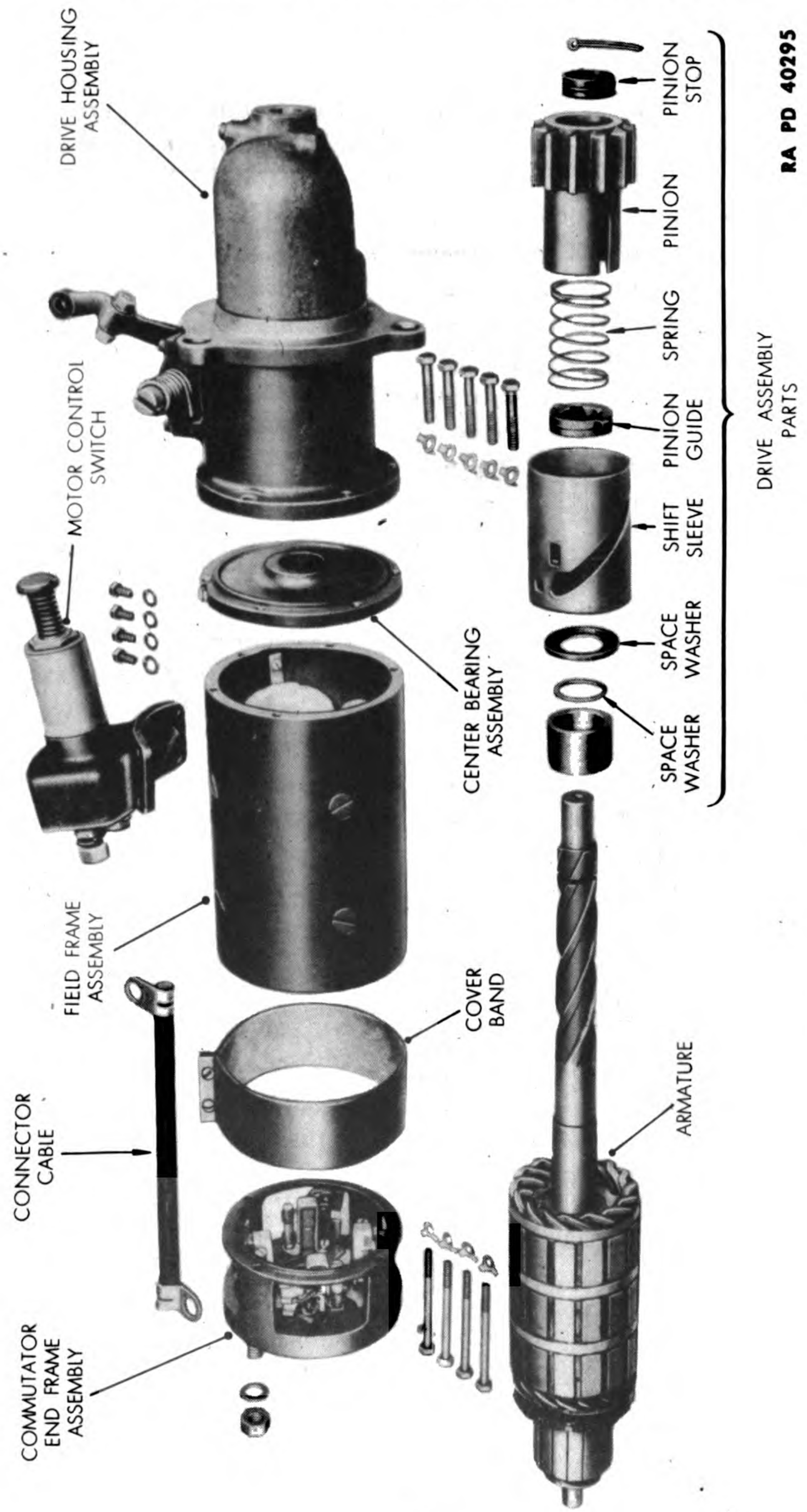


***Figure 126—Starting Motor—Exploded View***

pinion so that it rotates without forward movement. The pinion rotates only a few degrees until the teeth aline and meshing can take place. Then further shift lever movement closes the starting motor switch and cranking is accomplished. As soon as the armature begins to rotate, the shift sleeve spins back out of the way and the driving torque of the armature through the pinion holds the pinion in mesh with the flywheel. When the engine begins to operate, it attempts to drive the starting motor armature, with the result that the pinion is driven faster than the armature is turning and the pinion consequently is spun back out of mesh and returns to the demeshed position. The pinion guide drops into a milled section on the armature splines so that it and the pinion are locked in the demeshed position. Before the pinion can again be shifted into mesh, the shift lever must be released so the stud on the shift lever can rotate the shift sleeve, come to rest again on the flat portion of the shift sleeve slot and then move the entire assembly forward as already described.

e. **Detailed Description** (fig. 126). The starting motor consists of a commutator end frame assembly, field frame assembly, armature, center bearing, Dyer drive component parts, drive end assembly and switch.

(1) COMMUTATOR END FRAME ASSEMBLY (fig. 127). The commutator end frame assembly consists of an end frame with a bushing, terminal and brush plate assembly assembled to it. The brush plate assembly has four pairs of brushes placed 90 degrees apart. Two of the brush sets are connected to the terminal through a ring, while the other two brush sets are insulated from the first two sets and are connected to the field coils by leads. Current from the battery enters the terminal, passes through two brush sets into the armature, from the armature through the other two brush sets, from there through the starting motor field coils, then through ground back to the battery. Springs hold the brushes against the armature commutator with the proper tension to provide good contact. A cover band on the commutator end frame covers windows in the end frame, and can be removed so that the condition of the brushes and commutator may be noted.

(2) FIELD FRAME ASSEMBLY (fig. 128). The field frame assembly consists of four field coils, assembled to the field frame by pole shoes and pole shoe screws. The coils are connected in series by pairs—that is, two of the coils are connected in series, the other two are also connected in series, and both sets are connected in parallel from the brushes to the starting motor frame or ground.

(3) ARMATURE (fig. 126). The armature consists of a shaft on which lamination is pressed. The lamination is laterally slotted and the armature windings are assembled into the slots. The windings are connected

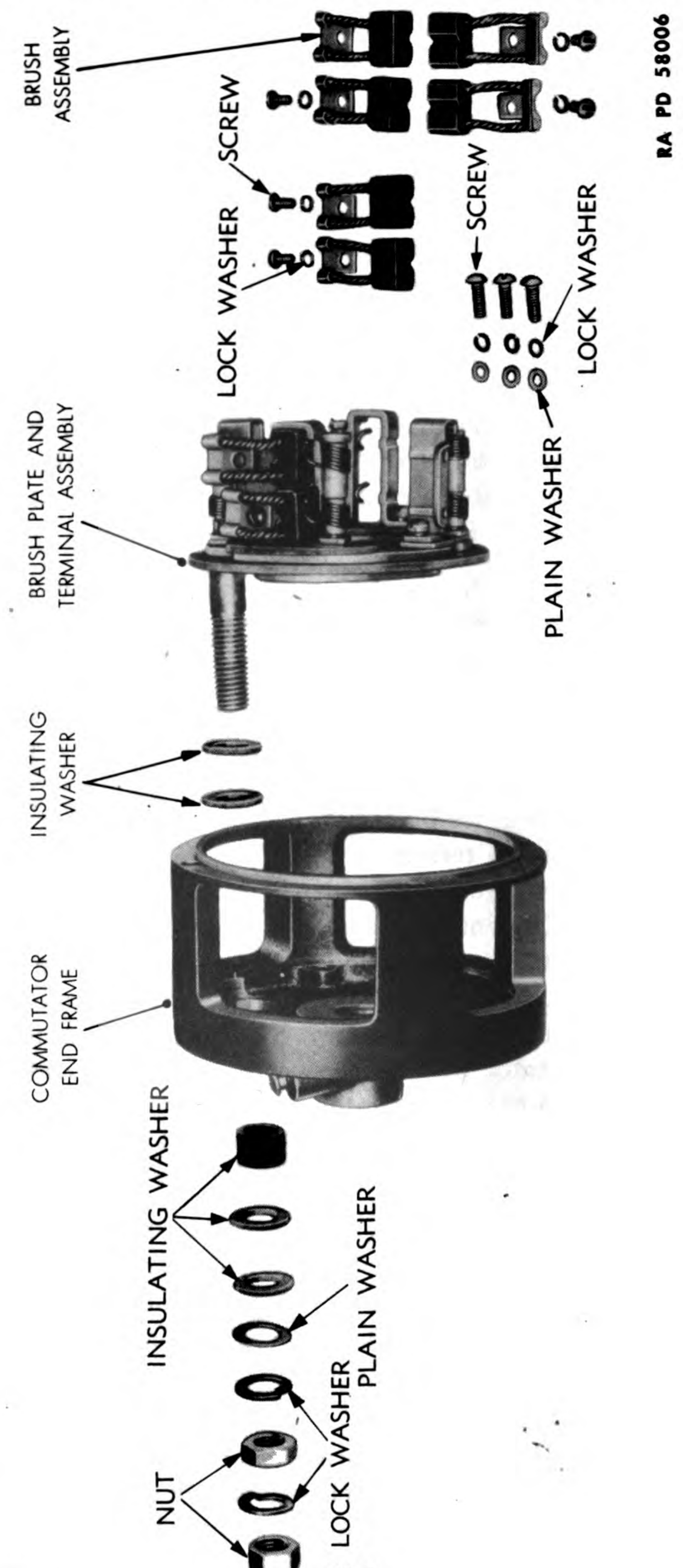


**Figure 127 — Starting Motor Commutator End Frame Assembly — Exploded View**

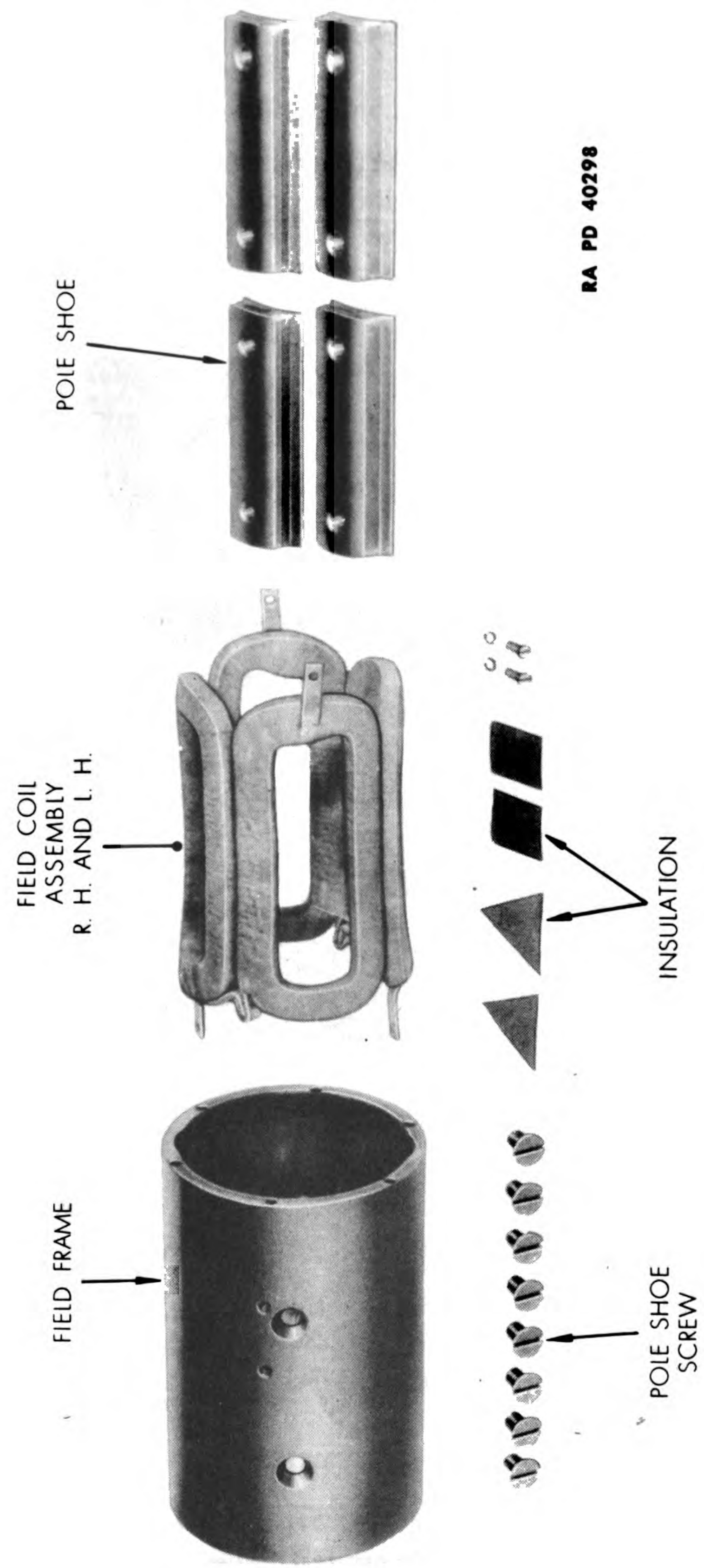


**Figure 128—Starting Motor Field Frame Assembly—Exploded View**

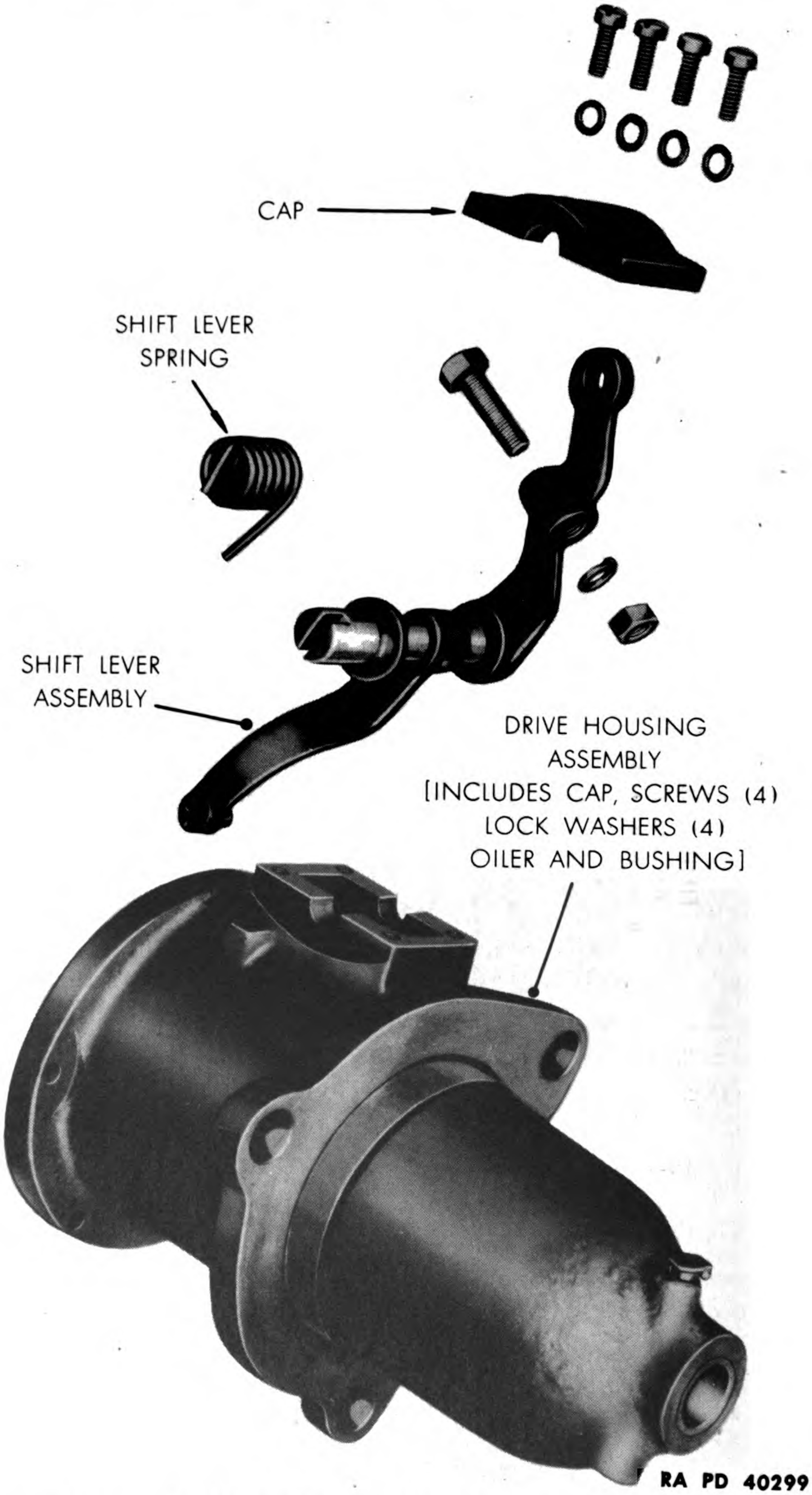


**Figure 129—Starting Motor Drive End Housing Assembly—Exploded View**

to the commutator segments so that current from the brushes can be fed into the windings and back out again. The armature is supported on three bushings and the drive end is spirally splined for the Dyer drive assembly.

(4) DRIVE END HOUSING ASSEMBLY (fig. 129). The drive end housing consists of the drive end housing, bushing and shift lever. The shift lever is assembled to the housing with a cover so that dust cannot enter the housing. A spring is assembled to the shift lever so that the shift lever will be returned to the demeshed position when released.

(5) STARTING MOTOR SWITCH (fig. 130). The starting motor switch mounts on the field frame and consists of two heavy terminals and a heavy contact disk assembled to and insulated from a push rod and push button. Operation of the push button forces the contact disk against the two terminals so the circuit between the battery and starting motor is closed. A quick-break mechanism is incorporated in the switch, the purpose of which is to insure a very rapid breaking of the circuit when the push button is released. Since a high current is taken through the switch, a slow opening of the circuit would permit heavy arcing and rapid burning of the contacts. Quick opening of the circuit reduces arcing to a minimum. Special alloy is used on the contact faces to resist the effects of the arcing which does take place. The quick-break mechanism consists of two triggers and a trigger spring together with a spring, stop washer and release cam on the push-button shaft. When the push button is depressed, the release cam moves out of the way so the triggers can drop down back of the stop flange on the push rod. This holds the contact disk against the terminals with spring pressure until the push button is released. As the push button moves back, the triggers still retain the contact disk firmly against the terminals until such time as the release cam trips the triggers, allowing the spring to release and quickly withdraw the contact disk from contact with the terminals.

## 132. TABULATED DATA.

a. The starting motor specifications are:

| | |
|---|---|
| Clockwise rotation | Viewed from drive end |
| Brush spring tension | 36 to 40 ounces |
| No load | 100 amperes at 11.6 volts at 5,000 revolutions per minute |
| Lock test | 20 lb-ft at 570 amperes at 2.3 volts |

## 133. PREVENTIVE MAINTENANCE.

a. **Operational Maintenance Checks.** Operational maintenance checks may be defined as the checks which may be made during the

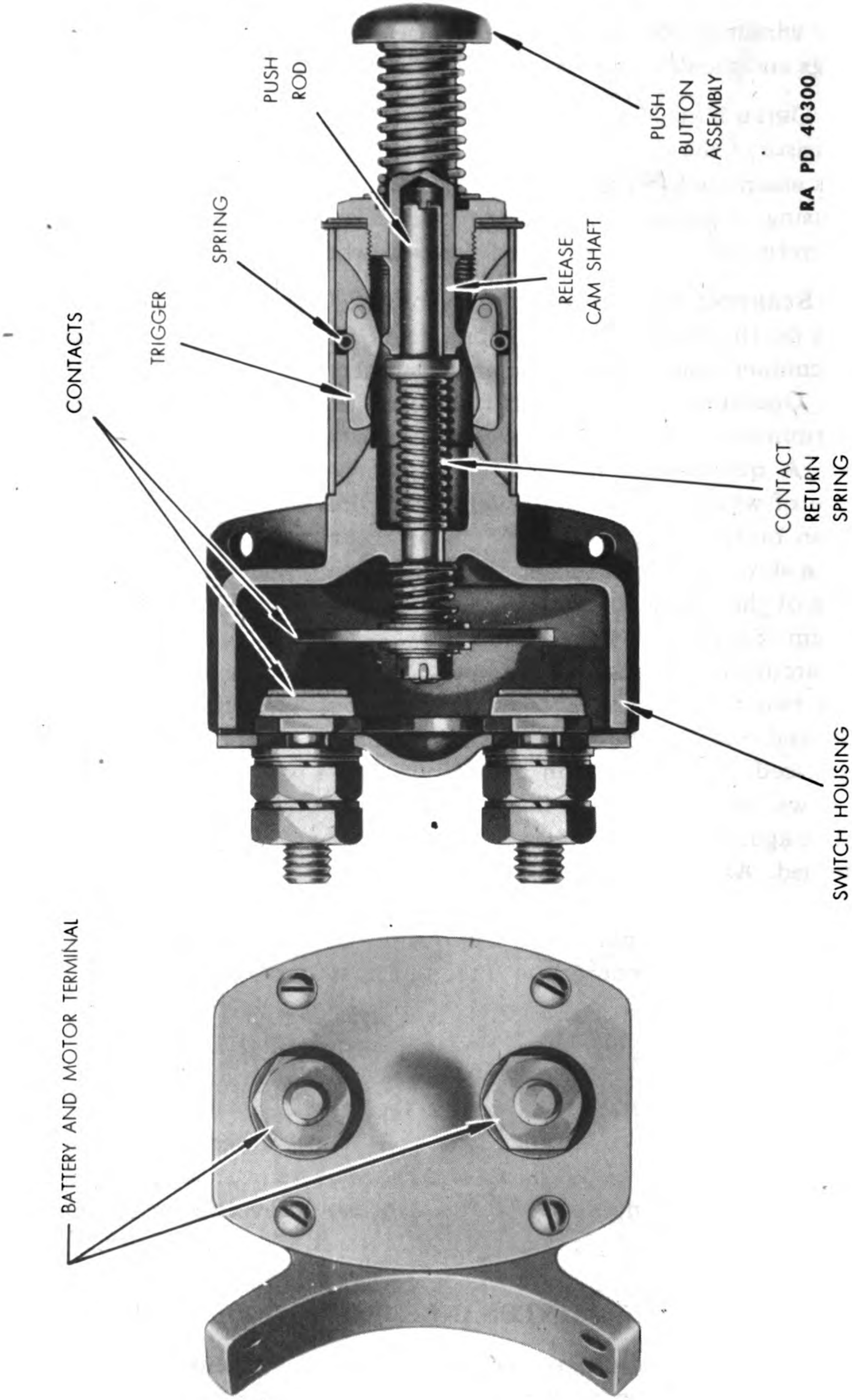


**Figure 130—Cut-Away View of Starting Motor Switch**

operation of the equipment. These checks give the operator some idea as to the condition of the starting motor so that if some abnormal condition of operation is noted, corrections may be made before complete failure of the unit takes place, with a consequent failure to start the engine. During starting, the action of the starting motor should be noted. In normal atmospheric temperatures of around 70 F the starting motor should take hold promptly and spin the engine at normal cranking speeds. In cold weather the engine would, of course, turn over harder and starting motor speed would naturally be decreased. After the engine starts and the starting motor switch is opened, the starting motor should stop operating. If the starting motor cranks the engine slowly or not at all, the equipment should be checked as outlined in paragraph 134. Failure to crank normally can be due to a low battery, defective battery cables, poor connections in the starting motor to battery circuit (including switch) defective starting motor, low temperatures, or various conditions in the engine. CAUTION: The starting motor must never be used for more than 30 seconds at any one time without a pause of several minutes to wait until the starting motor cools off. The starting motor must never be used to move the vehicle. Failure to observe these rules may result in complete failure of the starting motor.

b. **Inspection Checks.** Inspection checks include a periodic investigation every 100 hours of operation of the condition of the battery, battery cables and connections, starting motor switch, commutator, brushes, lead connections and mounting.

(1) BATTERY. The condition of charge of the battery should be noted as outlined in TM 9-787A, section XV, paragraph 86.

(2) STARTING MOTOR SWITCH. The starting motor switch should operate without binding, release the contact disk with a snap when the push button is released and the contact disk should be making good clean contact with the terminals (this to be checked at the periodic tear-down period).

(3) COMMUTATOR. The armature commutator may be observed by removing the starting motor cover band. It should be clean, not out-of-round or excessively worn, without high mica or burned bars. Armature leads must be properly connected to the commutator riser bars, and the banding wire should be in place. Failure to meet these specifications requires that the armature be removed and the commutator serviced as outlined in paragraph 143.

(4) BRUSHES. The brushes must be making good contact with the commutator and must not be worn any shorter than 1/4 inch (from an

original length of ½ inch). If worn down to—or almost to—this length, replace.

(5) LEAD CONNECTIONS. Lead connections must be tight and in good condition.

(6) MOUNTING. Mounting bolts must be tight.

(7) DRIVE ASSEMBLY. The drive assembly cannot be observed with the starting motor mounted on the engine, but its action can be noted by observing the operation of the starting motor as outlined in step **a** of this paragraph.

c. **Periodic Disassembly.** At periodic intervals of 400 hours of operation, the starting motor should be removed from the engine, disassembled and all parts cleaned and inspected as outlined in paragraphs 136 to 143. This guards against failure of the equipment at some critical instant, and must be considered an important part of the preventive maintenance routine.

## 134. TROUBLE SHOOTING.

a. **Slow Starting Motor Speed.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Loose connections. | (1) Tighten connections. |
| (2) Dirty connections. | (2) Clean connections. |
| (3) Defective cables. | (3) Replace cables. |
| (4) Worn brushes. | (4) Replace brushes. |
| (5) Dirty armature. | (5) Clean armature. |
| (6) Worn armature. | (6) Replace armature. |
| (7) Armature rubbing field coils. | (7) Replace bushings. |
| (8) Low battery voltage. | (8) Check generator and generator regulator unit. |
| (9) Discharged batteries. | (9) Test batteries with hydrometer. |
| (10) Lubricating oil too heavy. | (10) See lubrication specifications (TM 9-787A). |
| (11) Cold weather. | (11) See Engine Starting Instructions, TM 9-787A. |
| (12) Frozen or tight bearings. | (12) Check bearings. |
| (13) Loose pole shoe screws. | (13) Inspect starting motor. |

**b. Inoperative Starting Motor.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Battery discharged. | (1) Charge battery. |
| (2) Poor connections. | (2) Clean, tighten. |
| (3) Burned commutator bars. | (3) Recut commutator. |
| (4) Open or short circuits in field or armature. | (4) Eliminate defective condition. |
| (5) Starting motor switch points dirty. | (5) Clean. |
| (6) Defective starting motor switch. | (6) Check contacts. |
| (7) Burned circuit breaker. | (7) Replace. |
| (8) Open circuit between battery and starting motor or in starting motor itself. | (8) Check circuits. |
| (9) Brush leads loose. | (9) Tighten leads. |
| (10) Armature dirty. | (10) Clean armature. |
| (11) Brushes worn or dirty. | (11) Clean or replace brushes. |

## 135. INOPERATIVE OR SLOW CRANKING MOTOR.

**a.** In the event of an inoperative or slow cranking starting motor, a quick check may be made to find the approximate location of trouble by turning on the lights and operating the starting motor. One of three things will happen: The lights will go out, the lights will dim, or the lights will stay bright with no cranking action.

(1) LIGHTS GO OUT. When the lights go out as an attempt to crank is made, it often indicates a defective connection in the circuit between the starting motor and battery. Enough current can get through the bad connection to light the lights, but when the starting motor switch is closed, most of the current which can get through flows through the starting motor, so the lights go out. Not enough current can get through to operate the starting motor. The correction is to clean and tighten the connections and replace any defective cable.

(2) LIGHTS DIM. If the lights dim appreciably when the starting motor is operated and the starting motor operates slowly, it is often an indication of a discharged battery. The discharged battery can supply enough current to light the lights, but throwing the added burden of cranking on the battery causes the voltage to drop off and the lights to dim.

(3) LIGHTS STAY BRIGHT. If the lights stay bright with no cranking action when the starting motor switch is operated, it is an indication of an open circuit between the starting motor and battery, or within the starting motor itself. The circuit and switch should be examined for opens. If current is being delivered to the starting motor, the cover band should be removed and the starting motor brushes, commutator and leads should be examined. The brushes should be making good clean contact with the commutator, the commutator must be clean and the brush leads tight. If the brushes are worn, if the commutator is dirty, gummy, burned or has high mica, then that may be the cause of the open circuit and the proper correction must be made. Worn brushes should be replaced. If the starting motor is considered to be defective and the trouble—brushes, commutator and connections—is not readily apparent, the starting motor should be removed from the vehicle and checked on the no load and torque tests and with a test lamp and points as outlined in following paragraph.

## 136. REMOVAL OF STARTING MOTOR FROM ENGINE.

**a. Equipment.**

PLIERS
WRENCH, 9/16-in.
WRENCHES, two, 3/4-in.
WRENCH, open-end, 15/16-in.
WRENCH, socket, 7/8-in. with long extension

**b. Procedure.**

(1) REMOVE WINCH DRIVE SHAFT GUARD.

WRENCH, 9/16-in.
WRENCHES, two, 3/4-in.

Remove three cap screws from front end of guard (9/16-in. wrench) and three bolts from rear of guard (9/16-in. and 3/4-in. wrenches) and lift off guard.

(2) REMOVE LEFT FRONT FENDER.

WRENCHES, two, 3/4-in.

Remove the three bolts and one cap screw and lock washer, and remove the fender.

(3) DISCONNECT BATTERY CABLE.

WRENCH, 3/4-in.

Disconnect battery cable from starting motor. Tape the end of cable to prevent it from touching metal and shorting. Remove other wires on same post.

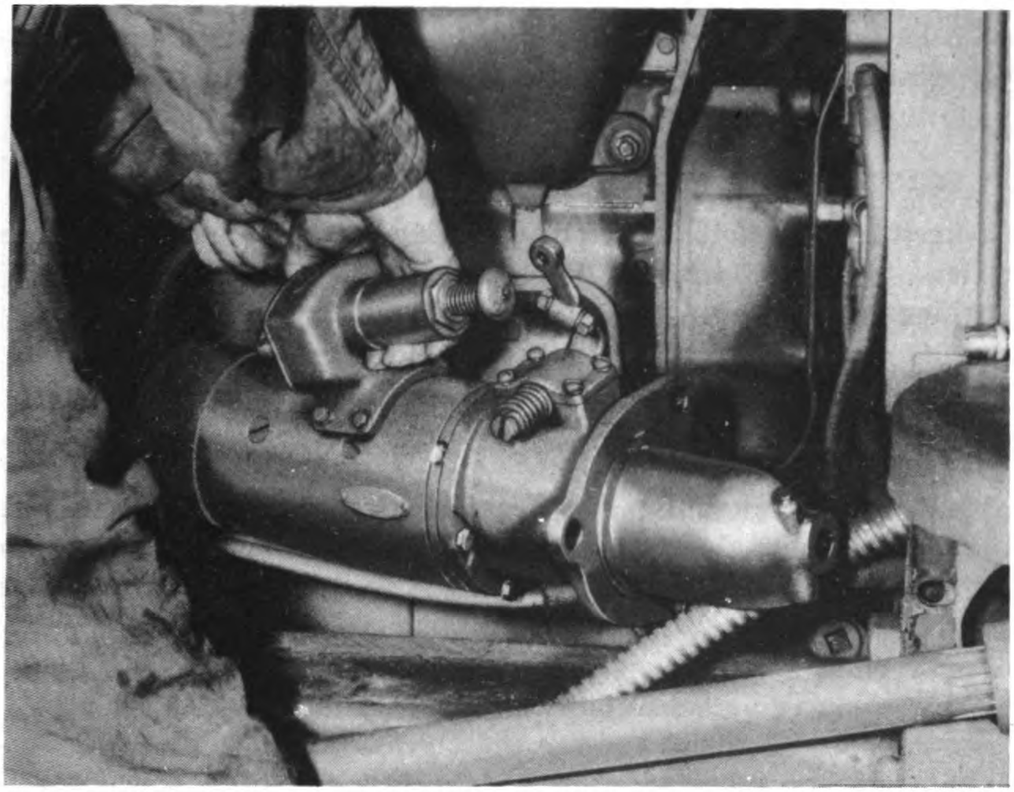

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*Figure 131 — Removing Starting Motor*

(4) DISCONNECT STARTING MOTOR ROD.

PLIERS

Remove pin from yoke of starting motor lever.

(5) REMOVE BOLTS HOLDING STARTING MOTOR.

WRENCH, open-end, 15⁄16-in.

WRENCH, socket, 7⁄8-in., with long extension

Remove the two cap screws (7⁄8-in. socket wrench) and one bolt (15⁄16-in. open-end wrench and 7⁄8-in. socket wrench), holding starting motor to flywheel housing.

(6) REMOVE STARTING MOTOR.

Jar the starting motor loose and remove starting motor from engine.

## 137. DISASSEMBLY INTO MAIN SUBASSEMBLIES (fig. 126).

**a. Equipment.**

HAMMER, ½-lb.
HAMMER, soft
PUNCH, small
SCREWDRIVER, 6-in.
SCREWDRIVER, 8-in.
WRENCH, 7⁄16-in.
WRENCH, ¾-in.

**b. Procedure.**

(1) DETACH CRANKING MOTOR SWITCH.

| | |
|---|---|
| SCREWDRIVER, 8-in. | WRENCH, ¾-in. |

Detach starting motor switch by removing nut (¾-in. wrench) attaching lead to switch terminal. Remove four screws (8-in. screwdriver) attaching switch to field frame, and lift off switch.

(2) DETACH DRIVE HOUSING ASSEMBLY.

| | |
|---|---|
| HAMMER, ½-lb. | PUNCH, small |
| HAMMER, soft | WRENCH, 7/16-in. |

Mark drive housing assembly center bearing and field frame so relationship is established. Bend up tangs on the five locking washers (hammer and punch) and remove five screws (7/16-in. wrench) and locking washers. Tap housing away from field frame (soft hammer).

(3) LIFT OUT ARMATURE.

Armature—with center bearing and Dyer drive assembly—will come out of field frame.

(4) DETACH COMMUTATOR END FRAME ASSEMBLY.

| | |
|---|---|
| HAMMER, ½-lb. | SCREWDRIVER, 6-in. |
| HAMMER, soft | WRENCH, 7/16-in. |
| PUNCH | |

Mark commutator end frame and field frame so relationship is established. Remove cover band by loosening screw (screwdriver). Note relationship of brush leads and brushes. Disconnect two leads from field coil conductors by removing two screws (screwdriver). Bend up tangs on locking washers (hammer and punch) and remove four screws (7/16-in. wrench) and locking washers. Tap commutator end frame assembly free (soft hammer).

## 138. DISASSEMBLY OF COMMUTATOR END FRAME ASSEMBLY.

**a. Equipment.**

| | |
|---|---|
| PRESS, arbor | WRENCH, ¾-in. |
| SCREWDRIVER, 8-in. | |

**b. Procedure** (fig. 127).

(1) REMOVE BRUSH PLATE ASSEMBLY.

| | |
|---|---|
| SCREWDRIVER, 8-in. | WRENCH, ¾-in. |

From terminal, remove nut (3/4-in. wrench) lock washer, lead, nut, lock washer and two insulating washers. Remove three screws (screwdriver) lock washers and flat washers and lift brush plate assembly from commutator end frame assembly. Remove from terminal eight small insulating washers and two large insulating washers.

(2) DISASSEMBLE BRUSH PLATE ASSEMBLY (fig. 132).

Remove six brush lead attaching screws (screwdriver), lift up on brush springs and remove eight brushes. (NOTE: Further disassembly will not be required normally unless insulators, brush holders, springs or plates require replacement.) Remove brush holders to which were attached field coil leads by unscrewing brush spring pin and brush holder screw (screwdriver). Two springs will come off with each brush spring pin. There are lock washers under the pin and screw. Parts will come off in the following order: brush holder, thin spacer plate, brush holder insulating plate, four insulating washers, and—from opposite side—brass brush holder support plate and brush plate insulating plate. Remove other two brush holders from brush plate and stud assembly by unscrewing brush spring pin and brush holder screw (screwdriver). Under each will be a lock washer. Brush holders and thick spacer plate will come off. Two brush springs will come off on pin.

(3) PRESS OUT COMMUTATOR END FRAME BUSHING.

PRESS, arbor

If the bushing is worn, it may be pressed out and a new one installed. The plug must first be removed. Install new oil wick and oiler as required.

(4) BRAKE WASHER.

Remove old brake washer and install new one (shellac in place), if necessary.

## 139. DISASSEMBLY OF FIELD FRAME ASSEMBLY.

**a. Equipment.**

SCREWDRIVER, 6-in.

SCREWDRIVER, pole shoe

**b. Procedure** (fig. 128).

(1) DISCONNECT FIELD COILS FROM FIELD FRAME.

SCREWDRIVER, 6-in.

Disconnect field coils from field frame, by removing screws and lock washers.

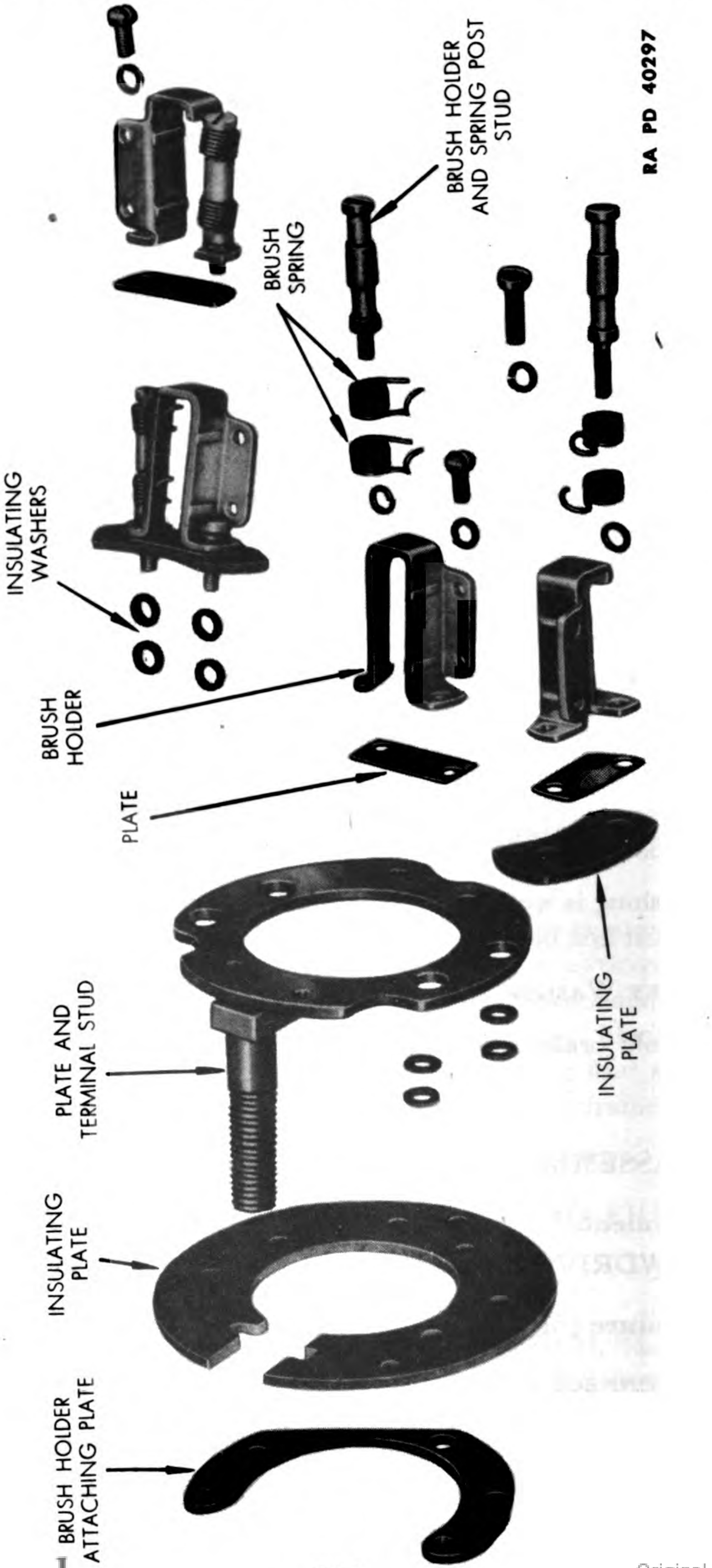



**Figure 132—Starting Motor Brush Plate Assembly—Exploded View**

(2) REMOVE FIELD COILS FROM FRAME.
SCREWDRIVER, pole shoe

Remove field coils from field frame by removing eight pole shoe screws, four pole shoes and coils. Be careful with coils to avoid bending lead connections or damaging insulation.

## 140. DISASSEMBLY OF DRIVE END FRAME ASSEMBLY.

**a. Equipment.**

PRESS, arbor
SCREWDRIVER, 8-in.

**b. Procedure** (fig. 129).

(1) REMOVE SHIFT LEVER ASSEMBLY.
SCREWDRIVER, 8-in.

Remove shift lever assembly by unscrewing four screws and removing lock washers, cover, shift lever assembly and shift lever return spring.

(2) PRESS OUT BUSHING.
PRESS, arbor

If the bushing is defective, it may be pressed out and a new one installed. Install new wick and oiler as required.

## 141. DISASSEMBLY OF DYER DRIVE ASSEMBLY.

**a. Equipment.**

PLIERS
PRESS, arbor

**b. Procedure** (fig. 125).

(1) REMOVE DYER DRIVE PARTS FROM ARMATURE SHAFT.
PLIERS

Remove cotter pin, pinion stop, pinion, pinion spring, shift sleeve, two thrust washers, center bearing assembly and collar, from armature shaft, in order named. After cotter pin has been removed, pinion stop must be rotated until notches register with shaft splines before it can be removed. Rest of assembly slides off easily (press against shift sleeve).

(2) REPLACE BUSHING IN CENTER BEARING, IF NECESSARY.
PRESS, arbor

Replace wick and oiler, as required.

## 142. DISASSEMBLY OF STARTING MOTOR SWITCH.

**a. Equipment.**

PLIERS
SCREWDRIVER, 8-in.
WRENCH, 7/16-in.
WRENCH, 3/4-in.
WRENCH, 1 1/4-in.

**b. Procedure** (fig. 133).

(1) REMOVE TERMINAL PLATE ASSEMBLY.

SCREWDRIVER, 8-in.

Remove four screws and lift off terminal plate assembly.

(2) DETACH PUSH BUTTON AND SHAFT ASSEMBLY.

WRENCH, 1 1/4-in.

Unscrew push-button shaft nut and remove push button and shaft assembly, flat washer, gasket and sleeve from housing.

(3) DETACH CONTACT DISK.

PLIERS
WRENCH, 7/16-in.

Remove cotter pin (pliers) unscrew castellated nut (7/16-in. wrench) and lift off—in the order named—contact disk, spring retainer cupped washer, spring and spring retainer cupped washer. Remove spring and push rod from opposite end of housing.

(4) DISASSEMBLE TERMINAL PLATE ASSEMBLY.

WRENCH, 3/4-in.

Disassemble terminal plate assembly further, if necessary, by removing gasket, and removing from each terminal stud, nut, lock washer, washer, large insulating washer, small insulating washer, terminal plate and terminal stud insulating plate.

(5) DETACH TRIGGERS.

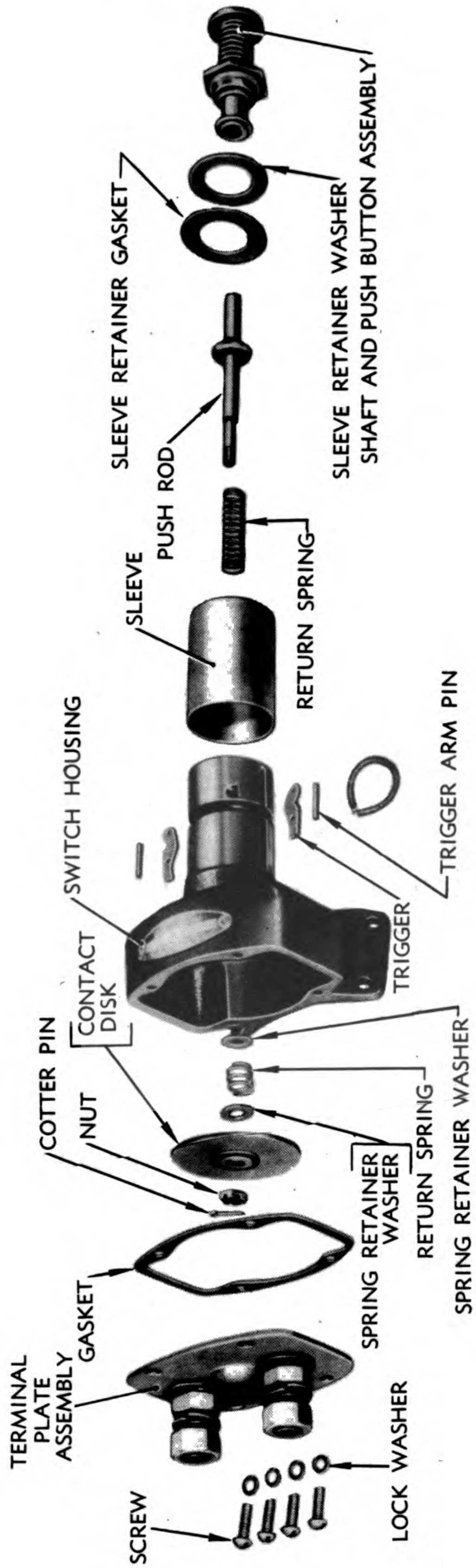
Remove coil spring from undercut in housing. With piece of stiff wire, push out two trigger pins. Triggers will come out.

## 143. INSPECTION AND REPAIR.

**a. General.** After disassembly, all parts should be cleaned and examined, and defective parts replaced. The procedure of cleaning and inspecting parts is given in the following paragraphs.

**b. Armature.** Do not clean the armature by any degreasing method, since this would damage the insulation and might ruin the armature.

## STARTING MOTOR




RA PD 58007

***Figure 133 — Starting Motor Switch — Exploded View***

Wipe with a clean cloth *slightly* dampened with CARBON TETRACHLORIDE or similar solvent. If commutator is rough, out-of-round, has high mica, filled slots, or is burned, it must be turned down in a lathe and the mica undercut. The shaft splines should not be worn excessively and the undercut into which the pinion stop fits must provide a snug fit for the pinion stop. Armature may be checked or repaired for ground, open or short circuit as follows:

(1) GROUND. Check with test lamp and test points from the commutator to the armature shaft or lamination. If the lamp lights—indicating ground—and if the ground is not readily apparent and repairable, the armature must be replaced.

(2) OPEN. An open circuited armature is often easy to detect, since this condition produces some badly burned commutator bars while other bars are fairly clean. The bars connected to the open armature windings soon burn in operation since every time they pass under the brushes they interrupt a flow of current so that heavy arcing occurs. The open will usually be found at the commutator riser bars and is often a result of excessively long cranking periods which overheat the unit and cause the connections to become bad. If the bars are not too badly burned the armature may often be saved by placing the armature in a lathe and turning down the commutator. This may also be done and should be done for a commutator that is worn, dirty, out-of-round, has high mica, or filled slots. Make cut no deeper than necessary. Minimum diameter of commutator should be 2 inches (original 2⅛-in.). If it is necessary to turn commutator down below this diameter, discard armature. Undercut mica $\frac{1}{32}$ inch (fig. 115).

(3) SHORT. A shorted armature may be detected on a growler. The growler is a strong electromagnet connected to a source of alternating current. When a shorted armature is placed on the growler, and a hacksaw blade held above the shorted coils in the armature, the blade will be alternately attracted to and repelled from the armature, causing the blade to buzz against the armature. Before discarding an armature testing shorted, inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts adjacent bars.

(4) ARMATURE BANDING WIRE LOOSE. If the banding wire has loosened, it may sometimes be repaired by rewrapping tightly and resoldering (silver solder).

c. **Fields.** The fields should not be cleaned by any degreasing method, since this would damage the insulation and might ruin the windings. Clean by wiping with a clean, dry cloth. Be careful in handling the windings to avoid breaking or weakening the connecting straps between windings. If the field insulation is charred or chafed so that the windings are exposed, it is sometimes possible to rewrap them with insulating tape and paint them with insulating compound. It must be remembered that if the wrapping is done carelessly so the insulation bulks up too large, it will be impossible to reassemble the coils under the pole shoes. All soldered connections should be made with rosin-flux solder.

d. **Brushes.** If the brushes are worn down to 1/4 inch (original length 1/2-in.) replace. Make sure that the pig tail leads are tight in the brushes and that the clips are fastened well to the leads.

e. **Brush Springs.** The brush springs should have sufficient tension to provide the proper pressure between the brushes and commutator after the unit is assembled. This may be checked by placing the armature and commutator end frame together in their normal operating position and then placing the brushes in their holders with the springs in place so that the tension of the springs against the brushes can be measured with a spring gage. Replace springs if the tension is not correct.

f. **Bushings.** If the bushings are worn, they should be replaced. Wear will not be even, but on the side which sustains the greatest thrust during cranking. If new bushings are installed, they should be finished as follows:

| | |
|---|---|
| Commutator end | Ream and burnish to 0.562 to 0.564 inch |
| Center bearing | Ream and burnish to 1.122 to 1.125 inch |
| Drive housing | Ream and burnish to 0.7805 to 0.7825 inch |

After a bushing is pressed in and reamed to size, the oil wick hole must be drilled out. This throws up a bur, which must be removed with burnishing tool of the same size as the reamer. Bushings must be reamed concentric with machined registers on castings.

g. **Brush Holders.** If the brush holders, spacer plates, insulators, etc., are warped, cracked, burned or otherwise damaged, replace.

h. **Starting Motor Switch.** The switch contacts should be clean, and the springs sufficiently strong to provide normal pressure between the contact disk and terminals.

i. **Dyer Drive Parts.** Pinion stop must not be worn and on assembly must fit in shaft undercut snugly. Pinion teeth must not be worn, burred or chipped excessively. Shift sleeve assembly must be in good condition, with parts tightly fastened together.

j. **Miscellaneous.** Any defective insulator, screw, washer, lead, stud, plate, etc., should be replaced. Cracked, bent, worn, burned insulators or washers are defective. Studs or screws which are bent, battered, broken, or which have crossed or damaged threads, are defective. Leads which have broken strands and frayed insulation are defective.

**k. Bearing Fits.** The armature shaft bearings and bushings measure as follows:

| | Drive End | Center Bearing | Commutator End |
|---|---|---|---|
| BUSHING .......... | 0.7805 to 0.7825 | 1.122 to 1.125 | 0.562 to 0.564 |
| SHAFT .............. | 0.778 to 0.779 | 1.112 to 1.113 | 0.5595 to 0.5605 |

## 144. ASSEMBLY OF STARTING MOTOR SWITCH.

**a. Equipment.**

PLIERS
SCREWDRIVER
WRENCH, 7/16-in.
WRENCH, 3/4-in.
WRENCH, 1 1/4-in.

**b. Procedure.**

(1) INSTALL TRIGGERS.

Install triggers in housing and secure with pins. Place spring in undercut in housing.

(2) ASSEMBLE TERMINAL PLATE ASSEMBLY.

WRENCH, 3/4-in.

On terminal studs place, in the order named, terminal stud insulating plate, terminal plate, small insulating washer, large insulating washer, washer, lock washer and nut. Contacts on stud heads should be positioned so maximum area will contact the contact disk.

(3) ATTACH CONTACT DISK.

PLIERS
WRENCH, 7/16-in.

Coat stop flange on push rod with petrolatum and put spring and push rod in housing. On threaded end of rod (opposite end), place spring retainer cupped washer, spring, spring retainer cupped washer, contact disk, nut and cotter pin (pliers). Cups in washers must face spring. Run nut down until castellations clear cotter pin hole in push rod (7/16-in. wrench).

(4) ATTACH PUSH BUTTON AND SHAFT ASSEMBLY.

WRENCH, 1 1/4-in.

Apply COMPOUND, joint and thread, type B, to bottom inside surface of sleeve. Put sleeve on housing. Coat shaft with petrolatum, place gasket and flat washer on housing, insert push button and shaft assembly and secure by running down nut.

(5) ATTACH TERMINAL PLATE ASSEMBLY.

SCREWDRIVER, 8-in.

Attach terminal plate assembly with four screws and lock washers. Plate may be ground off to match curvature of switch mounting bracket. Be sure this part of plate is assembled to conform with curvature.

## 145. ASSEMBLY OF DYER DRIVE ASSEMBLY (figs. 125 and 126).

**a.** Place on the armature shaft in the order named collar, center bearing assembly, small thrust washer, large thrust washer, shift sleeve, pinion guide, pinion spring, pinion, pinion stop and cotter pin. Side of center bearing assembly which projects most goes toward armature. Cupped side of large thrust washer is away from armature. Pinion guide is placed on shaft with lugs toward pinion (see fig. 125). Make lugs on pinion guide engaged in pinion slots by holding pinion guide near end of shaft, placing pinion spring in pinion and starting pinion on splines with pinion guide lugs engaged in pinion slots. Push pinion on shaft. With pinion stop in place, turn until holes aline, insert cotter pin and secure (pliers).

## 146. ASSEMBLY OF DRIVE END FRAME ASSEMBLY.

**a. Equipment.**

PLIERS — SCREWDRIVER, 8-in.

**b. Procedure** (fig. 129).

Place cover on shift lever and assemble to drive end frame with four screws and lock washers (screwdriver). Place spring on shift lever shaft with long tang on drive end frame boss. Catch other end of spring, twist it in a counterclockwise direction and drop end into slot in end of shaft (pliers).

## 147. ASSEMBLY OF FIELD FRAME ASSEMBLY.

**a. Equipment.**

SCREWDRIVER, 6-in. — SPREADER, pole shoe
SCREWDRIVER, pole shoe

**b. Procedure** (fig. 128).

Place field coils in position in frame with pole shoes, insert pole shoe spreader, tighten and, with pole shoe screwdriver, tighten pole shoe screws (two per pole shoe). Fasten coil leads to frame with screws and lock washers (screwdriver).

## 148. ASSEMBLY OF COMMUTATOR END FRAME ASSEMBLY.

**a. Equipment.**

SCREWDRIVER, 6-in.
SCREWDRIVER, 8-in.
WRENCH, ¾-in.

**b. Procedure** (figs. 127 and 132).

(1) Assemble Brush Plate Assembly.

SCREWDRIVER, 6-in.

Fasten two brush holders to brush plate and stud assembly with brush spring pins and brush holder screws. One brush holder is assembled directly above stud, while other is assembled 180 degrees from it. Use pins and screws with short threaded section. Thick spacers go under holders and lock washers go under screws and pins. Springs should go on pins with hooked ends toward brush plate and down in holders. Put insulating plate in position on opposite side of brush plate and stud assembly and place brass brush holder support plate next to it. Secure by fastening other two brush holders with pins and screws. Two insulating washers go in each screw hole to insulate pins and screws from plate and stud assembly. Above these go the insulating plate, thin spacer washer, brush holder, lock washers, pin and screw. Springs should go on pins with hooked ends toward brush plate and down in holders. Place eight brushes in holders and secure six of the brush lead clips to brush holders with screws and lock washers. Do not install the two screws which also fasten field leads to holders. (These are the outside holders 90 degrees from stud.)

(2) Attach Brush Plate Assembly.

SCREWDRIVER, 8-in.
WRENCH, ¾-in.

Place two large insulating washers and eight small insulating washers on terminal studs. Put brush plate assembly in position in commutator end frame and secure with three screws (screwdriver) and lock washers. Place on terminal stud two insulating washers, flat washer, lock washer, nut (¾-in. wrench), lead, lock washer and nut.

## 149. ASSEMBLY OF STARTING MOTOR.

**a. Equipment.**

HAMMER, ½-lb.
PUNCH
SCREWDRIVER, 6-in.
SCREWDRIVER, 8-in.
WRENCH, 7/16-in.
WRENCH, ¾-in.

**b. Procedure** (fig. 123).

(1) ATTACH COMMUTATOR END FRAME AND FIELD FRAME.

HAMMER, ½-lb. | SCREWDRIVER, 6-in.
PUNCH | WRENCH, 7/16-in.

Place commutator end frame and field frame together in correct relationship according to markings made during disassembly. Fasten with four screws and locking washers (7/16-in. wrench). Use *new* locking washers. Bend one tang up against screwhead. Bend other tang down against frame (punch and hammer). Connect two field coil leads to brush holders with screw and lock washer. This also fastens brush lead clips to brush holders (screwdriver).

(2) PUT ARMATURE IN POSITION.

SCREWDRIVER, 6-in.

Armature—with center bearing and Dyer drive—may be placed in position with the commutator end of the shaft in the commutator and bearings. Lift up the eight brushes and cock them in their holders so they will be up out of the way of the commutator while this is being done. Then drop brushes down on commutator, put cover band on and secure with screw.

(3) ATTACH DRIVE HOUSING ASSEMBLY.

HAMMER, ½-lb. | WRENCH, 7/16-in.
PUNCH

Put drive housing assembly in position on field frame. Bring in housing at an angle so the stud on the shift lever can engage the slot in the shift sleeve. Establish correct relationship of field frame, center bearing, and drive housing as determined by markings made on disassembly. Secure with five screws (7/16-in. wrench) and locking washers. Bend one tang of lock washers up against screwhead and other down against housing (hammer and punch).

(4) ATTACH STARTING MOTOR SWITCH.

SCREWDRIVER, 8-in. | WRENCH, ¾-in.

Attach starting motor switch to field frame with four screws and lock washers (screwdriver). Attach lead clip to terminal stud with lock washer and nut (¾-in. wrench).

## 150. TESTING STARTING MOTOR.

**a. Equipment.**

AMMETER, high reading | INDICATOR, rpm
BATTERY | VOLTMETER
EQUIPMENT, torque testing

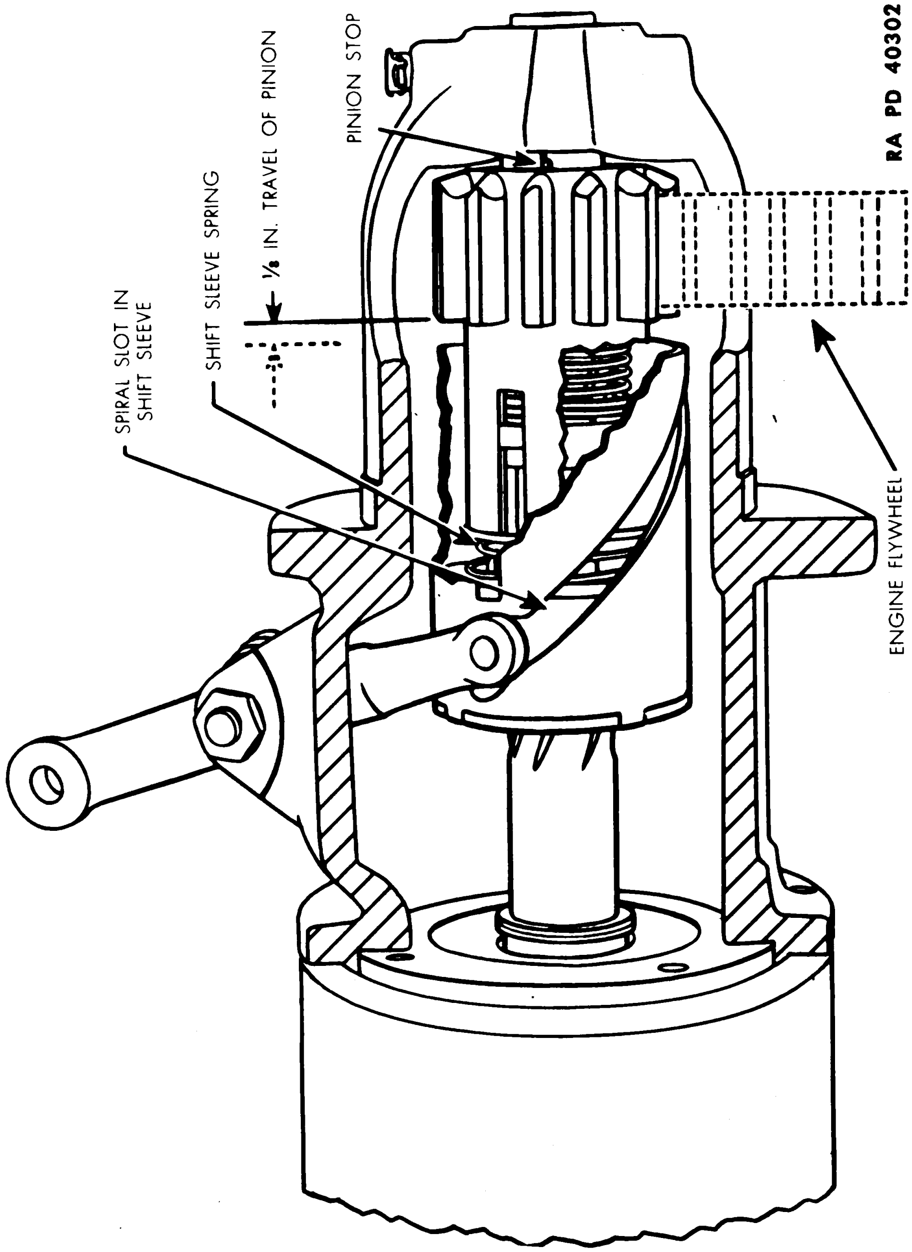



***Figure 134—Dyer Drive Adjustment***

**b. Procedure.**

(1) DYER DRIVE ADJUSTMENT.

When the shift lever has moved back against the starting motor switch and completed its travel so that the pinion is in the engaging position, it should be possible to move the pinion back 1/8 inch to 3/16 inch against the pinion spring as indicated in figure 124. This travel can be adjusted by loosening the lock nut on the shift lever and turning the screw in or out as required. Adjustment must be accurate, since improper adjustment might put sufficient thrust against the pinion guide lugs to break them off.

(2) NO LOAD TEST.

Connect the starting motor in series with a battery of the specified voltage and an ammeter capable of reading several hundred amperes. If a revolutions per minute indicator is available, read the armature revolutions per minute as well as the current draw with the unit running free speed or no load.

(3) TORQUE TEST.

Torque testing equipment is required for conducting a stall torque test of the starting motor. The torque developed, current draw and voltage are checked together.

(4) INTERPRETATION OF NO LOAD AND TORQUE TESTS.

*(a)* Rated torque, current draw, and no load speed indicate normal condition of the starting motor.

*(b)* Low free speed and high current draw with low developed torque may result from:

*1.* Tight, dirty, worn bearings, loose field poles which allow armature to drag.

*2.* Grounded armature or field. Check by raising brushes from armature commutator and testing with test lamp and points from starting motor terminal to frame and from commutator to frame. If the lamp lights, a ground exists. To check the fields for ground, the two field grounding screws at the opposite end of the field frame from the commutator must be removed and the fields then checked with the test points for ground.

*3.* Shorted armature. Check armature on growler.

*(c) Failure to Operate with High Current Draw.*

*1.* Direct ground in switch, at terminal or brushes.

*2.* Frozen shaft bearings which prevent armature from turning.

*(d) Failure to Operate with No Current Draw.*

*1.* Open field circuit. Trace with test lamp and points.

*2.* Open armature coils. See paragraph 143 for further data on this matter.

*3.* Broken or weakened brush springs, worn brushes, high commutator mica, or other conditions which would prevent good contact between brushes and commutator.

*(e) Low No Load Speed with Low Torque and Low Current Draw Indicates:*

*1.* Open field. Trace circuit with test lamp and points.

*2.* High internal resistance due to worn brushes, dirty commutator or weak or worn brush springs and other causes of poor contact between commutator and brushes.

*3.* Defective leads and connections.

*(f)* High free speed with low developed torque and high current draw indicates shorted fields. It is difficult to detect shorted fields with ordinary testing instruments, since the field resistance is originally low. If shorted fields are suspected, install new fields and check for improvement in performance.

## 151. INSTALLATION OF STARTING MOTOR.

**a. Equipment.**

PLIERS
WRENCH, 9/16-in.
WRENCHES, two, 3/4-in.
WRENCH, open-end, 15/16-in.
WRENCH, socket, 7/8-in., with long extension

**b. Procedure.**

(1) BOLT STARTER IN PLACE.

WRENCH, open-end, 15/16-in.
WRENCH, socket, 7/8-in., with long extension

Clean off mounting flange of starting motor and housing, set starting motor in housing and bolt in place.

(2) INSTALL STARTING MOTOR ROD.

PLIERS
WRENCH, 9/16-in.

Connect starting motor rod on shift lever pin with washer and cotter pin (pliers). Adjust cap screw on shift lever as follows: Screw the adjusting cap screw in toward the lever (9/16-in. wrench) so that the switch contacts do not touch when the lever is pushed all the way forward. Place the shift lever in full forward position (the starting motor pinion will be against the stop.) Back the cap screws out so that the switch contacts close. Pull the starting motor shift lever back and turn the adjusting screw out an ADDITIONAL TWO TURNS. Lock the nut.

(3) CONNECT BATTERY CABLE.

WRENCH, 3/4-in.

Connect battery cable, ammeter wire, generator regulator wires and electric brake wire to starting motor switch post. Put on washer and nut and tighten.

(4) INSTALL LEFT FRONT FENDER.

WRENCHES, two, 3/4-in.

Install left front fender with three bolts and one cap screw removed in removal procedure (par. 136).

(5) INSTALL WINCH DRIVE SHAFT GUARD.

WRENCH, 9/16-in. WRENCHES, two, 3/4-in.

Install guard with three cap screws in front (9/16-in. wrench) and three bolts in rear end of guard (9/16-in. and 3/4-in. wrenches).

## 152. SPECIAL TOOLS.

a. Special tools required:

AMMETER
EQUIPMENT, testing, torque
GROWLER
SCREWDRIVER, pole shoe
SPREADER, pole shoe
VOLTMETER

ORDNANCE MAINTENANCE — HEAVY TRACTOR M1
(ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

# CHAPTER 7

# LUBRICATION SYSTEM

## Section I

## DESCRIPTION OF SYSTEM



### 153. DESCRIPTION OF SYSTEM.

**a.** The engine is lubricated by a combination pressure, gravity and splash system. Oil is drawn from the crankcase sump through the oil pump inlet screen by a conventional gear-type oil pump driven by a chain and sprocket from a sprocket on the front end of the crankshaft. The pump maintains a pressure of from 25 to 35 pounds. Oil is forced by the pump through the full-flow type filter mounted on the front of the engine. It then flows through an oil cooler (fig. 135). This cooler is a single-pass, multiple-type, cooling unit. Cooling water from the radiator is drawn through the housing by the water pump and surrounds the cooling unit through which the lubricating oil flows. The cooled oil is then conducted through drilled passages in the cylinder block to the main bearings, camshaft, balance shaft and idler gear. Drilled passages in the crankshaft provide oil flow from the main bearing journals to the crankpins and connecting rod bearings.

**b.** Oil delivered to the connecting rod bearings is forced on up through a drilled passage in the connecting rod to the piston pin bushing and then out through four small holes located in the top of the connecting rod. This oil sprays against the under side of the top of the piston to cool it and runs back down the inside of the piston and cylinder walls, carrying heat away from the top of the piston and lubricating the cylinder walls.

**c.** The oil delivered to the camshaft and balance shaft lubricates the bearings on these shafts and is forced through passages in the cylinder head up through the drilled rocker arm bracket bolts to the rocker arm shafts. Feed holes in the rocker arm shaft supply oil to each rocker arm bushing. From each rocker arm clevis, an oilhole is drilled to the rocker shaft hole. Excess oil from rocker arms lubricates the exhaust valves and injector followers as well as upper push rod seats. Cam roller followers are lubricated by oil draining from cam pockets in cylinder head. The oil drains into cavities around camshaft and overflows through two passages in upper part of blower housing into the end housings of blower, lubri-

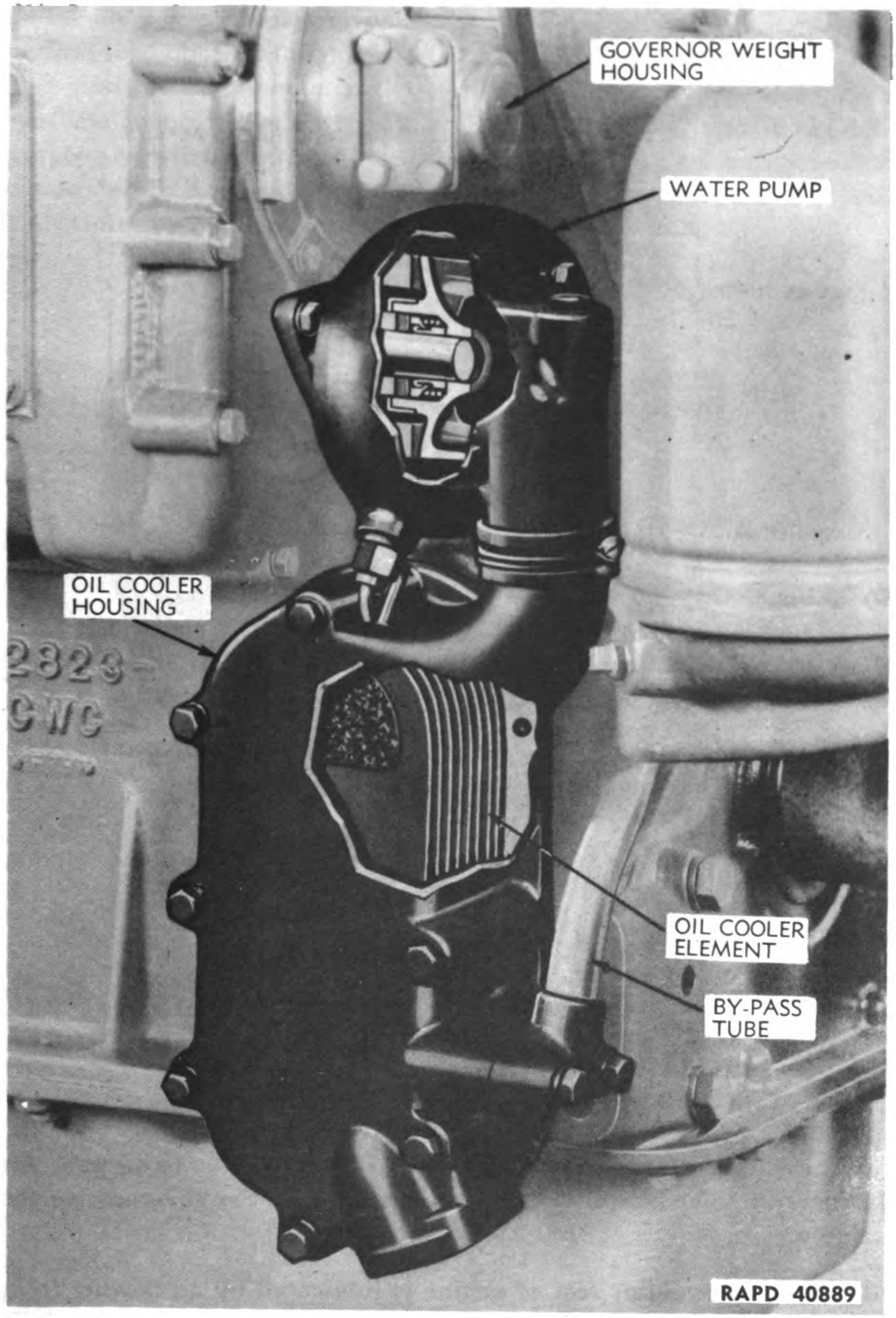



*Figure 135—Cut-Away View of Water Pump and Oil Cooler*

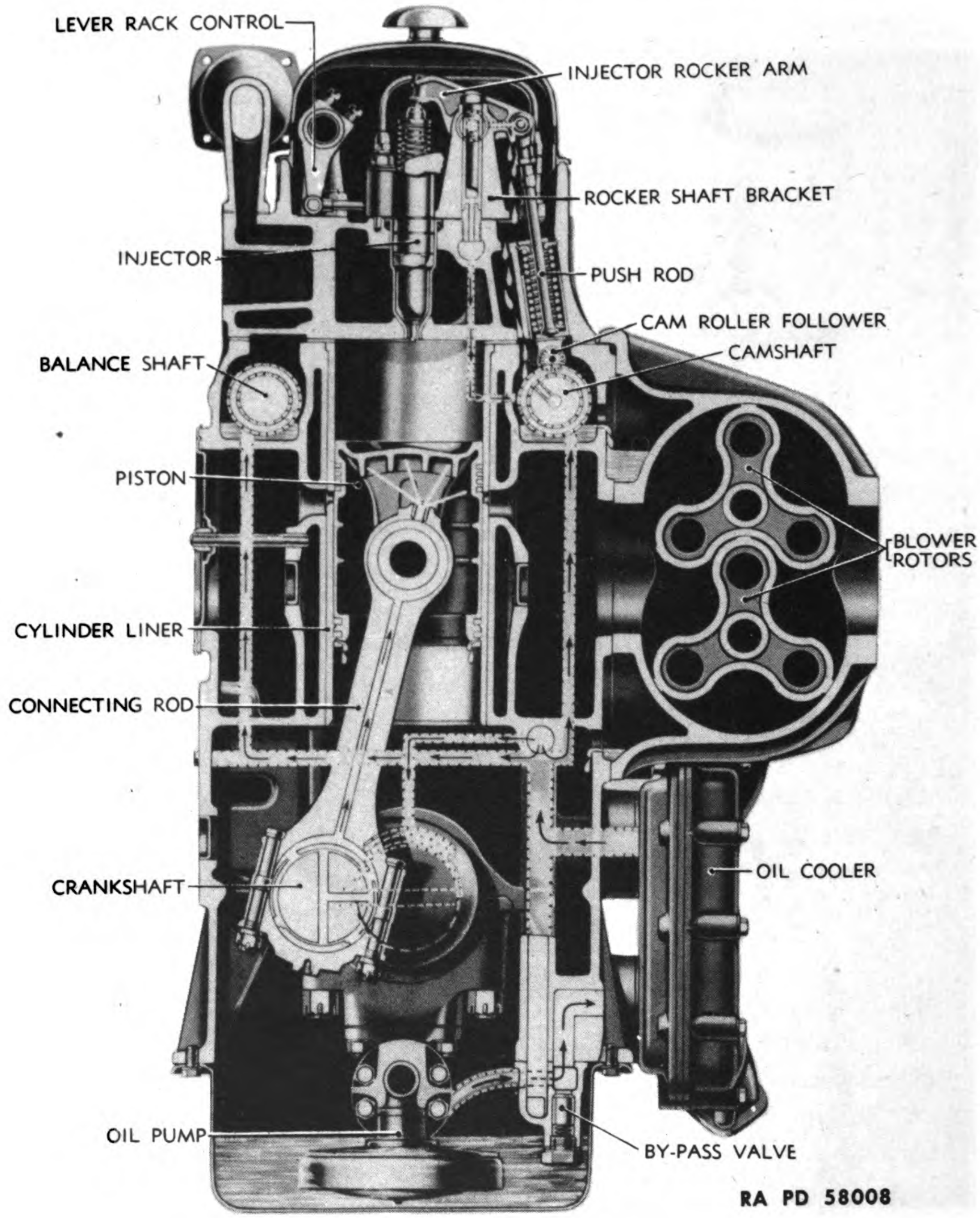



***Figure 136—Engine Lubrication***

cates the blower gears and bearings (fig. 61) and returns to oil pan. An oil slinger in front blower housing throws oil onto the governor weight assembly.

**d.** The gear train at rear of engine is lubricated by oil flowing from top deck of cylinder head, idler gear bearing, camshaft and balance shaft bearings. The blower drive bearing receives oil from an external line from the oil gallery in cylinder block.

## DESCRIPTION OF SYSTEM

e. To provide ample lubrication to the engine bearings, should either the oil filter or oil cooler become clogged, a bypass valve is provided in the line leading from the pump to the oil filter. When the pressure at the filter inlet reaches 40 pounds, the valve opens and oil is bypassed directly from the pump to the engine oil gallery. Under these conditions, however, *the oil will be neither filtered nor cooled,* and such a condition should be avoided by keeping the filter and cooler elements free from deposits at all times by regular servicing of these units.

## Section II

## TROUBLE SHOOTING



### 154. TROUBLE SHOOTING.

**a. Low Oil Pressure.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Insufficient oil in crankcase. | (1) Maintain proper oil level. |
| (2) Lubricating oil diluted with fuel oil due to loose or broken connections under rocker arm cover. | (2) Tighten or replace defective fittings. |
| (3) Clogged oil filter. | (3) Remove and clean filter element. |
| (4) Clogged oil passages. | (4) Remove and disassemble engine and clean passages. |
| (5) Clogged oil cooler. | (5) Remove, clean or replace. |
| (6) Worn bearings. | (6) Overhaul engine and replace bearings. |
| (7) Defective or clogged oil line to pressure gage. | (7) Replace oil line. |
| (8) Defective oil pressure gage. | (8) Replace. |
| (9) Leaks or loose connections at oil line or filter. | (9) Tighten or replace. |
| (10) Worn bypass valve assembly. | (10) Replace worn parts. |
| (11) Worn release valve, or weak spring in oil pump. | (11) Replace worn parts. |
| (12) Defective oil pump or connections. | (12) Repair or replace. |

**b. Water in Oil or Oil in Water.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Oil cooler element or gaskets defective. | (1) Repair or replace. |
| (2) Cracked or broken cylinder head. | (2) Repair or replace. |
| (3) Cracked or broken cylinder block. | (3) Repair or replace. |
| (4) Defective cylinder head gasket. | (4) Replace. |

## Section III

# LUBRICATING OIL PUMP

Paragraph



## 155. DESCRIPTION.

**a.** The lubricating oil pump is of the conventional gear type and is suspended from the second main bearing cap, and driven by a chain from sprocket on front end of crankshaft. The drive sprocket shaft assembly is suspended from the front main bearing cap. A self-alining coupling sleeve connects the sprocket drive shaft with the lubricating oil pump drive shaft. A screen is attached to the lubricating oil pump inlet to strain the oil before it reaches pump. An oil pressure relief valve, of the plunger type, is contained within the pump body so that when the pressure in the oil line exceeds approximately 100 pounds per square inch, the relief valve opens to bypass oil to the intake side of the pump.

## 156. TROUBLE SHOOTING.

**a. Low Oil Pressure.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Loose or broken inlet and outlet lines. | (1) Repair or replace. |
| (2) Defective gaskets. | (2) Replace. |
| (3) Relief valve, worn or sticking. | (3) Free or replace. |
| (4) Bypass valve assembly worn. | (4) Replace worn parts. |
| (5) Worn pump gears or housing. | (5) Replace worn parts. |
| (6) Clogged screen. | (6) Clean off screen. |
| (7) Pump drive chain broken. | (7) Replace. |
| (8) Worn pump bushings. | (8) Replace bushings. |

## LUBRICATING OIL PUMP

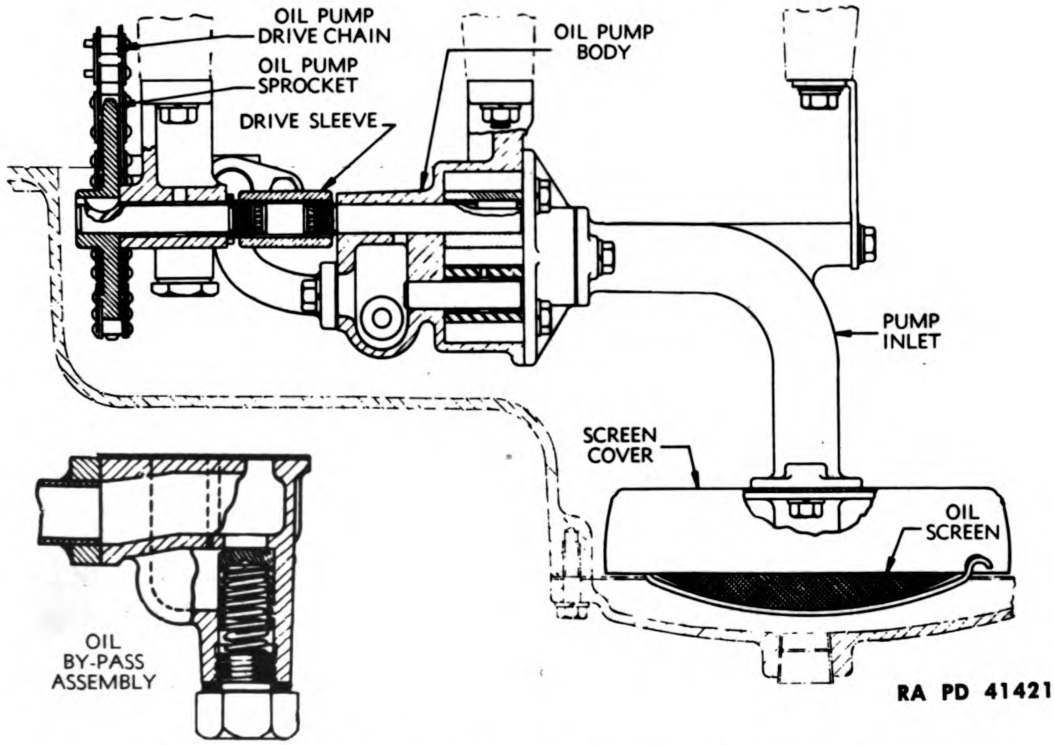



***Figure 137 — Cross-Section of Lubricating Oil Pump — Side View***

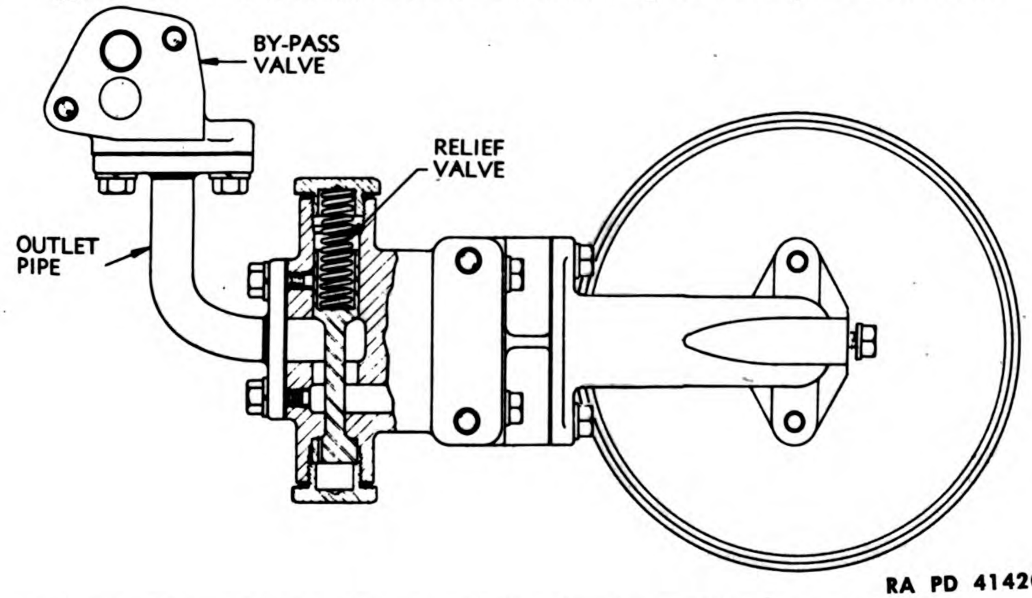



***Figure 138 — Cross-Section of Lubricating Oil Pump — Top View***

### 157. REMOVAL.

**a. Equipment.**

WRENCH, 9/16-in.
WRENCH, 7/8-in.
WRENCH, open-end, 1/2-in.
WRENCH, socket, 1/2-in., with extension

**b. Procedure.**

(1) REMOVE ENGINE SUPPORT BOTTOM COVER.

WRENCH, 7/8-in.

Remove the four cap screws holding bottom cover to engine support (see fig. 105). Remove cover.

(2) REMOVE OIL PAN.

WRENCH, socket, 1/2-in.

Drain oil from pan. Remove the 22 cap screws that hold oil pan to cylinder block. Remove oil pan.

(3) REMOVE OIL PUMP OUTLET TUBE AND BYPASS VALVE.

WRENCH, open-end, 1/2-in.

Remove four cap screws that hold oil pump outlet tube and oil bypass valve assembly to cylinder block. Remove outlet tube and bypass valve assembly.

(4) REMOVE OIL PUMP ASSEMBLY.

WRENCH, 9/16-in.

Remove two nuts and four cap screws that hold oil pump assembly to main bearing caps and remove oil pump assembly. Remove coupling with pump and then work drive sprocket out of drive chain if sprocket shaft assembly is to be removed.

## 158. DISASSEMBLY.

**a. Equipment.**

PLIERS
PRESS, arbor
WRENCH, 1/2-in.
WRENCH, 1-in.
WRENCH, 1 1/4-in.

**b. Procedure.**

(1) REMOVE RELIEF VALVE.

WRENCH, 1 1/4-in.

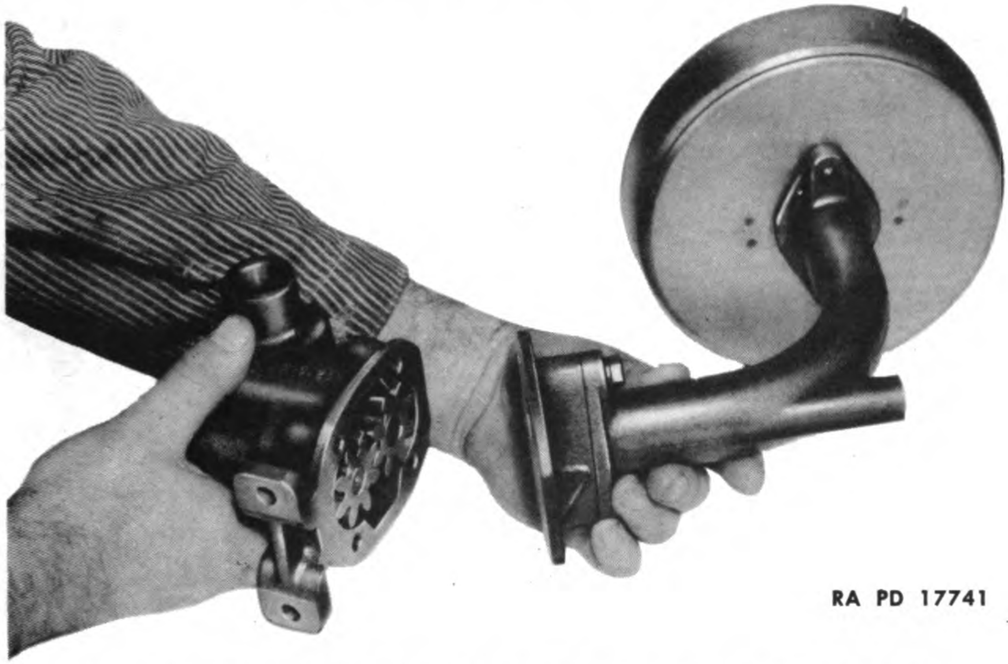
Remove the relief valve plug and copper gasket from each side of pump body. Jar relief valve and spring from body (fig. 143).

(2) REMOVE GEAR COVER.

WRENCH, 1/2-in.

Remove four cap screws holding cover to pump body and remove cover and oil pump inlet assembly.

LUBRICATING OIL PUMP



RA PD 17741

***Figure 139—Removing Lubricating Oil Pump Gear Cover***

RA PD 40640

***Figure 140—Lubricating Oil Pump Idler Gear Removed***

(3) Remove Idler Gear.

Remove lubricating oil pump idler gear from pump body.

(4) Remove Drive Gear and Shaft.

PRESS, arbor

Support pump body and drive gear assembly on bed of arbor press, cover side up and, with arbor slightly smaller than shaft, set on shaft so

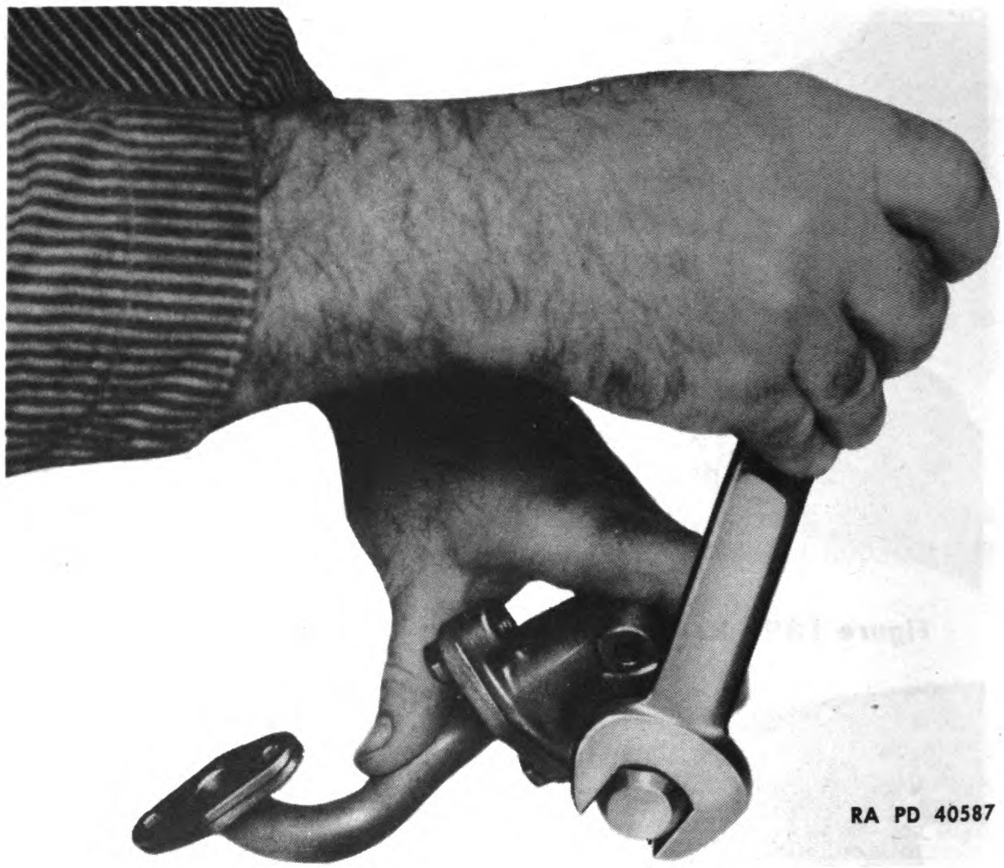



*Figure 141 — Removing Plug from Bypass Valve Body*

as not to cover keyway and press shaft from gear and body. Remove gear and key from housing.

(5) DISASSEMBLE SPROCKET SHAFT ASSEMBLY.

PLIERS PRESS, arbor

Support assembly on bed of arbor press, with sprocket up, edges of sprocket resting on bed of press. Press shaft and key out of sprocket. Remove key from shaft and slide shaft from sprocket support (pliers).

(6) DISASSEMBLY OIL PUMP INLET.

Remove screen retainer and drop oil screen out of screen cover.

(7) REMOVE BYPASS VALVE.

WRENCH, 1-in.

Remove plug from bypass valve assembly and remove spring and bypass valve.

## 159. INSPECTION OF PARTS.

**a.** Wash and inspect all parts for wear. Principal wearing parts are the gears and housing. If oil has been kept clean, wear on these parts is considerably lower than if dirt and sludge have been allowed to accumulate in lubricating system. Refer to paragraph 162 for clearances. If gear teeth are worn appreciably or scored, replace. If gear housing is scored, the pump body and cover should be replaced. Gears should form a free running fit inside housing with no perceptible looseness. Badly worn pump parts will result in low engine oil pressure. Inspect shaft bearings for wear and condition of splines, replacing parts containing worn bearings. Inspect sprocket for wear. Replace if badly worn.

**b.** Inspect bypass valve assembly. Replace scored or worn parts.

**c.** Wash and inspect oil screen for holes. Replace, if necessary.

## 160. ASSEMBLY.

**a. Equipment.**

OILCAN, with engine oil
PRESS, arbor
WRENCH, ½-in.
WRENCH, 1-in.
WRENCH, 1¼-in.

**b. Procedure** (figs. 137 and 138).

(1) INSTALL SHAFT AND GEARS.

PRESS, arbor

Lubricate pump shaft with oil and slide shaft into pump body. Install feather key in shaft and place gear on shaft with keyway lined up with key. Support splined end of shaft on bed of arbor press and press gear onto shaft. Leave end of gear flush with end of shaft. Install idler gear on stub shaft in pump body.

(2) INSTALL PUMP COVER AND OIL PUMP INLET.

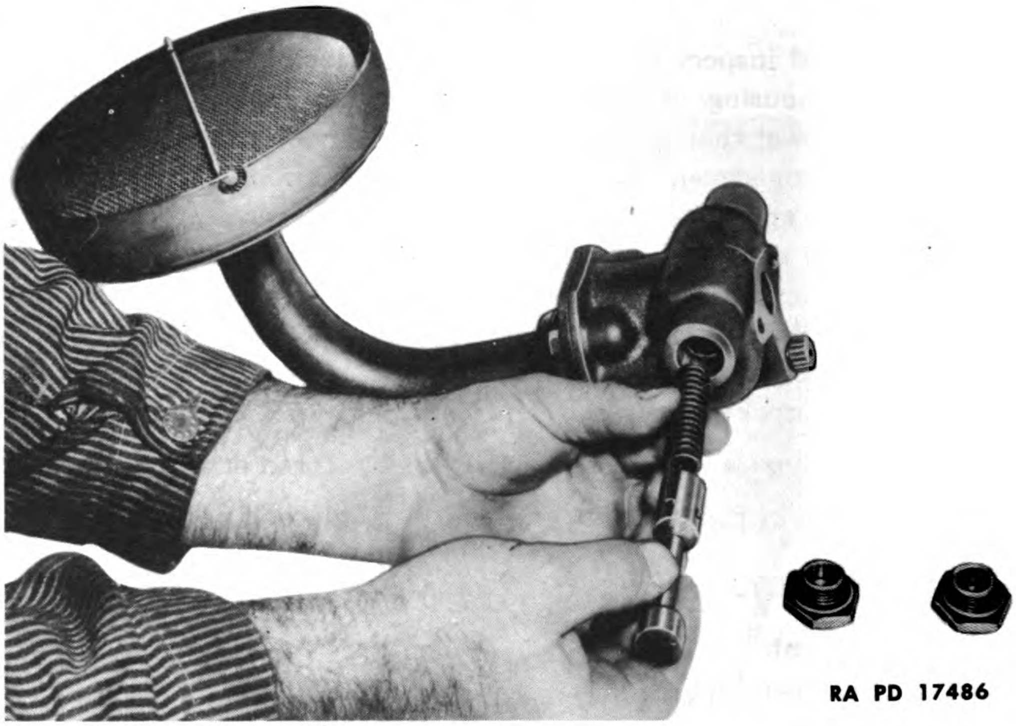
WRENCH, ½-in.

Be sure cover and mating surface of pump are clean and perfectly flat. Place cover on body with mark RH-TOP to top of pump body or attaching bracket. Secure with four cap screws with lock washers. Install oil screen in screen cover and secure with retainer snapped into slots in cover.

(3) INSTALL RELIEF VALVE.

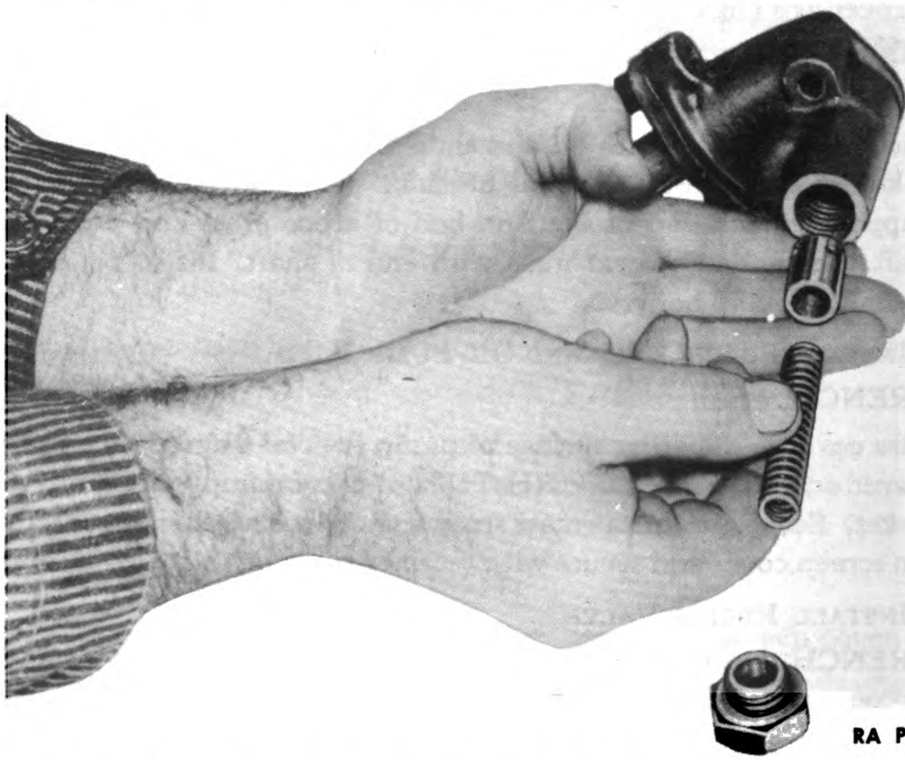
WRENCH, 1¼-in.

Lubricate piston and install relief valve, being sure that long end of valve spring is towards intake side of pump. Install the two relief valve plugs with copper washer under each one. Revolve shaft by hand for any bind. Pump shaft must turn freely when pump is assembled.



RA PD 17486

**Figure 142—Installing Lubricating Oil Pump Relief Valve**



RA PD 17684

**Figure 143—Installing Lubricating Oil Pump Bypass Valve**

(4) Assemble Sprocket Shaft Assembly.

PRESS, arbor

Lubricate and slide sprocket shaft through sprocket shaft support. Install key in slot in shaft; then set assembly on bed of arbor press and press sprocket onto shaft and key. Do not press sprocket on to point where sprocket and shaft cannot rotate freely.

(5) Assemble Bypass Valve.

WRENCH, 1-in.

Insert plunger in opening; then insert the valve spring. The spring should enter plunger. Use a new copper gasket and install bypass valve plug. Tighten plug securely.

## 161. INSTALLATION.

**a. Equipment.**

WRENCH, 9/16-in.
WRENCH, 7/8-in.
WRENCH, open-end, 1/2-in.
WRENCH, socket, 1/2-in.

**b. Procedure.**

(1) Install Sprocket Shaft Assembly.

Work oil pump drive sprocket into drive chain and turn sprocket support into position.

(2) Install Lubricating Oil Pump Assembly in Engine.

WRENCH, 9/16-in.

Place drive sleeve on pump drive shaft. Place assembly in position, engaging drive sleeve on splined end of sprocket shaft. Secure assembly to main bearing caps with two 3/8-inch nuts with lock washers on No. 2 main bearing cap. Then install two cap screws with lock washers through inlet bracket and into No. 3 main bearing cap. Too much slack in oil pump drive chain may be taken up by installing an *equal* amount of shims made from shim stock between sprocket shaft assembly, pump body and inlet bracket support and the bearing caps. A little slack, however, should be allowed in chain but if slack is excessive, install new chain.

(3) Install Outlet Tube and Bypass Valve.

WRENCH, open-end, 1/2-in.

Shellac new gaskets to tube flange and valve body. Install with two cap screws with lock washers in valve body and two cap screws with lock washers in tube flange.

(4) INSTALL OIL PAN.

WRENCH, socket, ½-in.

Shellac new gasket to oil pan. Install pan with 22 cap screws with lock washers. Fill engine with correct grade of lubricating oil, start engine and check for leaks.

(5) INSTALL ENGINE SUPPORT BOTTOM COVER.

WRENCH, ⅞-in.

Install engine support bottom cover and secure with four cap screws with lock washers.

## 162. FITS AND CLEARANCES.

**a.** Specifications and clearances for oil pump are as follows:

(1) SPROCKETS.

| | |
|---|---|
| Drive sprocket—number of teeth | 19 |
| Oil pump sprocket—number of teeth | 24 |

(2) GEARS.

| | |
|---|---|
| Backlash | 0.003- to 0.006-in. |
| End play | 0.001- to 0.0025-in. |
| Radial clearance | 0.002- to 0.0045-in. |

(3) OIL PRESSURE RELIEF VALVE.

| | |
|---|---|
| Clearance between plunger and housing | 0.0025- to 0.0045-in. |
| Spring—free length | 2 25/32-in. |
| Spring load-valve open | 21 to 23 lb. at 1 39/64-in. |

## Section IV

# LUBRICATING OIL FILTER



## 163. DESCRIPTION.

**a.** The lubricating oil filter located on the front of the engine consists of a double cylindrical metal filter element contained inside a steel housing. All the oil leaving the pump passes through this filter before being discharged into the lubricating oil cooler. These metal edge type elements remove all the large particles from the oil and collect a considerable portion of the sludge from the oil. A plug in the bottom of the filter base permits draining of sludge and foreign matter. The bracket supporting filter is cast with the adapter between lubricating oil cooler and engine block.

## 164. TROUBLE SHOOTING.

**a. Low Oil Pressure.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Clogged filter. | (1) Remove and clean filter; replace if unable to clean. |
| (2) Filter covered with gummy substance. | (2) Wash with SOLVENT, dry-cleaning. |

**b. Oil Leaks.**

| | |
|---|---|
| (1) Defective gasket. | (1) Replace gasket. |
| (2) Retainer stud loose. | (2) Tighten stud. |
| (3) Cracked filter base. | (3) Replace casting. |

## 165. REMOVAL.

**a. Equipment.**

WRENCH, socket, 1⅛-in. WRENCH, sq.-plug, ¼-in.

**b. Procedure.**

(1) REMOVE FILTER DRAIN PLUG.

WRENCH, sq.-plug, ¼-in.

Remove plug at base of filter and allow oil to drain from filter.

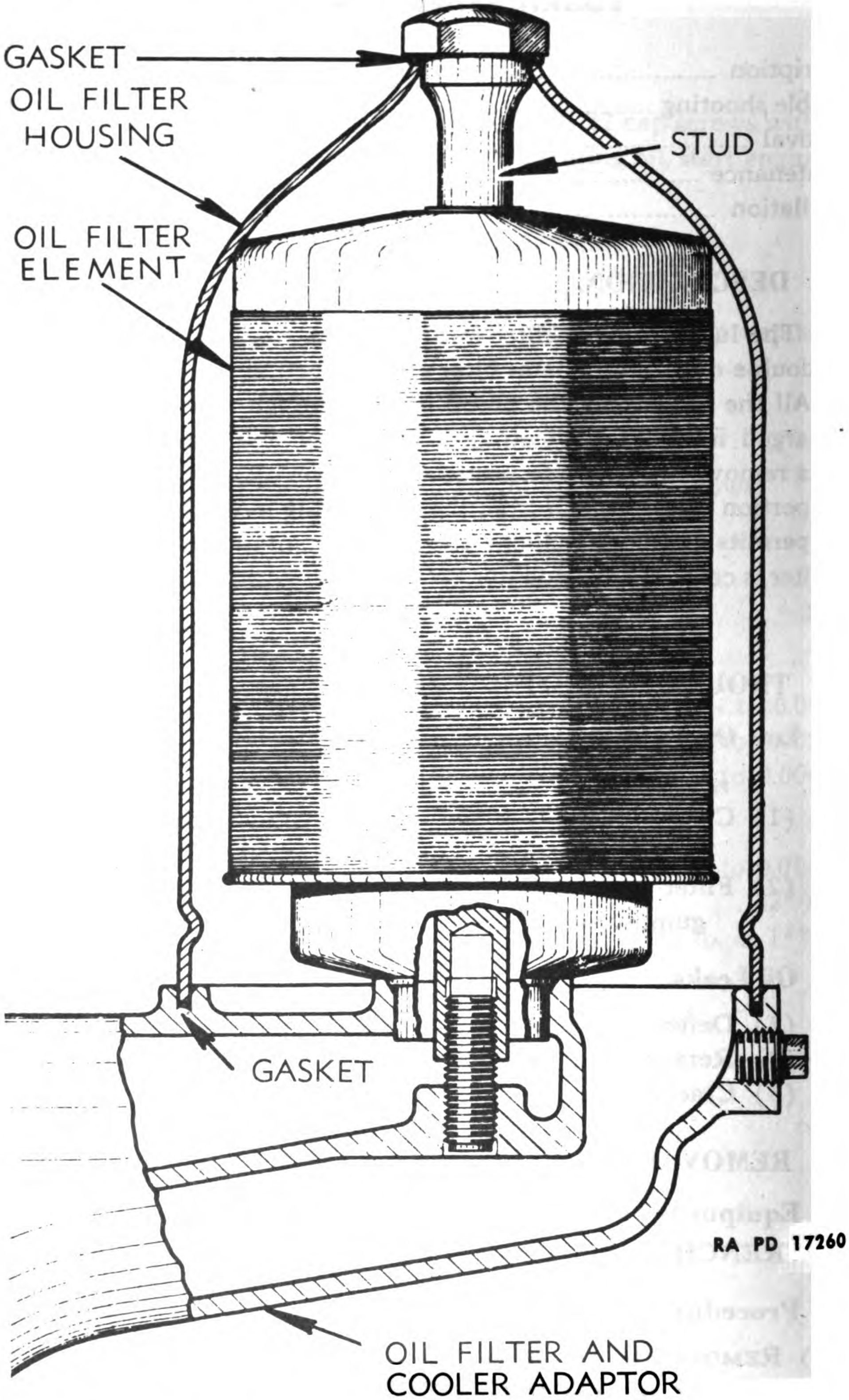
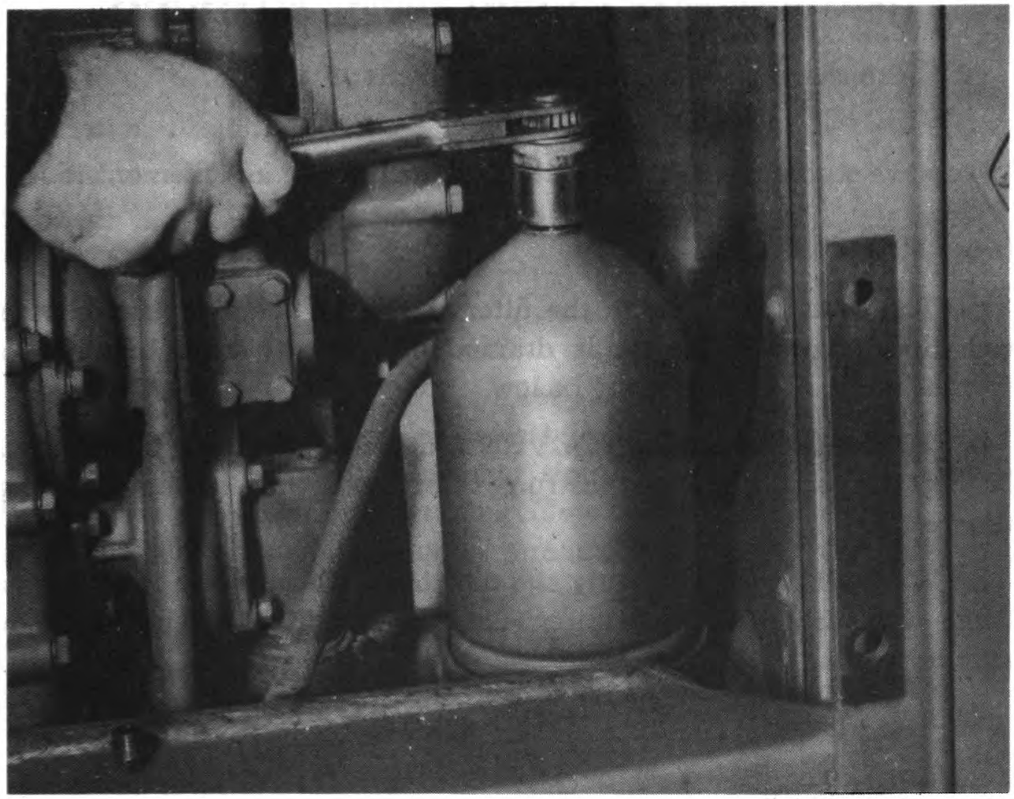


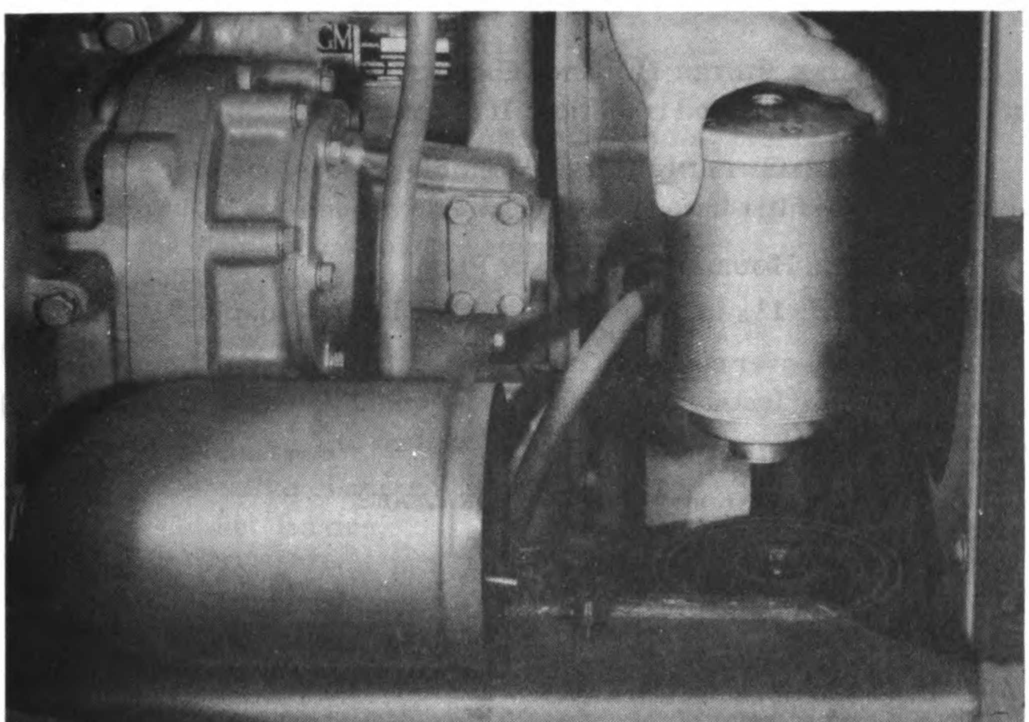

***Figure 144—Cut-Away View of Lubricating Oil Filter***

LUBRICATING OIL PUMP



RA PD 17605

**Figure 145 — Removing Lubricating Oil Filter**



RA PD 17601

**Figure 146 — Removing Lubricating Oil Filter Element**

(2) Remove Lubricating Oil Filter Stud.
WRENCH, socket, 1⅛-in.

Remove stud and gasket and lift off filter housing and element.

## 166. MAINTENANCE.

**a.** The metal elements in the filter should be removed and cleaned each time engine crankcase is drained and at any time between oil changes when oil pressure may be low.

**b.** Wash the elements in SOLVENT, dry-cleaning, using a soft brush. Do not scrape with a sharp instrument or use a wire brush, as damage may result.

**c.** Wash all parts thoroughly and dry them. Clean inside of filter base. Make sure gasket in base of filter is in good condition when filter is put back on tractor.

## 167. INSTALLATION.

**a. Equipment.**

WRENCH, 1⅛-in. WRENCH, sq.-plug, ¼-in.

**b. Procedure.**

(1) Examine Filter Housing Gasket. Make sure that this gasket in base of filter is in good condition. If not, replace it.

(2) Set Elements in Place. Assemble screens, one inside the other, and set them in filter base.

(3) Install Housing and Drain Plug.
WRENCH, 1⅛-in. WRENCH, sq.-plug, ¼-in.

Place housing over elements, making sure that bottom of housing enters groove in base. Install stud and gasket and tighten, using a 1⅛-inch wrench. Install filter drain plug (¼-in. wrench).

(4) Start Engine and Inspect for Leaks.

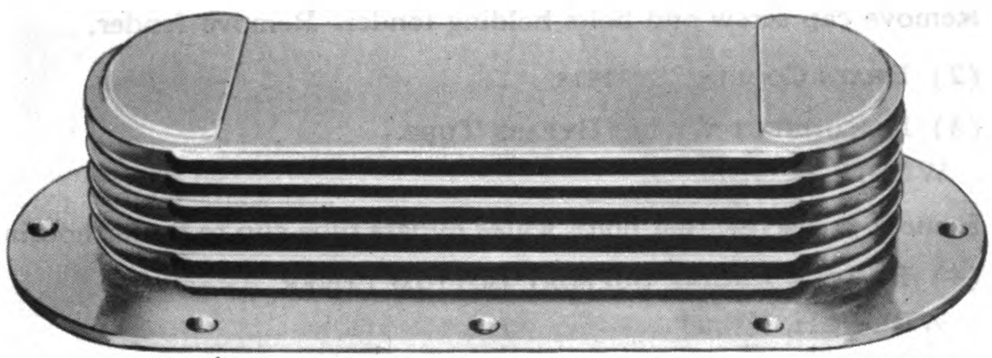
## Section V

# LUBRICATING OIL COOLER



## 168. DESCRIPTION.

**a.** The lubricating oil cooler assembly consists of a housing inside of which is a metal element somewhat similar to the core of a radiator. Water from the tractor radiator circulates around this element in the cooler and lubricating oil circulates through the element. The lubricating oil cooler plates are lined with small fins which dissipate heat from the oil inside the element to cooling water surrounding the element inside the cooler housing.



RA PD 41425

*Figure 147 — Lubricating Oil Cooler Element*

## 169. TROUBLE SHOOTING.

**a. Oil in Water or Water in Oil.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Defective element. | (1) Replace. |
| (2) Gasket leaking. | (2) Replace (shellac both sides). |

**b. Oil and Engine Overheating.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Clogged element. | (1) Remove and clean out element with SOLVENT, dry-cleaning, replace if unable to clean. |
| (2) Low on water. | (2) Keep radiator filled. |

c. **Low Oil Pressure.**

| | |
|---|---|
| (1) Clogged element. | (1) Remove and clean out element. Replace if unable to clean. |

## 170. REMOVAL.

a. **Equipment.**

SCREWDRIVER, 6-in.
WRENCHES, two, ¾-in.
WRENCH, ⅞-in.
WRENCH, socket, ½-in.
WRENCH, socket, $^{9}/_{16}$-in.

b. **Procedure.**

(1) REMOVE RIGHT FRONT FENDER.

WRENCHES, two, ¾-in.

Remove cap screw and bolts holding fender. Remove fender.

(2) DRAIN COOLING SYSTEM.

(3) DISCONNECT WATER BYPASS TUBE.

WRENCH, ½-in.

Remove cap screw that holds water bypass tube clip to cooler housing.

(4) REMOVE ENGINE SUPPORT BOTTOM COVER.

WRENCH, ⅞-in.

Remove four cap screws that hold cover to engine support and remove cover (fig. 105).

(5) DISCONNECT HOSES.

SCREWDRIVER, 6-in. WRENCH, ½-in.

Loosen clamp on hose connecting water pump and lubricating oil cooler (screwdriver). Slip hose connection between water pump and cooler down onto cooler tube. Remove two cap screws from lower water connection (½-in. wrench).

(6) REMOVE COOLER HOUSING.

WRENCH, socket, ½-in., with extension

Remove the eight cap screws holding cooler housing to lubricating oil filter and cooler adapter and remove housing and element.

(7) REMOVE LUBRICATING OIL FILTER AND COOLER ADAPTER.

WRENCH, socket, $^{9}/_{16}$-in.

Remove six cap screws holding adapter to cylinder block and remove adapter.

## LUBRICATING OIL COOLER

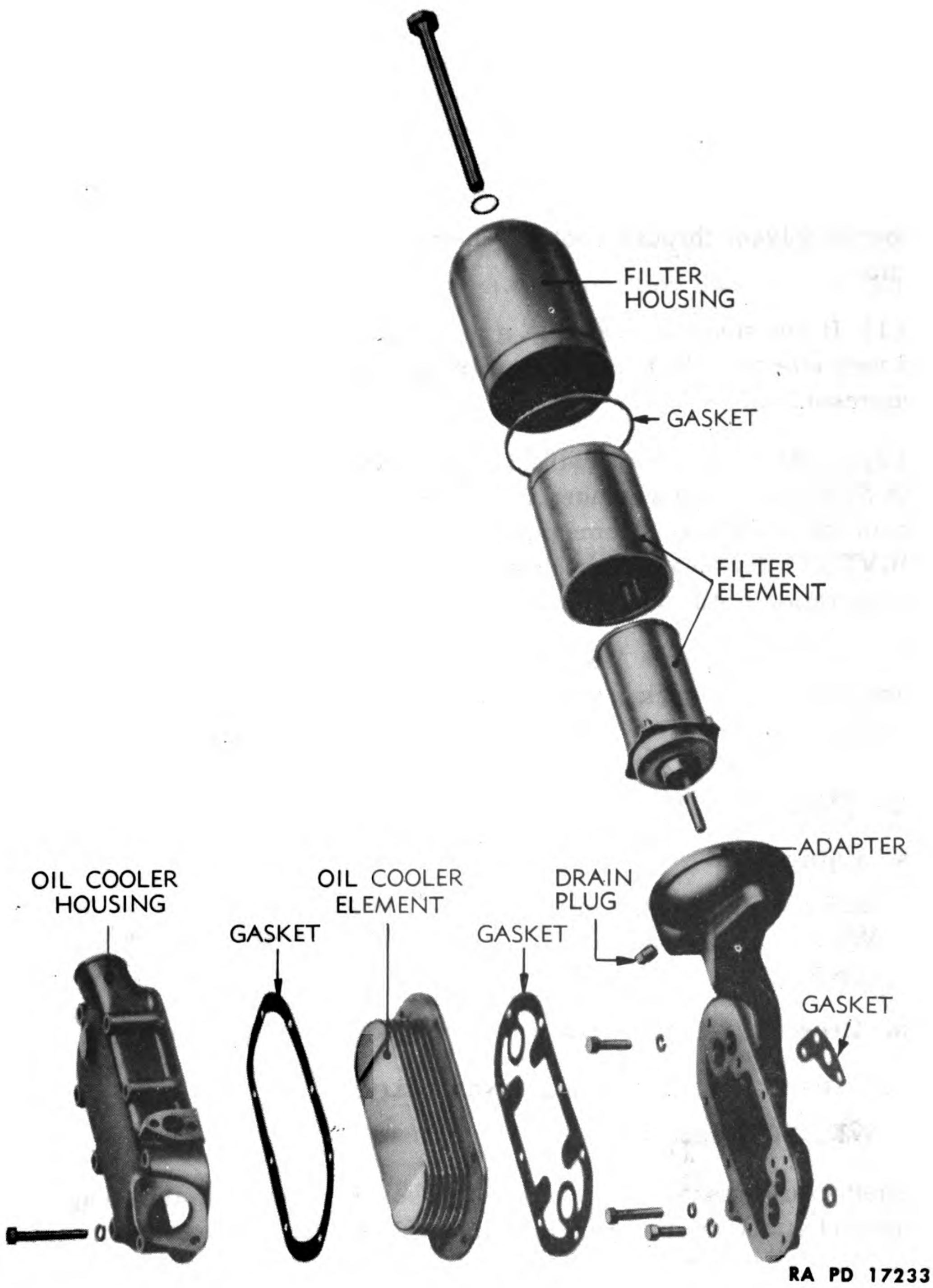



**Figure 148 — Lubricating Oil Filter and Cooler Assembly — Exploded View**

## 171. MAINTENANCE.

**a.** If proper lubricating oil maintenance procedure is followed, the cooler will function efficiently for an indefinite period. However, when oil is allowed to become laden with impurities, these impurities will deposit in the cooler, causing clogging and inefficiency. To effectively clean the cooler, it is necessary to remove cooler element and circulate a special solvent through cooler element for some time by use of a force pump.

(1) If live steam is available, a jet of steam, mixed with a SODA, ash, is a very effective cleaner. After cleaning, remove all traces of water with compressed air.

(2) If steam is not available, place the cooler unit in a vessel and fill with SOLVENT, dry-cleaning, to a level of at least one inch above openings in the unit plate. A force pump is suggested as a means of forcing the SOLVENT, dry-cleaning, back and forth through the plates. Continue this operation until unit is cleaned.

**b.** Inspect cooler for leaks or corrosion. Some kinds of water contain agents that will attack and corrode this element. Replace element, if corrosion is evident.

## 172. INSTALLATION.

**a. Equipment.**

SCREWDRIVER, 6-in.
WRENCHES, two, ¾-in.
WRENCH, ⅞-in.
WRENCH, socket, ½-in.
WRENCH, socket, $\frac{9}{16}$-in.

**b. Procedure** (fig. 148 shows relative position of parts).

(1) INSTALL ADAPTER TO CYLINDER BLOCK.

WRENCH, socket, $\frac{9}{16}$-in.

Shellac new gaskets to cylinder block bosses. Place adapter up against block and attach with a cap screw with lock washer in each hole in center of adapter at top and bottom, and four cap screws with lock washers in the other four recessed holes.

(2) SHELLAC COOLER GASKETS.

Clean element housing and adapter surfaces and shellac gaskets to both sides of cooler element. Then coat outer sides of gaskets with shellac.

## LUBRICATING OIL COOLER

(3) INSTALL ELEMENT AND HOUSING.

WRENCH, socket, ½-in.

Place element in housing and attach housing and element to adapter with eight cap screws with lock washers.

(4) INSTALL HOSES.

SCREWDRIVER, 6-in. WRENCH, socket, ½-in.

Connect hose at inlet of cooler and tighten clamp. Install two cap screws with lock washers in lower water connection and tighten, using a new gasket if necessary.

(5) CONNECT WATER BYPASS TUBE.

WRENCH, ½-in.

Shellac both sides of a new gasket and install gasket and water bypass tube to cooler with two cap screws with lock washers.

(6) INSTALL CAP SCREW HOLDING GOVERNOR BREATHER TUBE CLIP.

WRENCH, ½-in.

Install cap screw through clip and into cooler housing.

(7) INSTALL RIGHT FRONT FENDER.

WRENCHES, two, ¾-in.

Install right front fender with cap screw, bolts and lock washers.

(8) START ENGINE AND INSPECT FOR LEAKS. Fill system with water, start engine and inspect all connections for leaks.

(9) INSTALL ENGINE SUPPORT BOTTOM COVER.

WRENCH, ⅞-in.

Install engine support bottom cover and secure with four cap screws with lock washers.

ORDNANCE MAINTENANCE — HEAVY TRACTOR M1 (ALLIS-CHALMERS HD-10W) ENGINE ACCESSORIES

# CHAPTER 8

# EXHAUST MANIFOLD AND MUFFLER



## 173. DESCRIPTION.

**a.** Two exhaust passages from each cylinder lead through a single port in the cylinder head to the exhaust manifold. Studs in the cylinder head —located between each exhaust port and at each end—support and secure the manifold to the cylinder head by means of special flat washers and nuts. As a safeguard against exhaust gas leaks, a two-piece, heat-resisting gasket is used between the cylinder head and exhaust manifold.

**b.** The rear of the exhaust muffler is bolted to an elbow which is in turn bolted to the exhaust manifold outlet. This muffler consists of a sheet metal tube, welded to two end plates, and containing a series of baffles. The exhaust tail pipe is bolted to the front end plate of the muffler and extends up through the engine hood. The muffler is supported by a support brace on each end and a clamp extending around both exhaust pipe and muffler.

**c.** Exhaust gases from the engine are held in suspension by the restriction of the baffles in the muffler. This tends to partially silence exhaust noise and prevents the escape of any sparks from unburned fuel or carbon deposits.

## 174. TROUBLE SHOOTING.

**a. Loud Exhaust.**

| Probable Cause | Probable Remedy |
|---|---|
| (1) Gasket blown. | (1) Replace gasket. |
| (2) Holes in muffler. | (2) Replace muffler. |
| (3) Break in manifold. | (3) Replace manifold. |
| (4) Broken braces. | (4) Replace braces. |

# EXHAUST MANIFOLD AND MUFFLER

## 175. REMOVAL.

### a. Equipment.

BAR, pry
WRENCHES, two, 7/16-in.
WRENCHES, two, 9/16-in.
WRENCH, socket, 5/8-in., with extension

### b. Procedure.

(1) REMOVE PRE-CLEANERS AND HOOD.

BAR, pry
WRENCHES, two, 7/16-in.
WRENCH, 9/16-in.

Loosen clamps at base of pre-cleaners (two 7/16-in. wrenches) and lift pre-cleaners off. Loosen bolts at corners of hood; pry bolts out of slot. Lift hood off over air cleaner extension tubes and exhaust stack.

(2) REMOVE MUFFLER SUPPORT BOLTS.

WRENCHES, two, 9/16-in.

Remove nuts from bolts that hold lower ends of supports to engine and plates and remove or push bolts back out of supports.

(3) REMOVE ASSEMBLY.

WRENCH, socket, 5/8-in., with extension

Loosen the five nuts on stud bolts that hold manifold to cylinder head and lift exhaust manifold and muffler assembly off studs and away from engine. NOTE: Because the heat to which cap screws in the muffler are subjected causes them to "seize" in the threads, it is advisable to leave the muffler support braces attached to the muffler and manifold unless repair or replacement of some of the parts is necessary.

## 176. DISASSEMBLY.

### a. Equipment.

WRENCHES, two, 9/16-in.
WRENCH, 3/4-in.

### b. Procedure.

(1) REMOVE MUFFLER SUPPORTS.

WRENCH, 9/16-in.
WRENCH, 3/4-in.

Remove two cap screws that hold rear support to muffler inlet elbow and flange of manifold outlet (3/4-in. wrench). Remove the two cap screws that hold front support to muffler (9/16-in. wrench). This removes muffler supports.

(2) REMOVE MUFFLER.

WRENCHES, two, 9/16-in. WRENCH, 3/4-in.

Remove the two remaining cap screws from muffler inlet elbow and flange at exhaust outlet (3/4-in. wrench) and four bolts from muffler clamp (two 9/16-in. wrenches). This separates muffler and exhaust manifold.

(3) REMOVE MUFFLER INLET ELBOW.

WRENCH, 9/16-in.

Remove four cap screws at rear of muffler to remove inlet elbow from muffler.

(4) REMOVE EXHAUST TAIL PIPE.

WRENCH, 9/16-in.

Remove the two remaining cap screws holding tail pipe to front of muffler.

## 177. MAINTENANCE AND REPAIRS.

a. Clean all parts after disassembling and inspect for cracks or breaks in manifold, muffler and muffler supports. A cracked manifold in some cases may be repaired by welding. Muffler supports may be welded if broken or cracked. If muffler is plugged or caked with carbon on inside or if outside tube is broken or rusted through, replace. Do not attempt repairs on muffler except in cases where cap screws are twisted off in disassembling. The parts of cap screws remaining in muffler end plates can be removed by drilling through the cap screw and inserting an "easy out" in drilled hole to screw the part out.

## 178. ASSEMBLY.

a. **Equipment.**

WRENCHES, two, 9/16-in. WRENCH, 3/4-in.

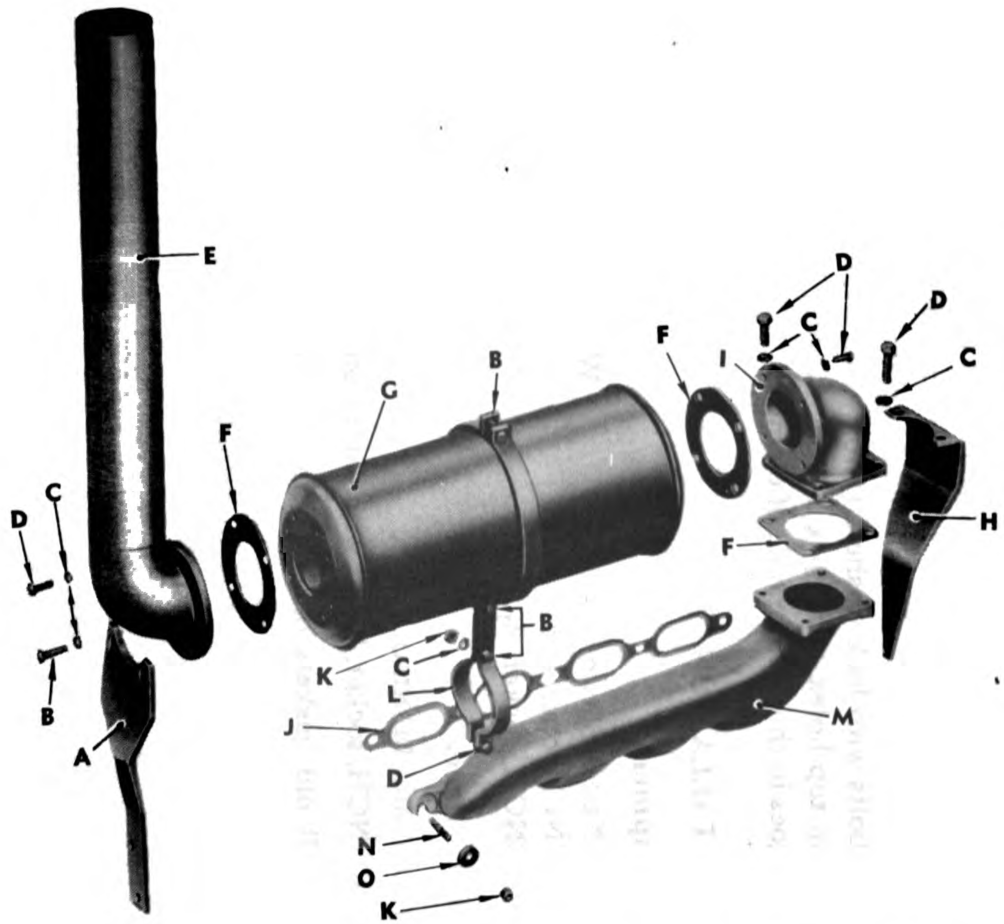
b. **Procedure.**

(1) INSTALL EXHAUST TAIL PIPE.

WRENCH, 9/16-in.

Using new gasket shellacked to tail pipe, install tail pipe on one end of muffler with two cap screws with lock washers. These two cap screws should be inserted in the two holes that will be at the top when muffler

## EXHAUST MANIFOLD AND MUFFLER




A — FRONT SUPPORT
B — CAP SCREW
C — LOCK WASHER
D — BOLT
E — EXHAUST OUTLET W/ELBOW PIPE
F — GASKET
G — EXHAUST MUFFLER
H — REAR SUPPORT
I — ELBOW
J — EXHAUST MANIFOLD GASKET
K — NUT
L — SUPPORT STRAP
M — EXHAUST MANIFOLD
N — SPECIAL EXHAUST MANIFOLD STUD
O — STUD WASHER

RA PD 58114

**Figure 149 — Exploded View of Exhaust Manifold and Muffler Assembly**

is installed. Then insert two cap screws with lock washers into the other two holes. Tighten the first two cap screws inserted to hold tail pipe but leave the other two loose so they can be removed to install muffler support when unit is installed on engine.

(2) INSTALL MUFFLER ELBOW.

WRENCH, 9/16-in.

Shellac new gasket to elbow and install muffler elbow on other end of muffler with elbow pointing in opposite direction from tail pipe. Use four cap screws with lock washers.

(3) CONNECT MUFFLER ASSEMBLY TO EXHAUST MANIFOLD.

WRENCHES, two, 9/16-in. WRENCH, 3/4-in.

Shellac new gasket to elbow. Hold muffler directly above manifold and install two cap screws with lock washers through the two front holes in muffler elbow and into flange on exhaust outlet (3/4-in. wrench). Install two cap screws in other two holes but do not tighten these two, as they will have to be removed to install rear muffler support when installing assembly on tractor. Install muffler clamp on muffler and manifold with four bolts with lock washers (two 9/16-in. wrenches). A 3/8- x 2-inch bolt goes in top holes, two 3/8- x 1 1/4-inch center holes, and a 3/8- x 1 3/4-inch bolt goes in the bottom hole of clamps.

## 179. INSTALLATION.

**a. Equipment.**

WRENCHES, two, 7/16-in.
WRENCH, open-end, 9/16-in.
WRENCH, socket, 9/16-in.
WRENCH, socket, 5/8-in., with extension

**b. Procedure.**

(1) INSTALL MANIFOLD.

WRENCH, socket, 5/8-in., with extension

Clean all old gaskets off manifold and head. Remove the nuts and washers from stud bolts in head and place new gaskets on studs. Shellac or grease is unnecessary. Place manifold on studs in cylinder head. Place special washers on studs and start nuts. Then tighten all nuts *evenly.*

(2) INSTALL MUFFLER SUPPORTS.

Put supports in place and install bolts and cap screws with lock washers in muffler and elbow, but do not tighten nuts ar cap screws. Insert bolts through bottom ends of supports.

## EXHAUST MANIFOLD AND MUFFLER

(3) TIGHTEN ALL BOLTS.

WRENCHES, two, $^9/_{16}$-in. WRENCH, $^3/_4$-in.

Tighten cap screws bolting muffler elbow to manifold first ($^3/_4$-in. wrench). Then tighten all cap screws and nuts of bolts in muffler supports (two $^9/_{16}$-in. wrenches).

(4) INSTALL HOOD AND PRE-CLEANERS.

WRENCHES, two, $^7/_{16}$-in. WRENCH, open-end, $^9/_{16}$-in.

Lower hood over exhaust tail pipe and air cleaner extension tubes. Tap bolts on hood into clips and tighten ($^9/_{16}$-in. wrench). Install pre-cleaners and tighten clamps (two $^7/_{16}$-in. wrenches).

# CHAPTER 9

# GOVERNOR AND CONTROLS

## Section I

## GOVERNOR



### 180. PURPOSE OF ENGINE CONTROL.

a. Horsepower requirements on a tractor vary continually with different loads and ground conditions. To hold the tractor speed reasonably constant, regardless of the variation in load, a variable speed governor is used, which regulates the fuel supplied to the engine in proportion to the load. A hand throttle lever permits the operator to vary the engine speed maintained by the governor.

b. This governor is of the simple "fly-ball" type in which the centrifugal force of rotating weights is used to control the actuating mechanism.

### 181. DESCRIPTION OF GOVERNOR.

a. **General Description.**

(1) The governor—mounted at the front of the blower—is divided into three main assemblies contained in separate housings. These assemblies are: The governor weights and weight housing, the control mechanism and control housing, and the cover assembly.

(2) A set of weights is carried on a horizontal shaft inside the governor weight housing. The front end of the weight carrier shaft is mounted on an annular ball bearing. The serrated rear or drive end engages in

## GOVERNOR

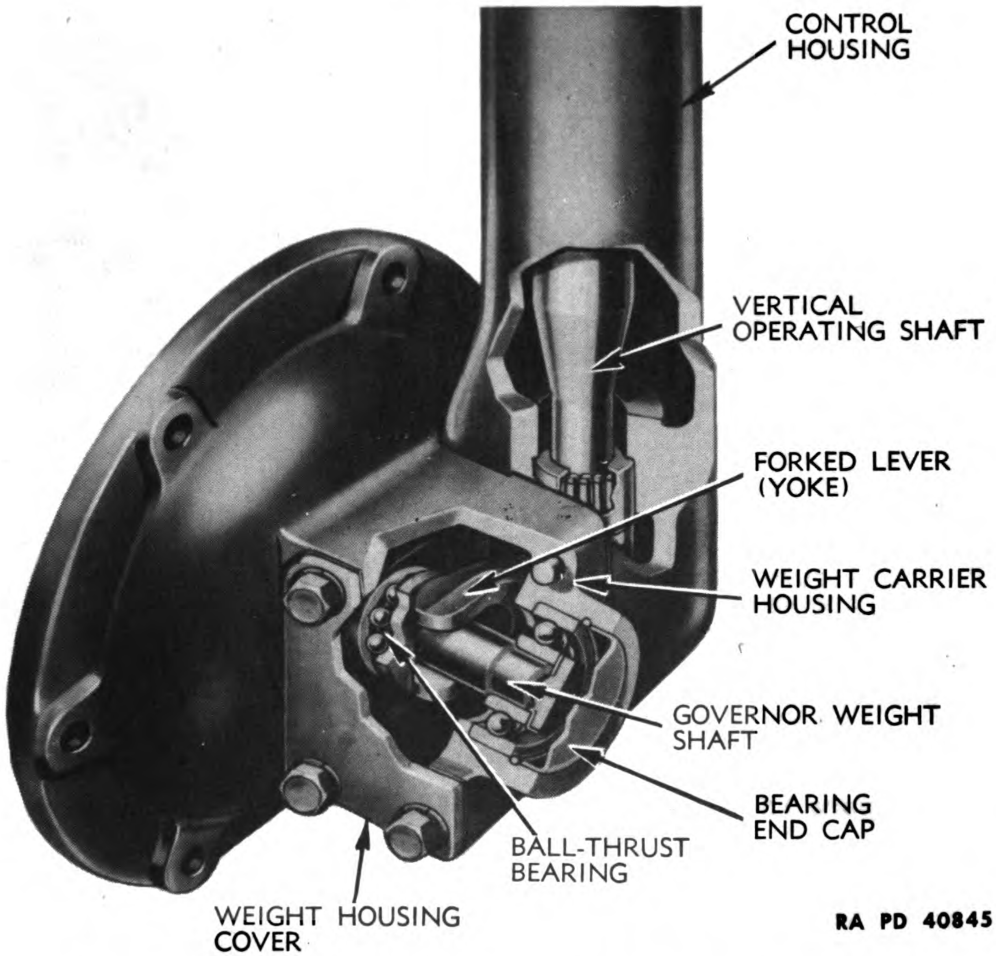



***Figure 150—Cut-Away View Showing Governor Weight Housing Assembly***

splines in the end of the blower upper rotor shaft. The governor shaft and weights are thus driven by this rotor shaft.

(3) The control mechanism transmits the motion of the governor weights to the injector racks. This mechanism consists of a vertical shaft mounted inside a housing. A fork or yoke is located at the lower end and an operating lever is located at the upper end, together with a speed governing spring with suitable adjustments. The vertical shaft is mounted on an annular ball bearing at the upper end and a roller bearing at the lower end.

(4) The endwise motion of the governor weights is transmitted to the vertical shaft through a movable riser on the weight carrier shaft and the fork on the lower end of the vertical shaft. This motion is, in turn, transmitted to the injector control tube by means of the operating and differential levers on the upper end of the vertical shaft.

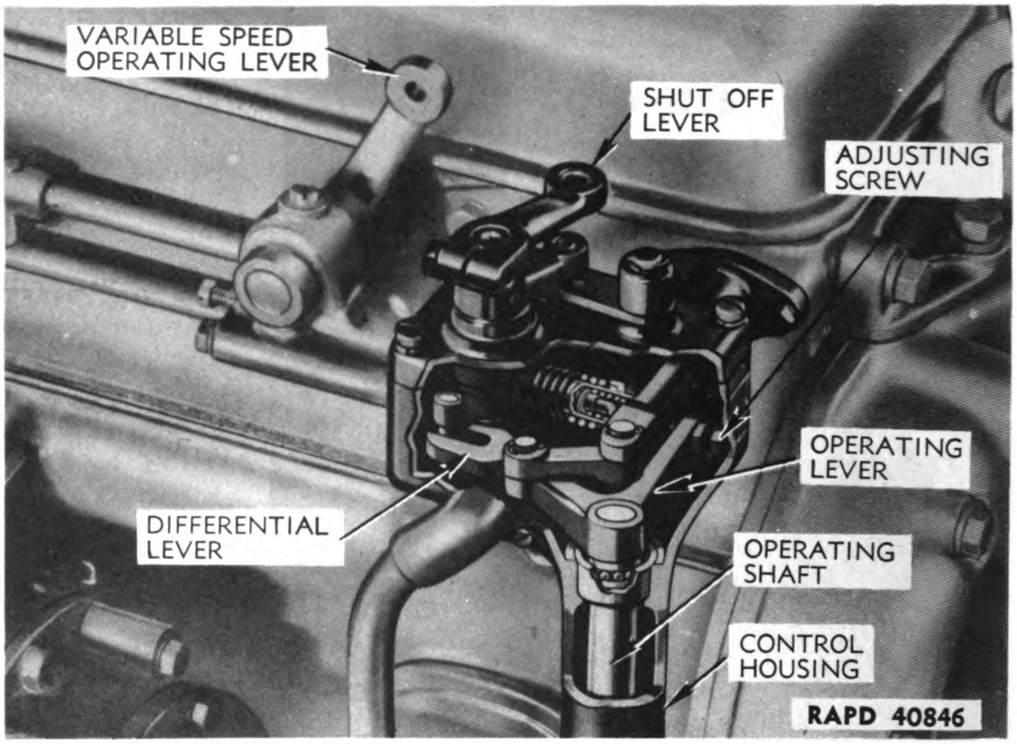



***Figure 151 — Cut-Away View Showing Governor Control Housing Assembly***

(5) The cover assembly serves as a carrier for the stop lever and the hand throttle control lever, and closes the top of the control mechanism housing.

(6) The specifications of the governor differ according to the duty required of the engine. For this reason certain definite information must be supplied when ordering a replacement governor for a specific engine. Always give engine number found on the bronze plate on cylinder block in back of governor.

**b. Operation.**

(1) The plunger at one end of the variable speed spring in the top of the governor control housing bears against the operating lever on the vertical operating shaft (fig. 151). The opposite end is retained and guided inside a spring retainer which in turn bears against a variable speed control lever operated by the rod from the throttle lever. The governor is designed to control the engine at any constant speed—within the limits of the governor spring—that the operator may desire. Such control is made possible by the idle adjusting screw, for the low engine speeds; and imposing more or less tension on the spring by means of the

throttle linkage and variable speed control lever, for higher speeds. The greater the tension on the spring, the higher the engine speed.

(2) For starting, the throttle lever is moved to the running position. This moves the injector control racks to full fuel position. Then, as soon as the engine starts, the governor moves the injector racks "OUT" to the position required for idling. The engine can then be brought up to any desired operating speed, within the limitations of the spring, by increasing the tension on the spring by means of the speed control lever. The engine speed control is entirely automatic from this point on, depending upon spring tension. The engine may be stopped by moving the throttle lever to the "OFF" position.

## 182. TROUBLE SHOOTING FOR GOVERNOR AND CONTROLS.

**a.** Governor faults are usually indicated by speed variations of the engine, but not all such speed variations are caused by improper functioning of the governor. Therefore, when improper speed variations occur, eliminate other possible causes before tampering with the governor. Check as follows:

(1) Check the load being pulled to be sure that the speed changes are not the result of changes in load.

(2) Check engine to be sure that all cylinders are firing properly.

(3) See that no bind exists in any of the governor mechanism or operating linkage between governor and engine; also, that no bind exists in the injector control tube shaft or its mounting brackets. With the governor control link connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of injector control racks. Binding may be due to any of the following conditions:

*(a) Injector Racks May Stick or Move Too Hard.* This may be due to the injector clamp being held too tightly or not positioned properly, and can often be eliminated by tapping the foot of the clamp lightly with small hammer and long punch or screwdriver. The injector control rack may stick, due to being cramped by control rack lever being out of position or cocked. Test by loosening adjusting screws. If bind is relieved, move lever endways slightly on shaft and adjust screws again as described in Injector Equalizing, paragraph 30.

*(b) Injector Control Tube May Stick or Work Hard.* This can be caused by dirt or chips in the bearing of the brackets supporting the tube,

lack of lubrication, poor alinement of the brackets or worn out bearings. Correct by cleaning and lubricating bearings, realining brackets or replacing bearings.

(c) *Return Spring May Be Bent or Linkage Binding.* The control tube should rotate and return injector control racks to the "NO FUEL" position by return spring only. *Never stretch or tamper with rack control spring* to change the tension. If spring is bent or not standard, replace. If pin in link connecting governor to injector control tube lever is binding, remove bind.

(4) Check adjustments of governor and control rods as outlined in paragraph 200.

**b.** If governor still fails to control the engine properly after above checks, the governor may be worn or broken parts may make it unfit for further use until the unit has been disassembled and rebuilt.

## 183. REMOVAL OF GOVERNOR.

**a. Equipment.**

BAR, pry
PLIERS
SCREWDRIVER, 6-in.
WRENCHES, two, 7/16-in.
WRENCH, 1/2-in.
WRENCH, open-end, 9/16-in.

**b. Procedure.**

(1) REMOVE PRE-CLEANERS AND HOOD.

BAR, pry
WRENCHES, two, 7/16-in.
WRENCH, open-end, 9/16-in.

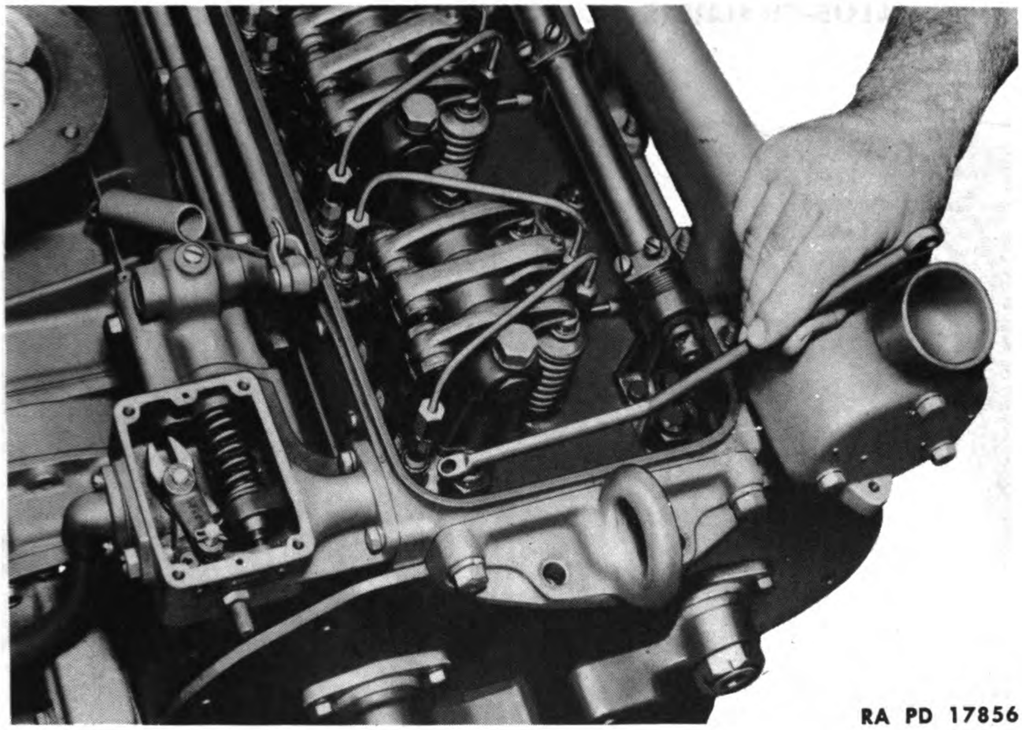
Loosen clamp at base of pre-cleaners (two 7/16-in. wrenches) and lift pre-cleaners off. Loosen the nuts on the hood hold-down straps at each corner of the hood; pry bolts out of slots. Lift hood off over air cleaner extension tubes and exhaust stacks.

(2) REMOVE ROCKER ARM COVER AND DISCONNECT LINKAGE.

PLIERS

Pull cotter pin and remove pin from governor control lever and rod. Clean dirt from rocker arm cover, unscrew hand screws through cover and lift cover from cylinder head. Pull cotter pin and remove pin from governor control link and injector control tube lever (fig. 152).

GOVERNOR



RA PD 17856

***Figure 152—Removing Governor Control Link***

(3) REMOVE COVER FROM GOVERNOR CONTROL HOUSING.

PLIERS SCREWDRIVER, 6-in.

Disconnect fuel shut-off rod from lever on cover by removing pin and cotter pin (pliers). Remove four screws and lift off control housing cover assembly (screwdriver).

(4) REMOVE GOVERNOR BREATHER TUBE.

SCREWDRIVER, 6-in.

Remove the two screws holding tube to control housing and lift tube out of clip on lubricating oil cooler housing.

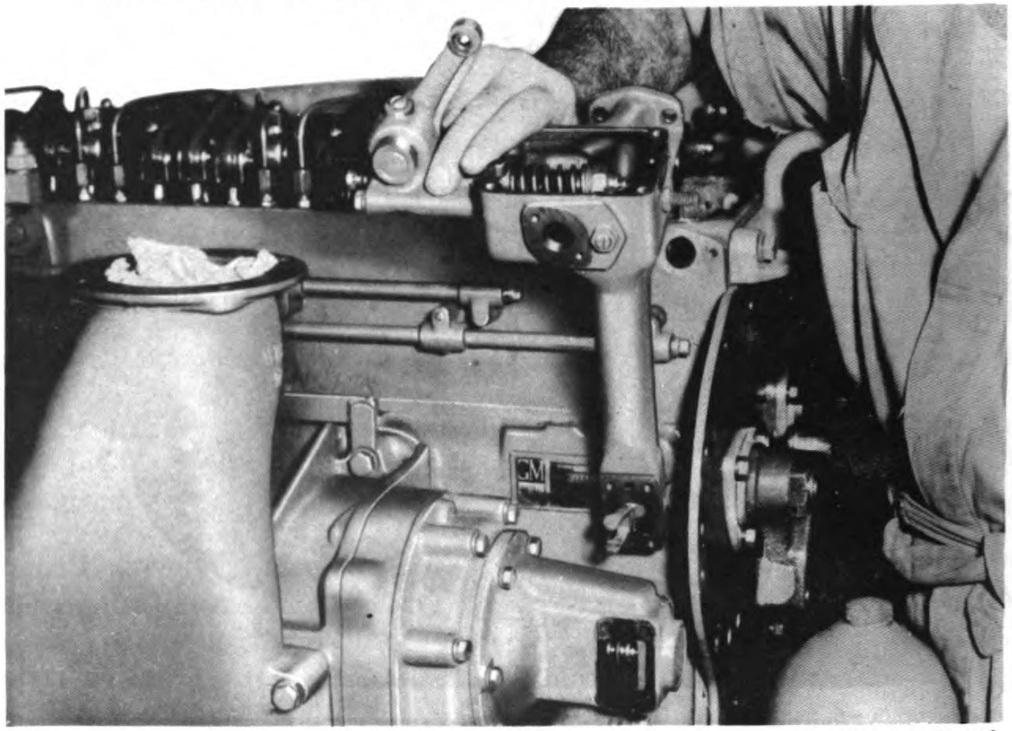
(5) REMOVE CONTROL HOUSING ASSEMBLY.

PLIERS WRENCH, 7/16-in.

Remove the four cap screws from weight housing cover (7/16-in. wrench). This also disconnects bottom of control housing from weight housing. Remove spring clip from differential lever pin (pliers) and lift control link off pin. Remove the two cap screws holding upper end of control housing to cylinder head (7/16-in. wrench). Remove control housing assembly.

(6) REMOVE GOVERNOR WEIGHT HOUSING.

WRENCH, ½-in.



RA PD 17809

*Figure 153—Removing Governor Control Housing*

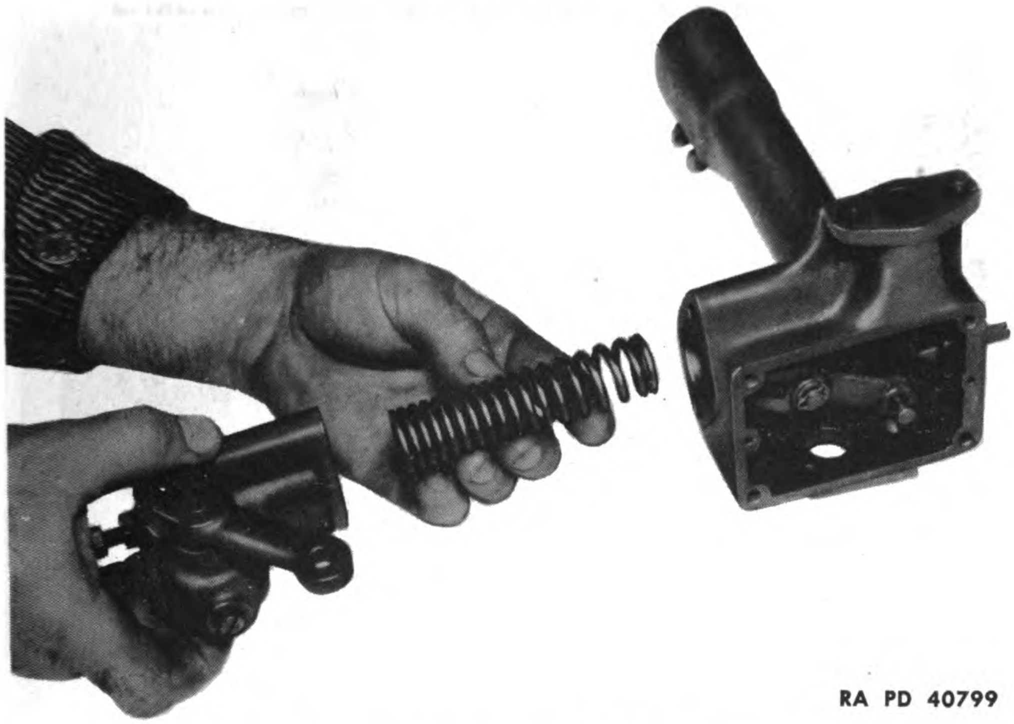
Remove the six cap screws from weight housing and pull housing from front end housing of blower.

## 184. DISASSEMBLY OF GOVERNOR.

**a. Equipment.**

CHISEL, small
HAMMER, ½-lb.
PLIERS, long-nosed
PRESS, arbor
PUNCH, small
SCREWDRIVER, 6-in.
WRENCH, ½-in.
WRENCH, hexagon, $\frac{3}{16}$-in.
WRENCH, socket, $1\frac{1}{16}$-in.

GOVERNOR



RA PD 40799

***Figure 154—Spring Housing and Spring Removed from Control Housing***

**b. Procedure.**

(1) REMOVE VARIABLE SPEED SPRING HOUSING.

WRENCH, ½-in.

Remove the two cap screws holding variable speed spring housing to control housing. Remove spring from control housing (fig. 154) and spring retainer and washers from spring housing (fig. 163).

(2) REMOVE VARIABLE SPEED SPRING PLUNGER.

HAMMER, ½-lb. PUNCH

Slip variable speed spring plunger from plunger guide. Then tap guide out of boss in control housing with hammer and punch.

(3) REMOVE DIFFERENTIAL LEVER.

PLIERS, long-nosed

Remove pin clip and washer from pin on operating lever and lift off differential lever (fig. 158).

(4) REMOVE VERTICAL OPERATING SHAFT ASSEMBLY.

HAMMER, ½-lb. SCREWDRIVER, 6-in.
PUNCH, small

Using hammer and punch, dislodge the two expansion plugs at bottom

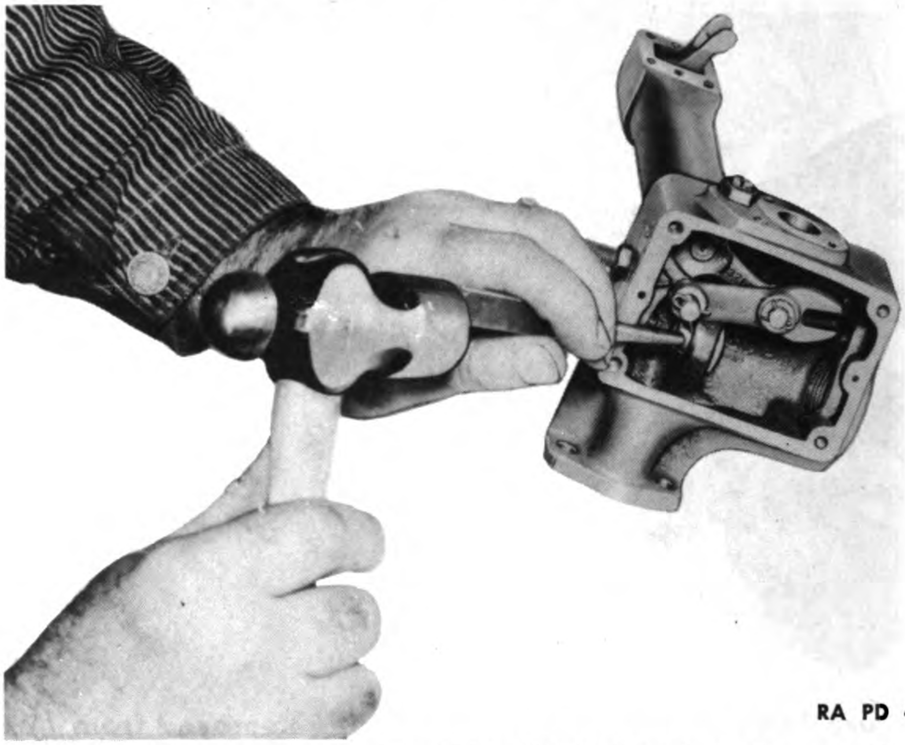



*Figure 155—Removing Variable Speed Spring Plunger Guide*

and side of control housing (fig. 156). Drive the tapered pin from yoke and lower end of operating shaft (fig. 157). Remove lock screw, lock washer, and flat washer holding upper bearing in control housing and back out governor buffer spring screw at side of control housing (screwdriver). Then drive operating shaft out of yoke and out through top of housing (hammer and punch). The operating lever and upper bearing will come out with shaft. Upper bearing can then be tapped off shaft and lower roller bearing out of control housing.

(5) DISASSEMBLE VARIABLE SPEED SPRING HOUSING ASSEMBLY.

SCREWDRIVER, 6-in.
WRENCH, hexagon, 3/16-in.

Remove pipe plug (fig. 159) from rear end of housing (screwdriver). Remove set screw (fig. 160) from spring lever through hole from which pipe plug was removed (3/16-in. hexagon wrench). Remove variable speed lever shaft from housing. Variable speed spring lever will now drop out of housing.

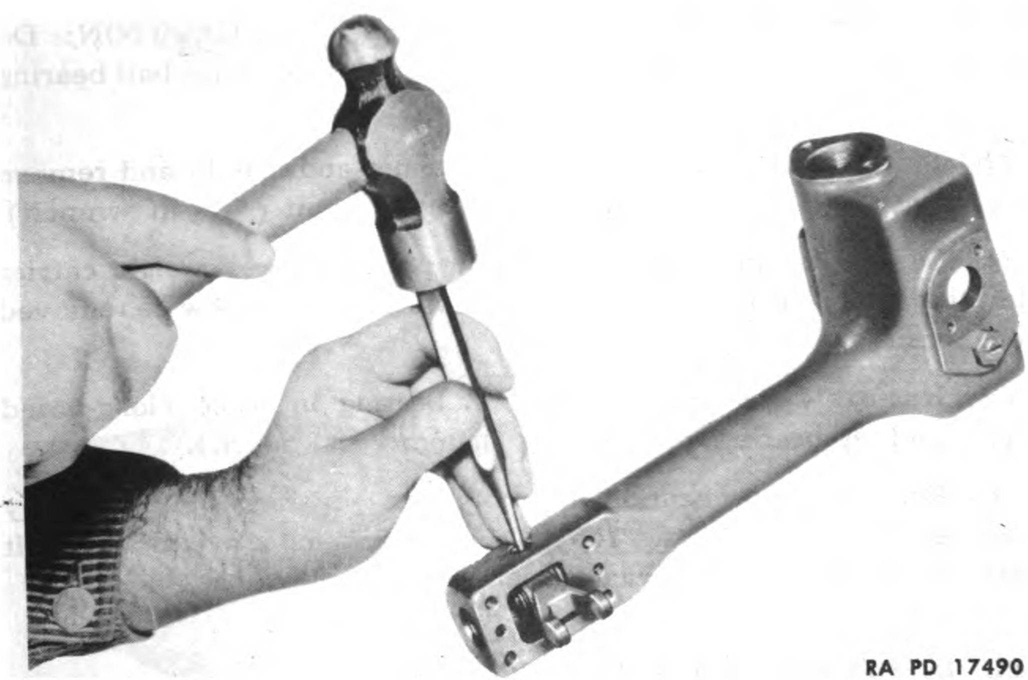
(6) DISASSEMBLE GOVERNOR WEIGHT HOUSING ASSEMBLY.

CHISEL, small
HAMMER, 1/2-lb.
PLIERS, long-nosed
PRESS, arbor
PUNCH, small
WRENCH, socket, 1 1/16-in.

## GOVERNOR

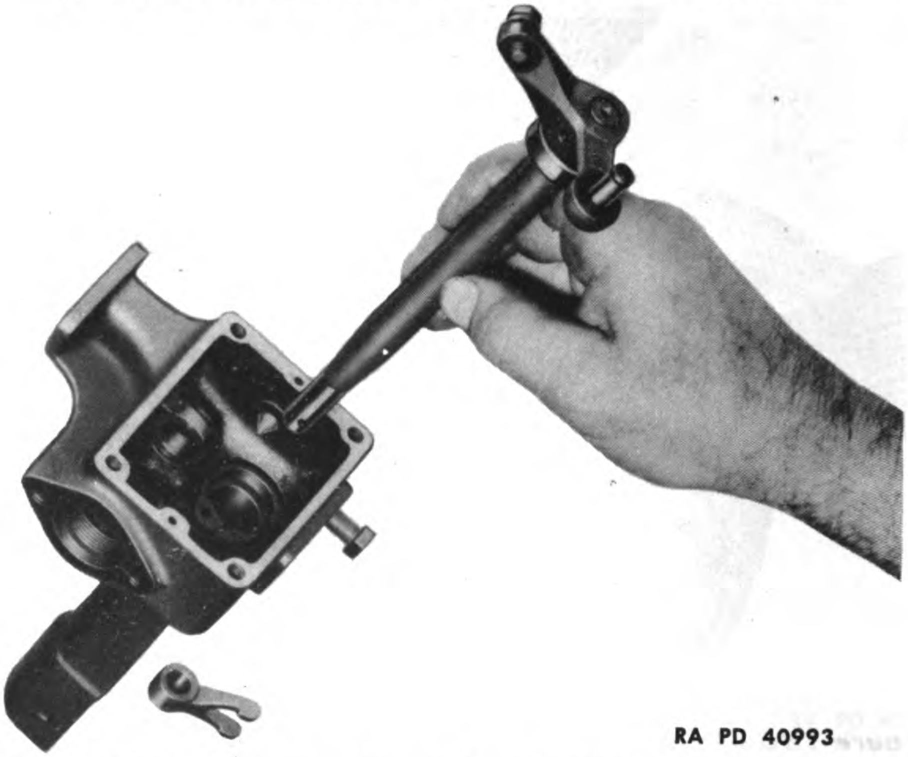
RA PD 40795

**Figure 156 — Expansion Plugs Removed from Control Housing**



RA PD 17490

**Figure 157 — Removing Tapered Pin from Governor Yoke and Shaft**



RA PD 40993

***Figure 158—Governor Operating Shaft Assembly Removed***

*(a)* Support governor weight housing in vise and remove bearing cap by driving punch through cap and prying from place. CAUTION: Do not drive punch through too far so end of punch will damage ball bearing beneath cap.

*(b)* Straighten lip on lock washer (hammer and chisel) and remove lock screw (fig. 161) from outer end of carrier shaft ($^{11}/_{16}$-in. wrench).

*(c)* Support housing assembly in arbor press and press weight carrier shaft from ball bearing. Shaft and weight assembly may now be removed from housing.

*(d)* Remove snap ring holding ball bearing in place (long-nosed pliers) and tap bearing from housing (hammer and punch).

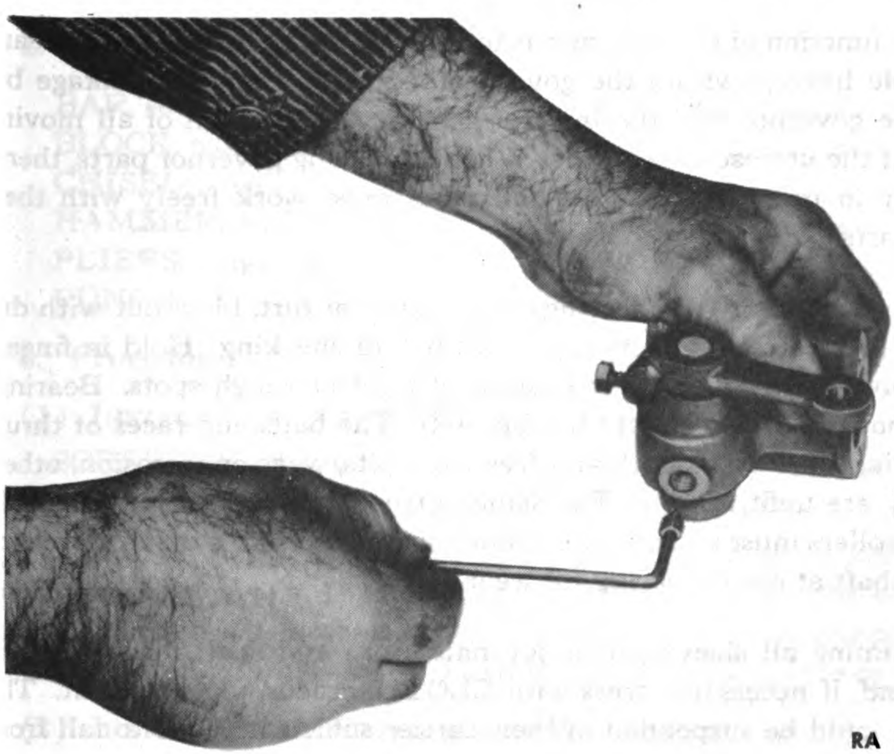
*(e)* Remove thrust bearing assembly and governor riser assembly from weight carrier shaft (fig. 166). Do not disassemble weight and shaft assembly as they are not serviced separately.

## 185. INSPECTION OF GOVERNOR PARTS.

**a.** Wash all parts in SOLVENT, dry-cleaning, and dry with compressed air. Then inspect to see if the various parts are fit for further use.

RA PD 41000

Figure 159 — Removing Pipe Plug from Spring Housing



RA PD 17489

Figure 160 — Removing Set Screw from Spring Variable Speed Spring Lever

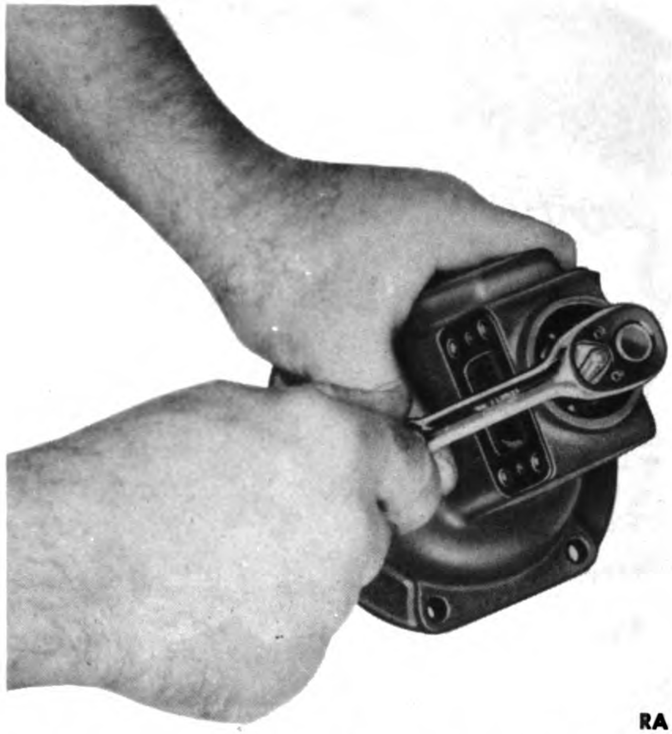


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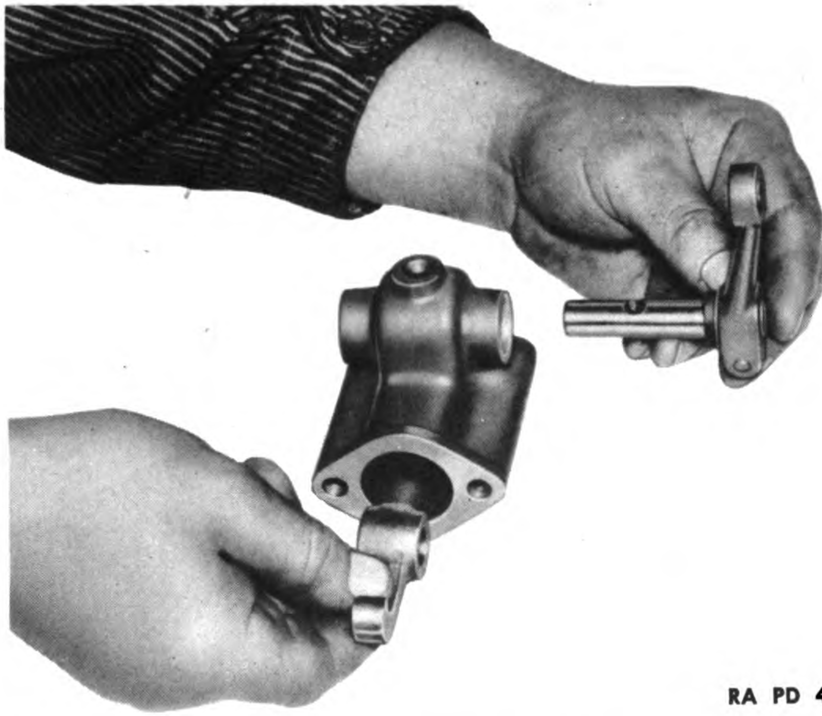
***Figure 161 — Removing Lock Screw from Weight Carrier Shaft***

Since the function of the governor is to control the fuel injection by means of suitable linkage within the governor and inter-connected linkage between the governor and the injector control, the freedom of all moving parts is of the utmost importance. When inspecting governor parts, therefore, bear in mind the fact that all parts must work freely with their mating parts.

**b.** Clean annular ball bearings thoroughly of dirt, blow out with dry air, then lubricate with light engine oil before checking. Hold in fingers and revolve slowly for any indication of tight or rough spots. Bearings that do not roll freely should not be used. The balls and races of thrust ball bearing must be smooth and free from pits, wear or corrosion, otherwise they are unfit for use. The same is true of roller bearings; in addition, the rollers must be perfectly round and not worn to a taper. Examine vertical shaft at roller bearing for wear.

**c.** Examine all sleeves, pins, journals, links and shaft for wear; also for fits and, if necessary, dress with CLOTH, crocus, for proper fit. The weights should be suspended in their carrier sufficiently free to fall from the extended to the inner position by their own weight, and the suspending pins should not be more than 0.002-inch out-of-round.



RA PD 40904

*Figure 162—Installing Variable Speed Spring Lever and Shaft*

## 186. ASSEMBLY OF GOVERNOR.

### a. Equipment.

| | |
|---|---|
| BAR, soft | SCREWDRIVER, 6-in. |
| BLOCK, wooden | WRENCH, $7/16$-in. |
| CHISEL, small | WRENCH, ½-in. |
| HAMMER, ½-lb. | WRENCH, hexagon, $3/16$-in. |
| PLIERS, long-nosed | WRENCH, socket, $11/16$-in. |
| PUNCH | |

### b. Procedure.

(1) INSTALL VARIABLE SPEED LEVER SHAFT.

SCREWDRIVER, 6-in. WRENCH, hexagon, $3/16$-in.

Place packing washer on shaft, then packing ring. Hold variable speed spring lever in position in spring housing and insert shaft into housing and through lever (fig. 162). Install set screw in spring lever so point of screw enters recess in shaft ($3/16$-in. hexagon wrench). Install ⅛-inch slotted pipe plug in hole at top of spring housing (screwdriver).

(2) INSTALL SPRING RETAINER AND WASHERS.

Drop washers formerly removed into variable speed spring retainer and drop retainer and washers into spring housing.

RA PD 40788

*Figure 163—Installing Variable Speed Spring Retainer*

(3) INSTALL OPERATING SHAFT ASSEMBLY.

| | |
|---|---|
| BAR, soft | PUNCH |
| HAMMER, soft | SCREWDRIVER, 6-in. |

Support shaft in vise and tap ball bearing into place on upper end of shaft (soft hammer). Apply light engine oil to lower roller bearing assembly and tap bearing into place in control housing for lower end of shaft (hammer and soft bar). Install shaft assembly in control housing. After end of shaft passes through lower bearing, place fork on lower end, with rounded sides of fork directed towards rear of governor (soft hammer). Line up holes in fork with hole in shaft and drive tapered pin (fig. 157) into holes tightly (hammer and punch). Install plain washer, lock washer and lock screw to hold upper ball bearing in place (screwdriver). Test shaft to see if it revolves freely in bearings. Then install expansion plugs in holes in bottom and side of control housing (fig. 156).

(4) INSTALL DIFFERENTIAL LEVER.

PLIERS

Set differential lever assembly on pin on operating lever and secure with washer and hairpin clip.

(5) INSTALL VARIABLE SPEED SPRING PLUNGER AND PLUNGER GUIDE.

| | |
|---|---|
| HAMMER, ½-lb. | PUNCH |

GOVERNOR

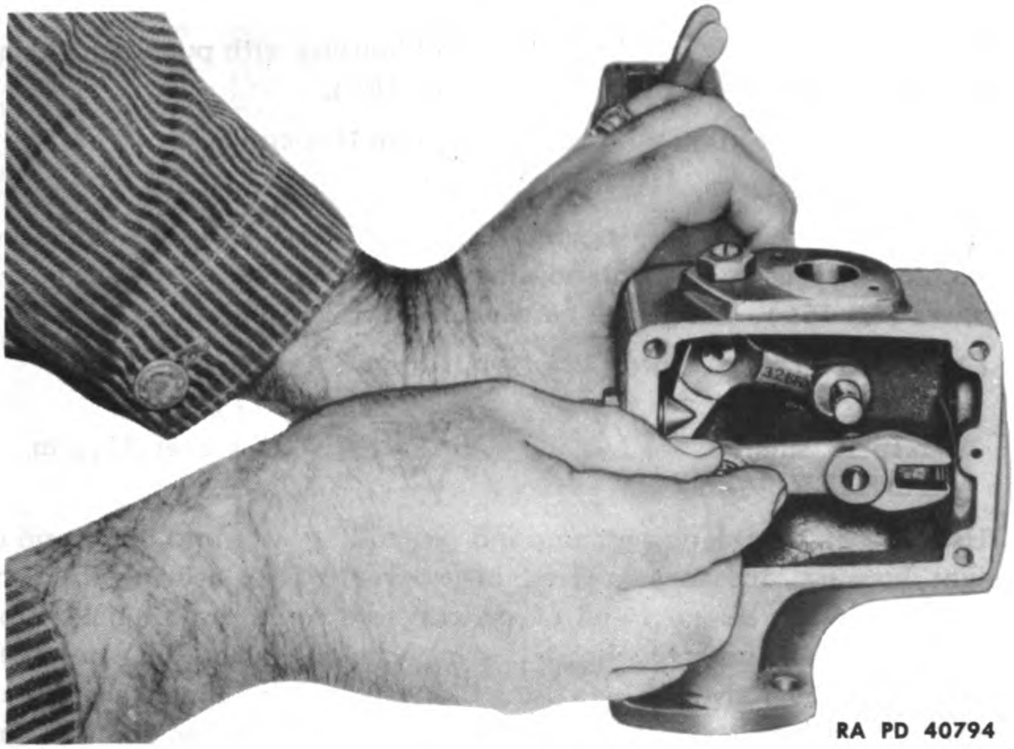



***Figure 164—Installing Differential Lever***

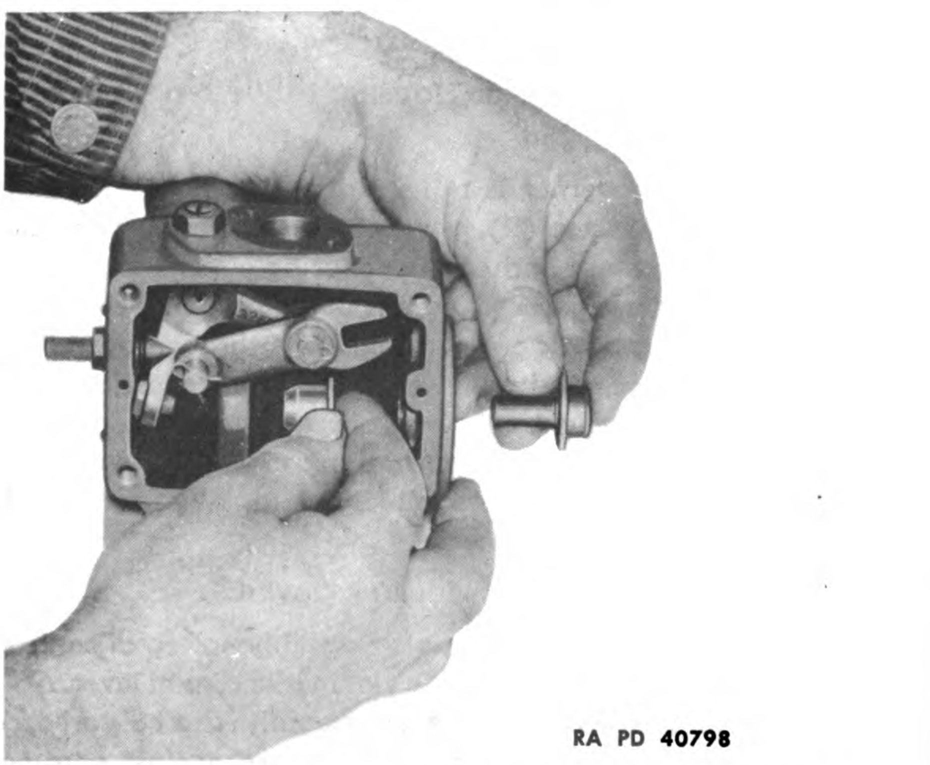



***Figure 165—Installing Variable Speed Spring Plunger and Guide***

Drive plunger guide into bore in control housing with punch and hammer. Insert plunger into plunger guide (fig. 165).

(6) INSTALL VARIABLE SPEED SPRING AND HOUSING.

WRENCH, ½-in.

Install variable speed spring into spring retainer in spring housing and assemble housing to control housing with two cap screws with lock washers (fig. 154). Use gasket between the two housings.

(7) ASSEMBLE GOVERNOR WEIGHT HOUSING ASSEMBLY.

BLOCK, wooden
CHISEL, small
HAMMER, ½-lb.
PLIERS, long-nosed
WRENCH, socket, 1$\frac{1}{16}$-in.

Use wooden block and hammer and tap ball bearing into outer end of weight housing. Install snap ring in groove to lock bearing in place (pliers). Support serrated end of shaft in soft-jawed vise or hold it on block. Slip riser and then thrust bearing assembly (fig. 166) on shaft. Drop housing over shaft. Then, using block of wood on inner race of ball bearing, drive bearing onto shaft tight against shoulder on shaft (hammer). Slip flat washer and lock washer on end of shaft and install retainer screw (1$\frac{1}{16}$-in. wrench). Bend lock washer over head of retainer screw (hammer and chisel). Install new housing end cap in end of housing (hammer).

(8) CONNECT CONTROL HOUSING TO WEIGHT HOUSING.

WRENCH, $\frac{7}{16}$-in.

NOTE: If governor is to be put on tractor immediately, do not perform this step or step (9), as weight housing and control housing must be installed separately and control housing cover removed. If assembly is to be put in spare parts stock, it is best to connect the two for a complete assembly. Insert fork of operating shaft through opening from rear side of weight housing and over shaft (with fork ahead of thrust bearing assembly). Hold weight housing cover and gasket in place and install four cap screws to connect control housing to weight housing. Pour about ½ pint of engine oil, crankcase grade, into top of governor to lubricate parts thoroughly.

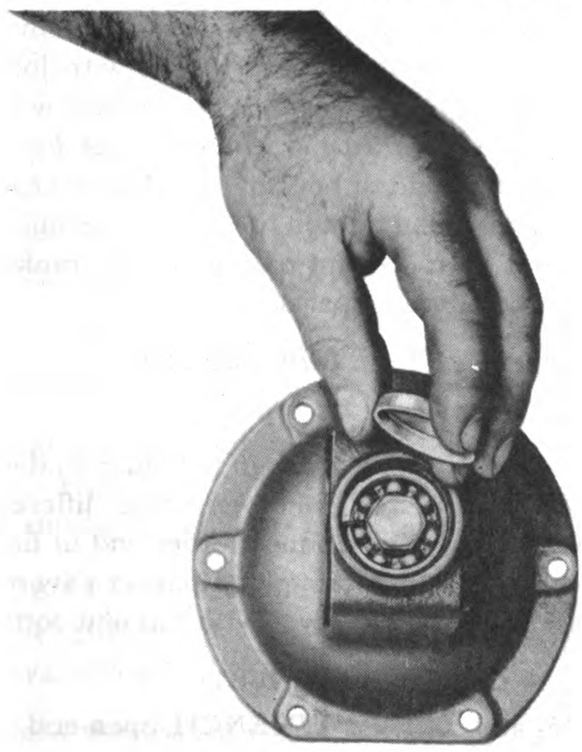
(9) INSTALL CONTROL HOUSING COVER.

Install cover gasket and cover assembly on top of control housing with pin on shut-off lever engaging in slot in differential lever. Attach cover with four screws with lock washers. If assembly is to be stored, cover openings with adhesive paper, if possible, to guard against entrance of dirt and moisture.

GOVERNOR

RA PD 40995

***Figure 166—Installing Riser and Thrust Bearing on Weight Carrier Shaft***



RA PD 40902

***Figure 167—Installing Weight Housing End Cover***

## 187. INSTALLATION AND ADJUSTMENT.

**a. Equipment.**

GAGE, feeler, 0.006- and 0.020-in.
INDICATOR, speed
PLIERS
SCREWDRIVER, 6-in.
WRENCH, ½-in.
WRENCH, open-end, ⅜-in.
WRENCHES, open-end, two, 7/16-in.
WRENCH, open-end, 9/16-in.

**b. Procedure.**

(1) INSTALL GOVERNOR WEIGHT HOUSING.

Shellac gasket to mounting flange of housing. Slide the housing assembly up against the front end of the blower with splined end of governor shaft (fig. 84) entering the hollow upper blower rotor shaft. Install the six cap screws with lock washers, *fingertight only*.

(2) INSTALL GOVERNOR CONTROL HOUSING.

WRENCH, 7/16-in.
WRENCH, ½-in.

Shellac new gasket to mounting surface at upper end of control housing. Place new paper gasket on dowels at lower end of control housing. Set control housing in position against weight housing; then put weight carrier housing cover and gasket in position, and lock cover, gaskets and the two housings together with four cap screws with lock washers. *IMPORTANT! Be sure that forked lever is assembled with rounded machined faces bearing on outer thrust washer and not between outer washer and balls.* Attach upper end of housing to cylinder head with two cap screws with lock washers. Then tighten the cap screws holding weight housing to blower. Pour at least ½ pint of engine oil, crankcase grade, into top of control housing to lubricate parts.

(3) CONNECT GOVERNOR CONTROL LINK (fig. 152).

PLIERS

Insert short bent end of control link through hole in cylinder head into control housing and set end of link on pin on governor differential lever. Secure with washer and hairpin clip. Connect other end of link to injector control tube lever with pin and cotter pin. Connect governor control rod to variable speed spring operating lever with pin and cotter pin.

(4) ADJUST GOVERNOR CONTROLS (fig. 168).

GAGE, feeler, 0.006- and 0.020-in.
SCREWDRIVER, 6-in.
WRENCH, open-end, ⅜-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.

## GOVERNOR

*(a)* Check (if necessary, adjust) valve clearance, timing and equalizing of injectors (pars. 28 to 30) before adjusting governor.

*(b)* Push fuel and air shut-off knob in against dash. Place throttle control in half open position.

*(c)* Loosen the lock nut on the adjusting screw (A) (7/16-in. wrench) and turn the adjusting screw in or out until a 0.006-inch feeler gage can be inserted between the spring plunger and spring plunger guide at (B). Tighten lock nut (7/16-in. wrench).

*(d)* Loosen the lock nut on the buffer adjusting screw (9/16-in. wrench). Push the governor control link toward the buffer spring so as to close the injectors completely. Turn the buffer spring adjusting screw in or out (screwdriver) until a 0.020-inch feeler gage can be inserted between the differential lever and the buffer spring adjusting screw at (C). Tighten lock nut (9/16-in. wrench).

*(e)* When the motor was originally assembled, the adjusting screw (D) was backed out as far as possible and the lock nut securely tightened. This screw plays no part in the adjustment or operation of this governor. It will *never* be necessary to change the original setting of the screw.

(5) INSTALL CONTROL HOUSING COVER ASSEMBLY.

| | |
|---|---|
| **PLIERS** | **SCREWDRIVER**, 6-in. |

Place gasket and cover on top of housing with pin on fuel shut-off lever engaging in slot of differential lever. Secure cover with four screws (screwdriver). Connect fuel shut-off rod to lever on cover with pin and cotter pin (pliers). Check travel of shut-off lever as described in paragraph 190. Replace rocker arm cover.

(6) INSTALL HOOD AND PRE-CLEANERS.

| | |
|---|---|
| **WRENCHES**, two, 7/16-in. | **WRENCH**, open-end, 9/16-in. |

Lower hood over exhaust tail pipe. Force hold-down strap bolts into clips and tighten (9/16-in. wrench). Set pre-cleaners on tubes at top of air cleaners and tighten clamps at base (two 7/16-in wrenches).

(7) CHECK IDLING SPEED (IF NECESSARY).

| | |
|---|---|
| **INDICATOR**, speed | **WRENCH**, 7/16-in. |
| **SCREWDRIVER**, 6-in. | |

The full load speed adjustment is made at the factory and must not be changed in the field. If it becomes necessary to change the idling speed, start the engine and operate until it has reached the normal operating

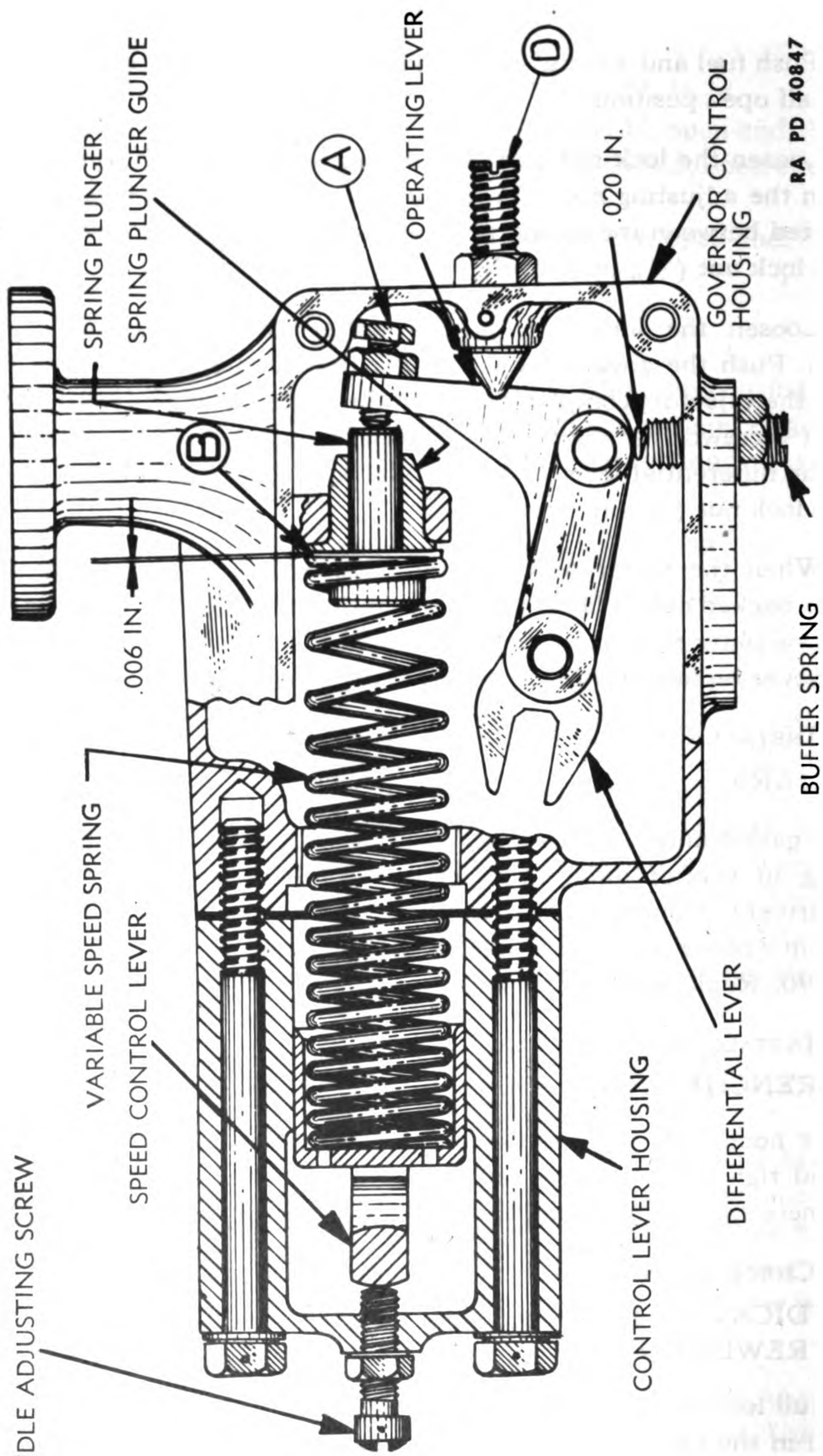



**Figure 168 — Governor Adjustments**

temperature. Loosen the lock nut (7/16-in. wrench) on the idle adjusting screw and turn the screw "IN" (clockwise) for higher speeds, or "OUT" (counterclockwise) for slower speeds (screwdriver) until the desired speed is obtained. The correct idling speed is 350 revolutions per minute. Tighten the lock nut securely. The revolutions per minute of engine can be checked by removing cover from rear of generator and checking speed of generator with a speed indicator but be sure generator belt is tight when making this test. Divide speed of generator by 1.7. This will give revolutions per minute of the crankshaft. Therefore, if speed of generator is 595 revolutions per minute, the idling speed of the engine is correct.

## 188. SPECIAL TOOLS.

**a.** Special tools required for governor are as follows:

| | |
|---|---|
| INDICATOR, speed | PRESS, arbor |

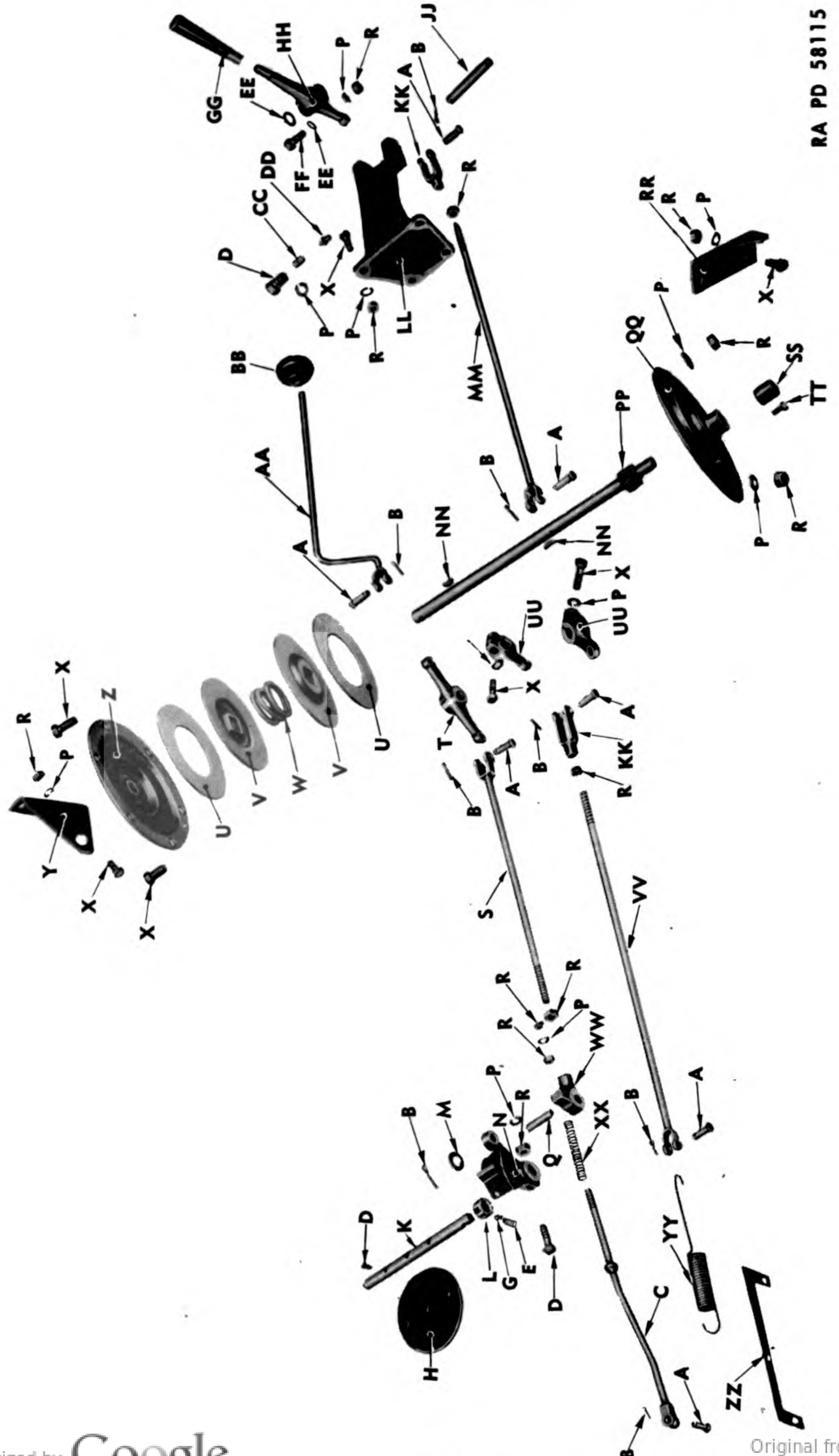



*Figure 169 — Exploded View of Engine Controls*

**A** — ROD END PIN
**B** — COTTER PIN
**C** — FUEL AND AIR SHUT-OFF ROD (FRONT)
**D** — CAP SCREW
**E** — AIR SHUT-OFF SHAFT BALL SPRING
**F** — AIR SHUT-OFF SHAFT SLEEVE
**G** — BALL
**H** — AIR SHUT-OFF VALVE
**J** — LOCKING WIRE
**K** — AIR SHUT-OFF SHAFT
**L** — AIR SHUT-OFF AIR SEAL
**M** — PLAIN WASHER
**N** — AIR SHUT-OFF SHAFT LEVER
**P** — LOCK WASHER
**Q** — SHUT-OFF ROD LEVER PIN
**R** — NUT
**S** — FUEL AND AIR SHUT-OFF ROD (INTERMEDIATE)
**T** — FUEL AND AIR SHUT-OFF LEVER
**U** — FRICTION FIBRE DISK
**V** — FRICTION PRESSURE PLATE
**W** — FRICTION PRESSURE PLATE SPRING
**X** — BOLT
**Y** — LEVER SHAFT BRACKET
**Z** — FRICTION DISK INNER COVER
**AA** — FUEL AND AIR SHUT-OFF ROD (REAR)

**BB** — FUEL AND AIR SHUT-OFF KNOB
**CC** — BRACKET PLUNGER SPRING
**DD** — BRACKET PLUNGER
**EE** — SHIM
**FF** — LEVER STOP PIN
**GG** — LEVER GRIP
**HH** — THROTTLE LEVER
**JJ** — PIVOT SHAFT
**KK** — ADJUSTABLE YOKE
**LL** — CONTROL BRACKET
**MM** — THROTTLE CONTROL ROD (REAR)
**NN** — WOODRUFF KEY
**PP** — THROTTLE CONTROL SHAFT
**QQ** — FRICTION DISK OUTER COVER
**RR** — FRICTION DISK COVER MOUNTING BRACKET
**SS** — FRICTION DISK COVER BUSHING
**TT** — PIPE PLUG
**UU** — SHAFT LEVER
**VV** — THROTTLE CONTROL ROD (FRONT)
**WW** — SHUT-OFF ROD LEVER
**XX** — FUEL AND AIR SHUT-OFF ROD SPRING
**YY** — SPRING
**ZZ** — BRACKET

RA PD 58115A

**Legend for Figure 169—Engine Controls**

## Section II

# ENGINE CONTROLS



## 189. THROTTLE CONTROL.

**a.** The throttle lever is connected by indirect linkage to the operating lever on the governor spring housing. Motion of the hand throttle is transmitted to the throttle shaft, which is mounted on the front side of the cowl by means of a link and lever. Another lever keyed to the other end of the throttle shaft transmits the motion by means of another link to the governor variable speed control lever. A spring loaded diaphragm with two fiber friction disks and pressure plates holds the throttle shaft in the position set by the throttle lever.

**b.** Moving the throttle lever causes more or less tension to be imposed on the variable speed spring and thus increases or decreases the governed engine speed.

## 190. FUEL SHUT-OFF AND AIR VALVE CONTROL.

**a.** Opening or closing of the air valve in the air intake elbow and of the fuel shut-off lever on the governor is accomplished with the fuel and air shut-off knob on the tractor dash. Pushing the knob in against the dash opens the air valve and moves the fuel shut-off lever on the governor control housing to the open position (back). Pulling the knob out closes the air valve and moves fuel shut-off lever on governor to the closed position (forward).

**b.** Correct adjustment of the fuel shut-off and air valve control can be easily checked as follows:

(1) With the shut-off knob pushed in to running position, check to see if the shut-off lever stop assembly is in position as shown (fig. 170). The ball in the stop assembly should be centered in the hole in the shut-off lever as shown. If not, the shut-off knob is probably hitting the dash. To adjust, remove pin "A" and move shut-off lever until the ball is centered in the front hole in the shut-off lever. Now adjust linkage at "B" until the rod can be reconnected at "A."

(2) With the linkage set in running position, check to see if the governor shut-off lever pin contacts the rear of the slot in the shut-off lever stop. If not, loosen the clamp screw on the governor fuel shut-off lever and position the lever pin until it contacts the rear end of the slot; tighten the clamp screw.

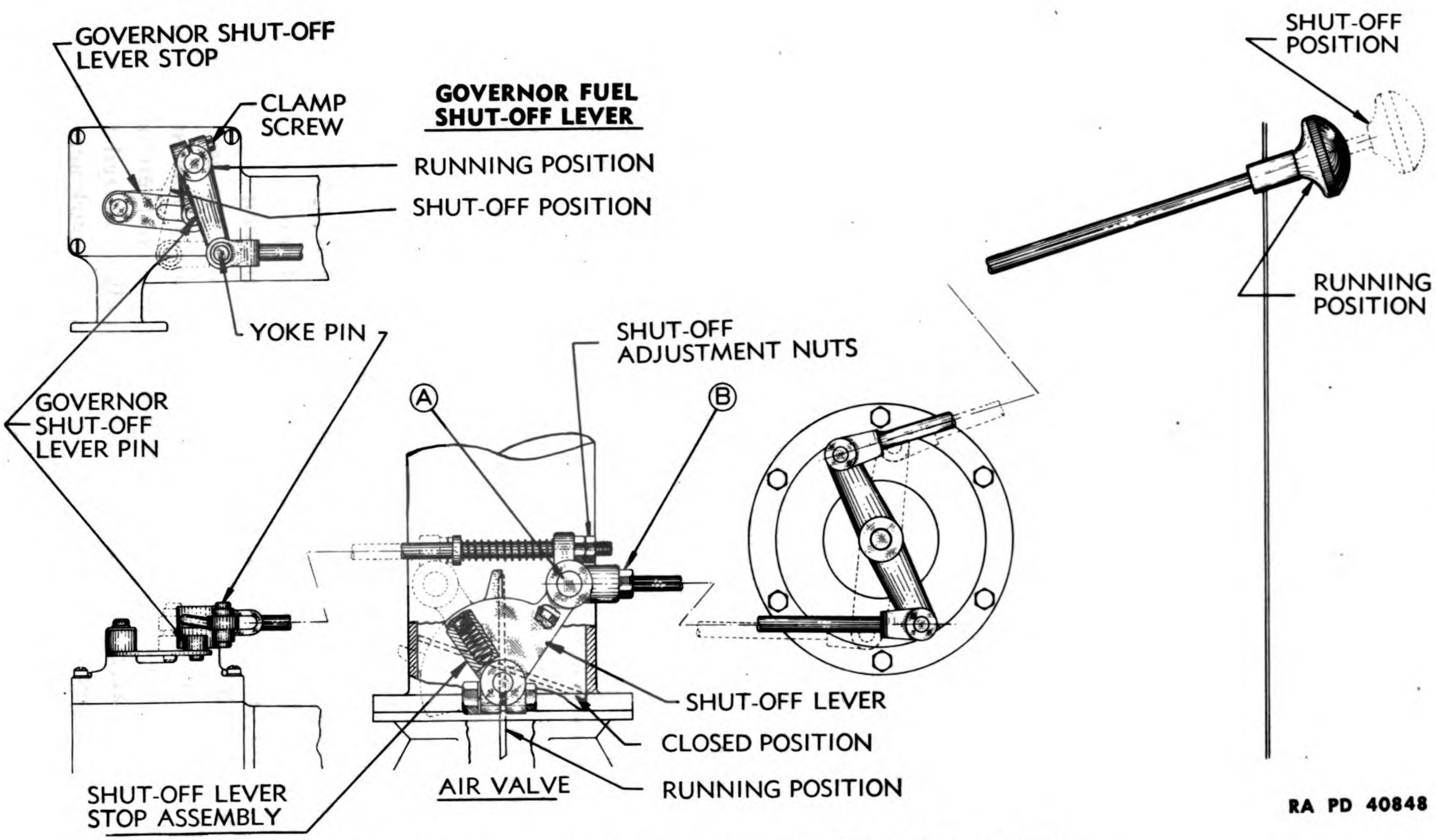



**Figure 170—Fuel Shut-Off and Air Valve Adjustments**

# CHAPTER 10

# HEATERS, ENGINE AND AIR

## Section I

## AIR HEATER



### 191. DESCRIPTION.

**a.** The engine air heater is essentially a small pressure oil burner with electric ignition. The burner proper is mounted in the engine air box. It obtains the necessary air for combustion from the charging blower and discharges the flame heated air into the engine cylinders with practically no loss of heat. The device consists of two assemblies. One unit comprises the pressure pump and ignition switch and is mounted on instrument dash in easy reach of the operator. The other unit contains the burner nozzle, filter, ignition coil and ignition points and is designed to replace one of the handhole cover plates of the engine air box. A check valve is located outside this unit to prevent fuel dribble.

**b.** The pump is intended to supply fuel under pressure to the burner unit where the charge is filtered before reaching the discharge nozzle. The suction side of the pump is connected to the engine supply line between the fuel tank and the fuel pump at the rear of the blower. The switch is connected between the ammeter outlet post and one terminal of the ignition coil on the burner. The other terminal of the coil is grounded inside the burner unit cover. The pump plunger, when not in use, is held in the "IN" position by a spring mechanism which can be released by turning the plunger knob about a quarter turn to the left (counterclockwise). The pump is operated by hand and delivers finely atomized fuel from the nozzle of burner unit. This fuel is ignited by the spark across the burner points which occurs when the switch on the dash is pressed into the closed position. Operation of the air heater in conjunction with cold weather starting is described in TM 9-787A.

## AIR HEATER

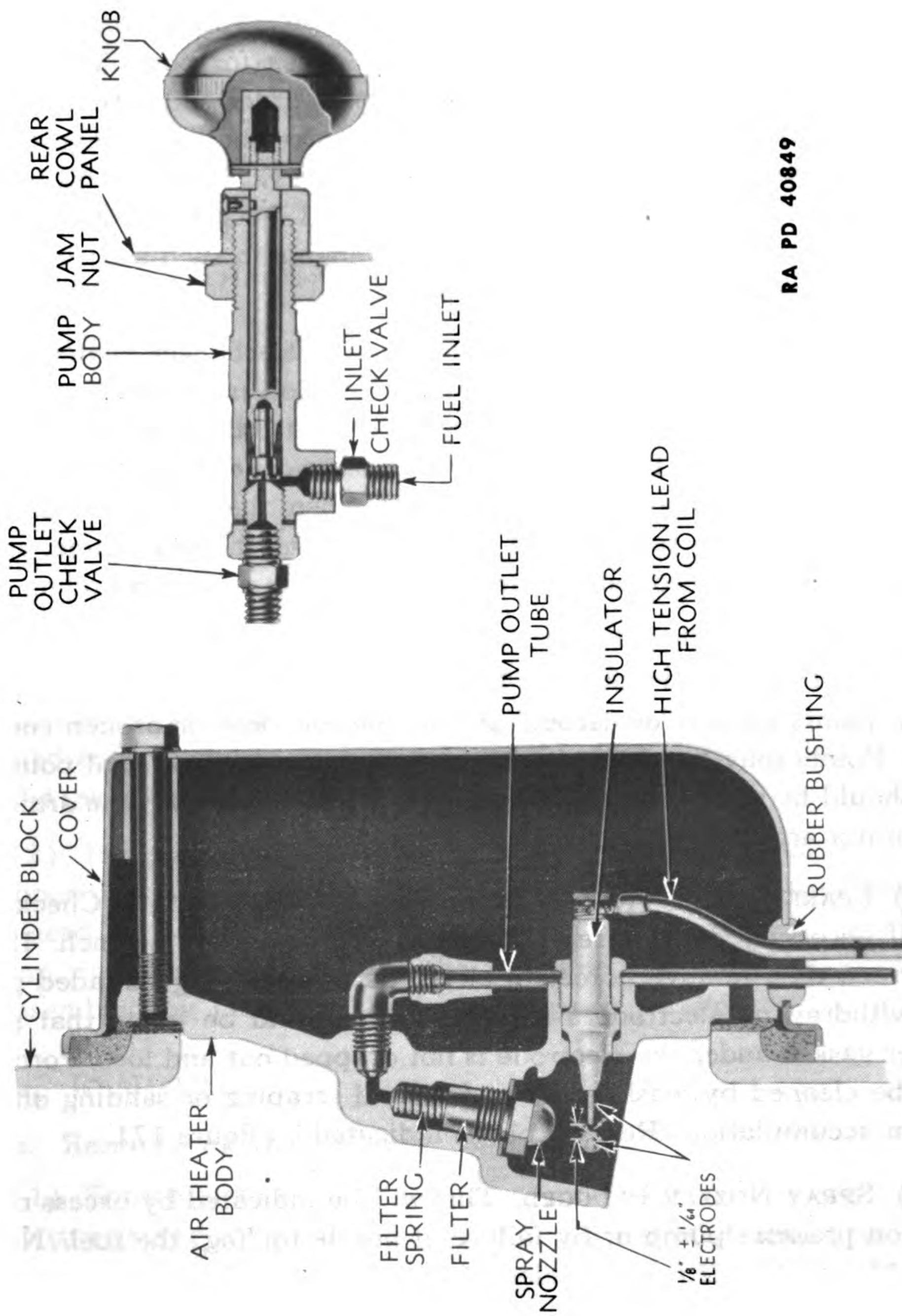



*Figure 171—Air Heater Assembly*

## 192. TROUBLE SHOOTING.

**a. Inoperative Burner Unit.** If two or three heater pump strokes, made while cranking the engine with wide open throttle, fail to produce a fire, it is advisable to stop cranking and check for possible causes of failure. Assuming that the engine is in running order and cranking speed is 80 revolutions per minute or over, the heater should be investigated for (a) failure of ignition, and (b) poor oil spray. To make this investigation, the burner element should be removed from its position on the engine air box and reconnected outside of engine in such a position that the burner operation can be easily observed.

**b. Checks for Inoperative Burner Unit.** Reconnect heater unit—*away from engine*. Turn the dash switch on. Coil interrupter should vibrate rapidly and a continuous hot spark should occur between the ignition electrodes. Then turn the dash switch off; a cone-shaped discharge of fuel should be emitted from the burner when the pump is operated. NOTE: These two tests should *not* be made at the same time, as the burner throws a considerable flame and will ignite any surrounding combustible material.

(1) COIL INTERRUPTER DOES NOT VIBRATE WHEN SWITCH IS CLOSED. Check points for dirt or carbon, and wiring for loose or broken connections. Points may be cleaned with fine sandpaper or a special point file and should be reset after cleaning to give ⅛-inch gap with the armature or vibrator arm held against the coil body.

(2) SPARK JUMPS ACROSS PORCELAIN OF ELECTRODE. Check gap and, if necessary, reset wire electrode to approximately ⅛ inch. If gap is correct, then remove porcelain electrode by removing threaded gland and withdrawing electrode assembly. Care should be taken that small copper gasket under the electrode is not dropped out and lost. Porcelain may be cleaned by washing off in fuel and scraping or sanding off any carbon accumulation. Reassemble as indicated by figure 171.

(3) SPRAY NOZZLE PLUGGED. This will be indicated by excess resistance on pressure pump or by failure of nozzle to "fog" the fuel. Nozzle assembly must be removed to clean (par. 194).

**c. Inoperative Pressure Pump.** Failure of the pressure pump can occur from two causes: (1) check valves and (2) plunger piston cups.

(1) The inlet and outlet check valve assemblies are threaded into the pump casting (fig. 171). An arrow indicating the direction of flow is stamped on each valve and the suction check valve (½-lb valve) is

AIR HEATER

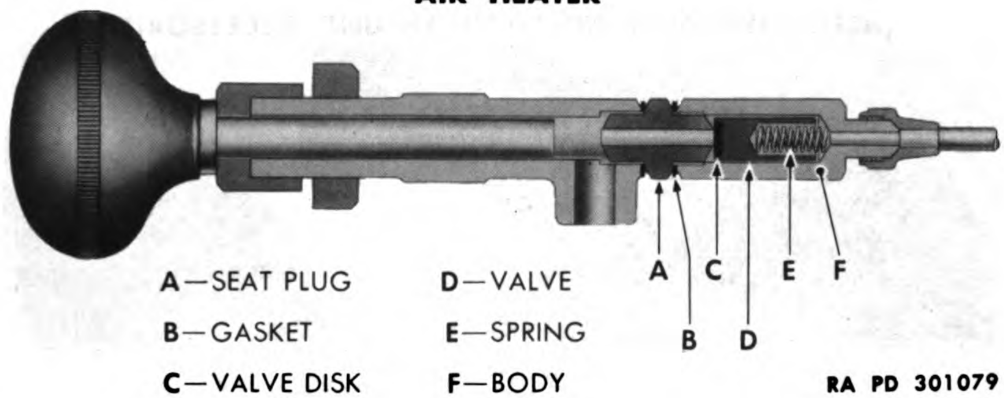



***Figure 172—Air Heater Pump Check Valve Assembly (No. 048604)***

marked ½ inch. The check valves are of the spring-loaded ball type, and the parts cannot be disassembled without being damaged. The valves can be cleaned, if necessary, by forcing fuel through them with any suitable pump.

NOTE: An improved outlet check valve assembly (fig. 172) at the pump No. 048604, is available, and became effective in production with Tractor HD 10W No. 2082. This improved check valve takes the place of both the No. 04435 check valve at the air heater cover and the No. 5153358 outlet check valve at the pump. The valve disk can be replaced or turned over when wear or leakage takes place. The seat plug can be turned end for end to provide a new valve face when needed. The ends of the seat plug can be lapped if necessary.

(2) The piston cups or leathers are molded from a special oil resistant composition, and if they should break or become worn, they should be replaced by duplicate parts. When any pump parts need replacing, the pump must be removed from the instrument panel, disassembled and reassembled by following the instructions in paragraphs 193 to 196.

## 193. REMOVAL.

### a. Removal of Burner Unit.

(1) EQUIPMENT.

WRENCH, ⅜-in.
WRENCH, ½-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.
WRENCH, socket, 9/16-in.

(2) PROCEDURE.

*(a) Remove Cover from Unit.*

WRENCH, ⅜-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.

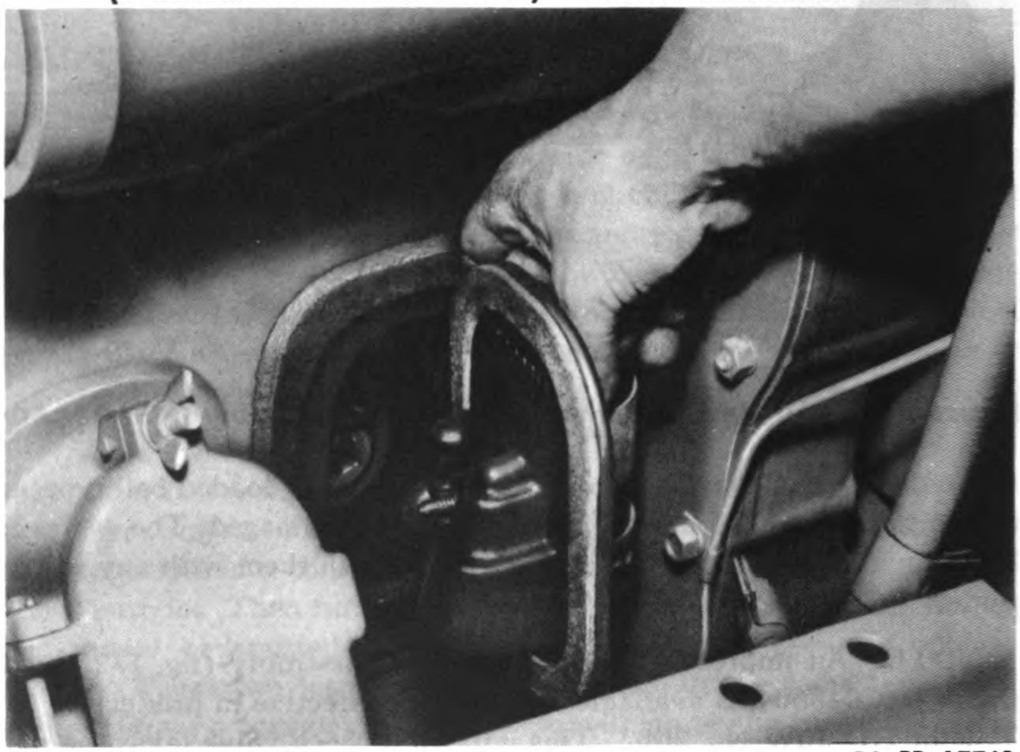


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*Figure 173—Removing Air Heater Burner Unit*

Disconnect air heater fuel line at rear of check valve on cover (7⁄16-in. and 9⁄16-in. wrenches). Remove cap screw from clip holding fuel line to cylinder block end plate (9⁄16-in. wrench). Remove the two cap screws attaching cover to cylinder block (½-in. wrench) and slide cover down on wire until wire can be disconnected from coil (⅜-in. wrench). Then lower cover further on wire out of way.

*(b) Remove Burner Unit.*

WRENCH, socket, 9⁄16-in.

Remove cap screw in center of unit and pull unit out away from engine.

**b. Removal of Pressure Pump.**

(1) EQUIPMENT.

PLIERS, two pairs of
WRENCH, open-end, 7⁄16-in.
WRENCH, open-end, 9⁄16-in.
WRENCH, open-end, ⅝-in.
WRENCH, open-end, ⅞-in.

(2) PROCEDURE (fig. 175).

*(a) Disconnect Fuel Lines.*

WRENCH, open-end, 7⁄16-in.
WRENCH, open-end, 9⁄16-in.
WRENCH, open-end, ⅝-in.
WRENCH, open-end, ⅞-in.

Close fuel shut-off valve at supply tank. Disconnect both intake and outlet fuel lines from pump (5/8-, 7/8-, 7/16- and 9/16-in. wrenches).

(b) *Remove Pump Assembly from Dash.*

PLIERS, two pairs of

Hold pump body to keep it from turning with one pair of pliers, unscrew the pump plunger nut from pump body with the other pair, and pull pump plunger assembly out of pump body. Pump body can now be removed from back of dash.

## 194. DISASSEMBLY.

### a. Disassembly of Burner Unit.

(1) EQUIPMENT.

| | |
|---|---|
| PLIERS | WRENCH, open-end, 7/16-in. |
| SCREWDRIVER, 6-in. | WRENCH, open-end, 5/8-in. |
| WRENCH, 1/2-in. | WRENCH, socket, 5/8-in. |

(2) PROCEDURE (fig. 174).

(a) *Remove Coil from Unit.*

| | |
|---|---|
| SCREWDRIVER, 6-in. | WRENCH, open-end, 7/16-in. |

Remove cap screw from clip holding fuel line to body of burner (7/16-in. wrench). Remove fuel line from elbow (7/16-in. wrench). Disconnect high tension wire from electrode. Then remove the two screws attaching coil to body of unit (screwdriver) and lift off coil.

(b) *Remove Insulator and Electrode Assembly.*

| | |
|---|---|
| PLIERS | WRENCH, open-end, 5/8-in. |

Remove insulator retaining nut (5/8-in. wrench) and pull insulator and electrode assembly from body, taking care not to lose copper gasket under electrode. Unscrew fuel line elbow and remove (pliers).

(c) *Remove Nozzle Assembly.*

| | |
|---|---|
| SCREWDRIVER, 6-in. | WRENCH, socket, 5/8-in. |
| WRENCH, 1/2-in. | |

Remove cap screw, with wire electrode on tip, from inside of body (1/2-in. wrench). Then remove burner nozzle (5/8-in. wrench) and remove swirl pin from nozzle (screwdriver). Jar filter and spring from heater body.

**b. Disassembly of Pressure Pump.**

(1) EQUIPMENT.

PLIERS
SCREWDRIVER, 6-in.
WRENCH, 7/16-in.
WRENCH, 9/16-in.
WRENCH, open-end, ½-in.

(2) PROCEDURE (fig. 175).

*(a) Disassemble Plunger Assembly.*

PLIERS
SCREWDRIVER, 6-in.
WRENCH, open-end, ½-in.

Remove piston retaining screw (screwdriver) and piston cups from end of plunger assembly. Remove piston cups and piston separator from retaining screw. NOTE: If any defect is apparent in the plunger nut or lock pin, this assembly can be removed as follows: Unscrew knob from plunger assembly (pliers). Remove pin from adapter and unscrew adapter from plunger (pliers and ½-in. wrench). Slide plunger nut off end of plunger, tap plunger nut to dislodge lock pin and spring (which come out inside of nut without disturbing plug).

*(b) Disassemble Pump Body.*

WRENCH, 7/16-in.
WRENCH, 9/16-in.

Clamp body between soft jaws in vise and remove inlet and outlet check valve assemblies (7/16-in. and 9/16-in. wrenches). Remove outlet check valve adapter and washer from pump body (9/16-in. wrench).

## 195. INSPECTION OF PARTS.

**a. Burner Unit.** Wash all parts, clean, and dry with compressed air, if possible. CAUTION: Do not use steel wire or drill to clean nozzle. The size and shape of the grooves and orifices are very important, and any damage will render nozzle useless. Inspect all parts, replacing those unfit for further use. Clean all fuel passages. Clean and adjust points as described in paragraph 192 b.

**b. Pressure Pump.** Thoroughly clean parts of pump in SOLVENT, dry-cleaning, checking to see that all fuel passages are open. Examine piston cups carefully for breaks, cracks or evidence of wear. If any of these conditions exist, replace piston cups.

AIR HEATER

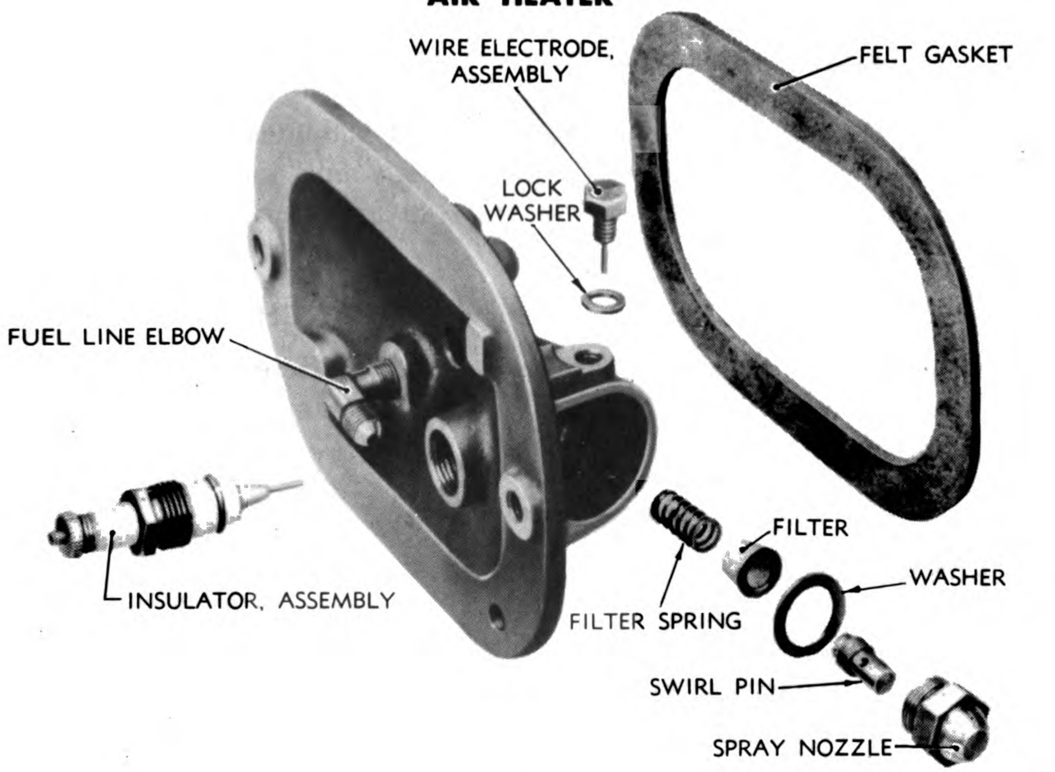



***Figure 174—Exploded View of Air Heater Burner Unit***

## 196. ASSEMBLY.

### a. Assembly of Burner Unit.

(1) EQUIPMENT.

PLIERS
SCREWDRIVER, 6-in.
WRENCH, 1/2-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 5/8-in.
WRENCH, socket, 5/8-in.

(2) PROCEDURE.

*(a) Assemble Spray Nozzle Assembly.*

SCREWDRIVER, 6-in.
WRENCH, 1/2-in.
WRENCH, socket, 5/8-in.

Screw swirl pin into nozzle (screwdriver). Insert spring and heater filter in cavity of heater body, with washer end of filter out. Position washer against shoulder of nozzle, and screw nozzle assembly into heater body (5/8-in. wrench). Install cap screw with wire electrode into side of heater body below nozzle (1/2-in. wrench).

*(b) Install Insulator and Electrode Assembly.*

PLIERS
WRENCH, open-end, 5/8-in.

Attach fuel line elbow to heater body (large end screws into casting). Tighten elbow until small end points down (pliers) in position to connect fuel line. Install insulator gasket on lower shoulder of electrode, and assemble electrode into heater body, tightening insulator nut firmly (5/8-in. wrench). Set electrode gap at 1/8-inch.

(c) *Install Coil and Fuel Line.*

SCREWDRIVER, 6-in. WRENCH, open-end, 7/16-in.

Attach coil to heater body with two screws (screwdriver). Connect high tension wire to electrode. Connect fuel line to elbow and install cap screw in clip to hold fuel line to heater body (7/16-in. wrench).

**b. Assembly of Pressure Pump.**

(1) EQUIPMENT.

PLIERS
PLIERS, small-nosed
SCREWDRIVER, 6-in.
SCREWDRIVER, small
WRENCH, 7/16-in.
WRENCH, 1/2-in.
WRENCH, 9/16-in.

(2) PROCEDURE (fig. 175).

(a) *Install Piston Cups.*

SCREWDRIVER, 6-in.

Slip one piston cup (leather)—large end first—over piston retaining screw. Slip piston separator over screw next to piston cup. Slide other piston cup (leather)—small end first—over screw and up against separator. Screw retaining screw, with cups and separator attached, into end of pump plunger.

(b) *Assemble Plunger Nut (if Disassembled).*

PLIERS
PLIERS, small-nosed
SCREWDRIVER, small
WRENCH, 1/2-in.

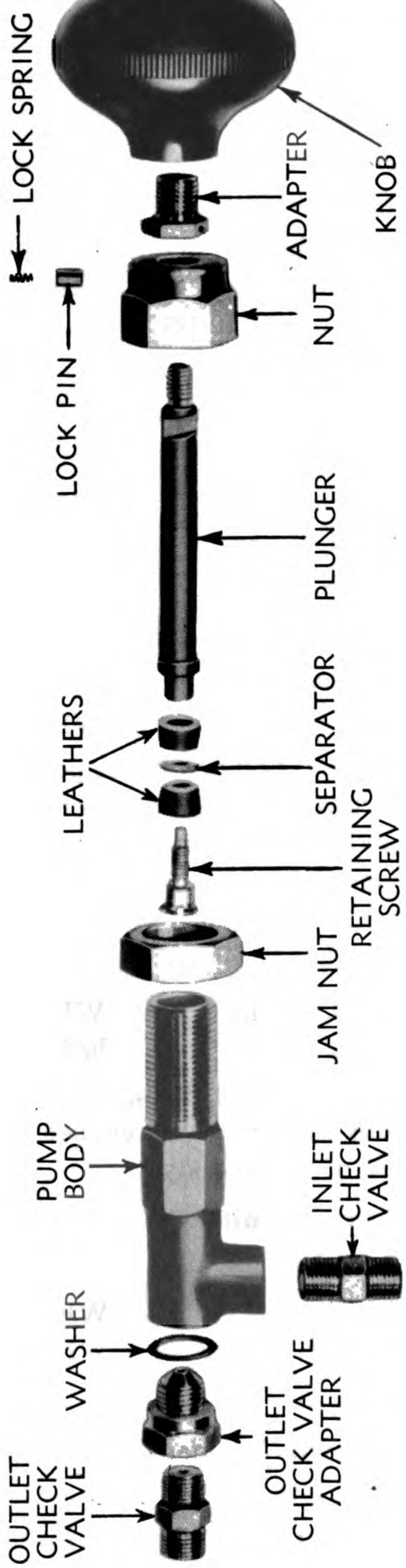
With small-nosed pliers, drop lock pin spring into hole on inside of plunger nut. Then drop lock pin into hole, recessed end first, on top of spring. Depress lock pin with small screwdriver, and slide plunger nut, hexagon end first, over small end of plunger. Attach knob adapter and tighten until pinholes in adapter and plunger line up (1/2-in. wrench and pliers). Then insert groove pin, apply COMPOUND, joint and thread, to knob adapter, and securely screw knob onto adapter (pliers).

(c) *Install Outlet Check Valve Assembly.*

WRENCH, 7/16-in. WRENCH, 9/16-in.

Install washer over shoulder of outlet check valve adapter, and screw adapter into outlet opening of pump body (9/16-in. wrench). Screw out-

AIR HEATER




RA PD 40851

**Figure 175—Exploded View of Pressure Pump Assembly**

let check valve into the adapter (7/16-in. wrench). NOTE: This check valve is marked "2" and the arrow—also marked on the valve—should point away from the pump body when assembled.

*(d) Install Inlet Check Valve.*

WRENCH, 7/16-in.

Install inlet check valve in side opening of pump body with arrow on valve directed towards pump body. (This valve is marked "½".)

## 197. INSTALLATION.

**a. Installation of Pressure Pump.**

(1) EQUIPMENT.

PLIERS
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.
WRENCH, open-end, 5/8-in.
WRENCH, open-end, 7/8-in.

(2) PROCEDURE.

*(a) Install Pump in Dash.*

PLIERS
WRENCH, open-end, 7/8-in.

Screw jam nut onto pump body as far as possible. Place threaded end of pump body through dash from inside. Soften pump plunger leathers with light engine oil, and carefully enter plunger into pump body so that leathers are not damaged. Tighten the plunger nut (pliers and 7/8-in. wrench); then tighten jam nut against inside of dash (7/8-in. wrench).

*(b) Connect Fuel Lines.*

WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.
WRENCH, open-end, 5/8-in.
WRENCH, open-end, 7/8-in.

Connect intake fuel line to side fitting on pump body, using the two larger wrenches, and use the smaller wrenches to connect the discharge fuel line to fitting in end of pump body.

**b. Installation of Burner Unit.**

(1) EQUIPMENT.

WRENCH, ½-in.
WRENCH, open-end, 7/16-in.
WRENCH, open-end, 9/16-in.
WRENCH, socket, 9/16-in.

(2) PROCEDURE.

*(a) Install Heater Body to Cylinder Block.*

WRENCH, socket, 9/16-in.

Clean old gaskets from cylinder block and install new ones. Set heater body in proper hole in block and secure with special cap screw in center.

*(b) Connect Wires and Fuel Lines.*

**WRENCH**, 1/2-in.
**WRENCH**, open-end, 7/16-in.
**WRENCH**, open-end, 9/16-in.

Connect wire in cover to coil. Then install cover on air heater with two cap screws with lock washers (1/2-in. wrench). Insert lower cover cap screw through clip on check valve and then through cover. Connect fuel line to rear of check valve (7/16-in. and 9/16-in. wrenches). Install cap screw in through clip on fuel line and into cylinder block end plate (9/16-in. wrench).

Section II

## ENGINE PRE-HEATER



### 198. DESCRIPTION.

**a.** The engine pre-heater—carried in a box on tractor fender—is a pressure burner unit designed to heat the engine previous to starting in extremely cold weather with temperatures below those in which starting the engine is possible with the air of only the air heater. An inlet elbow with hinged cover is provided on the engine in place of one of the air box handhole covers. The cover can be opened and pre-heater extension tube inserted in upper opening. The lower opening in elbow allows for circulation of air and burned gases while heater is in operation. The flame delivered by the heater will raise the temperature of the cylinder block and heat the cylinder walls where engine oil has congealed, causing resistance and hard cranking of the engine. After heater has been in operation for a specified time (see TM 9-787A par. 11 for operation of heater), the heater may be withdrawn, inlet elbow cover closed and engine started in regular manner with air of air heater.

**b.** The heater fuel tank, blower housing and burner housing are all one casting. Blower fan is mounted in top, air pressure pump in rear and air pressure gage on side. A hinged cover over the fan inlet regulates amount of air supplied for burning of fuel. The fuel filter and nozzle are located in a separate chamber and connected to fuel compartment by drilled passage in casting. A wire from blower or fan motor has a plug on end which is inserted in a socket provided in tractor cowl when pre-heater is to be used. The air pressure pump is hand operated to produce pressure for operation.

### 199. INSPECTION OF PARTS.

**a. General.** The fuel is forced by air pressure through the valve, filter and spray nozzle. Provided there is an ample supply of fuel in fuel supply chamber and air pressure has been raised to proper operating pressure (120 lb), failure of the unit to operate will likely be found due to clogged valve, filter or spray nozzle. In that event, these must be removed to clean or replace.

## ENGINE PRE-HEATER

**b. Spray Nozzle.** Do not clean nozzle with drill bit or steel wire, as this will damage nozzle and render it useless. With spray nozzle removed, check to determine if filter is clogged by pumping air pressure up to 120 pounds and opening fuel valve. If a good flow of fuel is evident, the fuel filter is free of obstruction. If fuel filter is clogged, replace. If unit is disassembled, clean all fuel passages and blow out with compressed air.

**c. Air Pump.** Air pump failure may be due to dry, cracked or worn leather. Leather may be softened, if dry, by soaking in warm engine oil. Replace leather if cracked or damaged.

**d. Blower.** Fan should start running as soon as plug on wire is inserted in socket in dash. If it does not, examine wires and connections before replacing motor.

## 200. DISASSEMBLY.

**a. Equipment.**

PLIERS
SCREWDRIVER, 6-in.
SCREWDRIVER, cross-recess
WRENCH, 7/16-in.
WRENCH, 5/8-in.
WRENCH, 1-in.
WRENCH, open-end, 9/16-in.
WRENCH, pipe, 10-in.
WRENCH, socket, 3/4-in.

**b. Procedure** (fig. 176).

(1) DISASSEMBLE INTO SUBASSEMBLIES.

PLIERS
SCREWDRIVER, 6-in.
WRENCH, 7/16-in.

Remove two cap screws attaching fan motor to housing (7/16-in. wrench). Pull motor and fan from housing. Remove air pressure gage by removing the eight attaching screws (screwdriver). Remove six cap screws from air pump tube nut at rear of housing (7/16-in. wrench) and jar pump assembly out of housing. Pull cotter pin, remove hinge pin (pliers), and lift spout from front of housing.

(2) REMOVE SPRAY NOZZLE AND VALVE ASSEMBLY.

WRENCH, 5/8-in.
WRENCH, 1-in.
WRENCH, socket, 3/4-in.

Remove nozzle from center of spout opening (5/8-in. wrench). Remove filter plug at bottom of housing (1-in. wrench) and jar filter from housing. Remove nut inside filter compartment (3/4-in. wrench) and lift valve assembly out of housing. Packing can be removed from needle valve if necessary at this time.

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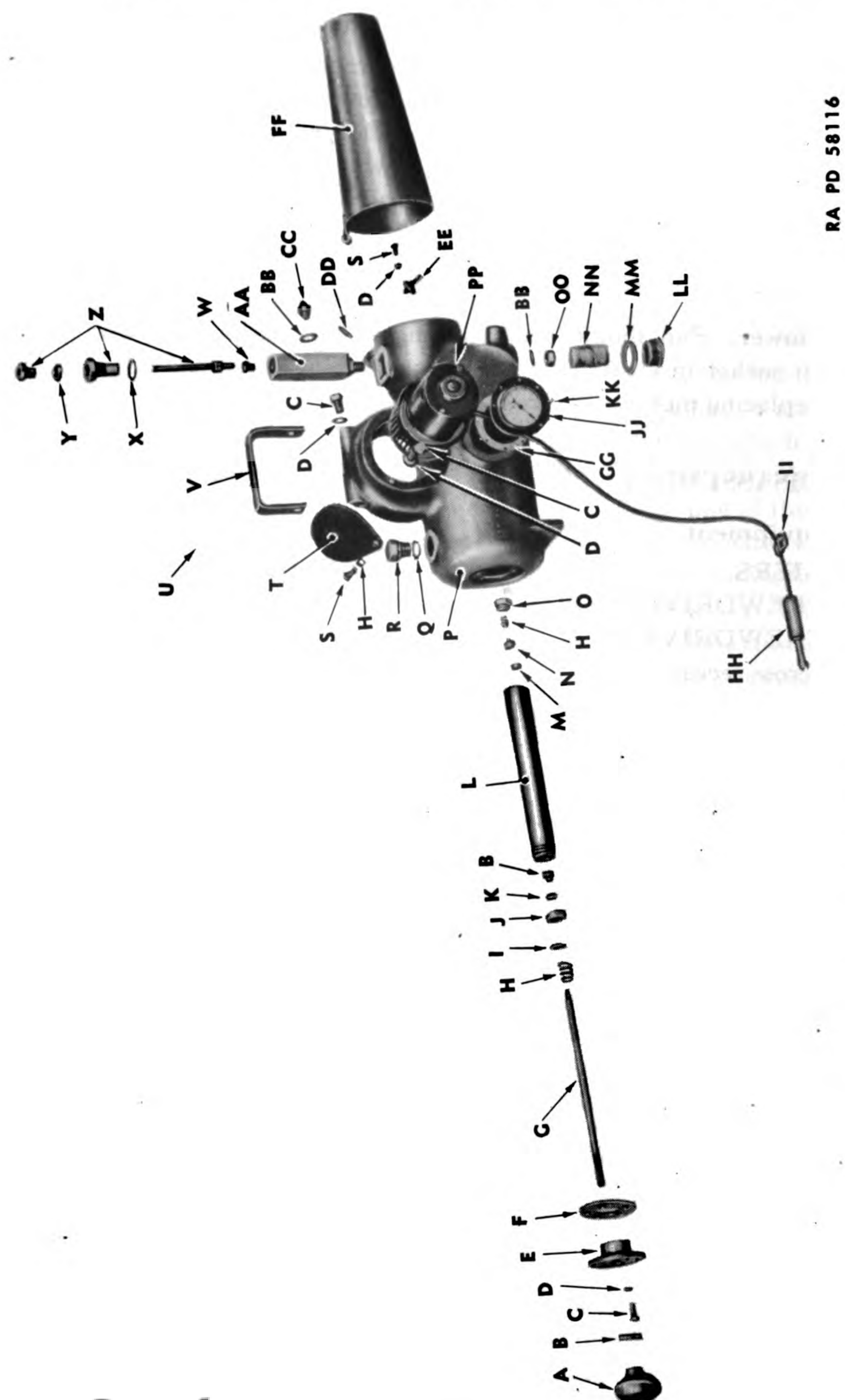


*Figure 176—Exploded View of Engine Pre-Heater Assembly*

A — AIR PUMP KNOB
B — AIR PUMP SHAFT NUT
C — CAP SCREW
D — LOCK WASHER
E — AIR PUMP TUBE NUT
F — AIR PUMP GASKET
G — AIR PUMP SHAFT
H — AIR PUMP SPRING
I — LARGE WASHER
J — LEATHER CUP
K — SMALL WASHER
L — AIR PUMP TUBE
M — AIR PUMP VALVE GASKET
N — AIR PUMP VALVE
O — AIR PUMP VALVE NUT
P — CASE
Q — FILLER PLUG GASKET
R — FILLER PLUG
S — TAPPING SCREW
T — AIR REGULATOR PLATE
U — PIPE PLUG
V — HANDLE
W — NEEDLE VALVE AND SEAT
X — VALVE GASKET
Y — NEEDLE VALVE PACKING
Z — NEEDLE VALVE STEM, ASSEMBLY
AA — NEEDLE VALVE BODY
BB — SPRAY NOZZLE GASKET
CC — SPRAY NOZZLE
DD — GROOVE PIN
EE — AIR DEFLECTOR BLADE
FF — EXTENSION TUBE
GG — PRESSURE GAGE GASKET
HH — JACK PLUG
II — CLIP
JJ — PRESSURE GAGE
KK — SCREW
LL — FUEL FILTER PLUG
MM — FUEL FILTER PLUG GASKET
NN — FUEL FILTER
OO — NUT
PP — BLOWER MOTOR AND FAN, ASSEMBLY (12-VOLT)

RA PD 58116B

***Legend for Figure 176 — Engine Pre-Heater Assembly***

(3) REMOVE AIR DEFLECTOR BLADE.

SCREWDRIVER, cross-recess

Remove two cross-recessed screws and remove air deflector blade.

(4) DISASSEMBLE PUMP.

WRENCH, 5/8-in.
WRENCH, open-end, 9/16-in.
WRENCH, pipe, 10-in.

Loosen lock nut under knob (9/16-in. wrench) and remove knob and lock nut from pump shaft. Unscrew barrel from air pump tube nut (10-in. pipe wrench), and separate plunger shaft and tube. Unscrew check valve from end of tube (5/8-in. wrench).

## 201. ASSEMBLY.

**a. Equipment.**

PLIERS
SCREWDRIVER, 6-in.
SCREWDRIVER, cross-recess
WRENCH, 7/16-in.
WRENCH, 1/2-in.
WRENCH, 5/8-in.
WRENCH, 3/4-in.
WRENCH, 1-in.
WRENCH, open-end, 9/16-in.
WRENCH, pipe, 10-in.

**b. Procedure** (refer to fig. 176, for relative location of parts).

(1) ASSEMBLE AIR PUMP.

WRENCH, 1/2-in.
WRENCH, 5/8-in.
WRENCH, open-end, 9/16-in.
WRENCH, pipe, 10-in.

Place spring in valve nut, set valve washer on spring and valve gasket on washer. Hold pump tube up and screw valve nut into end of tube (5/8-in. wrench). Place pump shaft in vise (larger end up) and drop tube nut over shaft. Screw lock nut on shaft as far as possible, then screw knob onto shaft and tighten. Screw lock nut tightly against knob (9/16-in. wrench). Turn shaft other end up in vise and install in following order on end of shaft: Spring, large washer, cup leather—lips of cup up—small washer, and nut, and tighten (1/2-in. wrench). Soften leather with engine oil and insert shaft assembly into pump tube, taking care not to damage leather. Clamp tube nut in vise and screw tube into nut (10-in. pipe wrench).

(2) INSTALL PUMP ASSEMBLY.

WRENCH, 7/16-in.

Coat inside surface of pump tube nut with COMPOUND, joint and thread. Lay new gasket on this surface and coat other side of gasket with COMPOUND, joint and thread. Then insert pump tube into housing and

## ENGINE PRE-HEATER

secure tube nut to housing with six cap screws with lock washers (7/16-in. wrench).

(3) INSTALL AIR DEFLECTOR BLADE.

SCREWDRIVER, cross-recess

Install air deflector blade in center of spout opening with two cross-recessed screws.

(4) INSTALL NEEDLE VALVE ASSEMBLY.

PLIERS WRENCH, 3/4-in.

Install packing nut and packing on needle valve. Screw needle valve into needle valve body; then tighten packing nut (pliers). Insert needle valve assembly into heater body from top (with hole for spray nozzle towards front of heater), using new gasket at shoulder on lower end of valve body. Insert nut into opening for fuel filter and screw nut onto lower end of valve body tightly (3/4-in. wrench).

(5) INSTALL SPRAY NOZZLE AND FUEL FILTER.

WRENCH, 5/8-in. WRENCH, 1-in.

Screw spray nozzle into needle valve body (5/8-in. wrench) using new gasket. Install fuel filter in lower opening of housing under needle valve. Install filter plug (1-in. wrench) using new gasket.

(6) INSTALL SPOUT.

PLIERS

Set spout on front end of heater body and install pin through hinge joints, securing with cotter pin.

(7) INSTALL FAN AND MOTOR.

WRENCH, 7/16-in.

Install fan and motor in top of heater body with two cap screws with lock washers.

(8) INSTALL AIR PRESSURE GAGE.

SCREWDRIVER, 6-in.

Install pressure gage, using new gasket cemented on both sides, in heater body with eight No. 6-32 screws.

(9) TEST HEATER.

Fill heater one-half to two-thirds full with fuel oil and pump pressure up to 120 pounds. Light burner and let burn a short while. Then close spout over end of heater, plug wire into socket on cowl of tractor and test for operation.

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# CHAPTER 11

## REFERENCES



### 202. STANDARD NOMENCLATURE LISTS.

| | |
|---|---|
| a. Cleaning, preserving and lubricating material, recoil fluids, special oils, and similar items of issue | SNL K-1 |
| b. Tractor, Heavy, M1 | SNL G-98 |
| Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publication for Supply Index" | OPSI |

### 203. EXPLANATORY PUBLICATIONS.

**a. Automotive materiel.**

| | |
|---|---|
| Military motor vehicles | AR 850-15 |
| Motor transport | FM 25-10 |
| Tractor, Heavy, M1 (Allis-Chalmers HD-10W) Diesel engine | TM 9-1787A |
| Tractor, Heavy, M1 (Allis-Chalmers HD-10W) equipment | TM 9-1787D |
| Tractor, Heavy, M1 (Allis-Chalmers HD-10W) Gar Wood winch | TM 9-787A |
| Tractor, Heavy, M1 (Allis-Chalmers HD-10W) power train, frame assembly and seats | TM 9-1787C |

| | |
|---|---|
| b. Cleaning and preserving, lubricating and welding materials and similar items issued by the Ordnance Department | TM 9-850 |

**c. Diesels.**

| | |
|---|---|
| Diesel engines | TF 9-159 |
| Diesel engines and fuels | TM 10-575 |
| Diesel engines and fuels | FS 10-37 |
| Engine of the Diesel tractractor | TF 9-171 |
| Power train of the Diesel tractractor | TF 9-172 |
| The electric system of the Diesel tractractor | TF 9-169 |
| The fuel system of the Diesel tractractor | TF 9-170 |
| The track and suspension system of the Diesel tractractor | TF 9-173 |

## REFERENCES

**d. Inspection and Maintenance.**

| | |
|---|---|
| Echelon system of maintenance | TM 10-525 |
| First echelon of maintenance | FS 10-53 |
| Fire prevention, safety precautions, accidents | TM 10-360 |
| Inspection of motor vehicles | FS 10-58 |
| Motor transport inspection | TM 10-545 |
| Second echelon of maintenance | FS 10-54 |
| The motor vehicle driver, first echelon maintenance | TF 11-558 |

**e. Miscellaneous.**

| | |
|---|---|
| Automotive electricity | TM 10-580 |
| Electric fundamentals | TM 1-455 |
| List of training publications | FM 21-6 |
| Lubrication | FS 10-39 |
| The internal combustion engine | TM 10-570 |

**f. Shipment and Storage.**

| | |
|---|---|
| Loading of mechanized and motorized army equipment on open top railroad equipment | Association of American Railroads |
| Storage of motor vehicle equipment | AR 850-18 |

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BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
*Chief of Staff.*

OFFICIAL:

J. A. ULIO,
*Major General,*
*The Adjutant General.*

DISTRIBUTION: R 9 (2); Bn 9 (1); C 9 (4).
(For explanation of symbols, see FM 21-6.)