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WAR DEPARTMENT

TECHNICAL MANUAL

ORDNANCE MAINTENANCE

DIESEL POWER PLANT FOR SCOUT CAR M3A1

(HERCULES DJXD ENGINE)

OCTOBER 1, 1942

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DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

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Prepared under the direction of the
Chief of Ordnance

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Section I

INTRODUCTION

Paragraph

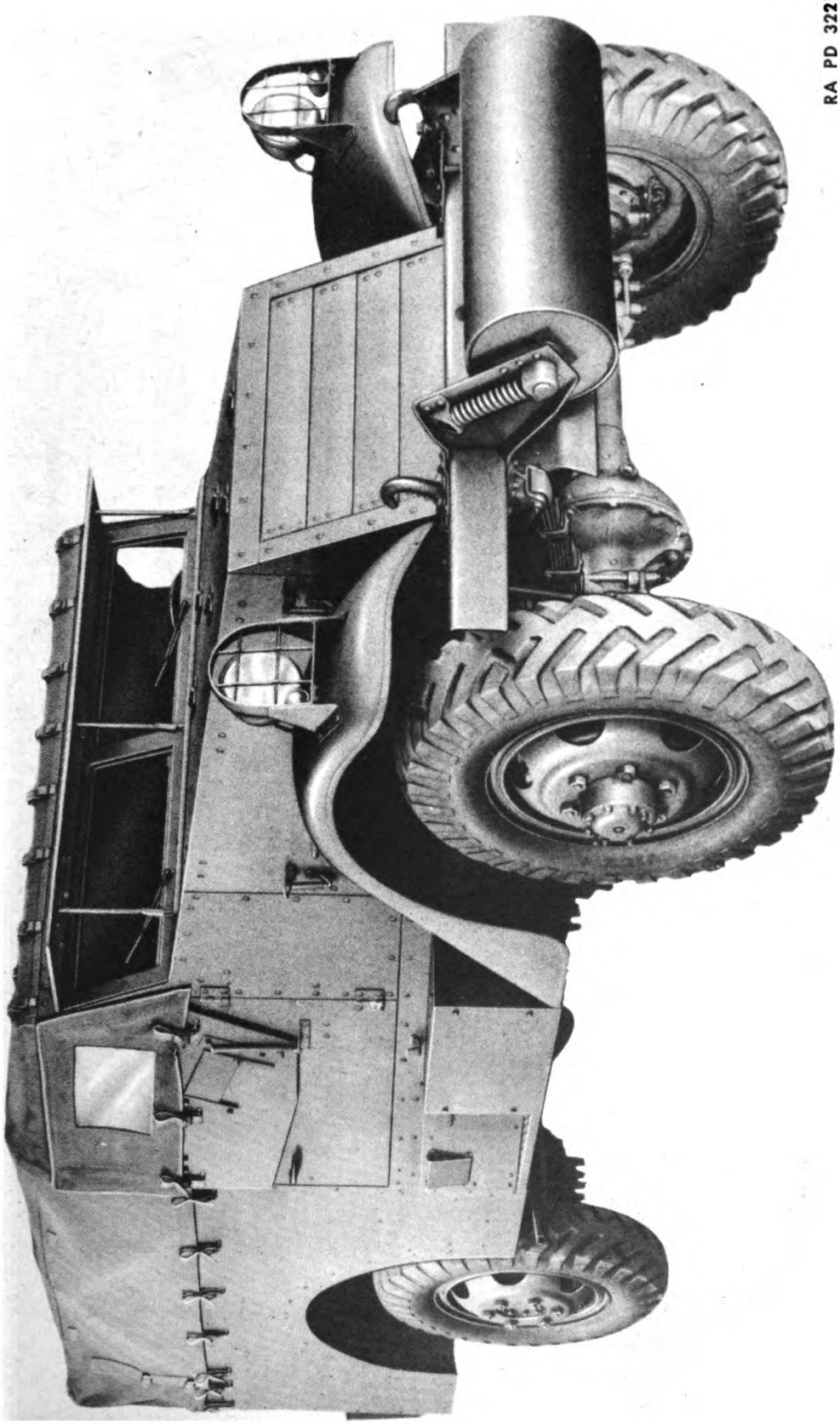
Scope 1

1. SCOPE.

This manual is published for the information and guidance of ordnance maintenance personnel. It contains detailed instructions for removal, disassembly, inspection, maintenance, repair, assembly, and installation of the Hercules DJXD Diesel engine and all its accessories for Scout Car M3A1 (figs. 1 and 2). These instructions are supplementary to Technical Manual 9-705 prepared for the using arms. Additional descriptive matter and illustrations are included to aid in providing a complete working knowledge of the materiel.

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INTRODUCTION



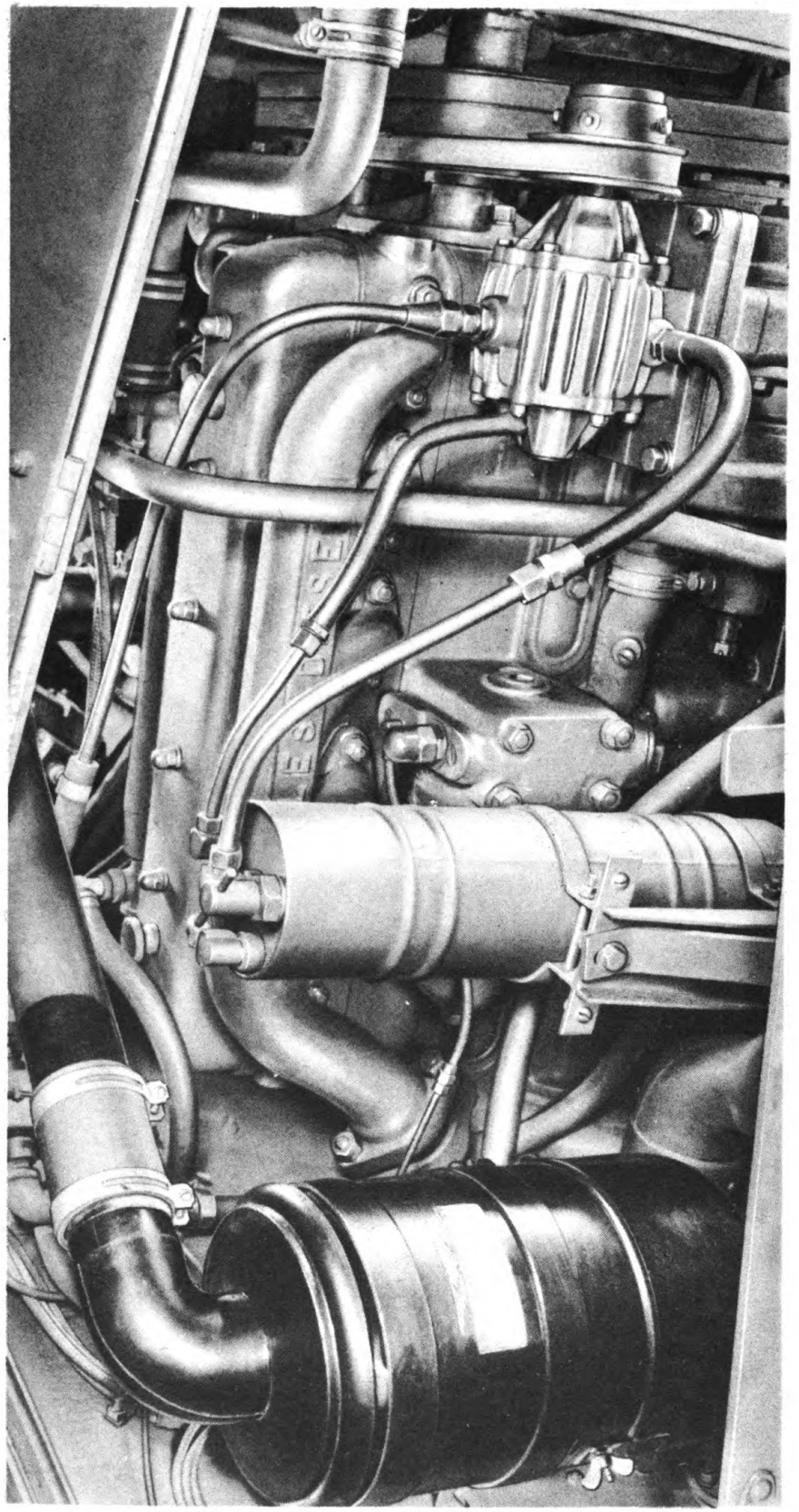
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Figure 1—Scout Car M3A1

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)



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Figure 2—Engine View in Vehicle—Right Side

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Section II

SERVICE MAINTENANCE

	Paragraph
Objectives	2
Definitions	3
Allocation of repair jobs	4

2. OBJECTIVES.

The primary objectives of maintenance operations performed by ordnance personnel are technical inspection, corrective actions and, in general, all repairs beyond the capacity of using arms personnel. These are accomplished by replacement, repairing, rebuilding or any other expedient considered most useful. The extent of maintenance operations by maintenance personnel is determined by the amount of time available, shelter, proximity to enemy fire, equipment and tools, parts available and skill of personnel.

3. DEFINITIONS.

The definitions given below are included so that the operation name may be correctly interpreted by those doing the work.

a. Service. Consists of cleaning, lubricating, tightening bolts and nuts, and making external adjustments of subassemblies or assemblies and controls.

b. Repair. Consists of making repairs to, or replacement of such parts, subassemblies or assemblies that can be accomplished without completely disassembling the subassembly or assemblies, and does not require heavy welding or riveting, machining, fitting, and/or alining.

c. Replace. Consists of removing a part, subassembly or assembly from the vehicle and replacing it with a new, reconditioned or rebuilt part, subassembly or assembly, whichever the case may be.

d. Rebuild. Consists of completely reconditioning and placing in serviceable condition any unserviceable part, subassembly or assembly of the motor vehicle including welding, riveting, machining, fitting, alining, assembling, and testing.

4. ALLOCATION OF REPAIR JOBS.

The chart below covers the allocation of maintenance operations on the Hercules DJXD Diesel engine and accessories and will be used as a guide in maintaining this unit.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

a. Clutch.

Unit	Operation	ECHELONS 2nd	3rd	4th
Clutch assembly	Replace	x		
Clutch assembly	Repair		x	
Clutch assembly	Rebuild			x
Clutch housing	Replace		x	
Clutch pedal	Adjustment	x		

b. Cooling System.

Unit	Operation	ECHELONS 2nd	3rd	4th
Fan assembly	Replace	x		
Fan assembly	Repair		x	
Fan belt	Adjust or replace	x		
Fan bushings or bearings	Replace		x	
Hose or pipe	Replace	x		
Radiator	Clean and flush	x		
Radiator	Replace	x		
Radiator	Repair		x	
Temperature gage	Replace	x		
Thermostat	Replace	x		
Water pump	Replace		x	
Water pump	Rebuild			x
Water pump	Repack	x		

c. Electrical System.

Unit	Operation	ECHELONS 2nd	3rd	4th
Generator	Replace	x		
Generator	Repair		x	
Generator	Rebuild			x
Starting motor	Replace	x		
Starting motor	Repair		x	
Starting motor	Rebuild			x
Starting motor spring (Bendix)	Replace	x		
Voltage regulator	Replace	x		
Voltage regulator	Adjust and repair		x	
Voltage regulator	Rebuild			x

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SERVICE MAINTENANCE

d. Engine.

Unit	Operation	ECHELONS 2nd	3rd	4th
Camshaft	Replace		x	
Connecting rod bearings	Adjust		x	
Connecting rod bearings	Replace		x	
Connecting rods	Replace		x	
Crankshaft	Grinding, polishing, straightening or replace			x
Crankshaft main bearings	Replace			x
Cylinder	Boring, honing			x
Cylinder head	Replace	x		
Engine	Replace		x	
Engine	Rebuild			x
Engine	Tune up	x		
Flywheel	Replace		x	
Manifolds	Replace		x	
Piston assembly	Replace		x	
Piston pins	Fitting		x	
Piston rings	Fitting		x	
Pistons	Fitting			x
Timing gear cover	Replace		x	
Timing gears or chains	Replace		x	
Valve covers	Replace	x		
Valve guides	Replace			x
Valve inserts	Replace			x
Valve lifters and valve lifter guides	Replace			x
Valve springs	Replace	x		
Valve tappets	Adjustment	x		
Valves	Clean carbon, light grinding	x		
Valves	Replace	x		
Valves	Reface and reseat		x	

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

e. Fuel System.

Unit	Operation	ECHELONS 2nd	3rd	4th
Air cleaner	Clean or replace	x		
Fuel gage	Replace	x		
Fuel gage	Repair		x	
Fuel injectors	Adjust or replace	x		
Fuel pipes and connections	Repair or replace	x		
Fuel injection pump	Replace	x		
Fuel injection pump	Repair		x	
Fuel injection pump	Rebuild			x

f. Oiling System.

Unit	Operation	ECHELONS 2nd	3rd	4th
Oil filter	Replace	x		
Oil lines, external	Clean or replace	x		
Oil lines, internal	Flushing	x		
Oil lines, internal	Repair or replace		x	
Oil pan	Replace	x		
Oil pressure	Adjustment	x		
Oil pump	Repair or replace		x	
Oil strainer	Clean or replace	x		

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Section III

TECHNICAL INSPECTION

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Inspection form	6
Practical application	7

5. DESCRIPTION.

Technical inspections are a follow-up and check on organizational maintenance inspections and other maintenance functions. They determine whether the vehicle should be continued in service or withdrawn from operation for overhaul. These inspections are covered in AR-850-15.

6. INSPECTION FORM.

War Department Quartermaster Corps Form No. 260, "Technical Inspection Report of Motor Vehicles," is the standard and official form for recording the inspection of all motor vehicles, including combat vehicles of the Ordnance Department. The extent to which use is made of this form or modification of it, depends entirely on the technical ability of available personnel, the time factor, and the test and shop equipment available.

7. PRACTICAL APPLICATION.

a. External Inspection of Clutch.

(1) Test foot lever and make sure of proper mounting. Examine return spring for wear or damage.

(2) Run vehicle to ascertain if clutch is smooth, jerky, or slips in operation.

b. Cooling System.

(1) Examine radiator and connections for signs of leakage, clogging or damage.

(2) Inspect fan supporting bracket and bearings.

(3) Look at water pump and casing for cracks and leaks.

c. Generator and Regulator.

(1) Examine pulley for looseness.

(2) Check all shielding conduits and connections.

(3) Make sure all mounting and fastening screws are tight. Examine armature and brushes.

(4) Check voltage and correct output of generator.

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(5) Inspect regulator contact points for burning and gap distance, and check tension of armature controlling springs.

(6) Examine regulator case for cracks.

d. Starting Motor.

(1) Examine all connections and terminals.

(2) Inspect and test starting switches.

(3) Inspect commutator and brushes.

e. Engine.

(1) Check crankcase, block, head, and head gasket for cracks or leaks. Use a torque wrench to draw bolts up evenly to avoid distortion of block. See that all bolts are tight.

(2) Remove cover and examine valve push rods, springs, and valve clearances.

(3) Run engine and listen for slapping pistons, knock at bearings, or knock due to presence of carbon.

(4) Check oil pressure for loose engine bearings.

f. Fuel System.

(1) Inspect fuel injection pump, its mounting and connections, and check operation. Examine fuel tanks and lines for leaks or damage.

(2) Examine Venturi and air cleaner. Try all screws. Inspect connections to accelerator and dash.

(3) Check fuel gage and switch.

g. Lubrication System.

(1) Check oil pressure at gage.

(2) Check oil line connections and brackets for tightness.

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Section IV

POWER PLANT TROUBLE SHOOTING AND TUNE UP WHILE INSTALLED

Paragraph

Trouble shooting 8
Engine tune up 9

8. TROUBLE SHOOTING.

Symptom and probable cause	Probable remedy
a. Clutch.	
(1) SLIPPING.	
Improper pedal adjustment.	Adjust pedal linkage.
Oily facings.	Clean and correct cause. Check bell housing oil seal. Do not overlubricate pilot or throw-out bearing. Replace driven member if necessary.
Weak clutch springs.	Replace springs.
Worn clutch facings.	Reface clutch-driven member.
Sticking release sleeve.	Check pull-back spring.
(2) WILL NOT DISENGAGE.	
Improper pedal adjustment.	See above.
Torn facings.	Replace driven member.
Warped or bent plate.	Replace driven member.
Clutch housing out of line.	Line up housing.
(3) RATTLING.	
Loose release fork.	Tighten fork.
Weak pull-back springs.	Replace springs.
Improper pedal adjustment.	Adjust pedal.
(4) CHATTERING.	
Broken dampener springs.	Replace clutch disk.
Oily facings.	Clean or replace.
Sticking release sleeve.	Check pull-back spring.
b. Cooling System.	
(1) OVERHEATING.	
Lack of water.	Fill radiator.
Fan belt loose.	Adjust belt for ¾-in. deflection.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Symptom and probable cause	Probable remedy
Cooling system clogged.	Clean and flush system.
Sticking thermostat.	Replace thermostat.
Water pump not functioning.	Check drive shaft and impeller.
Lime-coated water jacket.	Clean and flush system.
Dirt or insects in radiator air passages.	Blow out with compressed air.
Rotted hoses.	Replace.
Improper fuel injection timing.	Reset timing.

(2) Loss of Cooling Water.

Leaks in radiator core.	Repair.
Defective hose connections.	Tighten or replace.
Radiator tubes clogged so that water builds up in top tank and is lost through overflow pipe.	Clean system. If condition is not corrected, remove top tank and rod out tubes.
Cracked cylinder head or block.	Replace.
Leaky cylinder head gasket.	Replace gasket.
Loose expansion plugs (freeze plugs) in the block.	Replace plugs.

c. Electrical System.

(1) Slow Starting Motor Speed.

Loose connections.	Tighten connections.
Dirty connections.	Clean connections.
Worn brushes.	Replace brushes.
Dirty armature.	Clean armature.
Worn armature.	Replace armature.
Armature rubbing field coils.	Replace bushings.
Low battery voltage.	Check generator and regulator. Check battery water.

(2) Inoperative Starting Motor.

Battery weak.	Charge battery.
Poor connections.	Clean and tighten.
Burned commutator bars.	Recut commutator.
Open or short circuits in field or armature.	Eliminate defective condition.
Defective starter switch.	Check contacts.
Starter circuit fuses blown.	Change fuses, determine cause.

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POWER PLANT TROUBLE SHOOTING—TUNE UP WHILE INSTALLED

Symptom and probable cause	Probable remedy
(3) No Generator Output.	
Burned commutator bars.	Recut commutator.
Worn brushes.	Replace brushes.
Sticking brushes.	Clean brushes.
Open circuits in field or armature.	Replace unit.
Short circuits in field or armature.	Replace unit.
(4) Low or Unsteady Generator Output.	
Fully charged battery.	Check condition of battery. Fully charged battery will cause generator output to drop to very near zero reading.
Low brush tension.	Adjust or replace brush springs.
Brushes sticking.	Clean brushes.
Rough, dirty or greasy commutator bars.	Clean commutator bars.
High mica on commutator.	Undercut mica.
Commutator out of round.	Recut commutator.
Burned commutator bars.	Recut commutator.
(5) Noisy Generator.	
Loose mounting.	Tighten mounting bolts.
Worn pulley.	Replace pulley.
Loose pulley.	Tighten pulley.
Worn bearings.	Replace bearings.
(6) Excessive Generator Output.	
Discharged battery.	Check condition of battery. A battery discharged to the point of low voltage will cause an excessive generator output.
Regulator defective.	Check or replace regulator.
(7) Discharged Batteries.	
Short circuits.	Locate shorts and correct.
Connections loose.	Tighten connections.
Connections dirty.	Clean connections.
Voltage regulator out of order.	Adjust or replace.
Generator not charging.	Check regulator and generator.
No water.	Add water.
(8) Battery Overheating.	
High charging rate.	Check regulator, adjust or replace.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Symptom and probable cause	Probable remedy
d. Engine.	
(1) POOR COMPRESSION.	
Valves worn.	Grind valves.
Valve seats worn or pitted.	Grind seats with valve seat grinder.
Piston rings weak, broken, stuck, or worn.	Replace and correct cause of sticking.
Tappets sticking.	Clean guides.
Tappets set too close.	Set clearance at 0.010 inch for intake and exhaust.
Cylinder head loose.	Tighten head. If compression is lost remove head and replace gasket.
Cylinder head gasket leaking.	Replace gasket.
Worn pistons.	Replace worn parts.
Worn cylinders.	Rebore cylinders.
(2) ENGINE KNOCKING.	
Loose main bearings.	Replace.
Loose rod bearings.	Replace.
Loose piston pins.	Replace pins.
Worn pistons.	Replace pistons.
Worn cylinders.	Rebore cylinders.
Excessive tappet clearance.	Set to 0.010 in.
Loose flywheel.	Tighten in place.
Bent connecting rod.	Check and correct or replace.
(3) HARD STARTING.	
Weak batteries.	Charge batteries. Determine and correct cause of discharge.
Fuel too heavy to flow properly	Use specified fuel.
Improper timing.	Time properly.
Water in fuel supply.	Clean tank, lines, and filters.
Valve tappets improperly adjusted.	Adjust to 0.010 in.
Loose fuel line connections.	Tighten
(4) MISSING.	
Cylinder head gasket leaking.	Replace gasket.
Valves sticking.	Clean valves.
Valves warped or broken.	Replace valves.
Valve tappets improperly adjusted.	Set at 0.010 in.
Cracked or broken piston.	Replace piston.
Defective injector.	Clean, adjust or replace.

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POWER PLANT TROUBLE SHOOTING—TUNE UP WHILE INSTALLED

Symptom and probable cause	Probable remedy
Fuel valve stuck in body.	Remove and clean.
Defective fuel injection pump delivery valve spring.	Replace or repair.
Air or gas binding in fuel pump or lines.	Open nut and allow air to escape.
(5) EXCESSIVE SMOKE FROM EXHAUST.	
Too much oil in crankcase.	Fill only to mark on bayonet gage (9½-qt capacity, including filter).
Worn pistons, rings, or cylinders.	Overhaul.
Leaky cylinder head gasket.	Replace gasket.
Improper fuel oil.	Use specified fuel.
Dirty spray nozzles.	Clean.
Fuel injection timing too early or too late.	Adjust timing.
Fuel pump delivery valve stuck.	Remove and clean.
(6) EXCESSIVE CYLINDER AND PISTON WEAR.	
Improper grade and viscosity of oil.	Change oil to specified grade and viscosity.
Lack of oil.	Keep oil at correct level.
Dirty oil.	Always change dirty oil.
Dirty oil filter.	Clean oil filter.
Overheating.	See section VI.
Piston improperly installed and fitted.	Correct or replace.
Piston rings not properly fitted to piston groove and cylinder wall.	Replace rings and fit correctly.
Piston rings stuck in piston grooves or broken.	Clean or replace rings.
Air cleaner not clean, allowing dirt to enter combustion chamber.	Clean air cleaner mesh and sump.
(7) BEARING FAILURES.	
Crankshaft bearing journal rough or out of round.	Grind or replace shaft.
Crankshaft oil passages restricted.	Clean passages and line.
Bearings loose or improperly fitted.	Replace shells.
Crankshaft out of alinement.	Straighten or replace, if necessary.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Symptom and probable cause	Probable remedy
Lack of oil.	Add oil.
Low oil pressure.	Adjust pump to deliver 5-lb pressure at idling and at least 25-lb pressure at running speed. Fit bearings properly.
Overspeeding engine.	Avoid continuous operations at maximum speed or high speeds.
Restricted oil passages in block.	Clean oil passages and lines.
Bent connecting rod.	Replace or straighten rod.
Improper oil.	Use correct oil (see section XI).
(8) BURNED VALVES AND SEATS.	
Tappets set too close.	Set at 0.010 in.
Weak valve springs.	Replace springs.
Improper valve timing.	Time properly (see par. 59 g).
Excessive carbon deposits around seat and valve head.	Clean carbon.
Valves sticking in guides.	Clean stems and guides. Replace parts as required.
Improper type valves.	Use genuine parts.
Valve head too thin, causing hot section.	Replace valve.
Valve seats too narrow.	Cut seats to correct width.
Overheating.	See section VI.
Low grade fuel.	Use specified fuel.
(9) VALVES STICKING.	
Insufficient clearance between valve stem and guide.	Ream guides for proper clearance.
Valve springs weak or broken.	Replace springs.
Valve stems scored or dirty.	Replace or clean valves.
Gummy deposits from inferior fuels or oils.	Clean. Use specified fuels or oils only.
(10) OVERHEATING.	
Ineffective cooling.	See section VI.
Lack of oil.	Add oil.
Oil badly diluted.	Change oil.
Improper valve timing.	Time properly.
Brakes dragging.	Determine cause and correct.
Exhaust line restricted.	Check muffler and tail pipe.
Improper fuel injection timing.	Reset timing.

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POWER PLANT TROUBLE SHOOTING—TUNE UP WHILE INSTALLED

Symptom and probable cause	Probable remedy
(11) EXCESSIVE OIL CONSUMPTION.	
Piston rings worn or broken.	Install new rings.
Crankcase gasket leaking.	Tighten crankcase or replace gasket.
Front gear case loose.	Tighten.
Poor grade of oil.	Use specified grade oil (see section XI).
Cylinder walls scuffed or scored.	Rebore cylinders.
Main or rod bearings worn or loose.	Replace bearings.
Ring gaps too great.	Install new rings.
Ring gaps lined up.	This condition will correct itself.
Rings poorly seated.	Replace rings.
Overheating	See section VI.
Oil ring slots clogged with carbon.	Clean rings of carbon. Replace if necessary.
Excessive oil pressure.	Adjust pump pressure.
(12) LOW OIL PRESSURE.	
Improper oil.	Use specified oil (see section XI).
Pressure regulating plunger worn or clogged.	Clean or replace plunger and adjust properly.
Oil pump screen clogged.	Clean screen.
Excessive crankshaft and connecting rod bearing clearance.	Replace bearings.
Leaking oil line.	Repair oil line.
Oil pump worn.	Overhaul oil pump.
e. Fuel System.	
(1) EXCESSIVE FUEL CONSUMPTION.	
Fuel leaks.	Check tank, lines, etc.
Sticking controls.	Oil controls and eliminate binding.
Dirty air cleaner.	Clean air cleaner.
Overloading.	Stay within 11,660-lb chassis and 6,155-lb trailed loads.
Faulty operation.	Correct driving procedure.
Engine running too hot.	See overheating. Check timing.
Engine in poor condition and adjustment.	Make adjustments. Overhaul when necessary.

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Symptom and probable cause	Probable remedy
(2) FUEL PRESSURE LOW.	
Air leaks in system.	Tighten connections.
Pressure control valve set too low.	Adjust.
(3) LACK OF FUEL AT PRESSURE PUMP.	
Empty fuel tank.	Fill tank with fuel.
Bent or kinked tubing.	Straighten or replace tubing.
Clogged filtering screens.	Clean filter mesh. When replacing element in fuel filter, finger tightness is sufficient.
Fuel leaks.	Check tanks, lines, etc.
Defective transfer pump.	Repair or replace.
(4) FAST IDLING.	
Sticking controls.	Oil controls and eliminate binding.
Improper adjustment of governor.	Adjust.
(5) FUEL KNOCKING IS FROM ONE CYLINDER.	
Spray nozzle valve sticking from dirt or corrosion.	Clean valve with a cloth (not abrasives) and clean body with piece of wood. Turn valve stem in body until free, then smear with good clean OIL, lubricating engine or vaseline, and replace.
Spray nozzle spring broken.	Replace complete holder from spares. Never attempt to change nozzle springs in field as they must be accurately calibrated with instruments at the factory.
Fuel delivery valve in pump stuck open from dirt or corrosion.	Clean valve stem with cloth and valve seat with small piece of wood. Do not use abrasives or metallic tools; they will spoil these delicate parts.
Broken delivery valve spring in fuel pump.	Replace from spares.

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POWER PLANT TROUBLE SHOOTING—TUNE UP WHILE INSTALLED

Symptom and probable cause	Probable remedy
Inlet or exhaust valve not seating properly from sticking or in need of grinding.	Free valve with alcohol or oil such as kerosene or clean fuel oil. Grind valve if necessary.
Leaky cylinder head gasket.	Replace gasket.

(6) FUEL KNOCKING IS IN MORE THAN ONE CYLINDER AND ERRATIC AND INTERMITTENT.

Improper fuel. Has poor ignition qualities.	Used specified seasonal fuel oil.
Sticking nozzle valve. This comes from dirt in fuel oil or corrosion of these parts from acid in fuel oil.	Dismantle and cleanse these parts and also the fuel strainers. If parts are corroded, change fuel to an acid-free brand and install nozzle and barrel if necessary.
Water in fuel oil.	Drain fuel oil strainer sump and fuel tank of all water and sediment.

(7) FUEL KNOCKING IS IN ALL CYLINDERS CONTINUOUS AND STEADY AND IS USUALLY ACCOMPANIED WITH DARK SMOKY EXHAUST.

Improper fuel oil. Has poor ignition qualities.	Change to specified seasonal fuel oil.

9. ENGINE TUNE UP.

a. Best results are obtained in an engine tune up by using a systematic approach rather than a hit-or-miss search. Before a tune up is attempted, an engine compression test should be made. Successful tuning is impossible without a fairly even compression in the cylinders. Make compression test in the following manner:

(1) Remove all fuel injectors from the engine. CAUTION: Care must be observed in rotation of the engine with the injectors removed, as fuel oil is ejected under extremely high pressure from the injectors. The fuel spray at short range will damage the skin and it is likely to cause a dry gangrenous infection.

(2) Insert an accurate compression gage in injector hole and crank engine a few turns with starting motor, noting highest gage reading. Do this at each cylinder.

(3) Compression should be the same in each cylinder within five pounds.

b. If compression is found to be correct in all cylinders, proceed with the tune up in the following order:

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(1) BATTERY CABLES. Clean both ends of battery cables thoroughly. See that connections are tight.

(2) VALVE CLEARANCE.

(a) Remove the valve cover and adjust the push rod screw to valve stem clearance to 0.010 inch on both intake and exhaust valves. Be sure engine is thoroughly warmed before adjustment.

(b) Make a visual inspection for evidence of cracked valve spring coils or scored valve stems.

(3) FUEL INJECTORS. Clean the fuel injectors and test for pressure.

(4) FUEL TIMING. Examine timing marks on fuel injection pump coupling to see that the coupling has not slipped or been tampered with.

(5) FUEL FILTER. Clean filter and remove air by opening vent cocks.

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Section V

CLUTCH

	Paragraph
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Clutch disassembly	13
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10. DESCRIPTION (fig. 3).

The Borg Warner Model 12 CB-CL clutch assembly is bolted to the engine flywheel. It is the dry, single plate type, incorporating a mechanical vibration dampener.

a. Construction. The flywheel forms a part of the clutch housing and also acts as the front plate of the clutch. Friction material is riveted to both sides of the driven plate. Between the rear lining and disk are

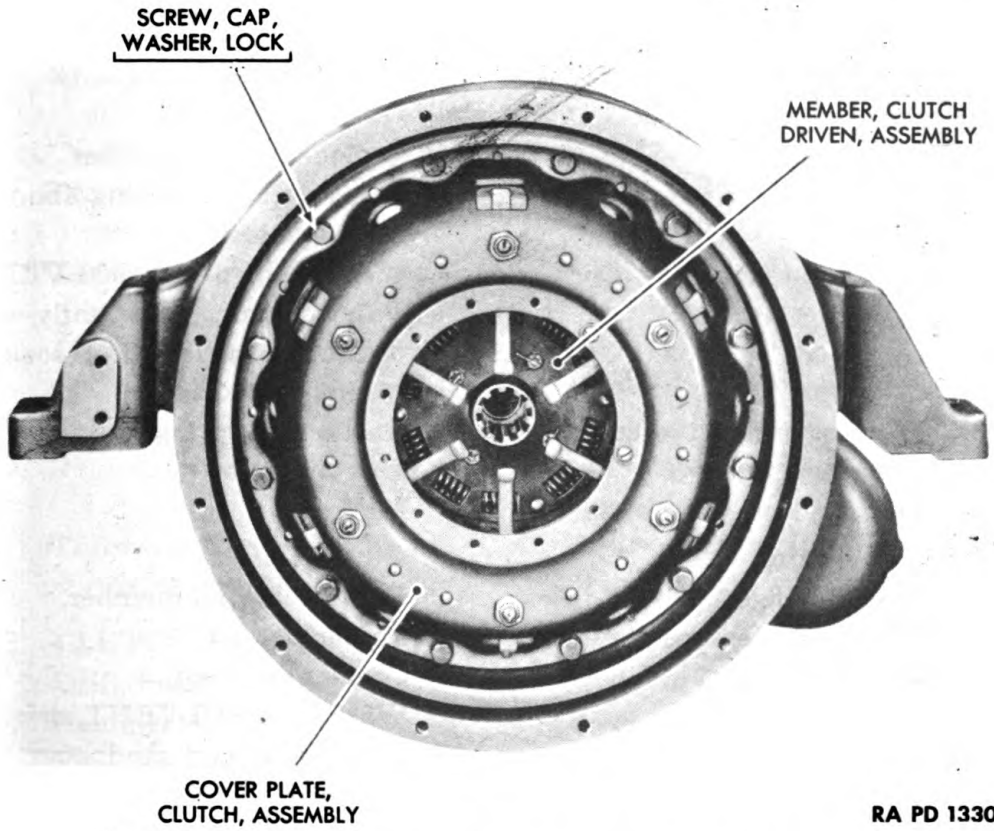


Figure 3—Clutch Assembly Installed

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six crimped spring-steel segments which constitute a cushioning effect for smooth operation. A circle of ten coil springs is installed in the hub of the driven plate to eliminate torsional vibration. The clutch cover plate contains the pressure plate, release levers, lever yokes with tension springs and adjusting nuts, pressure springs and their retainers. The release levers and the lever yokes are supported on needle bearings. The pressure springs are held in cups riveted onto the cover plate and recessed into the pressure plate. Insulator buttons are used under the springs on the pressure plate to insulate the springs from heat conducted to the pressure plate. Ball bearings, packed with grease at assembly, are used on the clutch shaft for the pilot and clutch release bearings.

b. Functioning. Depression of the clutch pedal moves the clutch pressure plate away from the driven plate, which is then disengaged from the engine flywheel drive plate, thus releasing the clutch and disengaging the transmission from the engine. This is accomplished by the connection of levers from the clutch pedal to the clutch release bearing, which is mounted on the splined clutch shaft and engages with the pressure plate release levers that control the movement of the plate. Engagement of the clutch is the reverse procedure.

11. TROUBLE SHOOTING.

Symptom and probable cause	Probable remedy
a. Slippage.	
Worn facings.	Replace driven member.
Clutch pedal riding floor board.	Adjust pedal, allowing about 1¼-in. lash.
Grease on facing	Wash facings with SOLVENT, dry-cleaning, rub lightly with fine sandpaper. If oil-soaked, replace.
Weak or broken pressure springs.	Replace all springs.
Distorted pressure plate.	Replace.
b. Grabbing.	
Worn facings.	Replace driven member.
Distorted pressure plate.	Replace.
Misalinement of bell housing.	Check alinement.
Grease on facings.	Wash with SOLVENT, dry-cleaning, and sandpaper lightly. Replace facings if oil-soaked.
Clutch parts binding.	Clean and lubricate.

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CLUTCH

Symptom and probable cause	Probable remedy
c. Chatter.	
Grease on facings.	Wash with SOLVENT, dry-cleaning, and sandpaper lightly. Replace if badly oil-soaked.
Insufficient cushion or dish in driven plate.	Replace.
Uneven release levers.	Reset on fixture.
Facings worn.	Replace driven member.
Facings glazed.	Sand lightly with fine sandpaper.
Warped or grooved pressure plate.	Replace.
d. Dragging.	
Grease on facings.	Clean with SOLVENT, dry-cleaning. Replace facings if oil-soaked.
Release lever out of adjustment.	Check on fixture.
Insufficient pedal travel.	Adjust pedal allowing about 1¼-in. lash.
Clutch hub binding shaft.	Free up.
Separator springs on center drive plate weak or broken.	Replace.
e. Noise.	
Throwout or pilot bearing needs lubrication.	Lubricate.
Throwout or pilot bearing worn out.	Replace.
Tips of release levers worn.	Replace.
Splines of hub worn.	Replace driven member.
Splines of clutch shaft worn.	Replace.
Release sleeve dry or worn.	Lubricate or replace if necessary.
Throwout bearing riding release levers.	Adjust lash in clutch pedal to 1¼-in.

12. CLUTCH REMOVAL FROM ENGINE.

Drift, brass	Screwdriver
Hammer	Wrench, box, ⅝-in.
Handle, speed	Wrench, open-end, $\frac{7}{16}$-in.
Hoist, chain	Wrench, open-end, $\frac{9}{16}$-in.
Pliers	Wrench, socket, $\frac{9}{16}$-in.
Rope, 1-in.	

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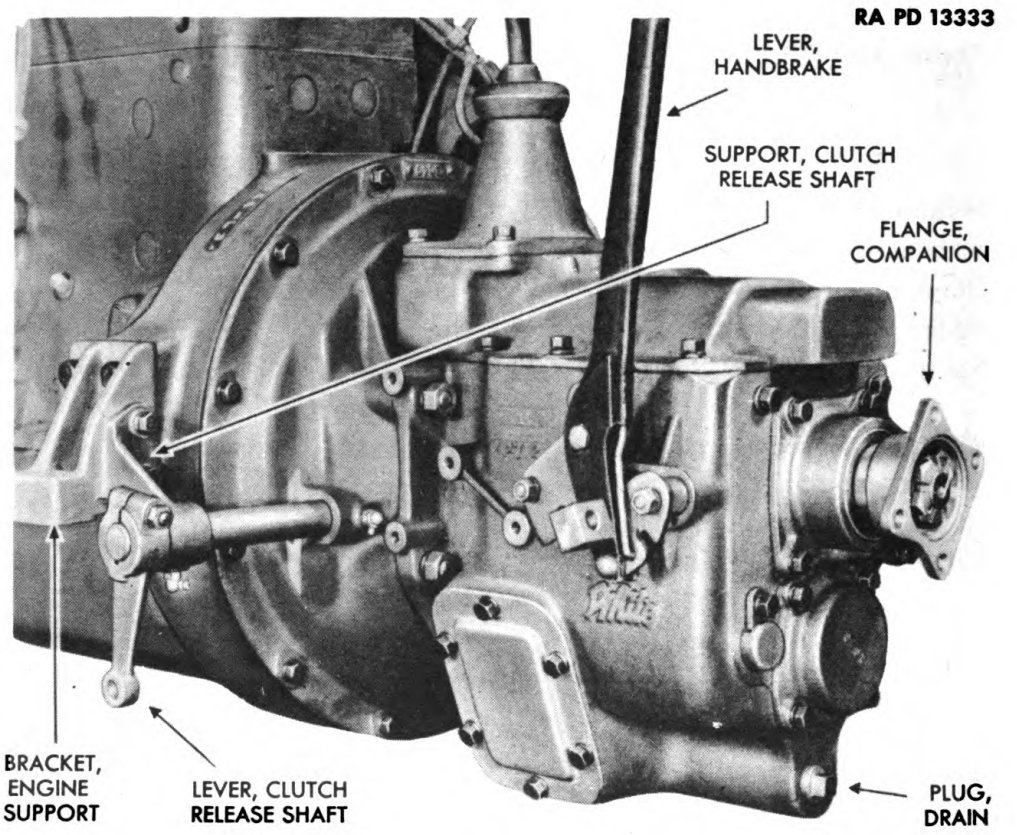


Figure 4—Transmission, Installed—Left Side

a. Remove Floor Plate Over Transmission.

Screwdriver

Unscrew transfer case shift lever ball. Remove six machine screws which hold center floor plate, and remove plate by lifting over transfer case shift lever.

b. Disconnect Propeller Shaft.

Wrench, box, 5/8-in. Wrench, open-end, 5/8-in.

Remove four nuts, bolts and lock washers which hold the propeller shaft to the companion flange on transmission (fig. 4).

c. Disconnect Clutch Release Shaft Lever.

Drift, brass Pliers
Hammer

Remove cotter pin and drive out rod end pin which holds the clutch release shaft lever to adjustable yoke (fig. 4).

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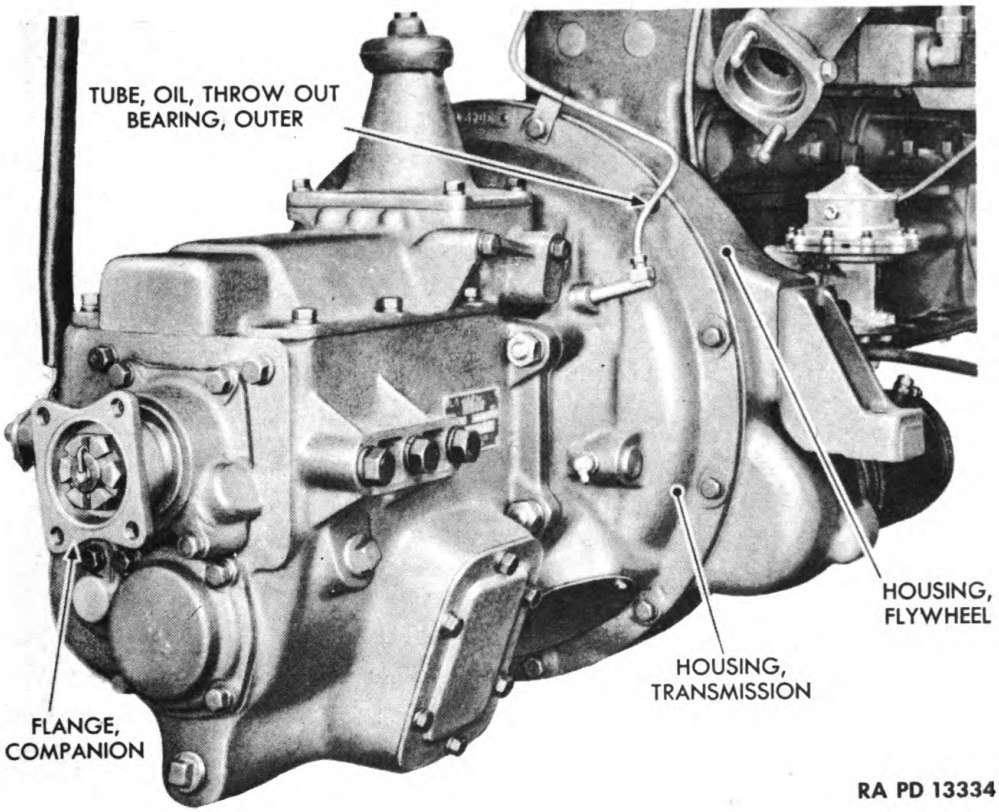


Figure 5—Transmission, Installed—Right Side

d. Disconnect Clutch Release Shaft Support.

Wrench, open-end, $\frac{9}{16}$-in.

Remove two cap screws, plain washer and lock washer which hold shaft support to engine support bracket (fig. 4). Remove shaft support shims. The support will remain hanging on the clutch release shaft.

e. Disconnect Transfer Case Shift Lever from Shift Rod.

Drift, brass
Hammer
Pliers

Remove cotter pin and drive out rod end pin that holds shift lever to the yoke end rod.

f. Remove Hand Brake Lever.

Wrench, open-end, $\frac{9}{16}$-in.

Remove two nuts which hold hand brake lever assembly to transmission (fig. 4).

g. Disconnect Throwout Bearing Outer Oil Tube.

Wrench, open-end, $\frac{7}{16}$-in.

Remove inverted flared tube nut from inverted flared tube elbow on inner oil tube, to disconnect outer oil tube from inner tube (fig. 5).

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h. Remove Master Cylinder Push Rod.

Drift, brass
Hammer
Pliers

Remove cotter pin and drive out rod end pin that holds master cylinder push rod to master cylinder operating lever, and remove rod.

i. Mount Sling Under Transmission.

Hoist, chain
Rope, 1-in.

Put rope around and under transmission, making certain that the assembly will be balanced in sling during removal, in order to prevent injury to the splined shaft (fig. 6).

j. Disconnect Transmission Bell Housing from Flywheel Housing.

Wrench, socket, $\frac{9}{16}$-in.

Remove 12 cap screws and lock washers which hold bell housing to flywheel housing (fig. 5).

k. Remove Transmission. Using the sling as a support, push the transmission slowly toward the rear, rocking it slightly as it is withdrawn, until the spline shaft is free from the clutch. Be sure to keep the transmission in line in order to prevent injury to the spline. Lower assembly to floor and slide out from under vehicle.

l. Detach Clutch Assembly.

Handle, speed
Wrench, socket, $\frac{9}{16}$-in.

Remove 12 cap screws with lock washers, which hold clutch assembly to engine flywheel. Unscrew each cap screw a few turns at a time, so the release of the spring load is equal all around (fig. 7).

m. Remove Clutch Cover Plate and Driven Member Assemblies. Lift off separately, cover plate assembly and driven member assembly. Take care that driven member does not fall out while removing cover plate assembly.

13. CLUTCH DISASSEMBLY.

Chisel
Gage
Hammer
Lands
Pliers
Punch, center
Rebuilder, clutch
Saw, hack
Spider
Wrench, socket, ¾-in.

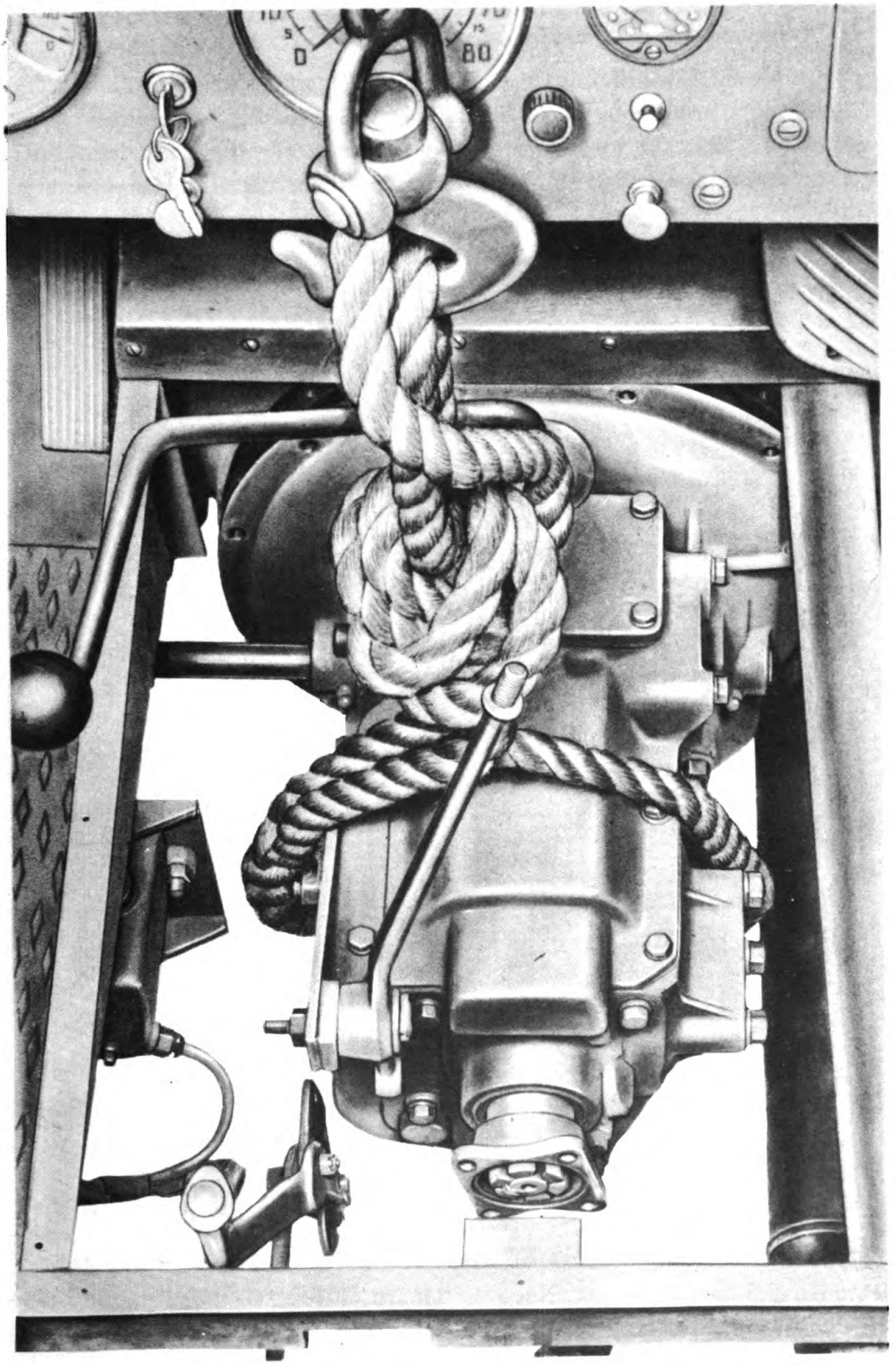
a. Dismantle Clutch Assembly.

Punch, center
Rebuilder, clutch
Saw, hack

Place and center clutch cover plate assembly on clutch rebuilder but do not clamp it down. Saw sealing burs off release lever nuts (fig. 8).

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CLUTCH



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Figure 6—Removal of Transmission

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b. Punchmark Cover and Bearing Lug.

Punch, center

Punchmark cover plate and lever bearing lug to assure accurate reassembly (fig. 9). Factory assembly is bored for weight balance and reassembly of the pressure plate must duplicate its original assembly.

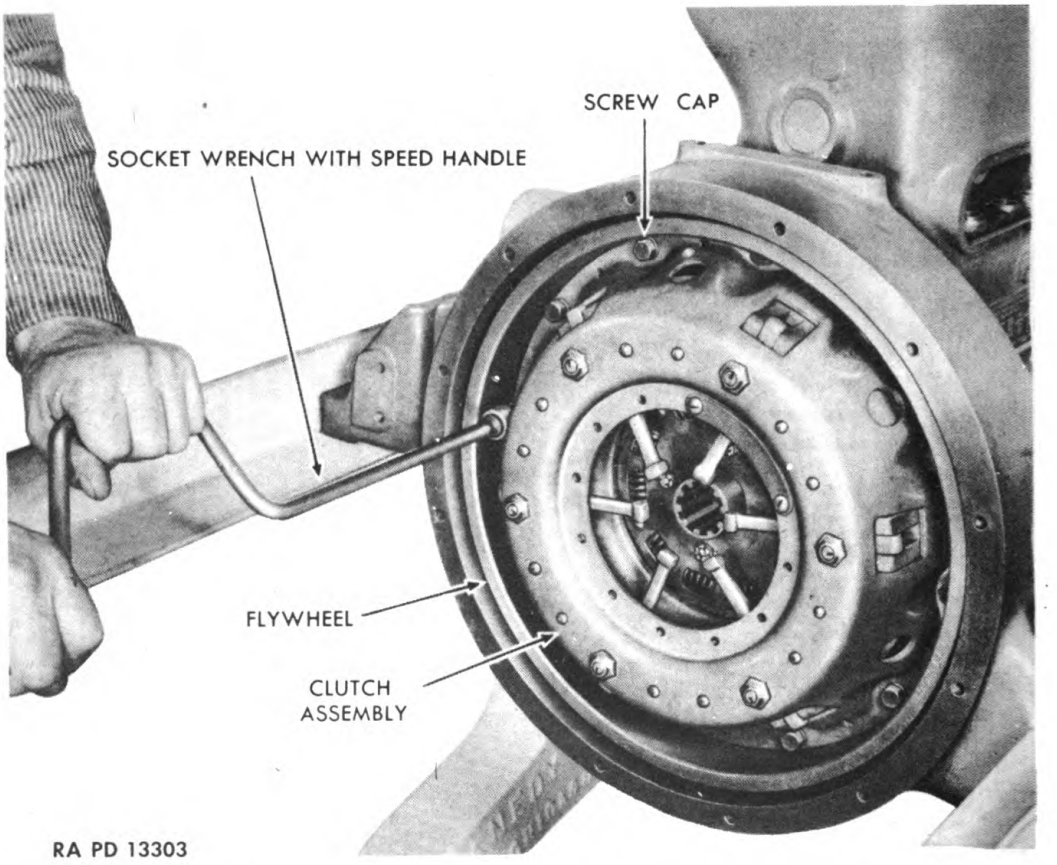


Figure 7—Removing Clutch Assembly

c. Remove Cover Plate from Assembly.

Lands	Spider
Screwdriver	Wrench, socket, ¾-in.

Place three lands on clutch rebuilder (see section XIV) and center clutch assembly on lands. Place spider on clutch rebuilder snaft. Lock spider and tighten spider lock set screw with screwdriver. Compress clutch sufficiently by turning the clutch rebuilder wheel to take spring pressure off cover plate. Remove release lever adjusting nuts (fig. 10). Release clutch rebuilder and remove spider. Lift off cover plate (fig. 11).

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d. Dismantle Cover Plate and Pressure Plate Assemblies (fig. 12).

Hammer Pliers

Lift out pressure springs and insulator buttons. Pull off release springs. Remove cotter pins from long rod pins and tap rod pins out with hammer. Shake levers until all 13 needle rollers are clear of lugs, and extract lever assembly. Remove cotter pins from short yoke rod pins and shake out 13 needle rollers (fig. 12).

e. NOTE: If clutch rebuilder is not available, an arbor press may be used as follows: Place cover plate assembly on press bed plate with

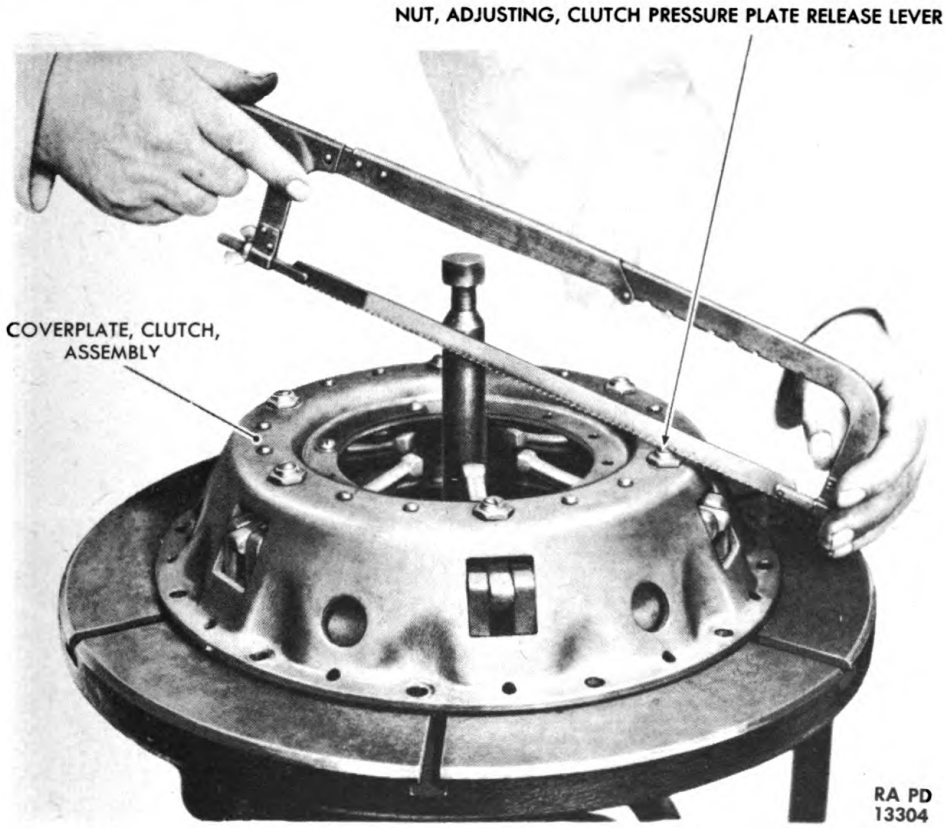


Figure 8—Clutch Lever Adjusting Nut Bur Removal

a wooden block under the pressure plate so arranged that the cover plate can move down. Place a block or bar across the top of the cover between release lever adjusting nuts. Compress cover to release spring tension, then disassemble as in steps **b**, **c** and **d**.

14. MAINTENANCE.

a. Precautions. Particular attention should be paid to the position of all clutch parts during disassembly so that replacements may be made correctly. Before inspection, wash all clutch parts in SOLVENT, dry-cleaning.

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b. Pressure Plate Assembly.

(1) A pressure plate that has been grooved, heat-checked, or warped should be replaced.

(2) When pressure plate is discolored due to heat, new pressure springs should be used; weak springs cause a slipping clutch.

(3) A scored or rough pressure plate causes rapid wear of friction facings and should be replaced.

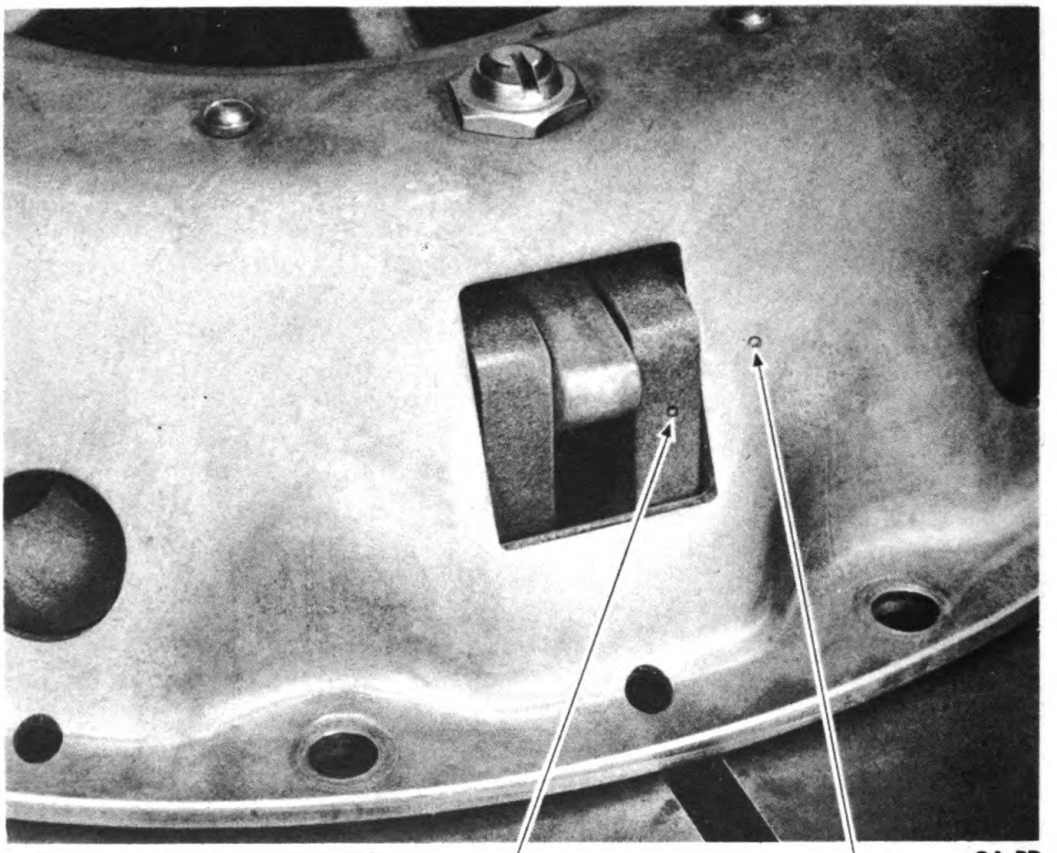


Figure 9—Clutch Cover and Bearing Lug Punch Mark Location

(4) Worn release levers cause poor clutch release and should be replaced.

(5) Inspect release lever nuts and threaded yoke ends for damaged threads and replace if threads have been crossed or damaged.

c. Driven Member Assembly.

(1) Inspect driven member friction facings for wear, and flat cushion springs for flexibility. If the driven plate friction facings are worn beyond operating limitations and the cushion springs have lost their flexibility,

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it is advisable to replace with a complete driven member assembly, rather than to install new friction faces and cushion springs on the old disk.

(2) Inspection of the friction faces with the clutch in the vehicle, is done by removing the clutch inspection plate. Clearance of less than ⅛ inch between the release levers and the inner edge of the cover plate indicates badly worn facings on the driven member. Renew facings by

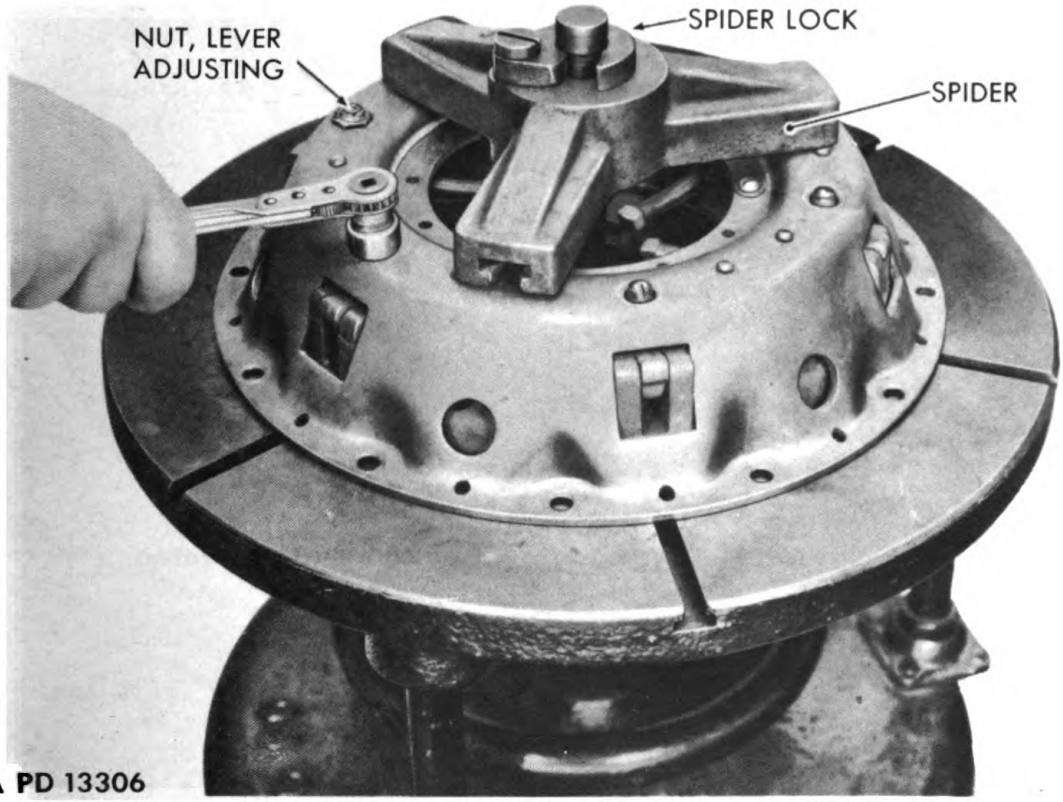


Figure 10—Clutch Lever Adjusting Nut Removal

installing a new driven member (plate) assembly. NOTE: Do not attempt to reline driven member assembly.

d. Cover Plate Assembly.

(1) Should the windows in the cover plate be worn so that there is more than 0.005-inch clearance between each side of the drive lugs on the pressure plate and the sides of the windows when centered, a new cover plate stamping should be used.

(2) Inspect the pressure spring cups that are riveted to the cover plate. Rivet loose cups to tighten and replace unserviceable rivets.

e. Adjustments.

(1) After the clutch has been installed, the clutch operating lever link should be adjusted so that there is at least 1¼-inch free movement between the clutch pedal arm and the floor board.

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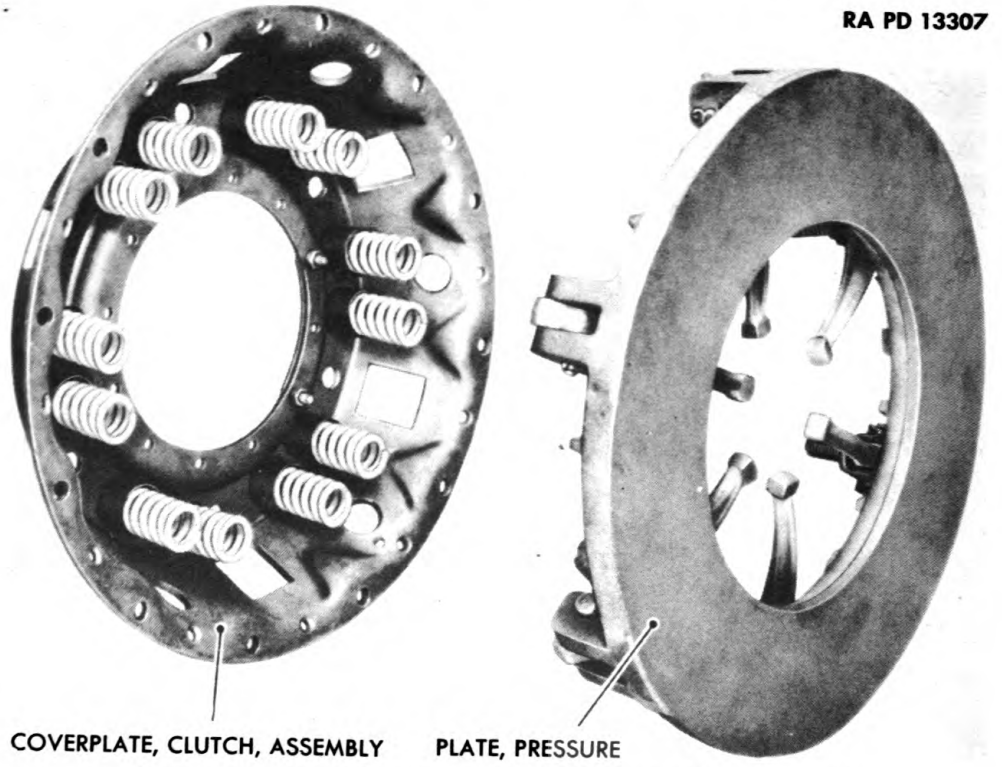


Figure 11—Clutch Plate Assemblies—Dismounted

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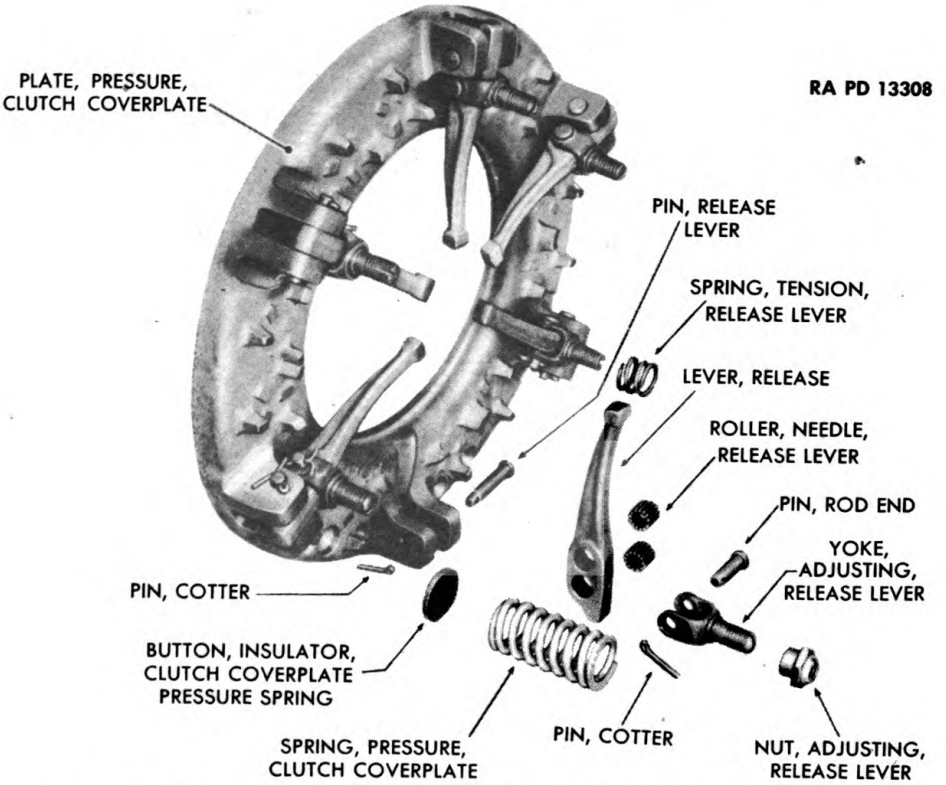


Figure 12—Clutch Pressure Plate Assembly—Exploded

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(2) Once the clutch is installed, no internal adjustments are necessary for the life of any one set of friction facings.

f. Lubrication. The clutch shaft pilot and release bearings are packed and sealed at assembly and requires no lubrication. Every 500 miles place a small quantity of engine oil in the oil cup fitting which lubricates the clutch shaft release bearing spline.

15. ASSEMBLY.

Adapter
Bar, pilot
Gage
Hammer
Lands
Pliers
Punch
Rebuilder, clutch
Saw, hack
Spider
Weight
Wrench, adjustable
Wrench, socket speed, ¾-in.

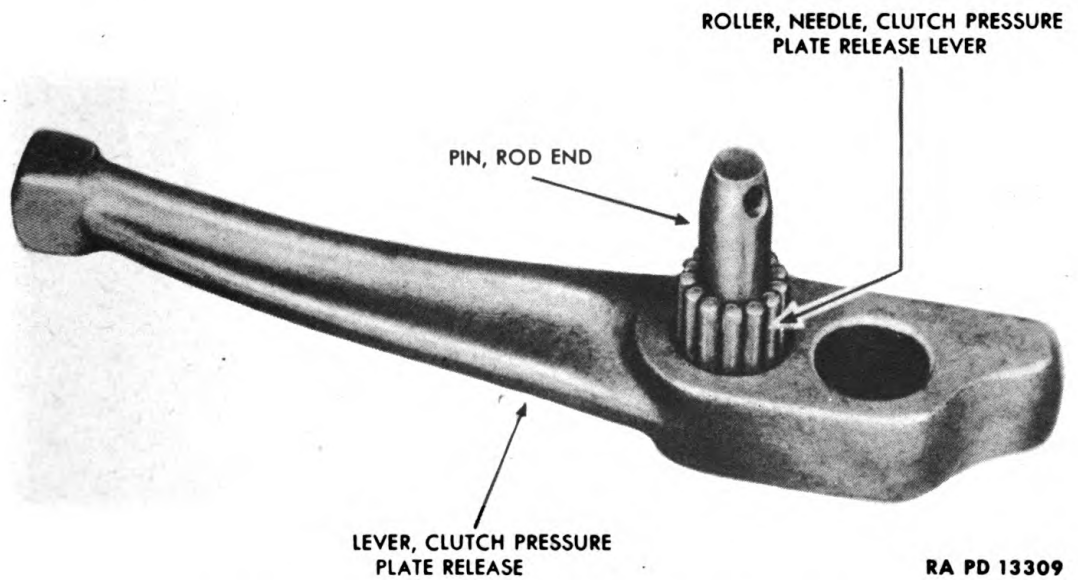


Figure 13—Clutch Lever Bearing Installation

a. Replace Release Lever Yokes.

Saw, hack

Saw off a short rod the same diameter as the rod end pin. Insert this rod in the lever yoke hole and push 13 needle rollers, which have been covered with heavy grease, in around this sawed-off pin. Line up the ends of the rollers and the sawed-off pin with the side of the yoke. Push the sawed-off pin out with the regular rod end pin and insert cotter pin (fig. 13). Make sure slot in threaded end of yoke points toward bearing end of lever to facilitate future disassembly. Repeat for all levers.

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b. Replace Release Levers.

Pliers

Proceed as in paragraph a, using long release lever pins through bearing lugs and making sure all release lever yokes point upward and all cotter pins are secure.

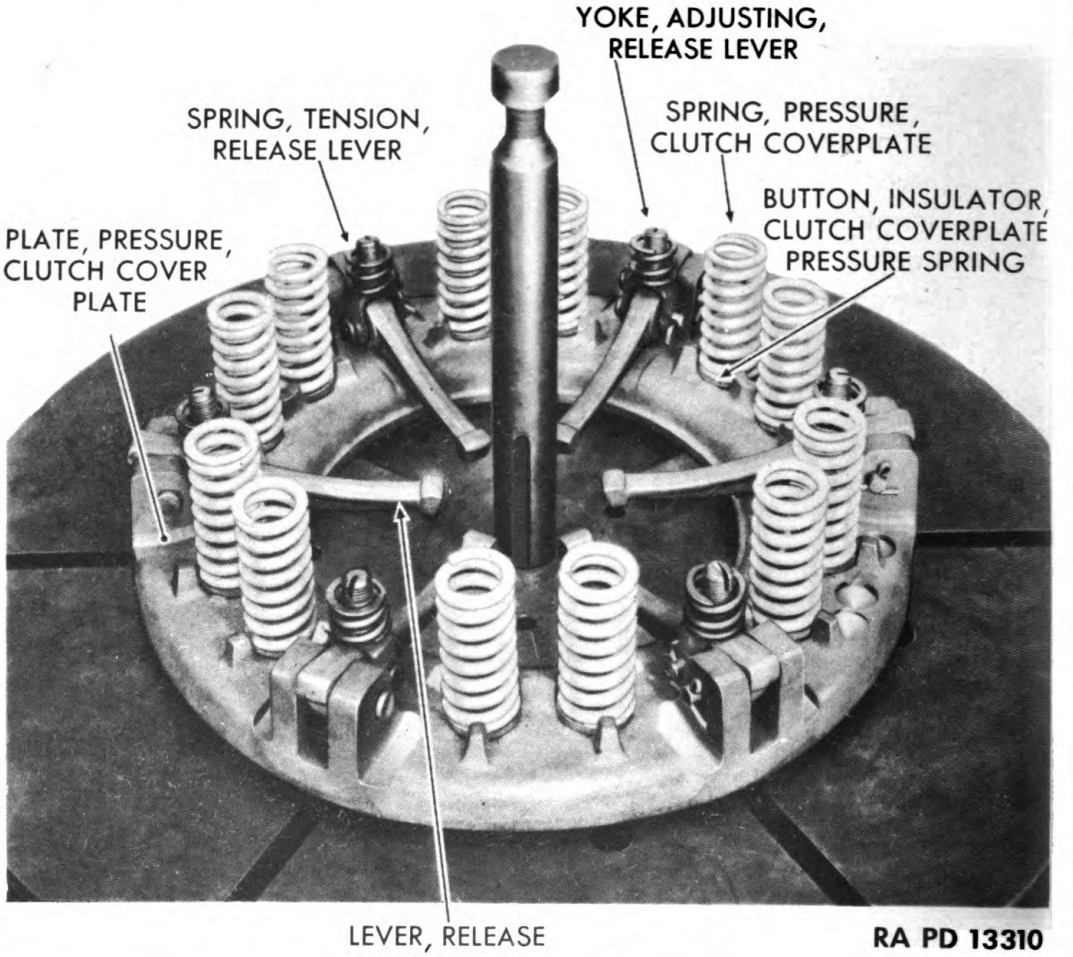


Figure 14—Clutch Pressure Plate Assembly

c. Assemble Cover Plate to Pressure Plate.

Adapter
Lands
Rebuilder, clutch

Place lands on clutch rebuilder fixture. Place adapter on lands to raise levers high enough so threaded ends of yokes can be steered through holes in cover when assembly is being compressed. Place insulator buttons on pressure plate. Place pressure springs on buttons (fig. 14). Place release lever tension springs on threaded ends of yokes.

d. Install Cover Plate. Aline punch marks on cover plate and lever bearing lugs (fig. 9). Locate pressure springs in their cups in cover plate.

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CLUTCH

Make sure springs are seated on yokes and that threaded ends of yokes will push through cover when it is compressed.

e. Reconnect Cover Plate.

Rebuilder, clutch — Wrench, adjustable
Spider — Wrench, socket speed, 3/4-in.

Line up 6 of the 12 cover-plate-to-flywheel-cap-screw holes with 6 clamp slots on the rebuilder fixture. Put spider on shaft and compress assembly gradually, by turning the clutch rebuilder wheel, until all threaded ends of yokes have been centered in and protrude through holes in cover plate. Slide six clamps in slots of rebuilder fixture and tighten with slight turn of adjustable wrench on clamp screws (fig. 15). Release spider and remove. Install lever nuts, stem end down, and screw on until flush with the threaded ends of yokes.

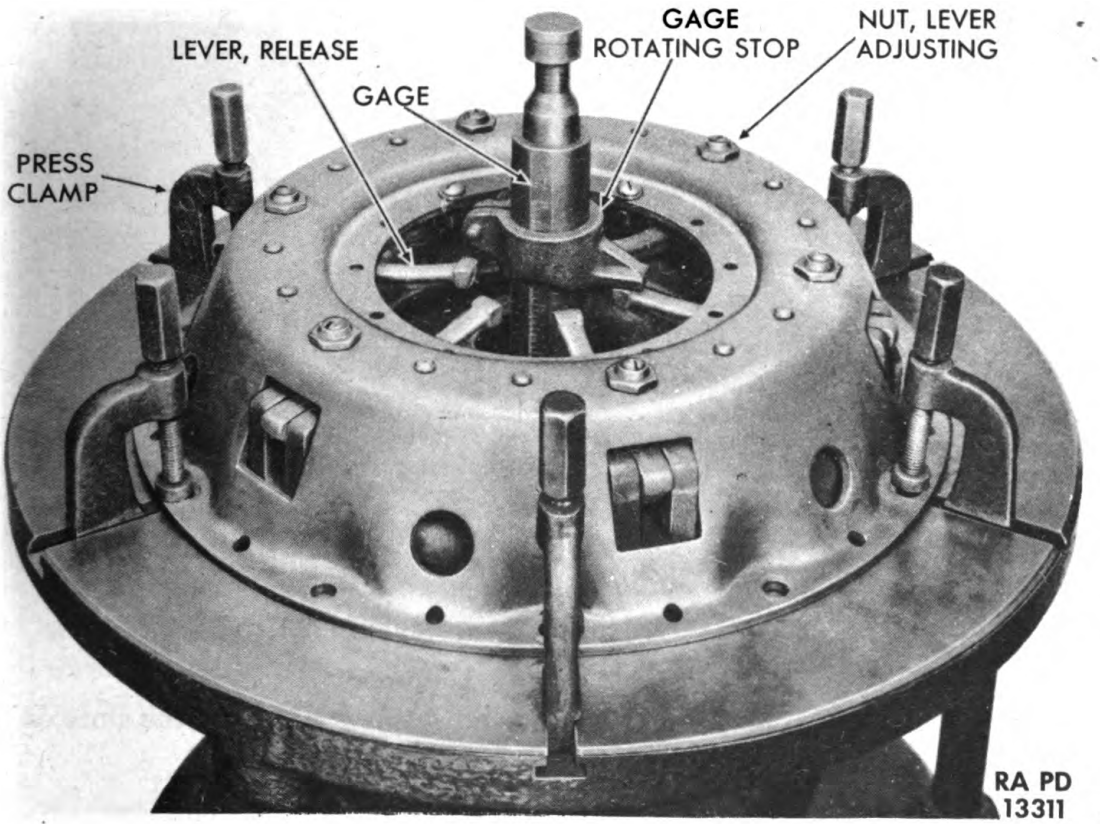


Figure 15—Clutch Lever Adjustment

f. Adjust Height of Levers.

Rebuilder, clutch, and gage Weight — Wrench, socket speed, 3/4-in.

Set clutch rebuilder adjustment gage at $2\frac{13}{32}$ inches and slide it onto rebuilder shaft (fig. 15). Tighten each lever nut until lever just touches

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gage stop without raising it. After adjusting each lever, turn stop around several times to see if it touches each lever, yet rotates freely. Remove gage and replace with press weight (fig. 16), compressing and releasing lever several times. Remove weight and replace gage and retest adjustment. If several tests show one lever cannot be adjusted, a weak spring is indicated, which must be replaced.

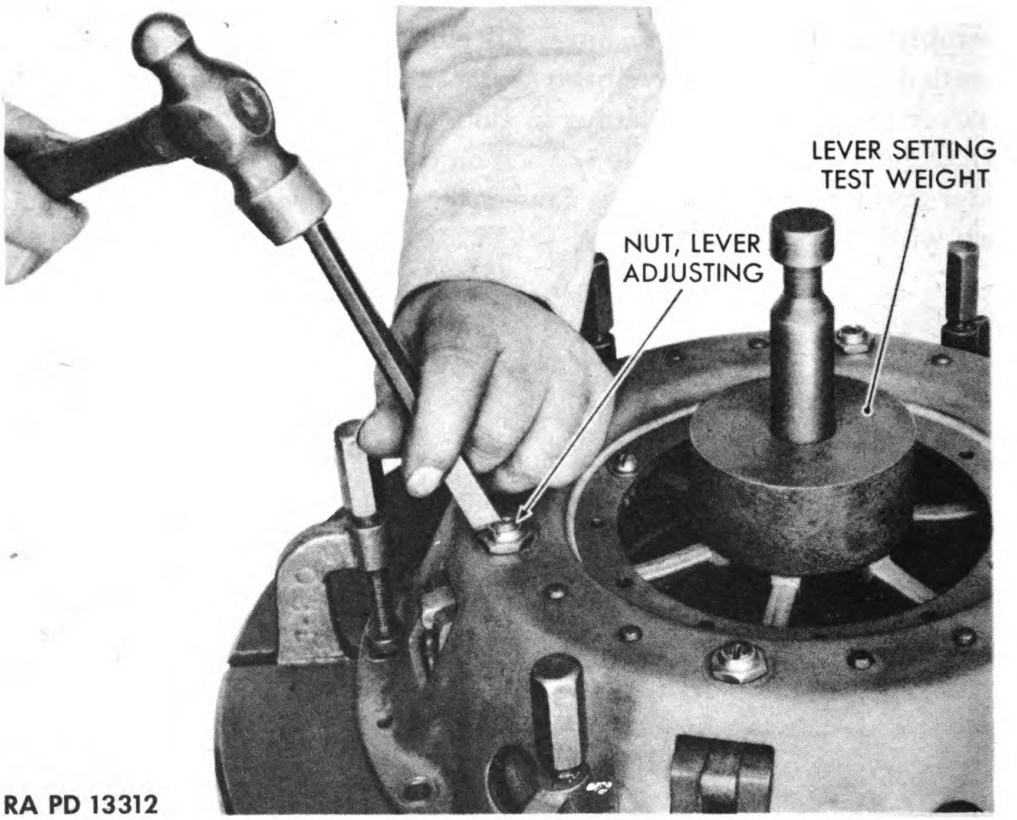


Figure 16—Locking Clutch Lever Adjusting Nut

g. Lock Cover Plate Assembly.

Chisel Hammer

After final adjustment, lock the lever adjustment nuts into the slots of the yoke stems with a blunt chisel and hammer (fig. 16).

h. Remove Assembly from Rebuilder.

Rebuilder, clutch

Compress clutch assembly by means of the rebuilder wheel; loosen and remove clamps. Release spider and remove clutch assembly.

i. NOTE: If clutch rebuilder is not available and an arbor press is used, place on press bed plate as described in disassembly and follow steps **d**, **e**, and **g** (par. 15). Adjustment of pressure plate levers may be made by placing a straightedge across the top surface of cover plate. Then,

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using a depth gage, adjust levers so that the distance from the top surface of cover plate to the tip of each lever is exactly $\frac{3}{32}$ inch.

16. INSTALLATION.

Bar, pilot
Bar, pinch
Hammer
Handle, speed
Hoist, chain
Pliers
Press
Rope, 1-in.
Screwdriver
Wrench, box, $\frac{5}{8}$-in.
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{5}{8}$-in.
Wrench, socket, $\frac{9}{16}$-in.

a. Install Clutch in Flywheel Housing.

Bar, pilot
Handle, speed
Wrench, socket, $\frac{9}{16}$-in.

A transmission main drive shaft may be used as a pilot bar to aline the splined hub with the flywheel pilot bearing. Place pilot bar in clutch disk hub and insert pilot bar in clutch pilot bearing. Place clutch cover plate assembly in position and secure to flywheel with 12 cap screws and lock washers. Tighten cap screws evenly so as not to bend cover plate. Remove pilot bar.

b. Install Transmission.

Bar, pinch
Hoist, chain
Rope, 1-in.

Slide transmission under vehicle in approximately the correct position and put rope under and around assembly. Raise transmission into position and push assembly forward, engaging the spline in the clutch hub. Do not force the spline into the hub. Be sure to keep the transmission in line in order to prevent injury to the spline. Engagement of the clutch shaft with the splined clutch hub can often be facilitated by placing the transmission in high gear and turning the companion flange on the rear of the transmission until the clutch shaft and clutch hub spline are alined.

c. Connect Bell Housing to Flywheel Housing.

Wrench, socket, $\frac{9}{16}$-in.

Install 12 cap screws and lock washers that hold bell housing to flywheel housing (fig. 5).

d. Install Master Cylinder Push Rod.

Hammer
Pliers

Set push rod into master cylinder and install rod end pin and cotter pin that hold master cylinder push rod to operating lever.

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e. Connect Clutch Release Bearing Outer Oil Tube.

Wrench, open-end, $\frac{7}{16}$-in.

Connect outer oil tube to inner by screwing inverted flared tube nut into elbow on inner oil tube (fig. 5).

f. Install Hand Brake Lever.

Wrench, open-end, $\frac{9}{16}$-in.

Replace two nuts that hold lever to transmission and connect lever to operating linkage to drive shaft brake (fig. 4).

g. Connect Transfer Case Shift Lever to Shift Rod.

Hammer Pliers

Install rod end pin and cotter pin that hold lever to rod.

h. Connect Clutch Release Shaft Support.

Wrench, open-end, $\frac{9}{16}$-in.

Install shims and two cap screws, plain washers and lock washers that hold shaft support to engine support bracket (fig. 4).

i. Connect Clutch Release Pedal Shaft Lever to Linkage.

Hammer Pliers

Install rod end pin and cotter pin that hold clutch release pedal shaft lever to adjustable yoke.

j. Connect Rear Propeller Shaft.

Wrench, box, $\frac{5}{8}$-in. Wrench, open-end, $\frac{5}{8}$-in.

Set shaft in place and install four nuts, bolts and lock washers that hold shaft to transmission companion flange (fig. 4).

k. Install Floor Board.

Screwdriver

Set floor plate down over transfer case shift lever and install six screws. Install transfer case shift lever ball.

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Section VI

COOLING SYSTEM

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17. DESCRIPTION.

The water cooling system consists of radiator, fan and shroud, centrifugal water pump, thermostat, and the connecting lines and hoses. The radiator is connected to the water pump inlet by a hose connection, and to the thermostat housing outlet by a pipe and hose connection. The fan is driven from the crankshaft by dual belts. These belts also drive the generator. A third belt from the fan pulley is used to drive the vacuum pump. The centrifugal-type water pump is mounted at the front of the engine crankcase on the right side and is gear driven from the timing gear train. The complete pump is readily removable from the engine. A bellows-type thermostat is located at the forward end of the water outlet manifold. A bypass pipe extends from the thermostat down to the water pump. The system can be drained by opening drain cocks under the radiator and at the left rear side of the engine block.

a. Functioning. Water is drawn from the lower radiator tank by the pump and circulated through the water jackets and around the cylinders. During the warm-up period the water is bypassed through a pipe to the water pump without circulating through the radiator. When the engine is warmed up, the water passes through the water outlet manifold and thermostat back into the top radiator tank. The warm water then passes down through the radiator tubes and is cooled by air drawn through the radiator by the fan.

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18. TROUBLE SHOOTING.

Symptom and probable cause	Probable remedy
a. Overheating.	
Radiator dirty inside or out.	Clean radiator thoroughly.
Dirty water.	Drain and refill with clean water.
Engine timing wrong.	Time engine correctly.
Leaking head gasket.	Replace gasket.
Fan belts slipping on fan pulley.	Take up belt slack.
Sticking thermostat.	Replace thermostat.
Restriction in system.	Clean system to remove restriction.
b. Loss of Cooling Liquid.	
Loose hose connections.	Tighten all connections.
Damaged hose connections.	Replace damaged hose.
Leaks in radiator core.	Remove core and repair leaks.
Loose or open drain cock.	Check and tighten.

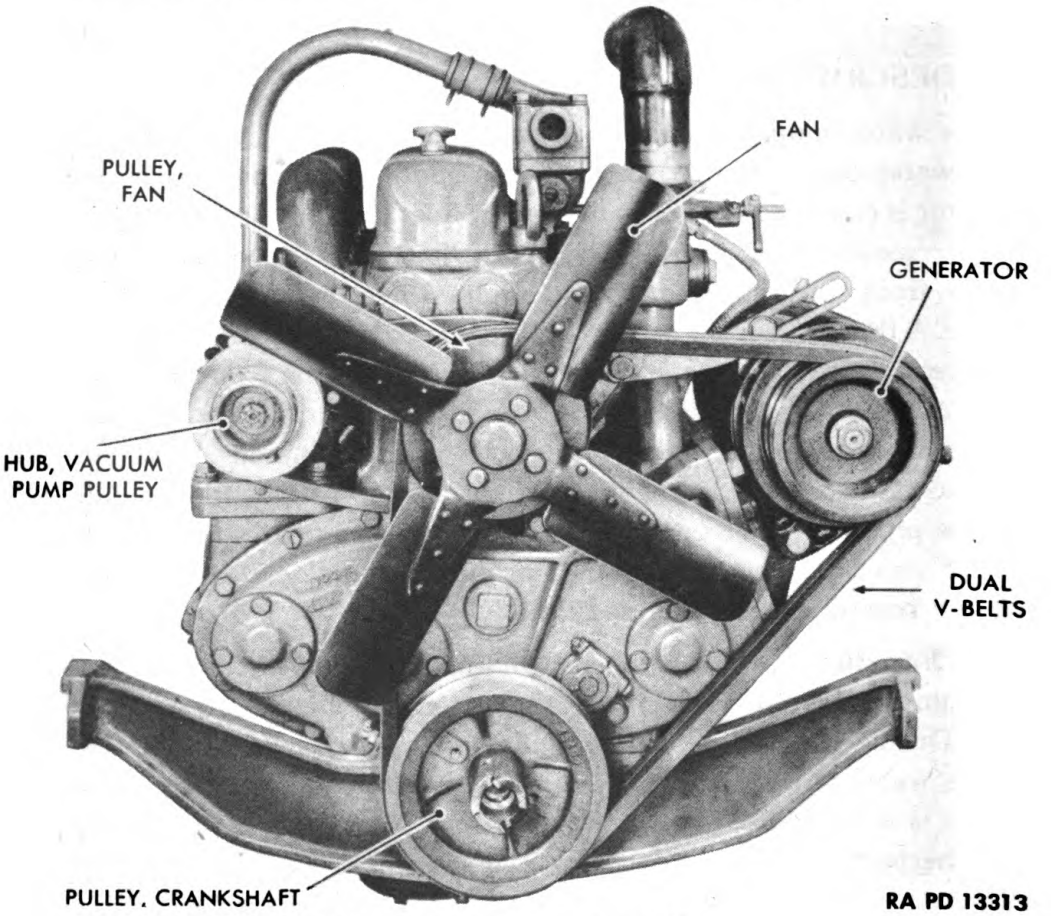


Figure 17—Fan and Belts

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COOLING SYSTEM

19. FAN AND BELTS.

a. Description (fig.17). The four-bladed, shroud-enclosed fan is equipped with a three-groove pulley. It is mounted at the front of the engine, and is driven from the crankshaft by dual belts.

(1) CONSTRUCTION. The fan blade assembly is secured to the pulley hub by four cap screws and lock washers. The pulley hub is attached to the cylinder block by four studs which extend through four drilled holes in the fan bracket. Nuts and lock washers secure the bracket to the cylinder studs.

(2) FUNCTIONING. The fan is driven from the crankshaft by dual belts which also drive the generator. A third belt from the fan pulley drives the vacuum pump. The fan draws air through the radiator to cool the water before it is circulated through the engine water jackets and forces air back over the engine to further aid the cooling process.

b. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) ENGINE OVERHEATING.	
Fan belts loose.	Adjust.
Fan belts bottoming in pulley.	Replace belts.
Broken belts.	Replace belts.
(2) UNEVEN BELT WEAR.	
Belts out of alinement.	Adjust and aline belts with pulley.
(3) OVERHEATED BEARING.	
Lack of lubrication.	Lubricate.
Tight belts.	Adjust belts.

20. REMOVAL OF FAN ASSEMBLY FROM ENGINE.

Pliers
Screwdriver, heavy
Wrench, box, ½-in.
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, ⅞-in.
Wrench, open-end offset, ¾-in.
Wrench, socket, ¾-in.

a. Remove Fan Belts.

(1) LOOSEN GENERATOR BRACKET BOLTS.

Wrench, open-end, ⅞-in.

Loosen, but do not remove the two bolts which hold the generator to the generator bracket. These bolts are located under the generator (fig. 18).

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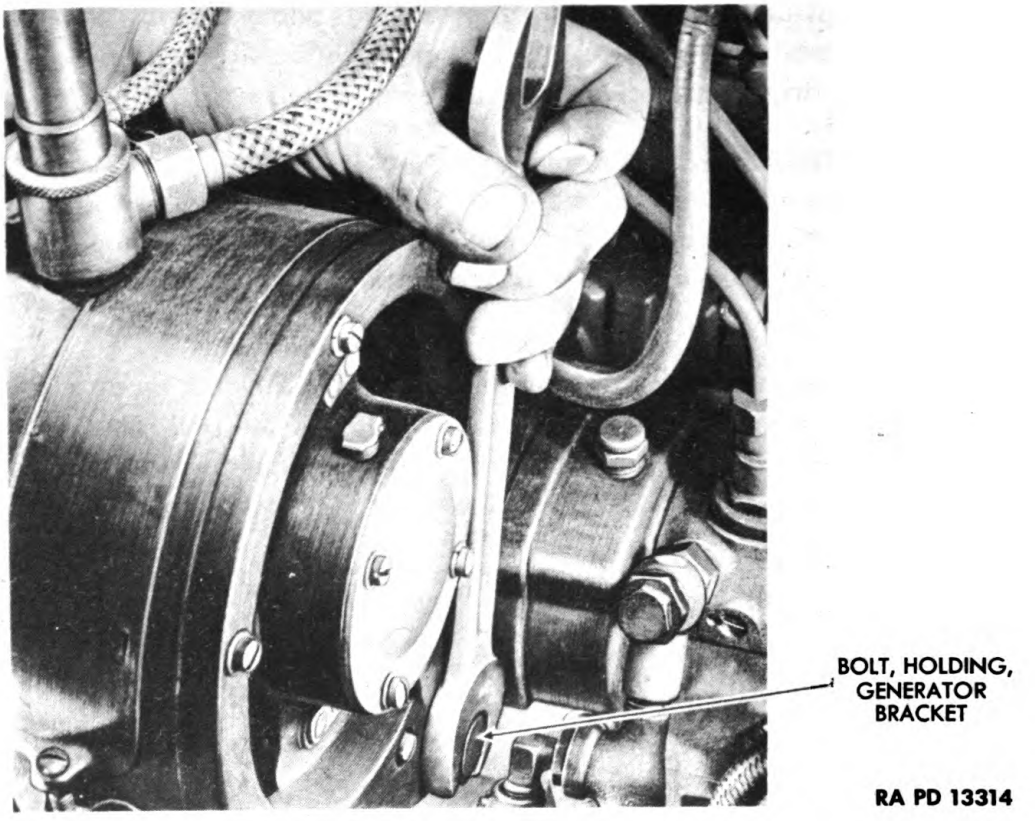


Figure 18—Loosening Generator Bracket Holding Bolt

(2) LOOSEN THE ADJUSTING BOLT.

Wrench, open-end, ¾-in.

Loosen, but do not remove the nut on the belt adjusting bolt which secures the slotted end of the generator belt adjusting strap to the generator housing (fig. 19).

(3) RELEASE BELT TENSION. Push the generator in toward the engine as far as it will go to loosen tension on the dual V-belts (fig. 17).

(4) REMOVE THE BELTS.

Screwdriver, heavy

Place the screwdriver under the dual V-belts at the pulley on the generator and pry them off.

b. Remove Generator Belt Adjusting Strap.

Wrench, open-end, ¾-in.

Remove oil filler breather cap. Remove the adjusting bolt, nut, lock washer, and plain washer from the adjusting strap (fig. 19). Remove cap

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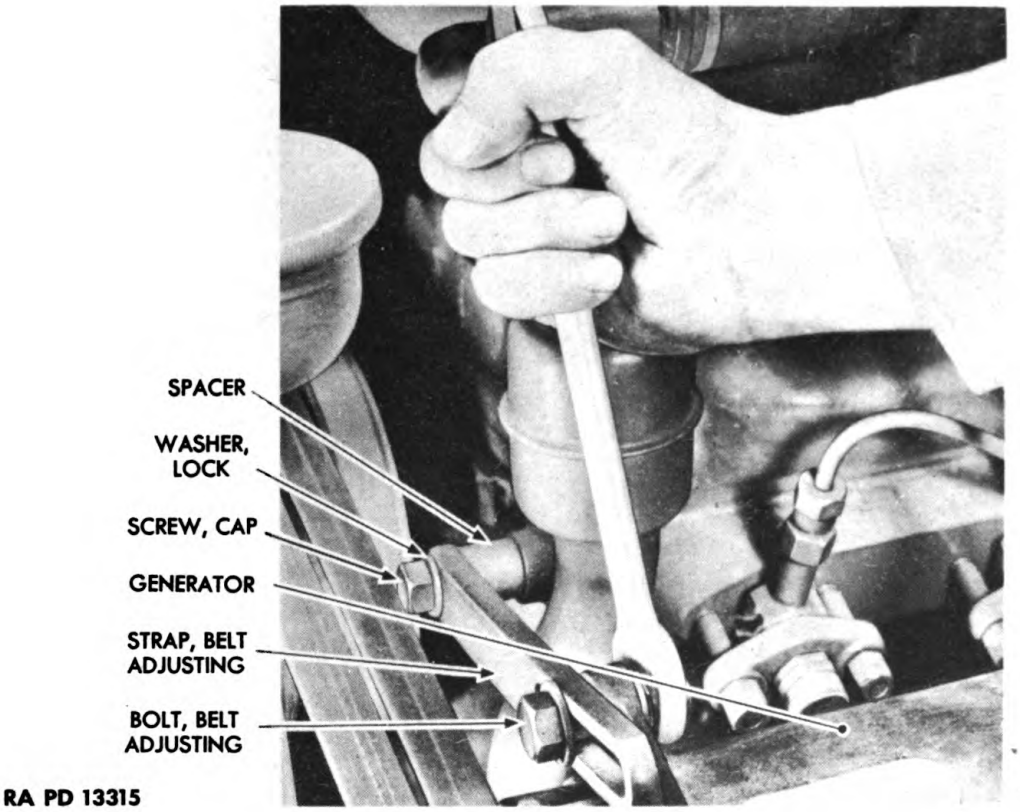


Figure 19—Loosening Adjusting Strap Bolt

screw that holds adjusting strap to fan bracket. A lock washer and spacer will come away with the cap screw and strap (fig. 19).

c. Remove Fan Blades.

Wrench, box, ½-in.

Remove the four cap screws which hold the fan blades to the hub (figs. 20 and 21) and lift the fan blades out of the engine compartment (fig. 22).

d. Remove Vacuum Pump Belt.

Wrench, open-end, $\frac{7}{16}$-in.

Remove the two adjusting cap screws, plain washers and lock washers from the outside of the vacuum pump pulley hub. Pull off the front pulley flange, then slide off the vacuum pump belt (fig. 17).

e. Remove Fan Pulley and Bracket Assembly.

Wrench, open-end offset, ¾-in.

Remove the four nuts that hold the fan and pulley bracket to the engine block (fig. 23) and lift the fan pulley and hub assembly out over the oil filler pipe (fig. 24).

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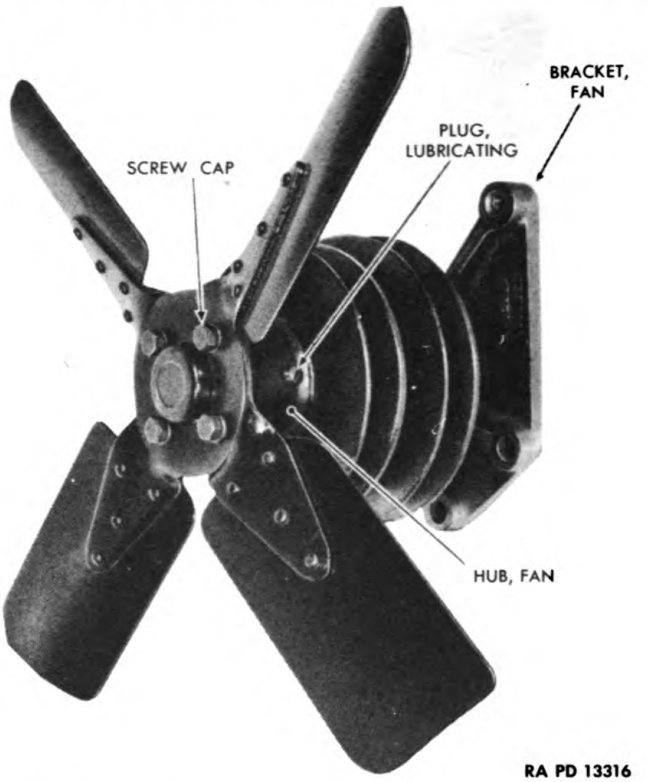


Figure 20—Fan Assembly—Belts Removed

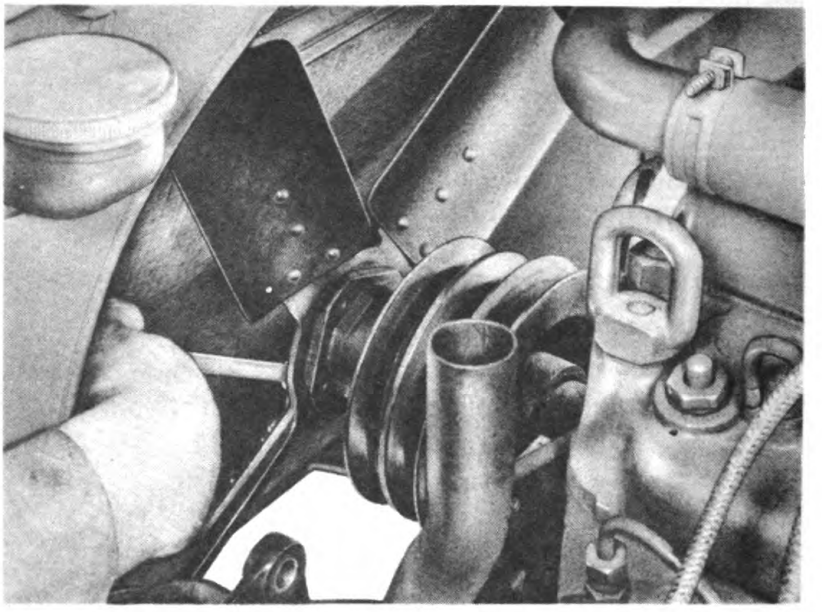
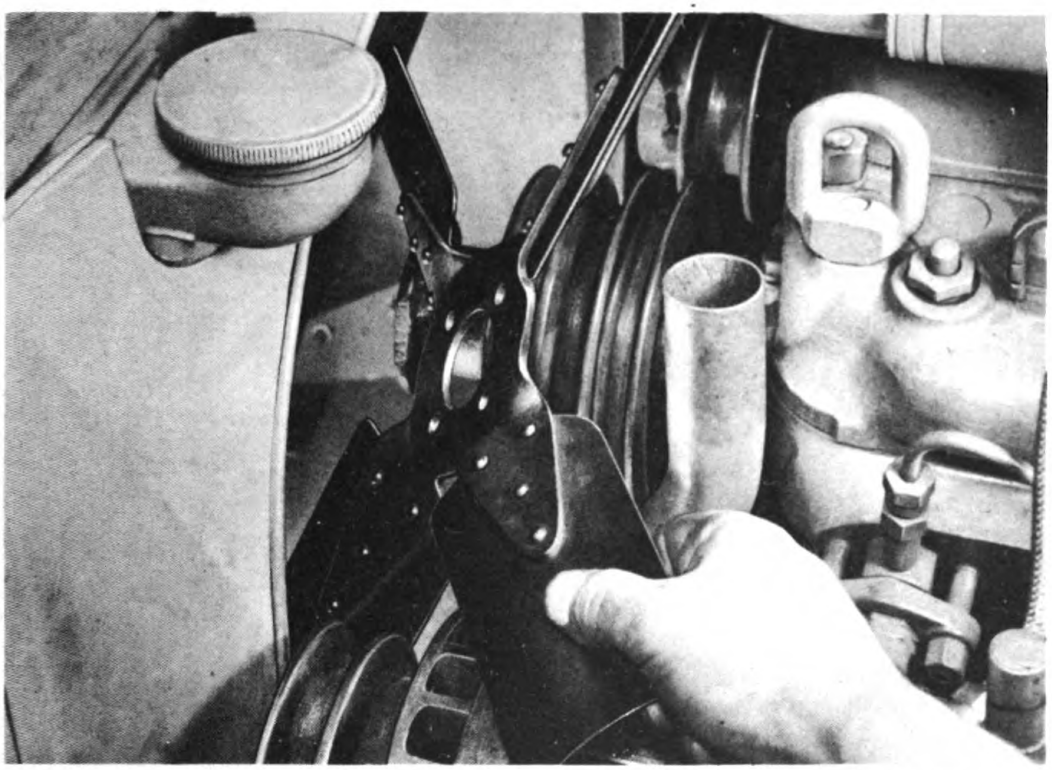


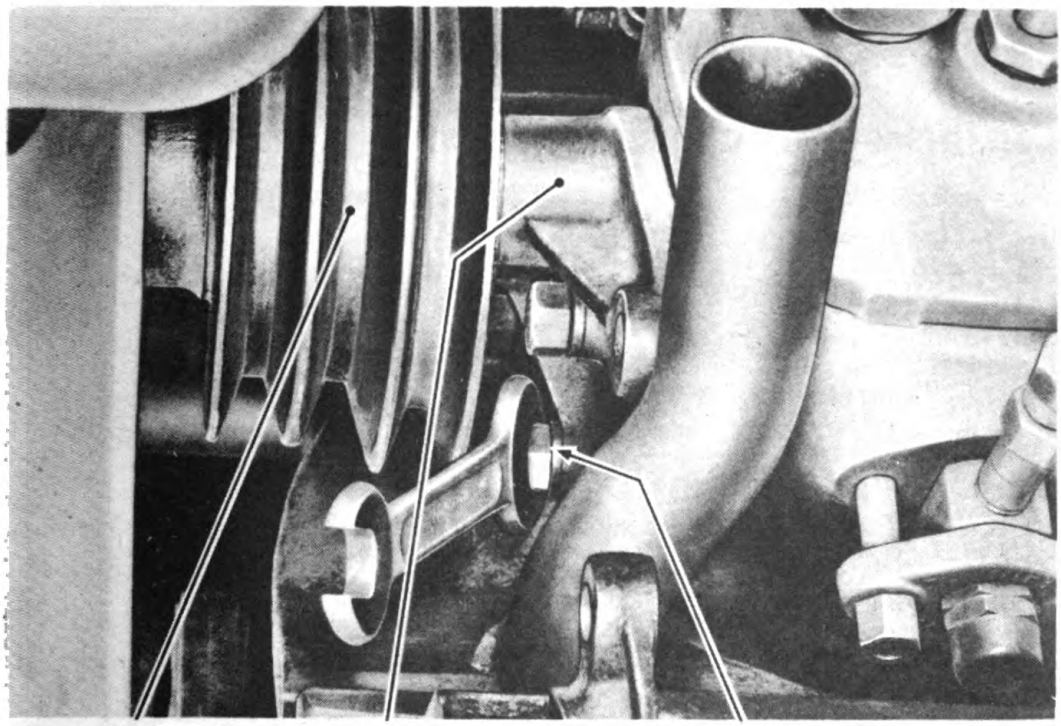
Figure 21—Removing Fan Blade Cap Screws

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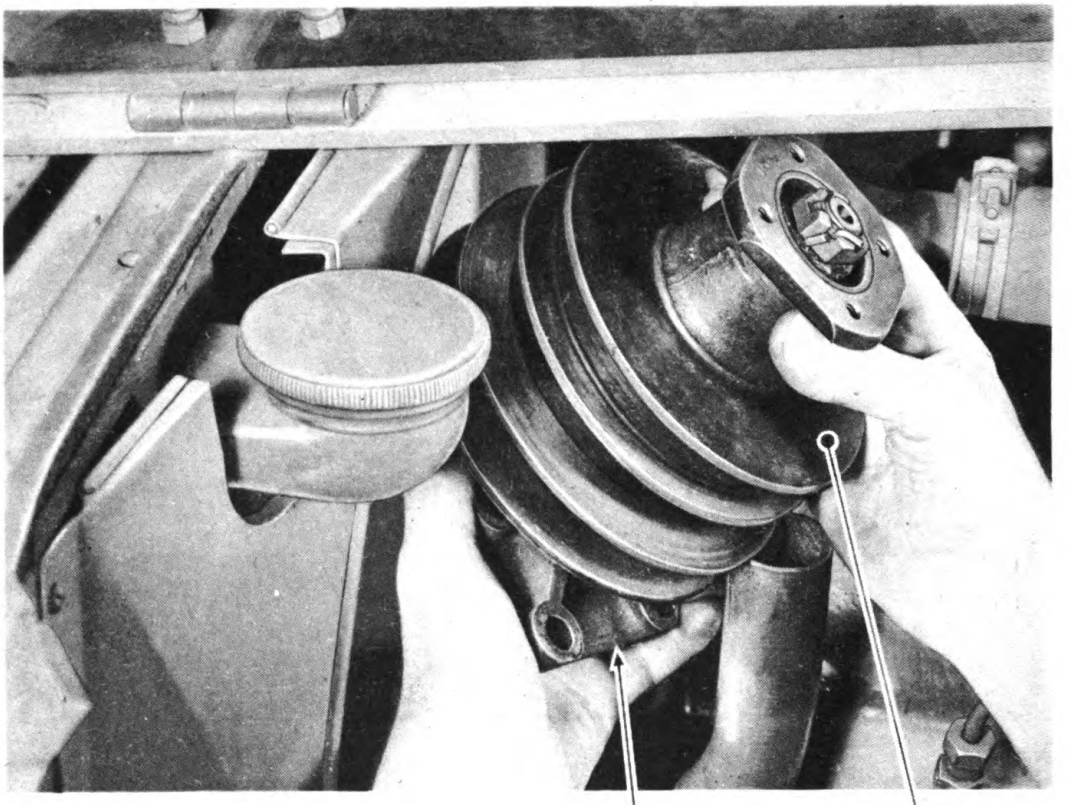
Figure 22—Removing Fan Blade from Engine Compartment



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Figure 23—Removing Pulley and Bracket Assembly Holding Nuts

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Figure 24—Removing Pulley and Bracket Assembly from Vehicle

21. DISASSEMBLY OF FAN ASSEMBLY (fig. 25).

Drift, long
Hammer
Pliers
Press, arbor
Screwdriver
Vise
Wrench, open-end, $\frac{15}{16}$-in.

a. Remove Spindle Castle Nut.

Pliers
Vise
Wrench, open-end, $\frac{15}{16}$-in.

Clamp fan assembly in a vise. Lift off grease cap and gasket. Remove cotter pin from castle nut at front of spindle. Using a $\frac{15}{16}$-inch open-end wrench, remove the castle nut and special washer.

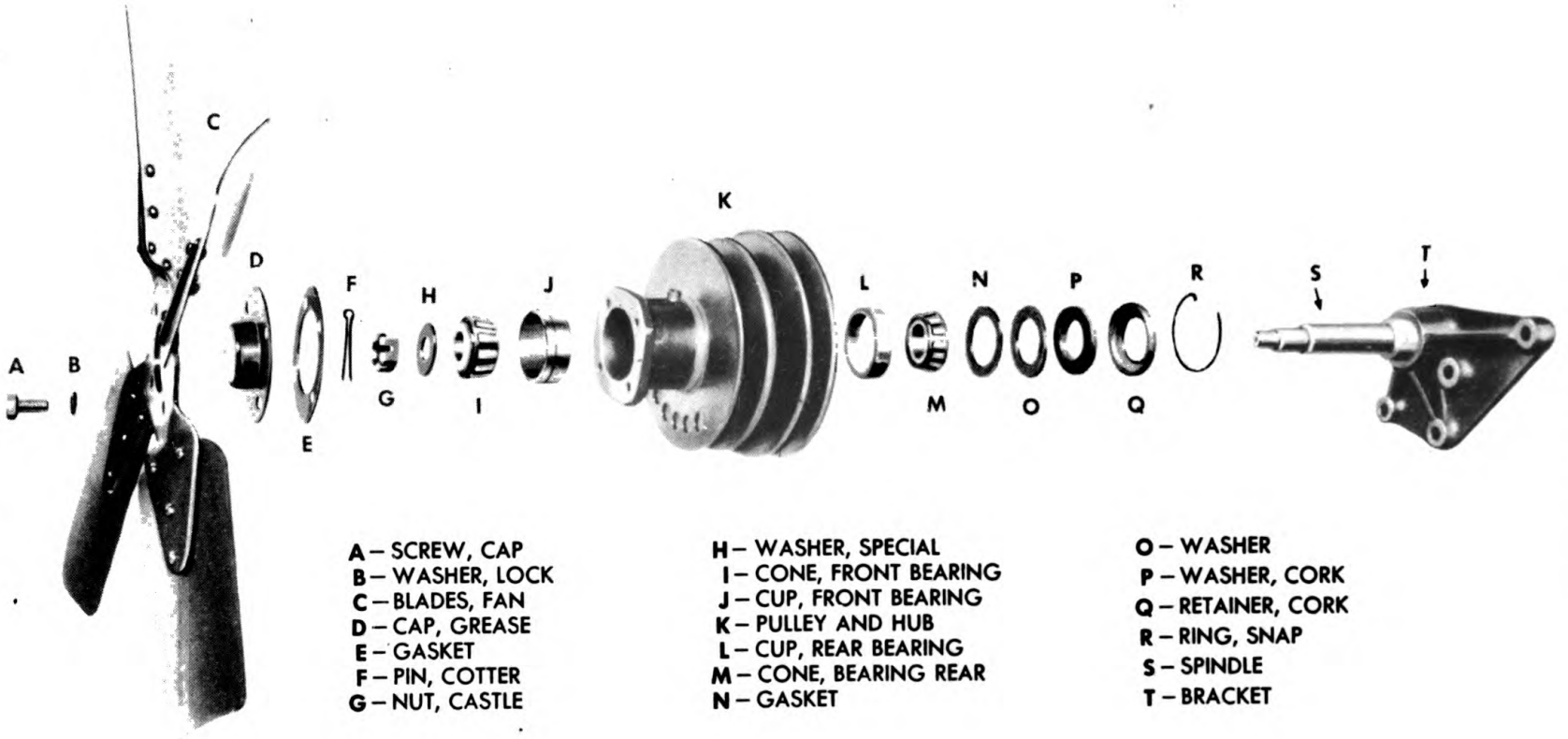
b. Press Out Spindle.

Press, arbor

Place fan hub in arbor press and press out spindle. The front bearing cone will drop out. The bearing cup remains in the hub for the present.

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A – SCREW, CAP
B – WASHER, LOCK
C – BLADES, FAN
D – CAP, GREASE
E – GASKET
F – PIN, COTTER
G – NUT, CASTLE
H – WASHER, SPECIAL
I – CONE, FRONT BEARING
J – CUP, FRONT BEARING
K – PULLEY AND HUB
L – CUP, REAR BEARING
M – CONE, BEARING REAR
N – GASKET
O – WASHER
P – WASHER, CORK
Q – RETAINER, CORK
R – RING, SNAP
S – SPINDLE
T – BRACKET

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Figure 25—Fan Assembly—Exploded View

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c. Remove Snap Ring.

Screwdriver

Turn the hub over and remove the snap ring from the hub groove inside the hub near the end.

d. Remove Rear Bearing Cone and Cup.

Drift, long Hammer

Support the hub on wood blocks on the work bench with the front of the hub upward, then reach through hub with a long drift and drive out the rear bearing cone. Be careful not to damage the bearing by striking too hard. Remove the following from the hub in the order named: Cork retainer, plain cork washer, plain washer, and gasket. Then, with the hub in the same position, drive out the rear bearing cup with drift and hammer.

e. Remove Front Bearing Cup.

Drift, long Hammer

Turn the hub over and drive out the front bearing cup.

22. FAN ASSEMBLY MAINTENANCE

a. Fan must be checked for balance at every major overhaul. Examine fan blade assembly for bent blades. Unless blades can be brought back to exact original shape, replace fan blade assembly, as bent blades will throw the fan out of balance.

b. Inspect fan belts for frayed condition, cracks or uneven wear. Replace badly frayed, worn or cracked belts.

c. Examine bearing cones, bearing cups, cork retainer and washers for wear or damage. If excessive wear is evident or if parts are damaged, replace them.

d. Examine spindle threads for burs or stripping. If threads are stripped replace the spindle; if burred, run proper size die over threads and use new nut.

e. Examine castle nut. If threads are damaged, replace nut.

f. Examine snap ring for tension. If ring lacks tension or is distorted, replace it.

g. Precautions. Care should be taken in driving out the rear bearing cone with the long drift and hammer to prevent possible damage. Handle bearing cones and spindle carefully during disassembly and assembly to prevent damage.

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23. ASSEMBLY OF FAN ASSEMBLY.

Fitting, alemite
Gun, alemite
Hammer, fiber
Screwdriver
Wrench, open-end, $\frac{15}{16}$-in.

a. Install Front and Rear Bearing Cups. Place the front and rear bearing inner cups in position against the shoulders in hub (fig. 25).

b. Install Rear Bearing Cone (fig. 25).

Hammer, fiber
Screwdriver

Insert the rear bearing cone in position in the hub. Pack with grease. Place gasket, plain washer, cork washer and cork retainer in position behind the bearing. Lock these in place in the hub with a snap ring (fig. 25). It may be necessary to drive the cork retainer in to free the groove for the snap ring. Use fiber hammer.

c. Install Front Bearing Cone (fig. 25). Install the hub on the bracket spindle and place the front bearing cone in position on the shaft and in the hub. Pack with GREASE, general purpose, No. 2. Make sure the cone is properly seated in the cup (fig. 25).

d. Install Adjusting (Castle) Nut.

Pliers
Wrench, open-end, $\frac{15}{16}$-in.

Place the special washer and adjusting nut (castle nut) on the spindle shaft. Draw up this nut but do not tighten so that the bearings will bind. To check, rotate the hub. See that it rotates freely and that the nut is not loose. Lock the castle nut in position with a new cotter pin. Place the gasket and grease cap in position on the front of the hub.

24. INSTALLATION OF FAN ASSEMBLY.

Pliers
Screwdriver, heavy
Wrench, box, ½-in.
Wrench, open-end, ⅞-in.
Wrench, open-end offset, ¾-in.
Wrench, socket, ¾-in.

a. Install Fan Pulley and Hub Assembly.

Pliers
Wrench, open-end offset, ¾-in.

Place the fan pulley and hub assembly in position on the studs and install the four nuts and lock washers that hold the bracket to the engine block (fig. 23).

b. Install Vacuum Pump Belt.

Wrench, open-end, $\frac{7}{16}$-in.

Install the vacuum pump belt in position on the fan pulley and vacuum pump pulley. Install the front pulley flange on the vacuum pump, then insert the two plain washers, lock washers and cap screws. Be sure to place the plain washers next to the pulley and under the lock washers. Tighten the cap screws.

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c. Install the Fan Blades.

Wrench, box, ½-in.

Place the fan blades in position on the hub. Install four cap screws and lock washers that hold the fan blades in place (fig. 21).

d. Install the Generator Belt Adjusting Strap.

Wrench, open-end, ¾-in.

Insert the cap screw with lock washer through the hole at the front of the adjusting strap. Slip on the spacer. Place the adjusting strap in position on the fan bracket, and tighten the cap screw (fig. 19). Insert belt adjusting bolt with plain washer through the slotted end of the belt adjusting strap and the generator housing boss. Place a lock washer and nut on the bolt but do not tighten (fig. 19).

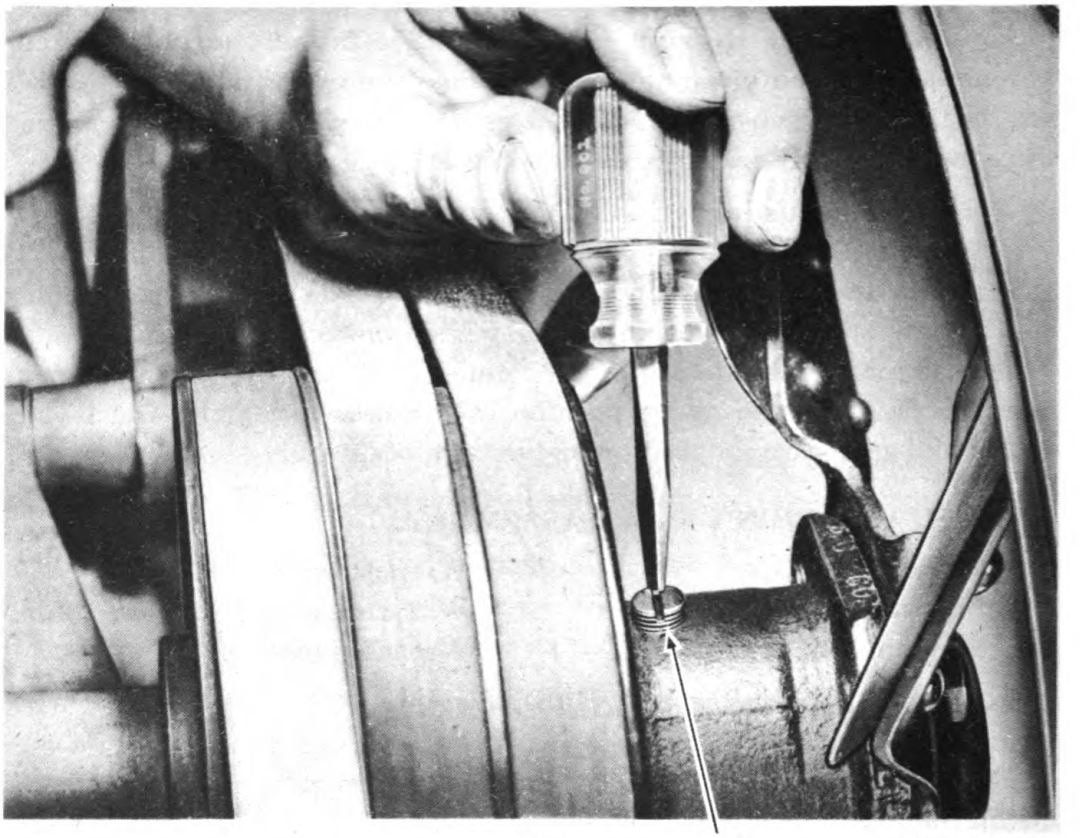


Figure 26—Removing Lubrication Plug on Fan Assembly

e. Install and Adjust Fan Belts.

Screwdriver, heavy
Wrench, socket, ¾-in.
Wrench, open-end, ⅞-in.

Push the generator in towards engine and install the two generator drive belts. Pull generator away from engine until the fan belts midway be-

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tween pulleys, may be deflected about ½-¾ inch. Tighten the adjusting bolt and two generator bracket holding bolts underneath the generator (figs. 27 and 18). Install the oil filler cap on the oil filler pipe.

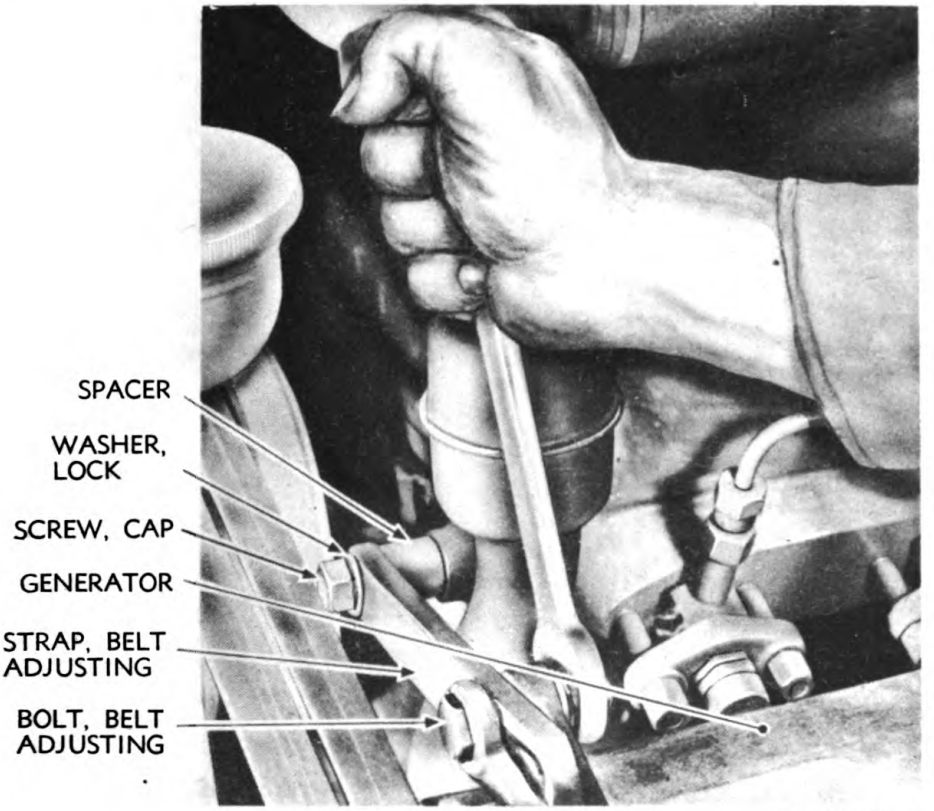


Figure 27—Tightening Adjusting Strap Bolt

25. WATER PUMP.

a. Description. The centrifugal-type water pump is mounted at the front of the engine crankcase at the right side. It is gear driven from the timing gear train. The complete pump assembly is removable from the engine.

(1) CONSTRUCTION. There are two packless seals in the hub of the impeller. The bushing in the pump at the timing gear end is lubricated through an oil passage which connects with the gear compartment of the engine. The bearing at the water inlet end of the pump must be lubricated through the oiler provided on the pump housing.

(2) FUNCTIONING. Rotation of the pump impeller draws water from the bottom of the radiator and circulates it through the water jackets around the cylinders and out through the water outlet manifold and thermostat housing to the upper radiator.

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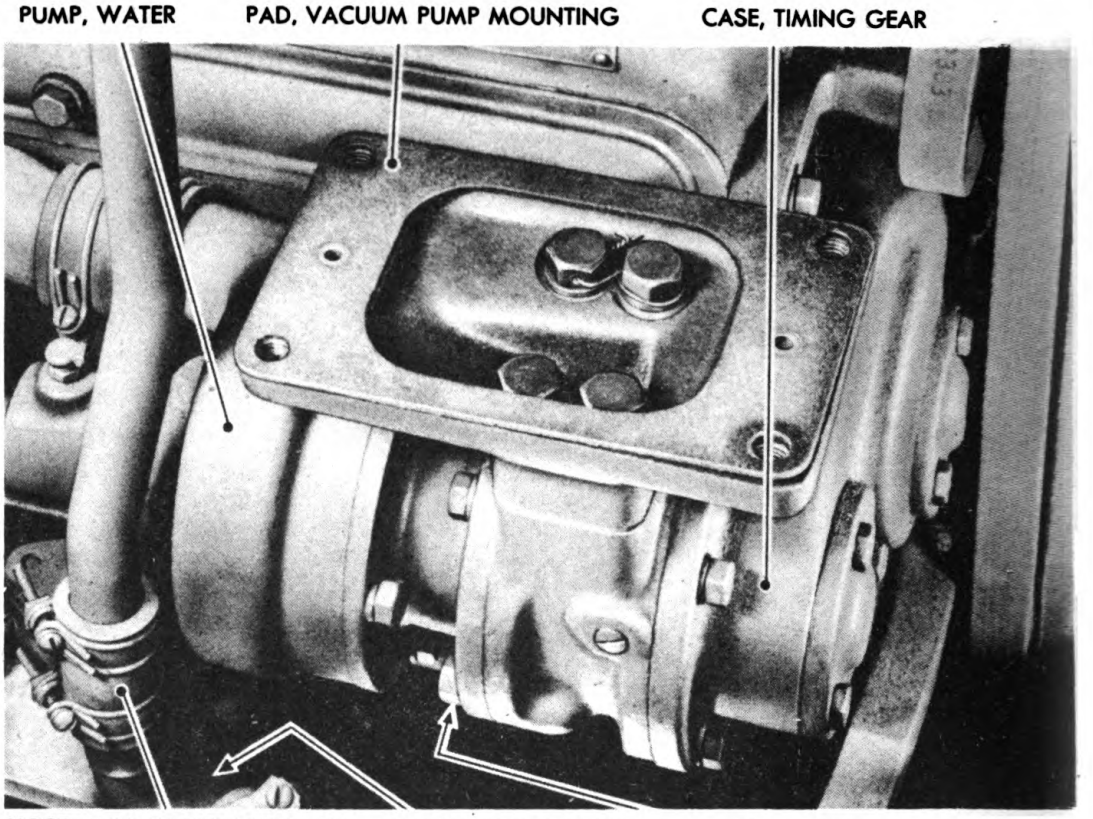


Figure 28—Water Pump—Installed

b. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) Loss of Cooling Water.	
Damaged seal.	Replace seal, check bearings
Damaged shaft.	Replace shaft.
Defective hose.	Replace hose.
Loose hose connection.	Tighten connections.
(2) Overheating.	
Pump not functioning.	Check impeller. Repair or replace pump.
Lack of water.	Refill system.

26. REMOVAL OF WATER PUMP.

Pliers
Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.

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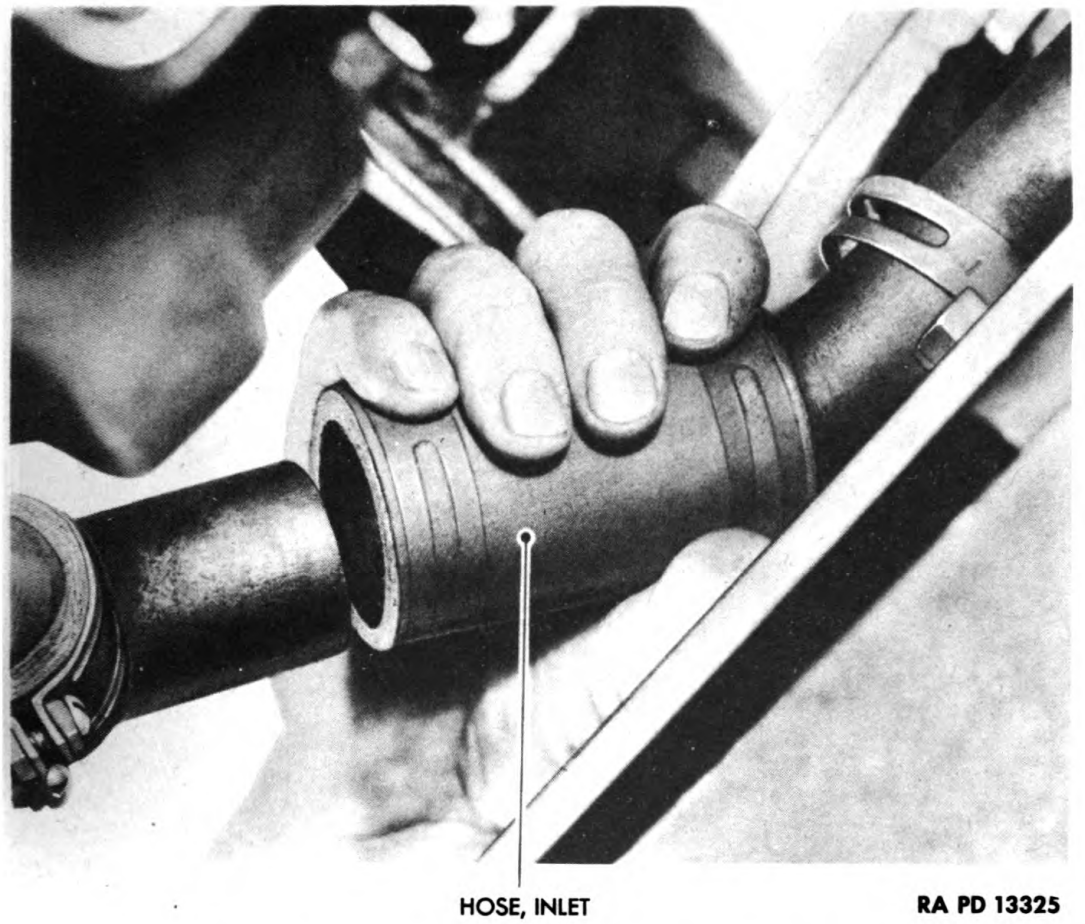


Figure 29—Removal of Lower Radiator Hose Connection

a. Drain Cooling System.

Pliers

Drain the cooling system by opening drain cocks under the radiator and at the left rear side of the engine block.

b. Remove Hose.

Screwdriver

Free the hose clamps and remove, from the water pump, the lower radiator hose connection (figs. 28 and 29), thermostat bypass lower hose connection (fig. 28), and lower heater hose (fig. 30).

c. Remove Pump.

Wrench, open-end, $\frac{9}{16}$-in.

Remove four mounting flange cap screws and lock washers at the front of the pump assembly (fig. 28). Also remove two cap screws and lock washers at the water connection at the side of the cylinder block. Pull

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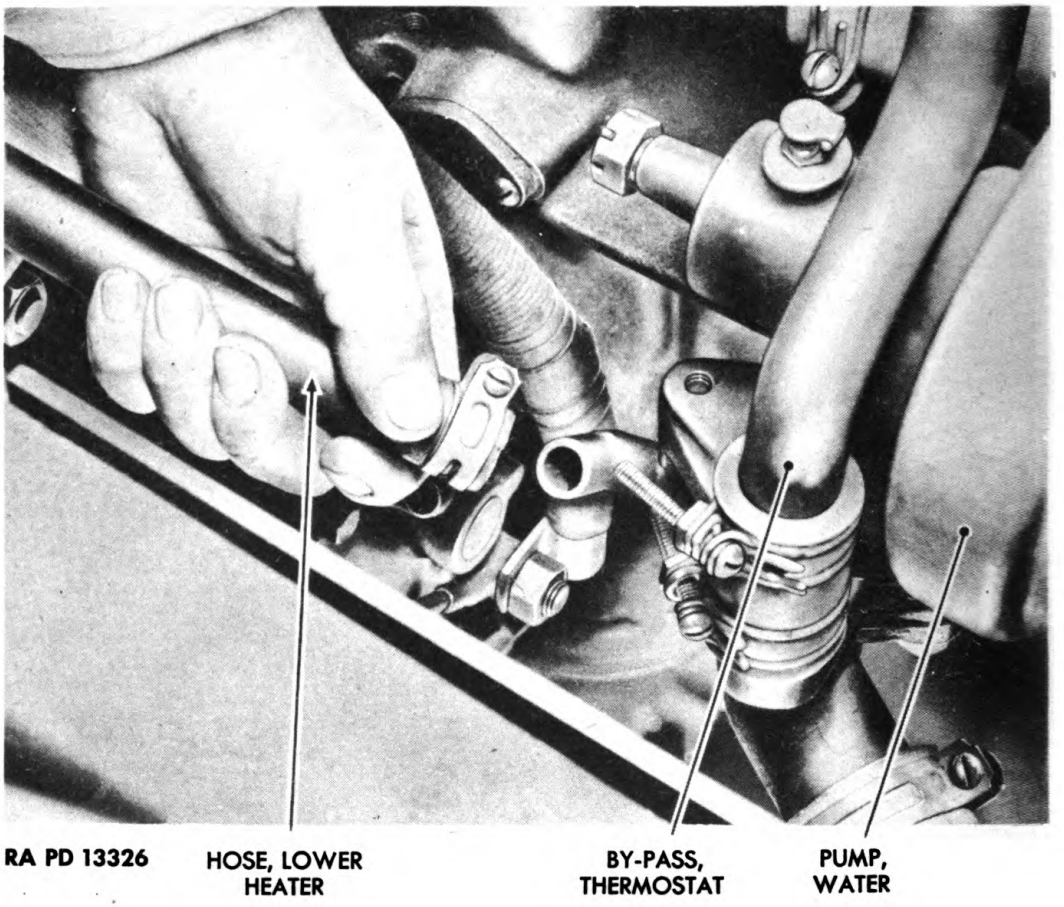


Figure 30—Disconnecting Lower Heater Hose

the water pump directly toward the rear of the engine (fig. 31) and remove the pump and two gaskets—one gasket from each connection.

27. WATER PUMP DISASSEMBLY.

Hammer
Pliers
Press, arbor
Punch, pin
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

a. Remove Castle Nut.

Pliers
Wrench, open-end, $\frac{3}{4}$-in.

Remove cotter pin from the castle nut on the rear end of the water pump shaft. Remove the castle nut (fig. 32).

b. Separate Pump Body from Cover.

Wrench, open-end, $\frac{9}{16}$-in.

Remove four cap screws and lock washers which fasten the pump body and cover together (fig. 32). Pull the body, shaft and impeller assembly from the pump cover.

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COOLING SYSTEM

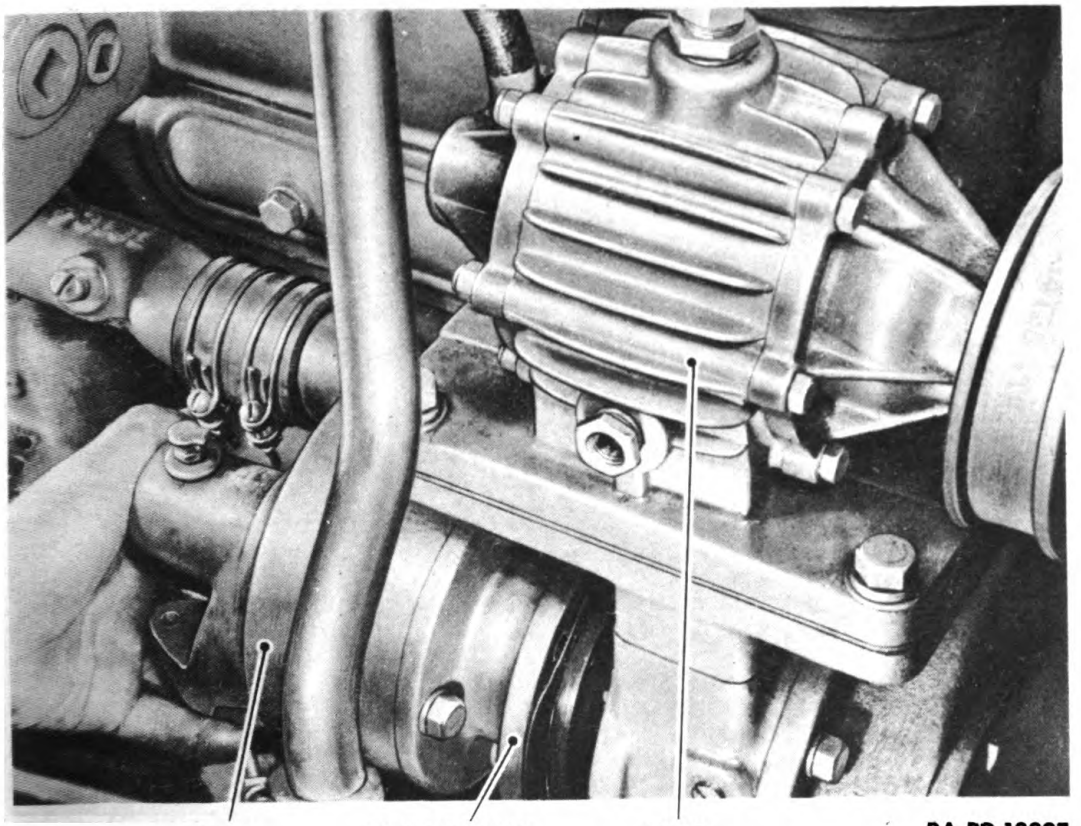


Figure 31—Removal of Water Pump

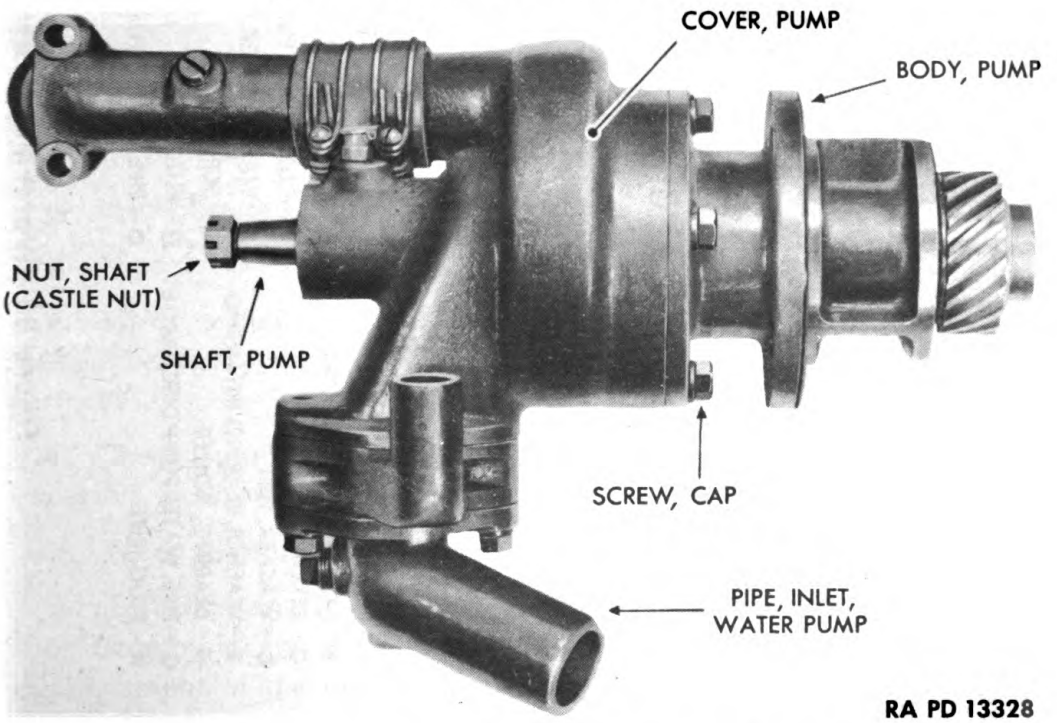


Figure 32—Water Pump Assembly

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

A – PIN, COTTER
B – NUT, SHAFT (CASTLE NUT)
C – RETAINER, FELT
D – WASHER, FELT
E – WASHER, BEARING RETAINING
F – BEARING, ROLLER
G – PIPE, WATER PUMP DISCHARGE
H – PLUG, PIPE
I – HOSE
J – CLAMP, HOSE
K – CUP, WATER PUMP OIL
L – WASHER, LOCK
M – SCREW, CAP
N – PLUG, PIPE
O – PIPE, WATER PUMP INLET
P – COVER, PUMP
Q – GASKET (COVER TO BODY)
R – CUP, SEAL RETAINING
S – SEAL, CARBON
T – SEAL, RUBBER
U – RING, SEAL CLAMP
V – RING, SEAL CLAMP
W – SPRING, SEAL
X – SHAFT, PUMP
Y – IMPELLER
Z – BODY, PUMP
AA – GEAR, DRIVE
BB – WASHER, LOCK
CC – SCREW, CAP
DD – PIN, IMPELLER

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Figure 33—Water Pump Assembly—Partially Exploded View

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c. Remove Rear Water Seal and Impeller Pin.

Hammer — Punch, pin

Remove rear water seal assembly consisting of the carbon and rubber seals, seal clamp rings and seal spring. Remove the impeller pin with a pin punch and hammer (fig. 33).

d. Remove Impeller.

Press, arbor

Place the body, shaft and impeller assembly in an arbor press and remove the impeller and front water seal assemblies.

e. Remove Pump Shaft. Remove the pump shaft from the pump body (fig. 33). Remove the thrust washer from the pump shaft.

f. Remove Pump Drive Gear.

Pliers — Press, arbor

Place the pump shaft in an arbor press and remove the pump drive gear from the shaft. Remove the Woodruff key with pliers. If it is necessary to replace the bushing in the pump body, place the body in the arbor press and remove bushing.

g. Remove Roller Bearing. Remove the felt retainer and washer, bearing retaining washer and the roller bearing from the pump cover (fig. 33).

28. WATER PUMP MAINTENANCE.

a. Clean and inspect all parts before reassembly.

b. Inspect bushing at the timing gear end and bearing at the water inlet end of the pump for excessive wear. If damaged, replace.

c. Inspect pump shaft. If badly scored or worn, replace shaft.

d. If packless seals are damaged, replace them.

e. Make certain that the thrust surfaces against which the carbon washer bears are clean and smooth to prevent leakage between the two surfaces

f. Check pump drive gear teeth. If there is indication of fracture or excessive wear, replace the gear.

g. When reassembling, use a new gasket between cover and body.

h. Lubrication. The bushing in the pump at the timing gear end is lubricated by means of an oil passage which communicates with the gear compartment of the engine. The bearing at the water inlet end of the pump must be lubricated once a week through oiler provided on the housing. Use engine oil—never use grease.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

29. ASSEMBLY OF WATER PUMP.

Hammer — Press, arbor
Pliers — Wrench, open-end, ¾-in.

a. Press Drive Gear on Shaft.

Press, arbor

Place Woodruff key in pump shaft and press on the pump drive gear.

b. Install Pump Shaft in Pump Body. Place the thrust washer in position on the pump shaft behind the gear and install the pump shaft in the pump body.

c. Install Water Seal Assemblies and Impeller.

Hammer — Press, arbor

Place the pump body and shaft in an arbor press and install the front and rear water seal assemblies, consisting of carbon and rubber seals, seal clamp rings, seal springs, and the impeller. Fasten the impeller in position by driving in a new pin.

d. Install Body Assembly in Pump Cover.

Wrench, open-end, $\frac{9}{16}$-in.

Insert the shaft and impeller end of the body assembly into the pump cover, placing a new gasket between body and cover. Fasten them together with the four cap screws and lock washers.

e. Install Bearing, Washer and Oil Seal. Place the roller bearing, bearing retaining washer, felt retainer and washer in the pump cover.

f. Install Castle Nut.

Pliers — Wrench, open-end, ¾-in.

Screw the castle nut on the pump shaft. Insert a new cotter pin to lock the castle nut in place.

30. INSTALLATION OF WATER PUMP.

Screwdriver — Wrench, open-end, $\frac{9}{16}$-in.

a. Install Pump Assembly.

Wrench, open-end, $\frac{9}{16}$-in.

Using a new gasket at each connection, place the pump in position on the engine. Install four mounting flange cap screws and lock washers at the front of the pump assembly (fig. 28). Also install two cap screws and lock washers at the water connection at the side of the cylinder block.

b. Install Hose.

Screwdriver

Install the lower radiator hose, thermostat bypass lower hose, and lower heater hose and tighten the clamps.

c. Lubrication. See paragraph 28 h.

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d. Refill the Cooling System.

Pliers

Check to see that drain cocks are closed and refill the cooling system with water or antifreeze solution.

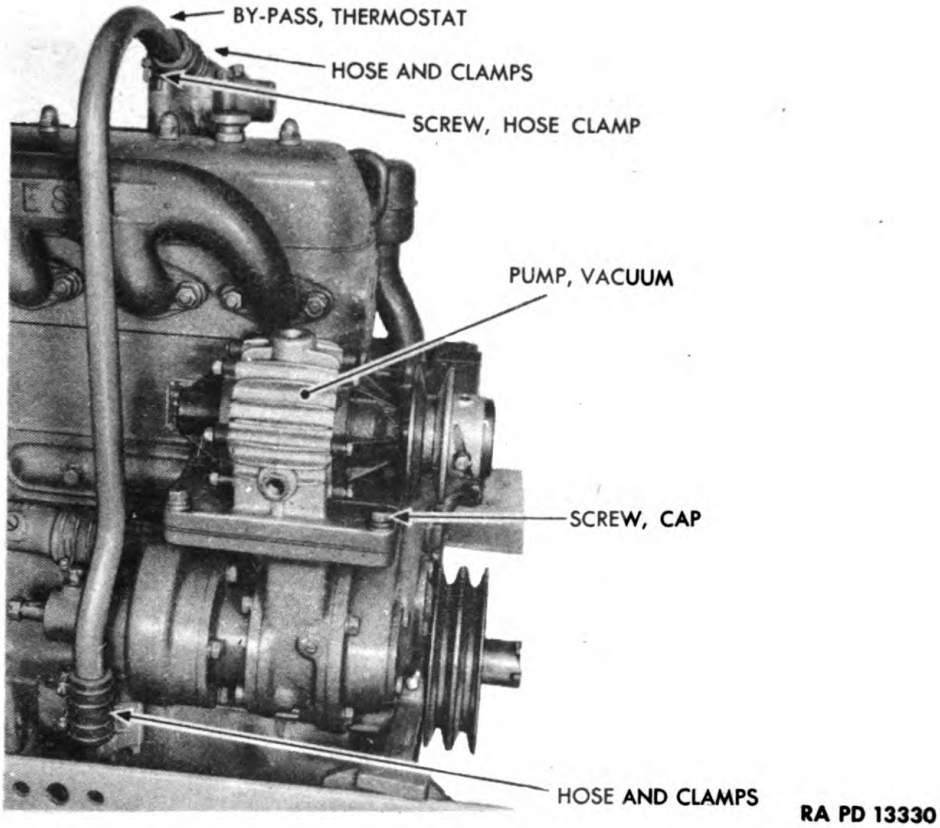


Figure 34—Thermostat Bypass and Hose Connections

31. THERMOSTAT.

a. Description and Functioning (fig. 34). A bellows-type thermostat is located in a housing at the forward end of the water outlet manifold. A bypass extends from the thermostat to the water pump. The thermostat aids in shortening the engine warming up period and in maintaining even engine operating temperatures. During the warming up period and when the engine temperature is below normal, the thermostat valve stops the flow of warm water from engine to radiator and diverts the water through the bypass back to the water pump. When engine operating temperature reaches normal, the thermostat valve opens and permits circulation of warm water from the engine to the radiator for cooling.

b. Removal.

Pliers
Screwdriver
Wrench, socket, $\frac{9}{16}$-in.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

(1) DRAIN COOLING SYSTEM.

Pliers

Partially drain the cooling system to lower the fluid level in the radiator below the level in the water outlet manifold.

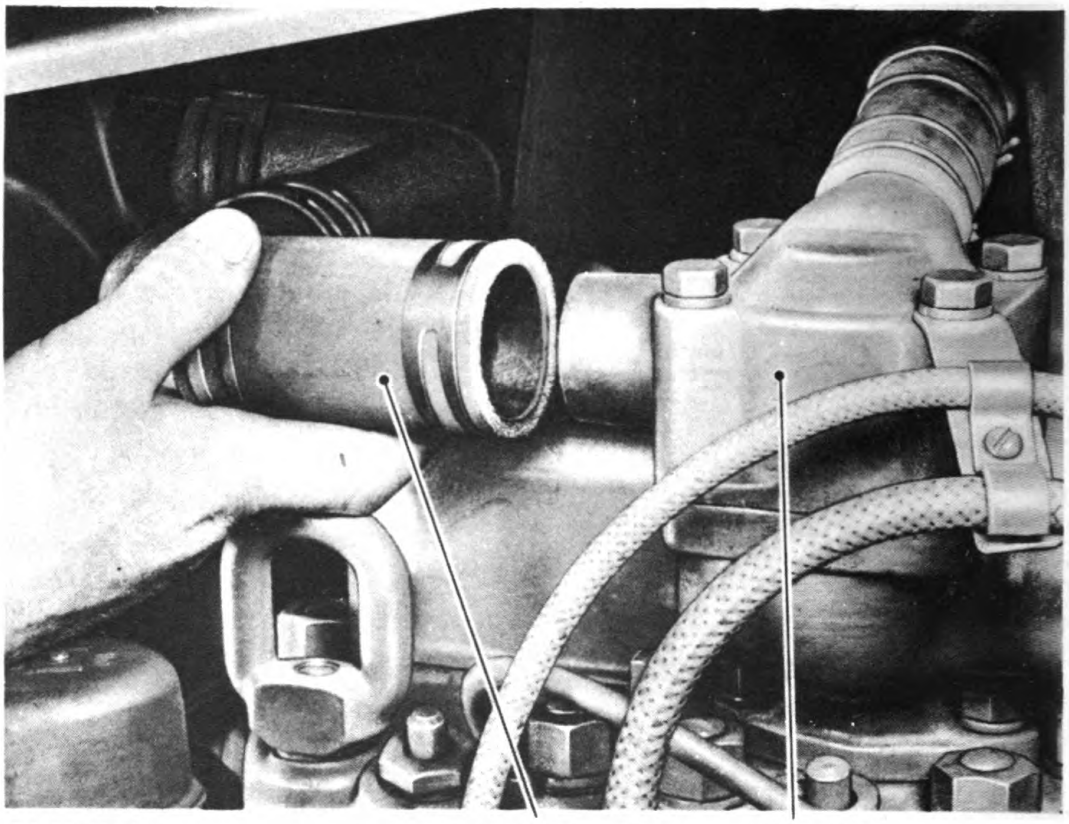


Figure 35—Disconnecting Upper Radiator Hose Connection

(2) DISCONNECT HOSES.

Screwdriver

Loosen the hose clamps and slide back the thermostat bypass hose connection (fig. 34) and the upper radiator hose connection (fig. 35).

(3) REMOVE THERMOSTAT.

Wrench, socket, $\frac{9}{16}$-in.

Remove the four cap screws and lock washers which attach the thermostat housing to the water outlet manifold (fig. 35). Raise the thermostat housing and lift out the thermostat (fig. 36).

(4) TESTING THERMOSTAT. Place thermostat in a vessel of water at room temperature and gradually heat the water, meanwhile observing temperature with a thermometer. Thermostat should open at around 160 F

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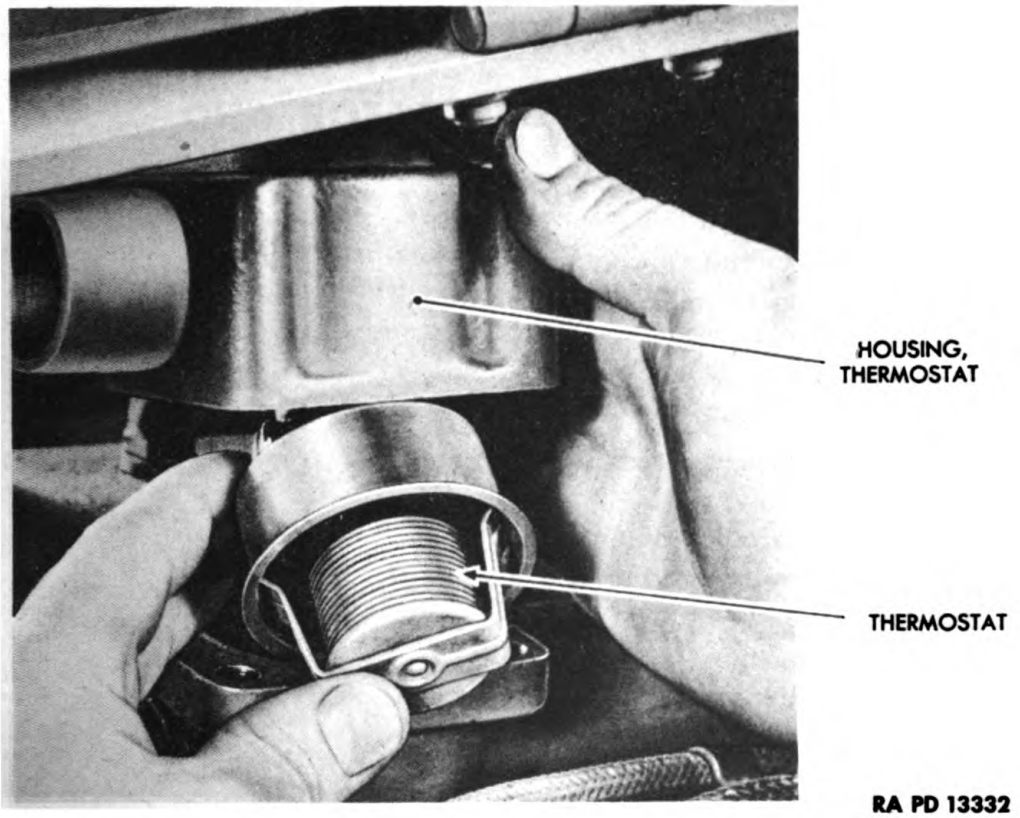


Figure 36—Removal of Thermostat

to operate correctly. If it does not open by the time it has reached 180 F it should be discarded.

c. Installation.

Screwdriver
Wrench, socket, $\frac{9}{16}$-in.

(1) INSTALL NEW GASKET. Place a new gasket between the thermostat housing and water outlet manifold (fig. 35).

(2) INSTALL THERMOSTAT.

Wrench, socket, $\frac{9}{16}$-in.

Place the thermostat in position (fig. 36). Install the thermostat housing on the water outlet manifold and insert and tighten four cap screws and lock washers (fig. 35).

(3) INSTALL HOSES.

Screwdriver.

Slide the hoses over the thermostat housing hose connections and tighten the hose clamps (fig. 34).

(4) REFILL COOLING SYSTEM. Be sure all water drain cocks are closed and refill the cooling system.

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Section VII

ELECTRICAL—GENERATOR AND VOLTAGE REGULATOR

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32. DESCRIPTION OF CIRCUIT.

The generator is a 12-volt, 4-brush, 4-pole heavy-duty type. It is located on the left side of the engine and is driven by V-belts. The regulator consists of a cut-out relay, a voltage regulating coil and a current regulating coil. Each unit controls a pair of contacts, located between the battery and the field and armature coils of the generator. These contacts automatically connect and disconnect the battery in circuit with the generator when charging; and keep the generator voltage and current within rated limits.

33. TROUBLE SHOOTING FOR CIRCUIT.

Symptom and probable cause	Probable remedy
a. Low or No Generator Output.	
Dry battery.	Refill cells.
Poor battery condition.	Replace battery.
Fully charged battery.	None (check output when battery is slightly discharged).
Loose connections.	Tighten.
Dirty connections.	Clean and tighten.
Burned contacts on regulator units.	Clean or replace contacts.

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Symptom and probable cause	Probable remedy
Grounded armature wires or terminal posts.	Replace wires, insulate terminals.
b. High Generator Output.	
Faulty regulator.	Check regulator.
Discharged or low body.	Check condition of battery and charge if necessary.
c. High Discharge On Ammeter.	
Regulator circuit breaker closed while generator is not operating.	Repair and adjust circuit breaker. Check generator for damage.
Reverse polarity.	Change polarity.

34. GENERATOR DESCRIPTION AND TROUBLE SHOOTING.

a. Description (fig. 37). The Autolite Model GDJ-4809A and 4809B generator is a 12-volt, d-c, shunt wound, 4-brush heavy-duty type. It is air-cooled by a fan which is part of the drive pulley assembly. Air is drawn in the generator from the commutator end, cooling the field and armature, and passes through the fan blades on the drive end.

(1) CONSTRUCTION. The generator is similar in construction to all heavy-duty truck units. The four field coils are held in position inside the hollow cylinder frame by the four pole shoes each of which is fastened to the frame by two screws. The armature is supported in position by roller bearings mounted in the two end heads. Brush holders are secured to the commutator end head and carry brushes which are kept in contact with the commutator by means of springs mounted on the holders. The armature shaft extends through the drive end head and a pulley and fan assembly is mounted on the extended part of the shaft. The fan cools the generator during operation by circulating air through the end head openings. The internal leads are connected to the insulated terminals mounted on the frame and field assembly. The coils in the armature are connected in parallel, and cannot be tested in a growler as ordinary armatures (fig. 59).

(2) FUNCTIONING. Refer to paragraph 40, a, (2), *(a)*.

b. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) NOISE AT ENGINE IDLE SPEED.	
Broken bearing.	Replace.
Dry generator bearing.	Oil the bearing.
Loose pulley.	Tighten.
Loose pole piece.	Tighten.
Commutator damaged.	Repair or replace.
Bent armature shaft.	Replace.

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Figure 37—Generator

Symptom and probable cause	Probable remedy
(2) LOW CURRENT OR NO CURRENT.	
Fully charged battery.	Check condition of battery. A fully charged battery will cause generator output to drop to very near zero reading.
Open circuit in brush connections.	Check and repair.
Brush sticking in holder.	Loosen and place on commutator.
Open circuit due to worn brush.	Replace brush.
Open circuit due to broken brush spring.	Replace spring.
Open circuit due to dirty commutator.	Clean commutator.
Open circuit in field coil.	Replace coil.
Short circuit or ground in commutator.	Repair or replace.

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Symptom and probable cause	Probable remedy
Short circuit or ground in armature.	Repair or replace.
Short circuit or ground at main terminal.	Repair or replace.
Short circuit or ground in brush connections.	Repair or replace.
Short circuit or ground in brush holders.	Repair or replace.

(3) BLUE SPARKING AT COMMUTATOR.

Flatted bars.	Turn down commutator.
Weak brush spring.	Replace brush spring.
Open circuit in armature.	Repair or replace.
Generator overcharging.	Check regulator.

(4) EXCESSIVE HEATING OF ARMATURE.

Ground or short circuit in armature.	Repair or replace.

(5) GENERATOR HOT OR BURNED OUT.

Circuit breaker open.	Repair and adjust circuit breaker. Test and repair or replace generator.

(6) BATTERY DISCHARGED AND GENERATOR INSULATION DAMAGED.

Circuit breaker closed.	Repair and adjust circuit breaker and repair or replace generator. Recharge battery.

35. REMOVAL OF GENERATOR.

Pliers	Wrench, open-end, 7/8-in.
Screwdriver	Wrench, socket, 9/16-in.
Wrench, open-end, 5/8-in.	Wrench, socket, 3/8-in. with 1/4-in. drive.
Wrench, open-end, 3/4-in.	

a. Disconnect the Armature Terminal.

Pliers	Wrench, socket, 9/16-in.

Using pliers, unscrew the condenser from the armature terminal (fig. 38). (This is the larger terminal.) Unscrew the coupling nut (fig. 39), then remove the nut which holds the wire to the terminal (fig. 40). Remove the wire from the generator terminal.

b. Disconnect Field Terminal.

Screwdriver	Wrench, socket, 3/8-in. with 1/4-in. drive
Wrench, open-end, 5/8-in.	

Remove the plug from the field terminal (fig. 41). (This is the smaller

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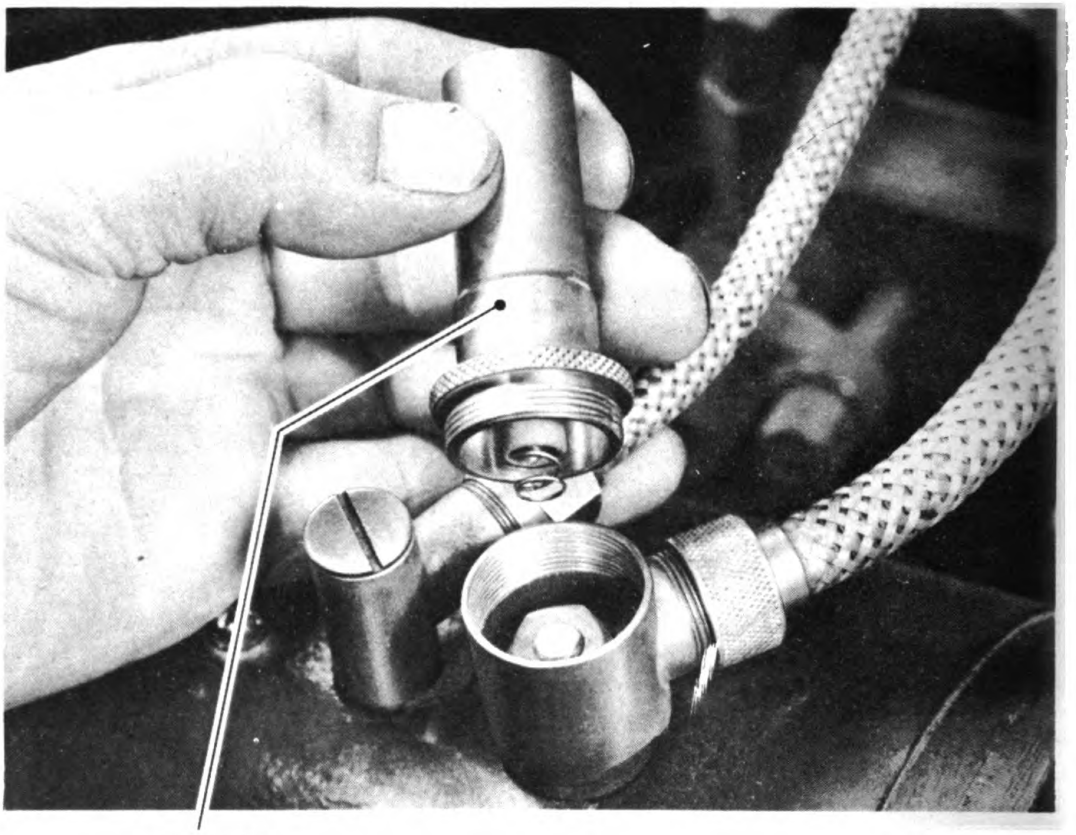


Figure 38—Removing Condenser from Armature Terminal

terminal.) Then, using a special ¼-inch drive with a ⅜-inch socket, remove the nut which holds the lead to the field terminal (fig. 42). Use a ⅝-inch open-end wrench, unscrew the coupling nut and remove the field terminal wire (fig. 43).

c. Loosen and Remove the Generator Belts.

Wrench, open-end, ¾-in.

Remove the bolt, nut and lock washer from the generator adjusting strap, then loosen the strap at the fan base assembly, and move out of the way. Loosen, but do not remove, the bolts on the generator base (fig. 44) and rotate the generator toward the engine. Slip the generator belts off the generator pulley (fig. 45).

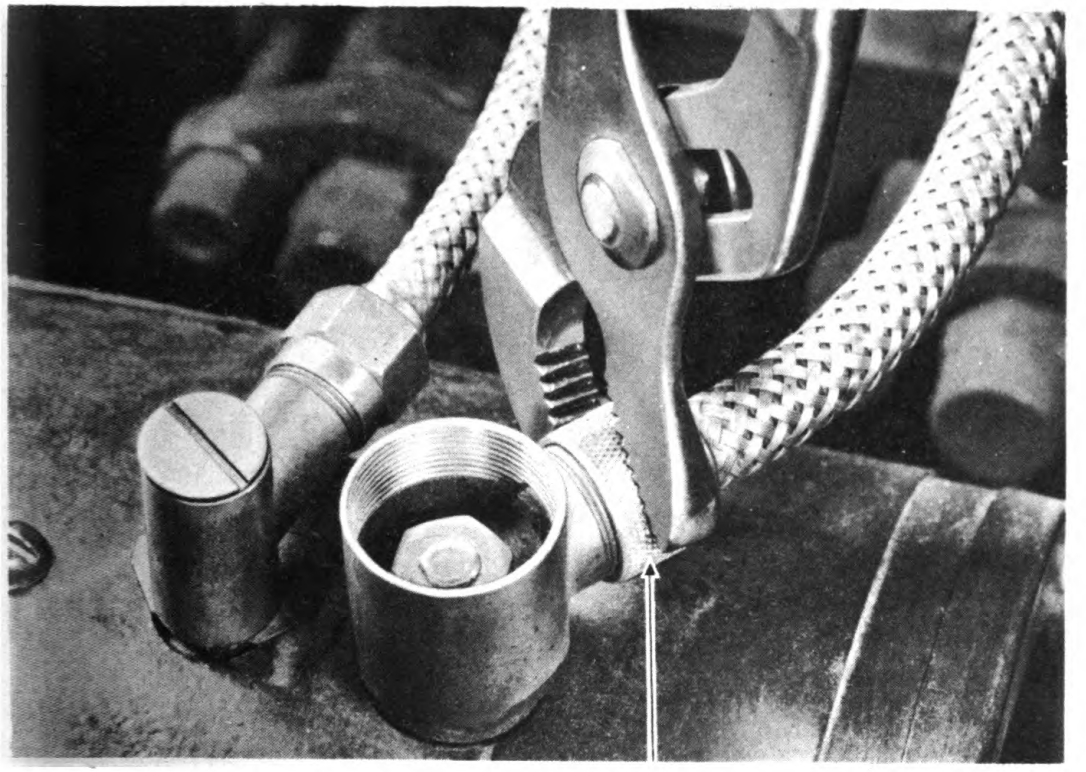
d. Remove Generator from Generator Support.

Wrench, open-end, ¾-in. Wrench, open-end, ⅞-in.

Swing the generator away from the engine block and rest it on the frame. Remove the two nuts, lock washers and bolts that hold the generator to the generator base (fig. 44). Lift out the generator.

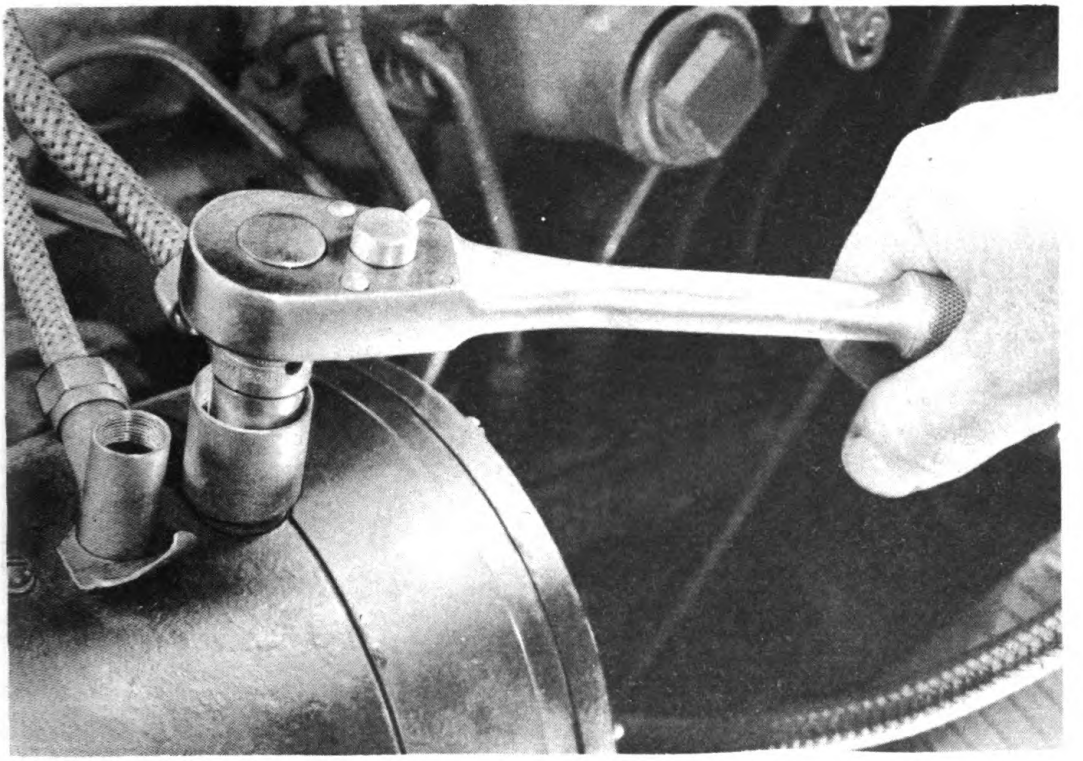
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ELECTRICAL—GENERATOR AND VOLTAGE REGULATOR



COUPLING NUT RA PD 13142

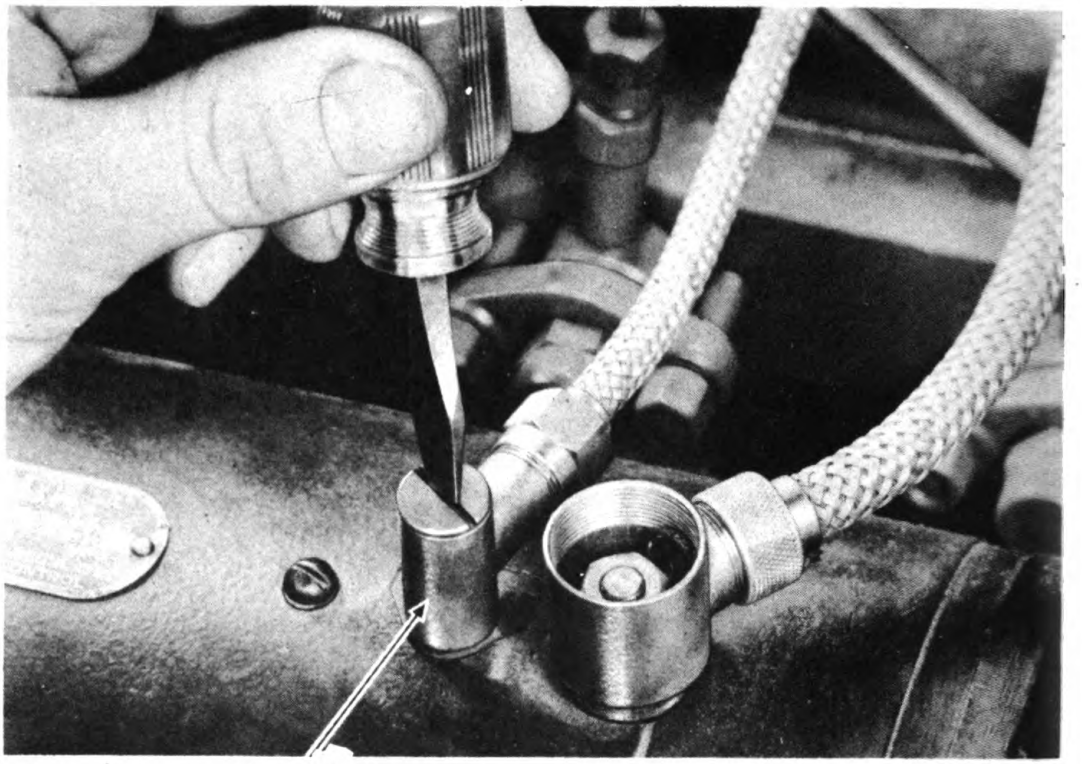
Figure 39—Removing Coupling Nut from Armature Terminal



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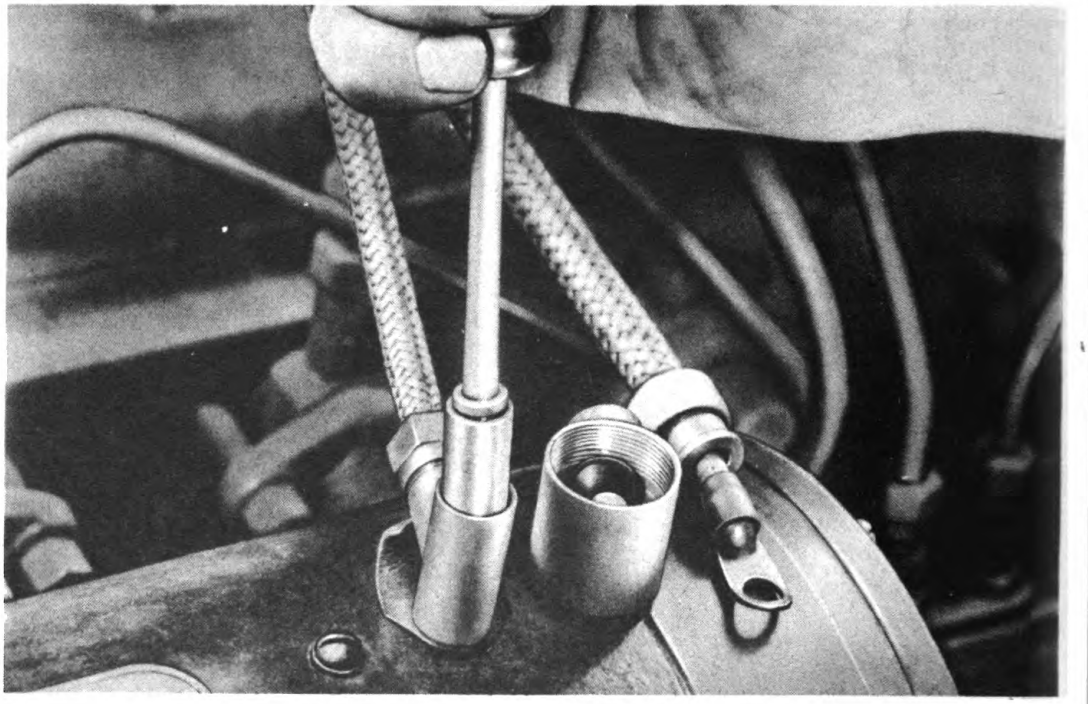
Figure 40—Removing Armature Terminal

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Figure 41—Removing Plug from Field Terminal



RA PD 13145

Figure 42—Disconnecting Generator Field Terminal

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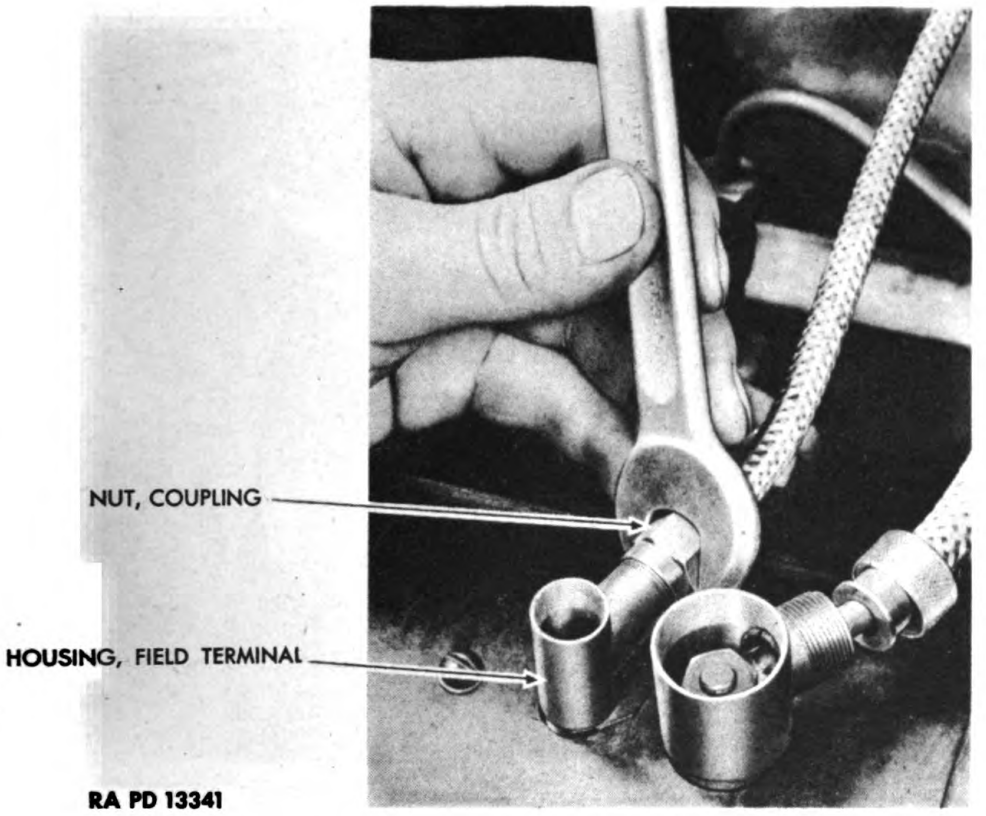


Figure 43—Removing Coupling Nut on Field Terminal

36. GENERATOR DISASSEMBLY.

Drift, soft metal
Hammer
Puller, gear, 7-in. spread
Punch, small
Screwdriver
Wrench, open-end, $\frac{15}{16}$-in.

a. Remove Generator Pulley.

Puller, gear, 7-in. spread
Wrench, open-end, $\frac{15}{16}$-in.

Remove the nut, special lock washer and plain washer from the pulley end of the generator shaft (fig. 46). Remove the drive pulley from the shaft (gear puller with 7-inch spread).

b. Remove End Head from Shaft.

Screwdriver

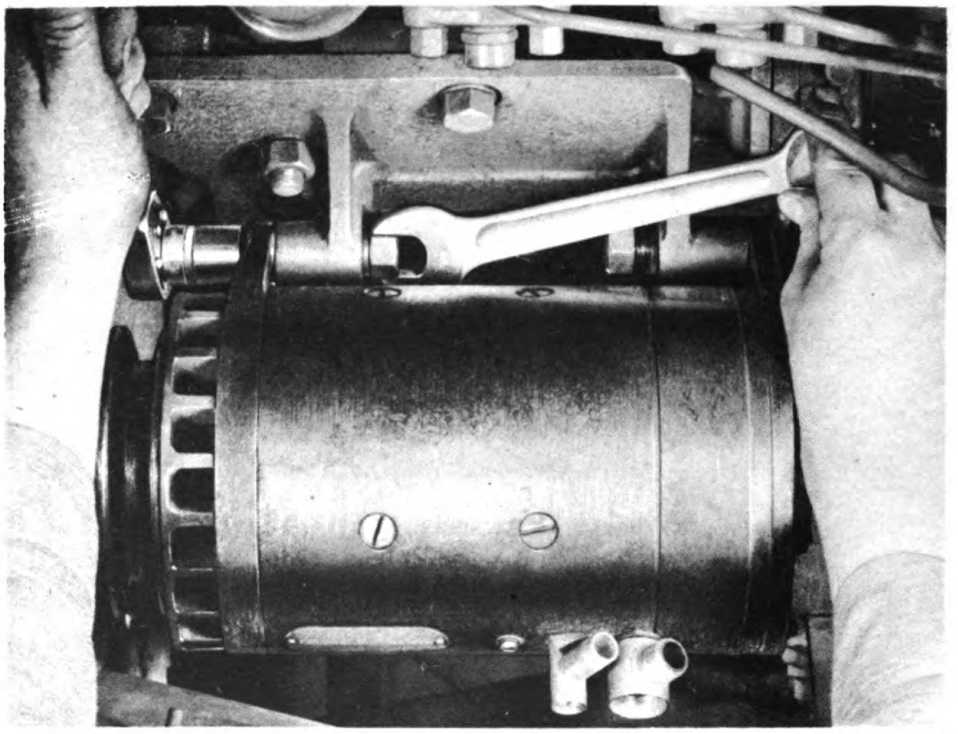
Punch mark the drive head, frame and field assembly to facilitate correct assembly. Remove the six fillister head screws and lock washers from the drive end head (fig. 46). Pull the end head from the shaft.

c. Remove Bearing Retainer.

Hammer
Punch, small
Screwdriver

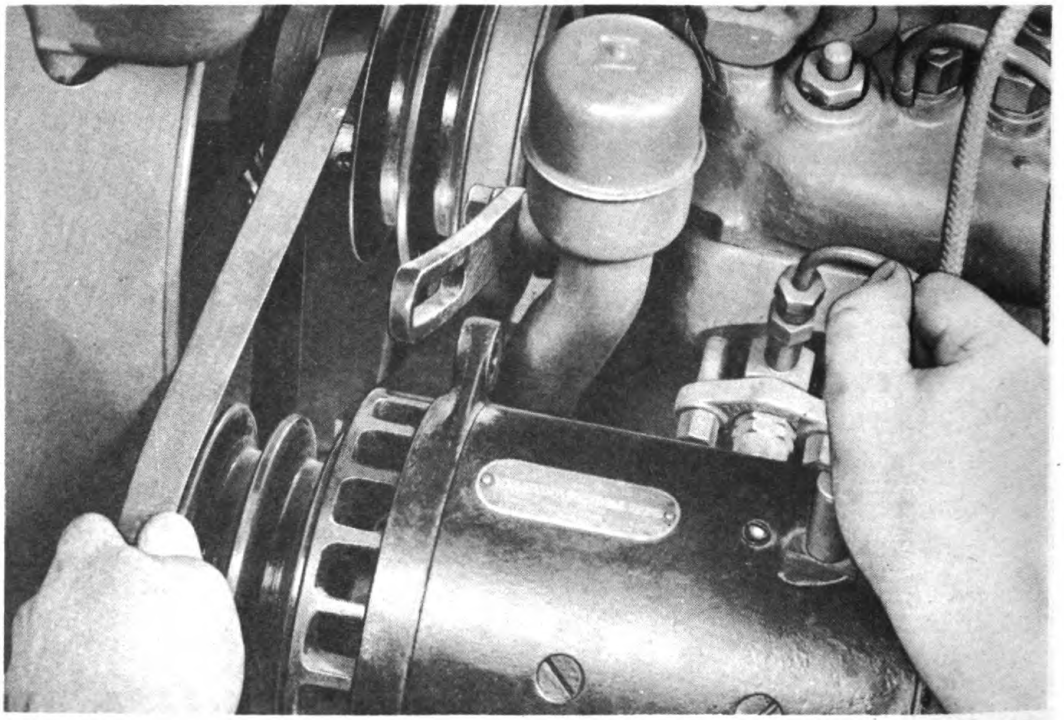
Remove the four fillister head screws and lock washers which hold the

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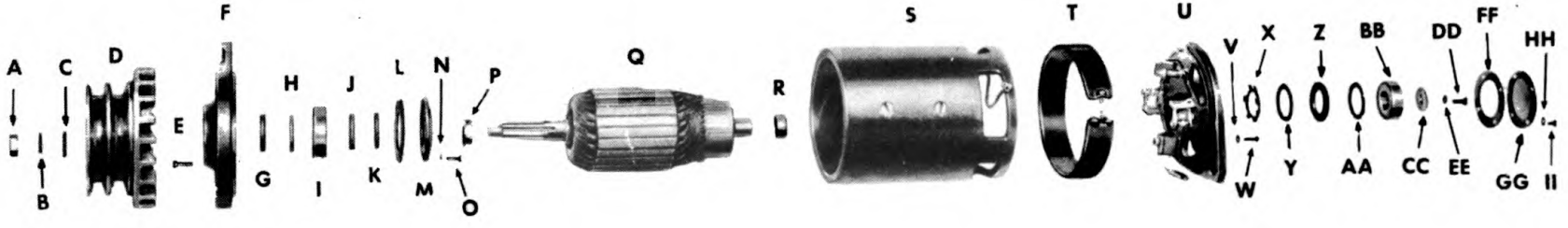
Figure 44—Removing Generator Bracket Holding Bolts



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Figure 45—Removing Belts from Generator Fan Pulley

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A – NUT, SHAFT
B – WASHER, LOCK
C – WASHER, PLAIN
D – PULLEY, DRIVE
E – SCREW, FILLISTER HEAD
F – HEAD, DRIVE END
G – WASHER, FELT
H – RETAINER, FELT
I – BEARING, BALL
J – RETAINER, FELT
K – WASHER, FELT,
L – GASKET
M – RETAINER, BEARING
N – WASHER, LOCK
O – SCREW, FILLISTER HEAD
P – SPACER
Q – ARMATURE AND SHAFT
R – SPACER
S – FRAME AND FIELD
T – BAND, HEAD
U – PLATE, COMMUTATOR END ASSEMBLY
V – WASHER, LOCK
W – SCREW, FILLISTER HEAD
X – WASHER, SPRING
Y – RETAINER, FELT WASHER
Z – WASHER, FELT
AA – RETAINER, FELT WASHER
BB – BEARING, BALL
CC – WASHER, BEARING RETAINER
DD – SCREW, BEARING RETAINER
EE – WASHER, LOCK
FF – GASKET
GG – COVER, COMMUTATOR END CAP
HH – WASHER, LOCK
II – SCREWS, FILLISTER HEAD

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Figure 46—Generator Assembly—Partially Exploded View

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bearing retainer in place on the inner side of the drive end head. Lift off the bearing retainer and gasket. Remove the felt washer and retainer from the bearing retainer with a small punch and hammer (fig. 46).

d. Remove Bearing and Retainer from Drive End Head.

Hammer Punch, small

Remove the bearing from the drive end head with a small punch and hammer. Be careful not to damage the bearing by striking too hard. Remove the felt washer and retainer from the drive end head in the same manner. Slide the spacer off the armature shaft (fig. 46).

e. Remove Head Band.

Screwdriver

Loosen the clamp screw on the head band and remove the head band (fig. 46).

f. Remove Commutator End Head Cover.

Screwdriver

Remove the four fillister head screws and lock washers which hold the commutator end head cover to the commutator end plate assembly (fig. 46). Pull off the end head cover and paper gasket.

g. Remove Bearing Retainer Washer.

Screwdriver

Remove the screw and lock washer which hold the bearing retainer washer in place on the shaft. Remove the retainer washer.

h. Remove Armature from End Plate.

Drift, soft metal Hammer

Drive the armature from the end plate with a ½-inch soft metal drift and hammer. Slide the spacer from the commutator end of the armature shaft (fig. 46).

i. Remove Brush Holder Leads.

Screwdriver

Reach down through the brush openings in the frame and field and remove the three leads from the brush holders (fig. 46).

j. Mark Commutator End Head and Generator Frame. Punch mark the commutator end plate and the generator frame so that they can be put back together in the same position.

k. Remove Commutator End Head Assembly.

Screwdriver

Remove six fillister head screws and lock washers from the commutator end plate assembly with a screwdriver. Remove the commutator end plate assembly from the generator frame and field. Brush holders and brushes will come off with the end plate (fig. 46).

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ELECTRICAL—GENERATOR AND VOLTAGE REGULATOR

l. Remove Ball Bearing from Commutator End Plate.

Hammer Punch, small

Remove the ball bearing from the commutator end plate with a small punch and hammer. Be careful not to damage the bearing by striking too hard. Remove from the end plate the felt washer retainer, felt washer, felt washer retainer and spring washer in the order named (fig. 46).

m. Remove Brushes and Holders.

Screwdriver

Unscrew four round head machine screws with lock washers at terminals of brush leads and slip brushes out of holders. Pull brush holders and springs off pivot studs.

n. Remove Pole Shoes.

Wrench, screwdriver socket, $\frac{9}{16}$-in. face

Remove flat head machine screws holding poles to frame and field assembly and remove pole shoes.

o. Remove Field Coils.

Wrench, thin socket, $\frac{7}{16}$-in.

Remove hex nuts, lock washers, terminal shield housing, plain washer and insulating washer from generator frame stud terminal post. Dismount post from frame and field assembly and remove field coils. Push post out of field coil terminal by hand. Remove terminal insulator and bushing.

p. Remove Armature Terminal Post.

Wrench, open-end, $\frac{9}{16}$-in.

Remove hex nuts, lock washers, shield housing, plain washer and insulating washers from armature terminal post. Remove post, two large pieces of insulation, and insulating bushing. Remove generator main brush control lead assembly.

37. GENERATOR MAINTENANCE AND ADJUSTMENTS.

a. The external circuit must be kept in good condition. Defective wiring, loose or corroded connections at the batteries, cranking motor, ammeter, and elsewhere in the circuit, must be checked for and eliminated when found. Loose or corroded connections in the charging circuit will cause high voltage which would result in injury to the generator and regulator, as well as shorten battery and light bulb life. Poor connections in the field circuit will cause a low generator output. Use resin flux in making all soldered connections. Never use an acid flux on electrical connections.

b. Lubrication. Ball bearings at both ends of the armature are packed half full with heat resisting grease, but should be given a few drops of engine oil every 1,000 miles.

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c. Commutator.

(1) If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper. CAUTION: Never use emery cloth to clean the commutator. All dust must be blown from the generator after the commutator has been cleaned.

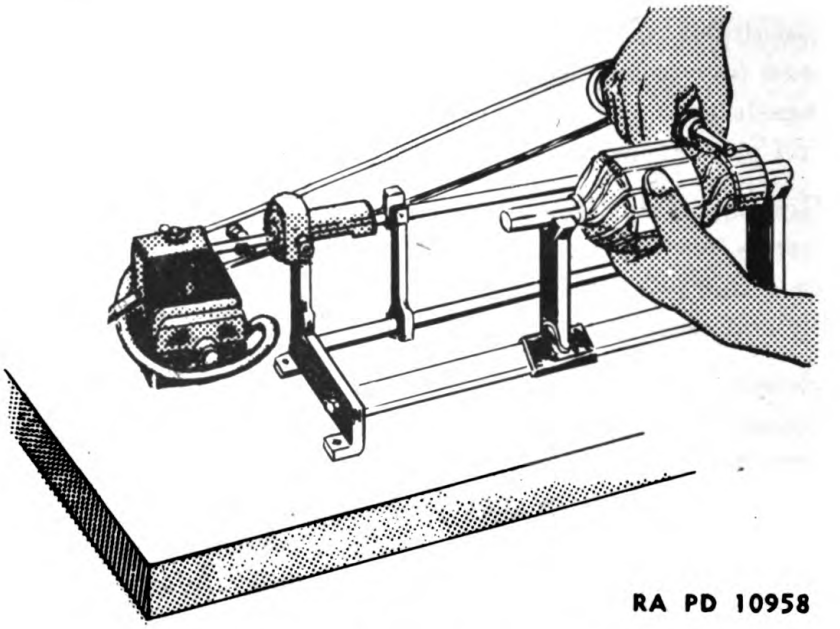


Figure 47—Undercutting Armature Commutator

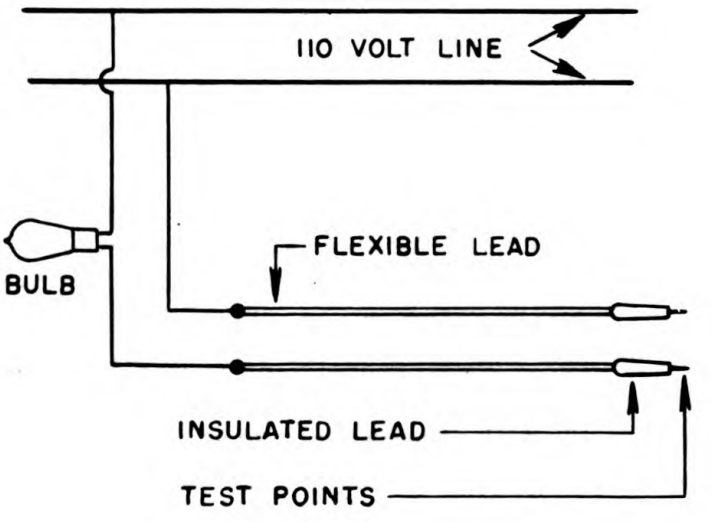


Figure 48—Test Point Assembly

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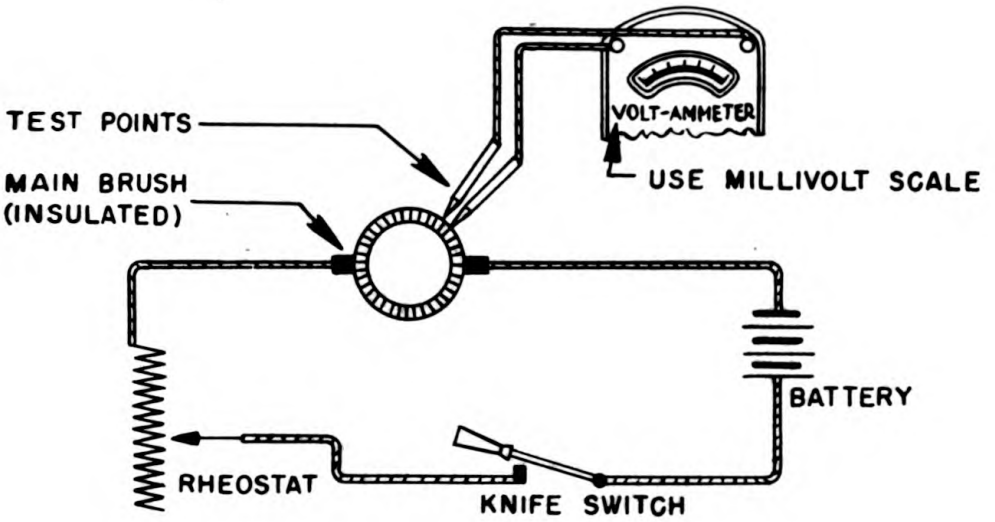


Figure 49—Armature Open Circuit Test

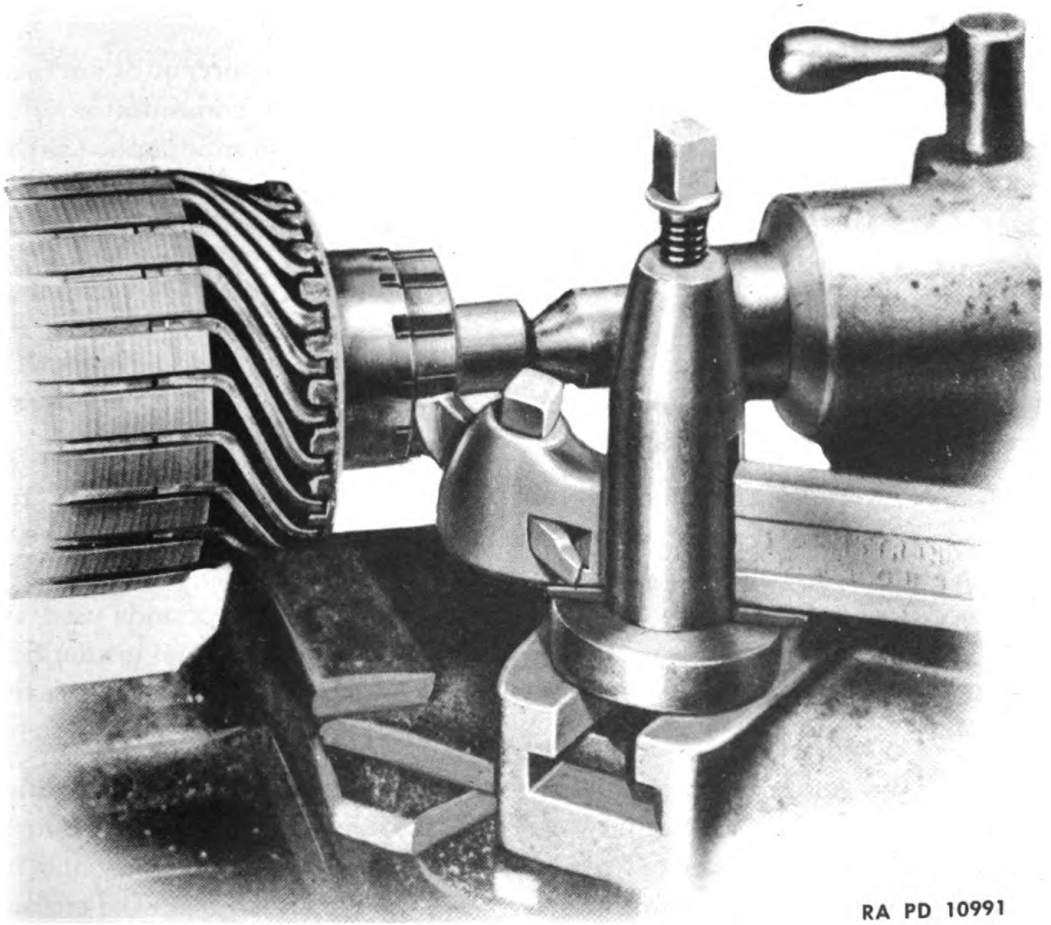


Figure 50—Turning Commutator

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(2) If the commutator is rough, out of round or has high mica, remove the generator from the engine and disassemble the armature from the generator. Turn the commutator down in a lathe, removing only sufficient material to true up the commutator and remove roughness and high mica. Undercut the mica (fig. 47). The commutator should be inspected at least every 10,000 miles.

d. Brushes.

(1) Check the brush spring tension by hooking a scale in a hole at the end of the brush arm and take reading as the arm leaves the brush. Spring tension should be from 71 ounces to 76 ounces. Excessive spring tension will cause the commutator and brushes to wear rapidly. Low spring tension will cause a reduced generator output, arcing and burning of the commutator and brushes.

(2) Check the lead connections at the brushes to see that they are tight. A poor connection in the charging circuit will cause the generator to build up excessive voltage, which may result in burned field or armature windings. A poor connection in the generator field circuit will cause a low output.

(3) Replace brushes if worn. Brushes must have 90 percent of surface in contact with commutator. To seat the brushes, clean commutator with a bedding stone. Then wrap a piece of No. 00 or No. 000 sandpaper (same width as commutator) around the commutator, sanded face against brushes. Turn the commutator clockwise from drive end until brushes seat properly. Blow the generator out with compressed air to remove all particles of abrasive. Never use emery cloth to seat brushes.

e. Check V-belt tension and tighten if necessary. Low belt tension will cause a reduced and unsteady output. Excessive belt tension will cause rapid belt and bearing wear. Replace the belt if it is frayed or worn.

f. At intervals of approximately 25,000 miles, depending upon the type of operations, the generator should be removed from the engine and completely disassembled. All parts should be cleaned. Do not clean the armature or fields in any degreasing tank, since the compounds used in this type cleaner may cause damage to rubber, mica, or enamel insulation. Ball bearings should be thoroughly cleaned and repacked with lubricant. All worn parts should be replaced.

g. If the generator is not performing according to specifications, and it has been checked and found to be at fault, remove the cover band and check for sticking brushes. If the brushes are seating satisfactorily and in good contact with the commutator, remove the generator from the engine and make the following tests:

(1) Raise the grounded brushes from the commutator and insulate

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them with a piece of cardboard. Use a set of test points (fig. 48) and check for ground from the armature terminal (fig. 39) to the generator frame. Should the test lamp light, indicating a ground, raise and insulate all brushes and check, in turn, the insulated brush holders, armature commutator, and field coils, to locate the ground. If a grounded field coil is found, check the regulator contact points, since a grounded field may permit a high field current which will cause burned and oxidized points. Repair or replace parts as required.

(2) If the generator does not show grounding, check the field circuit for open circuit by connecting test lamp across field terminals. If test lamp fails to light, test each coil separately to determine faulty coil after generator is disassembled.

(3) If the field is not open, check for shorts by testing the field circuit. Use a battery of the proper voltage and an ammeter, connected in series with the fields. Proceed with care, since a shorted field may draw an excessively high current. If the field current is not within specifications, new field windings will be required. Check the regulator contact points if a shorted field is found, since a shorted field may permit a high field current which will cause burned and oxidized points.

(4) Inspect the commutator bars, since an open circuit in the armature, which would result in a low or no output, will cause the commutator bars connected to the open-circuited coils to burn. As a further check for open circuit, the armature may be removed from the generator and tested by connecting with brushes to a battery. With test points connected to the terminals of a volt-ammeter, slowly rotate the armature, checking between adjacent bars with the test points (fig. 49). Any open circuited coils will cause a full battery voltage reading on the volt-ammeter.

(5) Never operate the generator on open circuit. To do so will allow it to build up a dangerously high voltage which will probably result in a complete generator failure.

h. Service Data.

Brush spring tension	71-76 ounces
End play of armature	0.003 in.—0.010 in. maximum

38. GENERATOR ASSEMBLY.

Belt, fan (or rope)
Screwdriver
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, socket, $1\frac{5}{16}$-in.
Wrench, screwdriver socket, $\frac{9}{16}$-in. face

a. Install Armature Terminal Post.

Wrench, open-end, $\frac{9}{16}$-in.

Place main brush control lead assembly, insulation and insulating

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bushing on post and insert post, from inside, through frame. Replace insulating washer, nut, second insulating washer, shield housing and insulating bushing assembly, plain washer, lock washer and second hex nut and tighten nuts.

b. Install Field Coils and Pole Shoes.

Screwdriver, socket Wrench, face, $\frac{9}{16}$-in.

Place coils in frame, upper left, lower left, lower right and upper right in order named, facing end with inspection openings. Insert pole shoes in coils and fasten each with two flat head machine screws.

c. Install Field Terminal Post.

Wrench, open-end, $\frac{7}{16}$-in.

Place two pieces of insulation and insulating bushing on terminal post and insert post, from inside, through frame. Replace insulating washer, nut, second insulating washer, shield housing and insulated bushing assembly, plain washer, lock washer and top hex nut on terminal post in the order named. Tighten nuts.

d. Mount Brush Holders and Brush Springs on Commutator End Head Assembly. Assemble springs and holders and force them on pivot studs.

e. Install Ball Bearing in Commutator End Plate. Place the spring washer in the commutator end plate with the projections facing the plate and install the following in the order named: Felt washer retainer, felt washer, felt washer retainer, and the ball bearing (fig. 46). The open end of the bearing should face outward. Lubricate the bearing thoroughly with GREASE, general purpose, No. 1.

f. Install Ball Bearing in Drive End Head.

Screwdriver

Place a felt washer and felt washer retainer in the drive end head. Then install the ball bearing and pack with GREASE, general purpose, No. 1. Install another felt washer retainer and felt washer. Place the bearing retainer gasket and bearing retainer on the drive end head. Fasten in position with four lock washers and fillister head screws (fig. 46).

g. Fasten Drive End Head Assembly to Frame and Field.

Screwdriver

Fasten the drive end head assembly to the frame and field with six lock washers and fillister head screws (fig. 46). Be sure to line up marks so that the drive end head will go back on in the same position.

h. Install Armature Shaft in Frame and Field. Place the spacer on the drive end of the armature shaft and install the armature shaft in the frame and field.

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i. Install Commutator End Plate on Armature Shaft.
Screwdriver

Place the other spacer on the commutator end of the armature shaft. Place the commutator end plate on the armature shaft and line up mark with one on frame and field assembly. Fasten commutator end plate in position with six lock washers and fillister head screws (fig. 46).

j. Install Bearing Retainer Washer.
Screwdriver

Install the bearing retainer washer, lock washer and screw in position on the end of the shaft (fig. 46).

k. Install Commutator End Cap Cover.
Screwdriver

Put a new gasket and the commutator end cap cover back on the commutator end plate. Fasten in position with four lockwashers and fillister head screws (fig. 46).

l. Install Drive Pulley.
Wrench, socket, $\frac{15}{16}$-in.

Place the drive pulley on the drive end of the armature shaft. Lock the drive pulley in place with a metal washer, lock washer and shaft nut (fig. 46). Tighten the nut.

39. MOUNTING GENERATOR ON ENGINE.

Pliers
Screwdriver
Wrench, open-end, $\frac{5}{8}$-in.
Wrench, open-end, $\frac{3}{4}$-in.
Wrench, open-end, $\frac{7}{8}$-in.
Wrench, socket, $\frac{9}{16}$-in.
Wrench, socket, $\frac{3}{8}$-in., with $\frac{1}{4}$-in. drive

a. Install Generator Belts (figs. 44 and 45).
Wrench, open-end, $\frac{3}{4}$-in.
Wrench, open-end, $\frac{7}{8}$-in.

(1) Place the generator in position and line up the holes in the generator end cover bosses with the holes in the bracket base. Insert the bolts. Place lock washers and nuts on the bolts. Use hands, as nuts should not be tightened. Push the generator towards the engine as far as it will go and put on generator and vacuum pump drive belts.

(2) Insert bolt with plain washer through the slotted end of the adjusting strap and generator housing boss. Place the lock washer and nut on the bolt with the hands.

(3) Pull the generator away from the engine until the fan belts across the top may be deflected $\frac{1}{2}$-$\frac{3}{4}$ inch, halfway between the fan pulley and generator pulley. Tighten the adjusting strap bolt nut; then tighten the two lower bracket base bolt nuts (fig. 44).

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b. Connect the Field Terminal.

Screwdriver
Wrench, open-end, 5/8-in.
Wrench, socket, 3/8-in., with 1/4-in. drive

Install the field wire and screw the wire shielding into place, using a 5/8-inch open-end wrench (fig. 43). Then, using a special 1/4-inch drive with a 3/8-inch socket, install the nut holding the lead to the field terminal (fig. 42). Install the plug in the field terminal (fig. 41).

c. Connect the Armature Terminal.

Pliers
Wrench, socket, 9/16-in.

Install the wire on the generator terminal (the large terminal) and the nut which holds the wire to the terminal (fig. 40). Screw the condenser onto the armature terminal (fig. 38).

40. REGULATOR DESCRIPTION AND TROUBLE SHOOTING.

a. Description (fig. 51). The Autolite Model VRH-4102A regulator is a single-core vibrating unit and consists of a cut-out relay, a voltage regulating unit, and a current regulating unit. The coil on each unit controls a pair of contacts, located between the battery and the field and armature coils of the generator. The contacts automatically connect and disconnect the battery in circuit with the generator when charging and

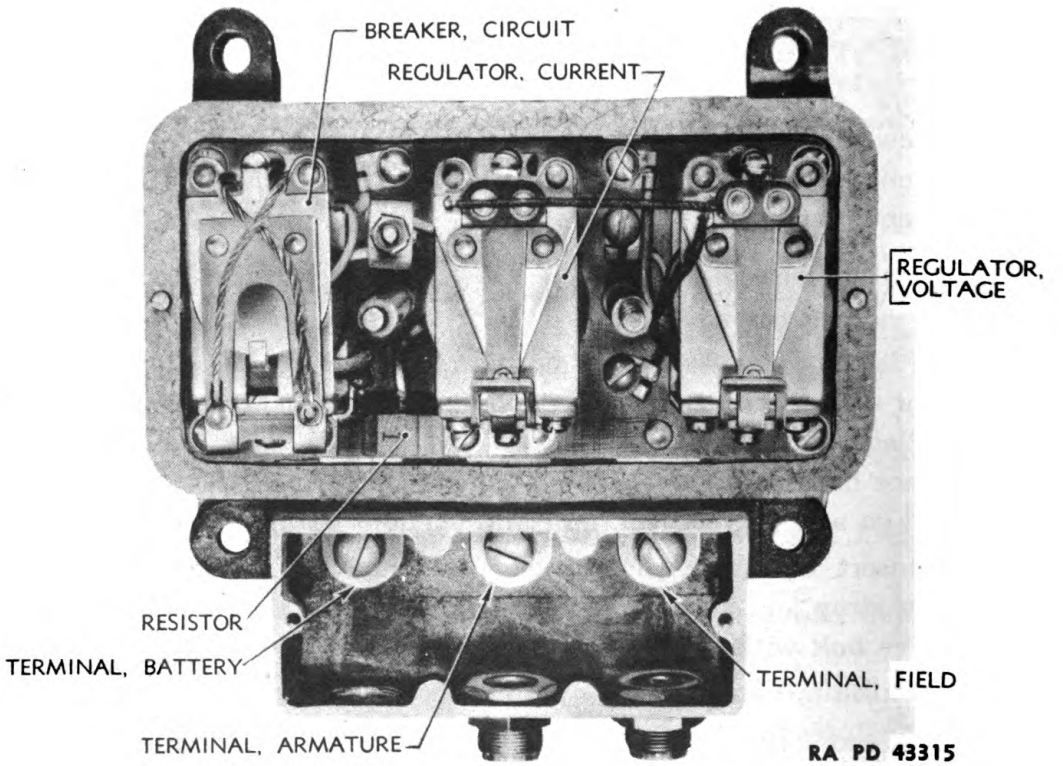


Figure 51—Generator Regulator—Top View

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keep the voltage and current delivered by the generator within rated limits. The regulator is mounted under the hood of the engine and is enclosed in a metal case.

(1) CONSTRUCTION (fig. 51).

(a) The regulator is mounted in a case with cover. The cover is secured by two nuts which engage two studs that are fixed to the bottom of the case and extend through holes in the cover. On the base, and extending beyond one side, are the battery, armature and field terminals. These are connected respectively to the circuit breaker assembly or cut-out relay for the battery, the current regulator assembly, and the voltage regulator assembly. All terminals are enclosed in a radio shield assembly at the side of the regulator case and are provided with openings for the battery, armature and field connections to terminals. On the bottom of the base are several resistances, and the circuits are such that whenever the voltage or current delivered is too high to be safe, resistance is automatically switched into the field windings of the generator to reduce output.

(b) The circuit breaker assembly (figs. 52 and 53) at the left end of the unit (viewed from the side with the three terminals), consists of an armature with contact points. These points are connected to the batteries and controlled by an electromagnetic core, wound with relatively large

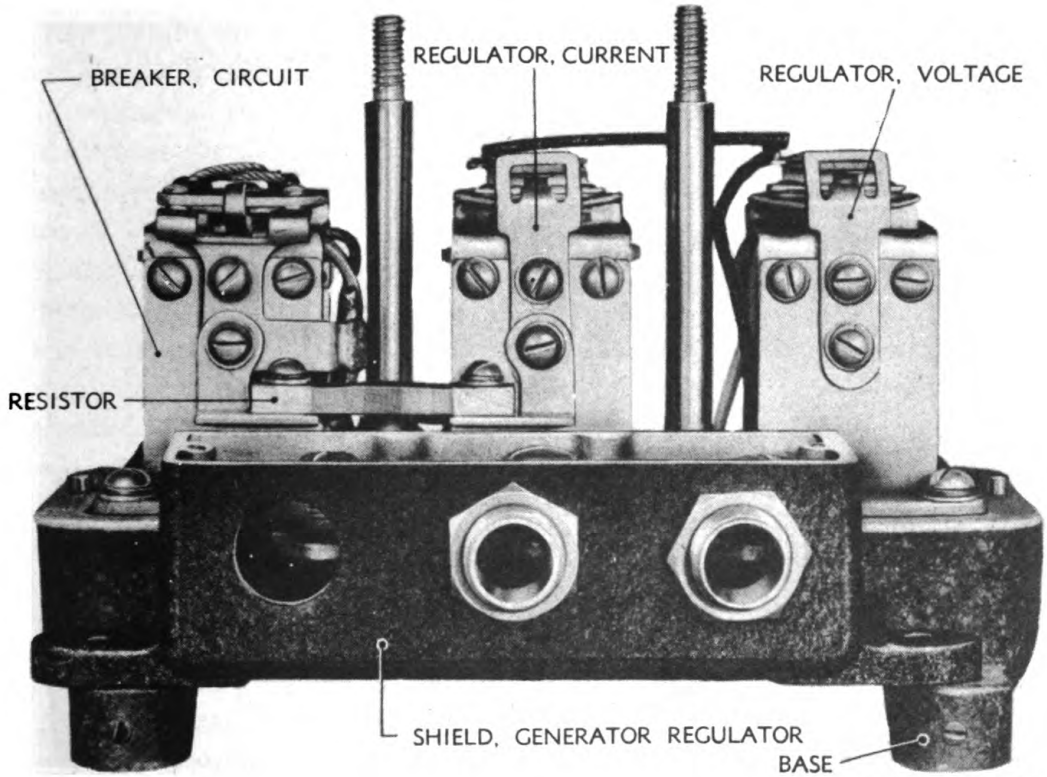


Figure 52—Generator Regulator—Front View

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wire, to serve as a current coil. One end of this coil is connected to two fixed contacts and the other to the armature of the regulator. A spring, attached to the armature of the circuit breaker, normally keeps the fixed and the movable contacts separated. The circuit breaker also includes a voltage coil on the same core, made up of a few turns of fine wire wound in the same direction as the current coil and connected in shunt to a ground.

(c) The current regulator assembly (center) and voltage regulator assembly (right) have similar magnetic cores and a hinged armature that carries a contact which is held against a fixed contact on a spring. The core of the voltage regulator assembly has a fine wire winding in shunt with the field coils of the generator. The core of the current regulator assembly has a winding of thick wire in series with the armature of the generator and the current coil of the circuit breaker or cut-out relay. Additional resistance for the field windings of the generator is also present, but is so arranged that, so long as the contacts of both current regulator assembly and voltage regulator are closed, it is not effective.

(2) FUNCTIONING.

(a) The generator operates to replenish that part of the energy of the batteries which has been consumed in starting, and the use of other

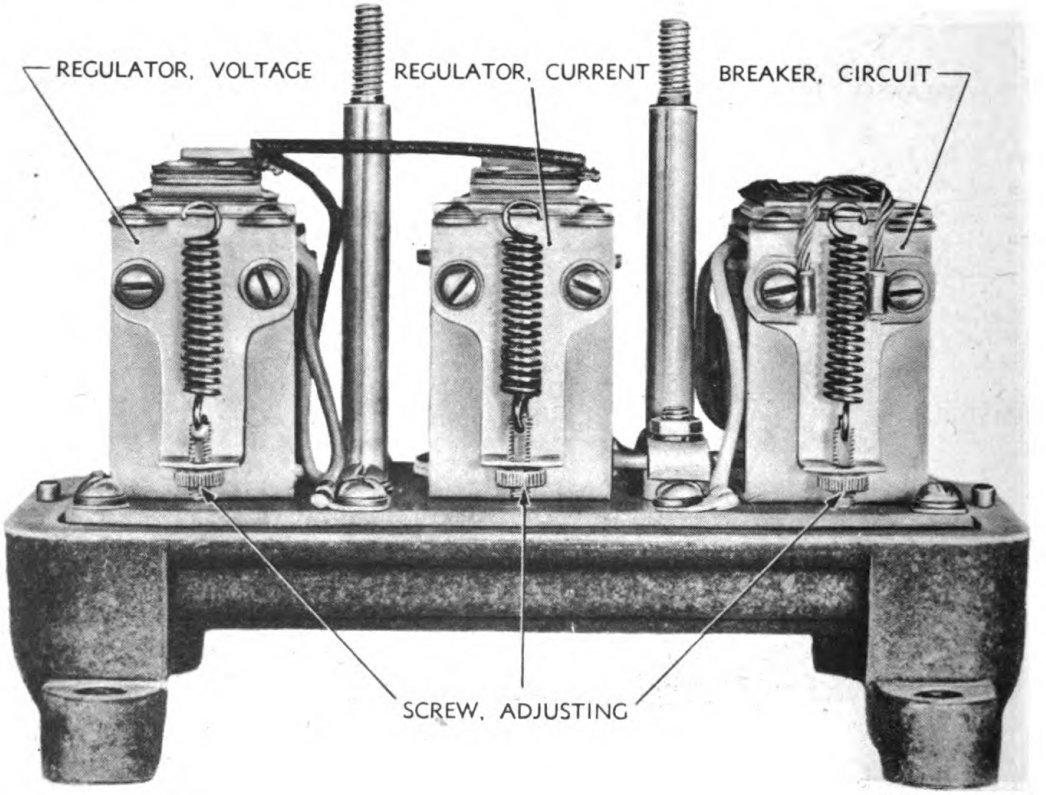


Figure 53—Generator Regulator—Rear View

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electrical accessories. As soon as the generator speeds up and its voltage exceeds the battery voltage, armature current flows first through the current regulator assembly and then, by way of the shunt or voltage coil of the circuit breaker (or cut-out relay) to ground. Thus the magnetic core of the circuit breaker is energized and the armature is attracted to bring the contacts together. Current then flows from the generator, through the current coil of the circuit breaker which is in series with the battery and generator and restores the full voltage to the batteries. The current coil and voltage coil of the circuit breaker are wound in the same direction, and one reinforces the other. As the battery voltage increases, less current flows through the current coil, although the effect of the voltage coil on the magnetization of the core is continued. When the battery voltage approaches its maximum, it opposes the further flow of generator current through the current coil of the circuit breaker. As soon as the generator stops, or slows down to a point where its voltage is less than the battery voltage, current from the battery flows through the current coil but in the reverse direction. The current and voltage coils now oppose each other and the magnetic effect on the armature is no longer great enough to overcome the spring. The contacts then separate, and battery and generator are disconnected. As long as the batteries are being charged the generator will supply the electrical system.

(b) While the batteries are being charged by the generator the current regulator assembly and voltage regulator assembly keep the current and voltage of the generator within safe limits. At predetermined points, the current regulator coil or the voltage regulator coil will act to cut in resistance in the generator field circuit and weaken the field. The armature of each assembly will then vibrate rapidly so that the generator voltage and current will never be permitted to exceed their maximum selected values. As the generator voltage is kept virtually constant, less current is forced into the batteries as their voltage is increased; thus the charging operation is properly performed. The voltage regulator is compensated for temperature variations by means of a magnetic bypass, to give a higher voltage under cold operating conditions than under hot operating conditions. The regulator is designed for a maximum current draw of 55 amperes. This is necessary, as a higher voltage is required to charge a cold battery than a hot battery.

b. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) OVERCHARGED BATTERY OR HIGH CHARGING RATE.	
Poor ground at regulator.	Check, repair and adjust.
High voltage setting at regulator.	Check and adjust.

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(2) Low Battery Charge or No Charge Rate.

Loose connections.	Tighten all connections.
Frayed or damaged wires.	Replace wires.
Poorly soldered terminals.	Resolder terminals.
Circuit breaker inoperative.	Check, repair and adjust.
Generator inoperative.	Check and repair or replace.
Low current regulator setting.	Check, repair and adjust.
Low voltage regulator setting.	Check, repair and adjust.

41. REGULATOR REMOVAL.

Pliers, channellock
Screwdriver
Wrench, open-end, ½-in.
Wrench, open-end, ⅝-in.
Wrench, socket, ½-in.

a. Remove Shield Cover.

Screwdriver

Remove screws, lock washers and plain washers holding terminal shield cover and lift off cover.

b. Disconnect Generator and Filter Conduits at Regulator.

Pliers, channellock
Screwdriver
Wrench, open-end, ⅝-in.

Remove terminal holding screws and lock washers to disconnect wires (fig. 54). Loosen conduit coupling nuts and pull away generator and filter conduit, with wire assemblies. NOTE: Care should be taken when removing filter terminal, unless battery has been disconnected.

c. Remove Regulator and Shield Assembly.

Wrench, open-end, ½-in.
Wrench, socket, ½-in.

Remove nuts, lock washers and cap screws holding regulator assembly and shield to dash and lift off regulator assembly and shield. Separate shield from regulator assembly.

42. REGULATOR DISASSEMBLY.

Iron, soldering
Screwdriver
Wrench, open-end, ⅜-in.
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, socket, $\frac{7}{16}$-in.

a. Remove Case Cover.

Wrench, open-end, $\frac{7}{16}$-in.

Break seal and remove two cover nuts and lock washers. Lift off cover and gasket.

b. Remove Complete Regulator Base Assembly.

Screwdriver

Take out round-head machine screws and lock washers from corners of base assembly, and round-head screws with lock washers and plain

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washers which connect leads of circuit breaker and voltage regulator to ground. Lift out the complete base assembly.

c. Remove Three Resistors Under Insulation.

Screwdriver

Extract two round-head machine screws with plain washers and lock washers at each resistor and remove the resistors.

d. Remove Jumper Between Voltage Regulator and Current Regulator Assemblies.

Iron, soldering

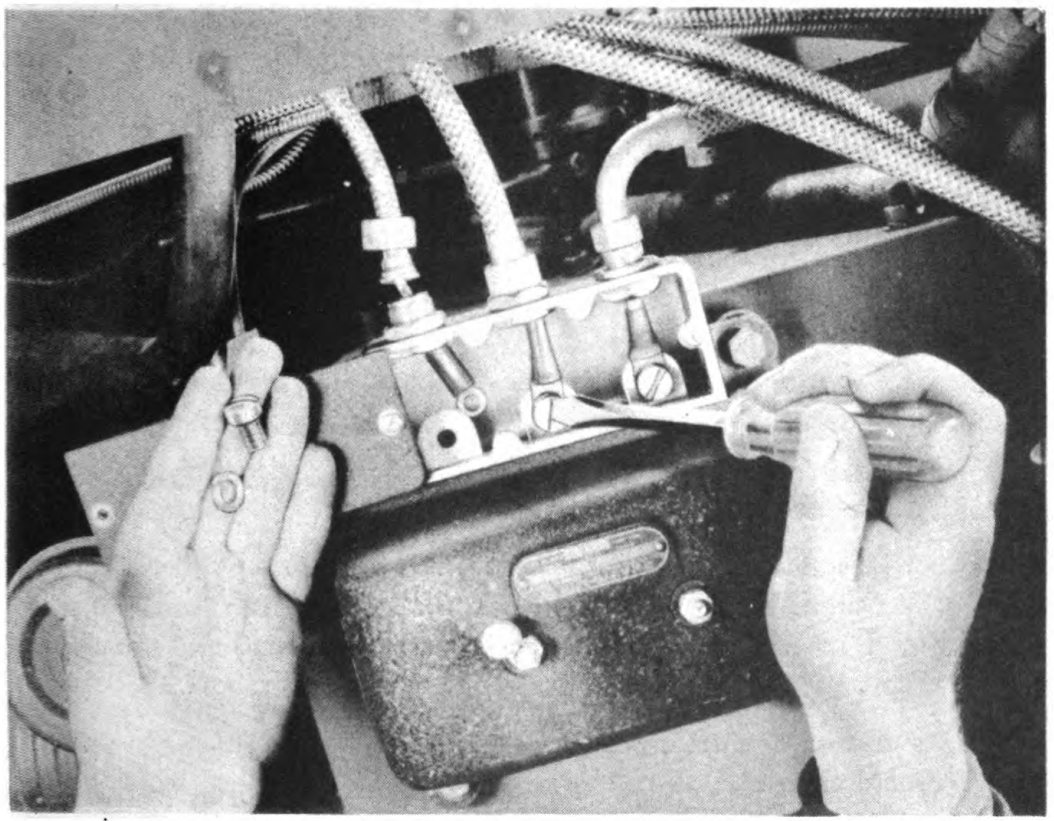
Heat soldered ends and disconnect jumper.

e. Remove Voltage Regulator Assembly.

Screwdriver Wrench, socket, $\frac{7}{16}$-in.

Unscrew two round-head machine screws with lock washers on top of insulation to disconnect leads of voltage coil. Remove nut and lock washer from lower end of core and lift out voltage regulator assembly.

f. Remove Armature Spring and Adjusting Screw Assembly from Voltage Regulator Assembly. Release upper end of spring from armature. Remove adjusting screw nut and lift out spring and adjusting screw assembly.



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Figure 54—Disconnecting Regulator Conduit Wire Assembly

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g. Remove Voltage Regulator Armature Assembly.
Screwdriver

Remove two machine screws with lock washers and plain washers and lift off armature assembly.

h. Remove Voltage Regulator Support Assembly.
Screwdriver

Unscrew three machine screws with lock washers from front of frame and remove support assembly.

i. Remove Voltage Regulator Coil Assembly.
Wrench, open-end, $\frac{7}{16}$-in.

Remove hexagon nut from end of core at bottom of frame and take out coil assembly.

j. Remove Current Regulator Assembly.
Screwdriver
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, $\frac{3}{8}$-in.

Remove machine screws, lock washers and plain washers holding resistor to current regulator and circuit breaker, and lift off resistor. Disconnect coil lower lead by removing hex nut, lock washer and clip. Disconnect coil upper lead by removing machine screw, lock washer and plain washer. Remove nut and lock washer from lower end of core and lift out current regulator assembly.

k. Remove Current Regulator Adjusting Screw and Spring. Unhook upper end of spring by hand from armature. Remove adjusting screw nut and lift out adjusting screw and spring.

l. Remove Current Regulator Armature Assembly.
Screwdriver

Extract two machine screws, lock washers and plain washers, and lift off armature assembly.

m. Remove Current Regulator Support, Core and Coil.
Screwdriver

Extract three machine screws, lock washers and plain washers holding support to frame. Remove hexagon nut holding core to frame. Remove support and core by hand from frame and take out end insulating washers, coil and paper sleeve. Pull out core from support.

n. Dismount Circuit Breaker Assembly.
Wrench, open-end, $\frac{7}{16}$-in.

Remove hexagon nut and lock washer from core at bottom of insulation. Lift off circuit breaker assembly.

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o. Remove Circuit Breaker Adjusting Screw and Spring. Unhook upper end of spring by hand from armature. Remove adjusting screw nut at lower end of spring and lift out adjusting screw and spring.

p. Remove Circuit Breaker Armature Assembly.

Screwdriver

Extract two fillister head screws, lock washers, and plain washers holding armature assembly to frame and lift off assembly.

q. Disconnect Circuit Breaker Coil Leads from Point Bracket.

Iron, soldering

Melt solder at bracket and pull out leads.

r. Remove Circuit Breaker Point Bracket Assembly and Insulation.

Screwdriver

Extract two machine screws, lock washers, plain washers, insulating washers and insulating bushings and remove bracket assembly and insulation.

s. Remove Circuit Breaker Frame Support.

Screwdriver

Extract two fillister head machine screws and lock washers and lift off support by hand from top of frame.

t. Remove Circuit Breaker Coil Assembly.

Wrench, open-end, $\frac{7}{16}$-in.

Unscrew hexagon nut on bottom of frame and pull coil assembly out of frame.

u. Separate Circuit Breaker Series Coil and Shunt Coil Assembly. Lift out shunt coil assembly, series coil and bottom insulation.

43. REGULATOR MAINTENANCE AND ADJUSTMENTS.

a. If regulator is found to be faulty, remove the cover and make a close visual inspection of the following and make all possible corrections at once.

(1) Evidence of burning or abnormally high temperature at the coils, contacts, insulation, external terminals or any other point. This test should be made with a magnifying glass.

(2) Loose connections which result from poor soldering.

(3) Loose nuts on the bottom of the magnet cores, loose rivets or screws. All nuts and screws must have lock washers.

(4) Loose contact points.

(5) Misalinement of contact points.

(6) Bent armature either at the contact or hinge end. The armature should be perfectly straight from one end to the other.

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(7) Field frame bent.

(8) Bent armature hinges.

(9) Stripped or crossed threads on any screw or nut.

(10) Corrosion due to scale or acid.

(11) Evidence of water having been inside of cover.

(12) Incorrect, bent or distorted armature adjusting spring. In case of doubt it is recommended that the spring be replaced.

(13) Broken gaskets.

(14) Incorrect wiring connections between units.

(15) Shunt leads and terminal on circuit breaker armature must be free and not interfere with armature movement or touch tension spring.

(16) Metal transfer or built up on regulator contact points.

b. After any faults indicated by visual inspection have been corrected or ascertained and regulator continues to be defective, the following procedure should be used to locate the defects.

(1) Connect test lamp in series with battery. Attach one of the test leads to battery terminal and the other test lead to the armature terminal of regulator. Close the circuit breaker contacts and if lamp lights, the circuit is not broken.

(2) Attach the test leads to the armature and field terminals of regulator; the lamp should light if circuit is not broken. Separate the current regulator contacts first and then the voltage regulator contacts; the light should go out in both instances, indicating no shorts in circuit.

(3) Attach test lead points to regulator armature and ground terminals. The voltage windings of the circuit breaker and voltage regulator should pull the armatures down against the cores, indicating no breaks or shorts.

c. If any of these tests do not give the proper results, detach the complete base assembly, remove the resistors, disconnect each circuit, and make a continuation test and ground test of each individual circuit. If an ohmmeter is available, each circuit should be tested for resistance; and if the measured resistance does not come within specifications, see paragraph 43 g, Service Data. If the carbon resistors do not have enough resistance they may be filed until the proper resistance is obtained. If necessary, replace resistors or make repairs.

(1) Remove the armature adjusting springs and adjusting brackets from current regulator and voltage regulator. Be sure springs are taken off before brackets, otherwise the hinges of the armatures will be bent and damaged.

(2) Fasten each armature down with clamp, or hold by hand, and insert a piece of paper ¼-inch wide between the contact points. Connect

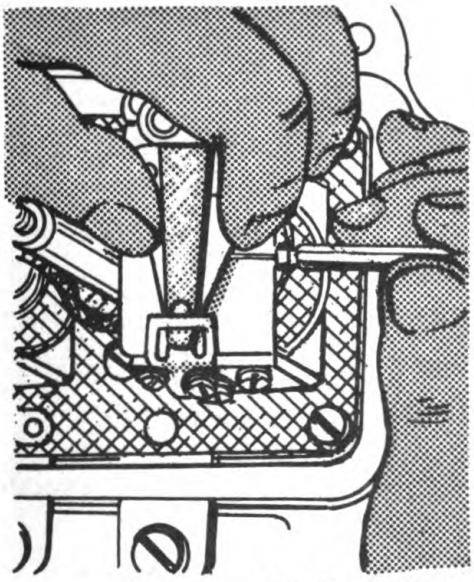
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spring scales to contact spring and take scale reading at instant when paper can be moved between the contacts by pushing. The pressure of the contact points of both current and voltage regulator should be 7 ounces to 8 ounces.

(3) Clean all contact points and check for wear. If they are too badly worn, replace with new contacts. If the contact points are pitted, they should be honed with a fine hone. When honing the contacts, hone parallel with the armature. Clean points with lintless tape saturated with CARBON TETRACHLORIDE; then, dry with lintless tape. When removing the tape from between the contacts, always open the contacts so as not to leave any lint between them.

d. Adjustments. After the regulator assembly has been disassembled or repaired if necessary, and reassembled, the armature air and point gap for the current regulator, voltage regulator and circuit breaker should be adjusted as follows:

(1) CURRENT REGULATOR. Using a test lamp set, connect the lamp in series with the battery and test leads and place the test leads on the regulator armature and field terminals. Place a 0.047-inch pin gage between the core and armature (fig. 55) just in front of the small brass pin, and depress the armature; the lamp should go out. Remove the 0.047-inch pin gage and replace it with a 0.049-inch pin gage. Depress the armature again; the light should remain lit. The adjustment is made by loosening the adjusting bracket screws and moving bracket. NOTE: Use two fingers to depress the armature, one on either side of the con-



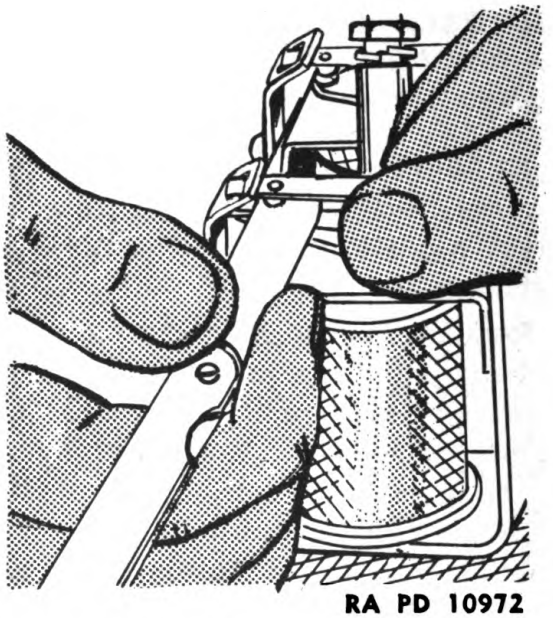
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Figure 55—Checking Armature Air Gap with Pin Gage

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tact spring so that the spring is not touched. After air gap has been correctly set, check contact point gap (fig. 56) and reset to specifications, if necessary (par. 43 g).

(2) VOLTAGE REGULATOR. Set the voltage regulator air gap, using the same test lamp set-up and procedure as above, but with 0.040-inch and 0.042-inch pin gages. Check and set point gap.



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Figure 56—Checking Contact Point Gap

(3) CIRCUIT BREAKER. Set the circuit breaker air gap by bending armature stop on frame support. Use test lamp set and 0.055-inch and 0.062-inch flat gages as in previous adjustments (fig. 57). Check and adjust contact points by bending the top arms of the point brackets (fig. 58).

e. After the foregoing adjustments have been made, proceed to make final regulator adjustments as follows:

(1) Mount regulator firmly and in same position as on vehicle.

(2) Connect regulator to generator and battery circuit.

(3) To test circuit breaker operation connect the ammeter in series between the battery and the battery terminal. The voltmeter is connected to the armature terminal and to the regulator case, which must be grounded.

(4) With regulator cover in place, heat regulator by running generator for a period of not less than 15 minutes, at sufficient speed to produce 10 amperes.

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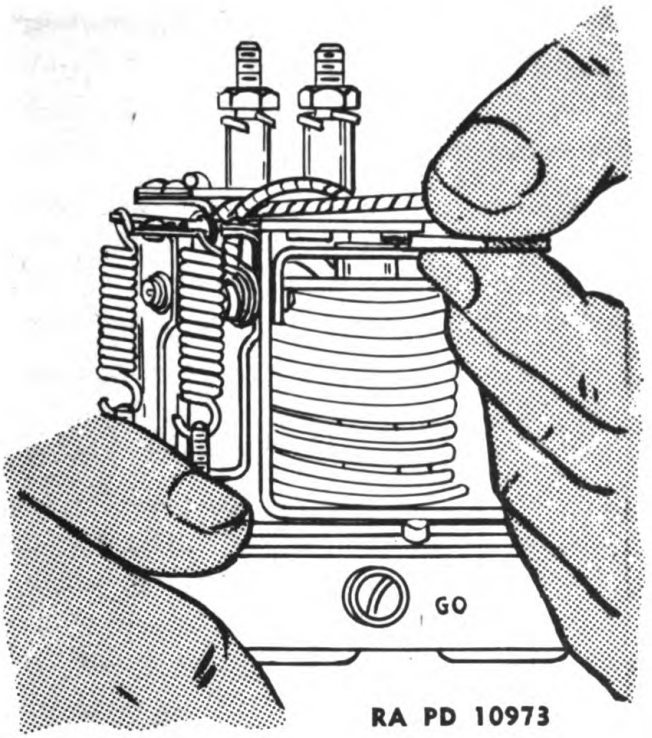


Figure 57—Checking Circuit Breaker Armature Air Gap

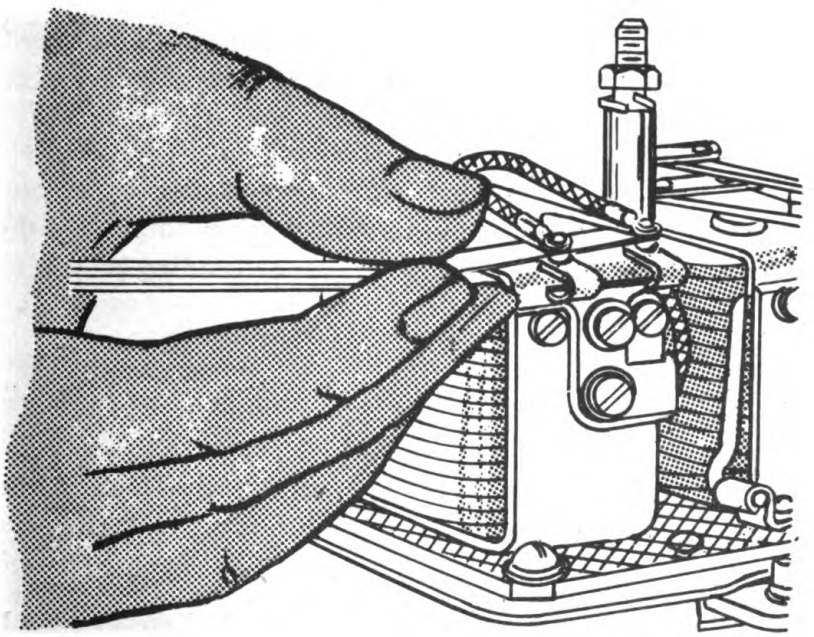


Figure 58—Checking Gap of Circuit Breaker Points

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(5) Check temperature with thermometer approximately two inches from regulator case (par. 43 g).

(6) Reduce generator speed until circuit breaker opens, then increase generator speed to between 1,120 to 1,170 revolutions per minute.

(7) To fix the cut-in voltage of the circuit breaker, remove the regulator cover and adjust the spring tension by means of nut on screw holding spring. Check this cut-in voltage accurately by close observation of voltmeter; voltmeter needle will flick when points close (par. 43g).

(8) To fix the cut-out amperage of the circuit breaker, adjust the contact point gap by raising or lowering the stationary points. Be sure that the armature and point bracket do not make contact.

(9) After adjusting, install the regulator cover and again test the circuit breaker operation. The voltage at which the circuit breaker closes should be 0.5 volts less than the voltage at which the regulator operates. After this check make a final test by stopping generator and restarting it and noting immediately the maximum voltage reading (par. 43 g).

(10) To adjust voltage regulator operation, connect voltmeter to battery terminal and ground and ammeter in series with battery terminal and battery. To raise voltage, screw up nut to increase spring tension on armature. To lower voltage, decrease spring tension.

(11) To adjust current regulator, connect an ammeter in series between the regulator battery terminal and battery. Increase or decrease current by adjusting spring tension on armature.

f. Check resistance of voltage regulator and disconnect both voltage regulator coil leads from base and connect them to an ohmmeter. (See Service Data, par. 43 g for correct resistance reading.)

g. **Service Data.** Carbon resistors (four used).

Resistance:
R1 marked 80, 76 to 84 ohms.
R2 marked 15, 13.5 to 16.5 ohms.
R3 marked 30, 28 to 32 ohms.
R4 marked 1, 0.9 to 1.1 ohms.

Circuit breaker:
Resistance of voltage winding, 49.7 ohms.
Armature air gap, 0.060 to 0.065 in.
Contact point gap, 0.015 minimum.
Points close, 13.0 to 13.5 volts.
Points open, 0.5 to 4.0 amp. discharge.

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ELECTRICAL—GENERATOR AND VOLTAGE REGULATOR

Voltage regulator:

Resistance of winding, 15.8 ohms.

Armature air gap, 0.040 to 0.042 in. (measured when points are just breaking).

Contact point gap, 0.010-in. minimum.

Pressure of contact points, 7 to 8 oz.

Operating voltages:

Allowable variation, plus or minus 0.15 volts.

Temperature,	60 F	70 F	80 F	90 F	100 F	110 F	120 F.
Volts,	14.51	14.48	14.45	14.39	14.36	14.33	14.30.

In vehicles having the old-type generator filter assembly and equipped with a radio, the voltage regulator is to be set at 15.5 volts; if not radio-equipped, the voltage regulator is to be set at 15.0 volts. Battery overcharge occurring with the 15.0-volt setting can be eliminated by reducing the voltage to as low as 14.5 volts.

In vehicles having the new-type rectangular-shaped filter assembly adjust the voltage regulator to a voltage setting of not more than 15.0 volts. If battery overcharge occurs, correct it by reducing the voltage regulator setting to as low as 14.5 volts. Be sure that the voltage setting of the cut-out is lower at all times than the setting of the voltage regulator.

Current regulator:

Armature air gap, 0.047 to 0.049 in. (measured when points are just breaking).

Contact point gap, 0.010-in. minimum.

Pressure of contact points, 7 to 8 oz.

Operating amperes, 54 to 56 amp.

44. REGULATOR ASSEMBLY.

Iron, Soldering
Screwdriver
Wrench, open-end, $\frac{7}{16}$-in.

a. Install Circuit Breaker Series Coil and Shunt Coil Assembly.

Wrench, open-end, $\frac{7}{16}$-in.

Place bottom insulation and series coil in position in frame. Insert shunt coil assembly into series coil so that lower threaded end of core passes through hole in bottom of frame. Secure assembly with hex nut at bottom of frame.

b. Install Circuit Breaker Frame Support.

Screwdriver

Place support in upper end of frame, over upper end of core, so that slot and hook are closer to front of frame. Secure support with two fillister head machine screws and lock washers.

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c. Install Circuit Breaker Point Bracket Assembly.

Screwdriver

Lay insulation against front of frame, place bracket over it and secure with two fillister head screws with lock washers, plain washers, insulating washers and insulating bushings.

d. Connect Circuit Breaker Coil Leads to Point Bracket Assembly.

Iron, soldering

Insert coil leads into projection of point bracket assembly and solder securely.

e. Install Circuit Breaker Armature Assembly.

Screwdriver

Place armature assembly in position so that front end is under frame support hook. Secure assembly to frame by inserting one fillister head machine screw with lock washer and plain washer through each lead assembly terminal and armature support into frame.

f. Install Circuit Breaker Adjusting Spring and Screw. Hook spring on projection at rear of armature and pass screw down through hole in lower end of support. Attach round nut to bottom of screw.

g. Mount Circuit Breaker Assembly.

Wrench, open-end, $\frac{7}{16}$-in.

Insert threaded lower end of core through riveting base assembly and secure with lock washer and nut.

h. Install Current Regulator Support and Coil Assembly.

Screwdriver Wrench, open-end, $\frac{7}{16}$-in.

Insert flanged core through support from top side. Slip onto core one insulator washer for top of coil, paper sleeve, coil, and insulator washer for bottom. Turn coil so that when support is mounted, terminals will be at left, when frame is viewed from front.

i. Install Current Regulator Armature Assembly.

Screwdriver

Pass front end of spring through adjusting bracket and secure armature assembly to back of frame with two fillister head screws and lock washers.

j. Install Current Regulator Adjusting Spring and Screw. Hook end of spring on projection at rear end of armature and pass screw through lug at bottom of assembly. Install round adjusting nut on bottom of screw.

k. Mount Current Regulator Assembly.

Wrench, open-end, $\frac{7}{16}$-in.

Place assembly next to circuit breaker assembly, passing threaded

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end of core through riveting base assembly. Secure assembly to base with lock washer and nut. Connect current regulator coil top lead to front of base with machine screw, flat washer and lock washer. Connect bottom leads of current regulator and circuit breaker together with clip, lock washer and nut at rear of base.

l. Install Resistor "l".
Screwdriver

Secure one end of resistor to circuit breaker resistor bracket and the other end to current regulator resistor bracket with one machine screw, lock washer and plain washer at each end.

m. Assemble Voltage Regulator Coil and Mount in Frame.
Wrench, open-end, $\frac{7}{16}$-in.

Insert core through coil, install insulation at bottom and insert threaded end of core through hole in frame. Secure assembly to frame with nut. Coil leads should be at left.

n. Install Voltage Regulator Support Assembly.
Screwdriver

Place support assembly in position in frame, fitting upper end of core in opening with magnetic shunt piece to rear. Secure assembly to front of frame with three fillister head machine screws and lock washers.

o. Install Voltage Regulator Armature Assembly.
Screwdriver

Pass front end of spring through adjusting bracket at front of frame and secure assembly to back of frame with two plain washers, lock washers and fillister head machine screws.

p. Install Voltage Regulator Adjusting Spring and Screw. Hook end of spring on projection at rear of armature and pass screw through lug at lower end of assembly. Install round adjusting nut on bottom of screw.

q. Mount Voltage Regulator Assembly on Riveting Base Assembly.
Wrench, open end, $\frac{7}{16}$-in.

Insert threaded end of core through insulation and secure assembly with nut and lock washer at bottom of insulation.

r. Connect Voltage Regulator Coil Lead and Fixed Contact Lead.
Screwdriver

Fasten eyelet terminal of fixed contact lead to internally threaded tubular rivet at front of riveting base assembly with round-head machine screw and lock washer. Connect voltage regulator coil front lead in a similar manner to rivet at rear of base.

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s. Connect Jumper to Voltage and Current Regulator Assemblies.
Iron, soldering

Solder ends of jumper to projections on insulated ends of contact springs of voltage and current regulator armature assemblies.

t. Install Three Resistors on Bottom of Riveting Base.
Screwdriver

Using two round-head machine screws, lock washers and plain washers for each resistor, mount resistor "80" crosswise with one end on field terminal and opposite end on connector strip. Mount resistor "15" crosswise with one end on opposite end of connector strip and the other end on metal piece receiving lower end of current regulator core. Mount resistor "30" lengthwise of riveting base assembly, with one end fastened to same metal piece and the opposite end to terminal which is attached to tubular rivet of voltage regulator lead.

u. Install Complete Regulator Base Assembly.
Screwdriver

Set complete base assembly on case and fasten with four round-head machine screws and lock washers through corners.

v. Connect Voltage Regulator and Circuit Breaker Leads to Ground.
Screwdriver

Pass round-head machine screw with plain washer and lock washer through eyelet terminal of each lead and hole in riveting base assembly and fasten screws to case.

w. Install Case Cover.
Wrench, open-end, $\frac{7}{16}$-in.

With gasket in position place cover on case with studs projecting through cover and secure with two nuts and lock washer on studs.

45. REGULATOR INSTALLATION.

Pliers, channellock
Screwdriver
Wrench, open-end, ½-in.
Wrench, open-end, ⅝-in.
Wrench, socket, ½-in.

a. Install Regulator Assembly and Shield on Vehicle.
Wrench, open-end, ½-in.
Wrench, socket, ½-in.

Place regulator assembly in position on dash, place shield on regulator base feet and secure both to dash with cap screws, lock washers and nuts.

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b. Connect Generator Field and Armature Leads and Filter Lead to Regulator.

Pliers, channellock
Screwdriver
Wrench, open-end, 5/8-in.

Insert leads through shield and connect them to respective regulator terminals with lock washer and fillister head machine screws. NOTE: Care should be taken when connecting filter lead unless battery has been disconnected. Secure generator and filter conduits to shield with conduit coupling nuts. To assure correct polarity of the generator, connect a jumper lead *momentarily* between the terminals marked "Armature" and "Battery" on the generator regulator *before* starting the engine. The momentary surge of current will polarize the generator correctly with respect to the battery it is to charge.

c. Install Shield Cover.

Screwdriver

Secure cover to shield with plain washers, lock washers and machine screws at corners.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Section VIII

ELECTRICAL—STARTING MOTOR

	Paragraph
Description and trouble shooting	46
Removal of starting motor	47
Disassembly of starting motor	48
Maintenance and adjustment	49
Assembly of starting motor	50
Starting motor installation	51

46. DESCRIPTION AND TROUBLE SHOOTING.

The Delco-Remy DR 702 starting motor is a 6-pole, 12-brush, 24-volt, heavy-duty unit flange-mounted on the flywheel housing. A solenoid starting switch is mounted on the starting motor frame.

a. Construction.

(1) STARTING MOTOR. The high compression and the speed of cranking necessary to start the Diesel engine requires a great amount of cranking horsepower. This is accomplished with the use of a heavy-duty 24-volt type starting motor. The wire used in the armature and field coil winding is of sufficient size with adequate insulation to carry safely the high currents and voltages used. Six field poles and field windings are used to give maximum torque with smooth operation. A longer commutator makes it possible to use 12 brushes in 6 pairs. Each pair of brushes acts as a single brush, but greatly increases the current-carrying capacity due to the larger contact area with the commutator.

(2) THE DYER DRIVE. The Dyer drive consists of the splined portion of the armature shaft, the shift lever, the pinion guide, the pinion, the pinion stop, washers, and springs. The thrust washers furnish a thrust bearing for the shift sleeve when it is in the returned position. The springs aid in the lock operation and in the engagement action. The entire drive is contained in the starting motor drive housing and is operated by a controlled solenoid. The movement of the pinion is controlled by means of a shift lever which is connected directly to the shift sleeve. The Dyer drive provides for positive engagement of the cranking motor pinion with the engine flywheel before the cranking motor switch contacts are closed and the armature is rotated.

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ELECTRICAL—STARTING MOTOR

(3) SOLENOID STARTING SWITCH. The solenoid switch mounted on the starting motor frame provides for remote control operation. Inside the solenoid is a heavy plunger which is connected by linkage to the pinion shift lever. When the solenoid is energized the plunger pulls the pinion into mesh with the flywheel teeth. Further plunger movement closes the switch contacts mounted inside the unit. Two coils are provided in the solenoid switch, a "pull in" coil and a "hold in" coil. The "pull in" coil draws a comparatively heavy current for a short interval. This is needed to engage the pinion. The "hold in" coil also aids the "pull in" coil. As soon as the solenoid switch is closed (and the pinion shifted) the "pull in" coil is short-circuited by the contacts of the cranking motor circuit, so that only the "hold in" coil draws current. The solenoid starting switch is controlled by a series-parallel switch.

(4) THE SERIES-PARALLEL SWITCH. The series-parallel switch mounted on the right inside frame of the vehicle near the transmission permits the use of a 12-volt generator and conventional 12-volt lighting and accessory equipment with a 24-volt cranking motor. It is of rugged construction and incorporates the quick break action and the arc-resisting contacts.

b. Functioning. Three switches are used to complete the starting motor circuit. The manual switch, mounted on the dash (push button), the solenoid operated series-parallel switch, and the solenoid operated starting motor switch. When the buttton on the dash is pushed in, the solenoid in the series-parallel switch is energized acting on its plunger, which through an arrangement of contacts connects the two batteries (normally operating in parallel) in series to furnish 24 volts for the starting system. At this instant the solenoid in the starting motor frame is energized, causing its plunger first to act on a lever forcing the starting motor drive pinion to engage the flywheel ring gear, then to complete the starting motor circuit, by closing the starting motor switch contacts. When the dash button is released the series-parallel switch opens the starting circuit and reconnects the batteries in parallel, returning the system to 12 volts (fig. 59).

c. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) STARTING MOTOR FAILS TO OPERATE.	
Batteries discharged.	Recharge batteries.
Loose or dirty connections.	Clean and tighten connections.
Starting motor switch faulty.	Repair or replace switch.
Starting circuit fuses blown.	Change fuses. Determine cause.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

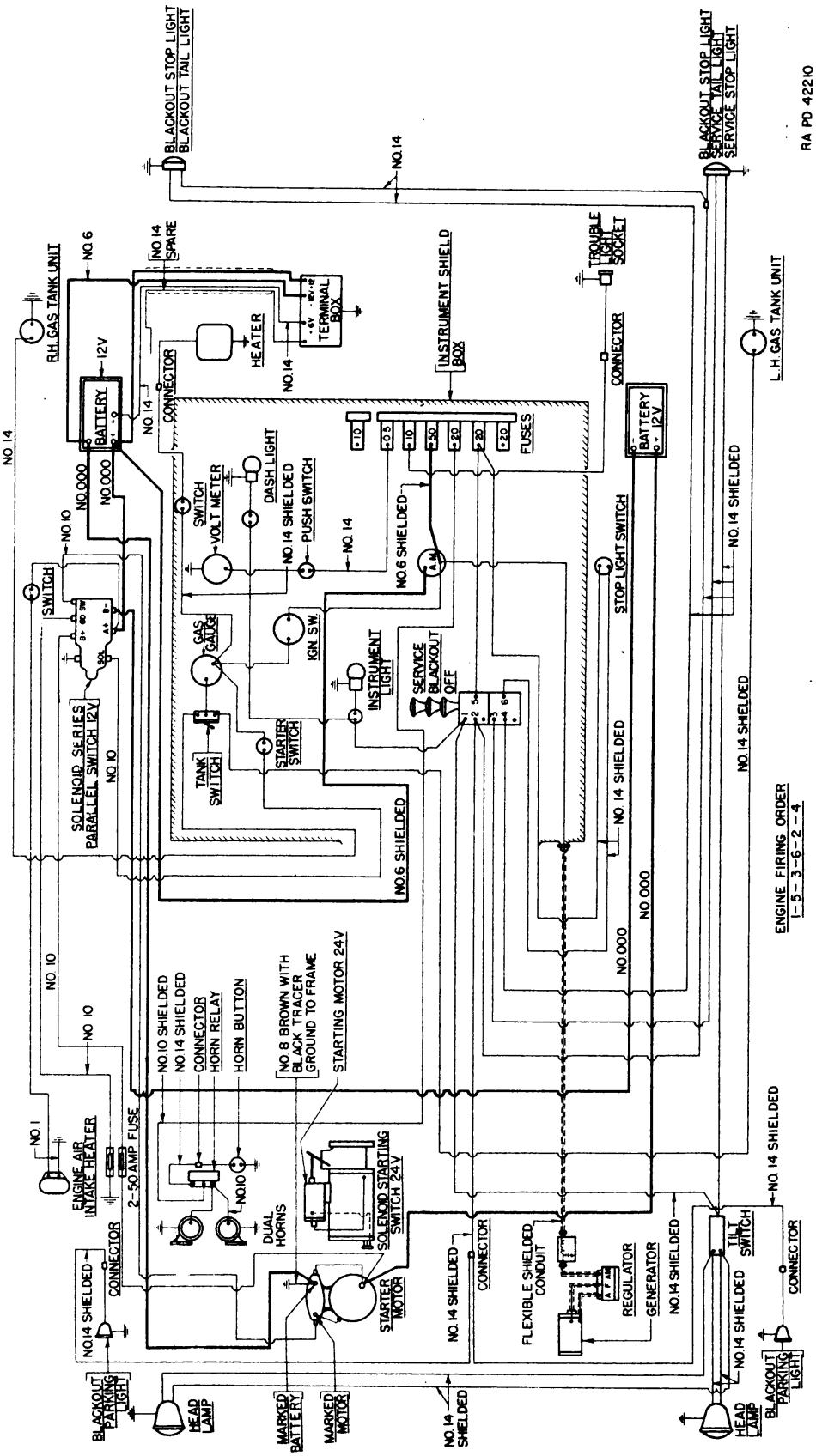


Figure 59—Wiring Diagram for Hercules Diesel Scout Car

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ELECTRICAL—STARTING MOTOR

(2) STARTING MOTOR CRANKS WEAKLY.

Battery weak.	Recharge battery.
Loose or dirty connections.	Clean and tighten connections.
Brushes stuck in holder.	Loosen and clean brushes.
Commutator dirty.	Remove band and clean commutator with No. 00 sandpaper.
Weak brush spring.	Replace brush spring.
Starting motor faulty.	Remove and repair or replace starting motor.

(3) STARTER TRIES TO ENGAGE WHEN ENGINE IS RUNNING.

Defective starter switch.	Repair or replace switch.
Weak or broken return spring.	Replace spring.

47. REMOVAL OF STARTING MOTOR.

Wrench, open-end, $\frac{7}{16}$-in
Wrench, open-end, $\frac{7}{8}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

Remove battery terminals from battery, disconnect the two large and the small starter terminals ($\frac{7}{16}$- and $\frac{3}{4}$-in. open-end wrench) (fig. 60).

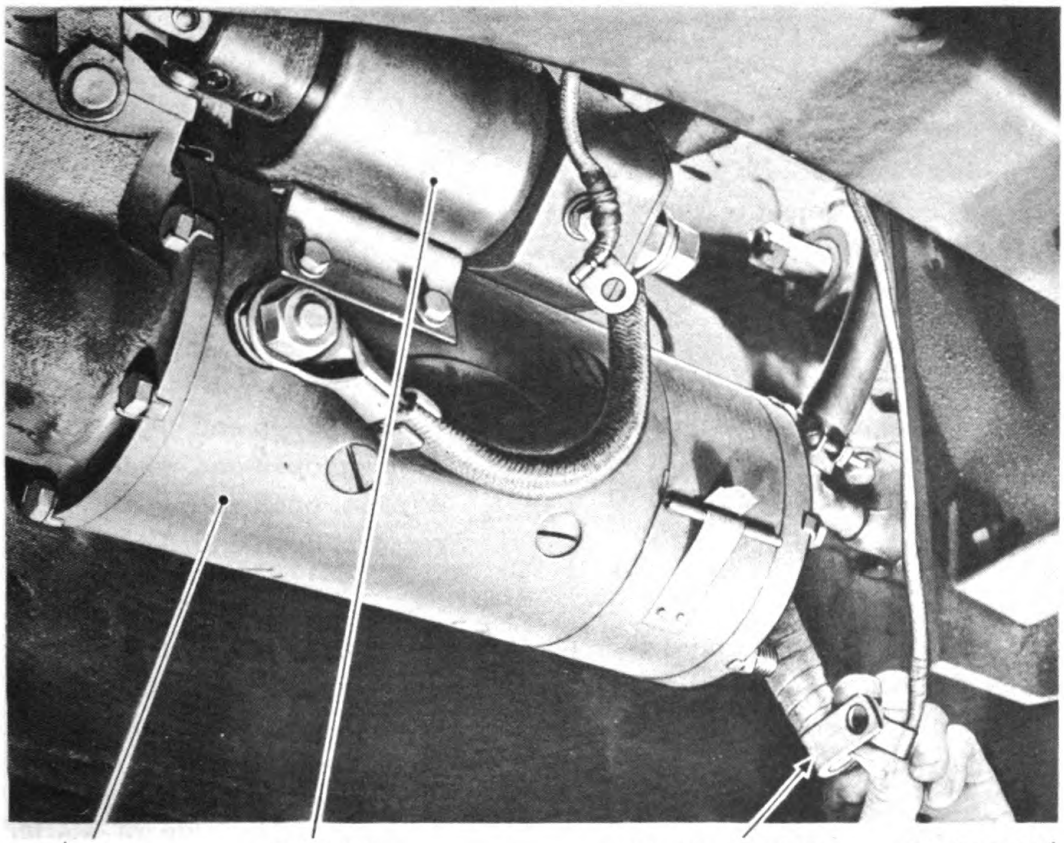
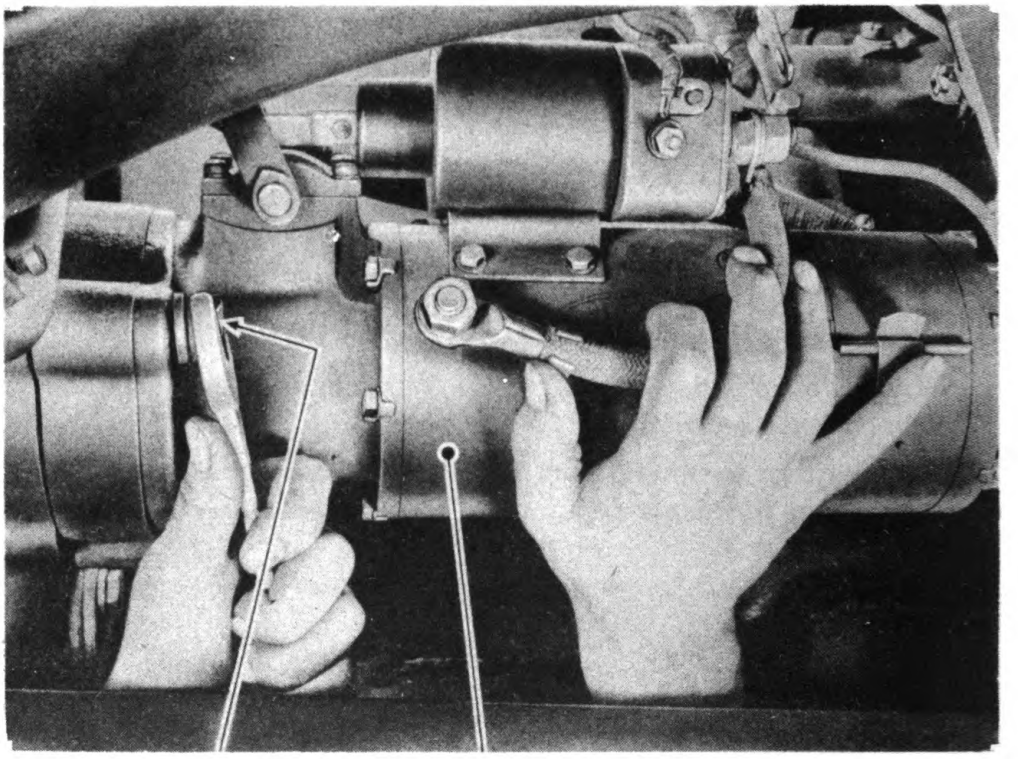


Figure 60—Disconnecting Starter Terminals

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Remove the three mounting cap screws and lock washers (⅞-in. open-end wrench) (fig. 61). Remove the starting motor and solenoid as an assembly. The adapter will come off with the starting motor.



SCREW, CAP, MOUNTING WASHER, LOCK MOTOR, STARTING RA PD 12559

Figure 61—Starting Motor—Removal

48. DISASSEMBLY OF STARTING MOTOR.

Chisel, small
Hammer
Pliers
Pliers, cutting
Screwdriver
Wrench, open-end, $\frac{5}{16}$-in.
Wrench, open-end, ⅜-in.
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, ¾-in.

a. Disconnect the wire that leads from the front end of the starting motor to the small terminal on the side of the solenoid (fig. 62). Use a ¾-inch open-end wrench at the front, and a $\frac{7}{16}$-inch open-end wrench at the side.

b. Disconnect the cable from the terminal on the side of starter housing to terminal on front of solenoid (fig. 62) (¾-in open-end wrench).

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ELECTRICAL—STARTING MOTOR

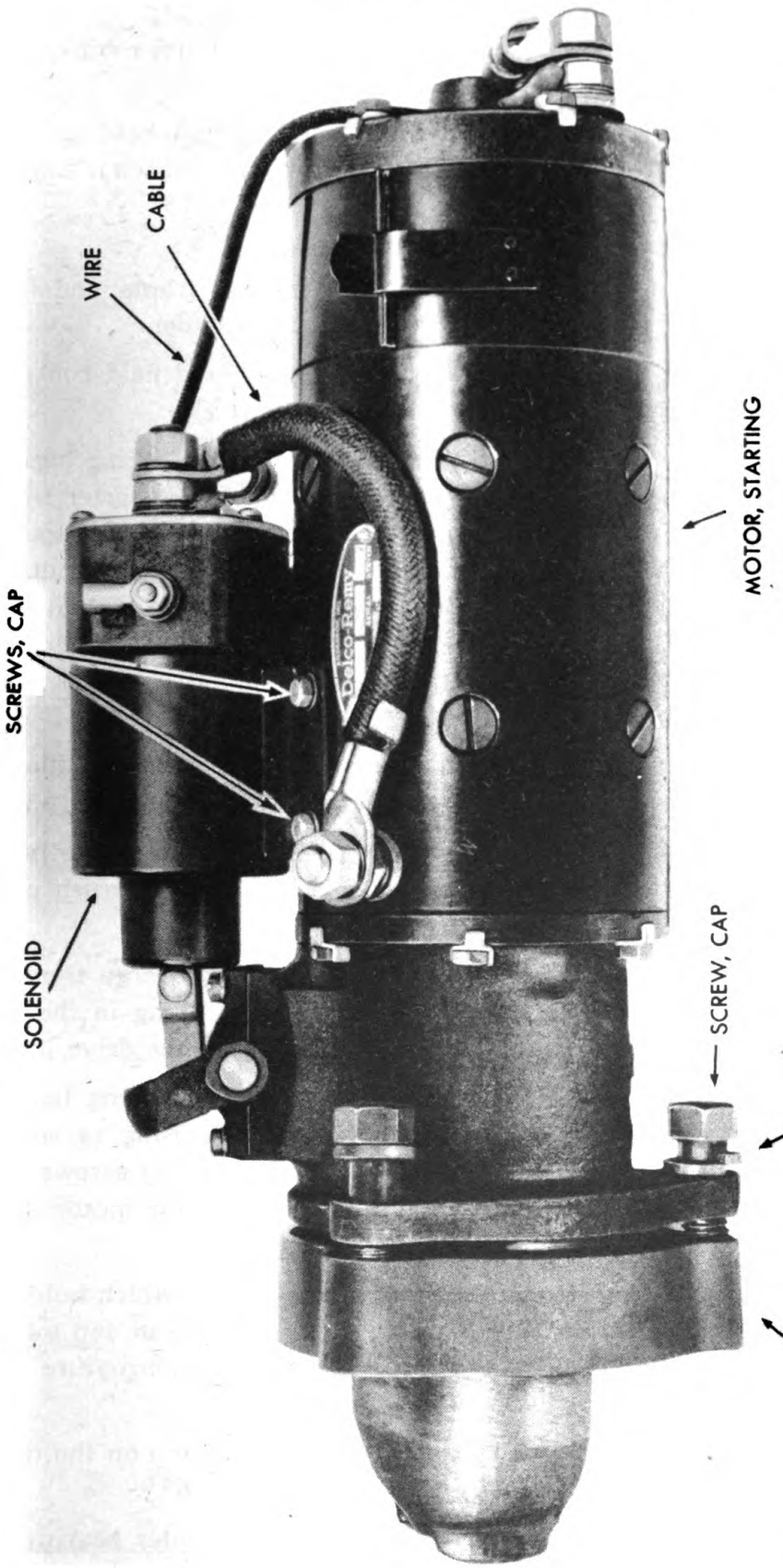


Figure 62—Starting Motor

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c. Remove cotter pin and link pin from solenoid links connecting starter pinion shift lever.

d. Remove four cap screws and lock washers which hold solenoid switch to starter housing (fig. 62) (3/8-in. open-end wrench). Lift off solenoid.

e. Remove the commutator cover band (fig. 63).

f. Mark the commutator end frame and starter frame and field assembly so they can be reassembled in the same manner.

g. Remove three screws that hold brush pigtails and field coil wire leads to brush holders on brush plate assembly (fig. 63).

h. With a small chisel and hammer, straighten the locking lugs on the six cap screws holding the commutator end frame to starter frame and field assembly (fig. 63). Remove the six cap screws and special locking washers with a 7/16-inch open-end wrench. Slide the commutator end frame, with brush plate assembly attached, from the commutator end of the shaft.

i. Remove the screws which hold the brush pigtails to the brush holders.

j. Remove the nut, lock washer, plain washer and two insulating washers from the large terminal stud on outside of end frame (fig. 63).

k. Remove the three screws and lock washers which hold the brush plate assembly to the commutator end frame. Lift off the brush plate assembly (fig. 63).

l. Remove nine insulating washers (two sizes) from large terminal stud attached to brush plate. NOTE: The bronze bushing in the end frame is not ordinarily removed. Should it need replacing, drive it out.

m. With a small chisel and hammer, straighten the locking lugs on the five cap screws which fasten the motor drive housing to starter frame and field assembly (fig. 63). Remove the five cap screws and special locking washers (7/16-in. open-end wrench). Pull the motor drive and armature from the starter frame and field.

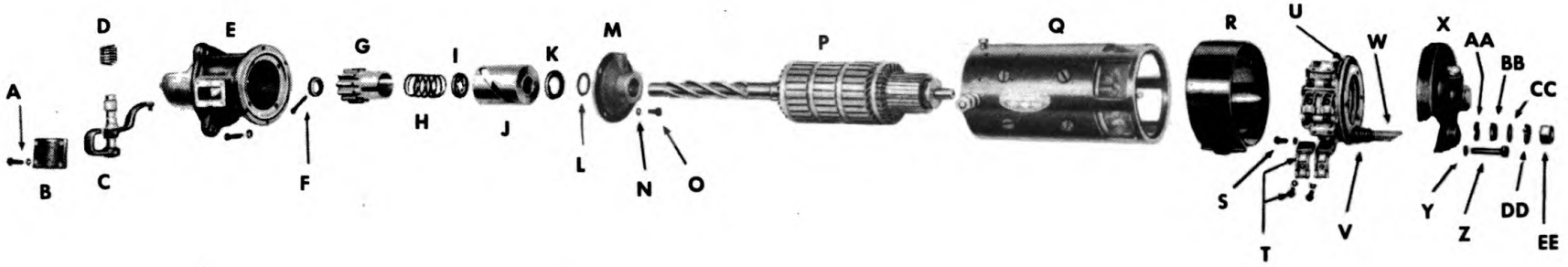
n. Remove the safety wire from the four cap screws which hold the center bearing to the motor drive housing. Remove the four cap screws and lock washers (5/16-in. open-end wrench). Pull the armature and motor drive assembly from the housing (fig. 63).

o. Remove the cotter pin which secures the pinion stop on the drive end of the armature shaft. Pull off the pinion stop (fig. 63).

p. Slide the complete motor drive assembly and center bearing off the shaft (fig. 63).

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A – SCREWS AND LOCK WASHERS, SHIFT LEVER COVER
B – COVER, SHIFT LEVER
C – LEVER, SHIFT, ASSEMBLY
D – SPRING, SHIFT LEVER RETURN
E – HOUSING, MOTOR DRIVE
F – STOP, PINION AND COTTER PIN
G – PINION, DRIVE
H – SPRING, PINION MESHING
I – GUIDE, PINION
J – SLEEVE, SHIFT
K – WASHER, SPACER – CUPPED
L – WASHER, SPACER – PLAIN
M – BEARING, CENTER
N – WASHER, LOCK
O – SCREWS, CAP
P – ARMATURE AND SHAFT
Q – FRAME AND FIELD ASSEMBLY
R – BAND, COVER
S – SCREW AND LOCK WASHER
T – BRUSHES AND SCREWS
U – PLATE, BRUSH, ASSEMBLY
V – WASHERS, TERMINAL INSULATION – TWO SIZES
W – STUD, TERMINAL
X – FRAME, COMMUTATOR END
Y – WASHER, LOCK
Z – SCREW, CAP
AA – WASHER, INSULATION
BB – WASHER, INSULATION
CC – WASHER, PLAIN
DD – WASHER, LOCK
EE – NUT

RA PD 12561

Figure 63—Starting Motor—Exploded View

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q. Remove the four screws and lock washers which fasten the starter pinion shift lever cover to the motor drive unit. Remove the shift lever and spring (fig. 63).

r. Remove the six field pole shoes from the frame and field assembly by unscrewing two flat-head screws from each shoe.

s. Remove field coils by disconnecting post from frame and field assembly and lifting out coil assembly.

49. MAINTENANCE AND ADJUSTMENT.

a. Lubrication. Put 8 or 10 drops of light engine oil into the hinge cap oilers every 1,000 miles. The drive housing bearing should be oiled whenever accessible, through the oiler provided.

b. Commutator.

(1) If the commutator is dirty or slightly burred, clean with No. 00 sandpaper while armature is revolving and blow dust from commutator and brushes. Never use emery cloth.

(2) If commutator is rough, has flat bars, or high mica, remove starter and turn armature in lathe.

c. Brushes. Check for sticking or worn brushes. If brushes are sticking, free them up. If brushes are worn, remove starter and change brushes.

d. Periodic Check. Every 25,000 miles or once a year, starting motor should be removed, disassembled and cleaned. Clean all metal parts in SOLVENT, dry-cleaning, and the armature and field coils with a clean soft brush. If necessary, wipe the coils lightly with a clean lintless rag and CARBON TETRACHLORIDE. After all parts have been thoroughly cleaned make the following inspection:

(1) Check for worn bushings, and replace if necessary.

(2) Check for broken or weak brush springs, replace when necessary. (See Service Data, paragraph 49 **h**).

(3) Check terminal post for stripped threads. Replace damaged post.

(4) Check and replace all damaged or cracked insulators.

e. External Circuit. The external circuit must be kept in good condition. All connections must be clean and tight. Cables should be well insulated, and mounted so that insulation will not wear through. Check operation of starter switch. If starting motor still does not operate properly, remove for bench torque test.

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f. Tests.

(1) If the motor fails to operate or the free speed and torque developed are low, with high current draw, the causes are:

(a) Tight, dirty or worn bushings, all resulting in a dragging armature.

(b) Bent armature shaft.

(c) Loose pole shoe screws, all resulting in a dragging armature.

(d) Shorted armature. Check the armature on the growler.

(e) Grounded armature or field. Raise grounded brushes and insulate them with cardboard or paper. Hold terminals of lamp test set on main terminal and frame. If lamp lights, remove the remaining brushes and test field and armature coils separately to ascertain where the ground exists.

(f) Grounded switch, terminal, or fields.

(2) Failure to operate or low speed and torque, with no current draw, indicates:

(a) Open field circuit.

(b) Open armature coils. Inspect commutator for badly burned bars. With motor running at free speed, an open armature will show excessive arcing at commutator bar which is open.

(c) Broken or weakened brush springs, worn brushes, high mica on commutator, or other causes which would prevent good contact between brushes and commutator. Any of these conditions will cause burned commutator bars.

(d) High internal resistance due to poor connections, defective leads, dirty commutator, or improperly seated brushes.

(3) High free speed with low developed torque indicates shorted fields. There is no easy way to detect shorted fields, since field resistance is already low. If shorted fields are suspected, replace the fields and check for improvement in performance.

g. Use the following tests on the various parts, with a test set consisting of two leads, with lamp in one, and two prods or points:

(1) FIELD COIL TEST FOR OPEN CIRCUIT. See section VII, paragraph 37.

(2) FIELD COIL TEST FOR GROUND. See section VII, paragraph 37.

(3) INDIVIDUAL FIELD COIL TEST GROUND. See section VII, paragraph 37.

(4) ARMATURE TEST FOR GROUND. See section VII, paragraph 37.

(5) INSULATED BRUSH HOLDER TEST FOR GROUND. Place one test prod to cover and the other to insulated brush holder. If lamp lights, brush holder is grounded and should be replaced.

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h. Service Data.

Brush spring tension	36 to 40 oz
Torque tests	
No load speed	6,000 rpm with 21.0 v and 77 amp
Locked torque	
350 amperes	2.8 v—23 lb ft

50. ASSEMBLY OF STARTING MOTOR.

Hammer	Wrench, open-end, $\frac{5}{16}$-in.
Pliers	Wrench, open-end, $\frac{3}{8}$-in.
Pliers, thin nose	Wrench, open-end, $\frac{7}{16}$-in.
Screwdriver	Wrench, open-end, $\frac{3}{4}$-in.

a. Push field coils into position in frame, and with insulators and washers in position slip post through frame and secure with nut.

b. Position four field pole shoes in the field coils and secure each with two flat head screws.

c. Install the shift lever and spring on the motor drive housing and fasten lever cover in position with four lock washers and screws (fig. 63). Spring tension is obtained by placing the lower spring end against the housing top and winding the spring about ¼ turn and then forcing the other end of the spring into the lever shaft slot.

d. Place the center bearing, plain spacer washer, cupped spacer washer, shift sleeve, pinion guide, pinion meshing spring, drive pinion, and pinion stop on the drive end of the armature shaft in the order named (fig. 63). Lock the pinion stop in position with a cotter pin. Install the armature in the motor drive housing. Make certain that the shift lever fits into the curved slot on the shift sleeve, and that the oil hole in the center bearing is up.

e. Fasten the armature assembly and motor drive housing assembly (fig. 62) together with four lock washers and cap screws. Tighten with a $\frac{5}{16}$-inch open end wrench. Safety-wire the cap screws.

f. Slide the frame and field assembly over the armature and fasten to the motor drive housing with five special lock washers and cap screws (fig. 62). Tighten the cap screws with a $\frac{7}{16}$-inch open-end wrench. Tap the lock washer lugs down with a hammer.

g. Place the nine insulation washers on the brush plate terminal stud. The two larger ones go first. Fasten the brush plate assembly to the commutator end frame with three lock washers and cap screws with slotted heads (fig. 63).

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h. Place the following, in the order named, on the brush plate terminal stud: Two insulation washers, plain washer, lock washer, and nut (fig. 62). Tighten the nut with a ¾-inch open-end wrench.

i. Assemble the commutator end frame assembly with brush plate assembly to the frame and field (fig. 63). Be sure to line up marks on both pieces for proper location. Tighten the six cap screws with a $\frac{7}{16}$-inch open-end wrench and flatten the lock washer lugs or ears with a hammer.

j. Lift up the edges of the brush holding springs with thin nose pliers. Insert brushes with the grooved edge joining the tongue on the brush holder. Fasten with lock washers and screws. NOTE: The three field connections line up with the brush connections. These should always be connected at the same time the brush pigtails are connected.

k. Place the cover band in place on the frame and field and tighten with a screwdriver.

l. Assemble the solenoid switch to the starting motor assembly with four lock washers and cap screws (fig. 62). Tighten with a ⅜-inch open-end wrench.

m. Connect the solenoid links to the starter shift lever and secure with a cotter pin. Connect cable to terminal on side of starting motor and to terminal marked "motor" on the solenoid switch (fig. 62). Install lock washers and nuts. Tighten nuts with ¾-inch open-end wrench.

n. Connect wire leading from front terminal on starting motor with a lock washer and nut (fig. 62) (¾-in. open-end wrench). Connect the other end of this wire to the small terminal on the side of the solenoid switch with a lock washer and nut. Use a $\frac{7}{16}$-inch open-end wrench.

51. STARTING MOTOR INSTALLATION.

Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, ¾-in.
Wrench, open-end, ⅞-in.

Place the starting motor and adapter in position on the bell housing and, using a ⅞-inch open-end wrench, tighten the three cap screws and lock washers (fig. 61). Connect the two large terminals, using a ¾-inch open-end wrench, and the small terminal, using a $\frac{7}{16}$-inch open-end wrench.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Section IX

ENGINE

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Engine removal from vehicle	54
Removal of accessories	55
Disassembly of stripped engine	56
Vacuum pump	57
Maintenance and repairs	58
Assembly of engine	59
Engine installation	60

52. DESCRIPTION (figs. 64 and 65).

The Hercules DJXD Diesel is a six-cylinder in-line type engine and operates on the four-stroke cycle principle. The engine has overhead valves and the cylinder block and crankcase are cast integral. The cylinder head is detachable and contains the valves and rocker arm assemblies. The exhaust manifold, lubrication oil filter, vacuum pump, water pump and starting motor are mounted on the right side of the engine (fig. 64). The generator, fuel injection pump and governor, oil filler and breather pipe, bayonet-type oil gage, leak-off manifold, fuel pump, fuel lines, nozzle holders and nozzles, and air intake Venturi are located on the left side of the engine (fig. 65).

a. Construction.

(1) A four-bladed fan equipped with a three groove pulley is mounted at the front of the engine. The fan and generator are belt-driven from the crankshaft pulley by two belts. A third belt operates the vacuum pump from the fan pulley.

(2) (Figs. 66 and 67). The cylinder block and the upper half of the crankcase are cast integral. The water jacketing runs the full length of the cylinder bore. The casting also contains drilled passages for carrying the oil under pressure to the crankshaft main bearings and other moving parts requiring constant forced feed lubrication.

(3) The cylinder head is a one-piece casting attached to the cylinder block by 39 studs (figs. 96 and 97). The cast head is fully water jacketed. The valve seats and the valve guides are a part of this casting, although the valve guide bushings are removable. A copper gasket is used between the cylinder head and the cylinder block.

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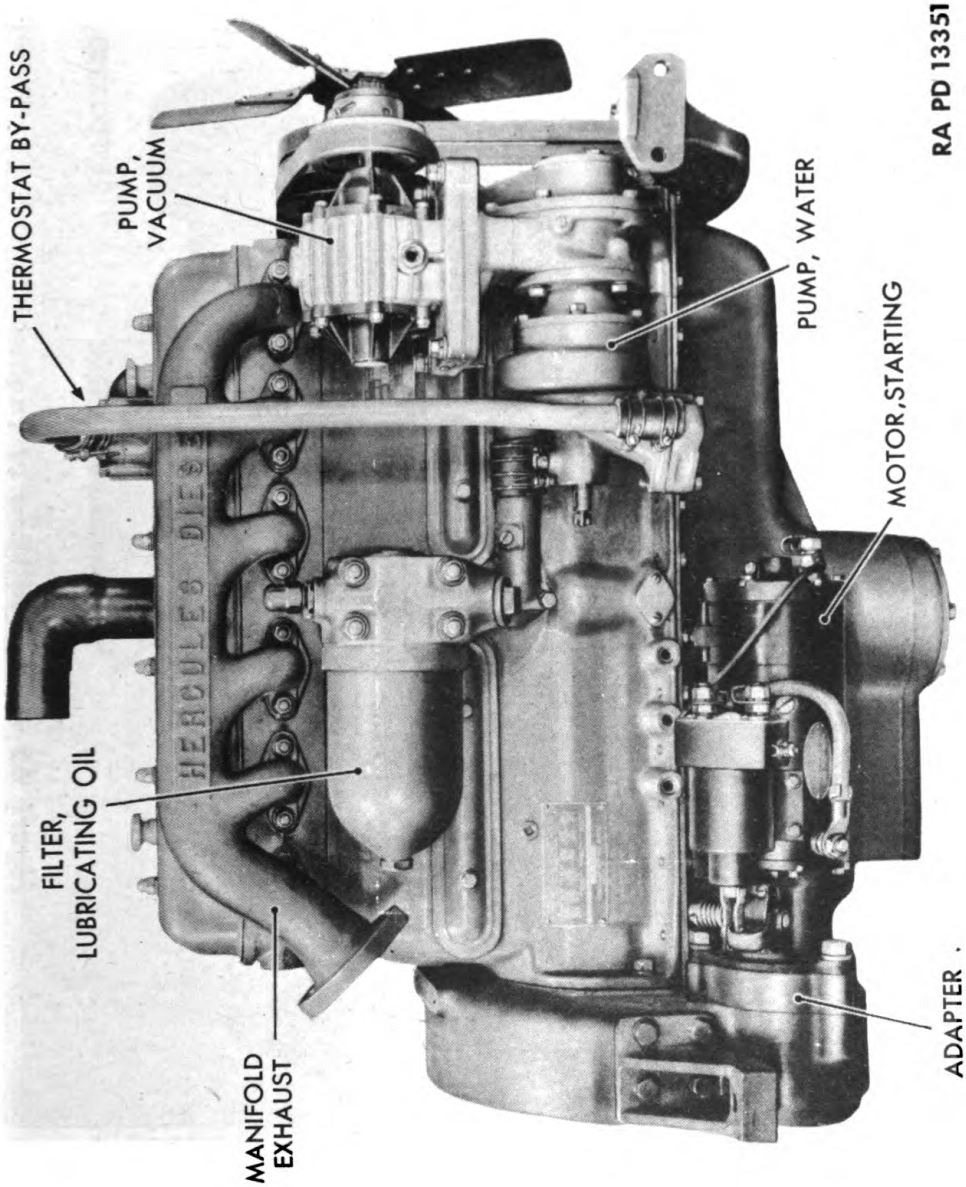


Figure 64—Right Side View of Engine

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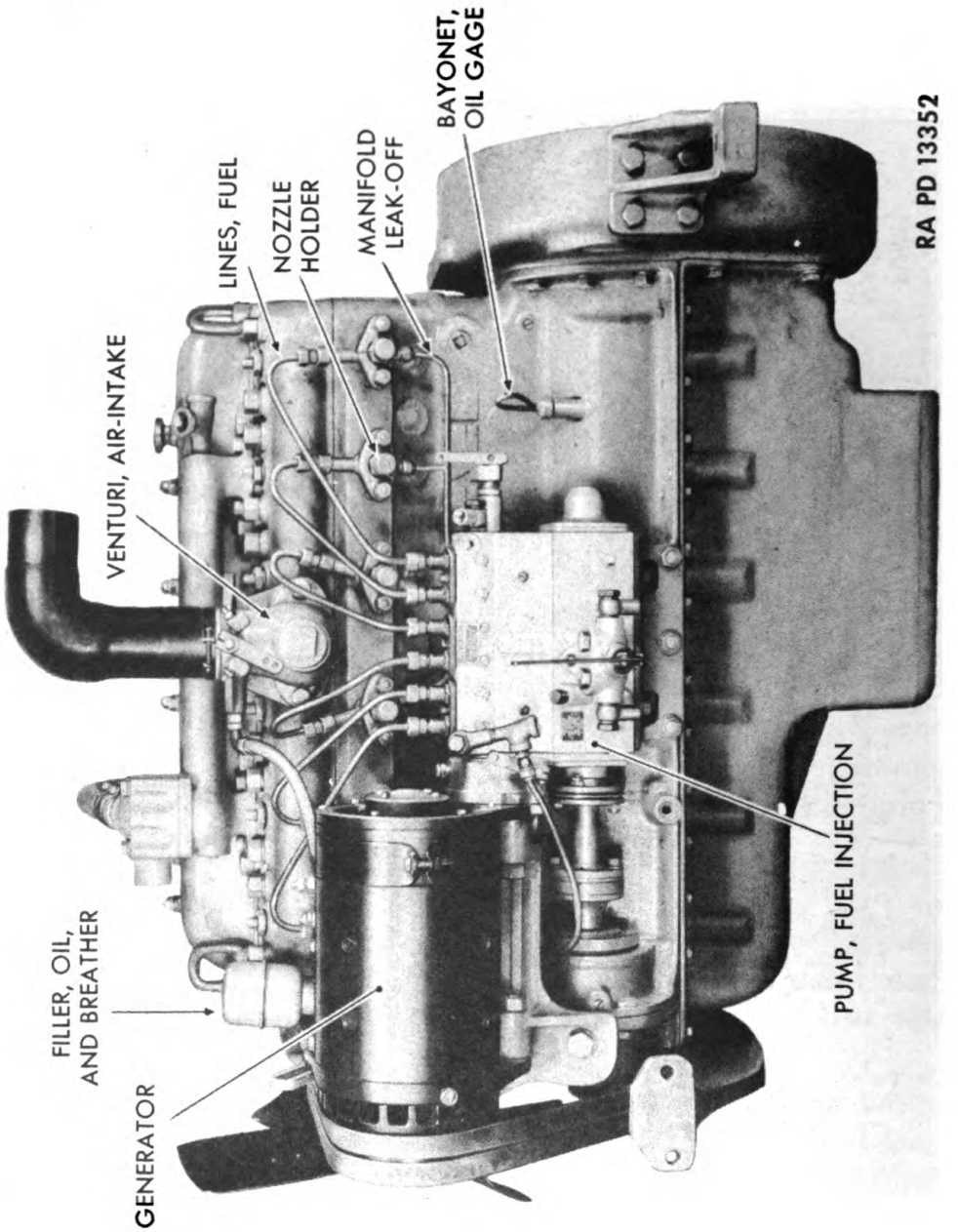


Figure 65—Left Side View of Engine

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ENGINE

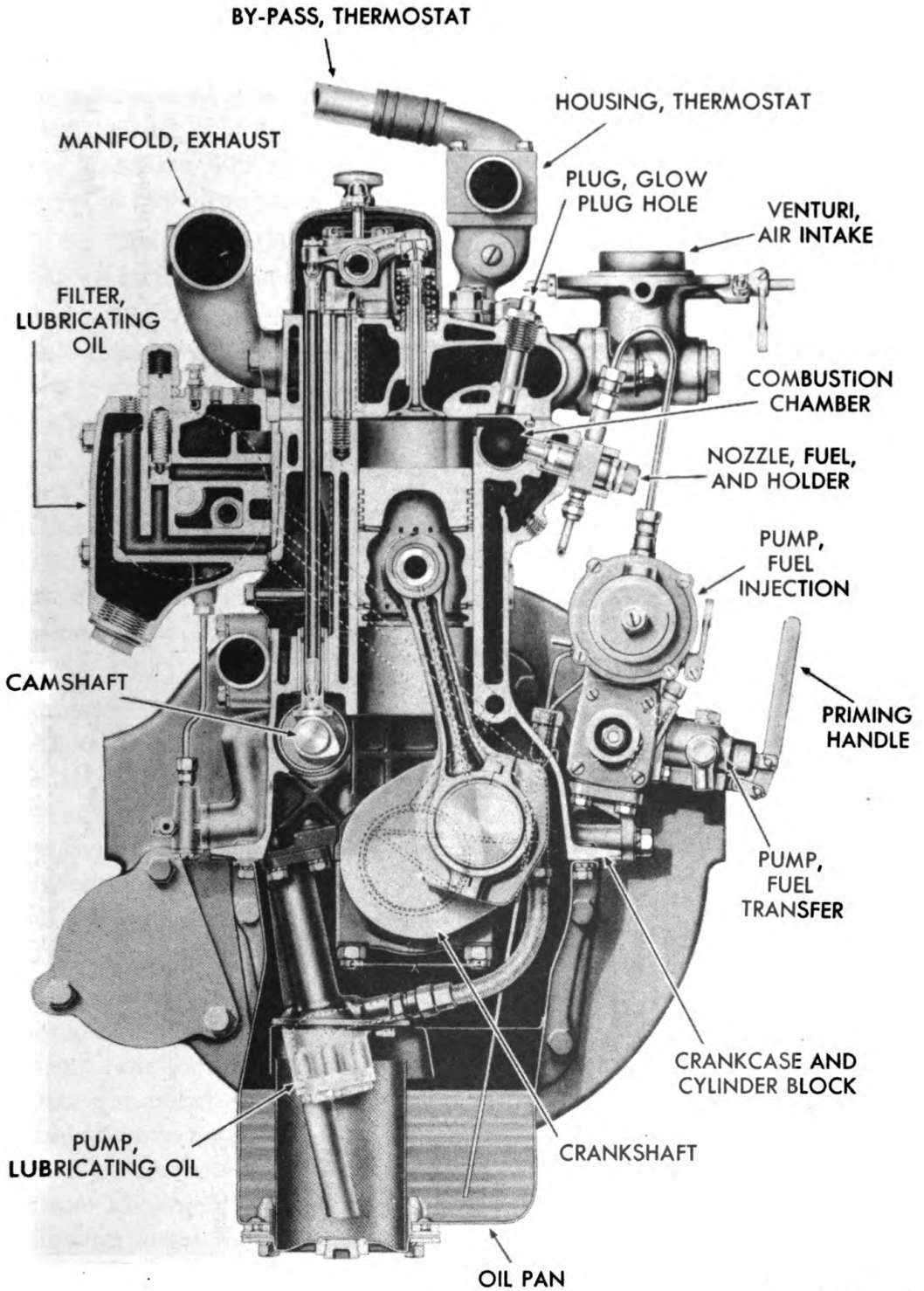


Figure 66—Front Sectional View of Engine

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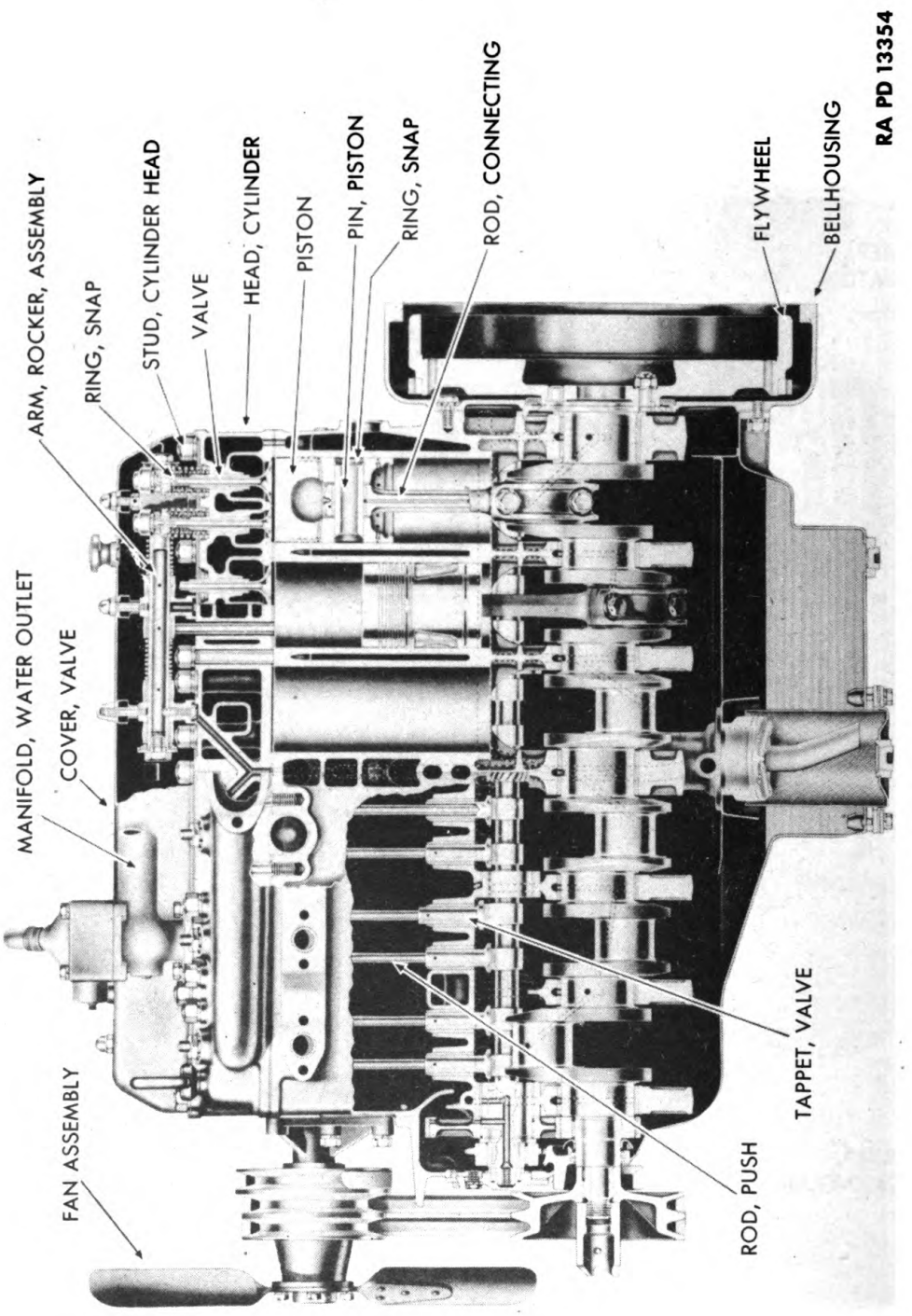


Figure 67—Side Sectional View of Engine

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(4) The crankshaft is a heat-treated steel drop forging (fig. 67), hardened and ground to close limits. It is balanced statically and dynamically. The seven main bearing design permits the use of a main bearing support on each side of the connecting rods to prolong bearing life and reduce engine vibration at high speed. Main bearings are of the removable shell type in both the crankcase and the bearing caps. The main bearing caps are drop-forged steel, securely fastened to the crankcase by studs. The main bearings are dowelled in place to permit removal of caps, and replacement without shifting bearings on the case.

(5) The connecting rods are drop-forged steel, drilled to allow oil to pass up to the piston pins (fig. 67).

(6) The pistons are made of an aluminum alloy. They are of the solid type, without saw slots or split skirt. Six piston rings are used on each piston. The top four rings are compression rings, and the two lower rings are oil regulating rings. Only one ring, the lower oil regulating ring, is below the piston pin. The piston pins are of the full-floating type. This means that the piston pin can rotate in both the piston and the connecting rod. The piston pins are prevented from moving endwise and striking the cylinder walls by the use of snap rings. These snap rings, one at each end of the piston pin, lock in grooves machined in the piston pin bosses of the piston.

(7) The valves are located in the cylinder head and are operated by conventional type tappets with hollow push rods running from the tappets to the rocker arms. The rocker arms are lubricated by means of oil forced through the hollow shaft on which they rotate. The oil is forced out through small holes in the rocker arms to the special ball cup over the valve stems. The valves are of the poppet type and have a 45-degree angle seat. The exhaust valves are made of silchrome steel and the intake valves of chrome nickel steel.

(8) The flywheel is marked (DC) "Dead Center," indicating *top dead center* for No. 1 piston, with graduations designating degree of crankshaft travel. These marks are easily visible through the flywheel timing hole located in the left front of the flywheel housing. The timing gears are punch-marked so that when the engine is disassembled for repair or overhaul, the gears can be properly assembled for correct timing. The flywheel is bolted to a flange at the rear end of the crankshaft. Proper alinement of the flywheel with crankshaft is obtained by a small locating dowel in the crankshaft flange and a dowel hole in the flywheel. The engine firing order is 1-5-3-6-2-4.

(9) The camshaft, made of cast alloy steel (fig. 66) is enclosed in the upper half of the crankcase. The camshaft rotates in four continuous ring type, steel-backed babbitt-lined bearings. These bearings will very

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rarely need replacing. The camshaft is driven by a helical cut gear on the crankshaft, which meshes with another helical cut gear mounted on the front end of the camshaft. The helical gear on the camshaft is keyed to the shaft and held in place with a nut and special lock washer.

(10) The engine is lubricated by a forced feed system which permits oil under pressure to be carried to the crankshaft main bearings through drilled passages in the crankcase.

(a) The connecting rods are lubricated through drilled holes in the crankshaft. These holes line up with the oil groove in the upper shell of the main bearings.

(b) The piston pins receive lubricating oil through a drilled passage in the connecting rods, and also by the oil scraped off the cylinder walls into the piston pin bosses of the pistons.

(c) Oil is forced to the rocker arms and valve compartment through drilled passages in the cylinder block. The passage in the cylinder block lines up with one of the rocker arm shaft brackets, permitting oil to be carried to the hollow shaft on which the rocker arms operate.

(d) The front cam bearing and the fuel pump drive shaft are also lubricated by pressure.

(e) The cylinders and pistons, valve tappets and the other cam bearings are lubricated by oil thrown off from the connecting rods and main bearings.

(f) The gears in the front compartment, as well as the timing chain, are oiled by means of suitable holes drilled through the front camshaft bearing and shaft. The same method is also used to lubricate the fuel injection pump drive assembly and the chain idler shaft. These drilled holes are metered by the rotation of the shafts so that the front compartment will not become overloaded with oil.

(11) The oil pump is a two-gear positive type pump attached to the inside of the crankcase. It is driven by a gear on the camshaft which meshes with a gear on the oil pump shaft. The lower end of the oil pump extends down into the oil pan. Oil enters into the pump through a large screen which aids the lubricating oil filter in removing foreign particles from the lubricating oil.

(12) Water is circulated through the engine cooling system by a centrifugal pump of the packless seal type. The pump is mounted on the right side of the engine crankcase at the front. The bushing in the pump at the timing gear end is lubricated through an oil passage which lines up with the gear compartment of the engine. The bearing at the water inlet end of the pump must be lubricated through the oiler provided on the pump housing.

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(13) The fuel pump is driven by a chain and sprockets. One sprocket is attached to the front of the camshaft and the other sprocket is fastened to the fuel pump drive shaft. Oil seals are provided at the rear of the fuel pump drive shaft to prevent oil leakage.

(14) The fuel injection equipment used on this engine consists of the following:

(a) Fuel Injection Pump. A Bosch fuel injection pump is equipped with a vacuum governor. A camshaft, mounted on ball bearings in the ends of the pump case, operates six plungers. A helix on the plunger controls the amount of fuel delivered to the fuel nozzles. The relation of the helix to the portholes in the fuel manifold of the pump is controlled by a toothed segment on the plunger mechanism. This mechanism operates a toothed control rod which, in turn, is connected to the governor. The plunger compresses the fuel and forces it through the delivery valve, fuel pipes and through the spring-loaded nozzle in the engine combustion chambers.

(b) Governor. A vacuum-type governor is operated by the change in vacuum created when a throttle valve, located in the air intake Venturi housing, is open or closed. The governor is connected to the air intake Venturi housing by a flexible tube.

(c) Check Valve. A check valve on the fuel outlet maintains a set pressure in the fuel manifold of the pump. The valve should never be completely disassembled unless absolutely necessary.

(d) Fuel Transfer Pump. The fuel transfer pump is located on the side of the lower injection pump case. It is actuated by one of the cams on the fuel injection pump camshaft which moves the pump plunger and, through suitable valves and drilled passages, delivers the fuel to the final filter, located between the transfer pump and the injection pump. The priming handle actuates the same plunger as the camshaft and is used in priming the fuel system manually. Should the engine be in the position where No. 1 cylinder is near the end of the compression stroke and the beginning of the power stroke, this plunger is inoperative; therefore, see that the engine is in some other position before working the priming handle.

(e) Fuel Nozzle and Holder Assembly. The fuel nozzle and holder assemblies inject the fuel into the combustion chamber.

(15) The combustion chambers, into which the air is compressed at the end of the compression strokes, are located at one side of the cylinder bores (fig. 66). Each of these chambers is lined with two removable sections known as combustion chamber liners (fig. 102). The spherically-shaped sections fit into those portions of the combustion chambers which

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are machined in the top of the cylinder block. The other sections, covers for the spherical sections, fit into recesses in the cylinder head.

(16) The clutch used with this engine is of the dry single-plate type incorporating a mechanical vibration damper. The flywheel forms a part of the clutch housing and is also the front plate of the clutch. Friction material is riveted to both sides of the clutch disk. Between the rear lining and disk are six crimped spring steel segments which constitute an independent cushioning for the linings. They also provide smooth clutch engagement. During the life of any one set of linings, no internal adjustment is required. The clutch throwout bearing is a ball bearing, completely enclosed, which receives lubrication from a well in the sleeve. The clutch shaft pilot bearing is also a ball bearing (located in the flywheel). This bearing is packed with lubricant and sealed so that no further attention is required.

b. Specifications.

Model	Hercules Diesel DJXD
Number of cylinders	6
Bore	4-in.
Stroke	4½-in.
Piston displacement (cu-in.)	339
Compression ratio	14.5 to 1
Rated horsepower (N.A.C.C.)	38.4
Maximum brake horsepower	103 at 2,600 rpm
Maximum torque (ft lb)	233 at 1,600 rpm
Crankcase capacity including oil filter	9½ qt
Firing order	1-5-3-6-2-4

53. TROUBLE SHOOTING.

Symptom and probable cause	Probable remedy
a. Lack of Power.	
Low or poor compression.	See below.
Air cleaner restricted.	Clean mesh element in SOLVENT, dry-cleaning.
Overheating.	See section VI.
Improper grade and viscosity of oil.	Change to specified seasonal grade.
b. Poor Compression.	
Valves worn.	Grind valves.
Valve seats worn or pitted.	Grind seats with valve seat grinder.
Piston rings weak, broken, stuck or worn.	Replace rings and correct cause of sticking.

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Symptom and probable cause	Probable remedy
Tappets sticking.	Clean guides.
Tappets set too close.	Set clearance at 0.010 in.
Cylinder head loose.	Tighten head.
Cylinder head gasket leaking.	Replace gasket.
Worn pistons.	Replace worn parts.
Worn cylinders.	Rebore cylinders.
Valve stems worn.	Replace valves.
Valve guides worn.	Replace guides.
Valve springs weak or broken.	Replace springs.
Valve timing incorrect.	Time properly.

c. Excessive Cylinder and Piston Wear.

Improper grade and viscosity of oil.	Change oil to specified seasonal grade.
Lack of oil.	Keep oil at correct level.
Dirty oil.	Always change dirty oil.
Overheating.	See section VI.
Piston improperly installed and fitted.	Correct or replace piston.
Piston rings not properly fitted to piston groove and cylinder wall.	Install new rings and fit correctly.
Piston rings stuck in piston grooves or broken.	Clean or replace rings.
Air cleaner not clean, allowing dirt to enter combustion chamber.	Clean air cleaner mesh and sump.

d. Bearing Failures.

Crankshaft bearing journal rough or out of round.	Grind or replace shaft.
Crankshaft oil passage restricted.	Clean passages and line.
Bearings sprung.	Replace sprung inserts.
Bearings loose.	Replace shells.
Crankshaft out of alinement.	Straighten or replace if necessary.
Lack of oil.	Add oil or check oil pump.
Low oil pressure.	Adjust pump to deliver 5-lb per sq in. pressure at idling and at least 25-lb per sq in. pressure at running speed. Fit bearings properly.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Symptom and probable cause	Probable remedy
Overspeeding engine.	Continuous operation at maximum speed or close to it is to be avoided. Exercise caution when going downgrade.
Restricted oil passages.	Clean oil passages and line.
Bent connecting rod.	Replace rod.
Improper oil.	Use specified seasonal grade oil.
e. Burned Valves and Seats.	
Tappets set too close.	Set at 0.010-in.
Weak valve springs.	Replace springs.
Improper valve timing.	Time properly (see par. 59 **g**).
Excessive carbon deposits around seat and valve head.	Clean carbon.
Valves sticking in guides.	Clean stems and guides. Replace parts as required.
Improper type valves.	Use genuine parts.
Valve head too thin causing hot sections.	Replace valve.
Valve seats too narrow.	Cut seats to correct width.
Overheating.	See section VI.
Low-grade fuel.	Use good quality fuel.
f. Valves Sticking.	
Insufficient clearance between valve stem and guide.	Ream guides for proper clearance.
Valve springs weak.	Replace springs.
Valve springs broken.	Replace springs.
Valve stems scored or dirty.	Replace or clean valves.
Gummy deposits from inferior fuel or lubricating oil.	Clean. Use proper seasonal grade fuel or lubricating oil.
g. Overheating.	
Ineffective cooling.	See section VI.
Lack of oil.	Add oil.
Improper valve timing.	Correct timing.
Exhaust line restricted.	Check muffler and tail pipe.
Faulty thermostat.	Change thermostat.
Cracked cylinder head.	Replace head.
Leaking head gasket.	Replace gasket.

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Symptom and probable cause	Probable remedy
h. Excessive Oil Consumption.	
Piston rings worn or broken.	Install new rings.
Crankcase gasket loose.	Tighten or replace.
Front gearcase loose.	Tighten.
Poor grade of oil.	Use recommended seasonal grade oil, (see section XI).
Cylinder walls worn.	Rebore cylinders.
Main or rod bearings worn or loose.	Replace bearings.
Ring gaps too great.	Install new rings.
Ring gaps lined up.	This condition will correct itself.
Rings poorly seated.	Replace rings.
Overheating.	See section VI.
Oil ring slots clogged with carbon.	Clean rings of carbon. Replace rings if necessary.
Excessive oil pressure.	Adjust pump pressure.
i. Low Oil Pressure.	
Improper oil.	Use proper seasonal grade oil.
Pressure regulating plunger worn or clogged.	Clean or replace plunger.
Oil pump screen clogged.	Clean screen.
Excessive crankshaft and connecting rod bearing clearance.	Replace shells.
Oil pump worn.	Overhaul oil pump.
j. Fuel Knocks.	
Spray nozzle valve sticking.	Clean nozzle and valve.
Spray nozzle spring broken.	Replace complete holder.
Fuel delivery valve in injection pump stuck open.	Clean valve stem and valve seat.
Broken delivery valve spring in injection pump.	Replace spring.
Inlet or exhaust valves sticking or not properly seating.	Free up valve stems. Check valve springs. Grind valves when necessary.
Leaking cylinder head gasket.	Replace gasket.
Improper fuel.	Use specified fuel.

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k. Engine "Missing" on One or Two Cylinders. To determine which cylinder or cylinders are "missing", loosen the nuts connecting the fuel lines to the fuel nozzles, one at a time. If the engine speed remains the same and exhaust sounds the same, this indicates that the cylinder is "missing." If the engine speed slows down and the exhaust loses its rhythm, then the cylinder is functioning.

Fuel valve stuck in body.	Remove and clean or install new injector.
Air or gas binding in fuel pump lines.	Usually, when testing to see which cylinder is "missing," this condition will be eliminated, as opening the nut allows the air or gas to escape.
Exhaust or intake valve stuck.	Remove valve cover and check to locate which one is stuck. Free with kerosene or alcohol poured down the stem. Alcohol is the quickest solvent. If still stuck, remove head and determine cause.
Exhaust or intake valve spring or spring retainer lock broken.	Replace defective unit.
Improper exhaust or intake valve clearance between valve and rocker arm.	Check clearance and reset to proper clearance.

54. ENGINE REMOVAL FROM VEHICLE.

Blocks, wood
Hammer
Hoist
Pail
Pliers
Pliers, channellock
Rope, Manila, 3/4-in. (at least 14 ft)
Screwdriver
Screwdriver, heavy-duty
Screwdriver, heavy-duty square shank
Wrench, box, 9/16-in.
Wrench, open-end, 3/8-in.
Wrench, open-end, 7/16-in.
Wrench, open-end, 1/2-in.
Wrench, open-end, 9/16-in.
Wrench, open-end, 5/8-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 7/8-in.
Wrench, open-end, 1 5/16-in.
Wrench, socket, 9/16-in.
Wrench, socket, 3/4-in.
Wrench, socket, 7/8-in.
Wrench, socket, 1 5/16-in.
Wrench, thin wall socket, 3/8-in.

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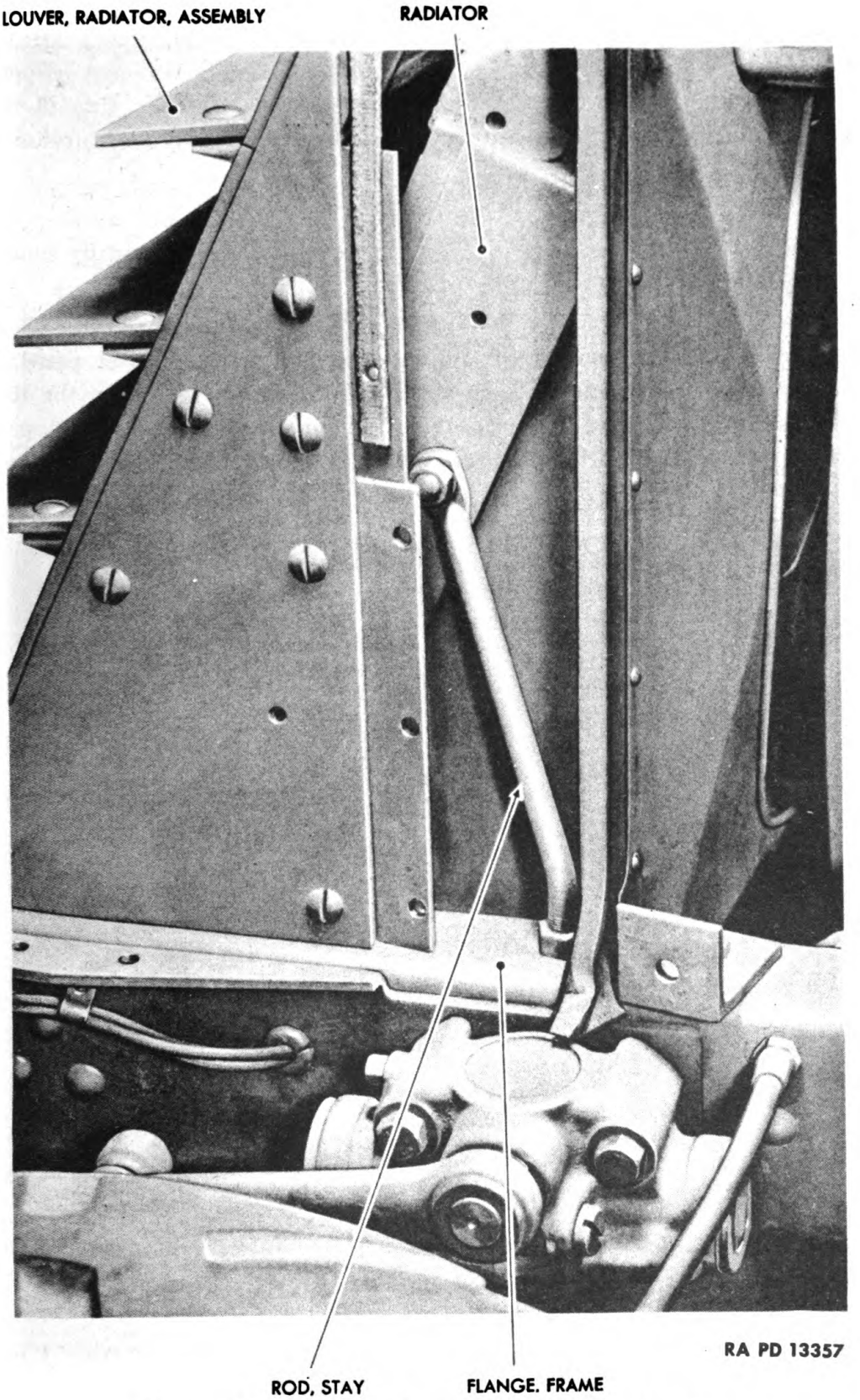


Figure 68—Radiator Support—Left Front View

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

a. Drain Radiator.

Pail
Pliers

Open drain cocks under radiator and in the left rear side of the engine block. Drain water into pail or on ground (save antifreeze if used).

b. Remove Hood.

Hoist
Rope
Screwdriver, heavy-duty square shank
Wrench, open-end, $\frac{9}{16}$-in.

Remove three elastic stop nuts and bolts at rear of center panel of hood. Remove nut and bolt on inside of shutter frame, near the top, on each side of frame. Use rope and hoist to lift off hood with top of shutter frame left on hood. Hood can also be slipped over front of car by three men.

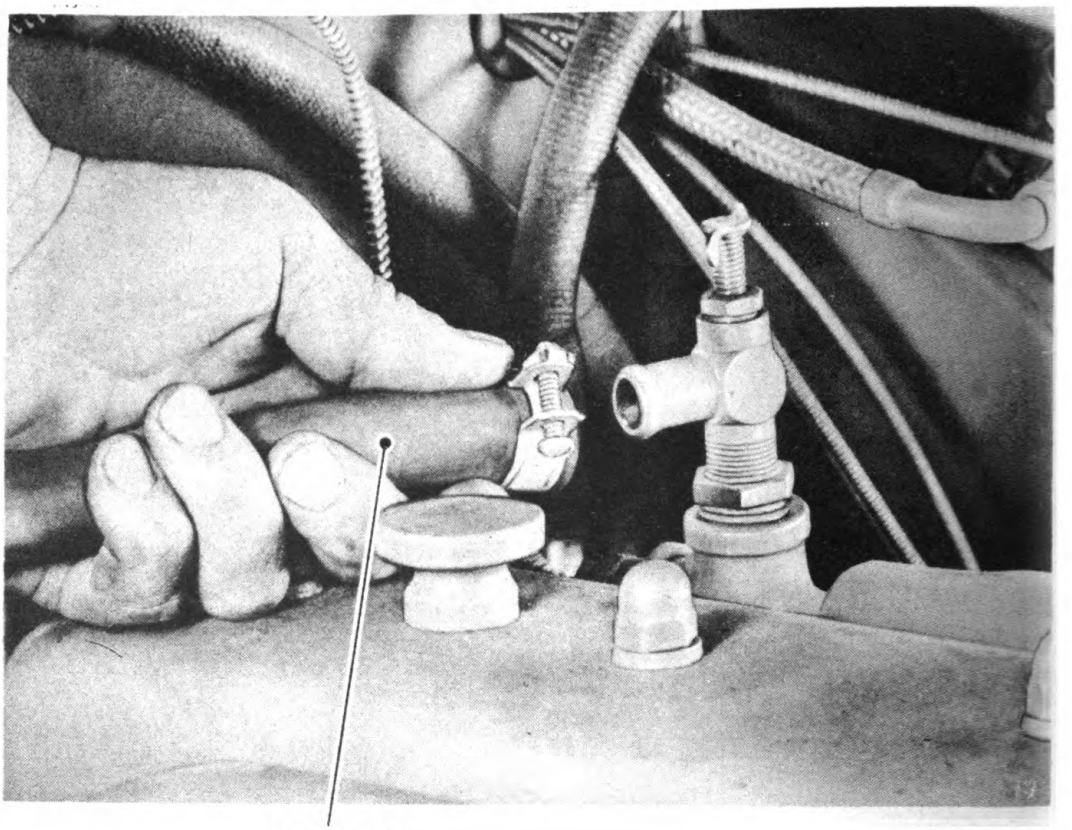


Figure 69—Disconnecting Upper Heater Hose

c. Remove Shutter Assembly.

Hoist, chain
Screwdriver, heavy-duty
Wrench, box, $\frac{9}{16}$-in.
Wrench, open-end, ½-in.

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Remove bolts and nuts that hold shutter frame to engine side armor plates. Disconnect shutter control on lower right side of radiator. Lift shutter frame straight up and out.

d. Remove Radiator Hose Connections.

Screwdriver

Loosen clamps that hold inlet and outlet radiator hoses and pull hoses loose from radiator.

e. Remove Radiator.

Hoist, chain
Wrench, socket, ¾-in.
Wrench, socket, ⅞-in.

Disconnect radiator from cross member by removing holding stud nuts, springs, washers and pads. Disconnect stay rods at frame by removing nuts from stay rod bolts underneath car on the bottom side of the top frame flange (fig. 68). Remove radiator assembly from car by lifting up and slightly forward.

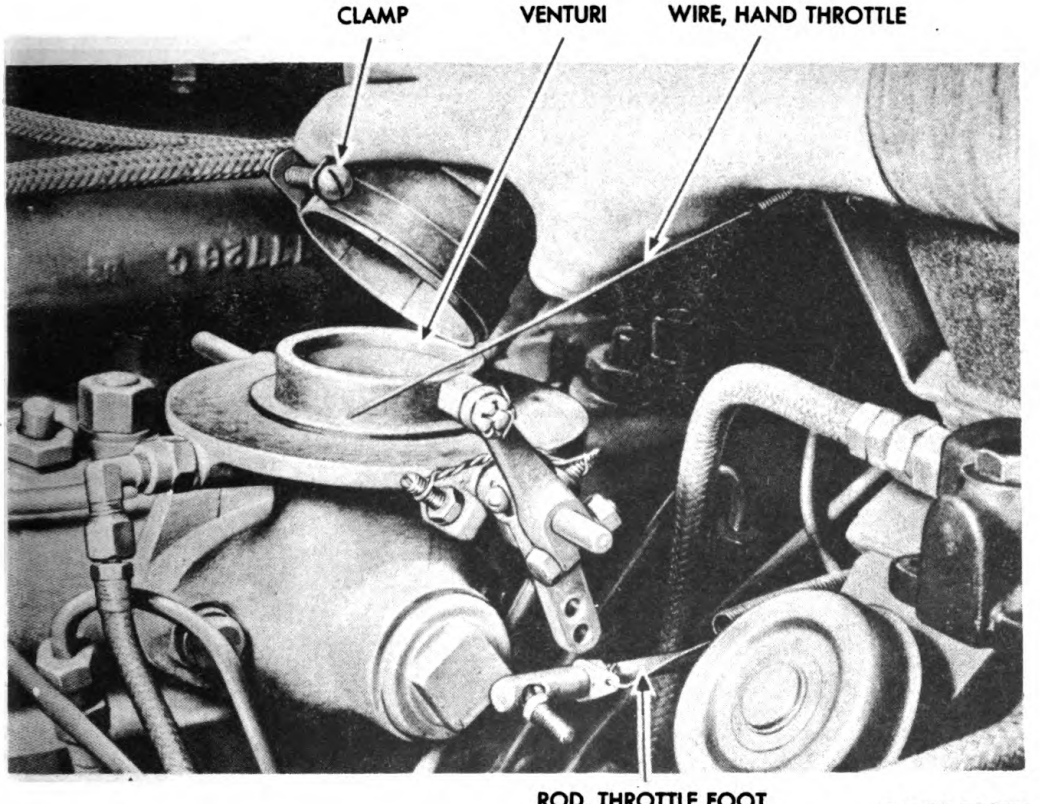


Figure 70—Removing Air Intake and Hand and Foot Accelerator from Venturi

f. Remove Heater Inlet and Return Hoses.

Screwdriver

Loosen clamp that holds inlet hose to cylinder head connection and

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pull off hose (fig. 69). Loosen clamp that holds return hose to water pump connection and the clip that holds hose at cylinder head. Pull hose from water pump connection.

g. Disconnect Battery.

Wrench, open-end, $\frac{9}{16}$-in.

Remove cap screws and lock washers that hold battery compartment covers and lift off covers. Loosen nuts which clamp cable terminals to battery terminals and pull off cables from terminals. Always pull off negative cable first. Tape cable terminals.

h. Remove Air Intake Pipe to Venturi.

Screwdriver

Loosen air intake pipe hose clamp at air cleaner and clamp at Venturi. Remove the air intake pipe (fig. 70).

i. Disconnect Throttle Controls.

Screwdriver Wrench, open-end, $\frac{7}{16}$-in.

Disconnect the hand-operated throttle wire from the Venturi. Disconnect the foot operated throttle rod from the Venturi (fig. 70).

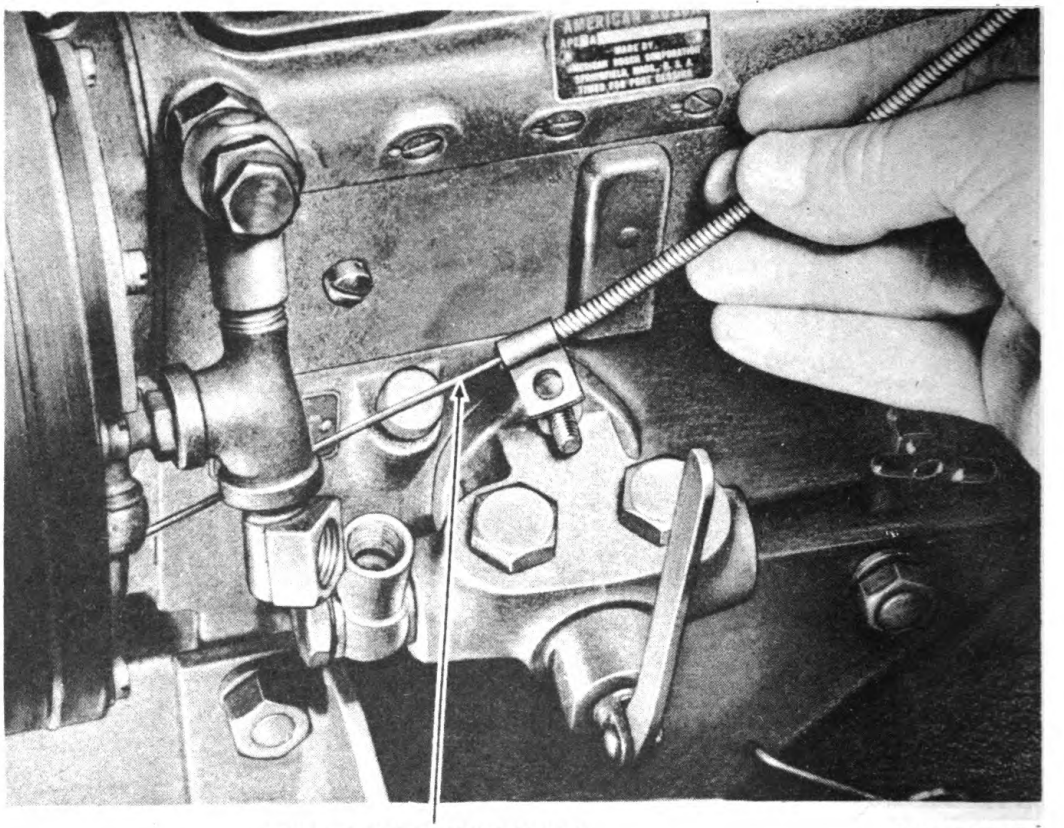


Figure 71—Disconnecting Governor Control Wire

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j. Disconnect Injector Controls

Screwdriver
Wrench, open-end, 3/8-in.

Disconnect the fuel injection pump shut-off wire and the governor control wire (fig. 71).

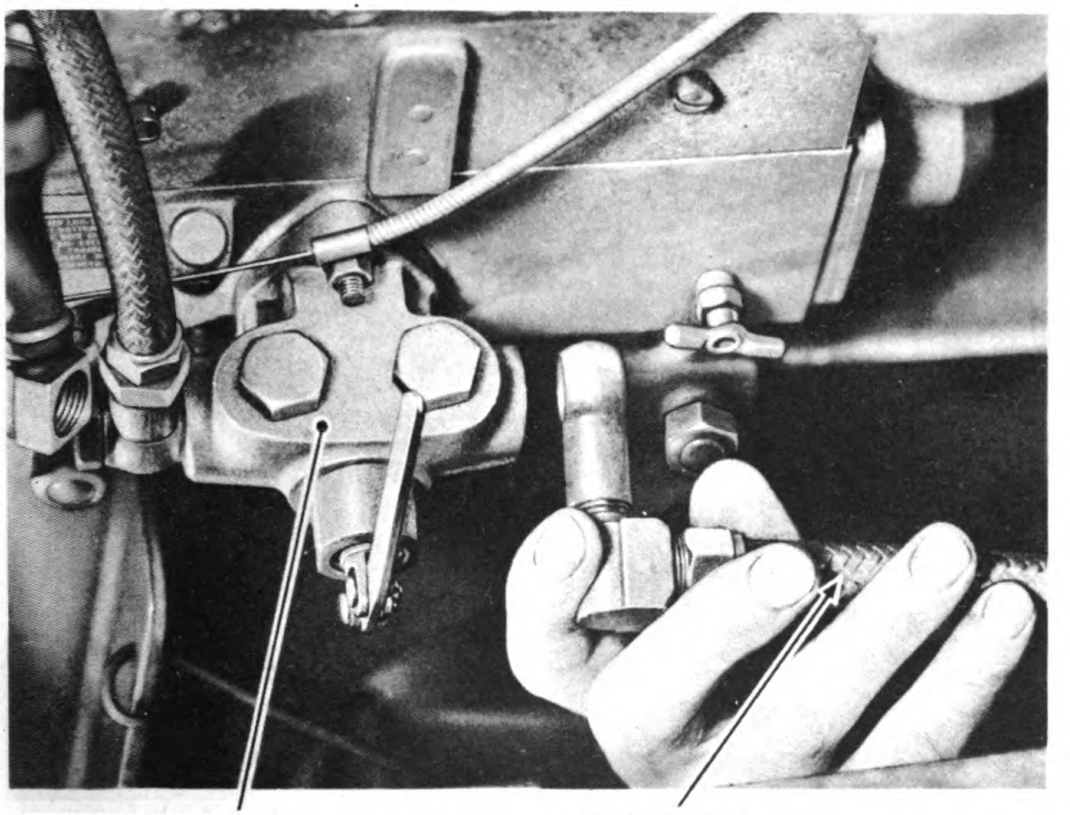


Figure 72—Disconnecting Main Line from Fuel Tank to Pump

k. Disconnect Fuel Lines.

Wrench, open-end, 5/8-in.
Wrench, open-end, 3/4-in.

Disconnect the main line to the fuel transfer pump (fig. 72) and the fuel return line (fig. 73). Disconnect the fuel line from the transfer pump to the filter at the pump end. Disconnect the fuel line from the filter to the fuel injection pump (fig. 74).

l. Disconnect the Generator Wires (figs. 38, 39, 40, 41, 42 and 43).

Pliers, channellock
Screwdriver
Wrench, open-end, 3/8-in.
Wrench, thin wall socket, 3/8-in.
Wrench, socket, 9/16-in.
Wrench, open-end, 5/8-in.

Remove armature condenser from housing and screw off armature conduit nut from housing. Remove armature terminal post nut, lift off cable terminal from armature terminal post and pull out conduit and wire assembly. Remove the generator field terminal housing plug and

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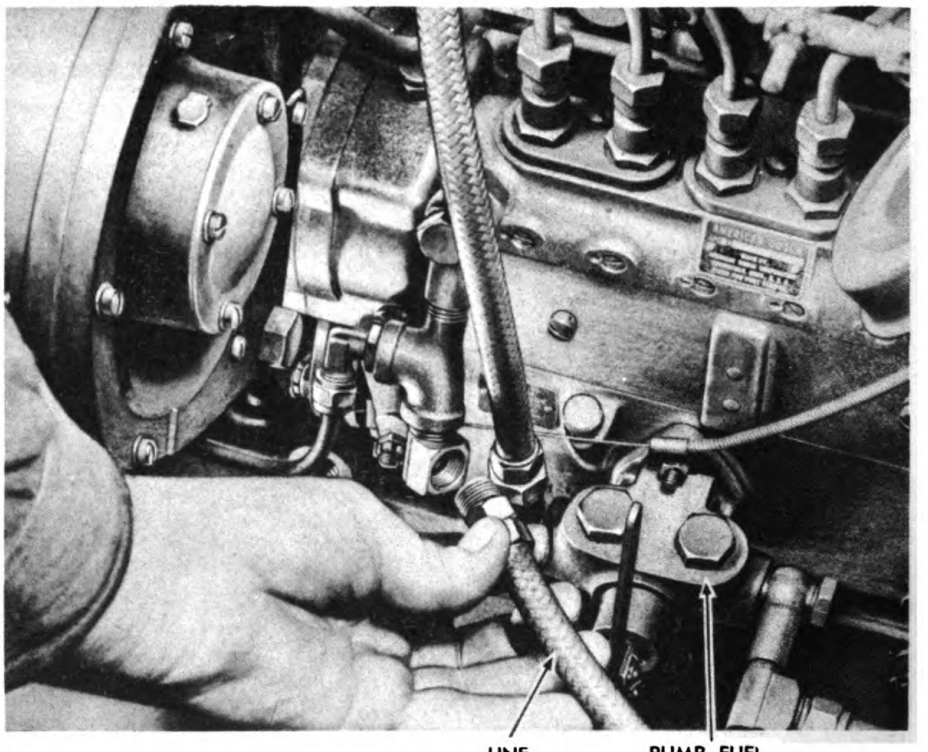


Figure 73—Disconnecting Fuel Return Line

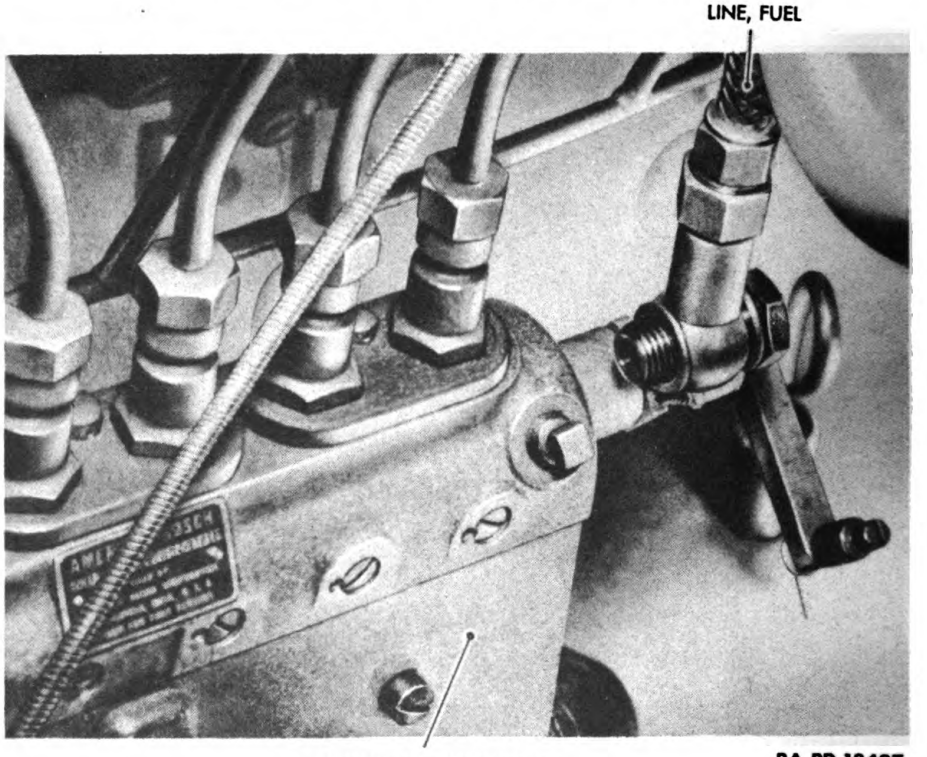


Figure 74—Disconnecting Line from Fuel Filter to Pump

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screw off conduit nut from housing. Remove field terminal post nut and pull out conduit and wire assembly. Remove the stove bolt that clamps the armature and field wires to the thermostat housing.

m. Disconnect the Venturi Heater Unit.

Wrench, open-end, $\frac{7}{16}$-in.

Disconnect the wire to the Venturi (intake) heater unit (fig. 75).

n. Disconnect the Heat Indicator Unit.

Wrench, open-end, $\frac{5}{8}$-in.

Loosen temperature gage bulb adapter nut at rear of water outlet manifold and pull out bulb from adapter (fig. 76).

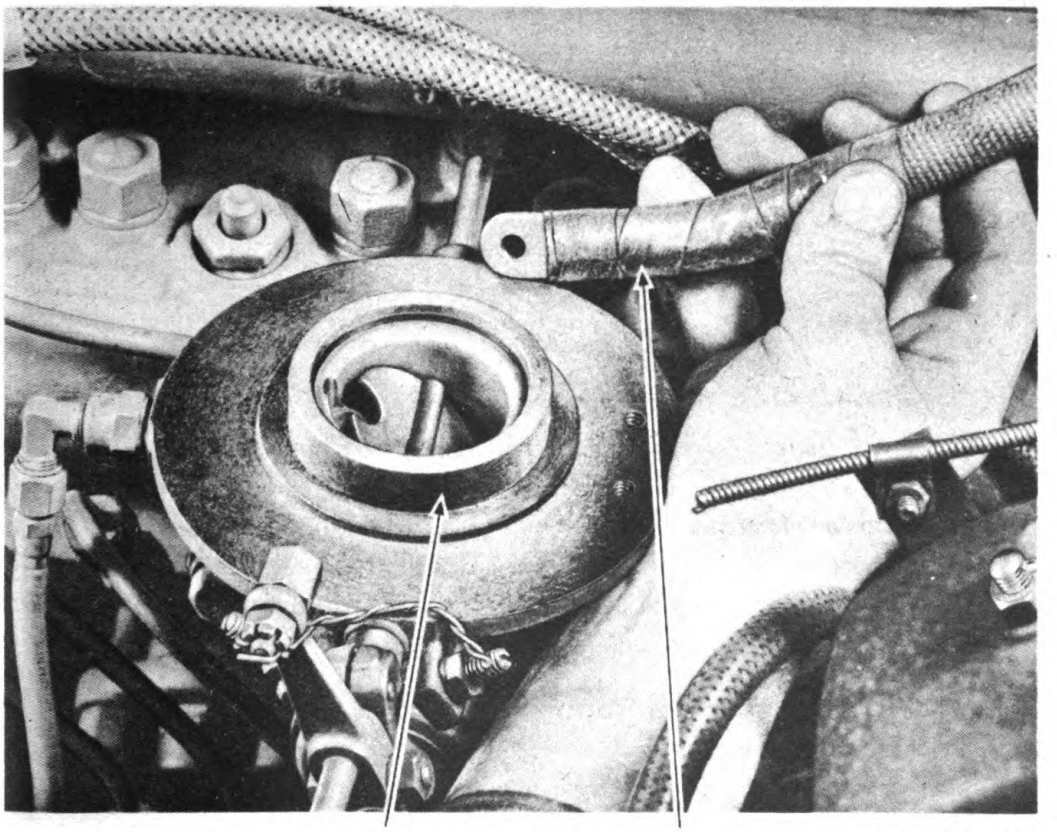


Figure 75—Disconnecting Heater Element at Venturi

o. Remove Left-hand Air Funnel Assembly.

Screwdriver

Wrench, open-end, $\frac{9}{16}$-in.

Loosen clamp that holds funnel assembly to ventilator box. Remove nut, cap screw and lock washer that hold funnel support clamp to bracket and lower assembly.

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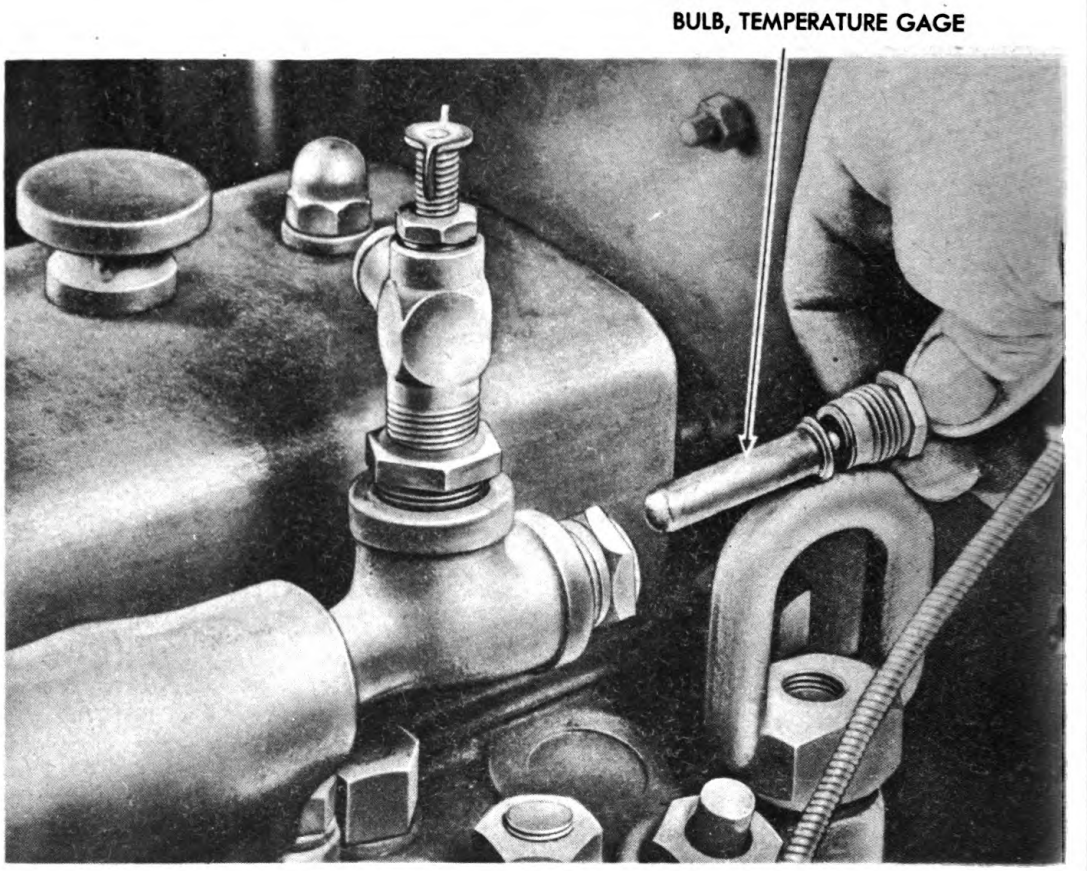


Figure 76—Disconnecting Heat Indicator Unit RA PD 13361

p. Remove Vacuum Line.

Screwdriver — Wrench, open-end, 7/8-in.

Remove the vacuum line and hose from the pump to the screen and check valve on dash.

q. Disconnect Vacuum Pump Lines.

Wrench, open-end, 5/8-in. — Wrench, open-end, 7/8-in.

Disconnect the vacuum pump lines to oil and air reservoir (fig. 77).

r. Remove Vacuum Pump Oil and Exhaust Tank.

Screwdriver — Wrench, open-end, 7/16-in.

Remove the four stove bolts that hold the vacuum pump oil and exhaust tank in position and remove the tank (fig. 78).

s. Disconnect Oil Filter and Pressure Gage Line Assemblies.

Wrench, open-end, 7/16-in. — Wrench, open-end, 1/2-in.

Disconnect oil gage line from oil filter by unscrewing inverted flared tube nut (fig. 79).

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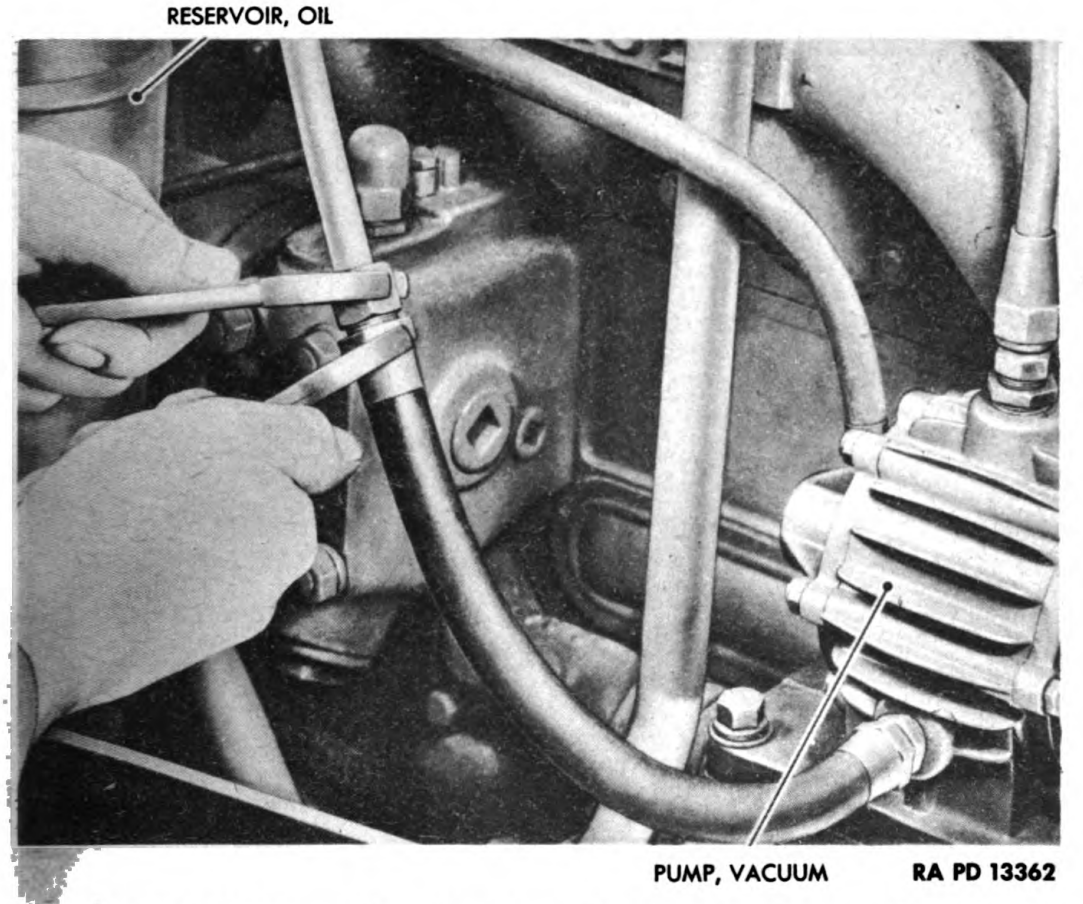


Figure 77—Disconnecting Line from Vacuum Pump to Oil Reservoir

t. Disconnect Exhaust Pipe at Manifold.

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

Disconnect exhaust pipe flange from manifold flange (fig. 80).

u. Remove Starter.

Wrench, open-end, 7/16-in.
Wrench, open-end, 7/8-in.
Wrench, open-end, 3/4-in.

Remove the two large terminals and one small terminal from the starter. Remove the three cap screws that hold starter in position. Remove the starter.

v. Disconnect Brake Vacuum Booster Cylinder.

Pliers

Remove the clevis pin from the clevis at the rear of the brake vacuum booster cylinder and disconnect the cylinder from the bracket.

w. Prepare Engine for Removal.

Hoist
Rope, Manila, 3/4-in. (at least 14 ft)
Wrench, open-end, 9/16-in.
Wrench, socket, 9/16-in.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

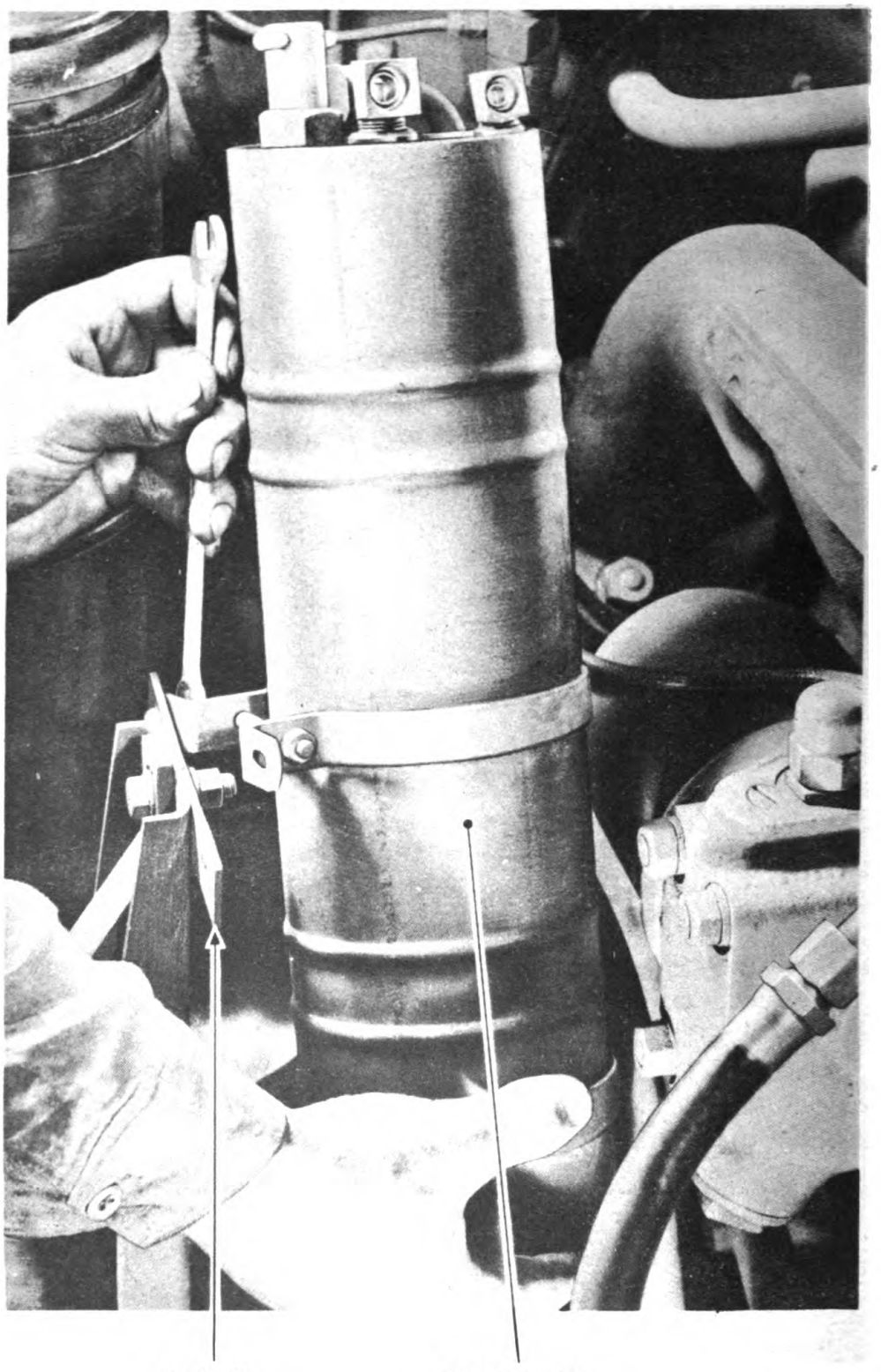


Figure 78—Removing Vacuum Pump Oil and Exhaust Tank

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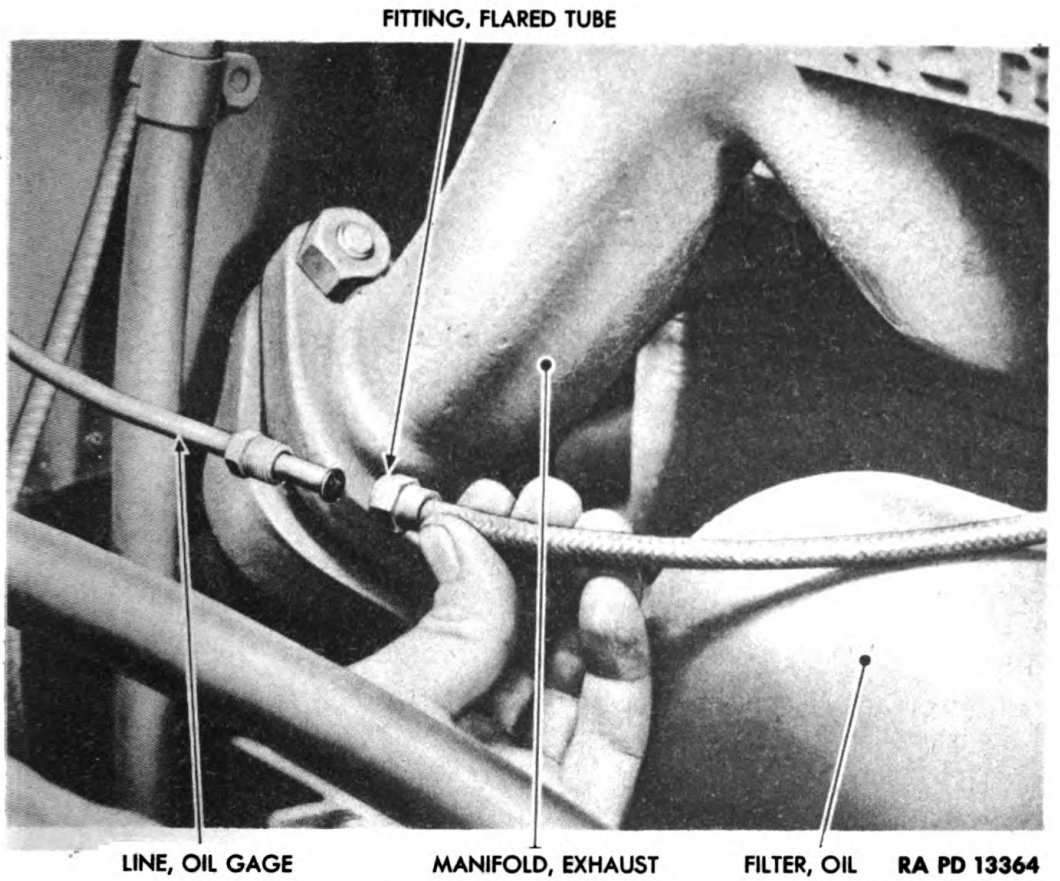


Figure 79—Disconnecting Oil Line to Gage

Tie rope, forming a figure eight around engine. Place hoist under rope for proper balance and remove slack by raising hoist hook. Remove cap screws and lock washers which hold transmission to engine bell housing (fig. 81).

x. Disconnect Engine Supports.

Pliers
Wrench, open-end, 3/4-in.
Wrench, open-end, 15/16-in.
Wrench, socket, 3/4-in.
Wrench, socket, 15/16-in.

Remove cotter pins from castellated nuts at rear engine support bolts and remove nuts, bolts, and washers (fig. 82). Remove nuts, lock washers and cap screws from front engine supports (fig. 83).

y. Remove Engine.

Blocks, Wood
Hammer
Screwdriver, heavy-duty

Lift engine until it is free of supports. Block up transmission rigidly in this position. Separate bell housing from transmission and move engine straight forward until clutch assembly is free of splined shaft. Guide engine out of vehicle and place in stand or on blocks.

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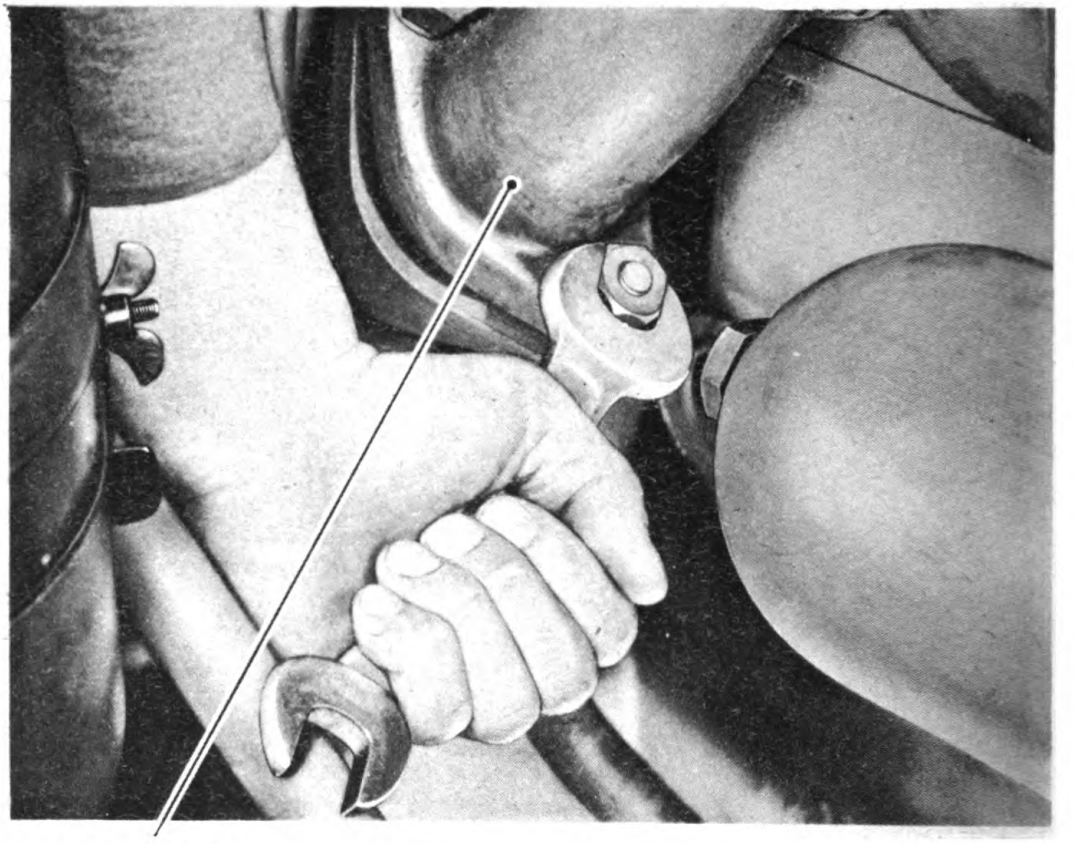


Figure 80—Disconnecting the Exhaust Pipe

55. REMOVAL OF ACCESSORIES.

Handle, speed
Pliers
Screwdriver, heavy
Wrench, open-end, 9/16-in.
Wrench, open-end, 5/8-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 7/8-in.
Wrench, socket, 9/16-in.

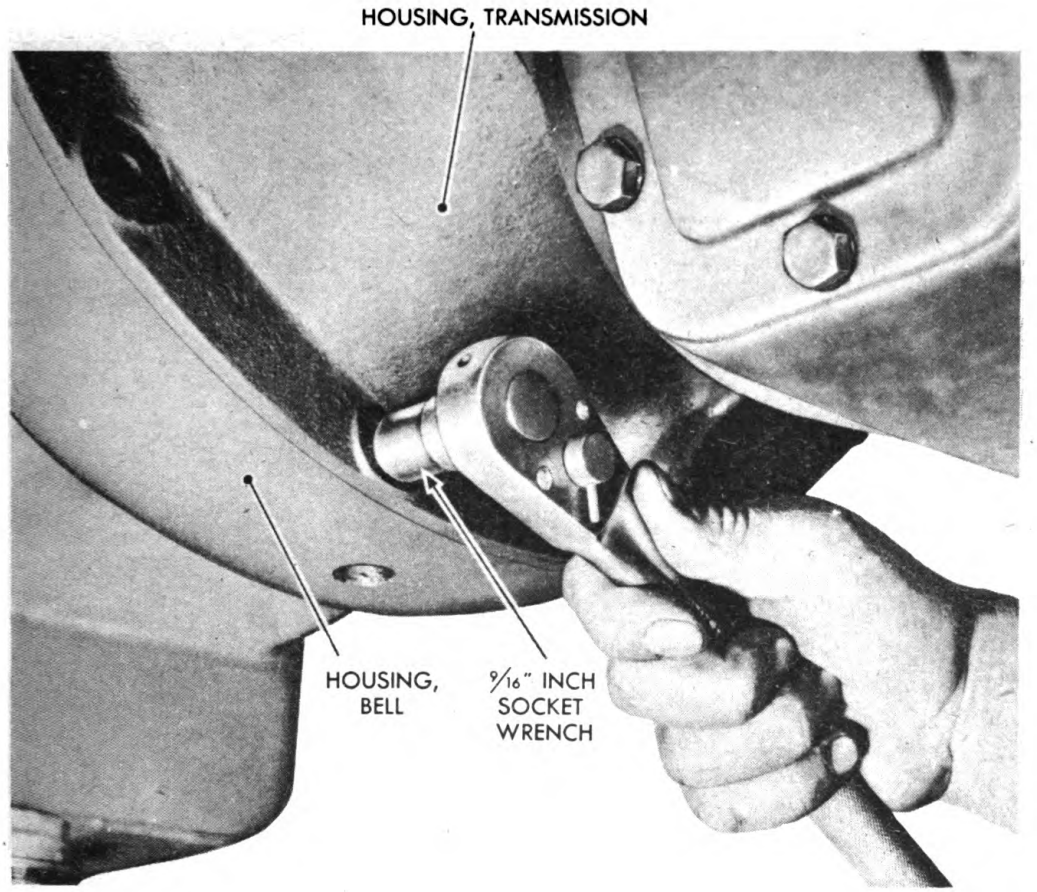
a. Remove Generator.

Screwdriver, heavy
Wrench, open-end, 3/4-in.
Wrench, open-end, 7/8-in.

(1) Loosen, *but do not remove,* the two bolts which hold the generator to the generator bracket. These bolts are located under the generator (fig. 44) (7/8-in. open-end wrench).

(2) Loosen the nut on the bolt which extends through the slotted end of the belt adjustment strap and through the lug of the generator housing (3/4-in. open-end wrench) (fig. 19). After these three bolts have been loosened, push the generator in toward the engine as far as it will go, to ease the tension on the generator drive belts.

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Figure 81—Disconnecting the Engine from Bell Housing

(3) Pry off the two generator drive belts with a heavy screwdriver.

(4) Remove the bolt, nut, lock washer, and plain washer from the adjustment strap. Remove the two bolts and lock washers from under the generator. Lift off the generator. Be sure to take a firm hold of the generator as this unit is heavy.

(5) Remove the slotted belt adjusting strap by loosening and removing the cap screw that holds this strap to the fan bracket. Use a ¾-inch open-end wrench. A lock washer and spacer will come away with the cap screw and strap.

b. Remove Fan Assembly.

Pliers Wrench, open-end, ¾-in.

Remove the four nuts and lock washers that hold the fan assembly to engine block. Remove the vacuum pump drive belt and lift off fan assembly.

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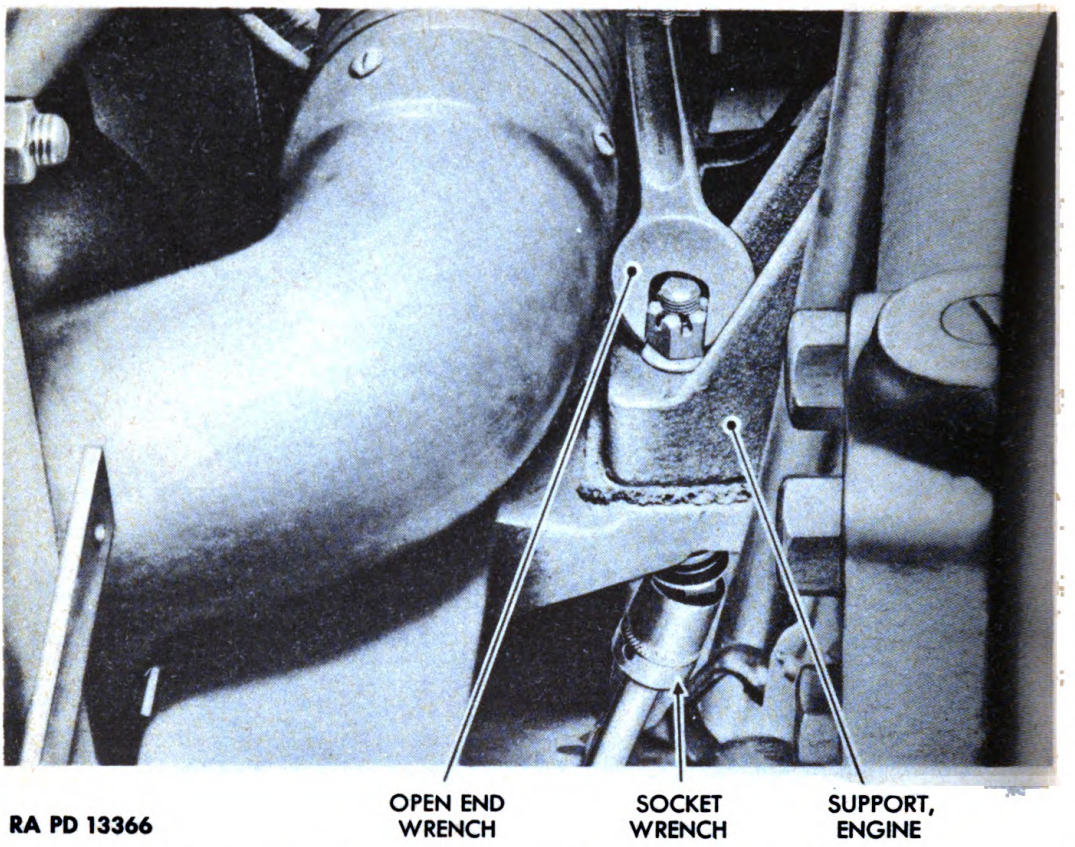


Figure 82—Removing Rear Engine Support Bolt

c. Remove Vacuum Pump (fig. 84).

Wrench, open-end, 5/8-in.

Remove the four cap screws, lock washers and plain washers from the base of the vacuum pump. Lift off the vacuum pump and heavy cork gasket. The vacuum pump drive pulley will come off as part of the pump assembly.

d. Remove Thermostat Bypass.

Screwdriver

Loosen two hose clamps, one at the top and one at the bottom of the thermostat bypass and slip off thermostat bypass assembly.

e. Remove Lubricating Oil Filter.

Wrench, open-end, 3/4-in.

Loosen and remove the four retaining nuts and lock washers. Lift the oil filter off the studs by pulling straight out. Remove the gasket and the small dowel which locates the filter in its proper position on the engine.

f. Remove Water Pump.

Wrench, open-end, 9/16-in.

The water pump assembly is secured to the engine by six cap screws and lock washers; four in the mounting flange at the front of the pump

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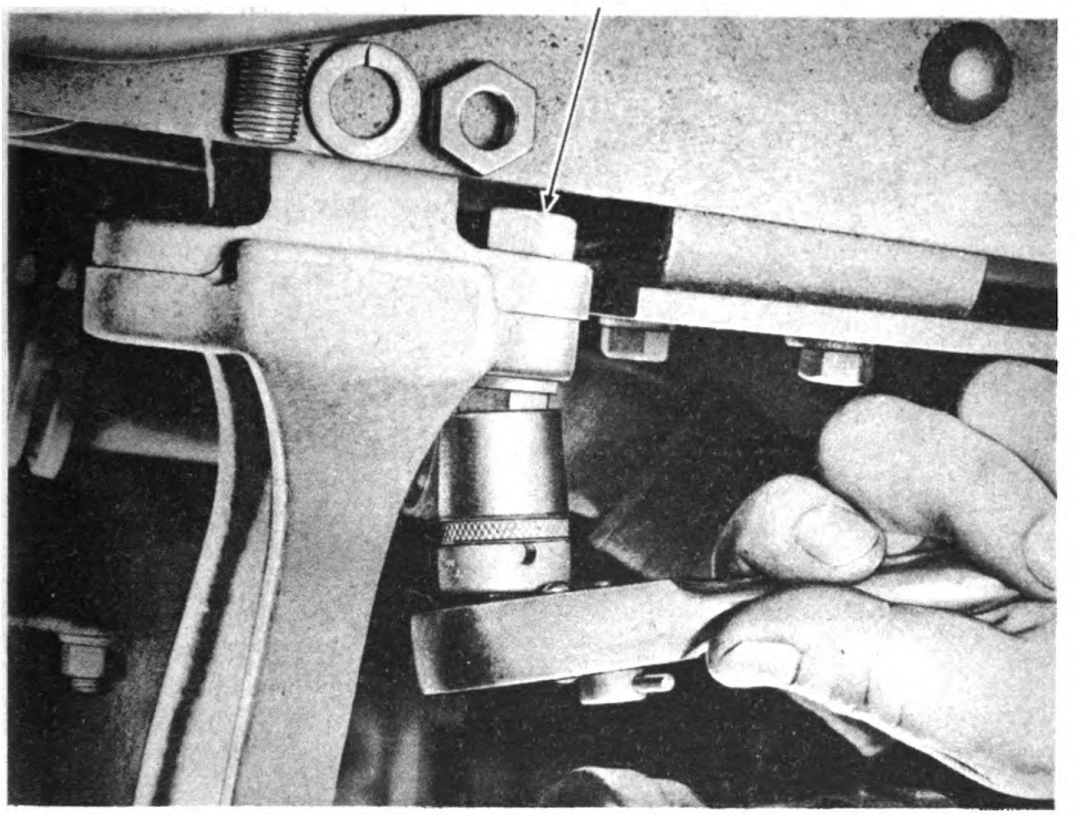


Figure 83—Disconnecting Front Engine Support

assembly (fig. 31); the other two in the water connection at the side of the cylinder block. Remove these six cap screws. Lift off the water pump assembly and two gaskets, one gasket from each connection.

g. Remove Fuel Injection Pump and Governor.

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{3}{4}$-in.

Loosen and remove the fuel nozzle leak-off manifold from the union at the pump. Remove the two front coupling cap screws with lock washers and plain washers. The floating member of the coupling will also come off when the pump is removed. Remove the three nuts and washers from the pump mounting bracket studs. Lift off the fuel injection pump assembly. **NOTE:** There are two collar dowels used on these bracket studs; one on each outside stud, none on the middle one. These dowels fit halfway in the cylinder block and halfway in the bracket. Remove these two collar dowels.

h. Remove Clutch Assembly (fig. 7).

Wrench, socket, $\frac{9}{16}$-in.

The clutch assembly is secured to the flywheel with 12 cap screws and lock washers. Remove these cap screws; the clutch assembly will come off in two parts—the clutch and the clutch-driven member.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

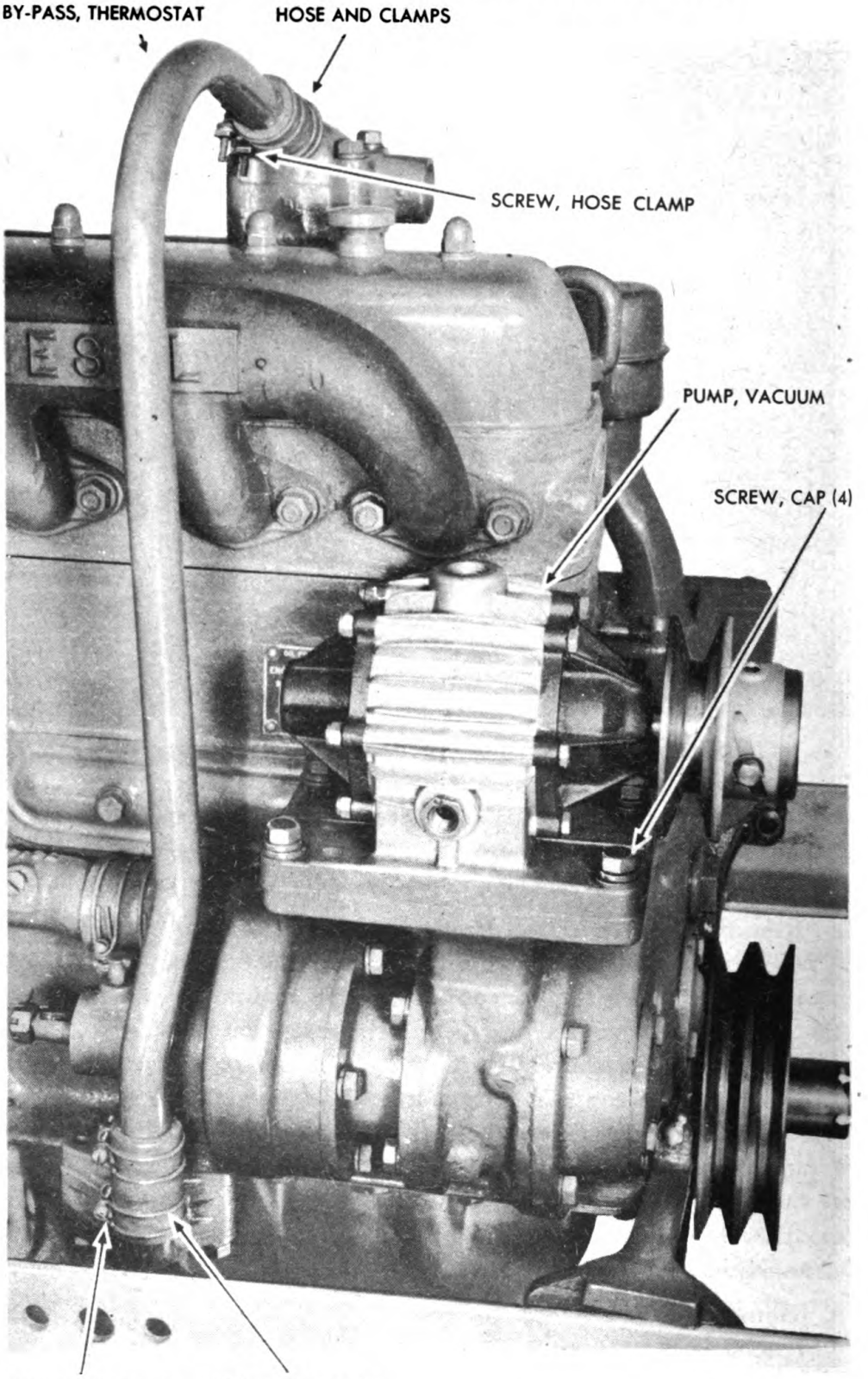


Figure 84—Removing Vacuum Pump

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ENGINE

56. DISASSEMBLY OF STRIPPED ENGINE.

Bar, pilot, driving
Bar, small
Blocks, wood, (2) 1¾-in. by 6-in. by 8-in.
Expander, ring
Extension, short
Eye, lifting
Hammer, fiber
Handle, speed
Hoist, chain
Pliers
Pliers, cutting
Puller.
Punch
Rack, valve
Screwdriver, thin blade
Tool, valve spring, lifting
Vise, with brass jaw inserts
Wrench, box, $\frac{9}{16}$-in.
Wrench, open-end, ½-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, ⅝-in.
Wrench, open-end, ¾-in.
Wrench, open-end, ⅞-in.
Wrench, open-end, $\frac{15}{16}$-in.
Wrench, open-end, 1-in.
Wrench, socket, $\frac{9}{16}$-in.
Wrench, socket, ⅝-in.
Wrench, socket, ¾-in.
Wrench, socket, ⅞-in.
Wrench, socket, $\frac{15}{16}$-in.
Wrench, socket, square, ½-in.

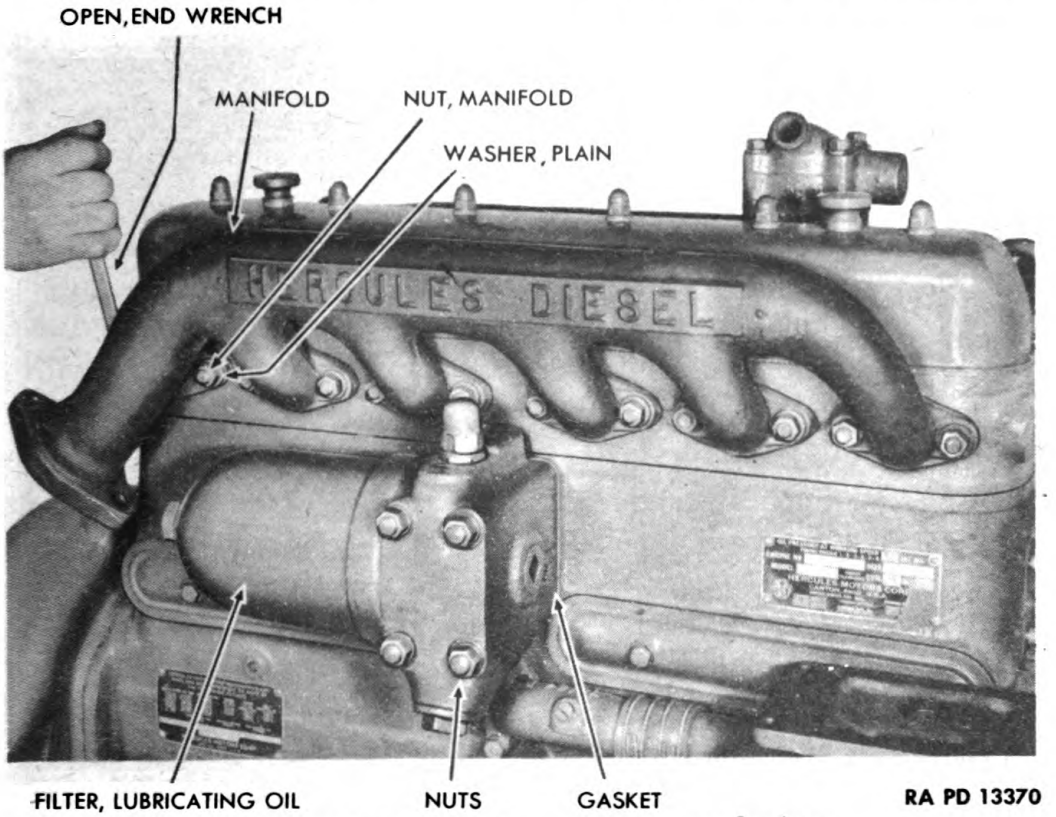


Figure 85—Removing Exhaust Manifold

a. Remove Exhaust Manifold (fig. 85).

Wrench, open-end, ⅝-in.
Wrench, socket, ⅝-in.

The exhaust manifold is secured to the cylinder block by 12 studs

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plain washers and brass nuts. Use a ⅝-inch open-end wrench on the 2 rear nuts; a ⅝-inch socket wrench with speed handle on the remaining 10. Lift off the exhaust manifold and remove the 6 composition asbestos gaskets.

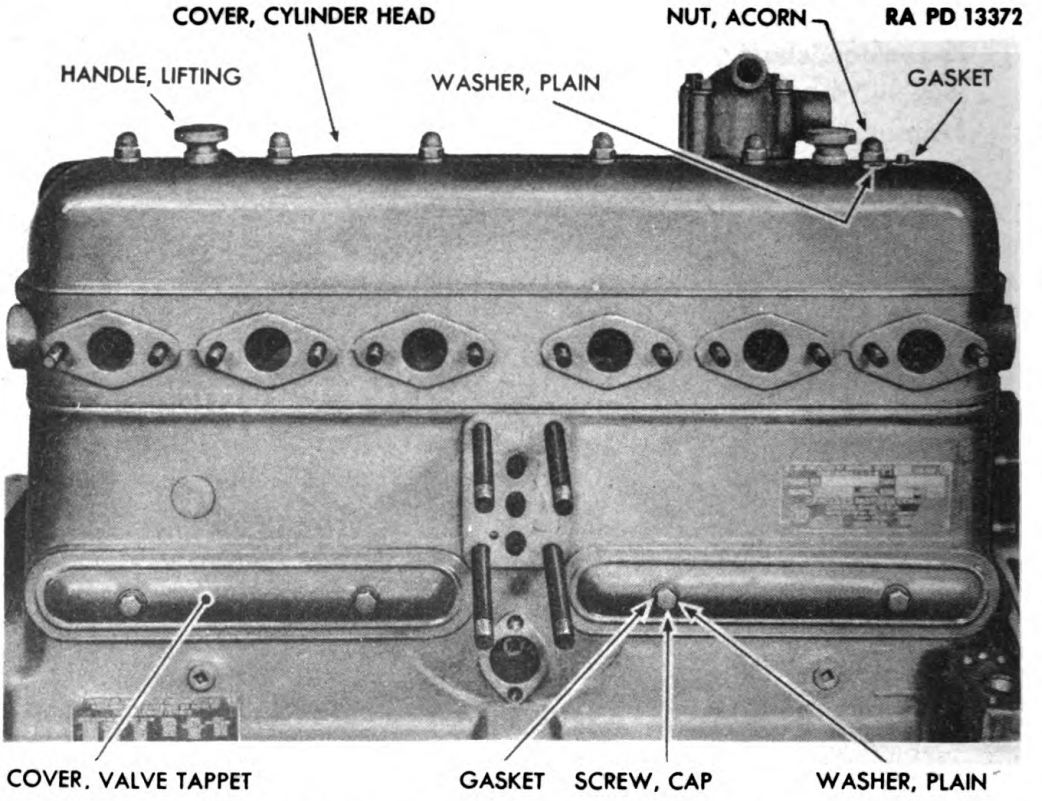


Figure 86—Removing Cylinder Head Cover

b. Remove Vacuum Pump Adapter Bracket.

Pliers
Wrench, socket, ¾-in.

The vacuum pump adapter bracket is fastened to the engine by four safety-wired cap screws. Remove the safety wiring and the four cap screws. Lift off the adapter bracket and the gasket.

c. Remove Cylinder Head Cover (fig. 86).

Wrench, open-end, ⅝-in.

Remove the six acorn cylinder head cover nuts, plain washers and copper gasket washers. Lift off the cylinder head cover. The cover is equipped with two round lifting knobs or handles which are not removed from the cover. A special gasket, shellacked to the bottom rim of the cover, will, of course, come away with the cover.

d. Remove Valve Tappet Covers.

Wrench, open-end, $\frac{9}{16}$-in.

Loosen and remove the cap screws, plain washers and copper gasket

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washers on the two valve tappet cover plates at the side of the cylinder block. Lift off the covers. Gaskets are shellacked to the lower side of these plates (fig. 86).

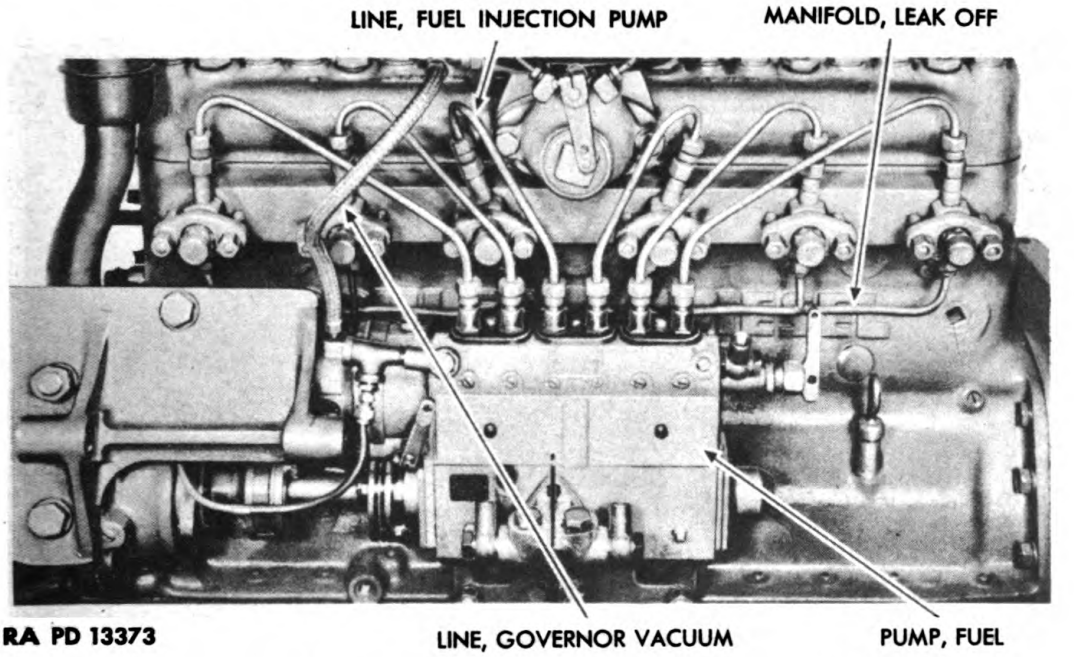


Figure 87—Removing Governor Vacuum Line

e. Remove Governor Vacuum Line.

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{5}{8}$-in.

Loosen the union nut at the top connection ($\frac{5}{8}$-in. open-end wrench). Unscrew the line at the lower connection ($\frac{9}{16}$-in. open-end wrench) (fig. 87).

f. Remove Water Outlet Manifold and Thermostat Housing.

Wrench, open-end, $\frac{9}{16}$-in.

The water outlet manifold and thermostat housing assembly is removed as a unit. It is held in position on the cylinder head by four cap screws—two in each mounting flange of the manifold. Remove the four cap screws and lock washers. Lift off the manifold and thermostat housing assembly. Remove the two gaskets from the manifold mounting flanges (fig. 88).

g. Disassembly of Water Outlet Manifold and Thermostat Housing Assembly (figs. 88 and 89).

Screwdriver Wrench, open-end, $\frac{9}{16}$-in.

Wrench, adjustable

Remove the four cap screws and lock washers which fasten the thermostat housing to the water outlet manifold. The housing gasket

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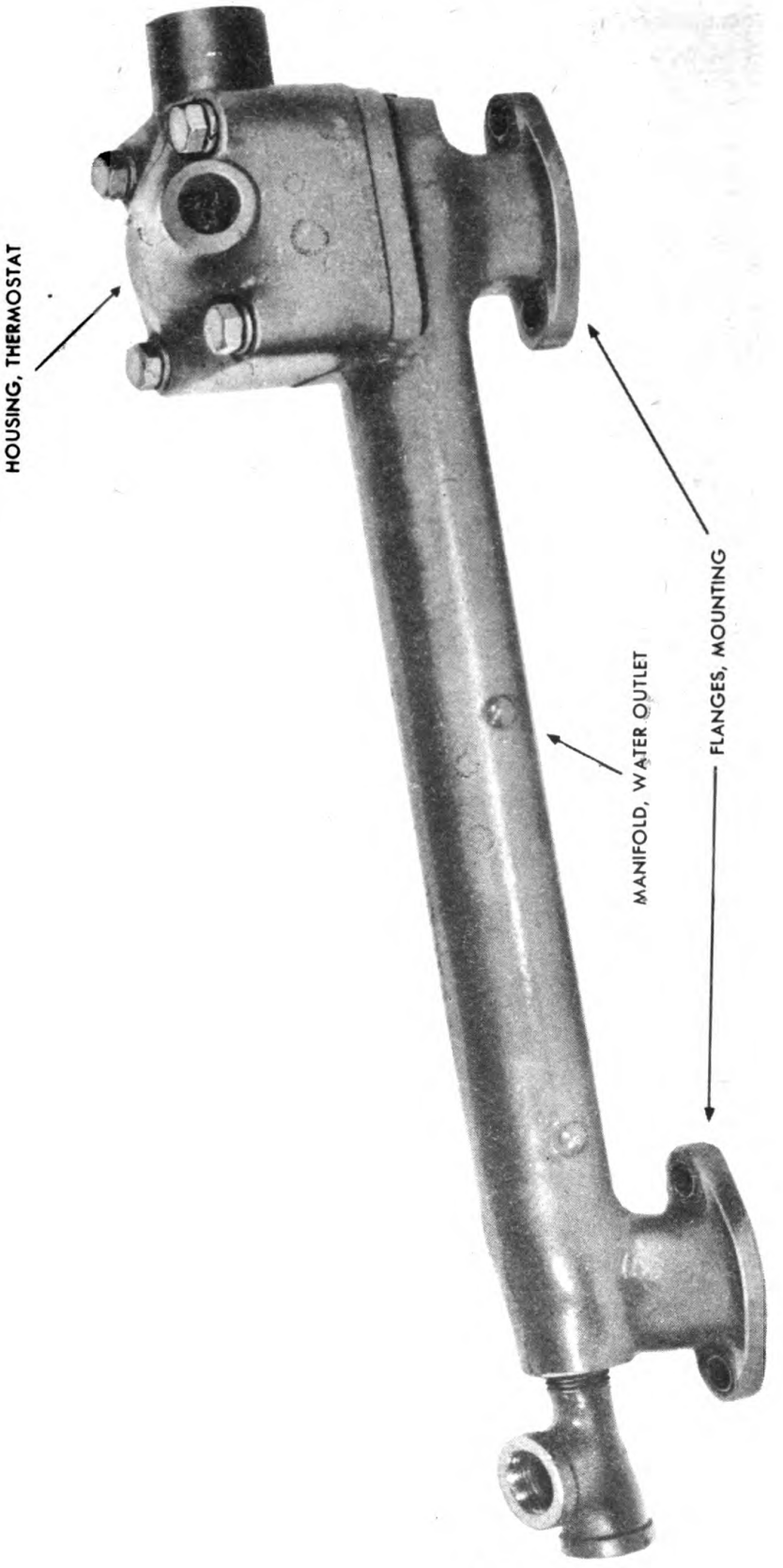


Figure 88—Water Outlet Manifold and Thermostat Housing Assembly

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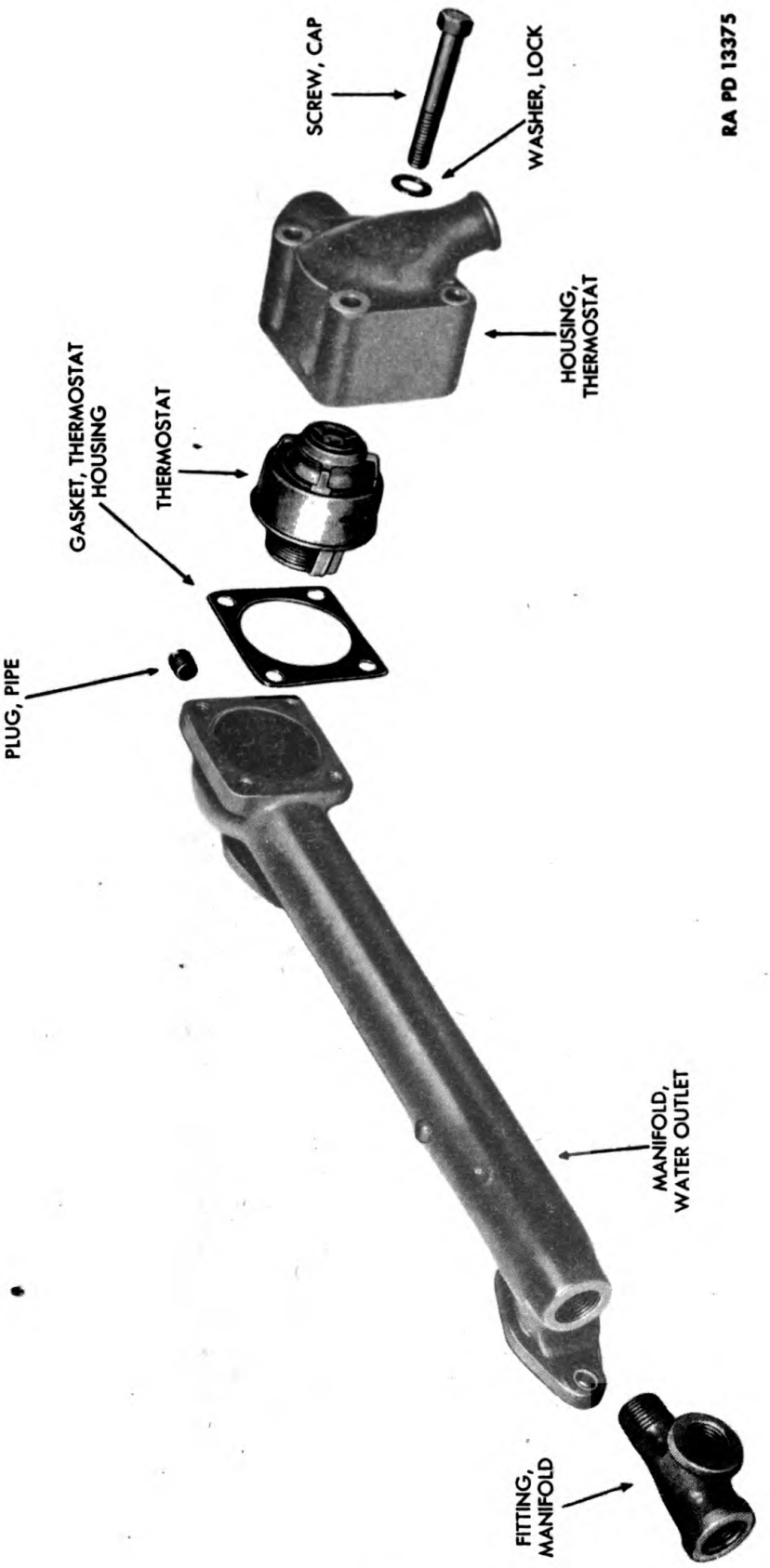


Figure 89—Water Outlet Manifold and Thermostat Housing Assembly—Exploded View

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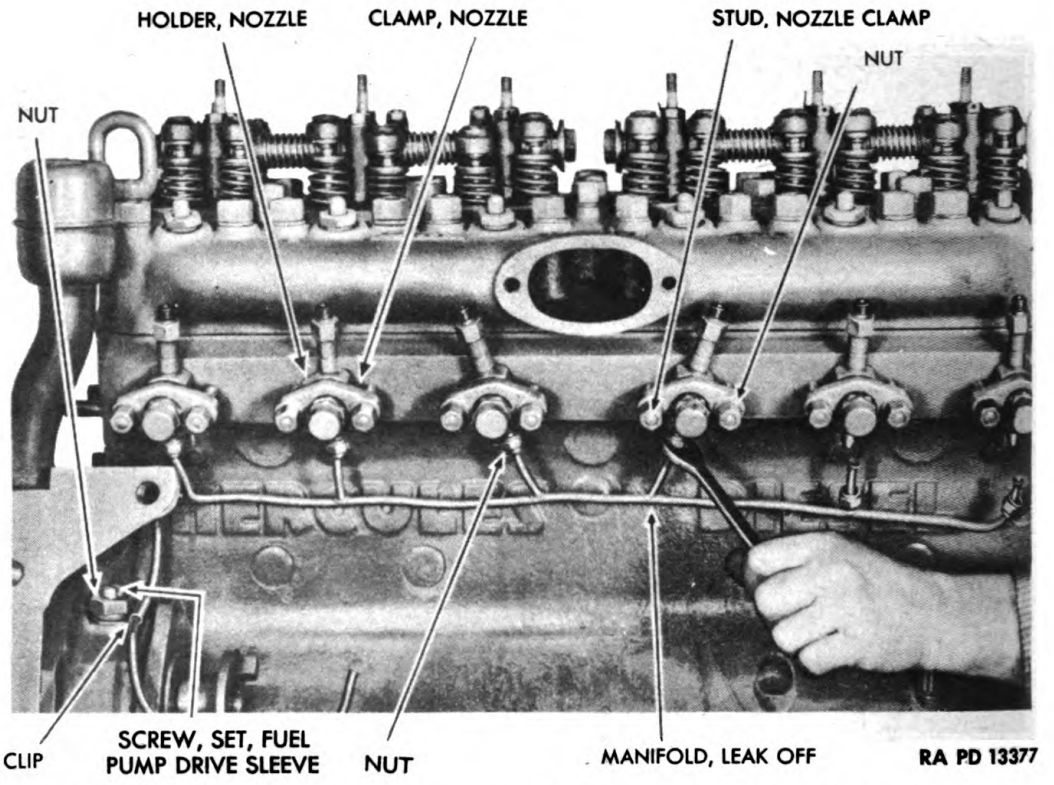


Figure 90—Removing Leak-Off Manifold and Nozzle Holders

and thermostat come away. Remove the pipe plug from the front end of the water outlet manifold. Unscrew the pipe connection from the rear of the manifold.

h. Remove Fuel Pump Fuel Lines.

Wrench, open-end, $\frac{11}{16}$-in.

The six fuel lines are attached to fuel nozzles on the engine at one end, and to the barrels on top of the fuel injection pump at the other end. Remove the lines by loosening the nut at each end of each fuel line. Tag each line with engine cylinder number it feeds.

i. Remove Air Intake Venturi Assembly.

Wrench, open-end, $\frac{5}{8}$-in.

The air intake Venturi assembly is fastened to the side of the cylinder head by two cap screws and lock washers. Remove the cap screws. NOTE: When the air intake Venturi is removed, the following parts come away with it in the order named: Gasket, monobestos spacer, thermal or heating unit, monobestos spacer and gasket. The thermal element of the heating unit faces the cylinder head.

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ENGINE

j. Remove Generator Bracket Base.

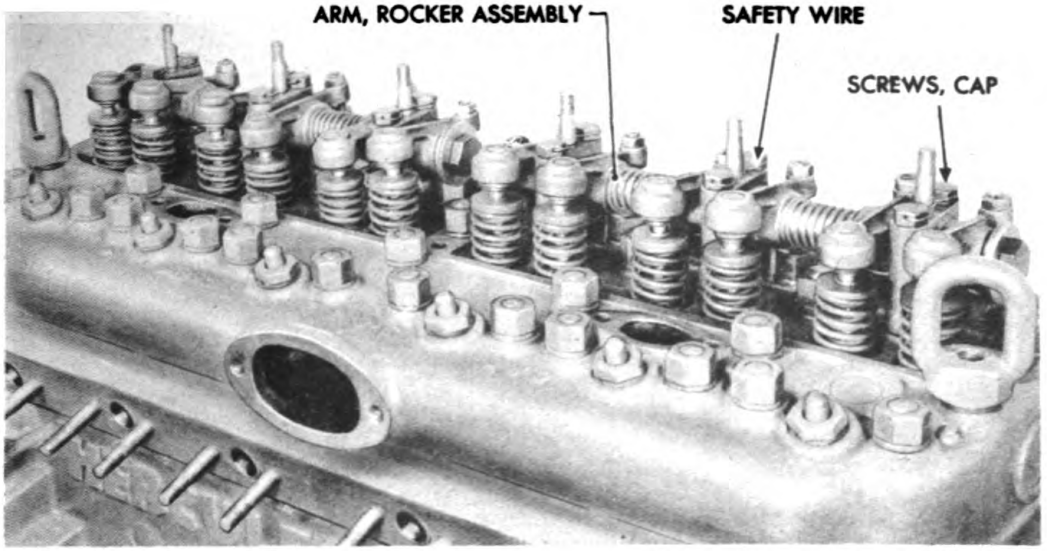
Wrench, open-end, 7/8-in. Wrench, open-end, 1 5/16-in.

The generator bracket base is the large casting in which the generator bracket swivels. This bracket base is fastened to the engine crankcase on the left side at the front. Remove the three cap screws and a nut which hold it in place. Lift off the bracket base.

k. Remove Leak-off Manifold (fig. 90).

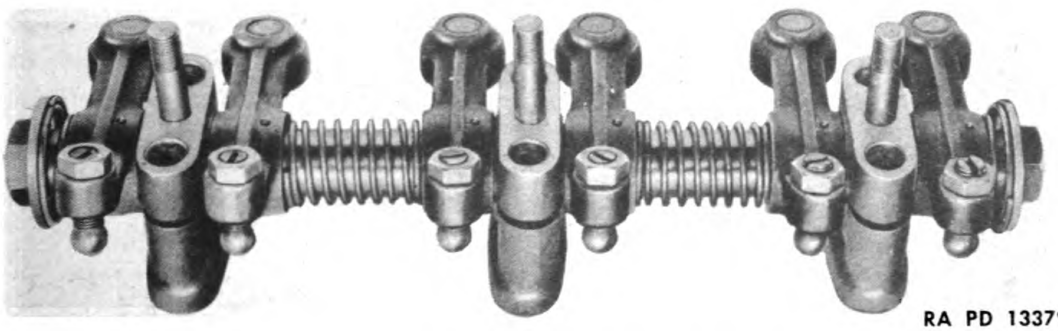
Wrench, open-end, 9/16-in. Wrench, open-end, 1 1/16-in.

The leak-off manifold is secured to each fuel nozzle with a union nut and clipped to the engine crankcase at the front with a large metal clip. Loosen the six union nuts. Remove the hold-down clip by removing the large nut and lock washer from the fuel pump drive sleeve set screw.



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Figure 91—Removing Rocker Arm Assemblies



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Figure 92—Rocker Arm and Shaft Assembly

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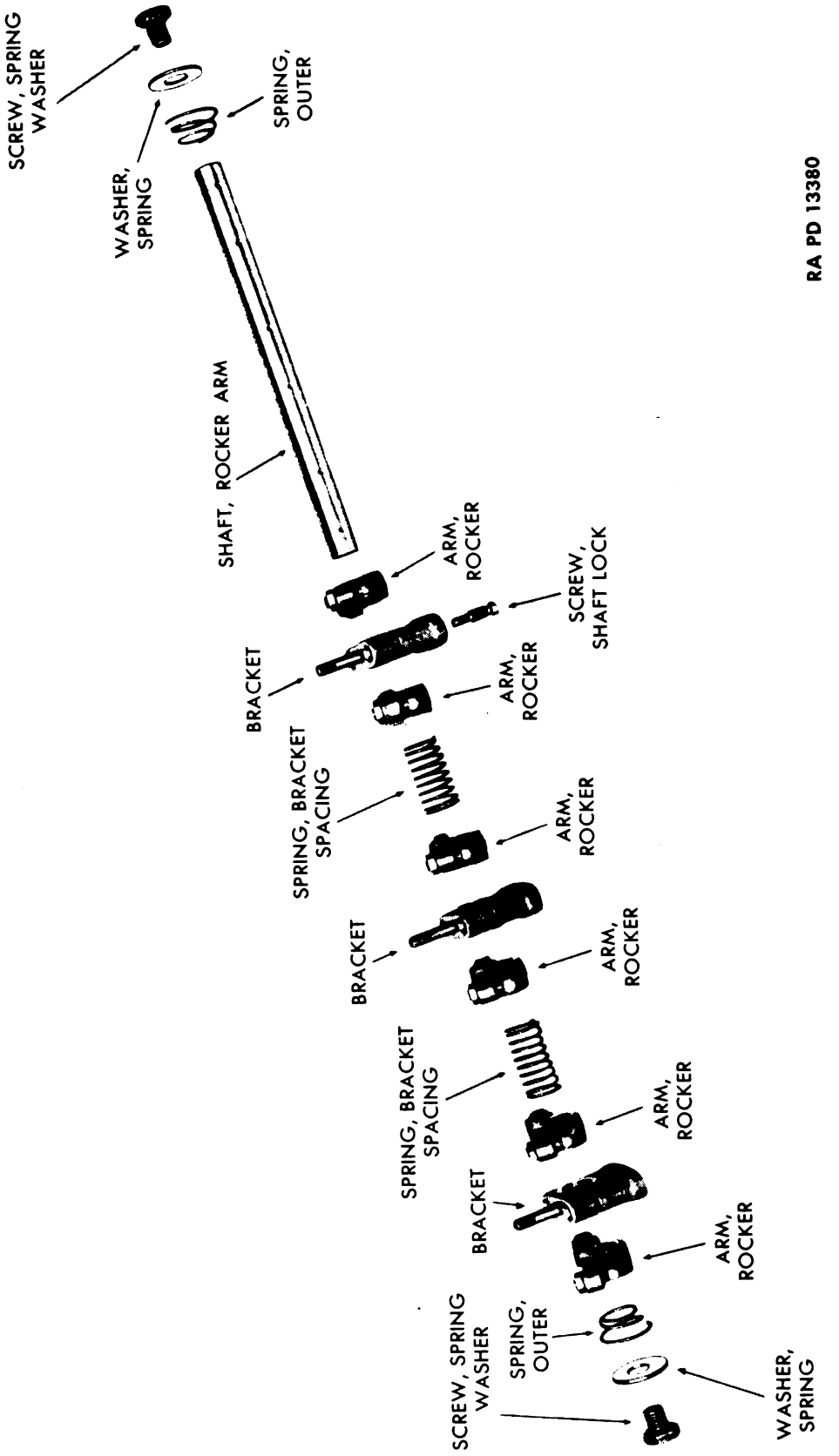


Figure 93—Rocker Arm and Shaft Assembly—Exploded View

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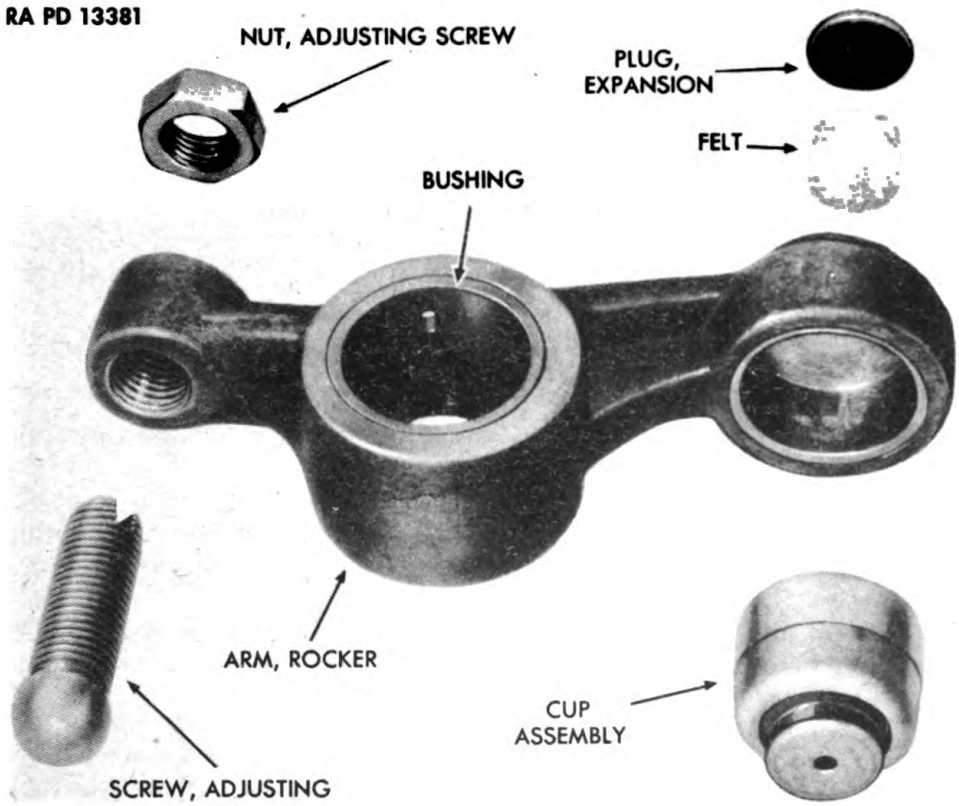


Figure 94—Rocker Arm—Exploded View

l. Remove Fuel Nozzle Holders (fig. 90).

Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.

The 6 fuel nozzles are held in place by 6 nozzle holders and 6 nozzle holder clamps. Remove the 12 nozzle holder clamp stud nuts. If the engine has been in operation for a considerable length of time, it may be necessary to pry out the nozzle holder assemblies due to carbon deposits. Use a screwdriver for this.

m. Remove Rocker Arm Assemblies (fig. 91).

Pliers
Wrench, socket, $\frac{5}{8}$-in.

The rocker arms are mounted to the cylinder head in two rocker arm assemblies. These assemblies each have three brackets held in place by two safety-wired cap screws. Remove the safety wire from the cap screws and remove the cap screws. Lift off the rocker arm assemblies.

n. Disassembly of Rocker Arm Assembly (fig. 93).

Hammer
Punch
Screwdriver
Wrench, open-end, $\frac{5}{8}$-in.
Wrench, open-end, $\frac{15}{16}$-in.

(1) **NOTE**: There are two interchangeable rocker arm assemblies.

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The procedure for disassembly is exactly the same for both of these assemblies.

(2) Loosen and remove the spring washer screws from each end of the rocker arm shaft. A spring washer and spring come off each end of the shaft when the spring washer screws are removed.

(3) A bracket is fastened to the shaft with a lock screw in the base of the bracket. Remove this special long nose shaft lock screw (drilled with oil passage) from the three brackets. In the order named, slide the following off the shaft: a rocker arm, bracket, rocker arm, bracket spacing spring, rocker arm, bracket, rocker, arm, bracket spacing spring, rocker arm, bracket and rocker arm.

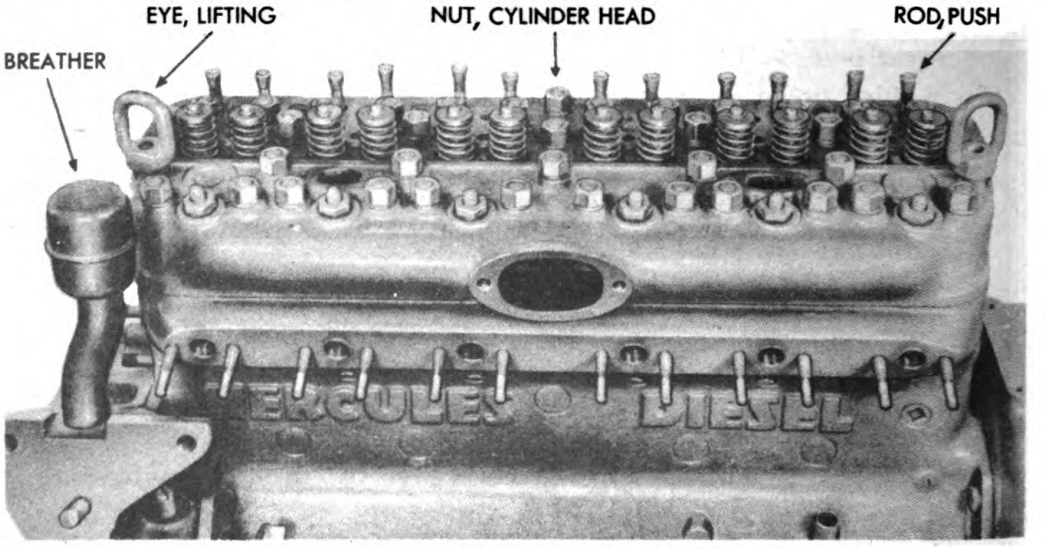
(4) The rocker arms will probably never need to be disassembled, but if this is absolutely necessary, it is done as follows (fig. 94):

(a) Loosen and remove the nut on the adjusting screw with the ball end.

(b) Unscrew the adjusting screw.

(c) Remove the expansion plug by driving a punch into it and lifting it out.

(d) Pull out the felt packing. Drive out the cup assembly.



RA PD 13382

Figure 95—Removing Cylinder Head

o. Removing Cylinder Head (fig. 95).

Bar, small
Hammer, fiber
Wrench, socket, 7/8-in.

Lift out the 12 push rods. Remove the oil filler and breather by tapping

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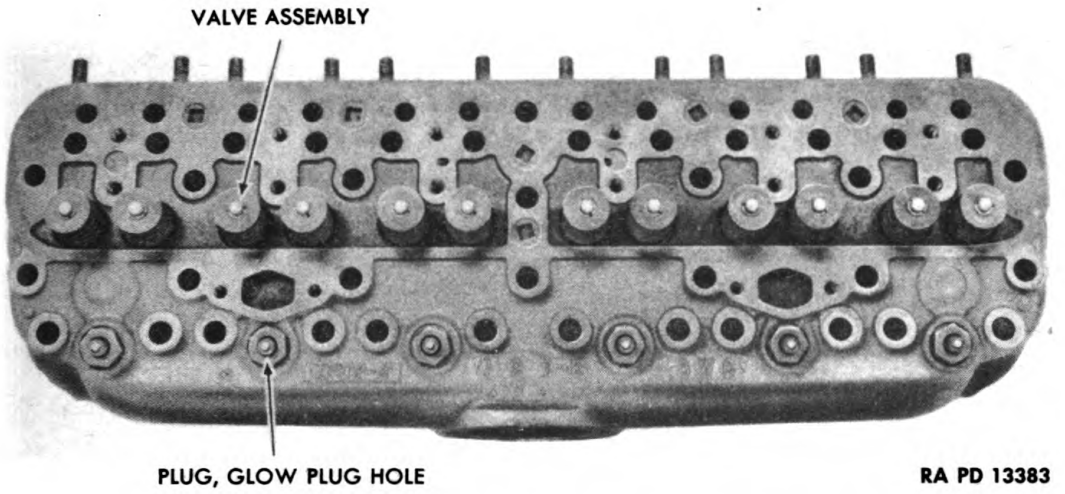


Figure 96—Cylinder Head Assembly—Top View

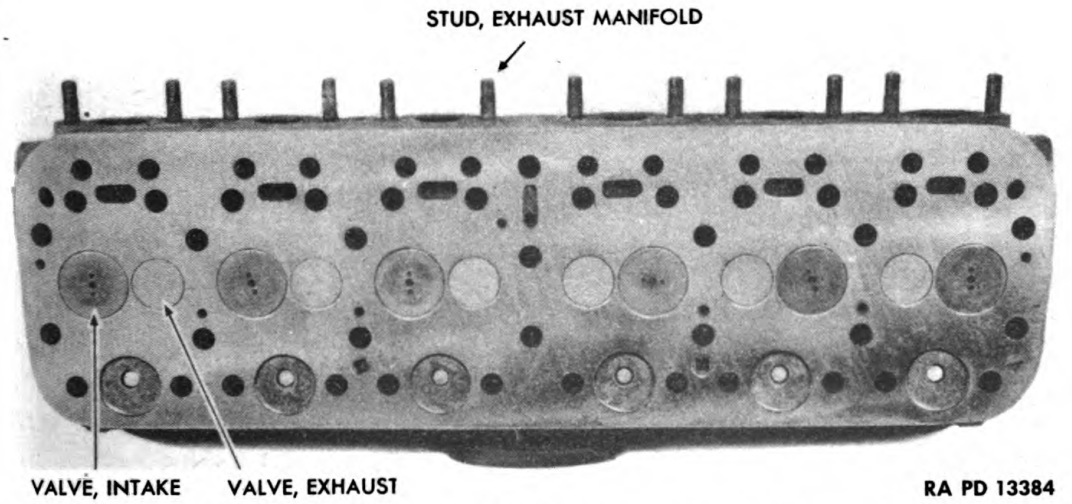


Figure 97—Cylinder Head Assembly—Bottom View

lightly with fiber hammer. Unscrew the 2 engine lifting eyes and plain washers. Use a small bar to unscrew the eyes. Remove the 37 cylinder head stud nuts and plain washers. Lift off the cylinder head and copper gasket.

p. Disassembly of Cylinder Head Assembly.

Bar, pilot driving	Screwdriver
Hammer	Tool, valve spring lifting
Rock, valve	Wrench, open-end, $\frac{15}{16}$-in.

(1) Place a valve spring lifting tool in position on the cylinder head assembly (fig. 98). NOTE: The following operations are to be performed on each of the 12 valves. As each valve is removed, mark it and

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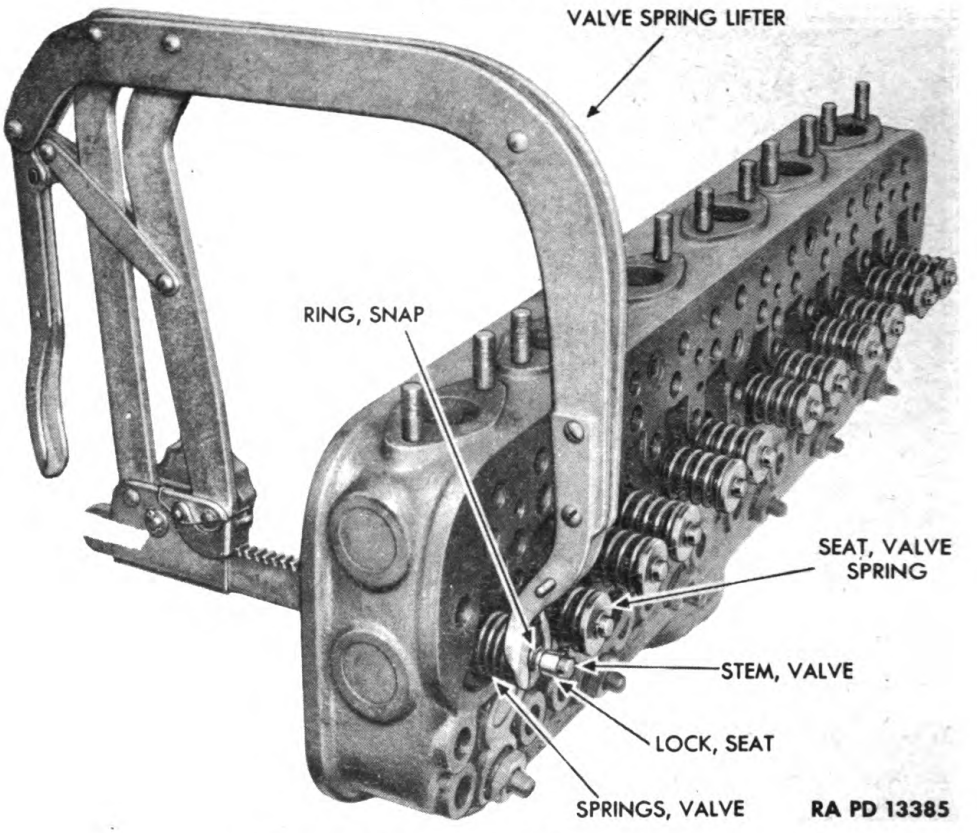


Figure 98—Removing Valve

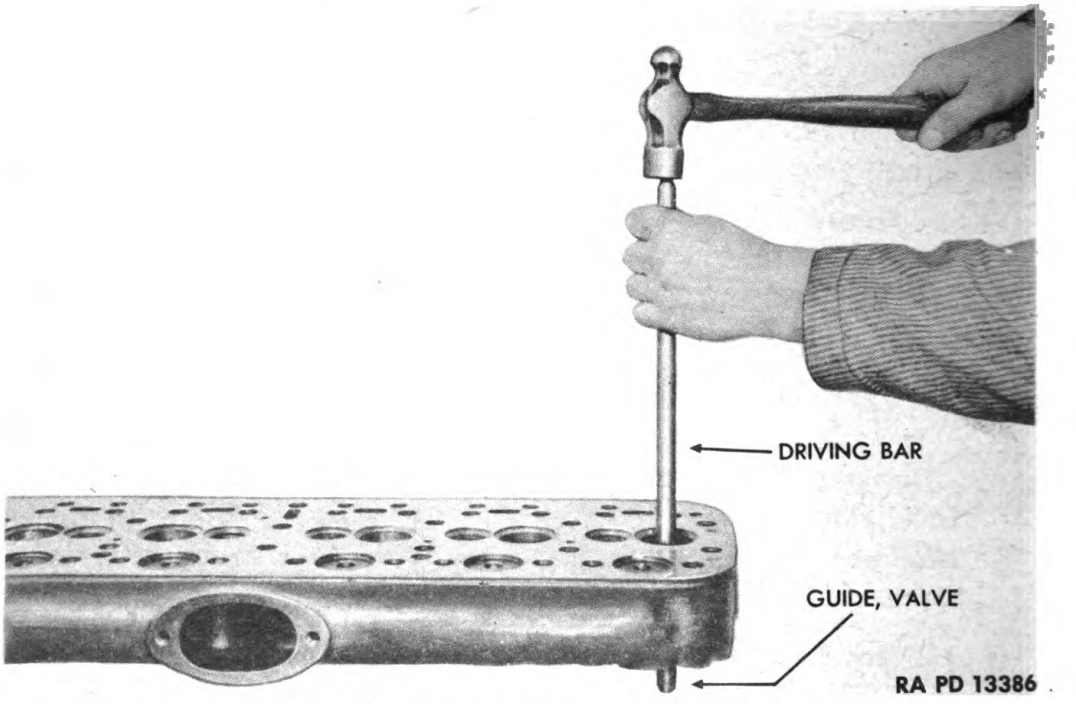


Figure 99—Removing Valve Guide

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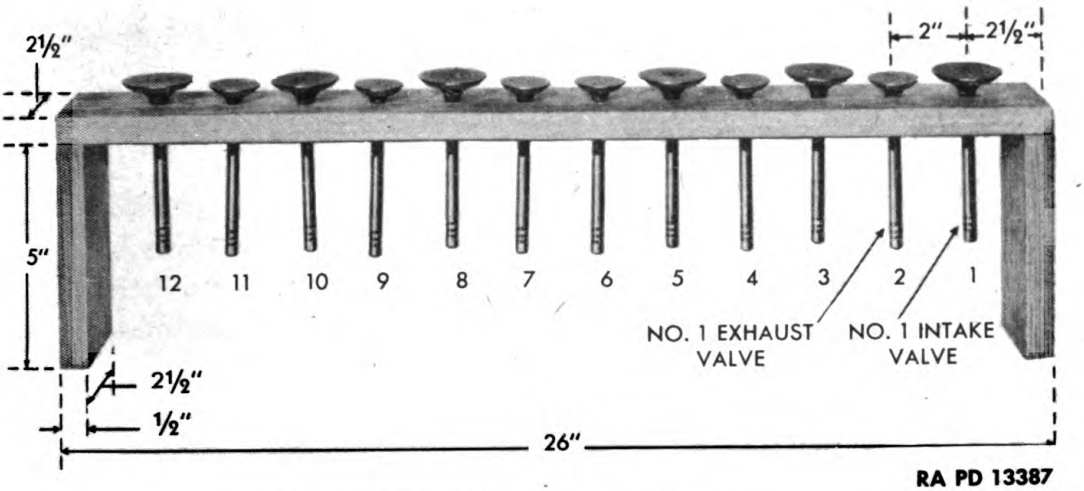


Figure 100—Valves in Valve Rack

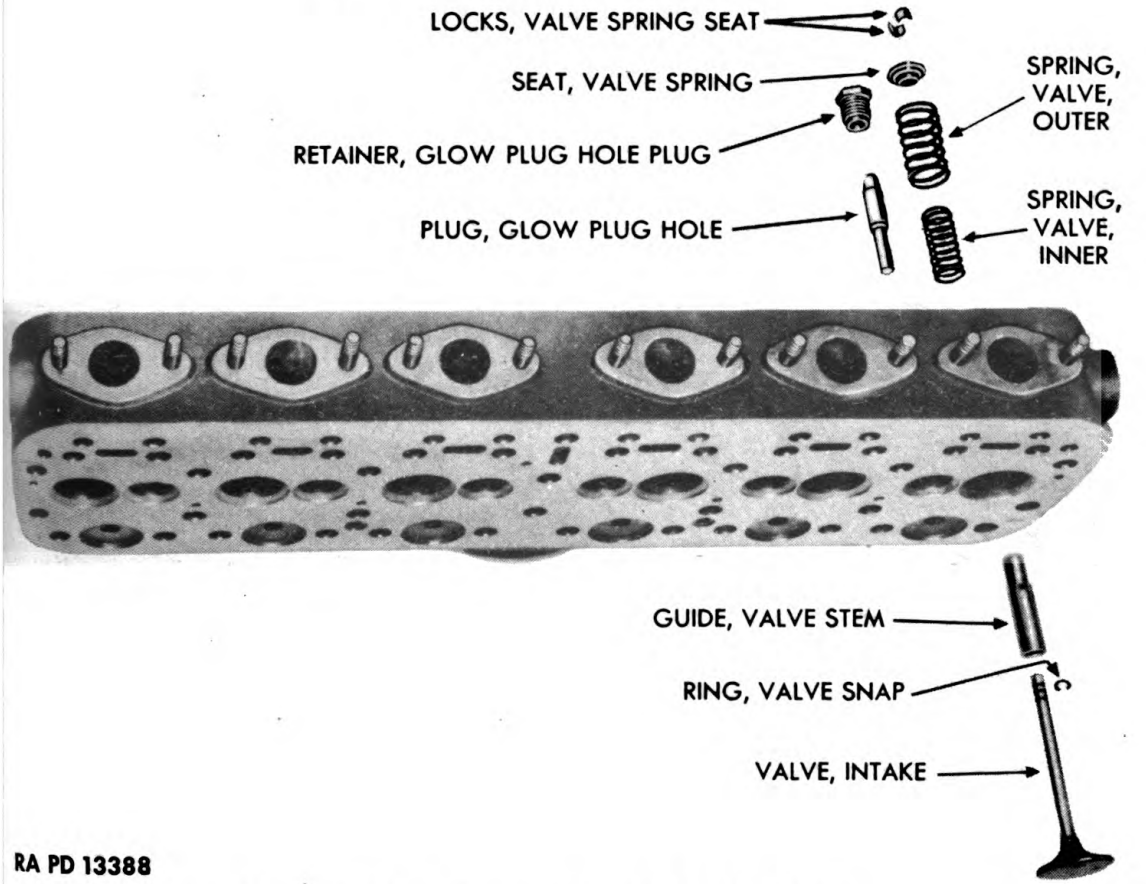


Figure 101—Cylinder Head—Exploded View

place it in a rack, so that it can be installed in the same valve stem guide from which it was removed (fig. 100).

(2) Remove the snap ring.

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(3) Lift off the seat lock.

(4) Release the valve spring lifting tool and remove the valve spring seat and concentric springs.

(5) Push the valve out.

(6) Remove the valve stem guide, if desired, with a pilot driving bar and hammer. Use a round cold rolled steel bar, 10 inches long, $\frac{5}{8}$ inch in diameter with a pilot on the end $\frac{7}{8}$ inch long and slightly less than $\frac{3}{8}$ inch in diameter (0.372 in.-0.373 in.) (fig. 99).

(7) The six glow plug hole plug retainers can be removed with a $1\frac{5}{16}$-inch open-end wrench; then remove the plugs (fig. 101).

(8) Drive out expansion plugs.

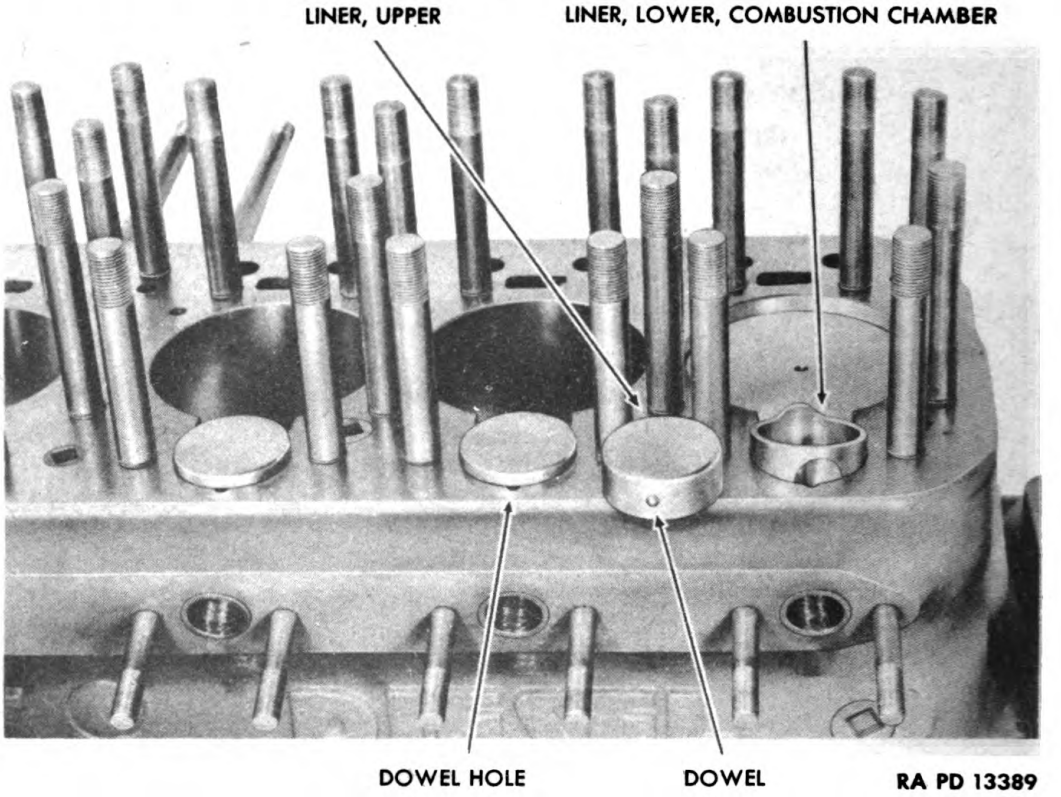


Figure 102—Removing Combustion Chamber Liners

q. Removing Combustion Chamber Liners (fig. 102).

Each of the combustion chambers is fitted with an upper and lower combustion chamber liner. The lower liners are spherical in shape; upper liners have a flat top. Note that each of the spherical liners has a lip on the side that goes nearest to the pistons. Holes are provided in the front of the liners for the fuel nozzles. The upper liners have small

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dowels which fit into dowel holes in the cylinder block. Remove these upper and lower liners by hand.

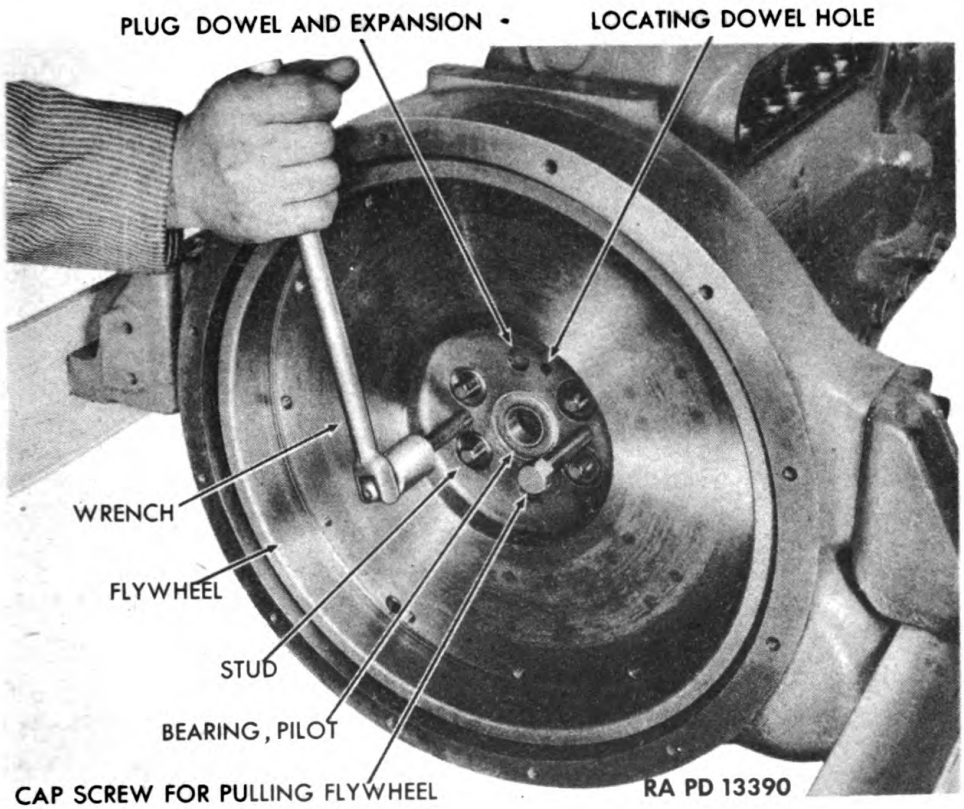


Figure 103—Removing Flywheel

r. Remove Flywheel (fig. 103).

Wrench, socket, ¾-in. with short extension handle

The flywheel is secured to the crankshaft by four studs, castle nuts and cotter pins. The studs are inserted in the crankshaft flange. Remove the cotter pins and the castle nuts. Insert two ½-inch by 3-inch cap screws in the two threaded holes in the flywheel. Screw these cap screws in to force off the flywheel. Lift off the flywheel and remove the two cap screws. The two dowels, expansion plugs and pilot bearing will come off with the flywheel.

s. Remove Oil Pan (fig. 104).

Wrench, open-end, ¾-in. Wrench, socket, $\frac{9}{16}$-in.

Remove drain plug from oil pan and drain oil. Rotate the engine in the stand so that it is in a vertical position. Remove the five cap screws and lock washers which secure the oil pan to the flywheel housing. Remove the 28 cap screws and lock washers which hold the pan in position on the crankcase and remove the oil pan and gaskets.

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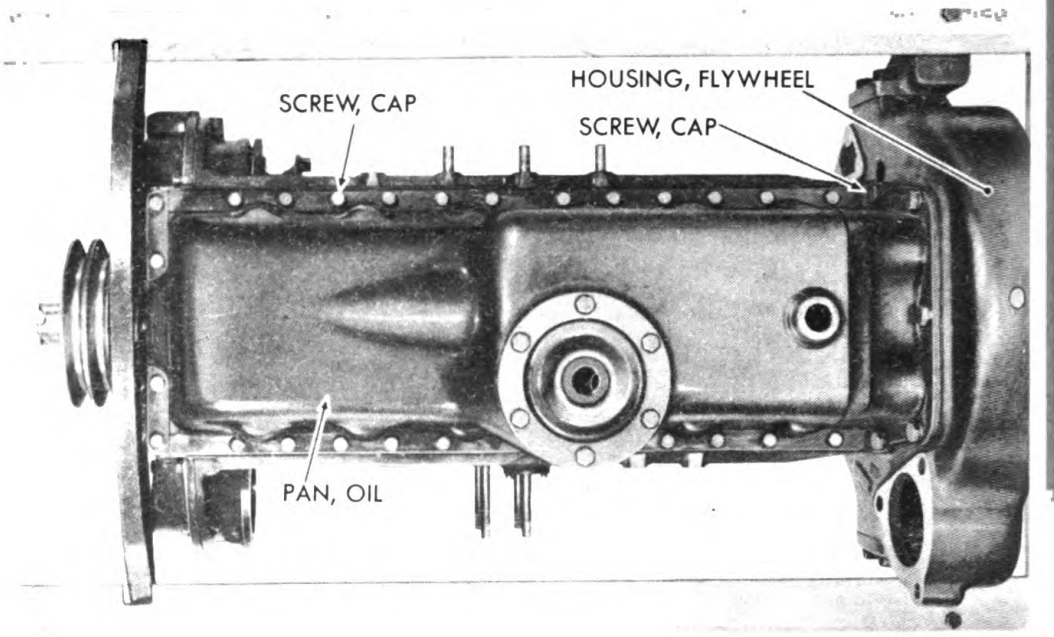


Figure 104—Removing Oil Pan

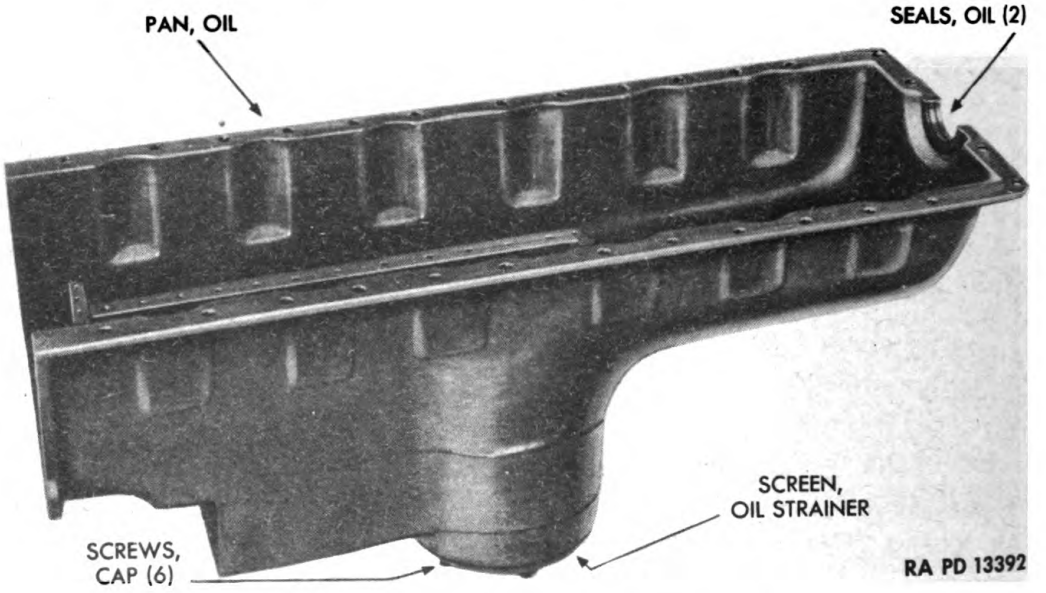


Figure 105—Oil Pan Assembly

t. Disassembly of Oil Pan Assembly.

Screwdriver
Wrench, socket, $\frac{9}{16}$-in.
Wrench, square socket, ½-in.

Remove the six cap screws and lock washers which hold the oil strainer in place at the bottom of the pan. Pull out the oil strainer and

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gasket (fig. 105). Remove the two oil pan seals (cork) from the front of the oil pan with a screwdriver or small punch. Unscrew the oil drain pipe plug and the oil strainer pipe plug from the bottom of the pan (fig. 106). Remove the two oil pan gaskets which are shellacked to the oil pan attaching flanges.

u. Remove Oil Pump Assembly (fig. 107).

Wrench, box, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{7}{8}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

Disconnect the discharge tube at both ends by loosening the nuts. Lift off the line. Remove the four cap screws and lock washers from the oil pump mounting flange. The pump can now be removed by rotating it one-half turn to the right and lifting it out.

v. Remove Connecting Rod and Piston Assemblies (fig. 108).

Bar, small
Hammer
Pliers, cutting
Wrench, socket, $\frac{3}{4}$-in., and handle

(1) Rotate the crankshaft so that the pistons in cylinders 1 and 6 will be on bottom dead center. Use a small bar in the starting crank jaw slots to rotate the crankshaft.

(2) Cut the safety wire from connecting rod bearing caps Nos. 1 and 6.

(3) Remove the special head cap screws from the bearing caps. Remove the bearing caps and their bearing shells.

(4) After the bearing caps have been removed from Nos. 1 and 6 connecting rods, these two connecting rod and piston assemblies can be removed from the cylinder block. Extreme care should be used in removing these assemblies so that the cylinder walls will not be gouged or scratched by the connecting rods. Removal is made in the following manner:

(a) Place a wooden hammer handle against the lower end of the connecting rod and push until the piston starts to come out of the cylinder bore.

(b) Pull out on the piston with one hand and guide the connecting rod through the bore until the piston and connecting rod assembly is free of the block.

(5) Replace the bearing caps and shells on the same connecting rods from which they were removed. The connecting rods and caps are marked with their cylinder numbers.

(6) Repeat the same steps for removing the connecting rod and piston assemblies from cylinders 2 and 5 and cylinders 3 and 4.

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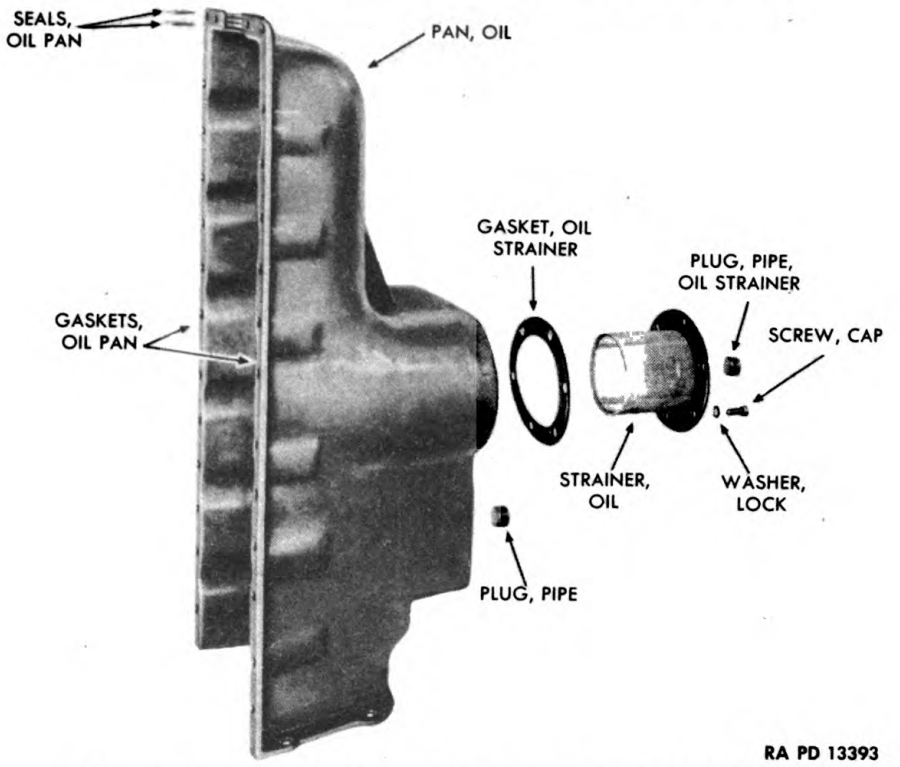


Figure 106—Oil Pan Assembly—Exploded View

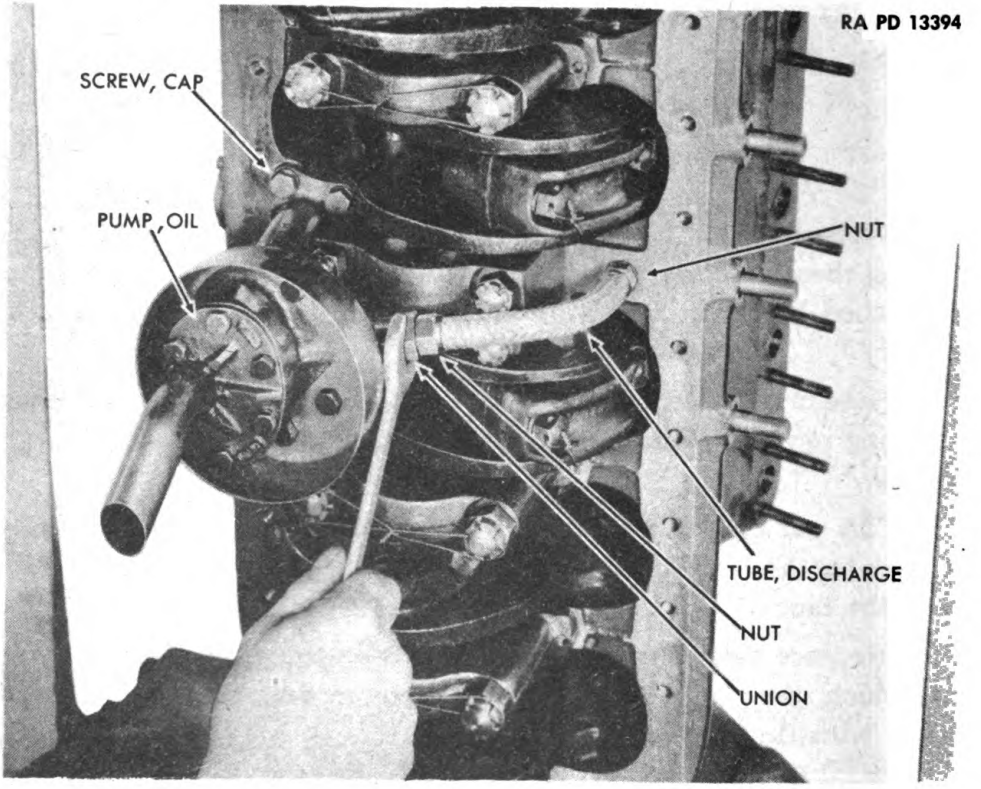


Figure 107—Removing Oil Pump Assembly

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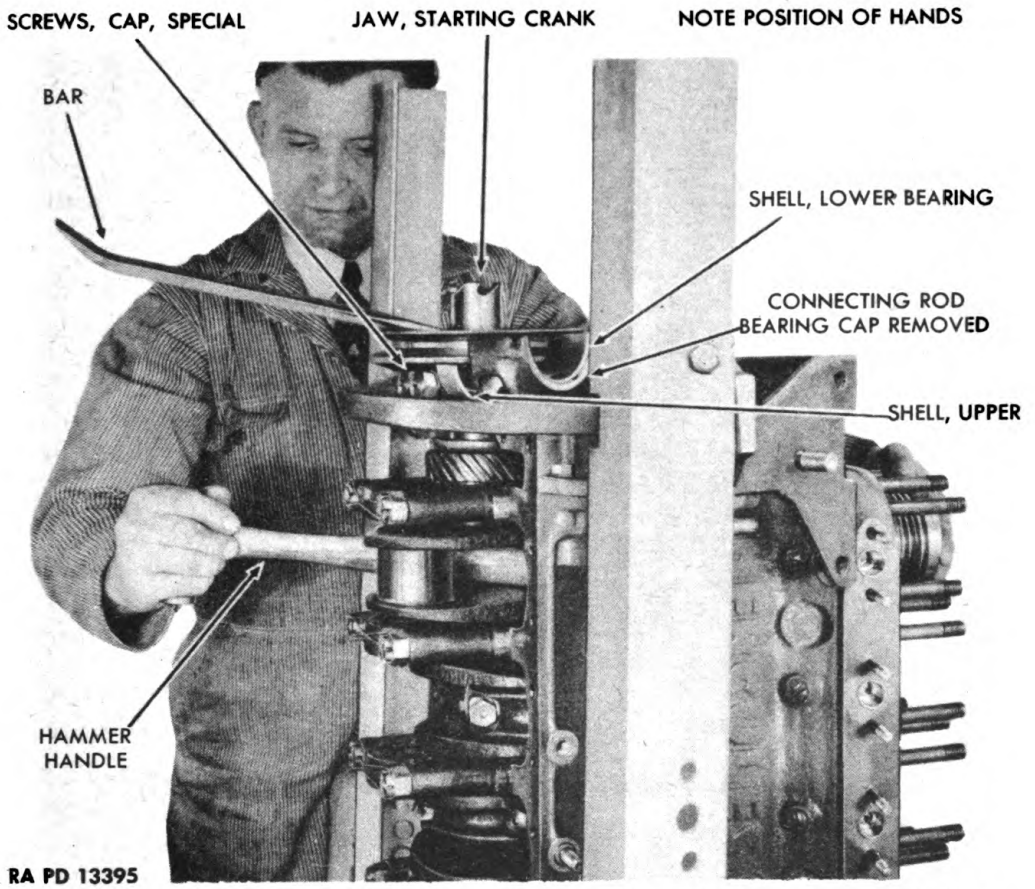


Figure 108—Removing Connecting Rod and Piston Assemblies

w. Disassembly of Piston and Connecting Rod Assembly.

Expander, ring
Screwdriver
Vise, with brass jaw inserts
Wrench, socket, ¾-in.

Place the piston and connecting rod assembly (fig. 109) in a vise fitted with brass jaws. Be careful not to mar or twist the connecting rod. Remove the four compression rings and two oil rings with a ring expander (fig. 110). Remove the piston pin retaining rings (screwdriver). Push the piston pin out (fig. 111). These pins are full-floating and can be easily removed with the fingers. Lift off the piston. Loosen and remove the two connecting rod cap screws and lift off the two bearing shells (fig. 111).

x. Remove Starting Crank Jaw (fig. 112).

Bar, small metal
Block, wood, or hammer handle

Insert the end of a small metal bar in the hole in the side of the starting crank jaw and unscrew the jaw. If the crankshaft turns with the jaw, place a piece of wood or wooden hammer handle between a throw on

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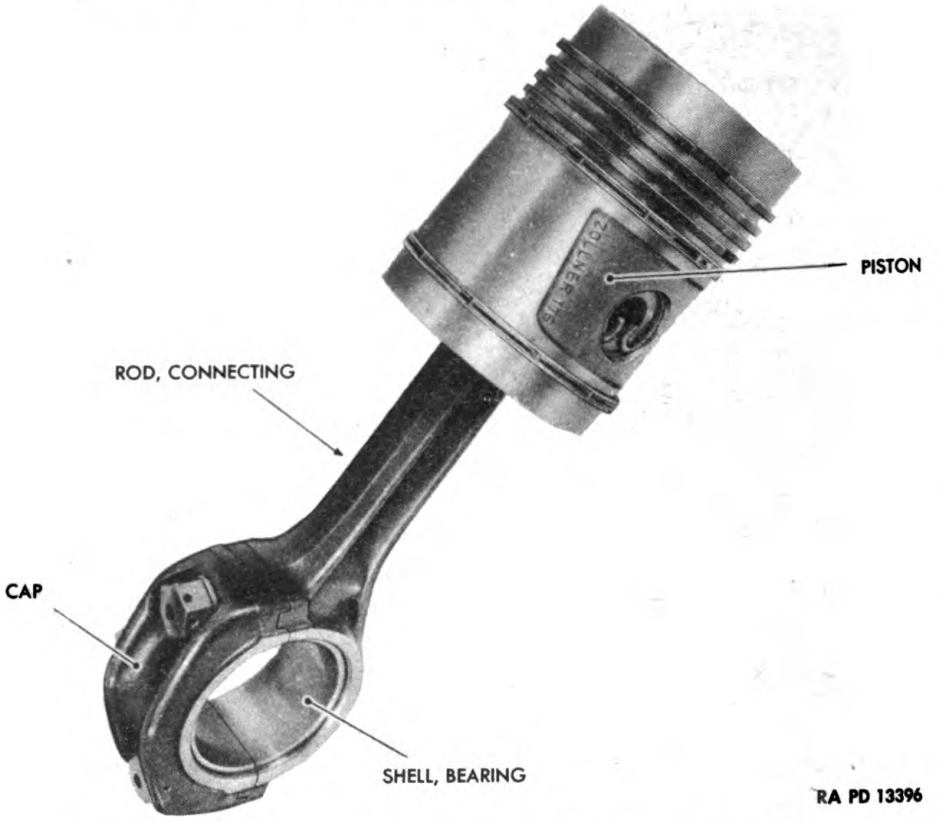


Figure 109—Piston and Connecting Rod Assembly

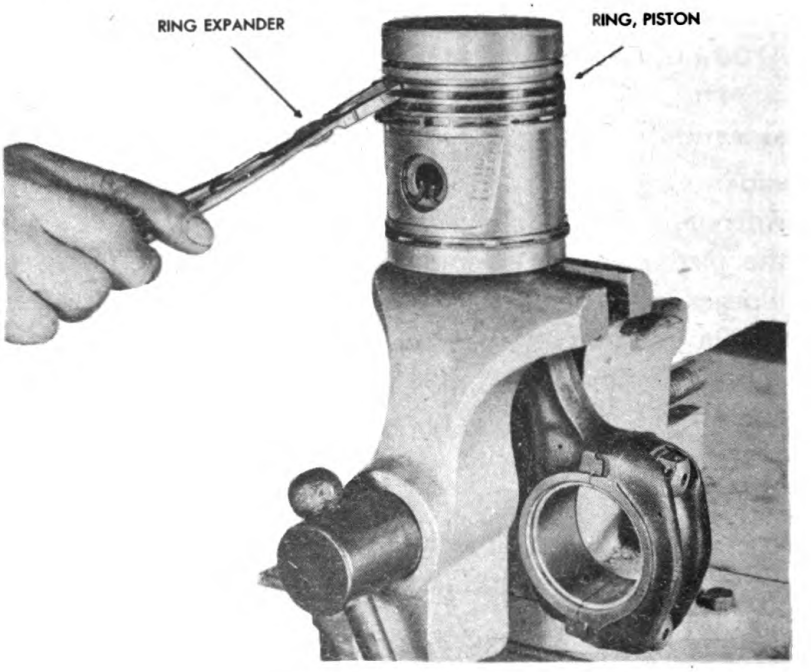


Figure 110—Removing Piston Ring

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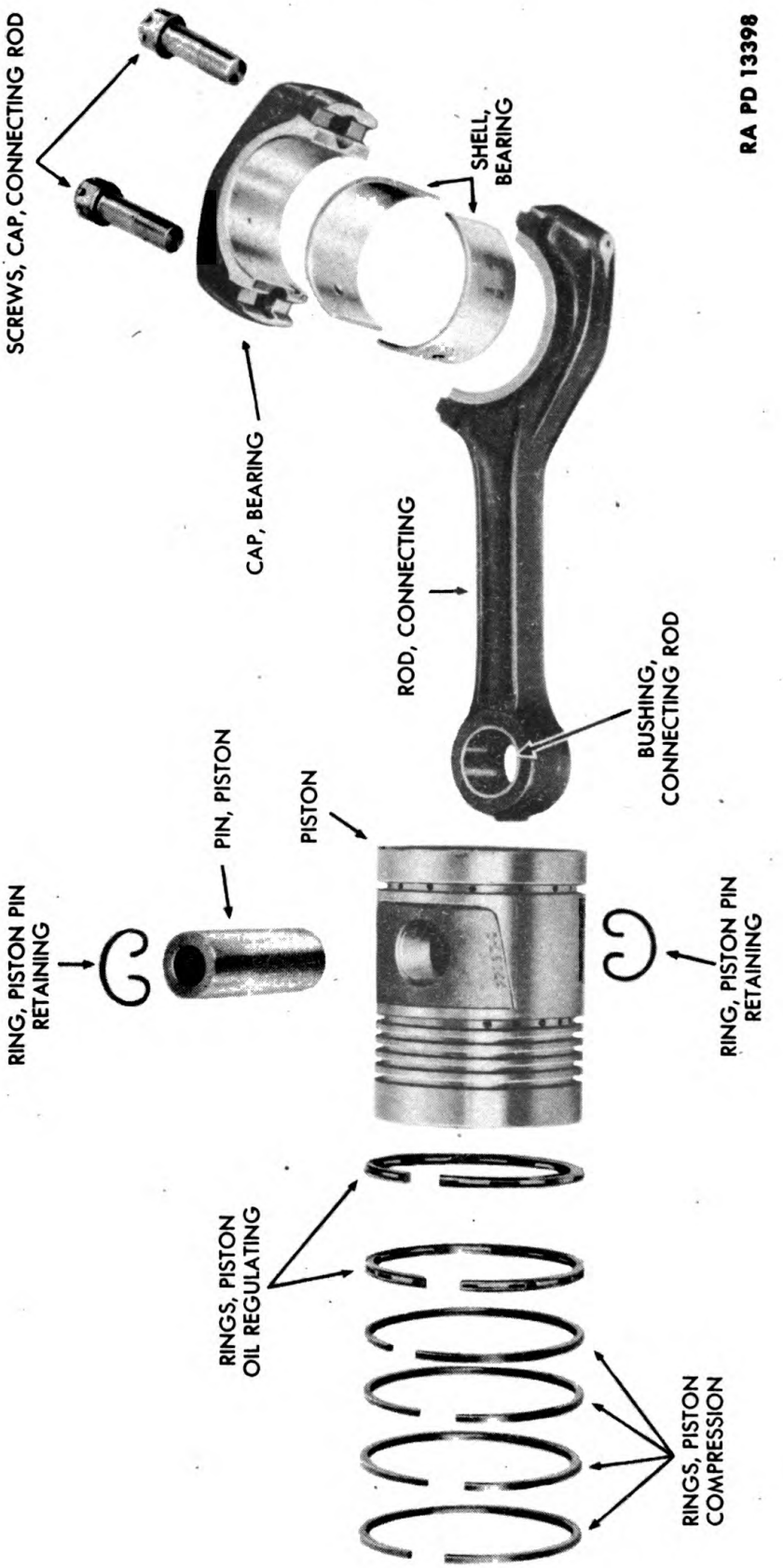


Figure 111—Piston and Connecting Rod Assembly—Exploded View

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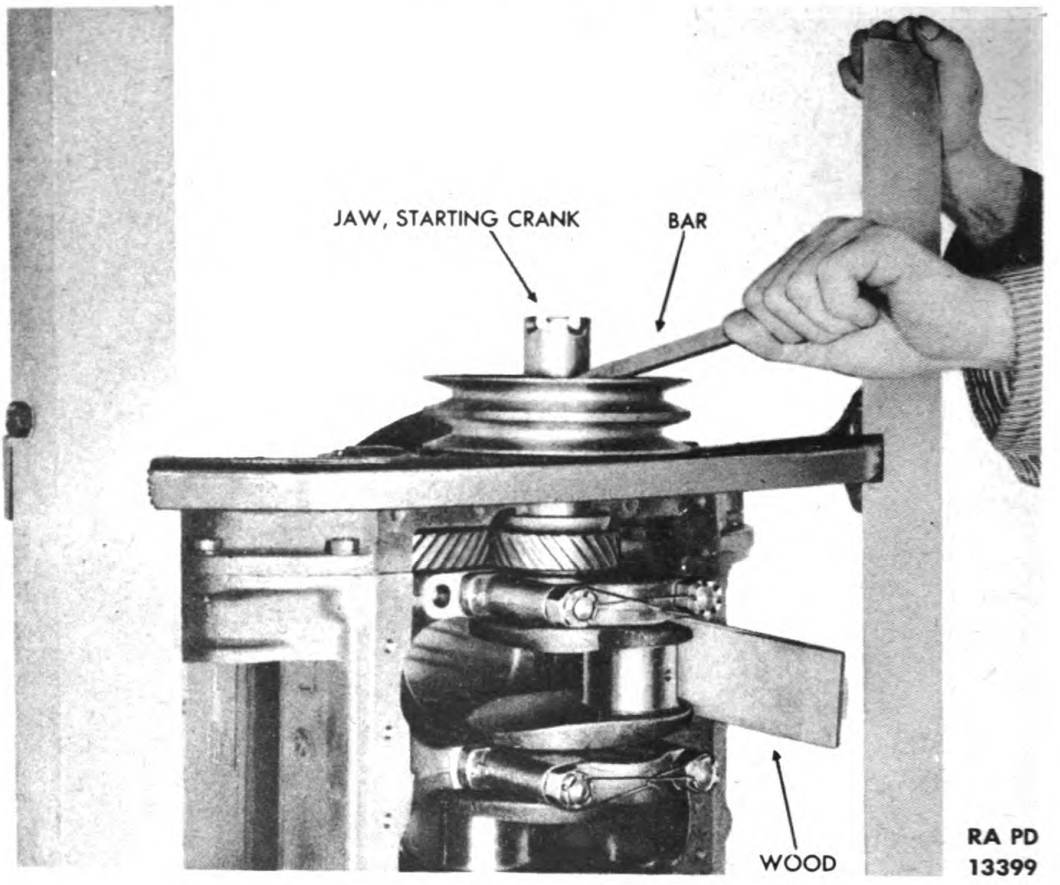


Figure 112—Removing Starting Crank Jaw

the crankshaft and the crankcase. Remove the starting crank jaw and special lock washer.

y. Remove Fan Drive Pulley (fig. 113).

Pliers
Puller
Wrench, open-end, $\frac{9}{16}$-in.

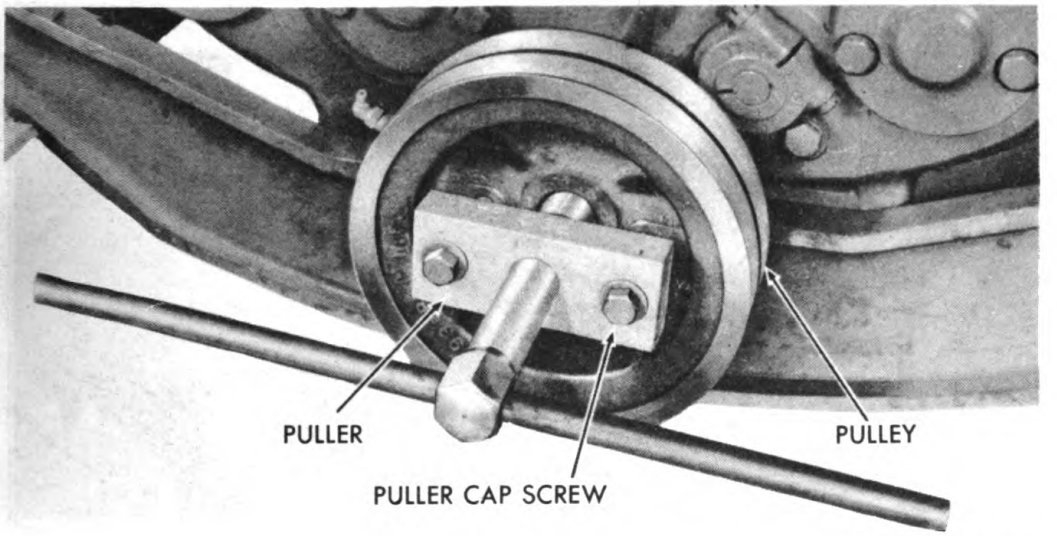
Rotate the engine and stand channels to a horizontal position. Place a pulley puller in position on the fan drive pulley. Tighten the two puller cap screws and turn the large center screw of the puller until the fan drive pulley comes off the crankshaft. Remove the Woodruff key from the crankshaft.

z. Remove Engine from Repair Stand (fig. 114).

Eye, lifting
Hoist, chain
Wrench, open-end, ¾-in.

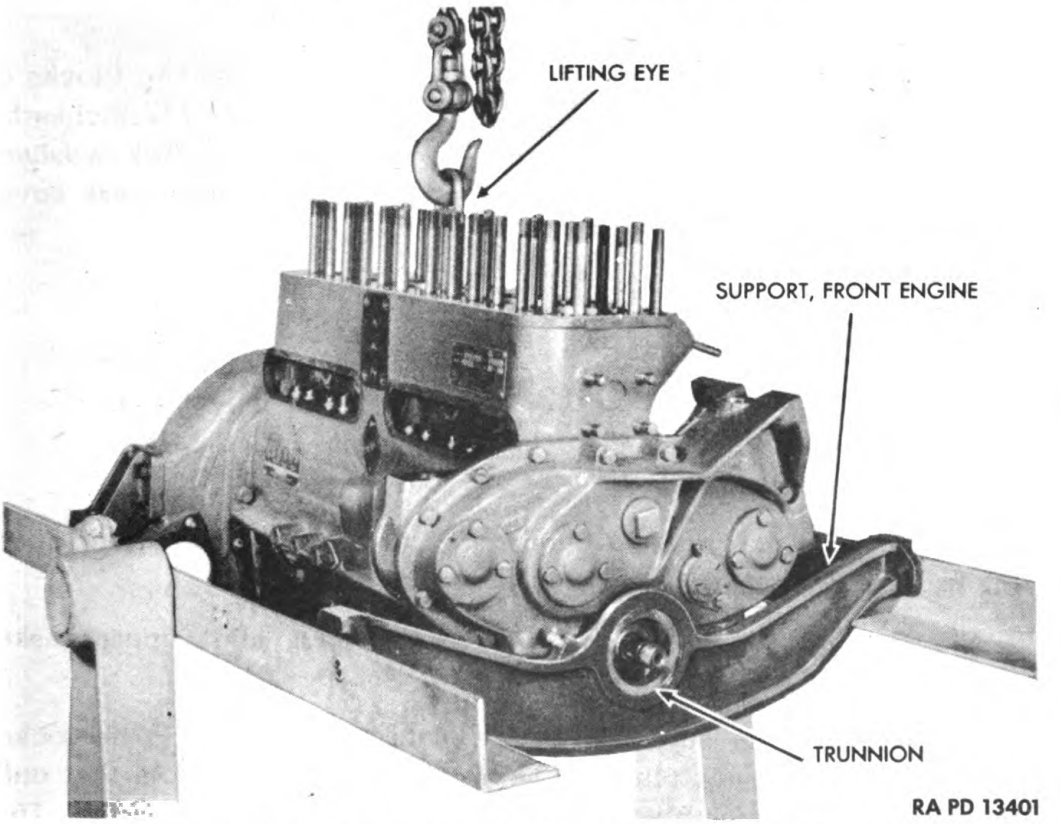
Loosen and remove the four bolts that fasten the engine in the stand. Place a lifting eye (one of the two which comes on the engine) on one of the center cylinder head studs. Lift the engine out of the stand with a chain hoist. Lift off the front engine support.

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RA PD 13400

Figure 113—Removing Fan Drive Pulley



RA PD 13401

Figure 114—Removing Engine from Repair Stand

aa. Remove Gear Case Cover (fig. 115).

Blocks, wood
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, socket, $\frac{9}{16}$-in.

Place the engine on a work bench with the cylinder head studs down.

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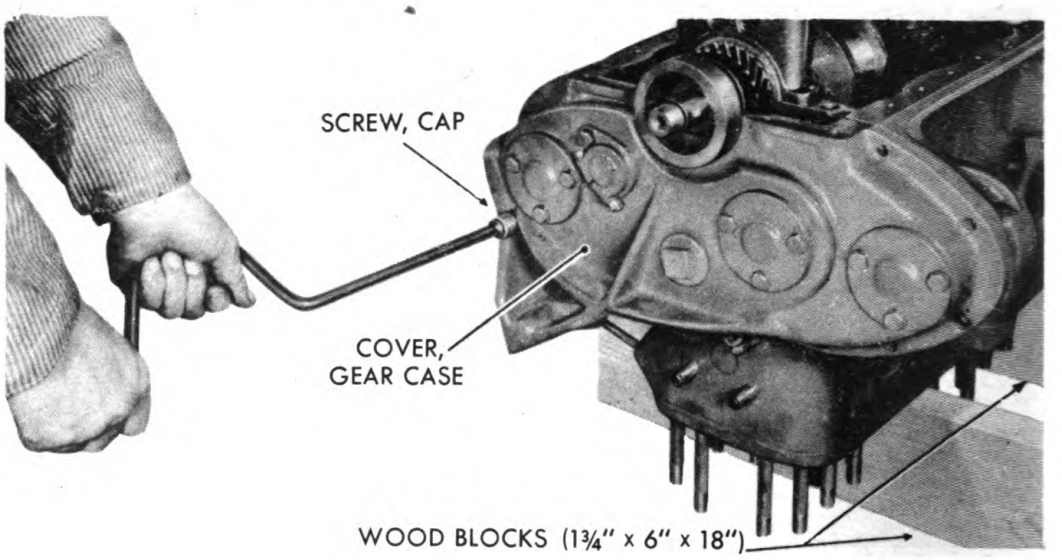


Figure 115—Removing Gear Case Cover RA PD 13402

To prevent the engine from resting on these studs, place two blocks of wood between the studs. These blocks should measure: 1¾ inches by 6 inches by 18 inches. Remove the 11 cap screws and lock washers which fasten the gear case cover in place. Lift off the gear case cover and gasket.

bb. Disassembly of Timing Gear Case Cover (fig. 116).

Pliers
Screwdriver
Screwdriver, small
Wrench, open-end, ½-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, 1-in.
Wrench, socket, $\frac{9}{16}$-in.

(1) Remove the two half-round cork seals from the crankshaft opening in the cover (screwdriver).

(2) Remove the timing chain inspection plug and copper gasket (1-in. open-end wrench).

(3) Remove the adjusting thrust plate cap screws ($\frac{9}{16}$-in. socket wrench). Thrust plate, plug and shims will come away. Note that only one thrust plate assembly is shown removed from the cover (fig. 116). Two others, identical to the one removed, are still in place. They can be removed in the same manner.

(4) Remove the cotter pin from the castle nut on the fuel pump drive adjusting screw and remove the nut (½-in. open-end wrench). Remove the adjusting screw.

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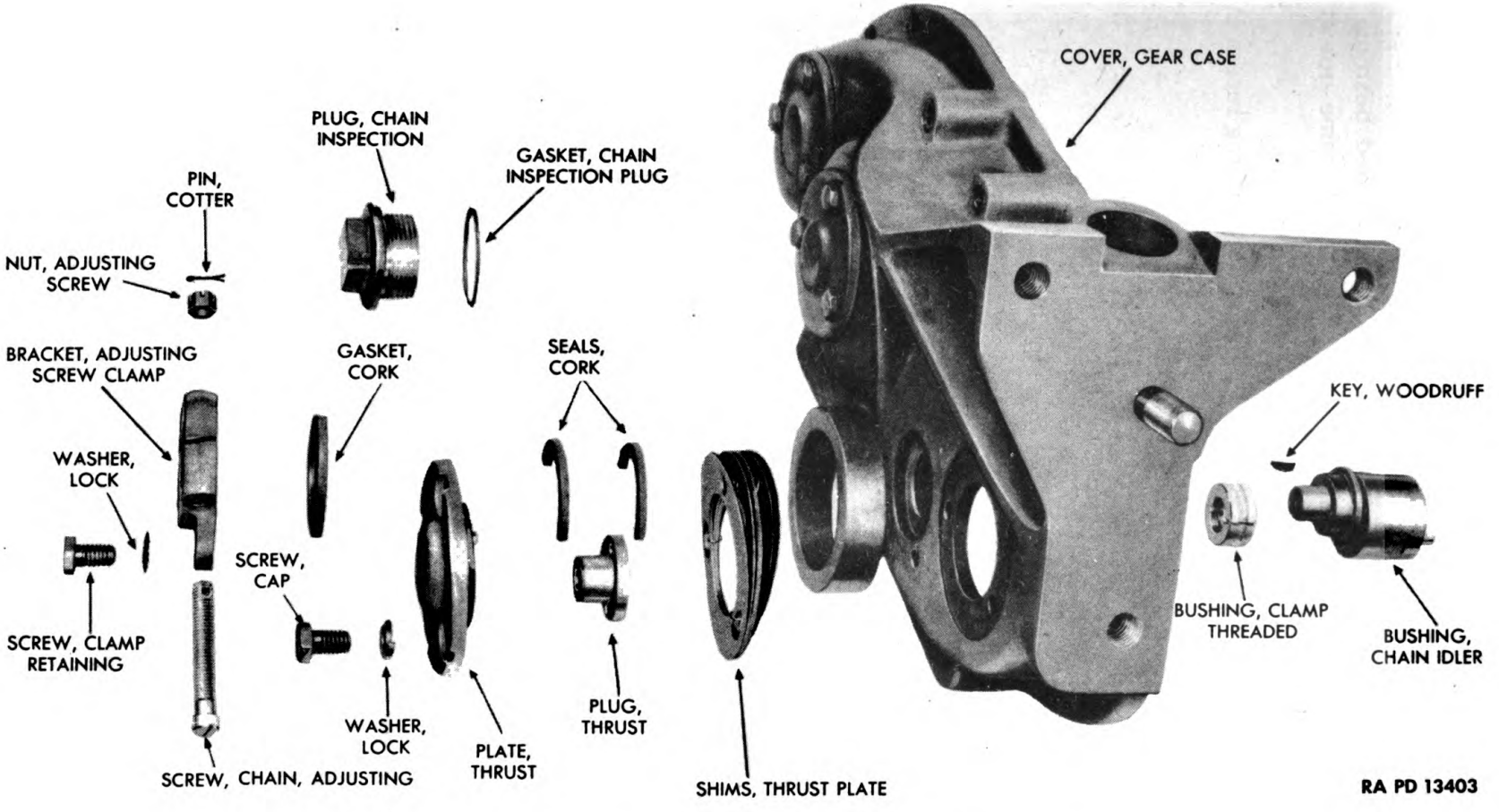


Figure 116—Gear Case Cover Assembly—Exploded View

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(5) Remove the clamp retaining screw and lock washer ($\frac{9}{16}$-in. open-end wrench).

(6) Remove the clamp by prying it off the threaded bushing. The clamp threaded bushing and chain idler bushing will come out at the rear of the case.

(7) Remove the cork gasket from the threaded bushing recess in the gear cover.

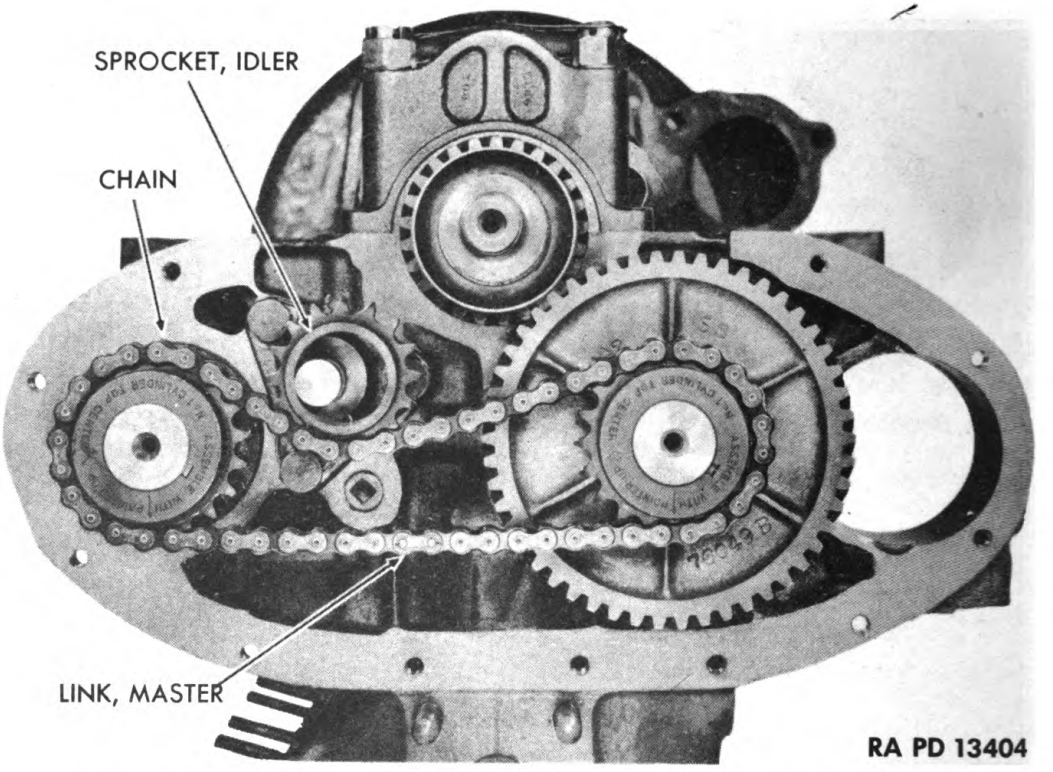


Figure 117—Removing Fuel Injection Pump Drive Chain

cc. Remove Fuel Injection Pump Drive Chain (fig. 117).

Screwdriver, thin blade

NOTE: The fuel injection pump drive chain is fitted with a master link for removal. To remove the chain, use following procedure: Remove the split clip from the master link with a thin screwdriver and pry off the top link plate (master link). Drive out the master link pins and bottom plate (one piece) and the chain will come apart and can be lifted off. Lift off idler sprocket. Install the master link in the chain.

dd. Remove Camshaft (fig. 118). Pull the camshaft out slowly and guide it through the camshaft bearings in the crankcase.

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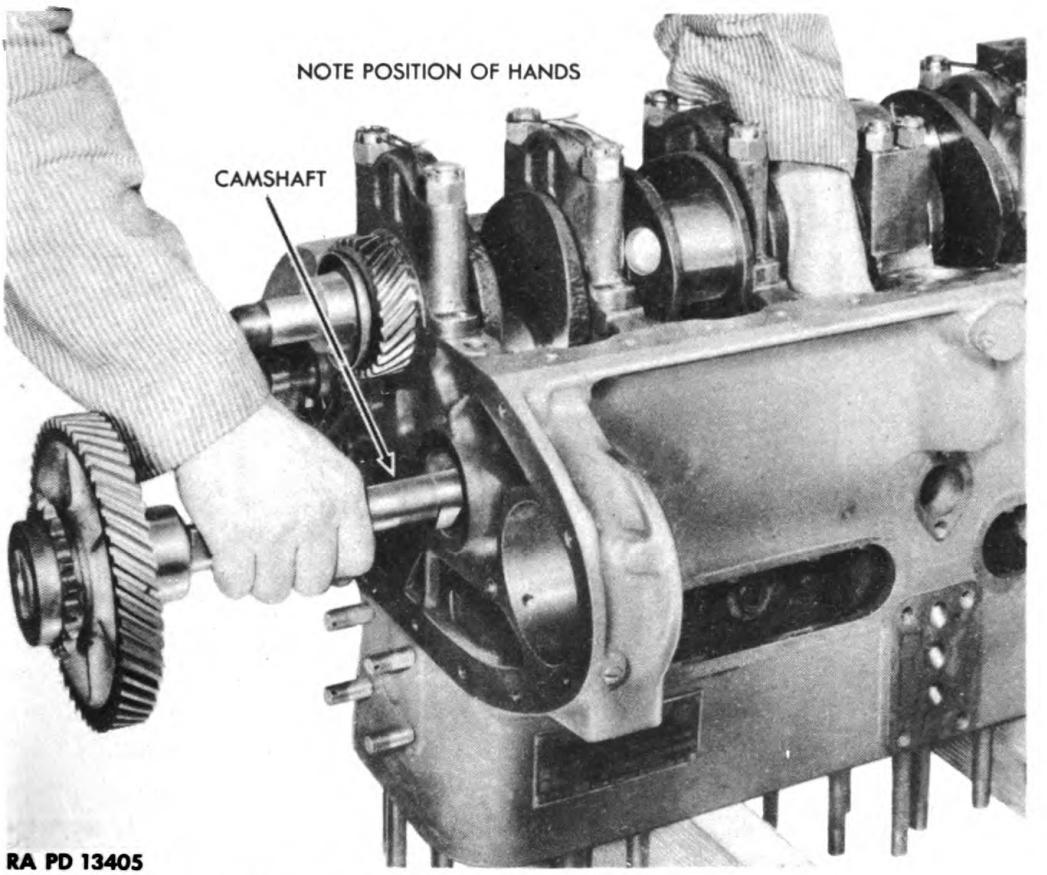


Figure 118—Removing Camshaft

ee. Remove Fuel Injection Pump Drive Sleeve (fig. 119).

Screwdriver

Remove the large set screw that secures the fuel injection pump drive sleeve and push the sleeve back.

ff. Disassembly of Fuel Injection Pump Drive Sleeve Assembly (fig. 120).

Drift, soft metal	Pliers
Hammer	Press, arbor
Hammer, fiber	Wrench, socket, 7/8-in.

(1) Remove nut and lock washer from the coupling end of the sleeve shaft (fig. 120).

(2) Drive the coupling hub off the shaft (fiber hammer) and remove Woodruff key.

(3) Pull sleeve shaft from the drive sleeve.

(4) Remove the brass thrust washer.

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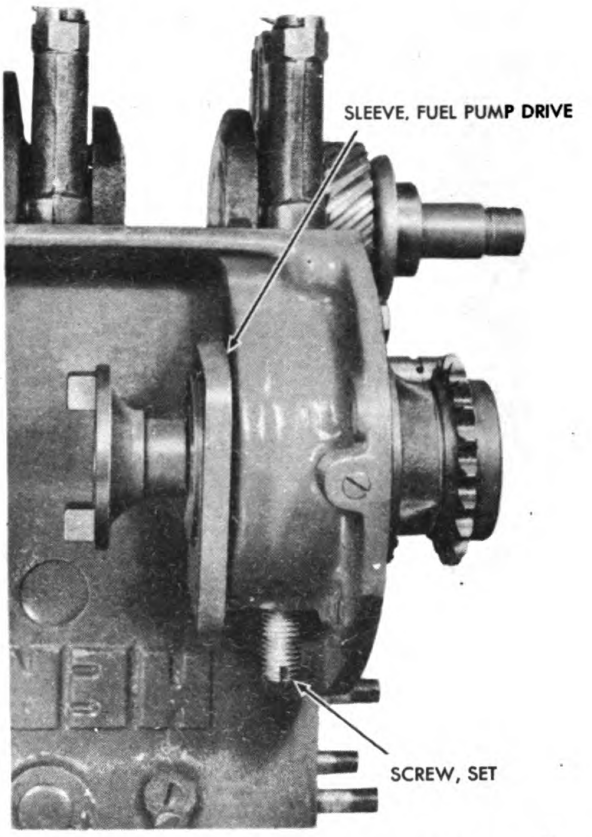


Figure 119—Removing Fuel Pump Drive Sleeve Assembly

(5) The oil thrower and sprocket (fig. 120) need not be removed from the sleeve shaft unless they show excessive wear or are damaged. The oil thrower has an easy driving fit on the shaft and can be removed by tapping lightly with a fiber hammer. The sprocket has a driving fit and is keyed to the shaft. It will be necessary to put this unit in an arbor press to remove the sprocket.

(6) Remove the oil seal from the pump drive sleeve (fig. 120) with a soft metal drift and hammer. Press out worn or damaged bushing from sleeve.

gg. Remove Bell Housing (fig. 121).

Wrench, open-end, ¾-in. Wrench, socket, ¾-in.

(1) NOTE: The bell housing is secured to the crankcase with six cap screws and lock washers. Two of these cap screws are put in through the rear of the housing.

(2) Remove the two cap screws from the inside of the housing (¾-in. socket wrench, short extension and handle).

(3) Remove the four cap screws on the outside of the housing. Note

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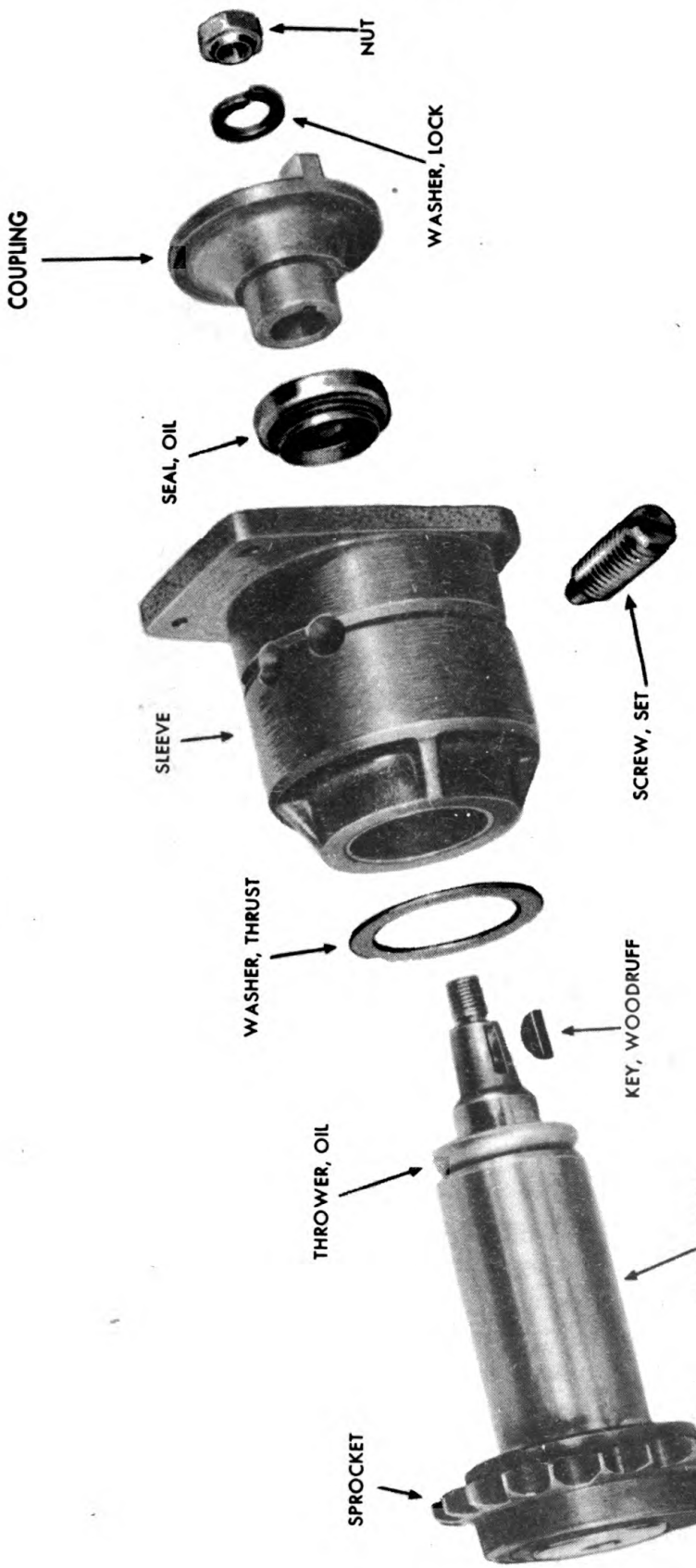


Figure 120—Fuel Pump Drive Sleeve Assembly—Exploded View

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that two of these cap screws have thin heads. Note the location of each screw so that they can be put back in the same places.

(4) Remove the flywheel housing and with it the gasket and the oil seal.

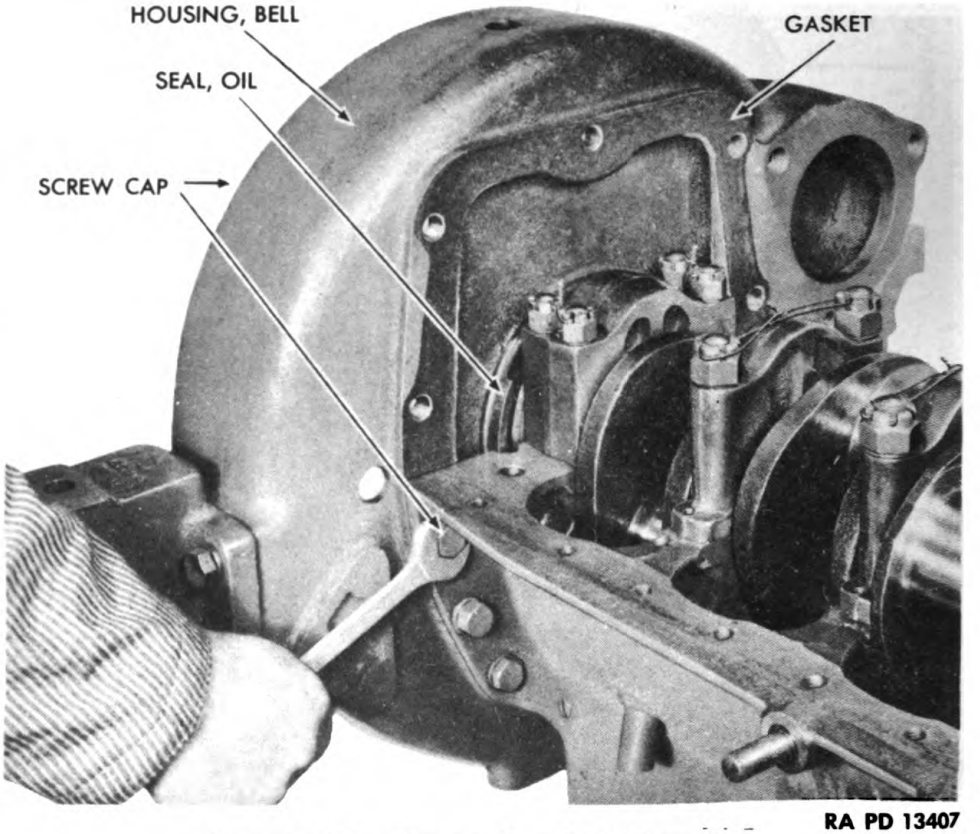


Figure 121—Removing Bell Housing

hh. Remove Main Bearing Caps (fig. 122).

Pliers, cutting
Wrench, socket, ¾-in.
Wrench, socket, $\frac{15}{16}$-in.

(1) NOTE: There are seven main crankshaft bearing caps held in position by studs, castle nuts and safety wire. The center and rear bearing caps are held in position by four studs each, and the intermediate (2) and front (3) main bearing caps are held by two studs each. The studs on the center and rear main bearing caps are smaller than those on the intermediate and front main bearing caps. All main bearing caps are stamped on the side next to the camshaft with the number of the main bearing it fits. These are numbered 1 to 7 inclusive, beginning with the front main bearing No. 1.

(2) Remove the safety wire from the castle nuts, then loosen and remove the 8 smaller castle nuts.

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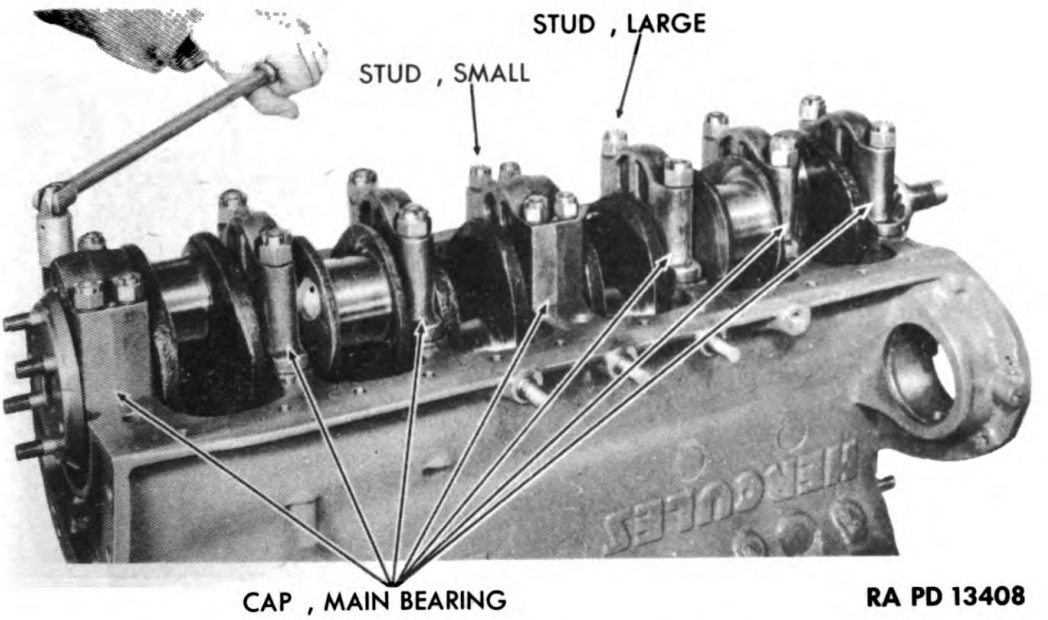


Figure 122—Removing Main Bearing Caps

(3) Loosen and remove the 10 larger castle nuts.

(4) Lift off the main bearing caps with their respective main bearing lower shells.

(5) Lift out the crankshaft.

(6) Remove the upper shells which are in the crankcase, by hand.

(7) NOTE: It is advisable to replace the upper and lower bearing shells each time an engine is torn down for a major overhaul. However, should these bearing shells be removed for some other reason and they are to be reinstalled, it will be necessary to mark each shell on the back with the bearing number from which it was removed. These should be numbered 1 to 7 inclusive, beginning with the front bearing No. 1.

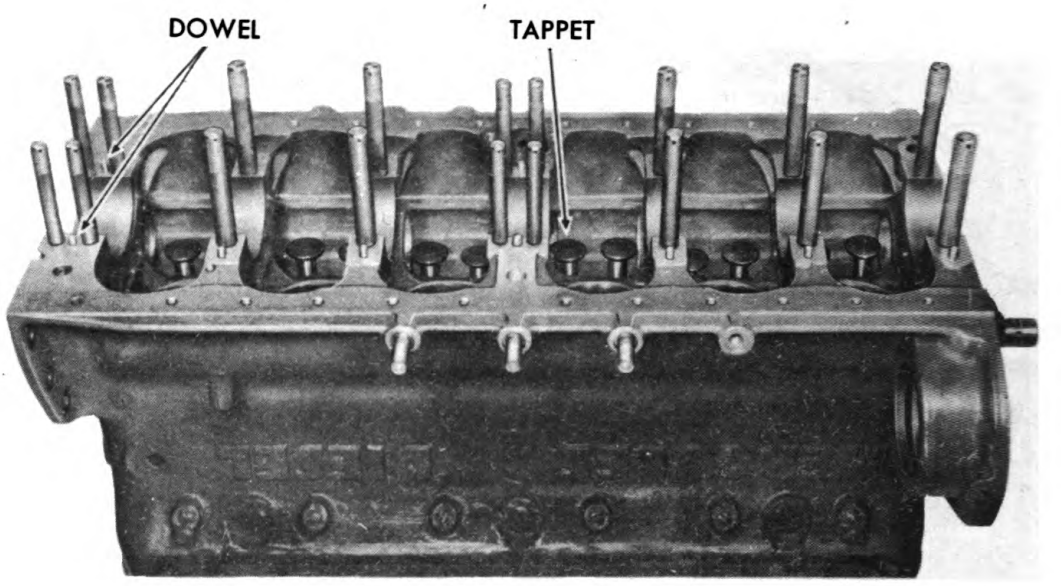
(8) Note the main bearing cap locating dowels in the crankcase. These permit removal and replacement of the main bearing caps without shifting the bearings in the case.

ii. Remove Valve Tappets (fig. 123). The 12 valve tappets are lifted out of the crankcase by hand.

57. VACUUM PUMP.

The removal of the vacuum pump as a unit, was done (par. 55, c) to facilitate the reconditioning operations on the engine proper. NOTE: For disassembly and maintenance of engine accessories, see sections VI "Cooling System," sections VII and VIII "Electrical System," section X "Fuel System," and section XI "Lubrication System."

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Figure 123—Removing Valve Tappets

58. MAINTENANCE AND REPAIRS.

After the engine has been completely torn down and subassemblies have been disassembled, all component parts of the engine should be thoroughly cleaned of oil, grease and carbon prior to inspection. The cleaning is done in the following manner:

a. Cleaning.

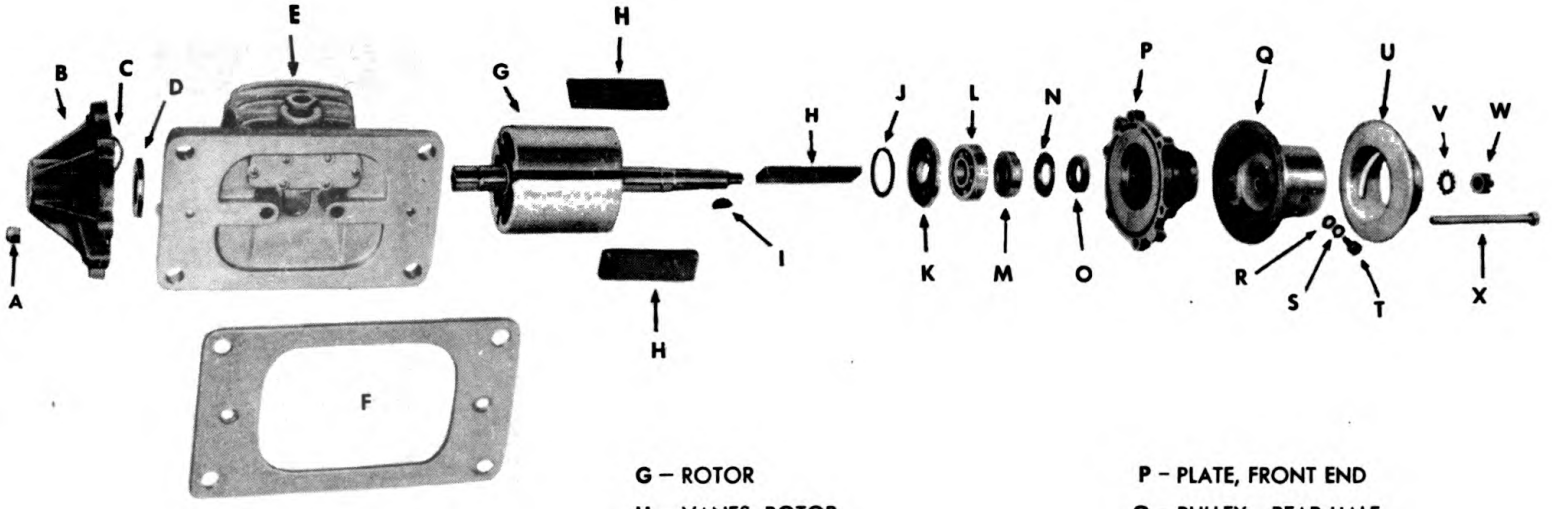
(1) Soak all aluminum parts overnight in SOLVENT, dry-cleaning. Rinse the parts off in hot water and dry them.

(2) Clean the pistons as explained above and clean the ring grooves with a broken piston ring ground flat on the end.

(3) Place all steel parts in Rock Island Arsenal No. 3 cleaner consisting of 90% sodium orthosilicate and 10% sodium resinate, heated to 200 F. Leave them in long enough to dissolve all grease and dirt. Remove the parts, rinse in hot water, blow out with compressed air, and wipe dry. Never, *under any circumstances,* immerse an aluminum or aluminum alloy part in a *steel stripping solution,* regardless of how weak the solution may be. It may be necessary under certain circumstances to further clean steel parts such as valve heads, piston pins, shafts, etc., by buffing on a wire wheel.

(4) Thoroughly clean all oil lines and passages in the crankcase, crankshaft, connecting rods and other parts where such passages are

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A – NUT – SPECIAL
B – PLATE, REAR END
C – GASKET, RUBBER
D – RING, ROTOR VANE SPACING
E – HOUSING
F – GASKET (HOUSING TO BRACKET)
G – ROTOR
H – VANES, ROTOR
I – KEY, WOODRUFF
J – RING, ROTOR VANE SPACING
K – BAFFLE
L – BEARING, BALL
M – SEAL, OIL
N – WASHER, FIBER
O – WASHER, FELT
P – PLATE, FRONT END
Q – PULLEY – REAR HALF
R – WASHER, PLAIN
S – WASHER, LOCK
T – SCREW, CAP
U – PULLEY – FRONT HALF
V – WASHER, LOCK
W – NUT, CASTLE
X – BOLT, HOUSING

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Figure 124—Vacuum Pump Assembly—Exploded View

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employed for lubricating reciprocating parts, by forcing steam through each opening until it flows without restriction.

(5) All gaskets shellacked onto the various parts must be stripped off and destroyed. All surfaces where sealing compound has been used must be thoroughly cleaned by scraping and washing with a suitable solvent, such as alcohol.

b. Inspection. As soon as each part has been cleaned as explained above, it should be inspected and kept properly covered to protect it from dust and dirt, etc., if it is to be used for reassembly. Set all discarded parts to one side and mark in such a manner that they will not become mixed with the new parts intended for replacement when the engine is reassembled.

(1) Where out-of-round, taper or wear exceeds limit values specified, a new part or a permissible reworking of an old part to the standard of oversize or undersize is the only remedy except, of course, complete replacement of the part or parts.

(2) If available, the magnaflux inspection process should be applied to all steel parts except ball and roller bearings, studs, standard nuts and washers.

(3) New piston rings should be installed at every overhaul.

(4) All main crankshaft bearing shells and connecting rod bearing shells should be replaced with new ones at every overhaul.

(5) Loose, damaged or worn bushings must be removed and new ones installed.

(6) Any loose, broken or damaged stud, or any stud that has been turned until it does not have proper height above its flange, must be removed and an oversize stud installed. Replacement studs should be 0.003-inch larger than those removed.

(7) Fan and flywheel must be checked for balance at every major overhaul.

(8) CYLINDER BLOCK AND CRANKCASE (fig. 125).

(a) Examine the block for cracks. If it is cracked, it must be replaced.

(b) Check top of block and resurface if necessary.

(c) Inspect all expansion plugs and replace loose or damaged plugs.

(d) Examine case for cracks.

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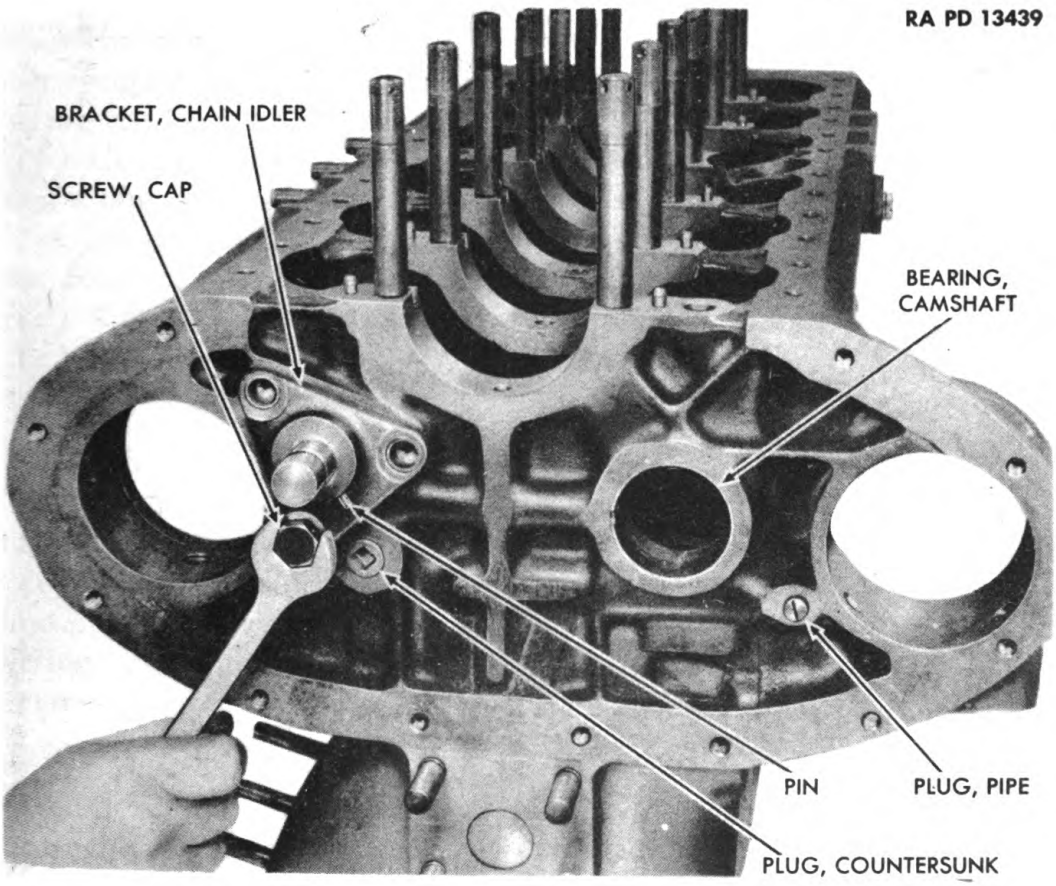


Figure 125—Crankcase

(e) Examine all studs for looseness and thread condition. Damaged and loose studs must be replaced.

(f) Examine the four camshaft bearings. These bearings are of the removable babbitt-lined type. Replace if necessary.

(g) Measure the cylinder bores with an inside micrometer to determine taper and out-of-round caused by wear. The measurements should be made at the top of the cylinder bore, preferably in the first ½ inch of top piston ring travel, in several places around the inside circumference of the bore, and again in several places near the bottom of the cylinder bore. If the difference between the top and bottom measurements exceeds 0.008 inch, the cylinder should be rebored as covered in paragraph 58 c(4).

(h) Replace all worn valve tappet guides.

(i) Examine the chain idler bracket (fig. 125) and, if worn, replace with a new bracket. This can be done by removing the three cap screws (¾-in. open-end wrench).

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

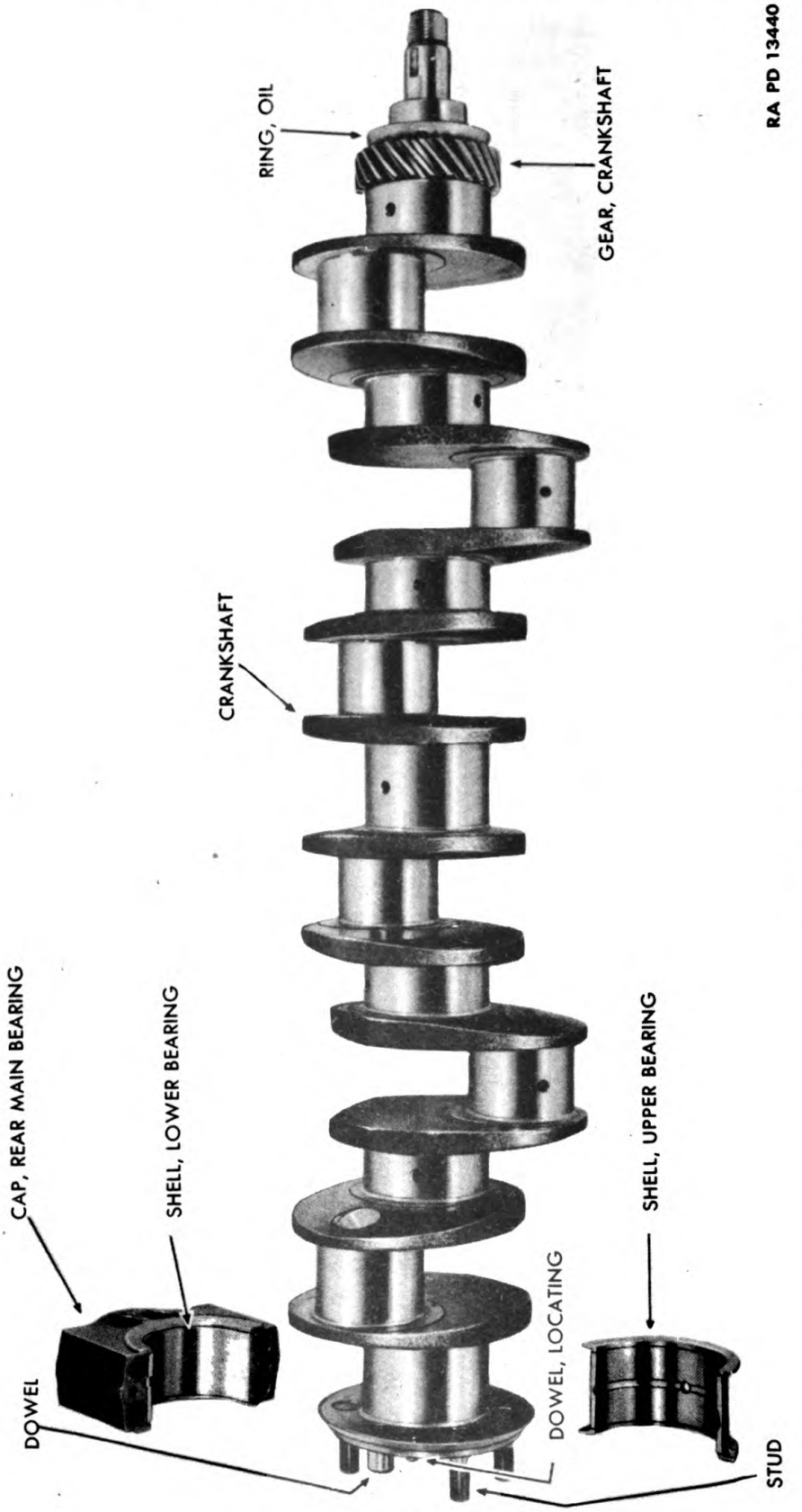


Figure 126—Crankshaft

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ENGINE

(9) CRANKSHAFT (fig. 126).

(a) The crankshaft main bearing and connecting rod journals should be measured for wear with a micrometer. Any journals under 2.993 inches should be reground and fitted with the next standard undersize bearing shells (par. 58 c(8)).

(b) Check crankshaft for alinement by placing it on V blocks and using a dial indicator on two center journals.

(c) Inspect the four rear flange studs for stripped threads and looseness. Replace if needed.

(d) Examine the flywheel flange dowels. Replace if too loose.

(e) Examine the crankshaft timing gear for condition. If it shows worn or damaged teeth, replace with a new gear.

(10) PISTONS.

(a) Check pistons for cracks. If cracked, replace with new pistons. If cylinders are rebored, use oversize pistons (par. 58 c(4)).

(b) The pin should have a clearance in the piston pin bosses of a hand-push-fit with the piston hot. Clearance of the piston pin in the connecting rod bushings should be 0.001 inch to 0.0015 inch. Replace pin if clearance exceeds limits.

(11) CONNECTING RODS.

(a) Clean and inspect the connecting rods, caps, and bushings very thoroughly. If a rod is twisted or damaged in any way, it must be replaced.

(b) All connecting rod bearing shells should be replaced each time an engine is disassembled for major overhaul.

(c) Replace all worn or damaged cap screws and connecting rod bushings.

(12) VALVES.

(a) Inspect for warping or elongation of stem. Replace if these conditions exist.

(b) Inspect for burning or pitting of face. Replace if this condition exists.

(c) Inspect for wear of stem as determined by micrometer (0.002-in.-0.003-in. clearance in guide). Replace valve if clearance exceeds limits.

(13) VALVE STEM AND TAPPET GUIDES. Inspect all the valve tappet guides in the crankcase, and the valve stem guides in the cylinder head for scoring. Replace guides if necessary.

(14) CAMSHAFT (fig. 127).

(a) Examine the timing gear for damaged teeth. Check backlash with crankshaft gear (0.005 in.-0.0015 in.). Replace a damaged gear or

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

RA PD 13441

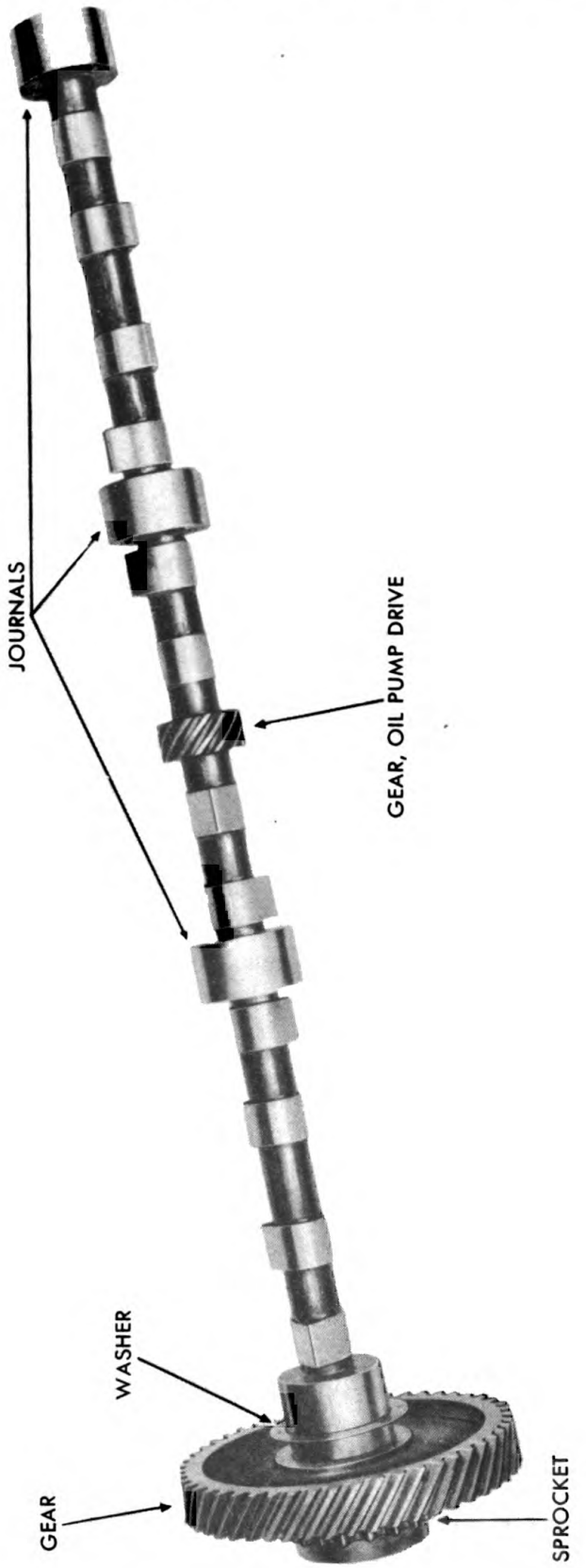


Figure 127—Camshaft

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one which is so badly worn that it will produce excessive backlash and chatter.

(b) Inspect all cams, journals, and the oil pump drive gear in the center of the shaft. If cams are defective or the gear is damaged replace the camshaft.

(15) CYLINDER HEAD.

(a) Inspect the cylinder head. If cracked, it should be replaced.

(b) If valve seats are pitted, they should be reground.

(c) Replace all worn, loose or damaged studs.

(d) Replace all loose or damaged expansion plugs.

(16) FLYWHEEL.

(a) The flywheel starter ring should be examined for broken teeth and for teeth worn so much that they cannot furnish proper engagement with the starter pinion. Replace the starter ring if necessary.

(b) Inspect the flywheel for elongation of stud and dowel holes. Replace flywheel if necessary.

c. Repairs.

(1) REPLACING CAMSHAFT BEARINGS (fig. 125).

(a) Press out the worn camshaft bearings on an arbor press.

(b) Press in new bearings, making sure that each bearing oil hole lines up with the oil passage in the cylinder block.

(c) After the new bearings are in position, they should be line reamed to give the proper clearance with the camshaft journals. This clearance is 0.0015 inch to 0.0025 inch.

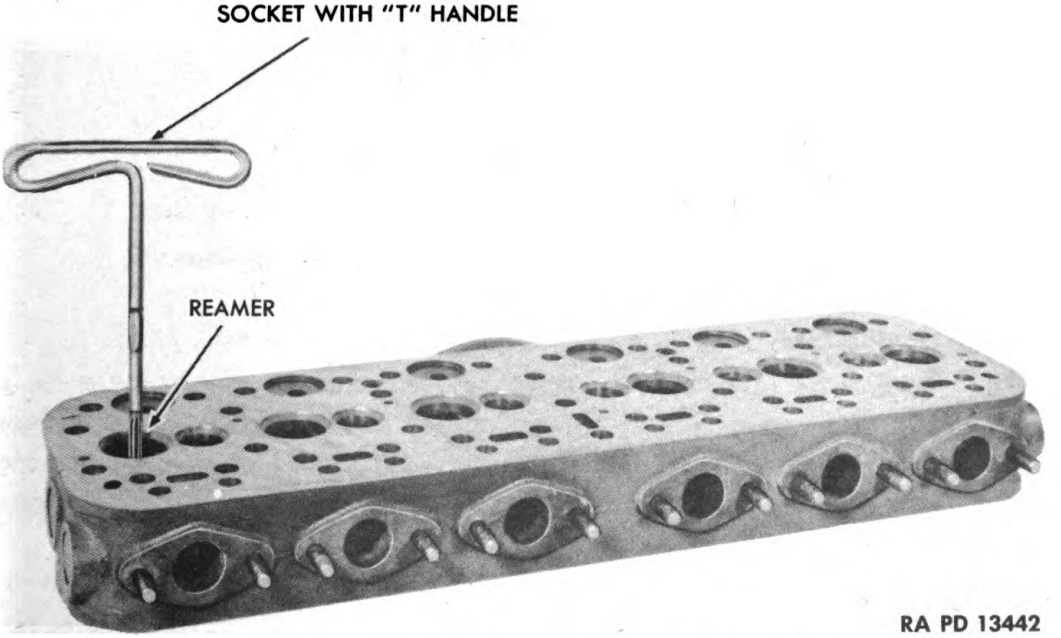


Figure 128—Reaming Valve Stem Guides

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(2) REPLACING VALVE STEM GUIDES (fig. 128).

(a) Drive the worn valve stem guides from the cylinder head with a steel pilot bar and hammer. The pilot bar should be about 8 inches long and 5/8 inch in diameter. The pilot on the end of the bar should be 7/8 inch long and slightly less than 3/8 inch in diameter (0.372 in.-0.373 in.).

(b) Insert the new guides with the same tools.

(c) Ream the new guides to get the proper clearance (0.002 in.-0.003 in.).

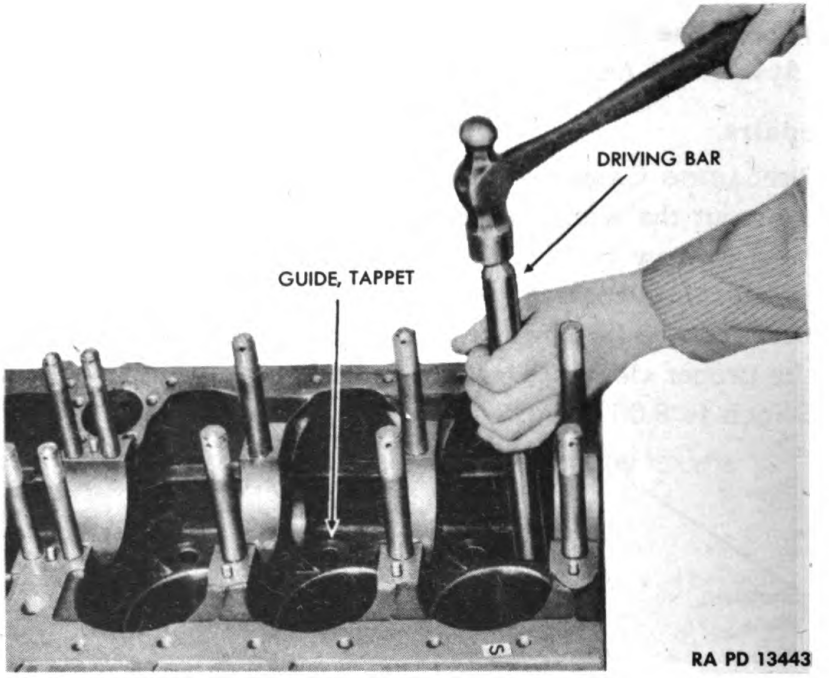


Figure 129—Removing Valve Tappet Guides

(3) REPLACING VALVE TAPPET GUIDES (figs. 129 and 130).

(a) Drive the worn valve tappet guides from the crankcase with a steel pilot bar and hammer. The pilot bar should be about 10 inches long and 7/8 inch in diameter. The pilot on the end of the bar should be 1 inch long and slightly less than 3/8 inch in diameter (0.372 in.-0.373 in.) (fig. 129).

(b) Insert the new guides with the same tools.

(c) Ream the new guides to get the proper clearance (0.001 in.-0.0015 in.).

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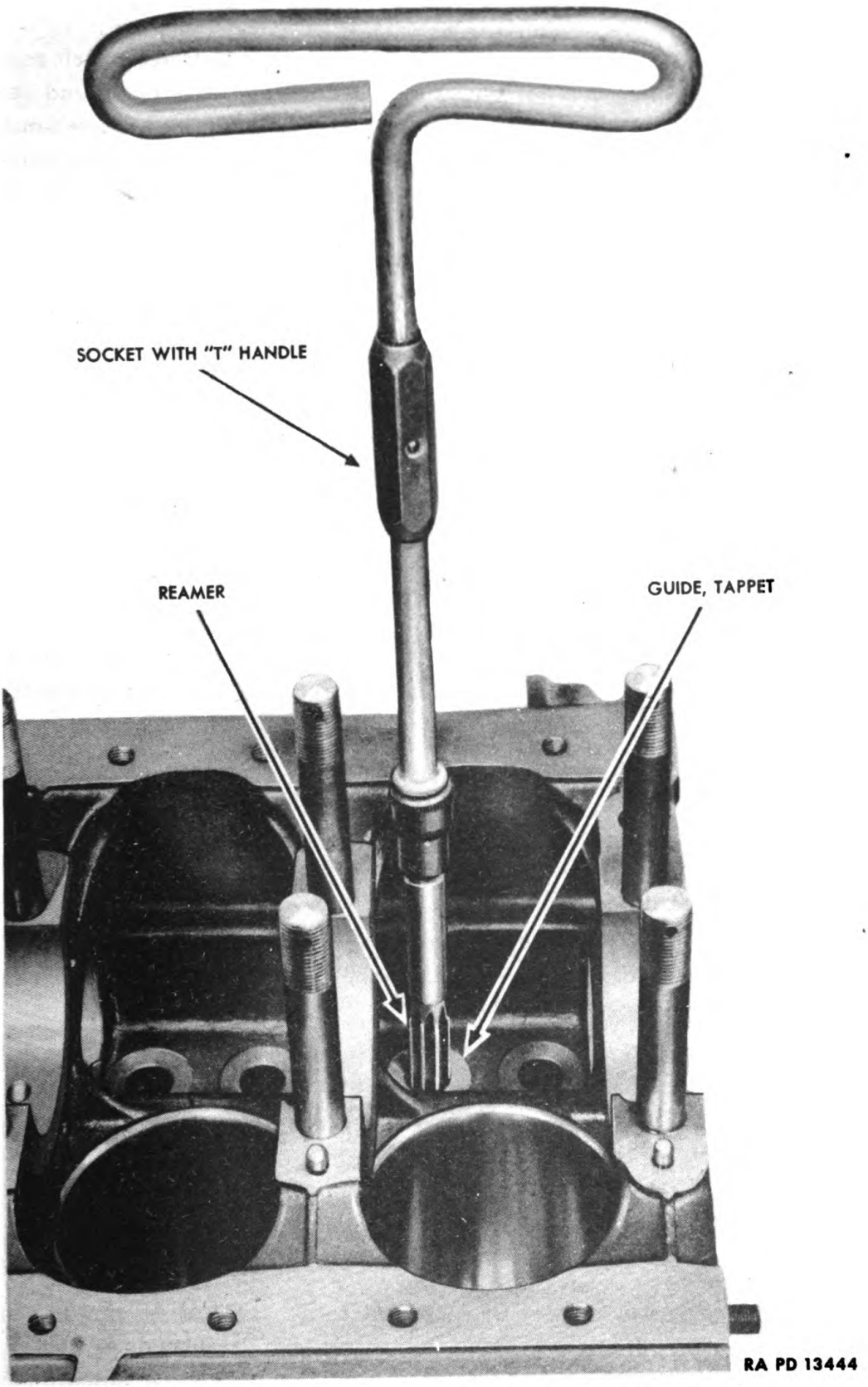


Figure 130—Reaming Valve Tappet Guides

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(4) REBORING AND HONING OF CYLINDER BLOCK. Bores which need cleaning and which are not badly scored, tapered, or out-of-round can be done by running a hone up and down the cylinder wall a few times. Cleaning solvent and oil at a ratio of 4 to 1 should be used while honing. NOTE: An excess of material should not be honed from the walls as this would cause piston slap and possible oil pumping. If the inspection indicates that the cylinder bores need reboring, it should be done as follows:

(a) Determine the oversize pistons to be used. Add amount of oversize piston to standard size of cylinder bore (4 in.). Subtract approximately 0.002 inch for honing. The balance will provide correct setting for boring equipment.

(b) Clamp the reboring tool over the cylinder to be rebored after having centered the tool by lowering the cutter into the cylinder.

(c) The cutter should be set to the desired diameter, as determined above. Start the machine and run it through the cylinder.

(d) After boring to the desired diameter, go through the cylinder several times with a hone. The hone is attached to a $\frac{5}{8}$-inch electric drill and lowered and raised in the cylinder.

(5) REAMING VALVE SEATS (fig. 131).

(a) Ream out the valve seats with a reseating tool until a new cut shows evenly all around the valve seat. Use a $1\frac{7}{8}$-inch by 45-degree cutter for reseating the inlet valves and a $1\frac{3}{8}$-inch by 45-degree cutter for reseating the exhaust valves. Bear down on the cutter or reamer to get the cut, otherwise a glazed surface will result after the engine has been in operation a short while.

(b) When valve seats are too wide, follow 45-degree cutter with a 15-degree cutter or stone to narrow seat to a width of $\frac{5}{32}$ inch.

(6) REFACING VALVES (fig. 132).

(a) Having checked all valves for condition of face and the stem for warping and wear, proceed to reface each valve in a refacing machine.

(b) Bring the valve face in each case to an angle of 45 degrees for both exhaust and inlet valves. The valve face is turned against an abrasive wheel until enough metal is removed to give a smooth 45-degree surface all around the face.

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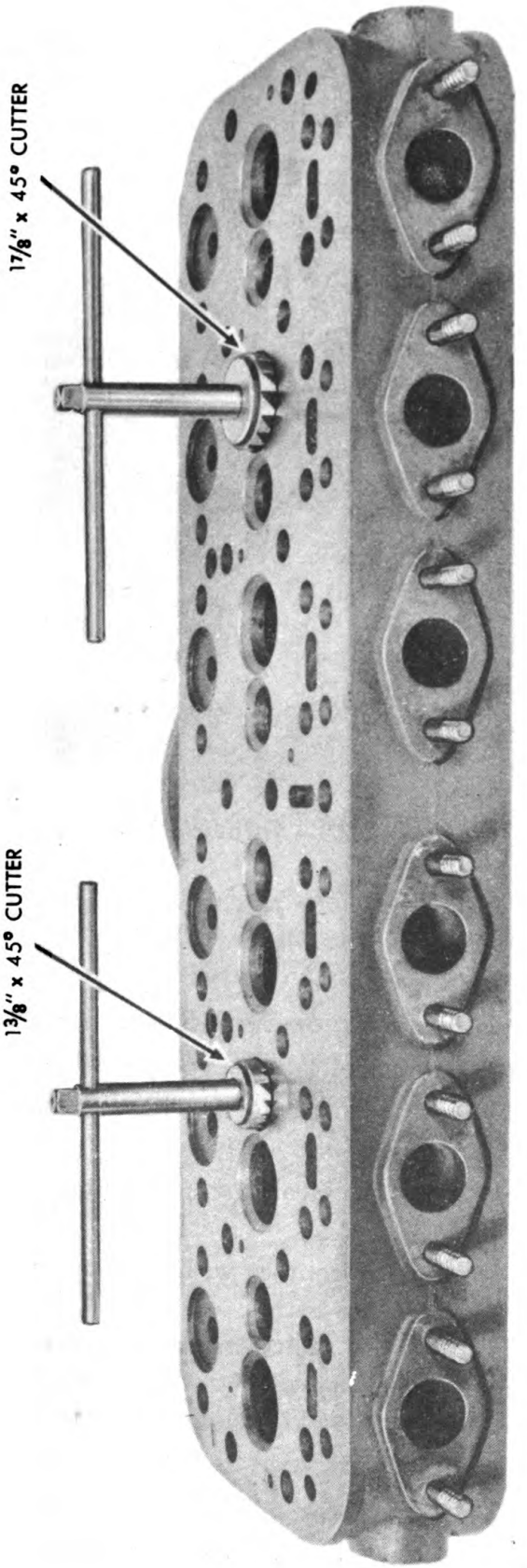


Figure 131—Refacing Valve Seats

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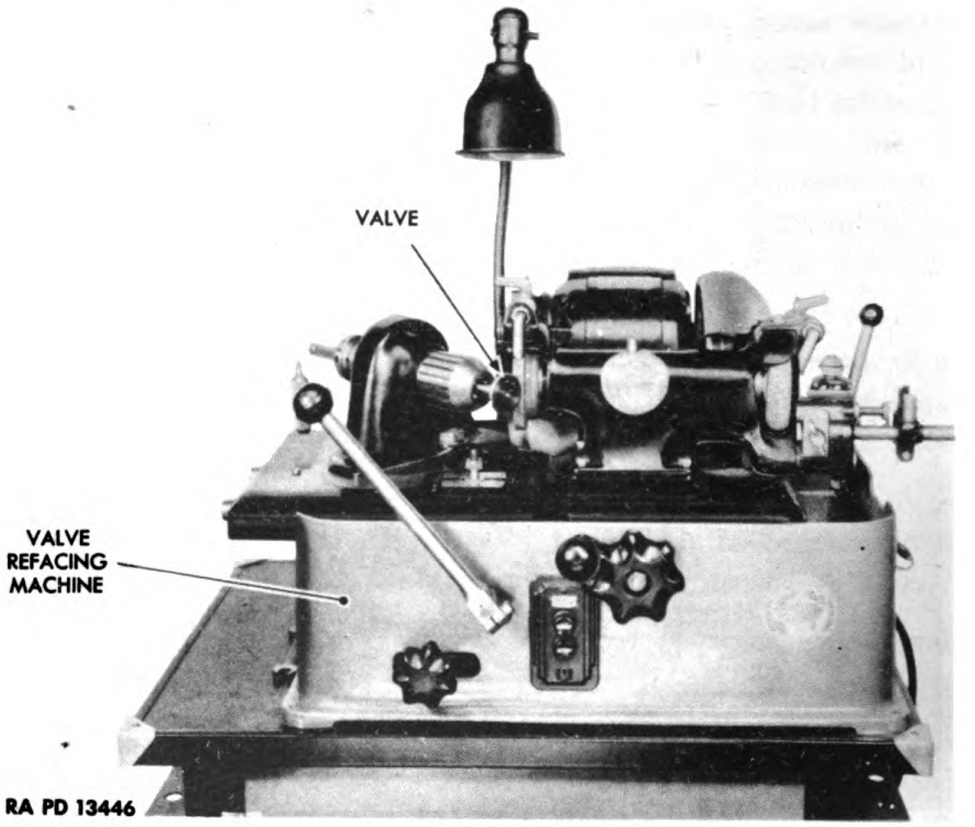


Figure 132—Refacing Valve

(7) GRINDING VALVES (fig. 133). After the valves have been refaced and valve seats in the head reamed, the valves and seats should be ground (lapped) as follows:

(a) Place each valve in its proper valve opening in the cylinder head.

(b) Place a small amount of lapping compound around the face.

(c) Rotate the valve back and forth with a hand or electric valve grinding tool until a finished surface is secured.

(d) Remove the valve and clean the compound from the valve and valve seat.

(e) Test valve for perfect contact with seat by marking lines about ¼ inch apart on face of valve with a lead pencil. Insert valve in guide and give a ¼ turn. If all the pencil marks are removed, the operation may be considered satisfactory. If, on the other hand, one or more pencil marks remain, the valve or seat should be reground or lapped until it seats properly.

(8) REGRINDING CRANKSHAFT JOURNALS.

(a) Place the crankshaft in a crankshaft grinding machine.

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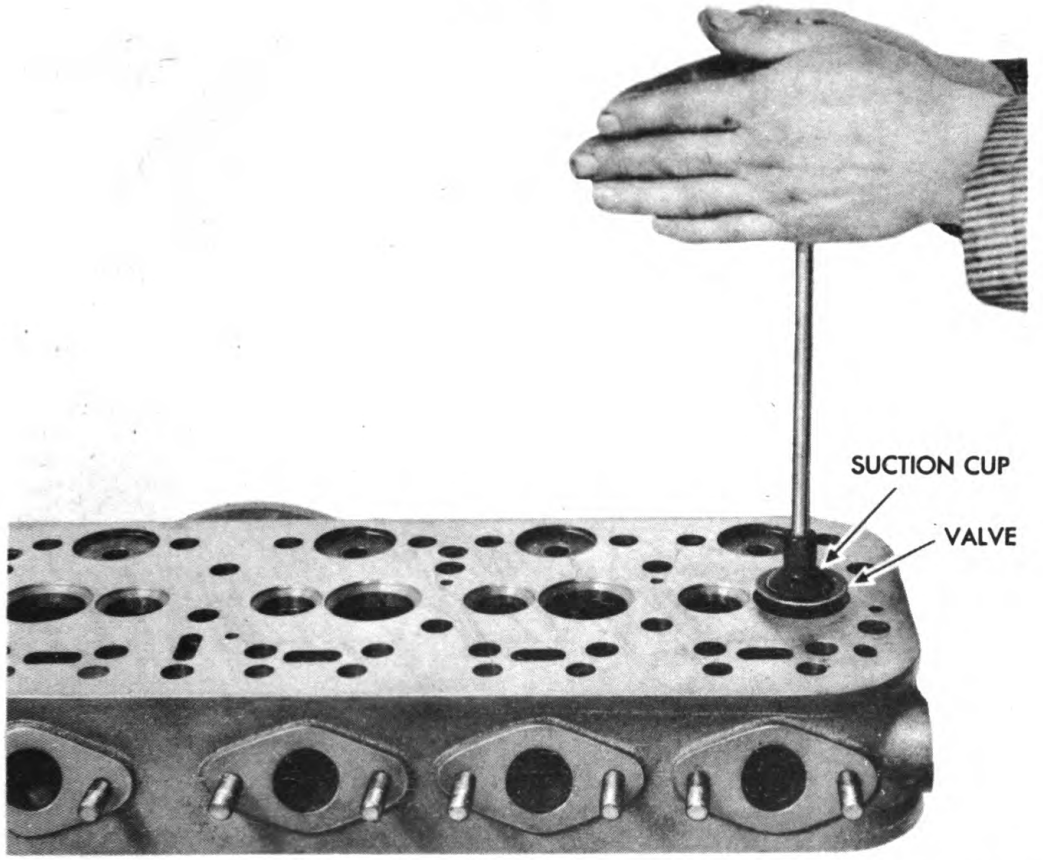


Figure 133—Grinding Valve RA PD 13447

(b) Grind journals to a diameter which will provide the proper clearance (0.003 in.-0.004 in.) with the nearest undersize bearing shells. **NOTE:** Shims are never used between the case and bearing caps. When the micrometer reading of crankshaft journal reads 2.993 inches or less, it should be ground and fitted with next standard undersize bearing shells.

(9) REGRINDING CONNECTING ROD JOURNALS.

(a) Place the crankshaft in its proper position in the crankshaft grinding machine and proceed to regrind the worn connecting rod journals in the same manner as the main crankshaft journals are reground.

(b) These worn journals should be reground to a diameter which will provide the proper clearance (0.003 in.-0.004 in.) with nearest undersize connecting rod bearing shells. **NOTE:** Shims are never used between the connecting rod and caps. When the micrometer reading of the journal reads 2.493 inches or less the journal should be ground and fitted with the next standard undersize bearing shells.

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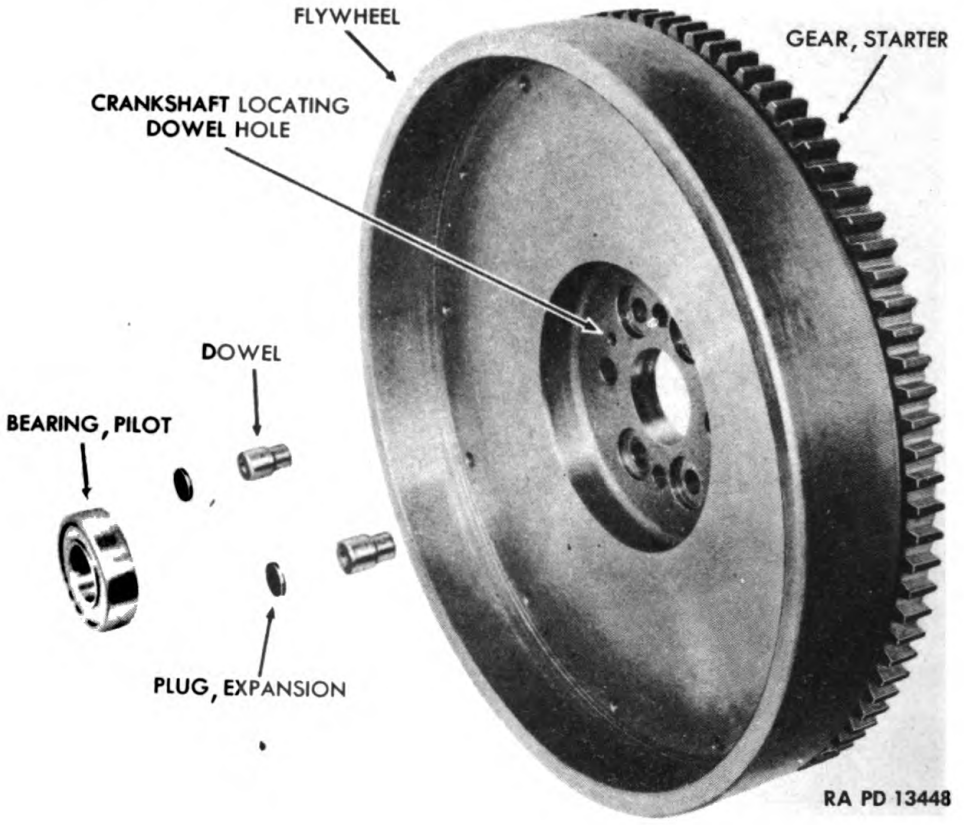


Figure 134—Flywheel

(10) INSTALLATION OF NEW FLYWHEEL RING GEAR (fig. 134). When inspection has indicated that a new flywheel ring gear is required, the gear should be installed in the following manner:

(a) Saw through and knock the old gear off the flywheel.

(b) Heat the new gear so that is can be installed on the flywheel. Allow it to cool. (Shrink fit.)

59. ASSEMBLY OF ENGINE.

Attachment, socket, ¾-in.
Attachment, socket, $1\frac{5}{16}$-in.
Bar, metal, small
Blue, Prussian
Compressor, piston ring
Compressor, valve spring
Expander, piston ring
Eye, lifting
Gage, feeler
Wrench, box, $1\frac{1}{16}$-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, ⅝-in.
Wrench, open-end, ¾-in.
Wrench, open-end, ⅞-in.
Wrench, open-end, $1\frac{5}{16}$-in.
Wrench, open-end, 1-in.
Wrench, open-end, $1\frac{1}{16}$-in.
Wrench, socket, ⅝-in.

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ENGINE

Gage, ribbon, 0.004-in.
Hammer, fiber
Hoist, chain
Pliers
Screwdriver
Straightedge
Vise
Wrench, adjustable
Wrench, box, $\frac{9}{16}$-in.
Wrench, socket, $\frac{7}{8}$-in.
Wrench, socket, $\frac{3}{4}$-in.; extension and handle
Wrench, socket, $\frac{9}{16}$-in., with speed handle.
Wrench, square male socket, $\frac{1}{2}$-in.
Wrench, tension

a. Install Crankshaft in Crankcase.

Attachment, socket, $\frac{3}{4}$-in.
Attachment, socket, $1\frac{5}{16}$-in.
Pliers
Wrench, tension

(1) Install new main bearing upper shells in the crankcase. Oil them thoroughly with clean engine oil.

(2) Place the crankshaft in position in the crankcase (fig. 135). Oil journals thoroughly. Install the bearing caps, fitted with new bearing shells. Each cap has a number stamped on its side, numbered 1 to 7 inclusive, beginning with the front main bearing as No. 1. Make certain that each cap is placed in the right position. The numbered side of the cap should always be placed towards the camshaft.

(3) Install the nuts on the main bearing studs and tighten with a tension wrench (fig. 135). Tighten the nuts on the center and rear main bearing studs to 77-foot pound tension and those on the front and intermediate main bearing studs to 94½-foot pound tension. Rotate the shaft to check the freeness in the bearings.

(4) Safety-wire the nuts after they have been drawn up properly.

b. Attach Bell Housing to Crankcase.

Gage, feeler
Wrench, open-end, $\frac{3}{4}$-in.
Wrench, socket, $\frac{3}{4}$-in.

Shellac a new gasket to the front face of the flywheel housing. Tap a new oil seal in place in housing (fig. 136). Attach the flywheel housing to the crankcase with six lock washers and cap screws (fig. 137). Two of these cap screws are installed through the rear of the bell housing. NOTE: After the six cap screws are drawn up tight, check the clearance around the oil seal and the crankshaft flange with a feeler gage. This clearance must be 0.012 inch to 0.025 inch all around.

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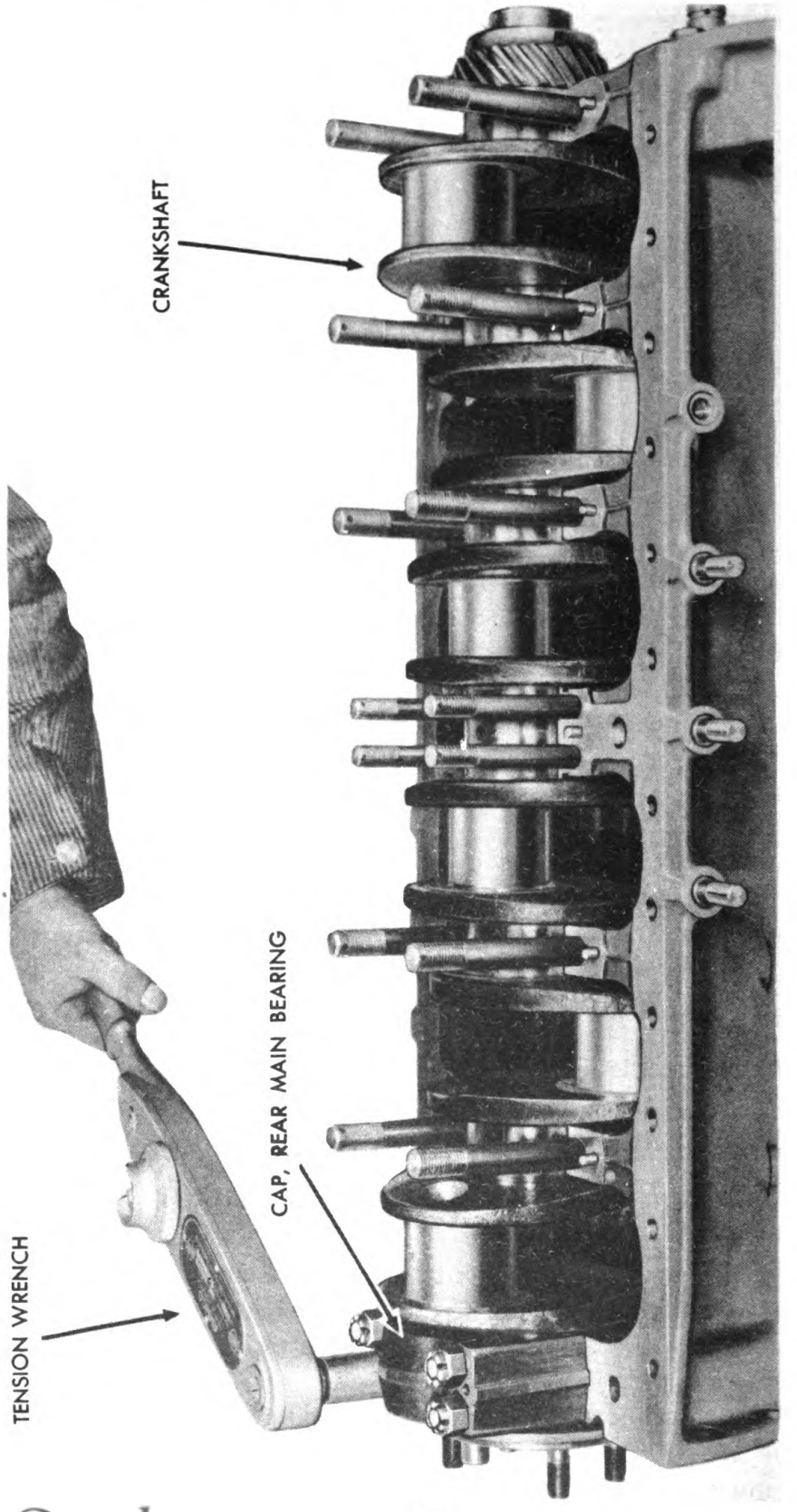


Figure 135—Installing Crankshaft

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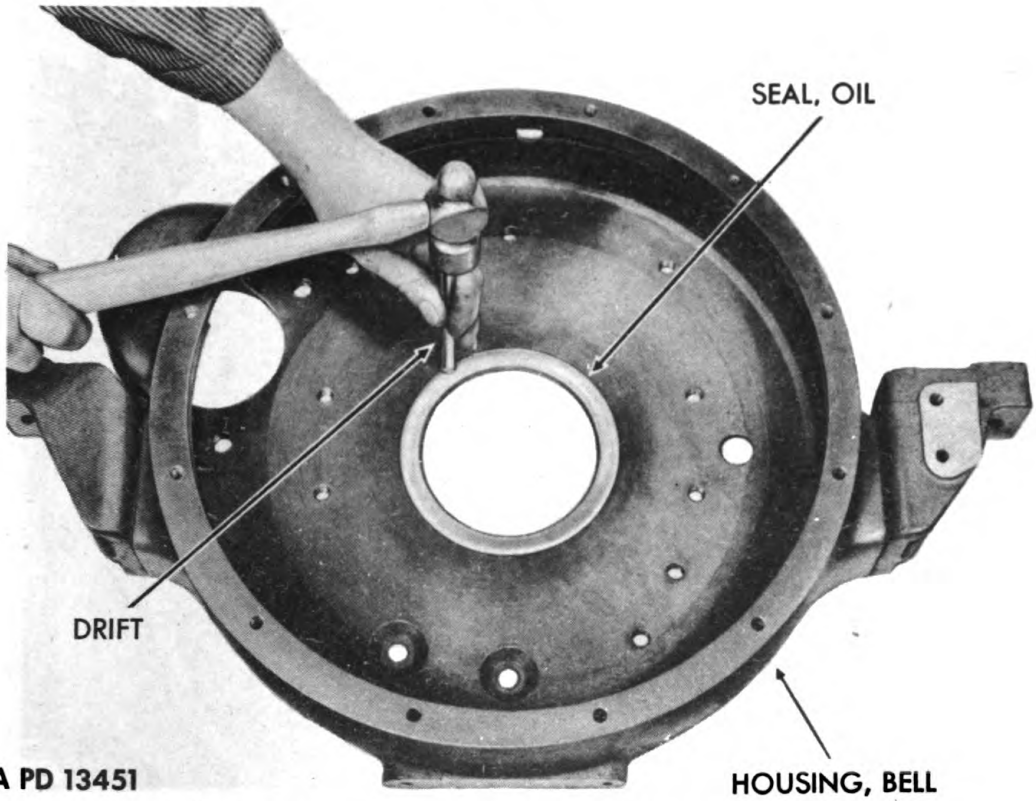


Figure 136—Inserting Oil Seal in Bell Housing

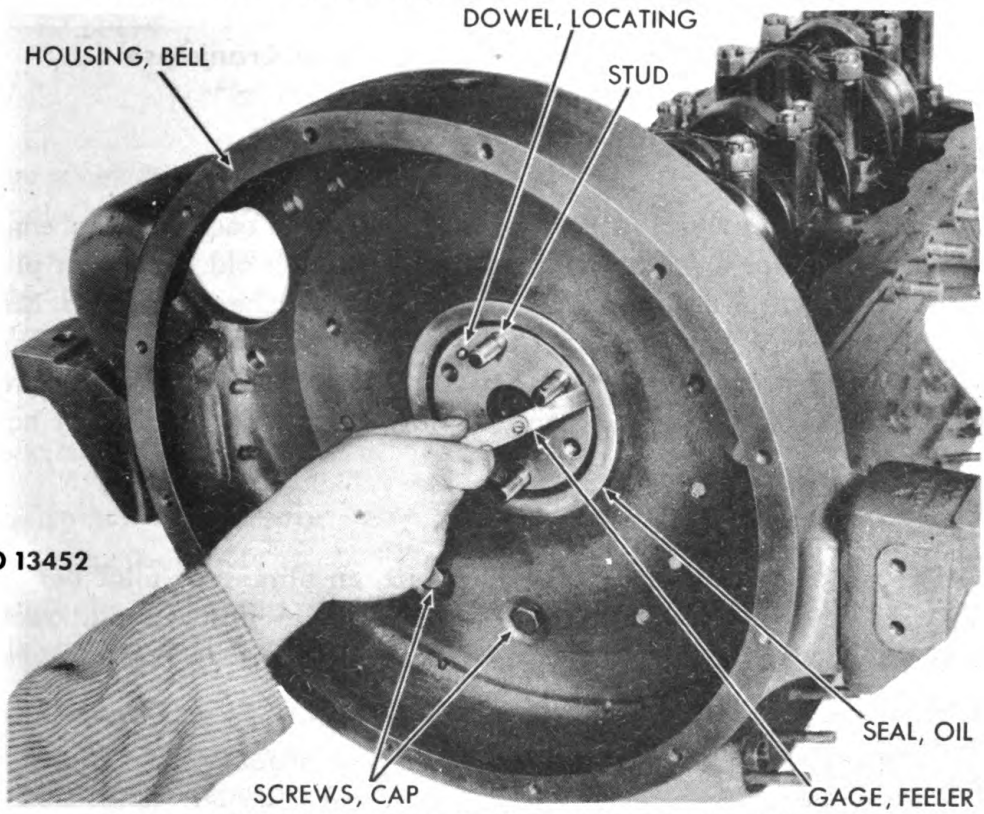


Figure 137—Attaching Bell Housing to Crankcase

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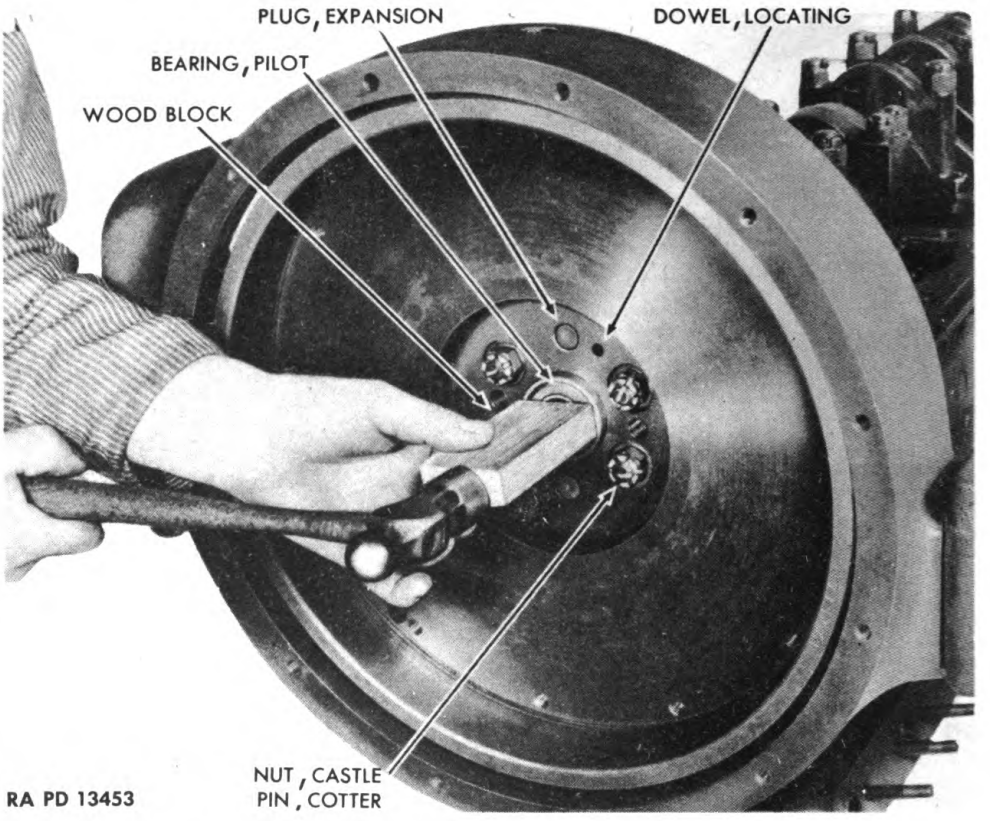


Figure 138—Attaching Flywheel to Crankcase

c. Attach Flywheel to Crankshaft.

Hammer, fiber
Wrench, socket, 3/4-in.

Replace the clutch pilot bearing in the flywheel each time an engine is taken apart for a major overhaul. Drive out the old expansion plugs. Place the flywheel in position on the crankshaft studs and dowels. Make certain the small locating dowel is in position on the crankshaft flange (fig. 138). Tighten the flywheel stud castle nuts and secure the nuts with cotter pins. Put new expansion plugs in the flywheel dowel holes.

d. Install the Clutch.

Wrench, socket, $\frac{9}{16}$-in.

Line up the clutch driven member with an alining or pilot bar (fig. 139). Place the clutch cover plate assembly in position and secure with the 12 cap screws and lock washers. Tighten cap screws evenly.

e. Assembly of Fuel Injection Pump Drive Sleeve (fig. 140).

Drift, soft metal
Hammer
Hammer, fiber
Press, arbor
Wrench, socket, 7/8-in.

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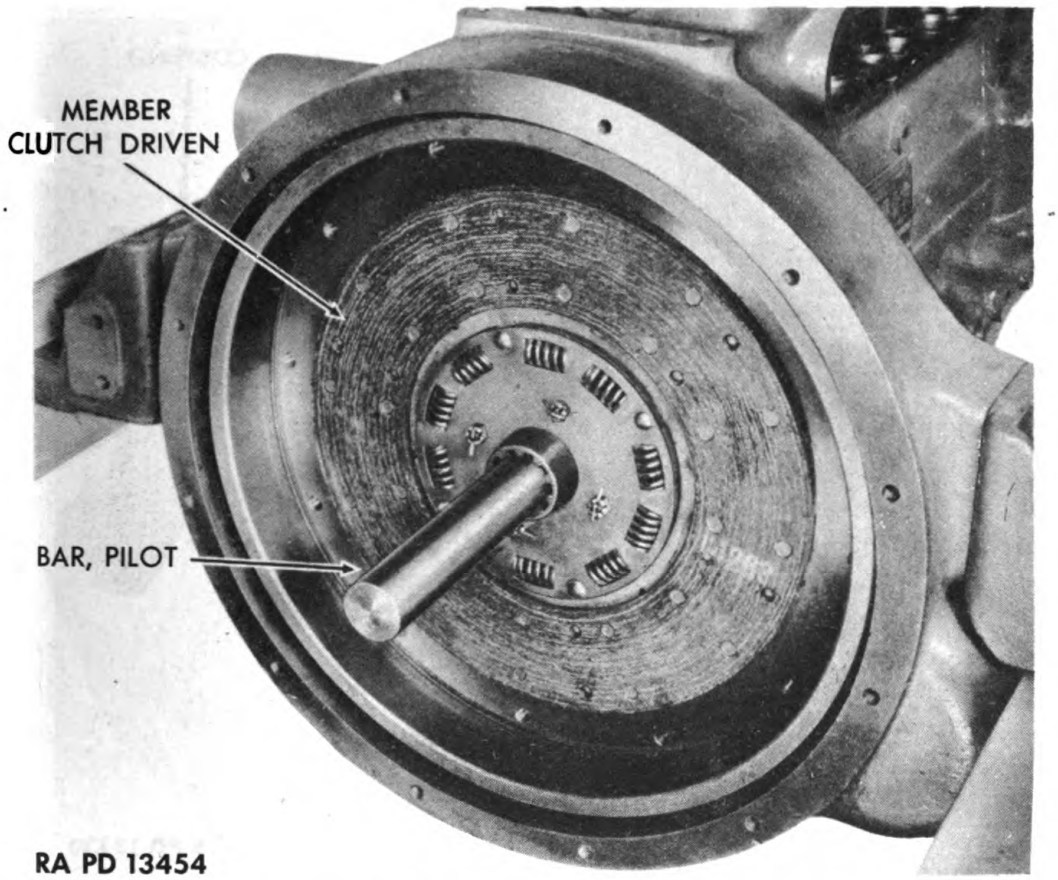


Figure 139—Lining Up Clutch Disk

Press new bushing into sleeve so that oil hole in bushing lines up with oil hole in sleeve. Place a new oil seal in the sleeve, tap into position using a hammer and soft metal drift. Position key on sleeve shaft and press on sprocket. Install oil thrower by tapping into position with fiber hammer. Place thrust washer on sleeve shaft and slide shaft through sleeve. Position Woodruff key on shaft and drive coupling on with fiber hammer. Secure nut and lock washer holding coupling to sleeve shaft.

f. Install Fuel Pump Drive Sleeve Assembly.

Screwdriver

Slide the fuel pump drive sleeve assembly in position and install the large set screw (fig. 119).

g. Install Camshaft. Install the camshaft, being careful not to damage the camshaft bearings in the crankcase (fig. 118). Make sure that the punch marks on the camshaft gear and the crankshaft gear line up. These are valve timing marks and must be right (fig. 141).

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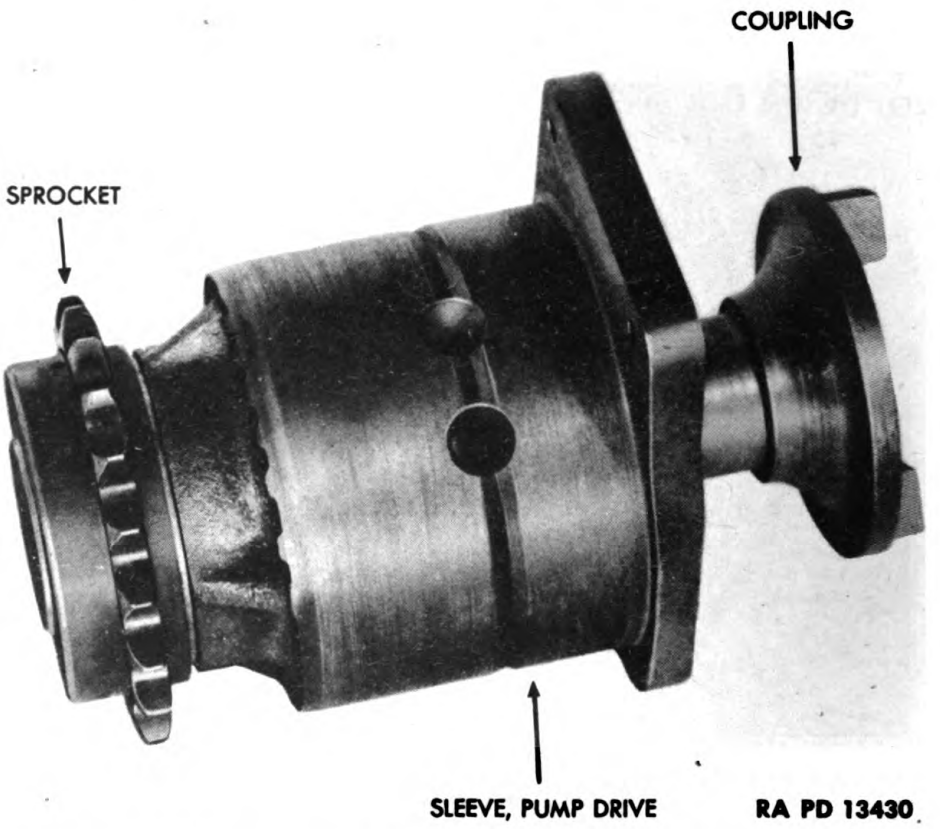


Figure 140—Fuel Injection Pump Drive Sleeve Assembly

h. Install Fuel Pump Drive Chain (fig. 142). Rotate the camshaft and the fuel pump drive shaft so that the arrows on the sprockets on these shafts point "up" or toward top of block. When the arrow is in this position on the camshaft sprocket, the "DC" mark on the flywheel is in line with the timing hole in the bell housing. Place the idler sprocket on its shaft and place the chain in position on the sprockets. Be sure that the split clip of the master link in the chain is to the front (fig. 117).

i. Assembly of Timing Gear Case Cover (fig. 116).

Screwdriver
Screwdriver, small
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, 1-in.
Wrench, socket, $\frac{9}{16}$-in.

Put in two new half-round cork seals in the crankshaft opening in the front of the gear case cover. Use a small screwdriver to position these seals properly, but be careful not to damage them. Install the timing chain inspection plug and new copper gasket. Do not tighten until engine is assembled. Install the adjusting plate assemblies, including thrust plugs and shims. Tighten cap screws and lock washers. Install the threaded bushing on the chain idler bushing and place this in the

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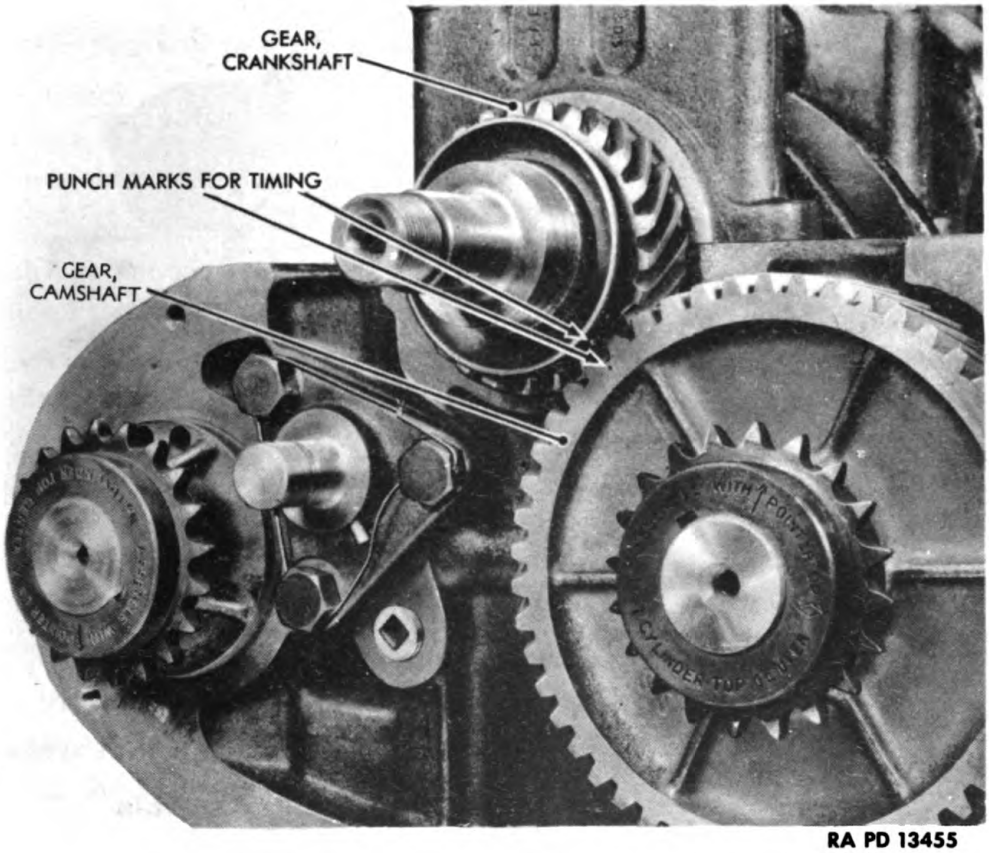


Figure 141—Lining Up Crankshaft and Camshaft Gears for Valve Timing

case cover from the rear with the clamp threaded bushing through the front of the case. Place a new cork seal in the recess in the front of the case cover around the threaded bushing. Reassemble the adjusting screw in the clamp. Do not tighten. Place this in position on the front of the case cover. Install the clamp retaining screw and lock washer and tighten. The castle nut and cotter key are not secured until the fuel injection pump drive chain has been adjusted.

j. Attaching Gear Case Cover (fig. 143).

Blue, Prussian
Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, 1-in.
Wrench, socket, $\frac{9}{16}$-in.

(1) Remove the idler sprocket eccentric bushing and the threaded bushing assembly from the case cover (fig. 116). (It was placed there temporarily when reassembling the gear case cover.) Place this assembly in position on the idler sprocket.

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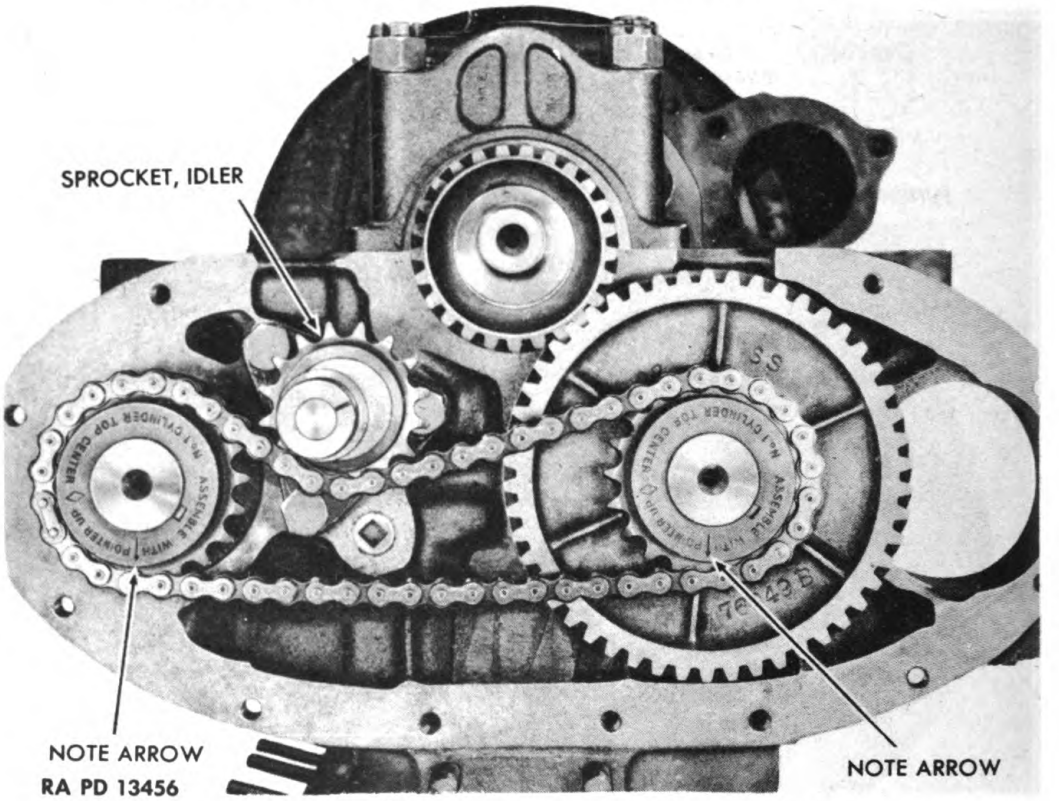


Figure 142—Installing Fuel Pump Drive Chain

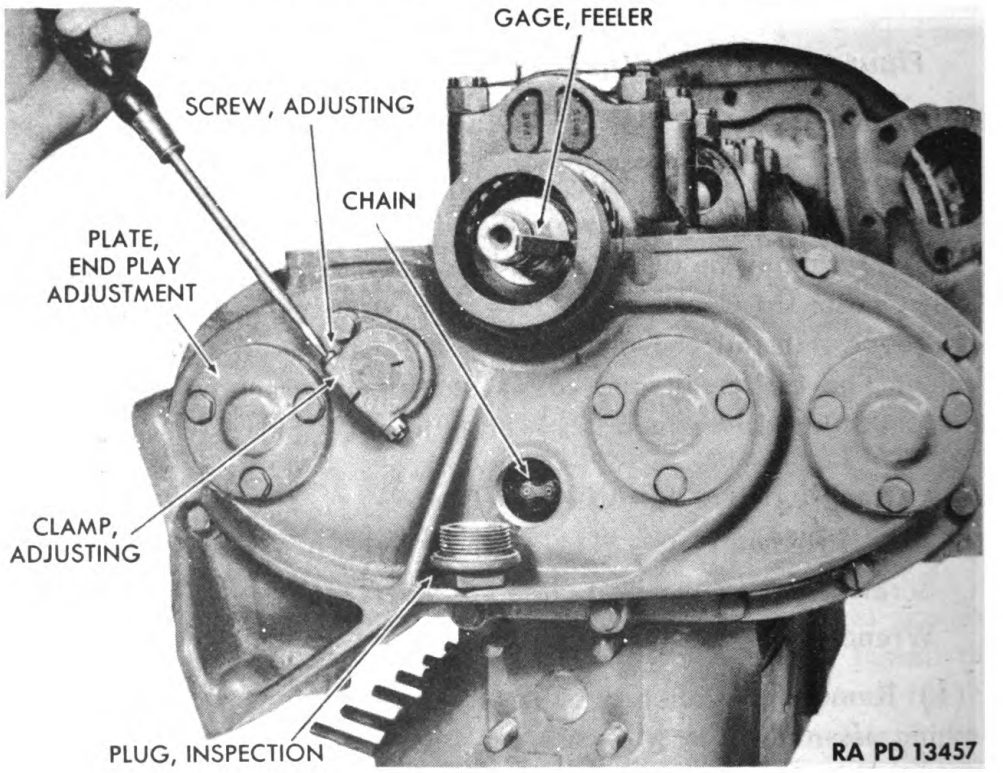


Figure 143—Attaching Gear Case Cover to Crankcase

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(2) Shellac a new gasket to the rear face of the case cover. Place the gear case cover in position on the front of the crankcase and secure it with 11 cap screws and lock washers (fig. 115).

(3) Check the clearance around the crankshaft and case cover opening with a feeler gage before the case cap screws are tightened. This clearance should be 0.006 inch to 0.015 inch (fig. 143).

(4) Tighten the cap screws with a $\frac{9}{16}$-inch socket wrench and a $\frac{9}{16}$-inch open-end wrench. (It is impossible to get a socket wrench on all these cap screws.)

(5) When the gear case cover is installed, the threaded bushing of the idler sprocket eccentric assembly will be in position in the timing chain adjusting clamp on the front of the case cover.

(6) Proceed to adjust the chain in the following manner:

(a) Remove the timing chain inspection plug and gasket from the case cover (fig. 143). (Since it was not tightened when the case was reassembled, it can be removed with the fingers.)

(b) Try the up-and-down movement of the chain by inserting a finger through the inspection plug opening. This up-and-down movement should be about $\frac{3}{8}$ inch.

(c) If the movement is greater than $\frac{3}{8}$ inch, turn the screw in the adjusting clamp clockwise with a screwdriver (fig. 143). This causes eccentric threaded bushing to turn clockwise, thus tightening the chain.

(d) Should the chain be too taut, turn the adjusting screw counterclockwise until the nut rests against the clamp or support, then turn the screwdriver until the chain is loose. Reverse action and tighten chain as outlined above.

(e) Always turn adjusting screw clockwise before installing the locking nut and securing with cotter pin. This insures that all chain slack will be removed.

(f) Install inspection plug and gasket and tighten.

(7) The end movement of the various accessory shafts are adjusted by means of shims. These shims are placed between the gear case cover and the thrust plates (fig. 116).

(a) The removal of shims will permit the plates to be reassembled so as to take up any end play on the camshaft, fuel pump drive sleeve shaft and the water pump shaft. Care must be exercised to prevent taking out too many shims, as this will throw too heavy a thrust load on the thrust bearings.

(b) To check adjustment put a thin layer of Prussian blue on the thrust surface, then bolt the plates into position. Turn the crankshaf

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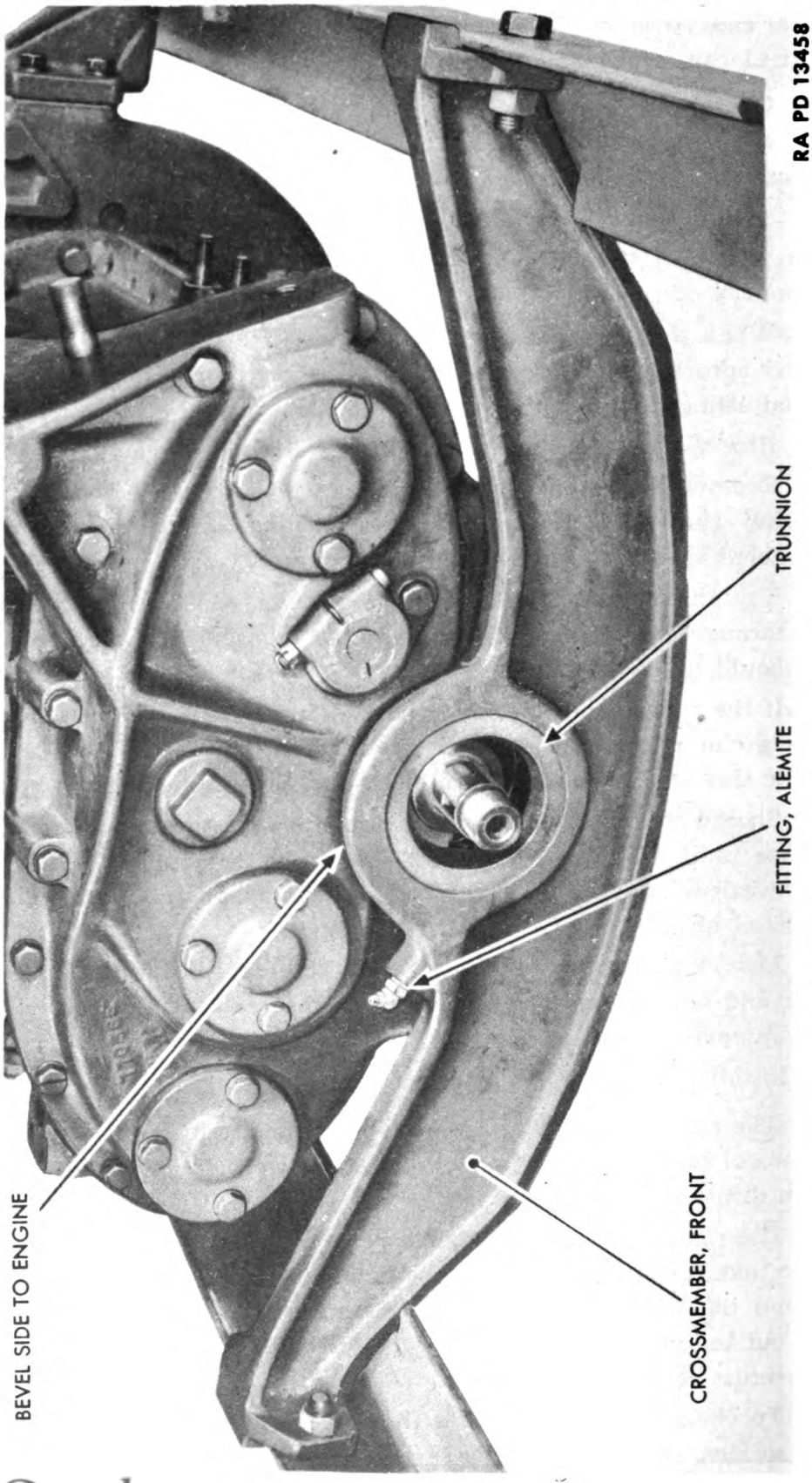


Figure 144—Installing Front Cross Member

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over one or two revolutions, remove the plate and observe the contact surface. If the surface shows a definite pressure (Prussian blue removed by friction), the adjustment is too close.

(c) The proper end clearance for these three shafts is 0.005 inch to 0.008 inch, since 0.002-inch to 0.004-inch clearance will be taken up by expansion when the parts become hot.

k. Place Engine in Repair Stand.

Eye, lifting
Hammer, fiber
Hoist, chain
Stand, engine repair
Wrench, open-end, ¾-in.

(1) At this point in the reassembly of the engine it is advisable to place the engine in a repair stand to facilitate assembly.

(2) First, place the engine front cross member in position on the trunnion after the trunnion has been oiled. This is a sliding fit and can be made with the hands, although it may be necessary to tap the cross member a few times with a fiber hammer in order to get it all the way back on the trunnion. Then make certain that the beveled part of the cross member is in toward the crankcase (fig. 144).

(3) Secure a lifting eye in place on one of the top cylinder block studs near the center. Lift the engine into the repair stand with a chain hoist. Be careful not to bend or damage the stud to which the lifting eye is fastened.

(4) Fasten engine in the repair stand with the four hold-down bolts and nuts.

(5) Remove chain hoist and lifting eye.

l. Assembly of Piston and Connecting Rod Assembly.

Expander, piston ring
Vise

(1) Install new connecting rod bearing shells in the rod and cap. The shells are held in place and rotation is prevented by means of an ear or lug on the shell at the split line. Do not tighten the cap screws, merely insert them far enough to hold rod, shells and cap in position. Place the rod in a vise. Attach piston to connecting rod (fig. 108).

(2) The piston pin floats in both the piston bosses and connecting rod bushing.

(3) Install the two snap rings which retain the piston pins. These lock in machined grooves in the piston pin bosses.

(4) Place six new rings in their proper positions in the piston ring grooves with a ring expander. The four upper rings are compression rings, the two lower rings are oil regulating rings.

(5) Each new ring should be tried for clearance in the piston groove by rolling the ring all around the groove as shown in figure 145.

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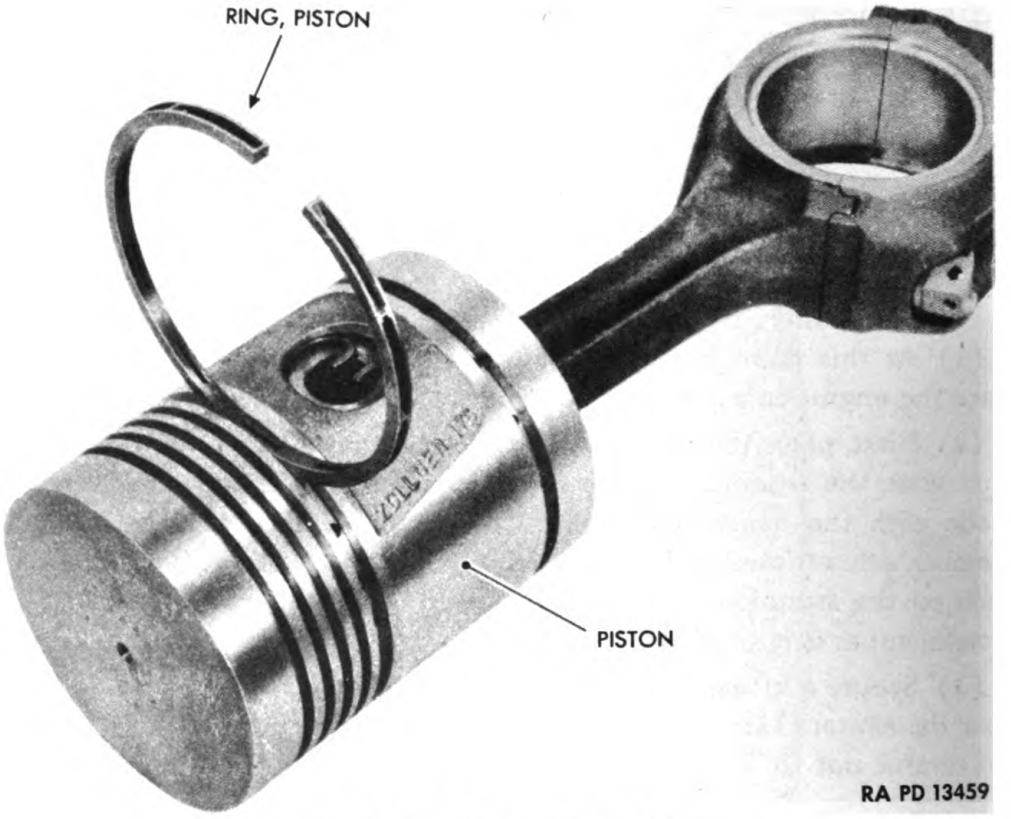


Figure 145—Checking Ring Clearance

(6) The clearance should be 0.0015 inch to 0.003 inch for all except the top ring. For the top ring the clearance should be 0.003 inch to 0.0045 inch.

(7) If the ring grooves have been carefully cleaned, the rings will be found to fit correctly in this respect, but if they are tight they can be lapped slightly on a sheet of CLOTH, emery (No. 000) laid on a flat surface. Use a light uniform pressure when lapping.

m. Install Connecting Rod and Piston Assemblies.

Compressor, piston ring	Handle, hammer
Gage, feeler	Handle, tension
Gage, ribbon, 0.004-in.	Wrench, socket, ¾-in.

(1) Rotate the engine in the stand to a vertical position.

(2) Oil the cylinder bores and connecting rod journals thoroughly. Rotate the crankshaft so that connecting rod journals in cylinders No. 1 and No. 6 are on bottom dead center.

(3) Insert the connecting rod and piston assembly in cylinder No. 1 with the aid of a piston ring compressing tool. When this tool is in posi-

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tion around the rings, push the piston down in the cylinder with a hammer handle and remove the ring compressor. Repeat this operation for cylinder No. 6 (fig. 146).

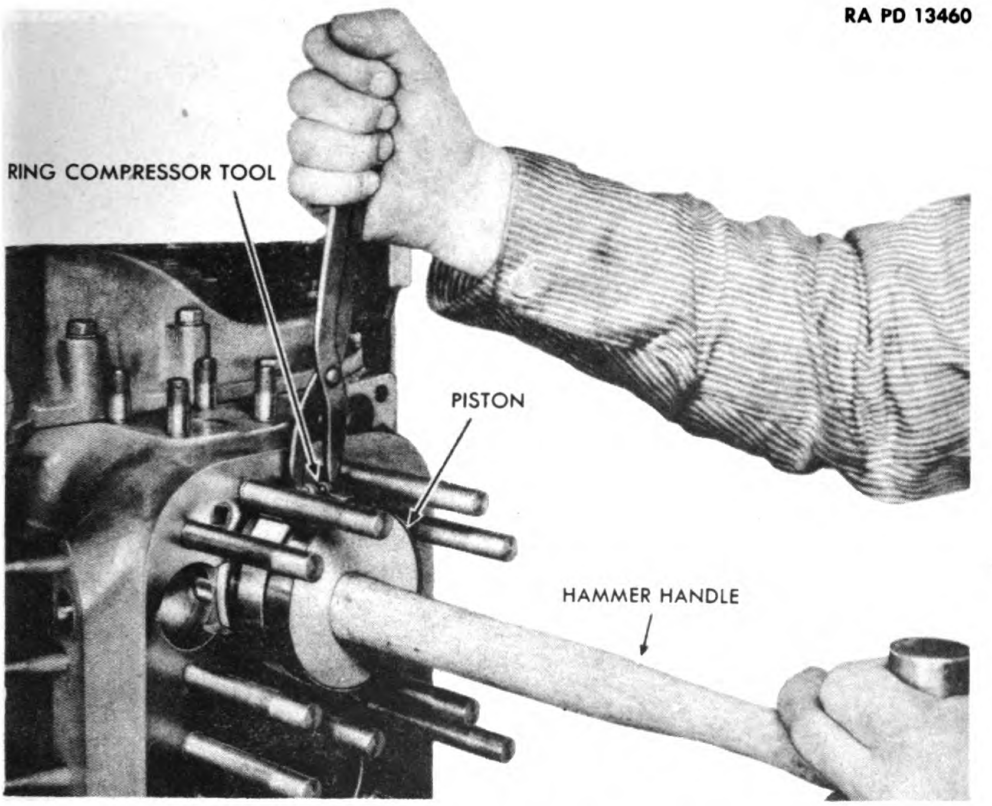


Figure 146—Installing Piston and Connecting Rod Assembly

(4) NOTE: When new pistons are being fitted to a rebored cylinder, the fit should be checked with a feeler gage as shown in figure 147. Insert a 0.004-inch ribbon gage about 10 to 12 inches long in between the cylinder bore and piston and rings. If this ribbon gage can be pulled out by hand with a slight drag feeling, the fit is proper. If a scale is used on the end of the ribbon gage, the pull exerted to remove the ribbon gage should read 5 to 6 pounds on the scale.

(5) Check the piston ring end gap or clearance by inserting the rings in the cylinder bore as shown in figure 148 and using a feeler gage. This end gap or clearance should be 0.018 inch to 0.022 inch.

(6) When installing piston and connecting rod assemblies be sure to guide the connecting rods through the bores so as not to score the bores.

(7) Secure No. 1 and No. 6 connecting rods to the crankshaft journals by placing the connecting rod caps in position and tightening the retaining cap screws with a ¾-inch socket wrench and tension handle (fig. 149).

(a) These nuts should be drawn up to a tension of 140 foot pounds

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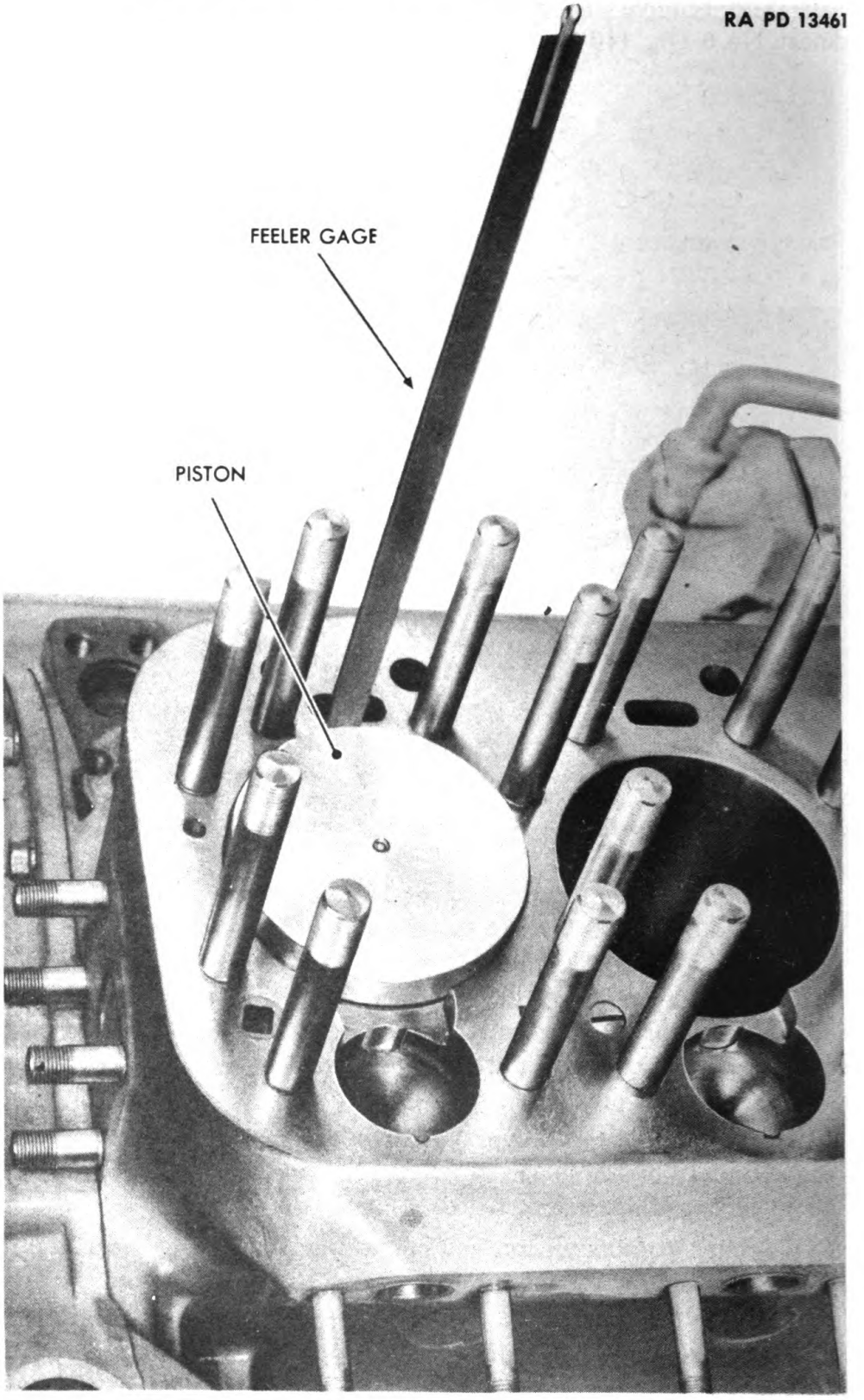


Figure 147—Fitting New Piston

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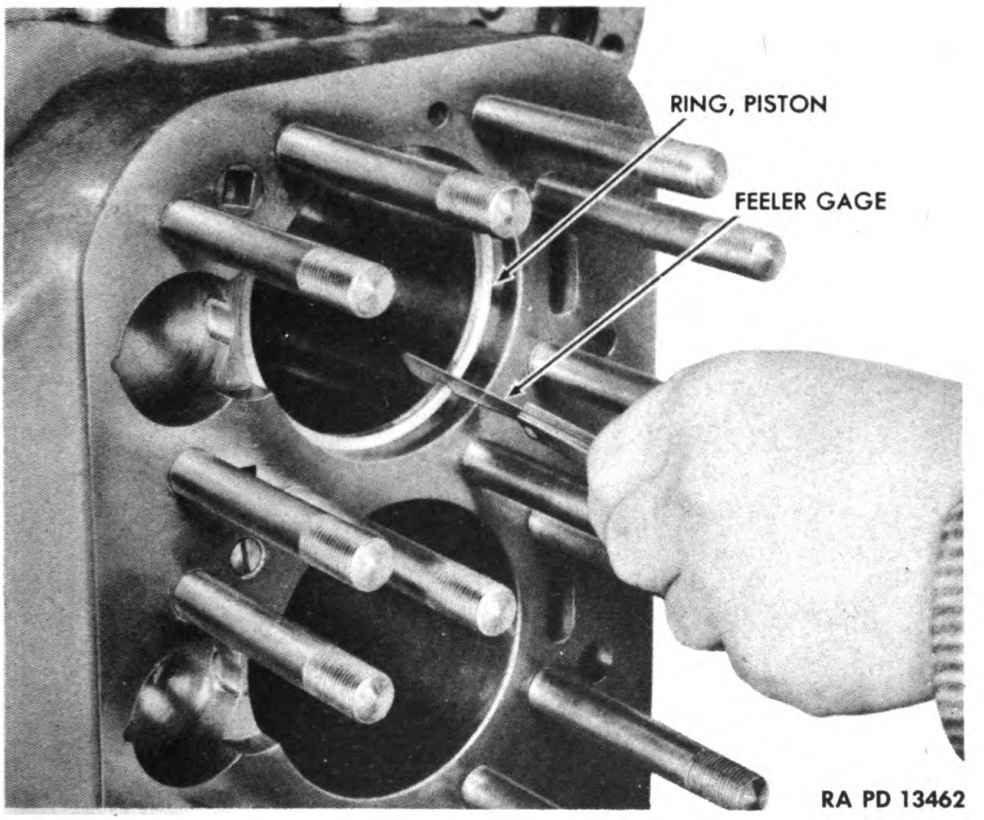


Figure 148—Measuring Piston Ring End-Gap

(1,680 inch pounds). Safety-wire the cap screws in position after they have been tightened properly.

(b) Repeat the same procedure for the installation of piston and rod assemblies in cylinders 2 and 5 and again for cylinders 3 and 4.

n. Installing Oil Pump Assembly (fig. 107).

Wrench, box, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{7}{8}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

Secure the oil pump assembly to the under side of the crankcase on the center bearing web with four lock washers and cap screws. Be sure the pump drive gear meshes properly with the gear on the camshaft. Connect the flexible line to the crankcase web and to the oil pump.

o. Assembly of Oil Pan (fig. 106).

Wrench, open-end, $\frac{9}{16}$-in.
Wrench, square male socket, $\frac{1}{2}$-in.

Clean and inspect the oil strainer screen, making certain that the mesh is in good condition. (Replace screen if necessary.) Install the oil strainer screen and new gasket and tighten the six cap screws and lock

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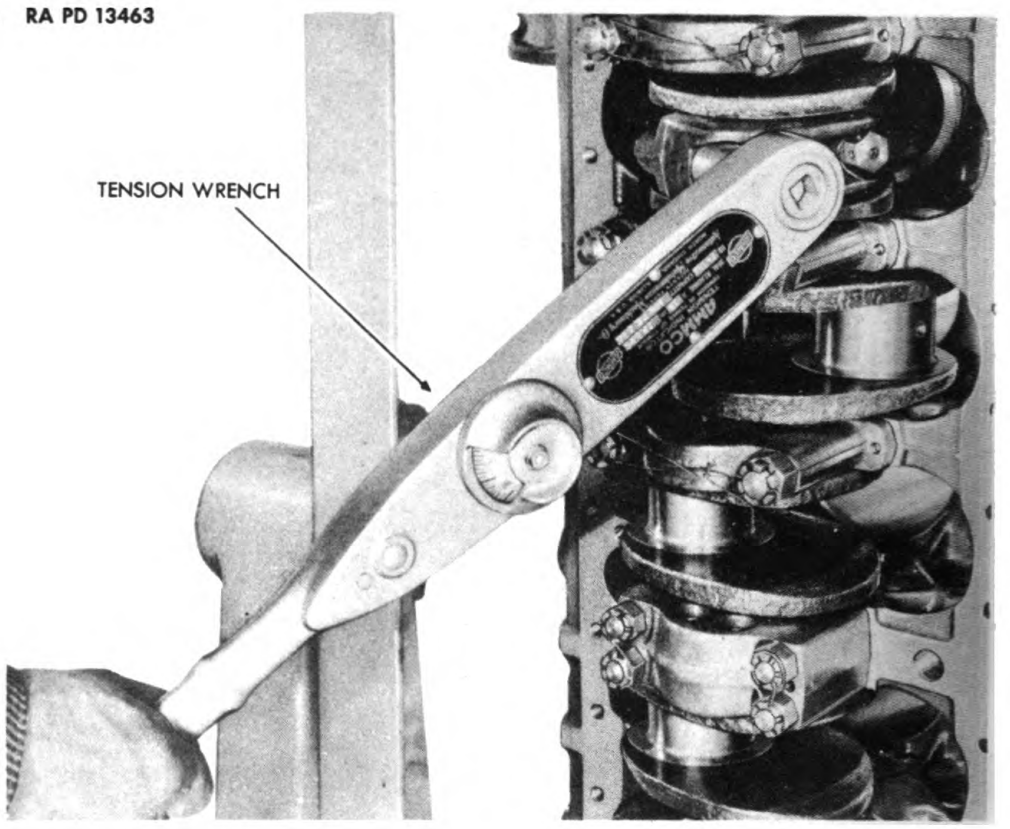


Figure 149—Tightening Connecting Rod Bearing Cap

washers which secure it to the oil pan. Shellac new gaskets to oil pan attaching flanges. Place two new oil seals in the front of the oil pan (screwdriver). Be careful not to damage seals. Install the two oil drain plugs.

p. Attaching Oil Pan to Crankcase.

Gage, feeler
Wrench, open-end, 3/4-in.
Wrench, socket, $\frac{9}{16}$-in.

Place the oil pan assembly in position on the crankcase and fasten with cap screws and lock washers. Five cap screws hold the oil pan to the bell housing, and 38 cap screws hold the oil pan to the cylinder block. Check the clearance of the oil pan oil seal around the crankshaft at the front end with a feeler gage. This clearance should be 0.006 inch to 0.015 inch (fig. 150).

q. Attaching Crankshaft Pulley and Starting Crank Jaw (fig. 151).

Bar, small metal
Hammer, fiber

Place the Woodruff key in the front end of the crankshaft and drive the crankshaft pulley on the shaft with a fiber hammer. Place the special

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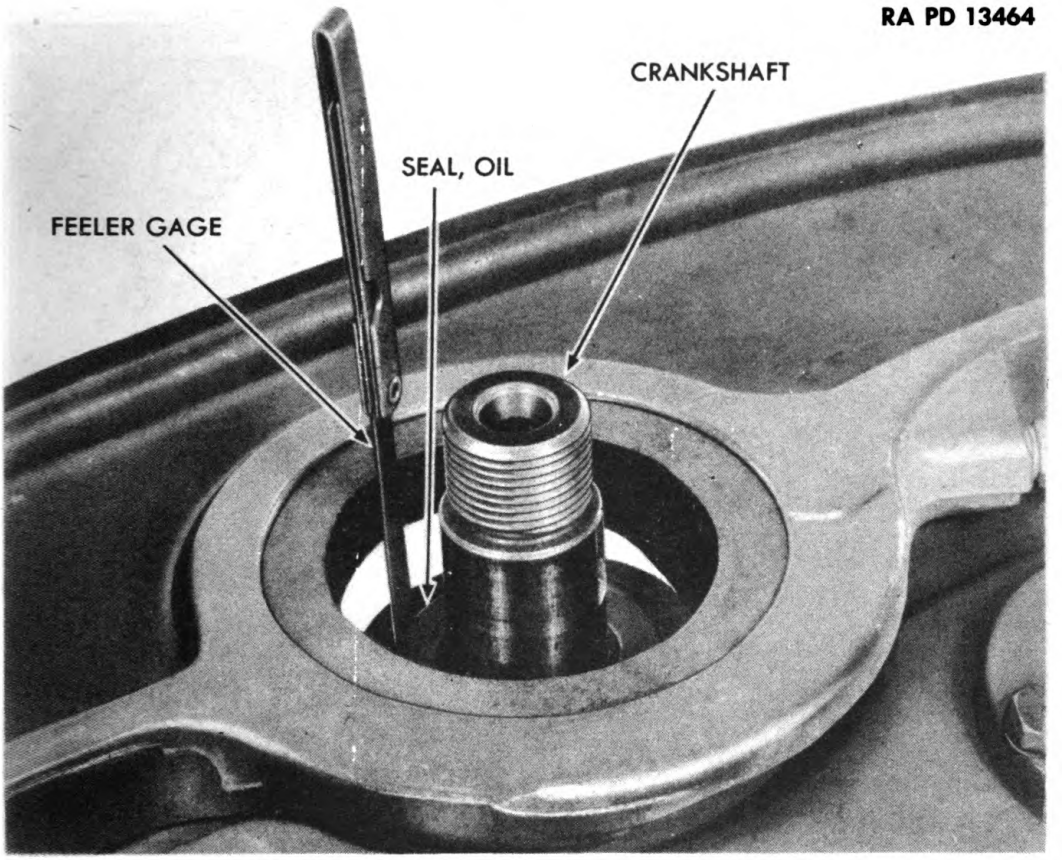


Figure 150—Measuring Oil Pan Oil Seal Clearance

lock washer in position on the crankshaft, making certain that the lug on the washer is in the crankshaft key slot. Screw on the starting crank jaw and use a small pry bar to tighten (fig. 112).

r. Assembly of Cylinder.

Compressor, valve spring	Straightedge
Gage, feeler	Wrench, open-end, $\frac{5}{16}$-in.

(1) Install the six glow plug hole plugs and retainers (fig. 101).

(2) Install the valves in their correct openings and check clearance with head surface. Place a straightedge over the valve tops; rest it on the cylinder head surface (fig. 152). Use a feeler gage to check the clearance of the valve tops with the bottom edge of the straightedge. This clearance should be 0.005 inch to 0.007 inch.

(3) Place the concentric springs and the spring seats in position on the valve stems (fig. 101).

(4) Place a valve spring compressing or lifting tool in position and compress the springs. Insert the split cone keepers in place on the valve stem. Place a new snap ring in position and remove the tool (fig. 98).

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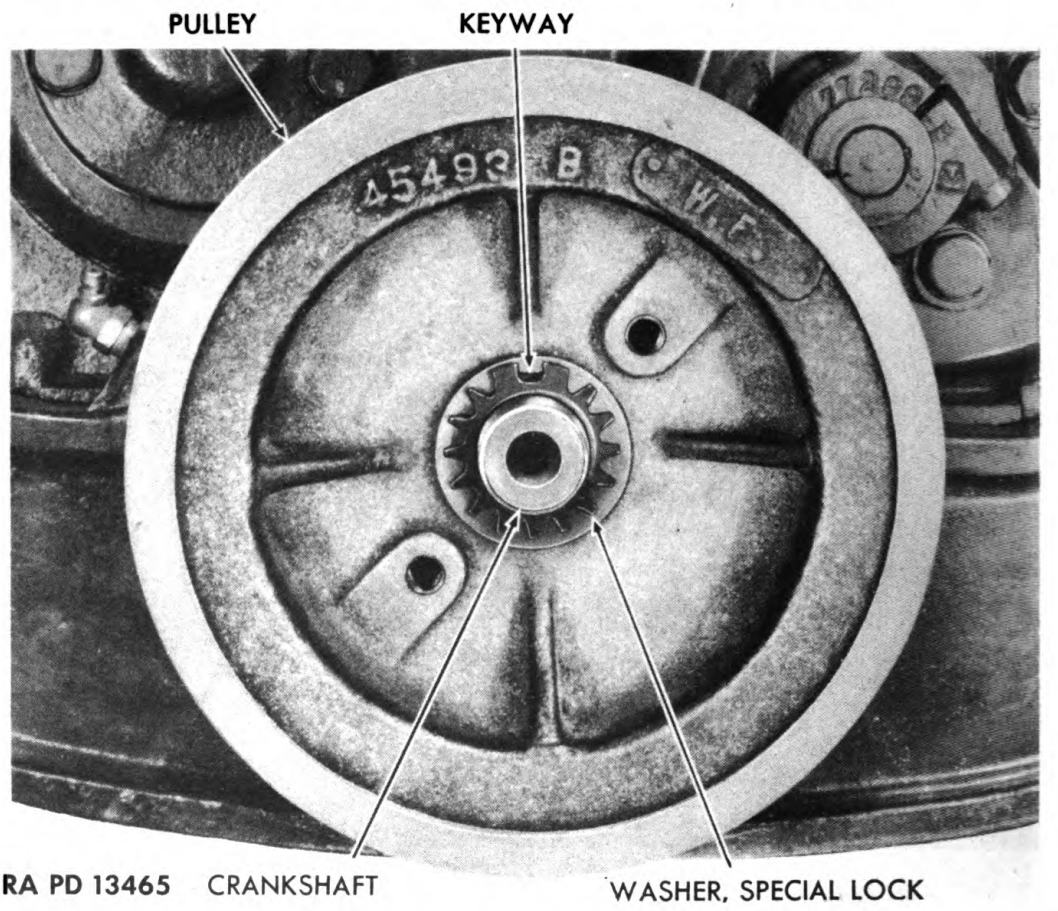


Figure 151—Installing Fan Drive Pulley

s. Installing Cylinder Head Assembly.

Bar, small metal
Wrench, socket, 7/8-in.
Wrench, tension

(1) Rotate stand to a horizontal position.

(2) Install the combustion chamber upper and lower liners (fig. 153).

(a) The lower liners are spherical in shape. The upper liners have a flat top.

(b) Note that the spherical liners each have a lip on one side. This lip goes in toward the pistons. Holes are provided in the front of the liners for the fuel nozzles. The upper liners have small dowels which fit into dowel slots in the cylinder block.

(3) Place the copper gasket (fig. 154) in position on the cylinder block.

(a) The cylinder head gasket is made of solid sheet copper, carefully annealed. While installing the cylinder head great care must be taken to

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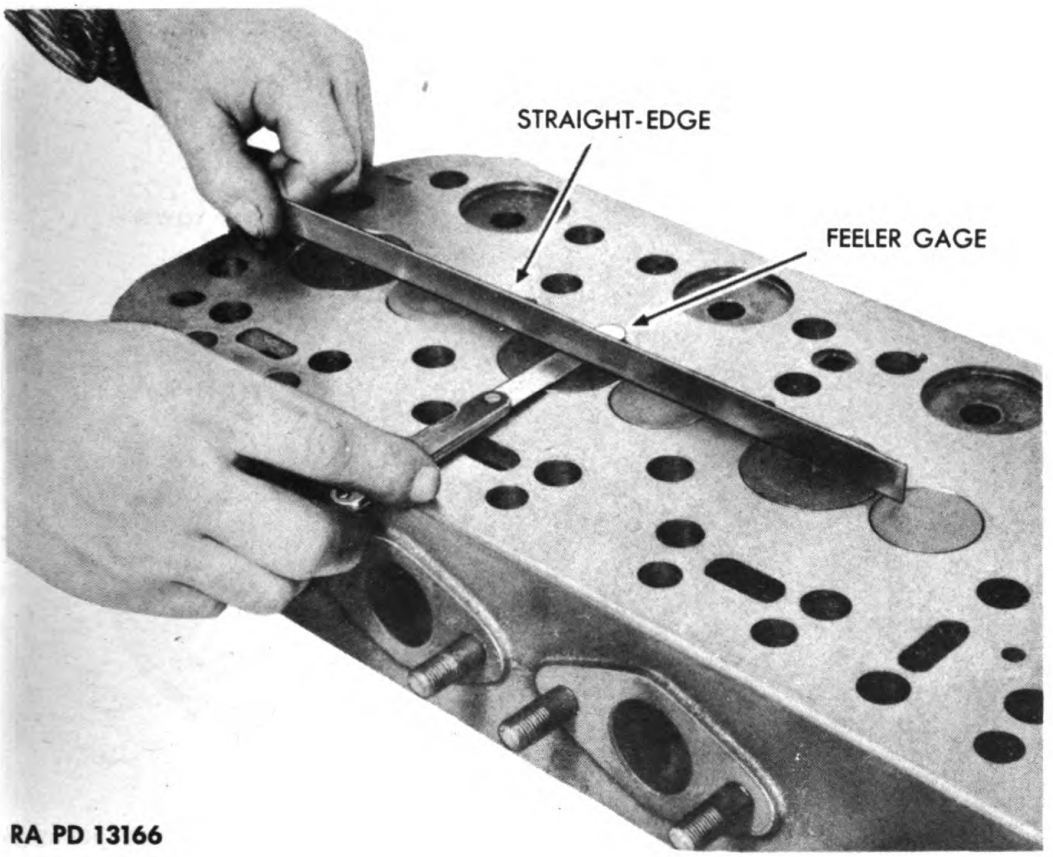


Figure 152—Measuring Valve Head Clearance

prevent dirt or foreign matter from lodging between the gasket and the head or block.

(b) If the gasket becomes deeply scratched or marred, it must be replaced by a new one.

(c) Always clean the gasket thoroughly, removing all carbon and sealing compound before putting it back on the engine.

(d) When installing, use a plastic sealing compound to insure a leak-proof installation.

(4) Install the cylinder head on the cylinder block and secure by tightening the 37 cylinder head nuts. Place a plain washer under each nut. Tighten cylinder head nuts to a tension of 157½-foot pounds (1,890-inch pounds). NOTE: These stud nuts should be progressively tightened, working from the center of the head toward the ends and sides (fig. 155).

(5) Screw the two engine lifting eyes back on their respective studs and tighten with a small bar (fig. 155).

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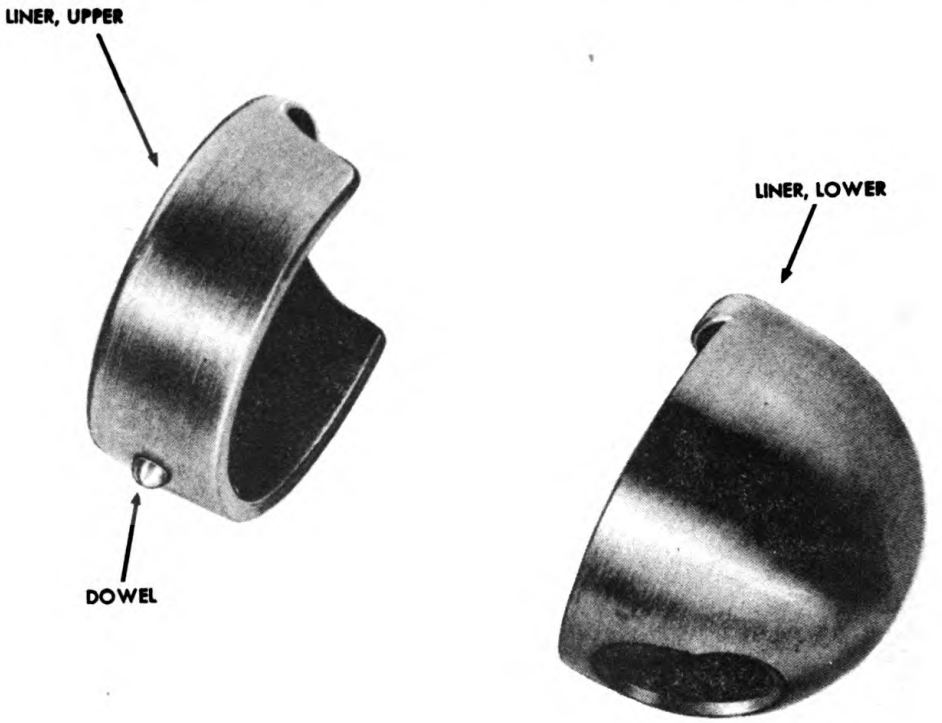


Figure 153—Combustion Chamber Liners

(6) Place the valve push rods back in position in the engine with the cupped ends up (fig. 156).

t. Assembly of Rocker Arms.

Screwdriver — Wrench, open-end, $\frac{15}{16}$-in.

(1) Place the rocker arm shaft bracket with the shaft lock screw (fig. 93) in position on the shaft. Tighten the lock screw with a screwdriver. Place one rocker arm on the rocker arm shaft at the right of the bracket. This will be the short end of the shaft. Be sure to put the rocker arm on with the push rod ball end towards you with the ball down. Put the outer spring and washer in position and insert and tighten the spring washer screw in the end of the shaft (fig. 93).

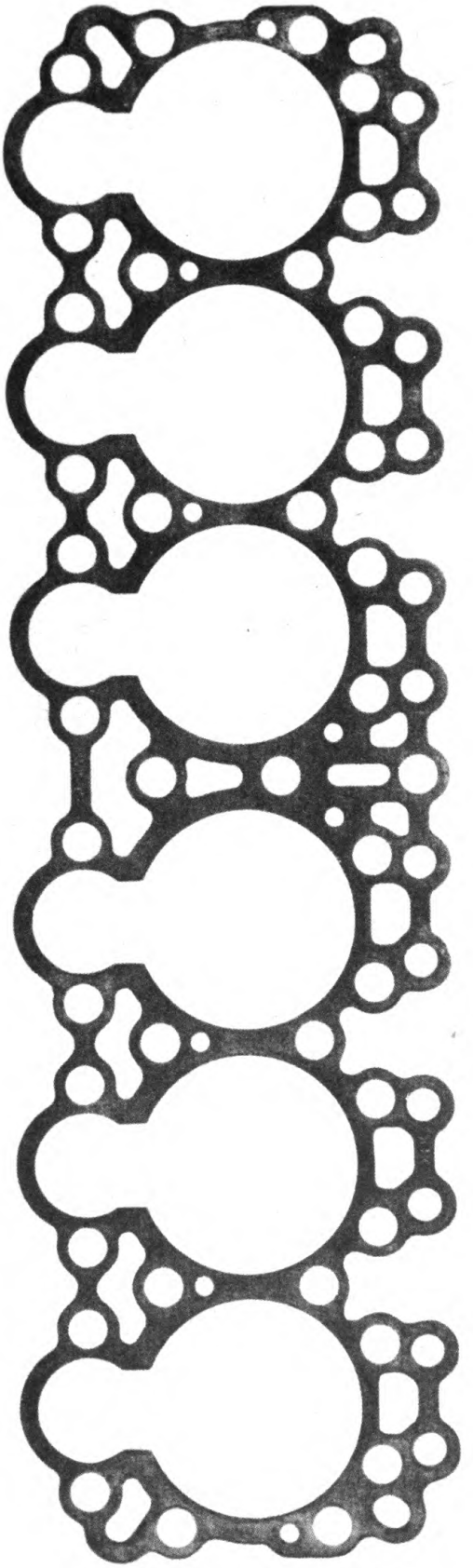
(2) Place the following on the long end of the shaft in the order named: Rocker arm, bracket spacing spring, rocker arm, bracket, rocker arm, spacing bracket spring, rocker arm, bracket, rocker arm, outer spring, washer (fig. 93).

(3) Insert the other spring washer screw in the shaft end and tighten.

(4) Repeat the same operations for the other rocker arm assembly.

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Figure 154—Cylinder Head Gasket

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

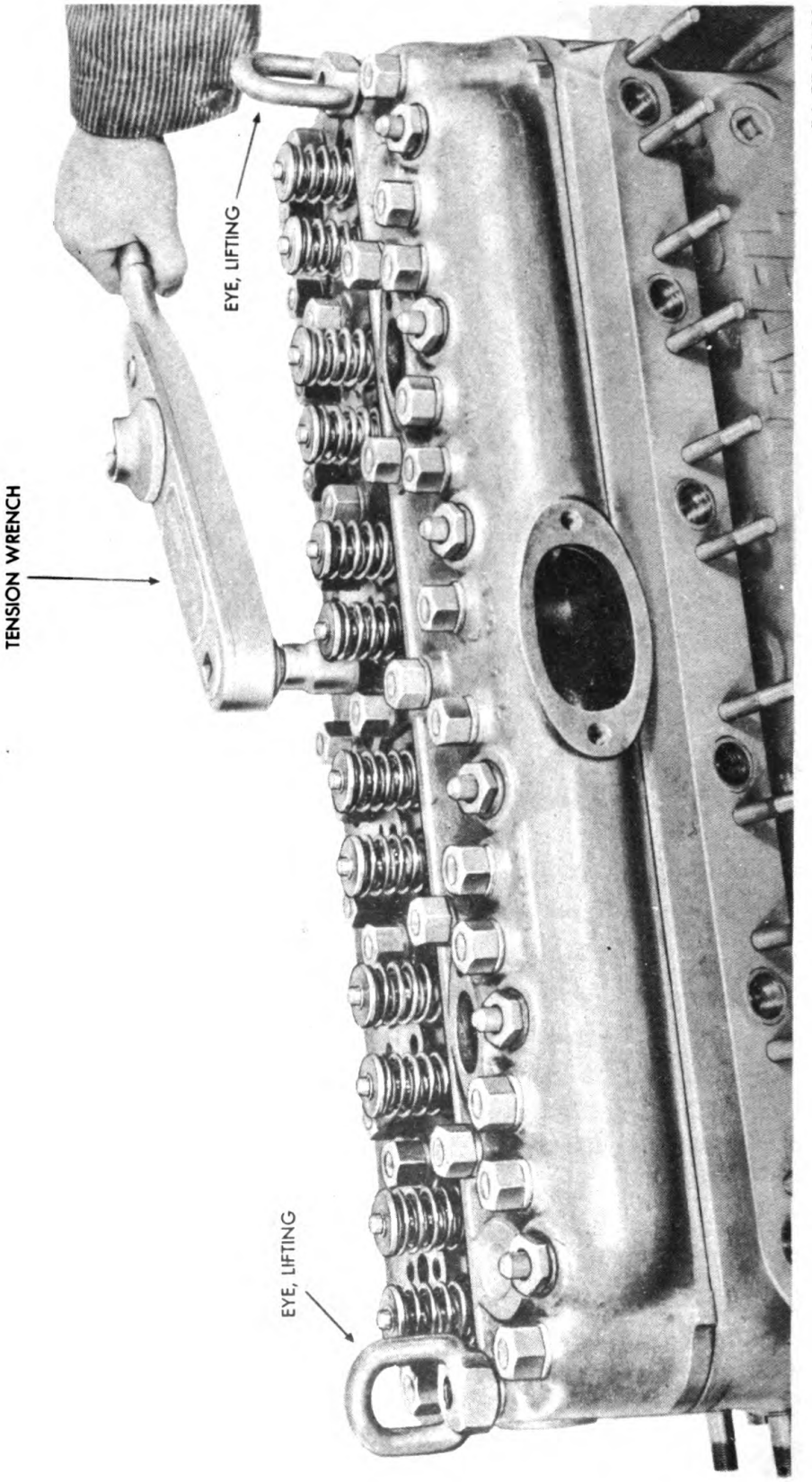


Figure 155—Tightening Cylinder Head Nuts

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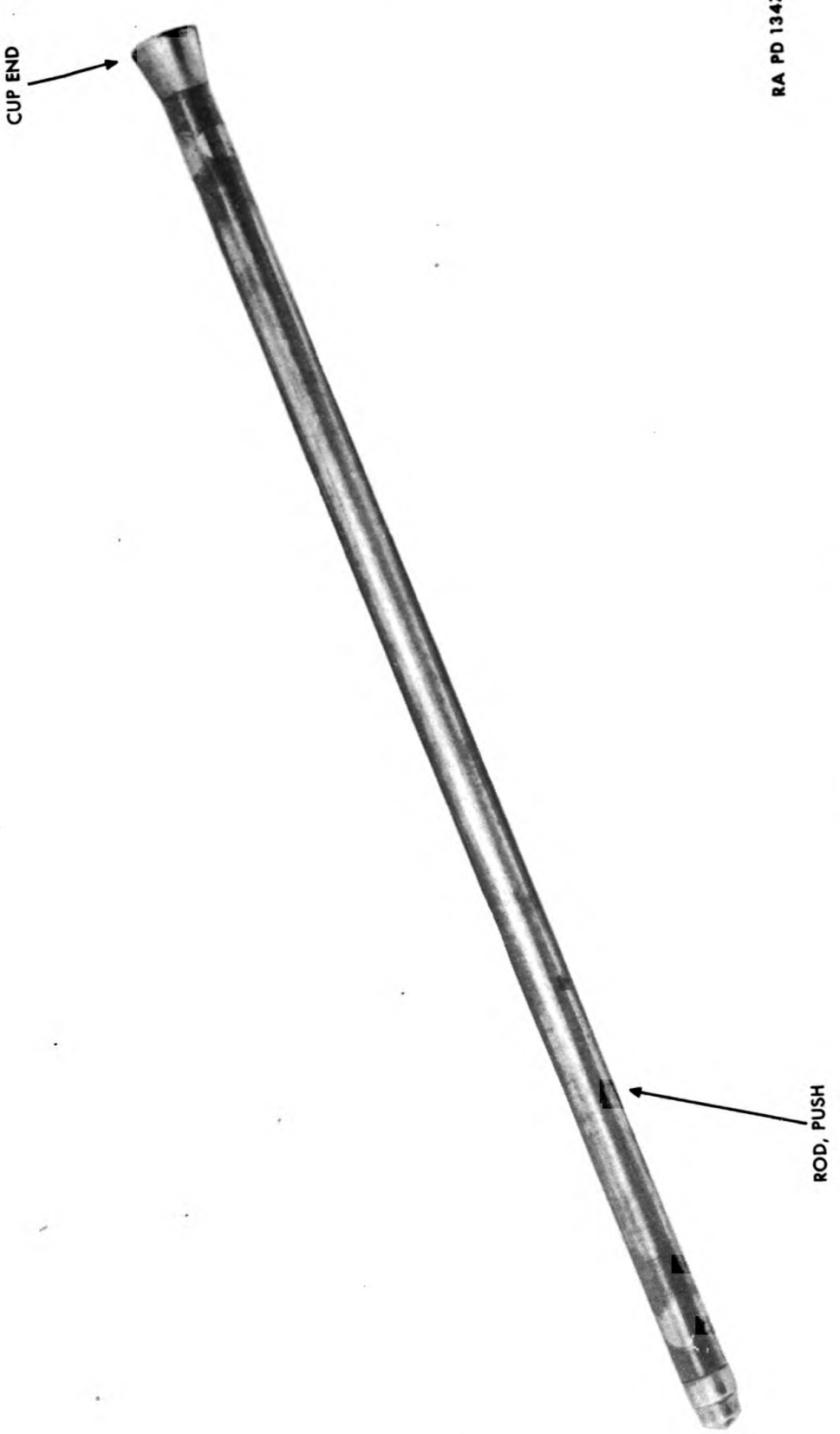


Figure 156—Push Rod

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

u. Install Rocker Arm Assemblies on Cylinder Head.

Wrench, socket, $\frac{5}{8}$-in.

Place the two rocker arm assemblies in position on the cylinder head. Be sure that the rocker arm brackets which have the lock screws are to the front of the engine. There are two recesses in the cylinder head for the heads of these lock screws. Insert and tighten the 12 rocker arm bracket cap screws which secure the rocker arm assemblies to the cylinder head. Safety-wire the cap screws in position.

v. Adjust the Valves.

Gage, feeler
Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.

The valve adjustment is made by rotating the crankshaft until each cylinder is in the firing position. A feeler gage is placed between the valve stem end and the rocker arm cup (fig. 157). The adjusting screw and lock nut are then adjusted so that the ball end of the rocker arm fits snugly in the push rod cup and the recommended clearance of 0.010 inch is obtained between exhaust and inlet valve stem and rocker arm cup with the engine hot.

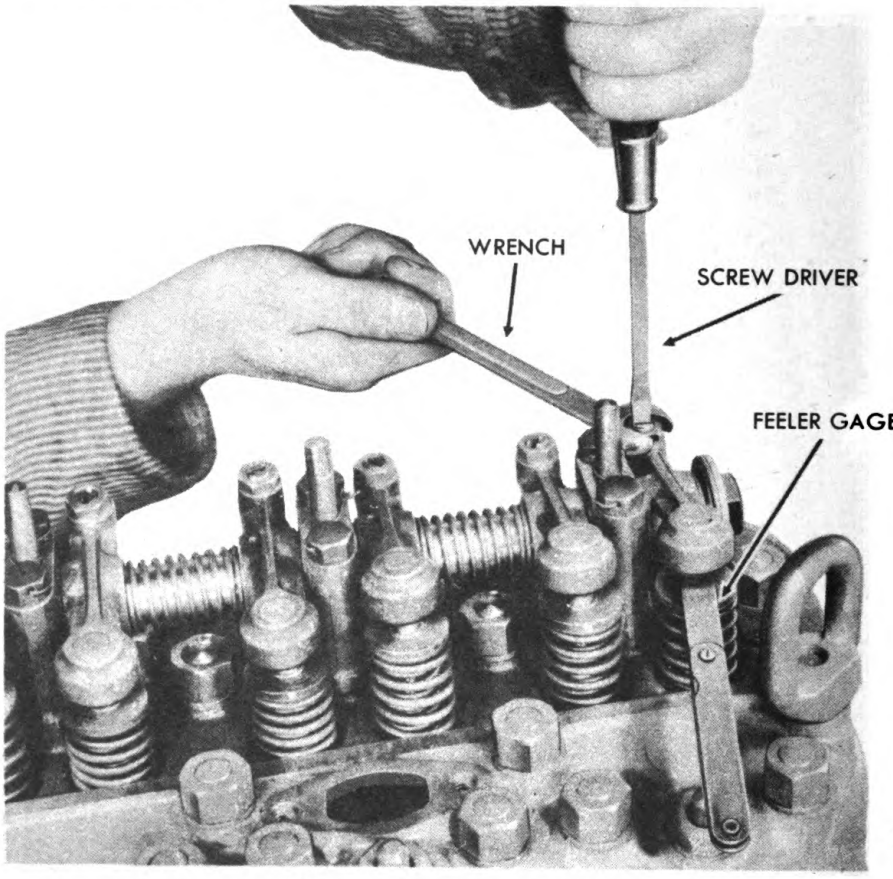


Figure 157—Valve Adjustment

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ENGINE

w. Assembly of Thermostat Housing and Water Manifold Assembly (figs. 88 and 89).

Screwdriver
Wrench, adjustable
Wrench, open-end, $\frac{9}{16}$-in.

Install the pipe connection in the rear of the manifold with an adjustable wrench. Install the pipe plug in the front end with a screwdriver. Place the thermostat in the thermostat housing and assemble thermostat and housing to water manifold after a new gasket has been placed between manifold and thermostat housing. Tighten the four cap screws and lock washers which secure the thermostat housing to the manifold with a $\frac{9}{16}$-inch open-end wrench.

x. Secure Water Outlet Manifold and Thermostat Housing Assembly to Cylinder Head.

Wrench, open-end, $\frac{9}{16}$-in.

Place two new gaskets in position on the water outlet manifold mounting flanges and secure the manifold and thermostat housing assembly in position with four cap screws and lock washers.

y. Install Cylinder Head Cover (fig. 158).

Wrench, open-end, $\frac{5}{8}$-in.

Install a new gasket on the bottom flange of the cylinder head cover and place the cylinder head cover in position on the six cylinder head studs. Place the following on the stud projection through the cover in the order named: Copper gasket, plain washer and acorn nut.

z. Install Water Pump.

Wrench, open-end, $\frac{9}{16}$-in.

With new gaskets in position on gear case, slide gear end of water pump assembly in position. Secure water pump mounting flange with four cap screws and lock washers. Place new gasket between water connection and side of cylinder block. Secure with two cap screws and lock washers. Tighten hose clamps.

aa. Install Valve Tappet Covers (fig. 159).

Wrench, open-end, $\frac{9}{16}$-in.

Shellac a new gasket to the mounting surface of each cover. Place the covers in position on the engine and secure in position with cap screws, copper gaskets and plain washers. The copper gasket goes next to the cover.

bb. Install Vacuum Pump Adapter Bracket.

Pliers
Wrench, socket, $\frac{3}{4}$-in.

Place a new gasket and the adapter bracket in position on the crank-

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

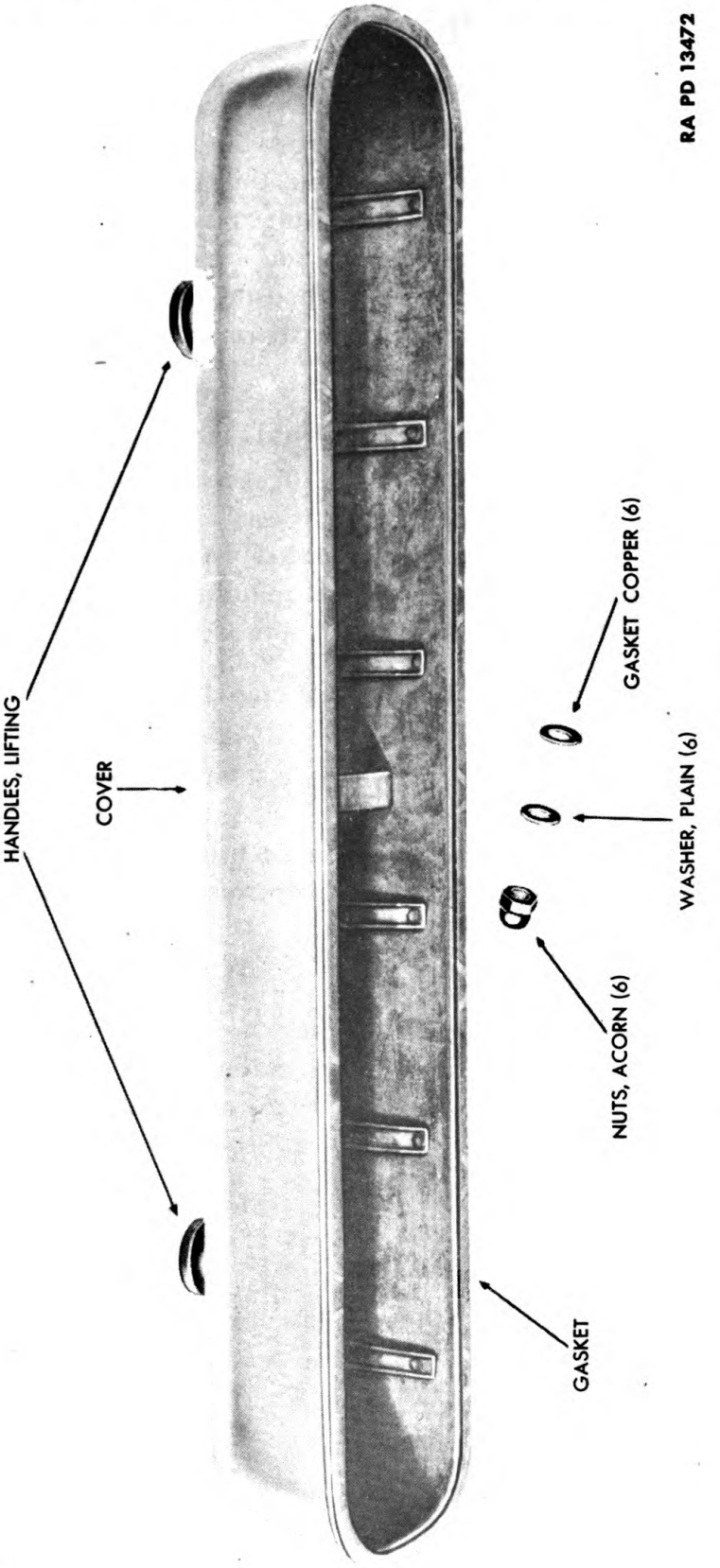


Figure 158—Cylinder Head Cover

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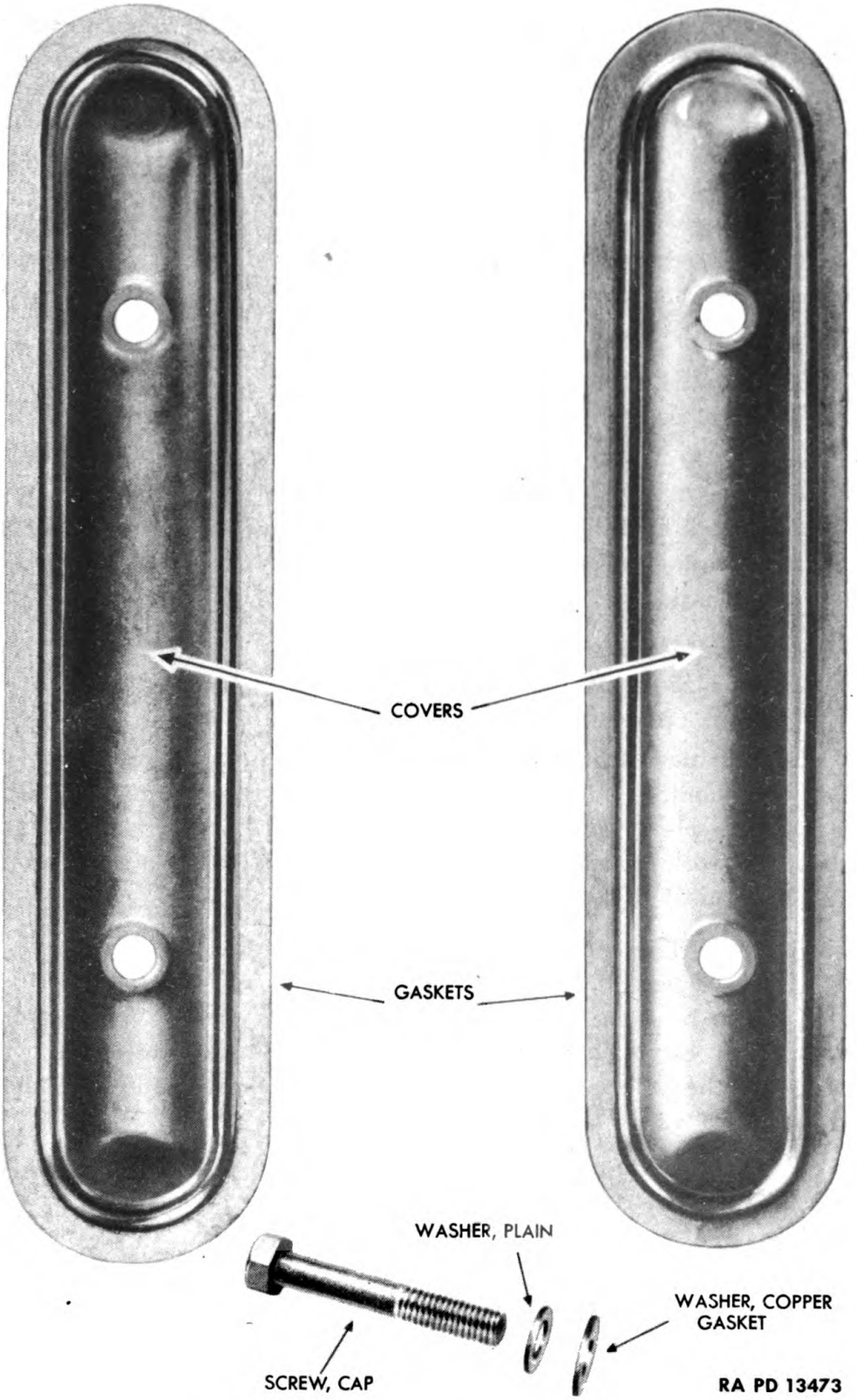


Figure 159—Valve Tappet Covers

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case mounting pad and install the four cap screws which secure the adapter bracket to the mounting pad. Safety-wire the cap screws in place.

cc. Install Vacuum Pump Assembly.

Wrench, open-end, 5/8-in.

Place a new cork gasket in position on the vacuum pump adapter bracket and secure the vacuum pump in position with plain washers, lock washers and cap screws. The plain washers go next to the pump base.

dd. Install Lubricating Oil Filter Assembly.

Wrench, open-end, 3/4-in.

Place a new gasket on the four lubricating oil filter studs in the side of the cylinder block. Place the small locating dowel in position in the cylinder block and slide the lubricating oil filter into position. Be sure that the locating dowel fits into the filter base. Install lock washers and nuts on the studs.

ee. Install Exhaust Manifold (fig. 160).

Handle, speed
Wrench, socket, 5/8-in.
Wrench, open-end, 5/8-in.

Place six new asbestos gaskets on the exhaust manifold studs and slide the manifold into place on the studs. Secure the manifold to the engine with plain washers and brass nuts. NOTE: Start at the center studs and work toward the ends, drawing nuts up only a small amount each time, until all are tight.

ff. Install Thermostat Bypass Assembly (fig. 161).

Screwdriver

Slide the hose on the lower end of the thermostat bypass onto the water pump connection. Slide the hose on the upper end of the bypass tube onto the thermostat housing connection. Tighten the hose clamps at both ends with a screwdriver (fig. 161).

gg. Mount Fuel Injection Pump Assembly and Bracket on Engine.

Wrench, box, 1 1/16-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 9/16-in.

Install the fuel injection pump and bracket on the three studs in the side of the engine. Be sure that the two collar dowels have been put on the two outside studs and are inserted halfway in the case. The collar dowels must also fit into the pump bracket. Install lock washers and nuts on the studs. NOTE: Fuel lines 1 and 6, 2 and 5, are interchangeable. Lines 3 and 4 are not interchangeable. These are the two shortest lines.

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Figure 160—Exhaust Manifold and Gaskets

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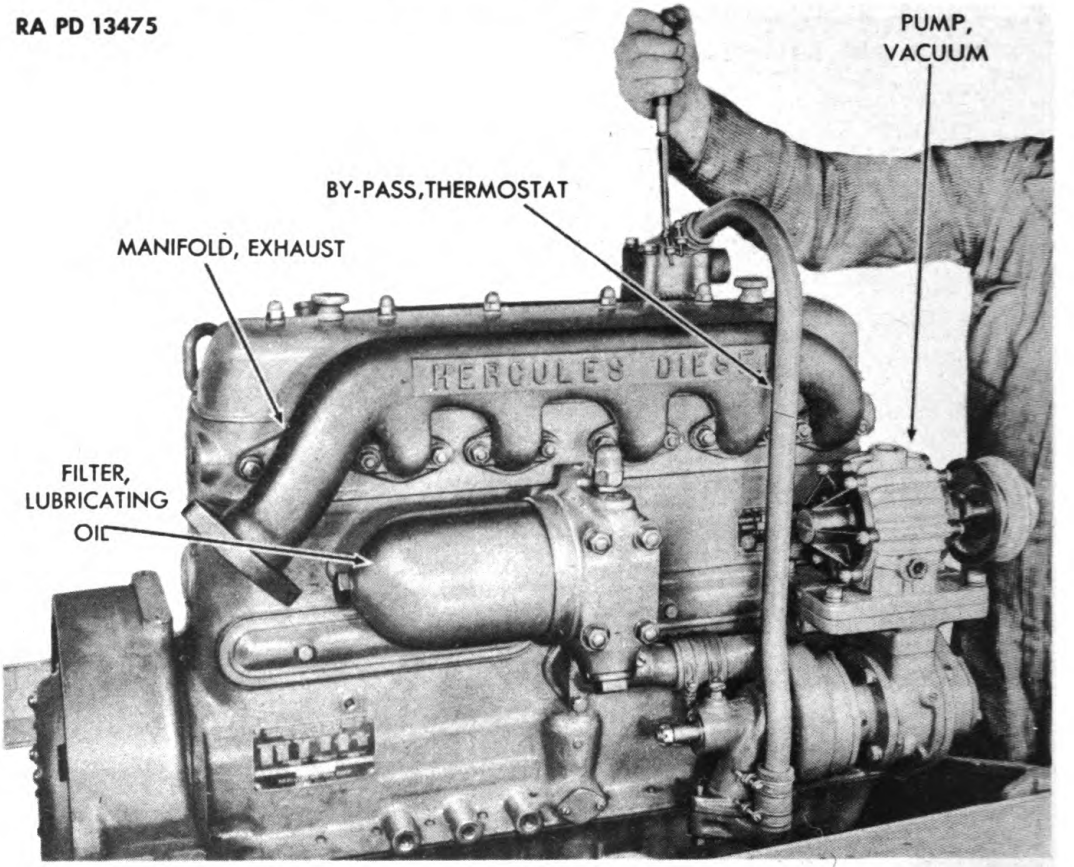


Figure 161—Attaching Thermostat Bypass to Engine

They cannot be confused because their shape permits them to be installed only one way. Tighten clamp stud nuts on nozzle clamps (fig. 90). Connect the fuel leak-off manifold to the injectors (fig. 90). It will be easier to install if you work from front of engine to rear. Push the clip on the fuel return line over the set-screw in the fuel pump drive sleeve (fig. 90). Connect the end of the fuel return line to the fuel return line "tee" (fig. 73). Install a lock washer and nut on the fuel pump drive sleeve set screw (fig. 90).

hh. Mount Air Intake Venturi Assembly on Engine.

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{5}{8}$-in.

Place the two retaining cap screws and lock washers in the mounting flange of the air intake Venturi. Position the following on the cap screws in the order named: Gasket, monobestos spacer, heating unit with the thermal element facing away from mounting flange, monobestos spacer, and gasket (fig. 162). Attach the above assembly to the engine with the cap screws. Connect one end of the governor vacuum line to the elbow fitting on the Venturi housing. Connect the other end of this line to the governor (fig. 87).

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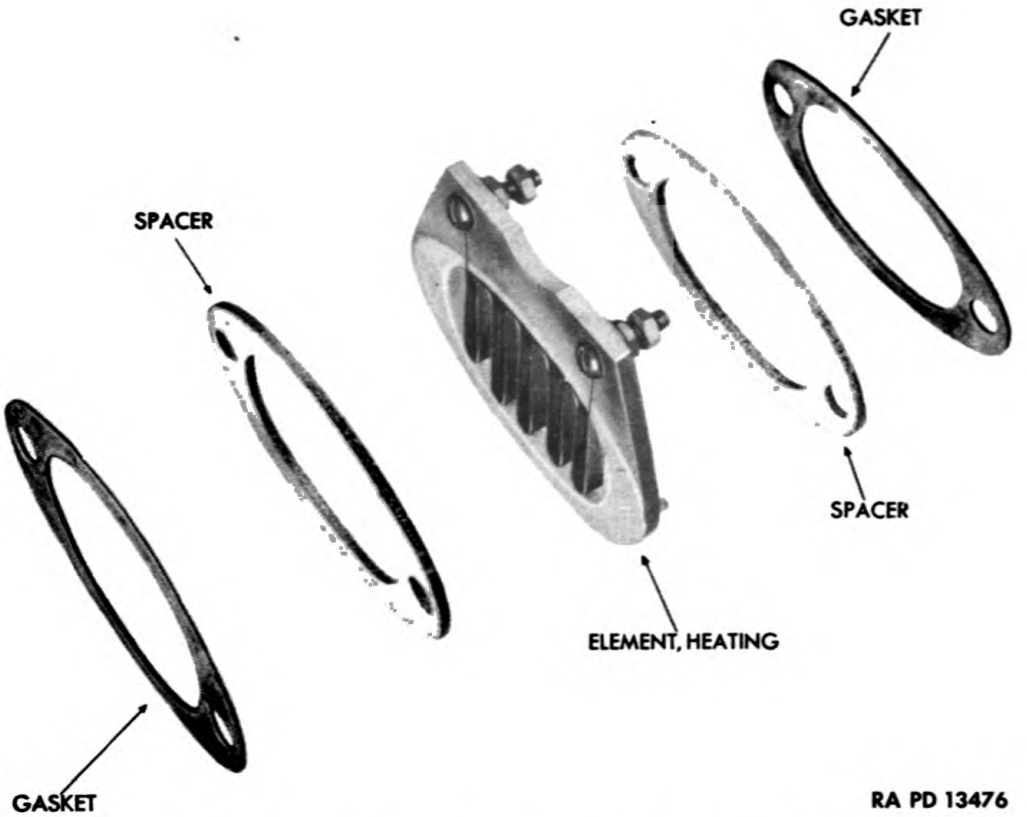


Figure 162—Heating Unit Assembly—Exploded View

ii. Install Generator Bracket Base.

Wrench, open-end, 7/8-in. Wrench, open-end, 15/16-in.

Place the generator bracket base in position on the gear case and secure with three cap screws with lock washers and one nut.

jj. Mount Fan Assembly on Engine.

Wrench, open-end, 3/4-in.

Place the fan bracket in position on the four studs in the front of the cylinder block and secure with nuts and lock washers (fig. 23). Install vacuum pump belt.

kk. Install Oil Filler and Breather Assembly.

Hammer, fiber

Insert the breather body in the oil filler opening in the engine and tap gently into position with a fiber hammer. Place the breather cap in position.

ll. Mount Generator on Engine.

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

(1) Line up the holes in the generator and cover bosses with the holes in the bracket base. Insert the bolts to secure the generator to the

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bracket base (fig. 18). Place lock washers and nuts on the bolts but do not tighten.

(2) Push generator toward engine as far as it will go and install generator drive belts on the pulleys.

(3) Place a cap screw and lock washer through the hole at the front of the adjusting strap. Slip on the spacer and tighten the cap screw in the adjusting strap bracket (cast integral with fan bracket) (fig. 19).

(4) Insert a bolt with plain washer through the slotted end of the adjusting strap and generator housing boss (fig. 19). Place a lock washer and nut on the bolt but do not tighten.

(5) Pull the generator away from the engine until the fan belts across the top may be deflected ½ to ¾ inch.

(6) Tighten the adjusting strap bolt nut with a ¾-inch open-end wrench.

(7) Tighten the two lower bracket base bolt nuts with a ⅞-inch open-end wrench.

mm. Mount Starting Motor on Bell Housing.

Hoist, chain
Wrench, open-end, ⅞-in.
Wrench, open-end, ¾-in.

(1) Remove the four engine mounting bolts and nuts with a ¾-inch open-end wrench and remove the engine from the repair stand with a chain hoist.

(2) Place the three retaining cap screws with lock washers in the starting motor mounting flange. Place the adapter on the cap screws and fasten adapter and starting motor to engine bell housing. Use a ⅞-inch open-end wrench to tighten the cap screws.

nn. Adjusting Oil Pressure (fig. 163).

Screwdriver
Wrench, open-end, $1\frac{1}{16}$-in.

After the engine is completely overhauled, it should be run in on a test stand for a number of hours. The oil pressure can then be regulated while the engine is warm. Remove the cap nut and copper gasket from the oil pressure adjusting screw in the lubricating oil filter. Loosen the lock nut on the adjusting screw. Screw *in* on the adjusting screw to increase the pressure and screw *out* to decrease the pressure. If the pressure does not change, remove the regulating piston and wash the parts in fuel oil or kerosene, reassemble and try again. If the pressure still shows no change, check oil pressure gage at oil lines. With the bearings in good condition and a proper grade of lubricating oil, the pressure should be 30 to 40 pounds at full engine speed. As the oil heats up, this pressure will be reduced.

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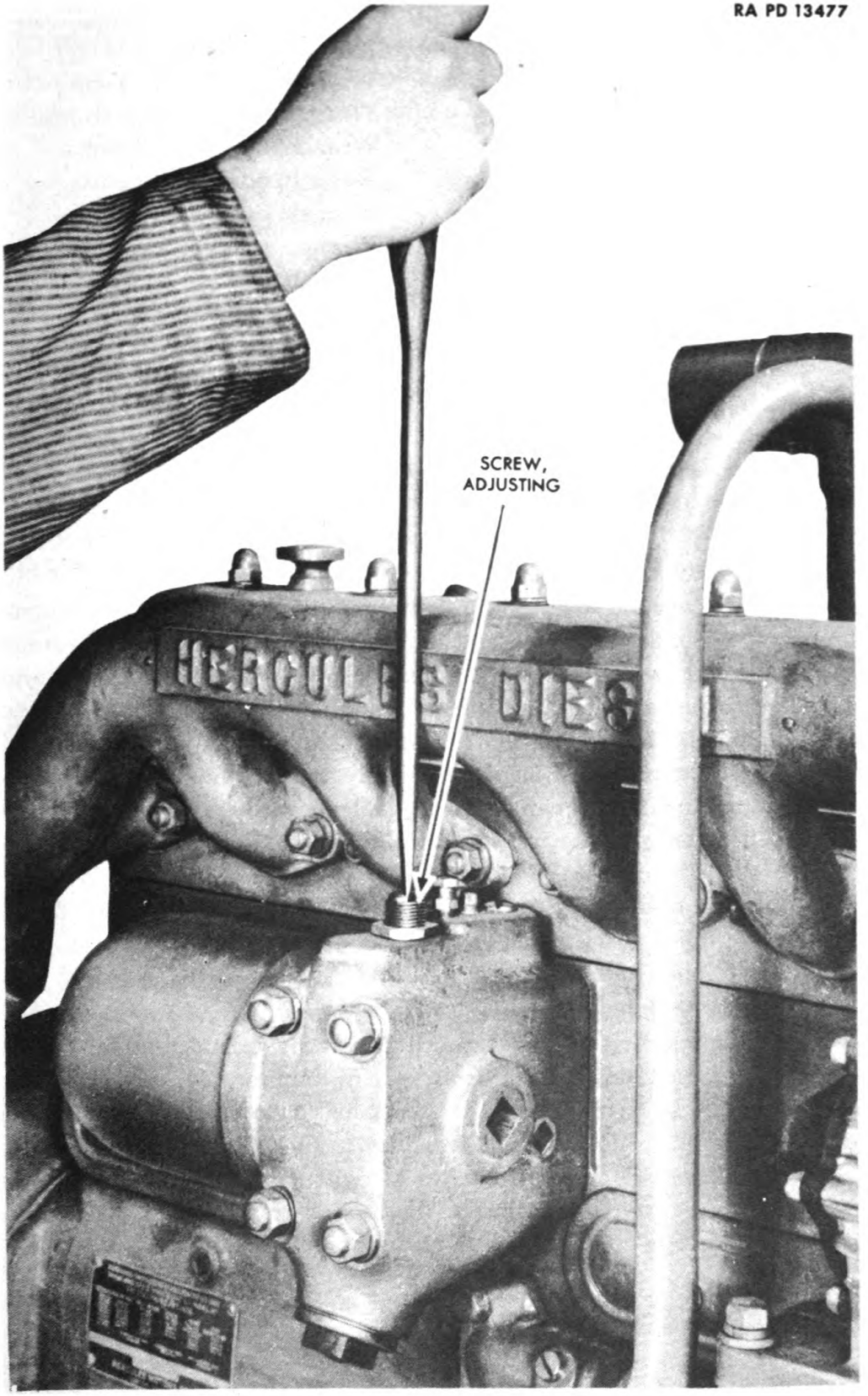


Figure 163—Regulating Oil Pressure

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

60. ENGINE INSTALLATION.

Extension, Ratchet
Hammer
Hoist, chain
Pail (or hose)
Pliers
Rope, Manila, 3/4-in.
Screwdriver
Screwdriver, heavy-duty
Wrench, box, 9/16-in.
Wrench, open-end, 3/8-in.
Wrench, open-end, 7/16-in.
Wrench, open-end, 1/2-in.
Wrench, open-end, 9/16-in.
Wrench, open-end, 5/8-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 7/8-in.
Wrench, open-end, 1 5/16-in.
Wrench, socket, 9/16-in.
Wrench, socket, 3/4-in.
Wrench, socket, 7/8-in.
Wrench, socket, 1 5/16-in.
Wrench, thin wall socket, 7/16-in.

a. Place Engine Assembly in Vehicle.

Hammer
Hoist
Rope, Manila, 3/4-in.
Screwdriver, heavy-duty
Wrench, open-end, 9/16-in.
Wrench, socket, 9/16-in.

Secure rope around engine in a figure eight. Place hoist hook in position on rope to balance engine and remove slack in rope by raising hoist hook. Raise engine and place it in position over frame; then lower and guide it into place so the hub of the clutch-driven member is in line with the clutch shaft. Line up splines of clutch hub with splines of clutch shaft and push the engine assembly tight against the transmission housing. Install the cap screws and lock washers that secure the engine bell housing to the transmission housing.

b. Connect and Bolt Engine Supports.

Pliers
Wrench, open-end, 3/4-in.
Wrench, open-end, 1 5/16-in.
Wrench, socket, 3/4-in.
Wrench, socket, 1 5/16-in.

Remove supporting blocks from under transmission, and with the engine in position, install the front engine support cap screws, lock washers and nuts (fig. 83). Install rear engine support bolts, lock washers and nuts (fig. 82). Use 3/4-inch wrenches to tighten rear right support bolts and nuts, and 1 5/16-inch wrenches to tighten rear left support bolts and nuts. Insert the cotter pins in the rear engine support castellated nuts. Remove rope sling and hoist from engine assembly.

c. Secure Brake Vacuum Booster.

Pliers

Secure brake vacuum booster to bracket by inserting clevis pin in clevis at rear of booster.

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ENGINE

d. Connect the Exhaust Manifold.

Wrench, open-end, ¾-in. Wrench, open-end, ⅞-in.

Install a new gasket between exhaust manifold and exhaust pipe flanges. Insert and tighten the bolts and nuts that secure the manifold to the pipe (fig. 80).

e. Connect the Oil Gage Line.

Wrench, open-end, $\frac{7}{16}$-in. Wrench, open-end, ½-in.

Join the oil filter to dash gage line at the union and tighten (fig. 79).

f. Connect Vacuum Pump Lines.

Screwdriver Wrench, open-end, ⅝-in.
Wrench, open-end, $\frac{7}{16}$-in. Wrench, open-end, ⅞-in.

Hold the vacuum pump oil and exhaust tank in position against the mounting bracket and insert the stove bolts to hold it. Use a screwdriver and $\frac{7}{16}$-inch open-end wrench to tighten the bolts. Install the vacuum line and hose from the pump to the screen and check valve on the dash (⅞-in. open-end wrench and screwdriver). Connect the vacuum pump and reservoir lines (⅞ and ⅝-in. open-end wrenches).

g. Install the Left Air Funnel Assembly.

Screwdriver Wrench, open-end, $\frac{9}{16}$-in.

Place the funnel assembly in position at ventilator box inlet and tighten clamp. Insert and tighten the cap screw, lock washer and nut that holds funnel support clamp to bracket.

h. Connect the Heat Indicator Unit.

Wrench, open-end, ⅝-in.

Connect the heat indicator unit to the water jacket at the left rear of the engine (fig. 76).

i. Connect the Venturi Heater Wire.

Wrench, open-end, $\frac{7}{16}$-in.

Connect the wire to the Venturi (intake) heater unit (fig. 75).

j. Connect the Generator Wires.

Pliers Wrench, socket, $\frac{9}{16}$-in.
Screwdriver Wrench, thin wall socket, $\frac{7}{16}$-in.
Wrench, open-end, ⅝-in.

Place the armature and field wires in position at the thermostat housing and insert and tighten the stove bolt that clamps them to the housing. Install the field terminal cable and secure it with the field terminal nut (thin-walled $\frac{7}{16}$-in. socket wrench) (fig. 42). Install the coupling nut (fig. 43) (⅝-in. open-end wrench). Install the plug on the field terminal (fig. 41) (screwdriver). Install the armature terminal cable and the armature terminal nut (fig. 40) ($\frac{9}{16}$-in. socket wrench with ratchet). Install the condenser (fig. 38) and coupling nut (fig. 39).

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k. Connect the Fuel Filter Lines.

Wrench, open-end, 3/4-in.

Connect the line from the filter to the injection pump (fig. 74). Connect the fuel line from the fuel transfer pump to the filter.

l. Connect Lines to Fuel Transfer Pump.

Wrench, open-end, 5/8-in. Wrench, open-end, 3/4-in.

Connect the main line from the fuel tank to the fuel transfer pump (fig. 72), using a 3/4-inch open-end wrench. Connect the fuel return line on the other side of the pump, using a 5/8-inch open-end wrench (fig. 73).

m. Connect Governor Control Wire.

Screwdriver Wrench, open-end, 3/8-in.

Connect the control wire at the governor.

n. Connect Fuel Injection Pump Shut-off Wire.

Screwdriver Wrench, open-end, 3/8-in.

Connect the shut-off wire at the fuel injection pump.

o. Connect the Throttle Controls.

Screwdriver Wrench, open-end, 7/16-in.

Put the throttle wire and rod in place at the air-intake Venturi. Using a screwdriver, secure the screw that holds the hand-operated throttle wire at the Venturi. Then, install the nut and lock washer that holds the foot-operated throttle rod at the Venturi lever (fig. 70).

p. Install Air Intake Pipe.

Screwdriver

Place the air-intake pipe in position and tighten the clamps at the Venturi and at the air cleaner.

q. Connect the Batteries.

Wrench, open-end, 9/16-in.

Remove tape from battery cable terminals. Attach the positive cable first to the battery, then attach the negative cable, and tighten the nuts. Install on the battery compartment covers and insert and tighten the cap screws and lock washers.

r. Install Heater Inlet and Return Hoses.

Screwdriver

Slide the return hose onto the water pump connection and tighten the clamp (fig. 30). Install the inlet hose and tighten the clamp (fig. 69).

s. Install Radiator.

Hoist, chain Wrench, socket, 7/8-in.

Wrench, socket, 3/4-in.

Place pads in position on cross member. Using a chain hoist, carefully

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swing the radiator assembly into position on the car. Connect the stay rods at the frame by installing stay rod bolts and nuts underneath car on the top frame flange (fig. 68). Connect radiator to cross member by installing holding washers, springs and nuts.

t. Install Radiator Hose Connections.

Screwdriver

Install the inlet and outlet radiator hoses and tighten the hose clamps (figs. 35 and 29).

u. Install the Shutter Assembly.

Hoist, chain	Wrench, box, $\frac{9}{16}$-in.
Screwdriver, heavy-duty	Wrench, open-end, ½-in.

Carefully lower shutter into position, using a chain hoist. Connect shutter control on lower right side of radiator. Insert and tighten the bolts and nuts that hold the shutter frame to the engine side armor plates.

v. Install Hood.

Hoist	Screwdriver, large
Rope	Wrench, open-end, $\frac{9}{16}$-in.

Use a rope and hoist to lift hood (with top of shutter frame attached to hood) into position. NOTE: Hood can also be slipped over front of car into position by three men. Install and tighten the nut and bolt on inside of shutter frame, near the top, on each side of frame. Install the three elastic stop nuts and bolts at rear of center panel of wood.

w. Prepare Vehicle for Road.

Pail (or hose)	Pliers

Be sure all drain cocks are tightly closed. Fill cooling system with liquid. Check oil level in crankcase. Start engine and check oil pressure; check cooling system and lubricating system for leaks.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

Section X

FUEL SYSTEM

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61. DESCRIPTION OF SYSTEM.

a. The engine fuel system consists of an injection pump, fuel transfer pump, vacuum governor, check valve, six fuel lines and injectors, two fuel filters and a leak-off manifold. The fuel injection pump is attached to the left side of the engine, and has the transfer pump mounted on it. The governor is mounted on the coupling end of the injection pump.

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The check valve is located at the forward end of the injection pump. Fuel lines carry the fuel from the injection pump to an injector at each cylinder, and a leak-off manifold returns fuel which was not injected from the injectors. A primary filter is located between the fuel tanks and the transfer pump, and a final stage filter filters fuel before it reaches the injection pump.

b. Functioning. The transfer pump forces fuel from the fuel tanks and primary filter to the final stage filter and fuel injection pump. The injection pump controls the feeding of fuel to the injectors. Pressure is built up until it is sufficient to open a spring-loaded valve in the injector. Fuel is then injected into the combustion chamber of the cylinder, and is ignited by the heat of the highly compressed air there.

62. TROUBLE SHOOTING.

Symptom and probable cause	Probable remedy
(1) FAST IDLING.	
Accelerator control sticking.	Free control.
Governor out of adjustment.	Adjust.
(2) HARD STARTING.	
Air in fuel lines.	Bleed lines.
Water in fuel.	Drain fuel system.
Air cleaner plugged.	Remove and clean.
(3) FUEL KNOCKS.	
Dirty injector nozzle.	Remove and clean.
Nozzle valve sticking.	Remove and clean.
Improper fuel oil.	Change fuel oil.
Fuel delivery valve stuck.	Remove and clean.
(4) NO FUEL AT INJECTION PUMP.	
No fuel in tank.	Fill tank.
Defective transfer pump.	Remove and repair or replace.
Obstruction in fuel line or filter.	Remove obstruction.
Fuel too heavy.	Use lighter fuel.
(5) EXCESSIVE SMOKE IN EXHAUST.	
Dirty spray nozzles.	Remove and clean.
Improper fuel oil.	Change fuel.
Incorrect fuel injection timing.	Adjust timing.
Fuel delivery valve stuck.	Remove and clean.
(6) ENGINE STOPS SUDDENLY.	
No fuel in tanks.	Fill tanks, prime and start.
Fuel lines air-bound.	Bleed lines.

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Symptom and probable cause	Probable remedy
Fuel filter plugged.	Clean filter and prime lines.
Obstruction in lines.	Check, starting with fuel tank to filter line.
Water in fuel.	Drain entire system and clean.
Transfer pump not functioning properly.	Inspect.
Broken fuel pump driving chain.	Replace with new chain and time engine.
Fuel pump adjustable coupling slipped.	Retime pump.
(7) ENGINE MISSING.	
Improper fuel.	Drain system and change fuel.
Water in fuel.	Drain system and refill.
Sticking nozzle valve stem.	Remove and clean.
Sticking delivery valve.	Remove and clean.
Plugged air cleaner.	Clean.
Fuel lines air-bound.	Bleed lines.

63. AIR CLEANER DESCRIPTION.

a. General Description. The air cleaner is of the oil bath type and is mounted on the dash at the right rear of the engine compartment.

b. Construction. The air cleaner consists of two cylindrical sheet metal sleeves, one inside of the other, with an air space between the inner and outer sleeves. The inner sleeve contains the air filter element, the air outlet elbow at the top, and a baffle plate attached to the bottom. The oil bath (reservoir) cup slides over the lower portion of the outer sleeves and is held in position by two thumb screws.

c. Functioning. The dust-laden air, entering around the space between the inner and outer sleeves in a rotary motion, causes much of the grit and dust to deposit on the walls. Additional dust is washed out when the air comes in contact with the oil bath. The semi-clean air is thoroughly filtered while passing through the filter element, which is kept moist by the splash of the agitated oil bath. Clean air proceeds to the Venturi while the dust is washed into the sump.

d. Trouble Shooting. Refer to paragraph 62, "Trouble Shooting".

64. AIR CLEANER REMOVAL.

Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.

a. Remove Venturi Air Horn and Rubber Hose Assembly.
Screwdriver

Loosen clamp which holds hose to air cleaner outlet, then loosen

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clamp which holds hose to Venturi air inlet. Lift hose from Venturi and remove pipe and hose assembly (fig. 70).

b. Remove Air Cleaner.

Wrench, open-end, $\frac{9}{16}$-in.

Take off four hexagon head nuts and lock washers from bolts that attach air cleaner to dash and remove cleaner.

65. DISASSEMBLY OF AIR CLEANER.

Screwdriver — Wrench, open-end, $\frac{3}{8}$-in.

a. Remove Oil Bath Cup. Loosen two thumb screws and remove cup from outer sleeve.

b. Remove Air Baffle Plate.

Screwdriver — Wrench, open-end, $\frac{3}{8}$-in.

Remove four bolts, nuts and lock washers from brackets and lift off baffle plate.

66. AIR CLEANER MAINTENANCE.

a. All connections between air cleaner and Venturi should be inspected at frequent intervals and should be kept tight.

b. The oil bath cup should be inspected daily and kept filled with engine oil or used crankcase oil to the oil level mark indicated on the cup. Do not remove oil cup while engine is running.

c. The air cleaner cup should be cleaned thoroughly and refilled with a fresh supply of the same grade of oil that is used in the engine, each time the crankcase is drained and refilled or at intervals of 2,000 miles.

d. Occasionally the air cleaner should be removed from the dash and cleaned by washing in SOLVENT, dry-cleaning, or gasoline to remove the accumulation of dust and dirt from the filter element.

67. ASSEMBLY OF AIR CLEANER.

Screwdriver — Wrench, open-end, $\frac{3}{8}$-in.

a. Install Air Baffle Plate.

Screwdriver — Wrench, open-end, $\frac{3}{8}$-in.

Place baffle plate on brackets and secure with four bolts, nuts and lock washers.

b. Install Oil Bath Cup. Slide cup in position over air cleaner outer sleeve and secure with two thumb screws.

68. INSTALLATION OF AIR CLEANER.

Screwdriver — Wrench, open-end, $\frac{9}{16}$-in.

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a. Install Air Cleaner on Dash.

Wrench, open-end, $\frac{9}{16}$-in.

Position air cleaner on dash so that the bolts come through the bracket holes, and secure assembly with four nuts and lock washers.

b. Install Pipe and Hose Assembly.

Screwdriver

Slide air hose over cleaner outlet elbow and place hose over Venturi air inlet. Tighten hose clamps.

69. FUEL INJECTION PUMP DESCRIPTION.

a. General.

(1) The fuel injection pump is of the constant-stroke, cam-actuated, lapped-plunger type. Its purpose is to meter the fuel accurately and to deliver it at a definite moment under high pressure to the spray nozzles by which it is injected into the respective cylinder of the engine.

(2) The pump consists of an aluminum alloy housing with camshaft compartment in the lower half and six-pump element assemblies in the upper half.

(a) The camshaft compartment contains the camshaft which runs in ball bearings supported by the end plates. Felt cushions, in the closing plugs in the housing base, facilitate lubrication of the cams and roller followers of the tappet assemblies. Directly above these are located the plunger and barrel assemblies, control sleeves with toothed segments, plunger return springs, spring seats and the control rod.

(b) The upper part of the housing contains the fuel pump, delivery valve assemblies with gaskets, delivery valve springs, delivery valve holders and nipple nuts for connection of the discharge tubings.

b. Functioning.

(1) Through the inlet connection, the fuel enters the sump in the upper part of the housing. As soon as the upper edge of the plunger, during its downward stroke, opens the two radially opposite ports in the barrel, known as inlet and bypass ports, the fuel rushes into the barrel while the plunger is at the bottom of its stroke. During the first part of the upward stroke of the plunger, some of the fuel in the barrel is displaced back into the sump through the inlet and bypass ports, until these two ports are completely closed. Shortly afterwards, the fuel is placed under pressure, the spring-loaded delivery valve is lifted off its seat, and the fuel is delivered through the discharge tubing into the spray nozzle, whence it is discharged into the combustion chamber of the engine.

(2) Delivery of fuel ceases as soon as the helix on the plunger passes

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the bypass port in the barrel, for at this instant the pressure chamber is connected with the sump by way of the vertical groove and helix on the plunger, allowing the fuel not yet delivered in the discharge tubing to bypass back into the sump.

(3) The termination of the fuel delivery, which also controls the quantity of fuel delivered per stroke, is varied by turning the plunger in its barrel, i.e., by bringing the helix into various positions with relation to the bypass port. To accomplish this, a control sleeve is installed over the barrel, the sleeve being provided with a toothed segment at its upper end and with two longitudinal, opposite slots at its lower end in which the cross flange of the plunger is guided. The teeth of the gear segment engage corresponding teeth on the control rod, and, by shifting the latter, either manually or automatically by means of a governor, the plunger is rotated in its barrel in either direction.

(4) The less the control rod is moved away from its "stop" position and the less the plunger is thereby turned in its barrel, the sooner the helix opens the bypass port and the smaller the fuel delivery per stroke will be. The farther the control rod is moved away from its "stop" position and the farther the plunger is turned in its barrel, the later the helix opens the bypass port and the larger the fuel delivery per stroke will be.

c. Injection Pump Trouble Shooting. Refer to paragraph 62.

70. REMOVAL OF FUEL INJECTION PUMP.

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{3}{4}$-in.
Wrench, open-end, $\frac{11}{16}$-in.

a. Detach the Governor Vacuum Line.

Wrench, open-end, $\frac{9}{16}$-in.

Unscrew the governor vacuum line at the lower connection by loosening the nut (fig. 87).

b. Detach the Fuel Pump Fuel Lines.

Wrench, open-end, $\frac{11}{16}$-in.

Loosen the fuel pump fuel lines at the barrels on top of the fuel injection pump (fig. 87).

c. Detach Leak-off Manifold from Pump.

Wrench, open-end, $\frac{9}{16}$-in.

Loosen and remove the fuel nozzle leak-off manifold from the union at the pump (fig. 164).

d. Remove Fuel Injection Pump and Governor (fig. 164).

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{3}{4}$-in.

Remove the two front coupling cap screws with lock washers and

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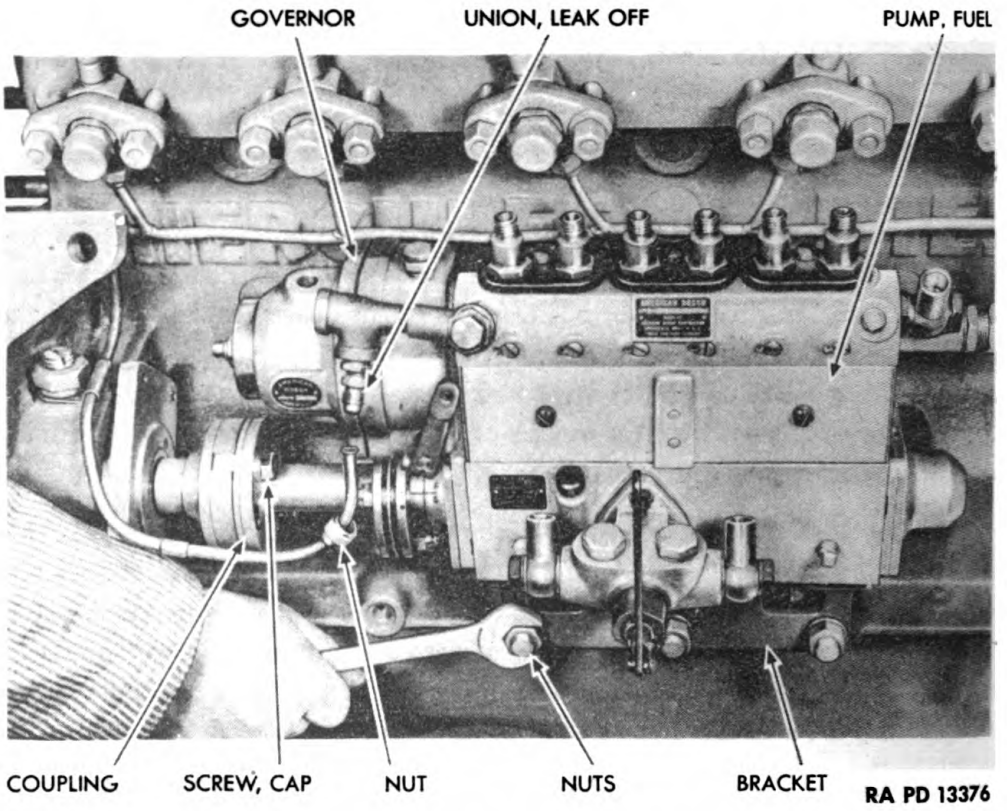


Figure 164—Removing Fuel Injection Pump and Governor

plain washers. (The floating member of the coupling will also come off when the pump is removed.)

Remove the three nuts and washers from the pump-mounting bracket studs. Lift off the fuel injection pump assembly. NOTE: There are two collar dowels used on the bracket studs, one on each outside stud. These dowels fit halfway in the cylinder block and halfway in the bracket. Remove these two collar dowels.

71. DISASSEMBLY OF FUEL INJECTION PUMP AND GOVERNOR ASSEMBLY.

Drift, metal
Hammer
Hammer, fiber
Pliers
Wrench, open-end, ½-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, socket, ¾-in.

a. Remove Fuel Pump Bracket.

Wrench, open-end, $\frac{9}{16}$-in.

Remove the bracket from the bottom of the fuel injection pump by removing four cap screws, lock washers and plain washers.

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b. Remove Coupling Flanged Shaft.

Wrench, open-end, ½-in.

Remove the two castle nuts from the two round head screws that secure the coupling flanged shaft to the rear hub. Two spring steel coupling disks and spacer will come off when the above screws are removed (fig. 165).

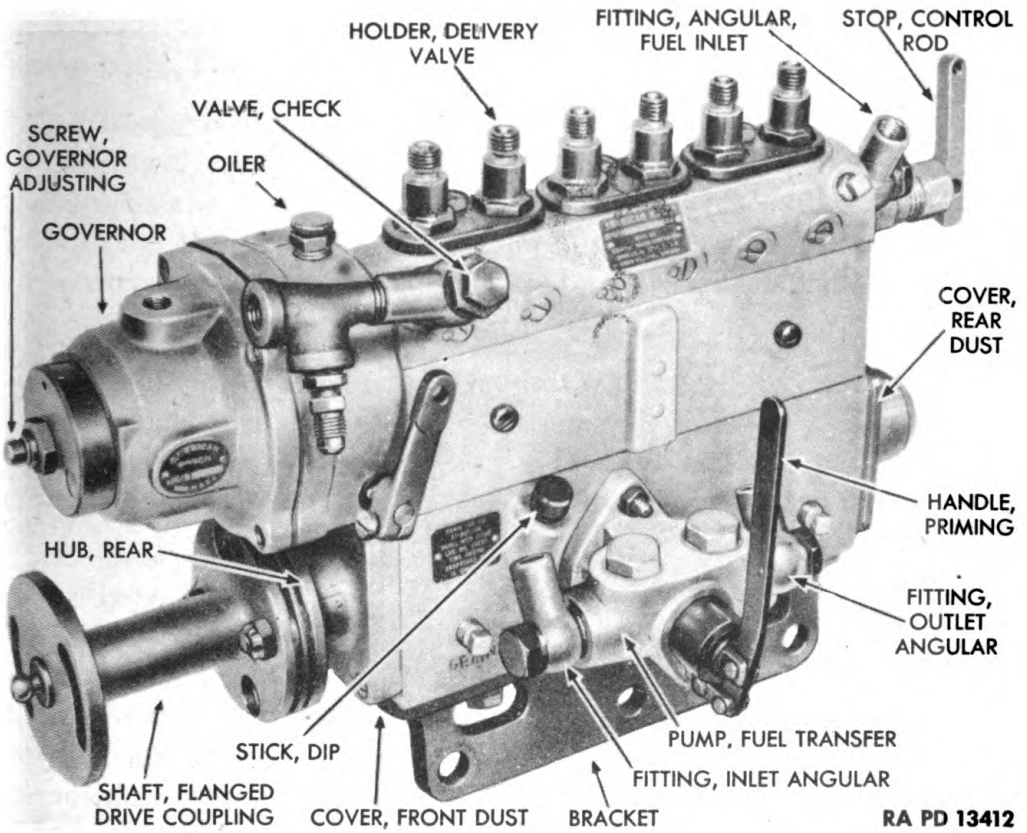


Figure 165—Fuel Pump and Governor

c. Remove Rear Hub.

Hammer, fiber
Pliers
Wrench, socket, ¾-in.

Remove the rear hub nut and lock washer from the fuel injection pump shaft. Drive the rear hub off the fuel injection pump shaft with a fiber hammer and remove the Woodruff key from the shaft (fig. 166).

d. Remove Coupling Shaft Ball End.

Drift, metal
Hammer

With a metal drift and hammer, drive out the coupling shaft ball end from the coupling flanged shaft.

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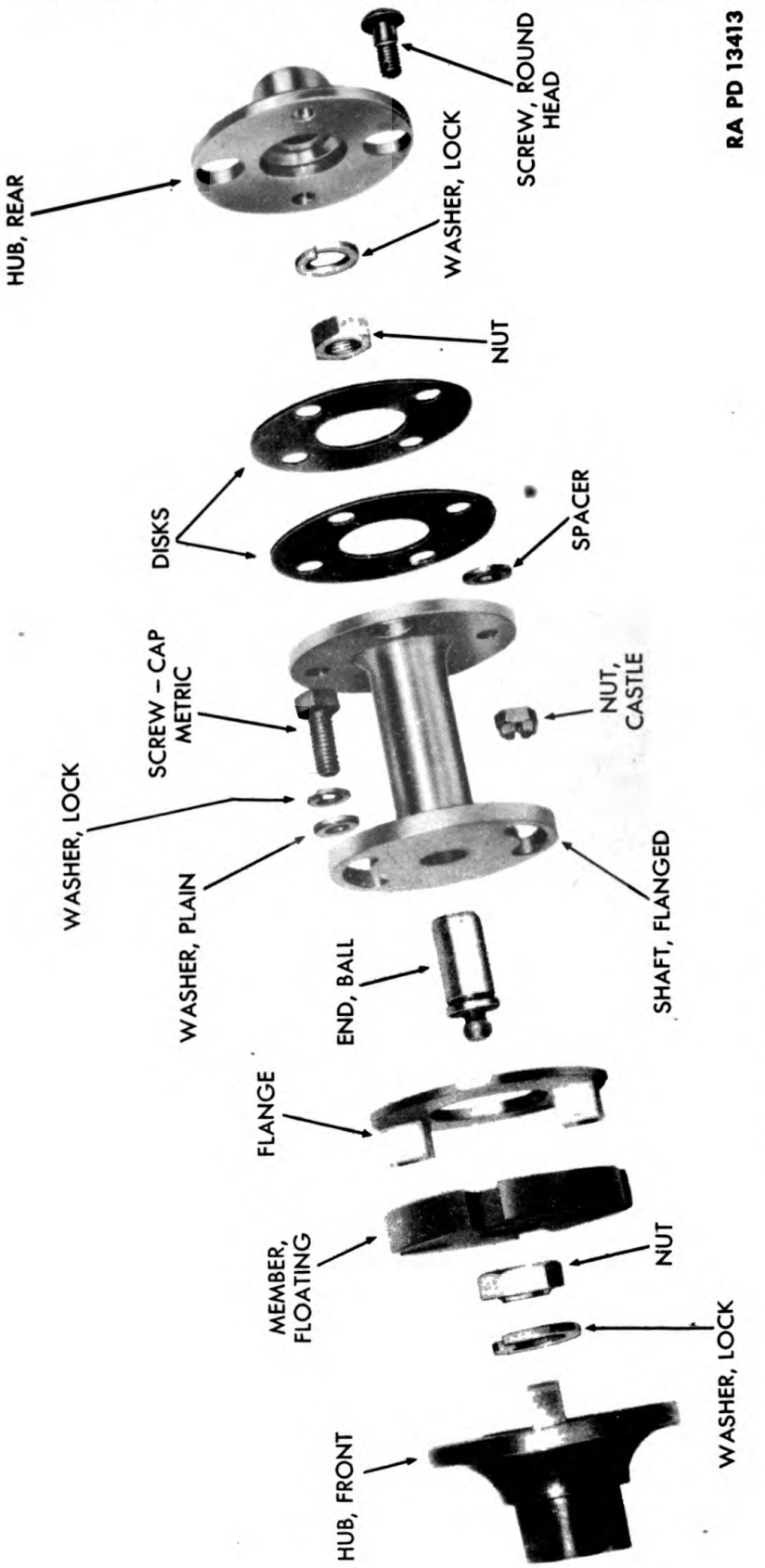


Figure 166—Fuel Pump Coupling—Exploded View

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FUEL SYSTEM

72. DISASSEMBLING FUEL TRANSFER PUMP.

Hammer
Pliers
Punch, small
Screwdriver
Screwdriver, wide blade
Wrench, open-end, 3/8-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 15/16-in.

a. Remove Transfer Pump from Injection Pump.

Wrench, open-end, 3/8-in.

Remove the fuel transfer pump and gasket from the fuel injection pump body. Three nuts and lock washers must be removed (fig. 167).

b. Remove Inlet and Outlet Fittings.

Screwdriver, wide blade
Wrench, open-end, 3/4-in.

Remove the fuel inlet and outlet angular fittings from the transfer pump (fig. 165). Remove the retaining screws and two copper washers from each angular fitting body (fig. 171). With a wide blade screwdriver remove the inlet screen from inlet retaining screw.

c. Remove Valve Spring Retaining Screws.

Wrench, open-end, 3/4-in.

Remove the two valve spring retaining screws, springs and fiber valves from the top of the fuel transfer pump body (fig. 168).

d. Remove Priming Handle.

Pliers

Remove the cotter pin from the priming handle pivot pin (fig. 168). Remove the washer from the pivot pin and push the pin out. Priming handle and links will come off also. Pull out the priming (rod) plunger far enough to remove the snap ring. After the snap ring has been removed, push the shaft and spring out of the plunger body.

e. Remove Tappet and Roller.

Hammer
Punch, small

Drive out the small pin which holds the tappet and tappet roller in the transfer pump body (fig. 168). Remove the tappet and roller, spring and spindle.

f. Remove the Lever Support.

Screwdriver
Wrench, open-end, 15/16-in.

Remove the lever support from the transfer pump body (fig. 168). Remove the snap ring, and the spring and plunger can be removed from the lever support.

73. DISASSEMBLING THE GOVERNOR.

Screwdriver
Screwdriver, small
Wrench, open-end, 11/16-in.

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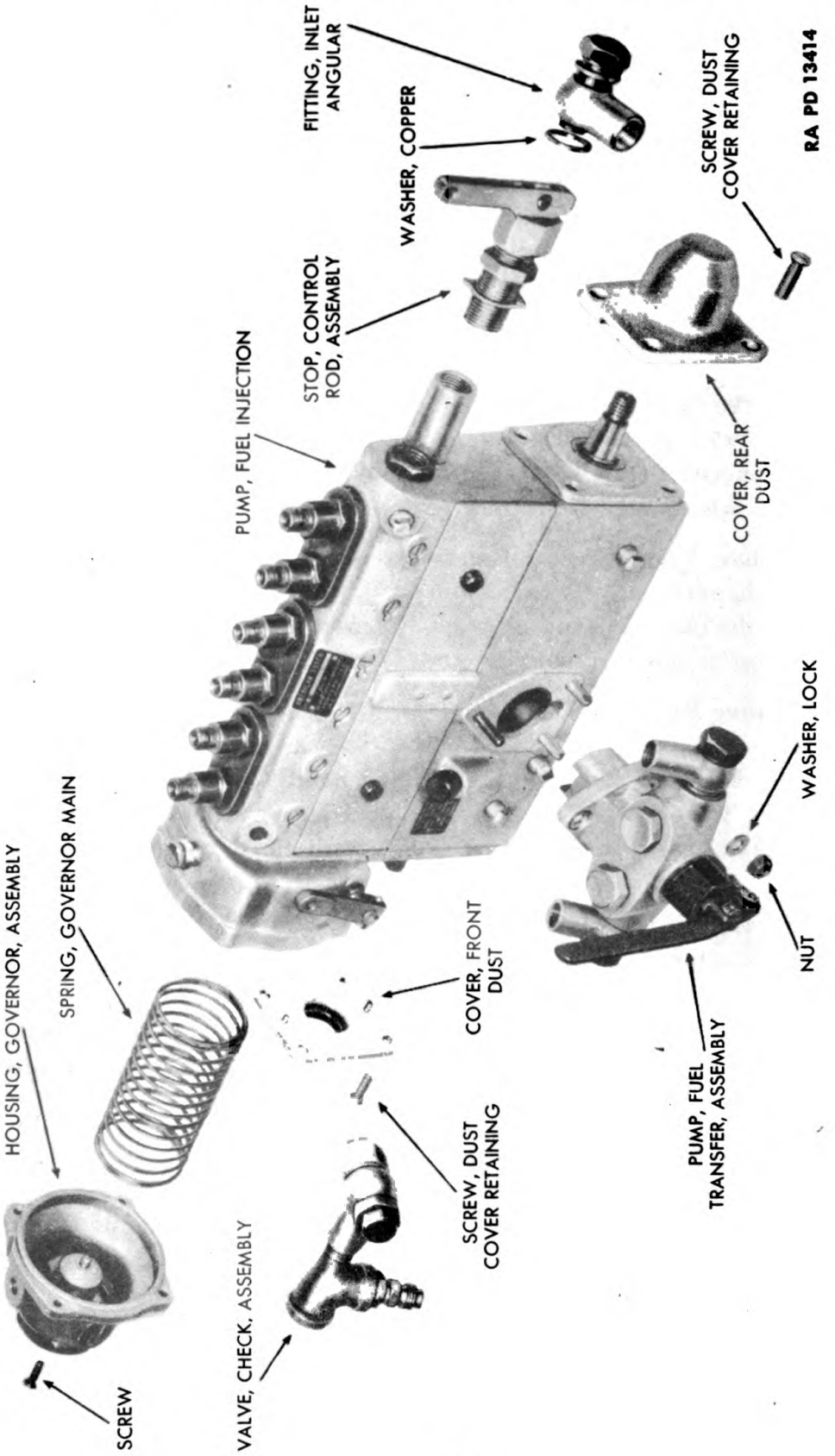
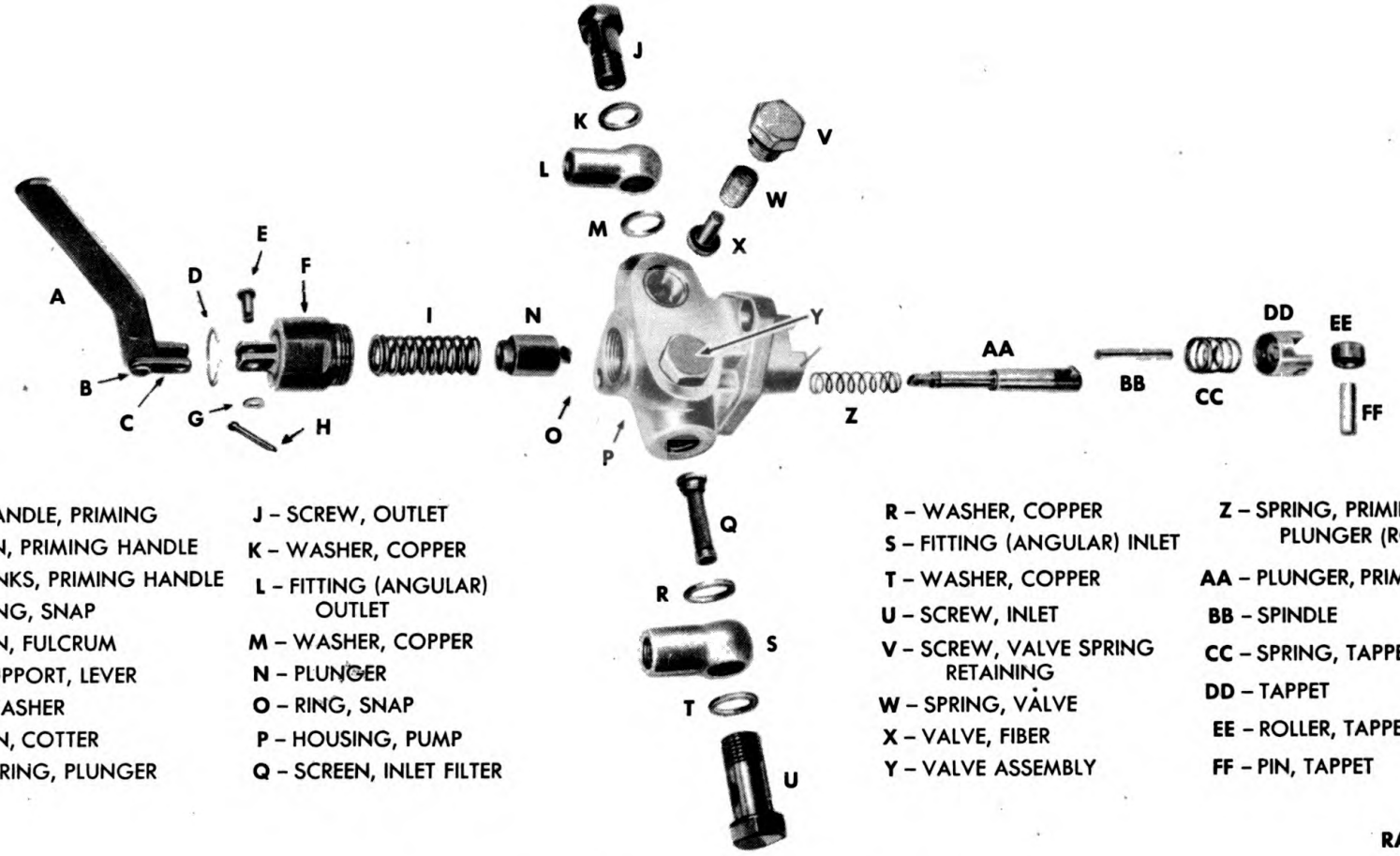


Figure 167—Fuel Pump Subassemblies

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A – HANDLE, PRIMING
B – PIN, PRIMING HANDLE
C – LINKS, PRIMING HANDLE
D – RING, SNAP
E – PIN, FULCRUM
F – SUPPORT, LEVER
G – WASHER
H – PIN, COTTER
I – SPRING, PLUNGER

J – SCREW, OUTLET
K – WASHER, COPPER
L – FITTING (ANGULAR) OUTLET
M – WASHER, COPPER
N – PLUNGER
O – RING, SNAP
P – HOUSING, PUMP
Q – SCREEN, INLET FILTER

R – WASHER, COPPER
S – FITTING (ANGULAR) INLET
T – WASHER, COPPER
U – SCREW, INLET
V – SCREW, VALVE SPRING RETAINING
W – SPRING, VALVE
X – VALVE, FIBER
Y – VALVE ASSEMBLY

Z – SPRING, PRIMING PLUNGER (ROD)
AA – PLUNGER, PRIMING (ROD)
BB – SPINDLE
CC – SPRING, TAPPET
DD – TAPPET
EE – ROLLER, TAPPET
FF – PIN, TAPPET

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Figure 168—Fuel Transfer Pump—Exploded View

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a. Remove Governor Housing and Spring.

Screwdriver

Remove the governor housing and main spring (inside) by removing four screws which hold the housing to the fuel injection pump end cover (fig. 165).

b. Remove End Cap Assembly.

Screwdriver

Remove the two screws from the front of the end cap. The end cap assembly will come off the governor housing (fig. 169).

c. Remove the Adjusting Screw.

Screwdriver, small
Wrench, open-end, $\frac{11}{16}$-in.

Remove the snap ring from the adjusting screw which projects through the end cap. Remove the stop ring from the adjusting screw. Remove the nut and spring steel washer from the adjusting screw. The end cap will now come off. Unscrew the adjusting screw from the bushing. Remove the idling spring and idling control pin from the bushing.

74. DISASSEMBLING THE CHECK VALVE.

Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

a. Remove the Check Valve from the Fuel Pump.

Wrench, open-end, $\frac{3}{4}$-in.

Remove the check valve and adapter assembly (fig. 165).

b. Remove the Adapter.

Wrench, open-end, $\frac{3}{4}$-in.

Remove the adapter from the check valve. A copper washer will come away when the adapter is removed. Pull out the retaining screw assembly, and another copper washer will come off (fig. 170).

c. Disassemble the Retaining Screw.

Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{3}{4}$-in.

Unscrew the check valve screw from the retaining screw. The valve spring and fiber valve will fall out of the retaining screw (fig. 170).

75. DISASSEMBLING THE FUEL INJECTION PUMP.

Drift, soft metal
Hammer
Hammer, fiber
Pliers
Pliers, long nose
Press, arbor
Puller, internal threaded
Screwdriver
Tool, tappet holder
Tool, tappet lifting
Vise, with brass jaw inserts
Wrench, box, $\frac{3}{4}$-in.
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, $\frac{3}{4}$
Wrench, open-end, $\frac{7}{8}$-in.
Wrench, screwdriver socket
Wrench, socket, $\frac{7}{8}$-in.

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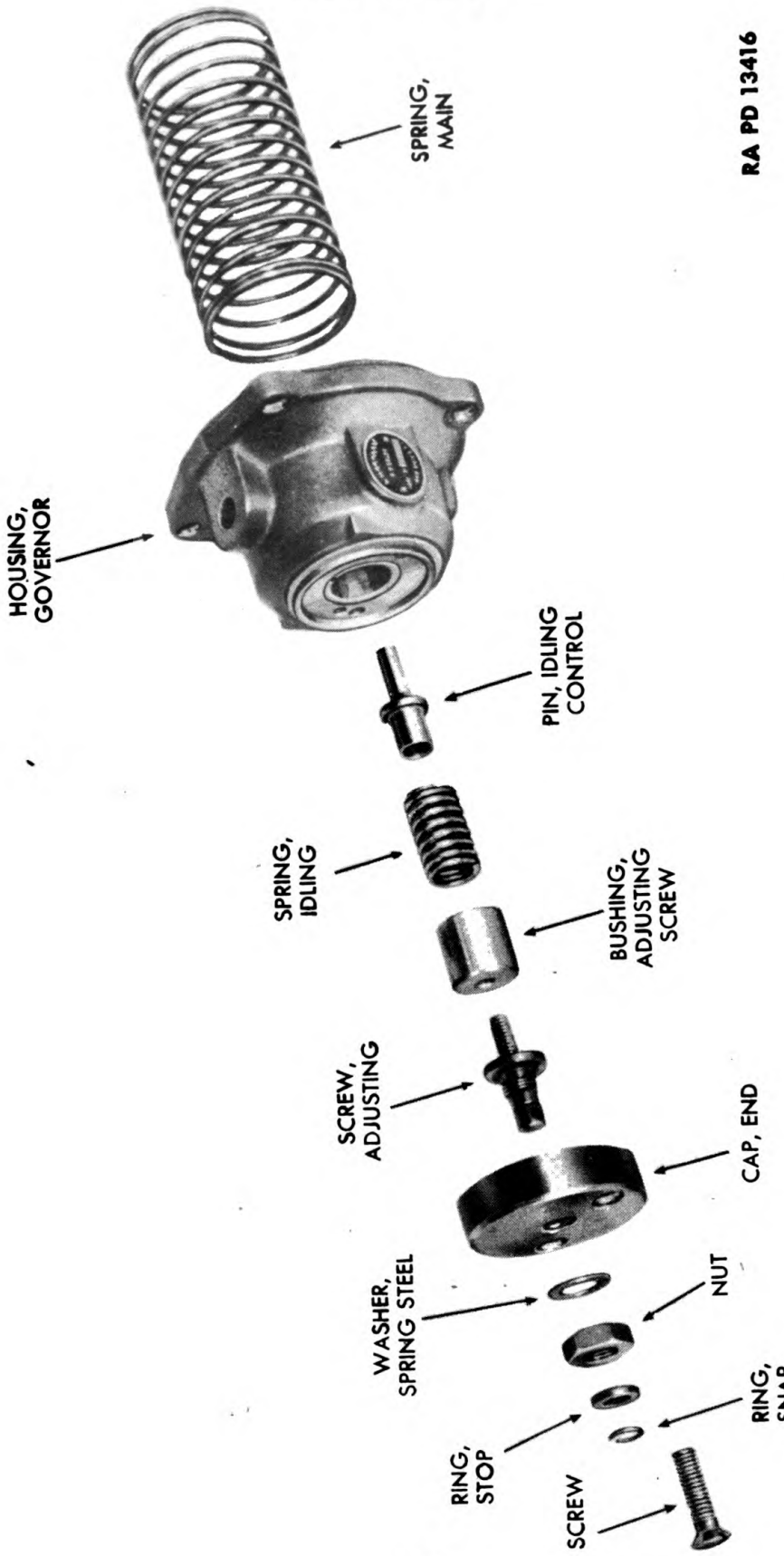


Figure 169—Fuel Pump Governor—Exploded View

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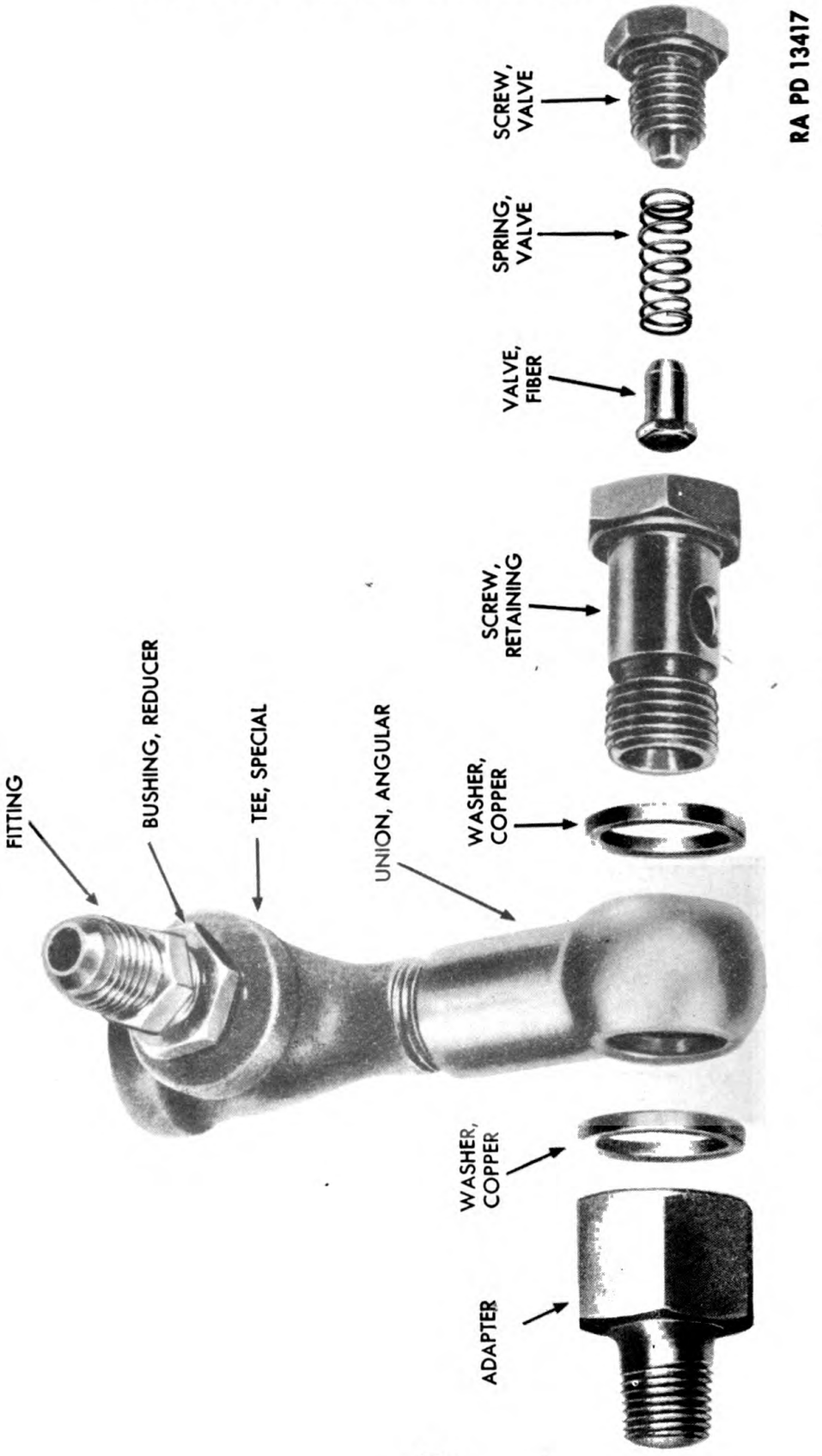


Figure 170—Fuel Pump Check Valve—Exploded View

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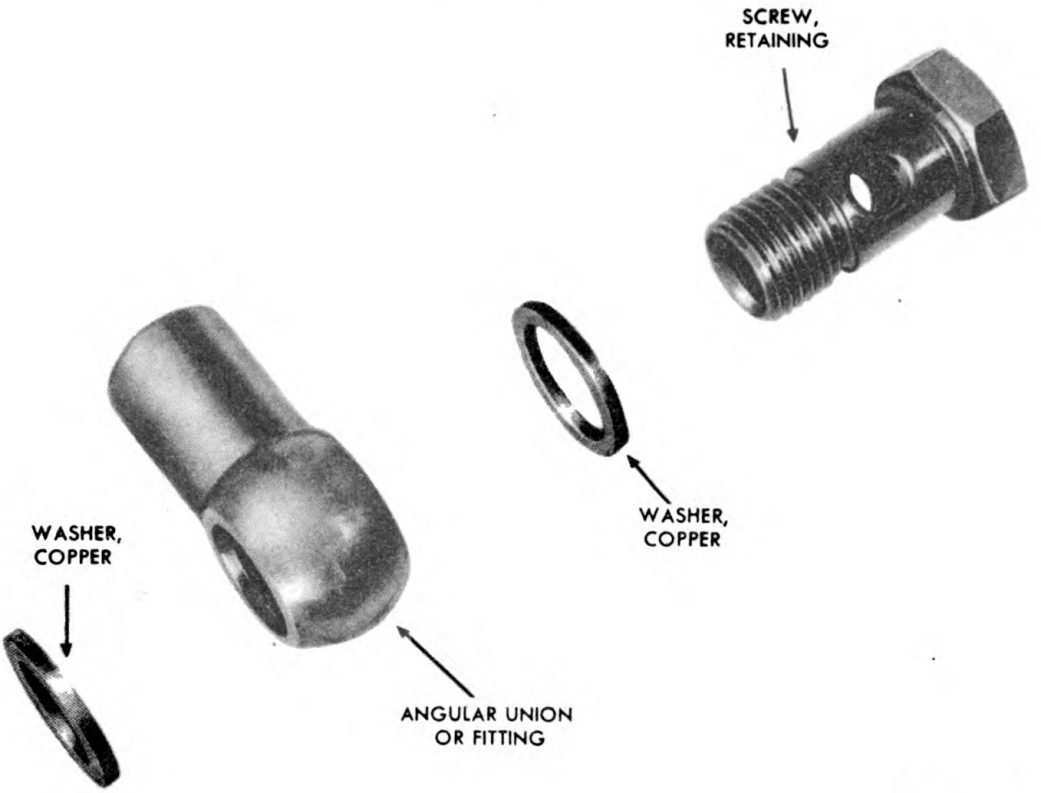


Figure 171—Fuel Pump Angular Fitting—Exploded View

a. Remove Fuel Inlet Angular Fitting.

Wrench, open-end, ¾-in.

Unscrew the fuel inlet angular fitting retaining screw from the fuel injection pump housing (fig. 165). Two copper washers, a union or fitting, and a retaining screw will also come off.

b. Remove Control Rod Stop Assembly.

Pliers Wrench, open-end, ⅞-in.

Remove the control rod stop assembly from the fuel injection pump (figs. 165 and 172). Remove the cotter pin and washer from the pivot pin in the lever and plunger. Pull out the pivot pin. Remove the plunger and spring. Pull off the special lock washer.

c. Remove Front and Rear Dust Covers.

Pliers Screwdriver

The front dust cover is removed by unscrewing four screws from the dust cover. The dust cover locating dowels can be removed with pliers. Two felt washers can be removed with the fingers. Remove the rear dust cover by removing the four retaining screws (fig. 165).

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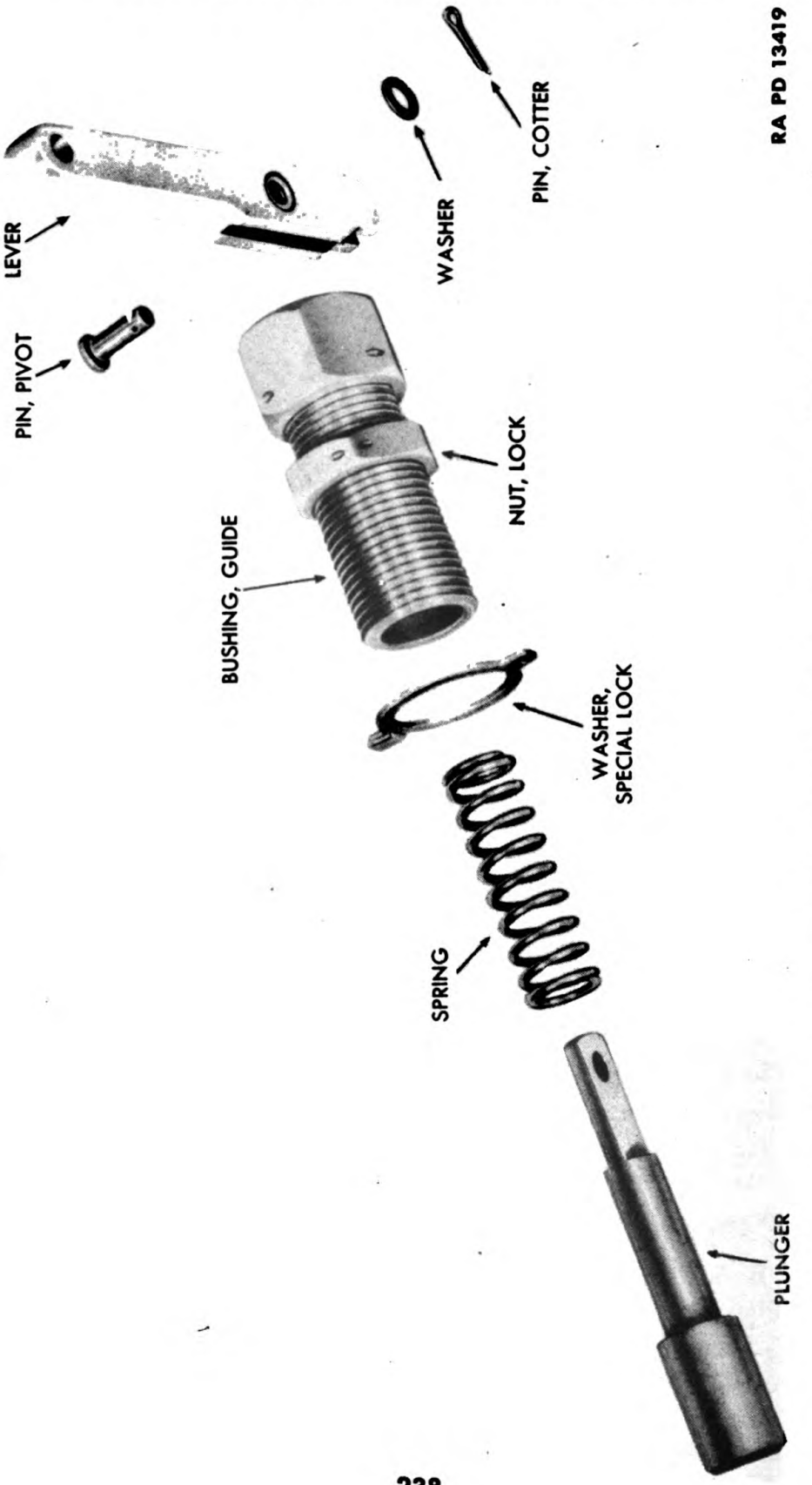


Figure 172—Fuel Pump Control Rod Stop Assembly—Exploded View

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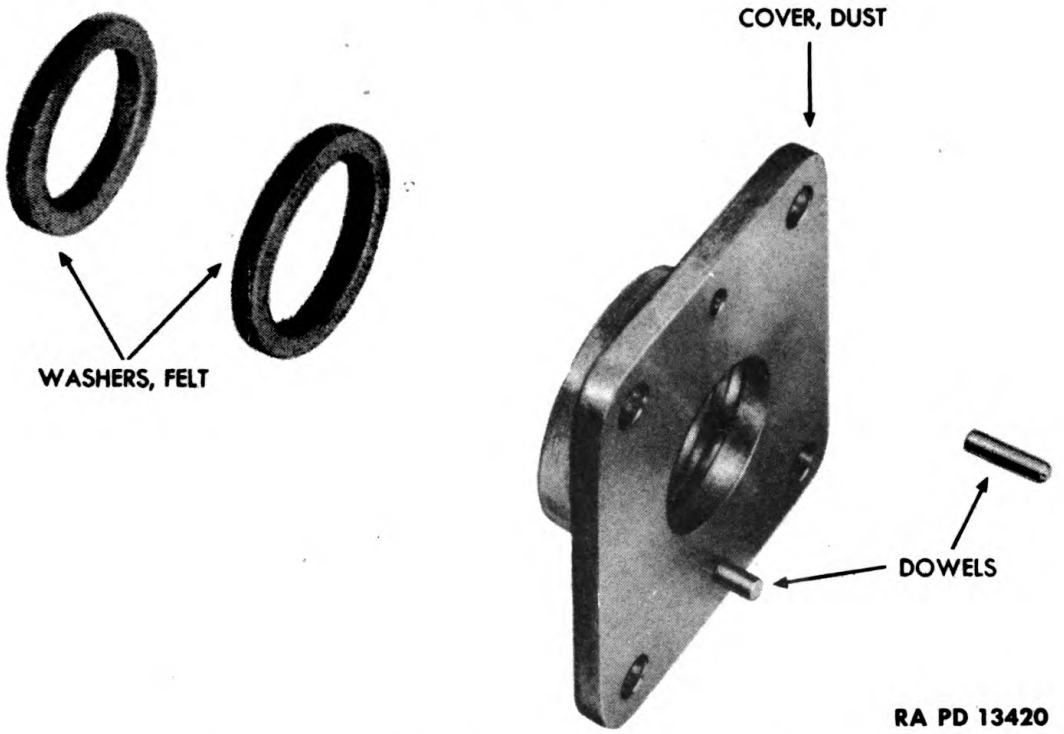


Figure 173—Fuel Pump Front Dust Cover—Exploded View

d. Remove Side Cover Plate.

Screwdriver

Remove the cover plate from the side of the fuel injection pump housing by unscrewing the two cover plate screws (fig. 174). Lift out dip stick.

e. Remove Rear End Plate.

Screwdriver

Remove the camshaft rear end plate by prying off with a screwdriver (fig. 174).

f. Remove End Cover Assembly.

Pliers, long nose
Screwdriver
Wrench, open-end, $\frac{7}{16}$-in.

Using long-nose pliers remove the governor membrane assembly (fig. 174) by reaching in the governor housing part of the end cover and removing the cotter pin from the linkage pin. Remove the linkage pin, nut and lock washer (fig. 174). Remove the end cover assembly by removing the special screw and pulling off the cover assembly.

g. Disassemble End Cover Assembly.

Pliers
Screwdriver

Loosen and remove clamp screw and lock washer from governor

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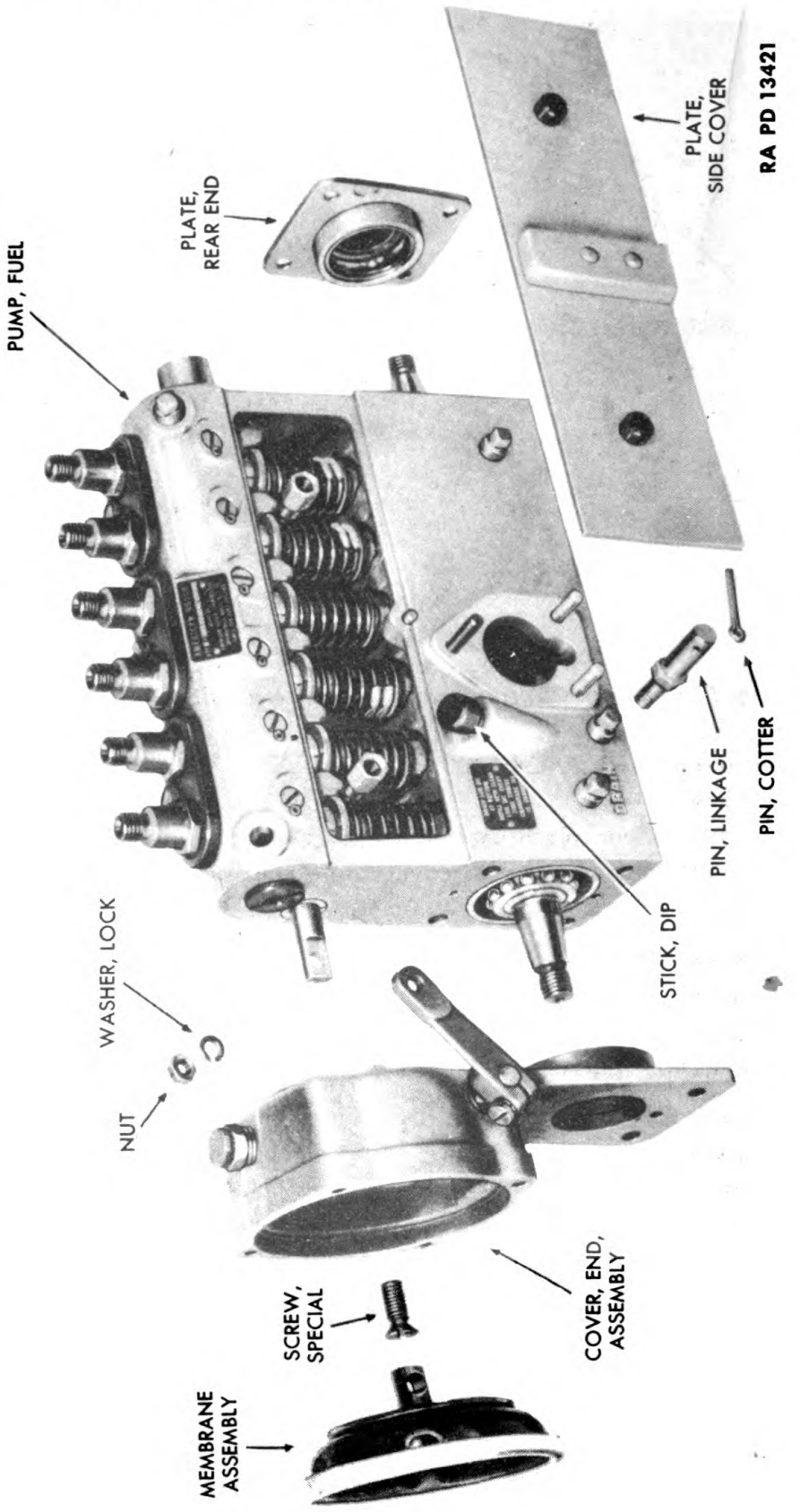


Figure 174—Fuel Pump Body—Exploded View

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operating lever and remove the lever and Woodruff key from the stop lever shaft (fig. 175). Remove the screw from the stop lever on the inside of the end cover (fig. 175). Remove the cotter pin from the stop lever shaft and pull out the shaft. Two plain washers will come off with the shaft. Lift out the bearing.

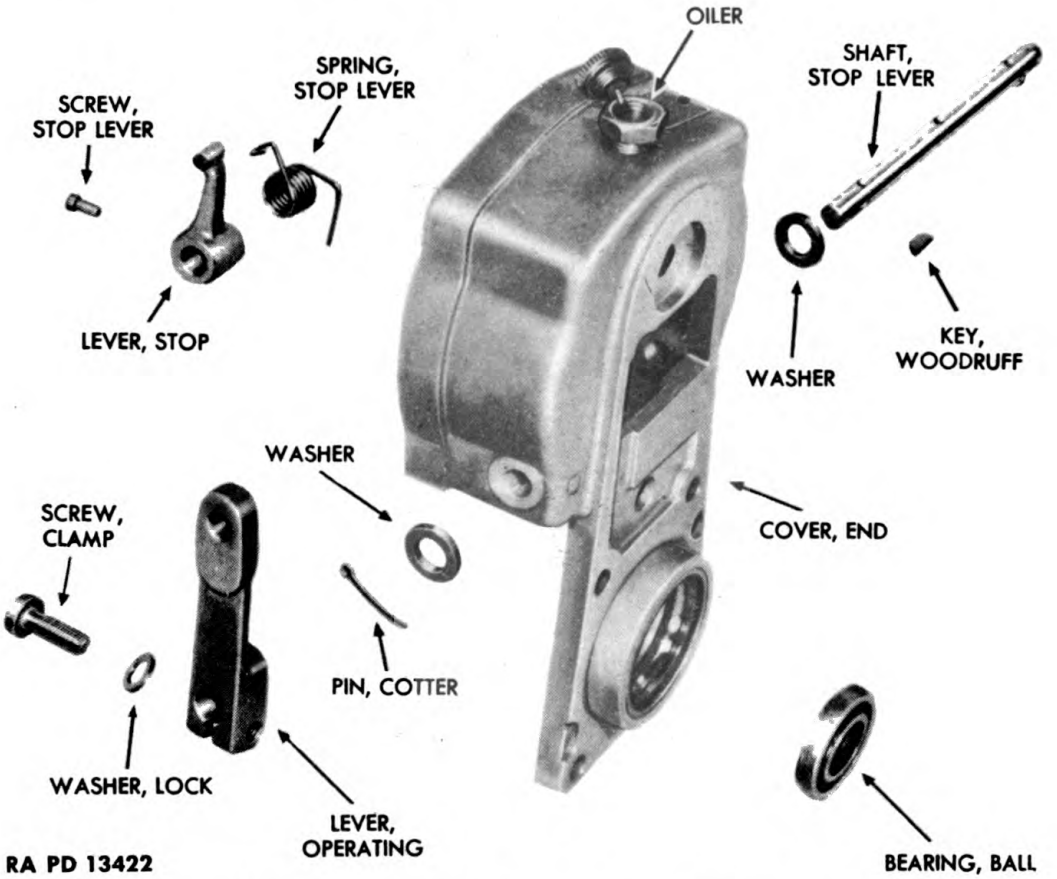


Figure 175—Fuel Pump and Cover Assembly—Exploded View

h. Remove the Camshaft.

Tool, tappet holder
Vise, with brass jaw inserts
Wrench, screwdriver socket

Rotate the fuel injection pump camshaft and when each spring in the fuel injection pump rises, place the special tappet holder tool in position as shown in figure 176. This takes the pressure of tappets off the camshaft cams. Place the fuel pump upside down in vise fitted with brass jaws. With a screwdriver attachment for a socket wrench, loosen and remove the six closing plugs from the bottom of the fuel injection pump body (fig. 177). Pull out the camshaft (fig. 178).

i. Remove the Tappet Assemblies.

Screwdriver
Tool, tappet lifting
Wrench, open-end, $\frac{7}{16}$-in.

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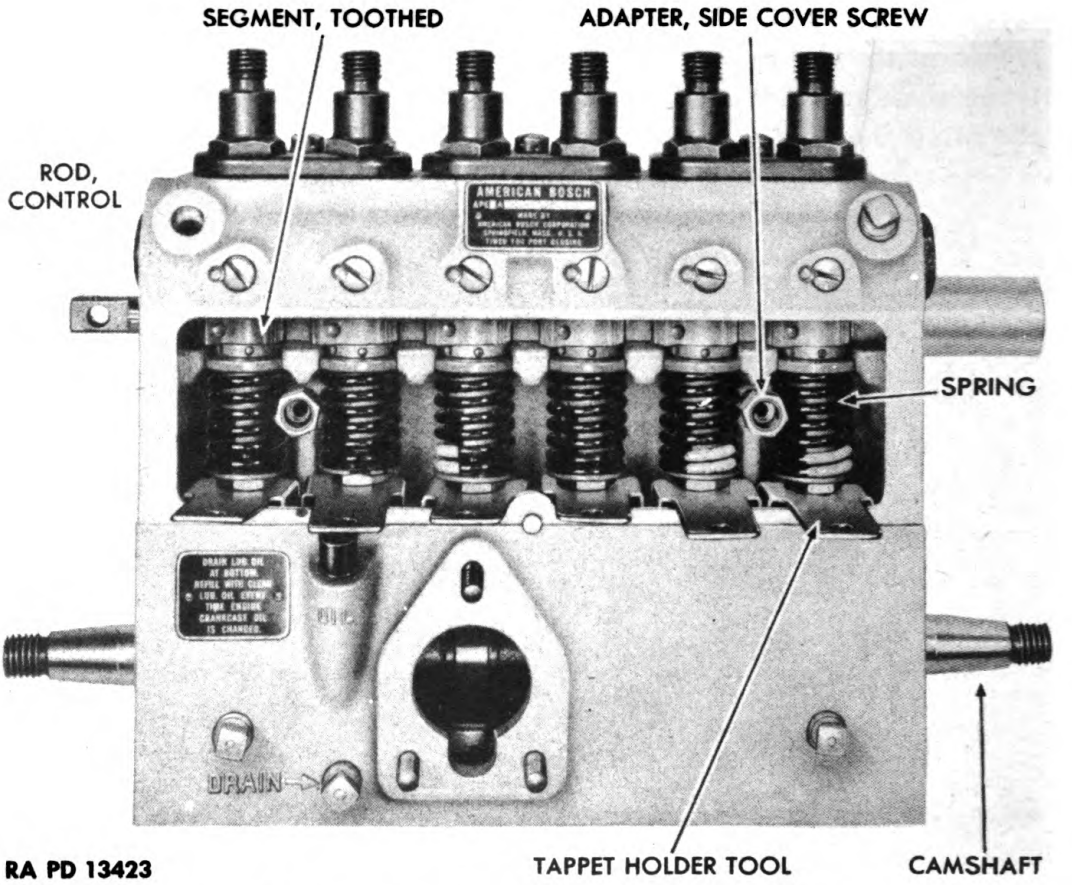


Figure 176—Fuel Pump with Tappet Holder Tools in Position

Using the special tappet lifting tool (fig. 179), lift out the tappets. Repeat the same procedure for each tappet assembly. Remove the plunger, plunger spring and upper and lower spring seats (fig. 182). Remove the two side cover screw adapters (fig. 176) ($\frac{7}{16}$-in. open-end wrench). Remove the six upper spring seats and six toothed segments from the pump housing (fig. 182). Remove the special securing screw from the back of pump housing and pull out the control rod (fig. 180).

j. Remove Delivery Valve Assemblies.

Puller, internal threaded
Screwdriver
Wrench, box, ¾-in.

Remove the three locking device securing screws (figs. 181 and 182). Lift off three locking device covers (fig. 182). Remove three locking device keys (fig. 182). Remove the six locking rings (fig. 182). Remove the six delivery valve holders (¾-in. box wrench). Springs and valves come out with the holders (fig. 182). A special internal-threaded puller must be used to pull the delivery valve seats. Thick delivery valve holder copper gasket comes with seat (fig. 182). Remove the six

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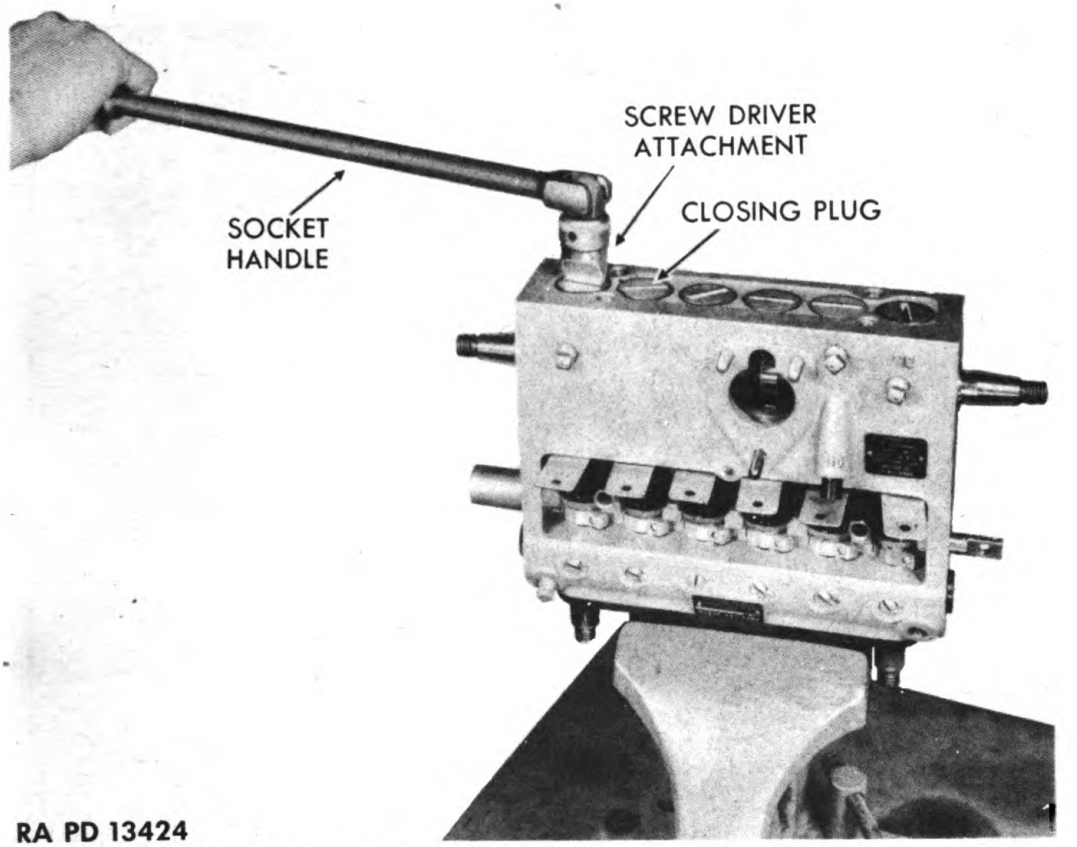


Figure 177—Removing Fuel Pump Closing Plugs

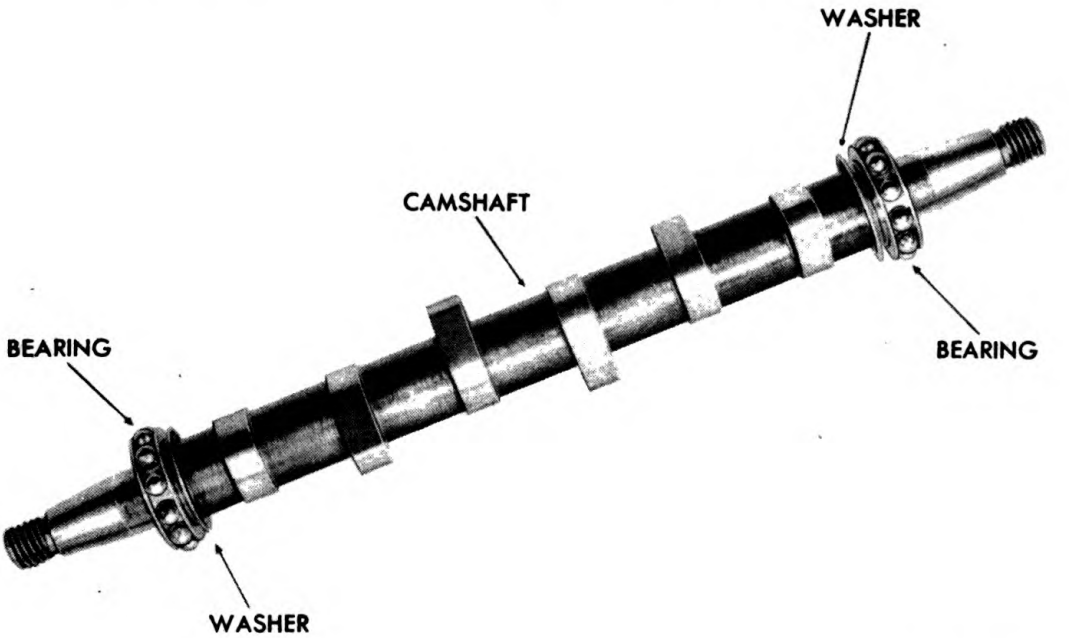


Figure 178—Fuel Pump Camshaft

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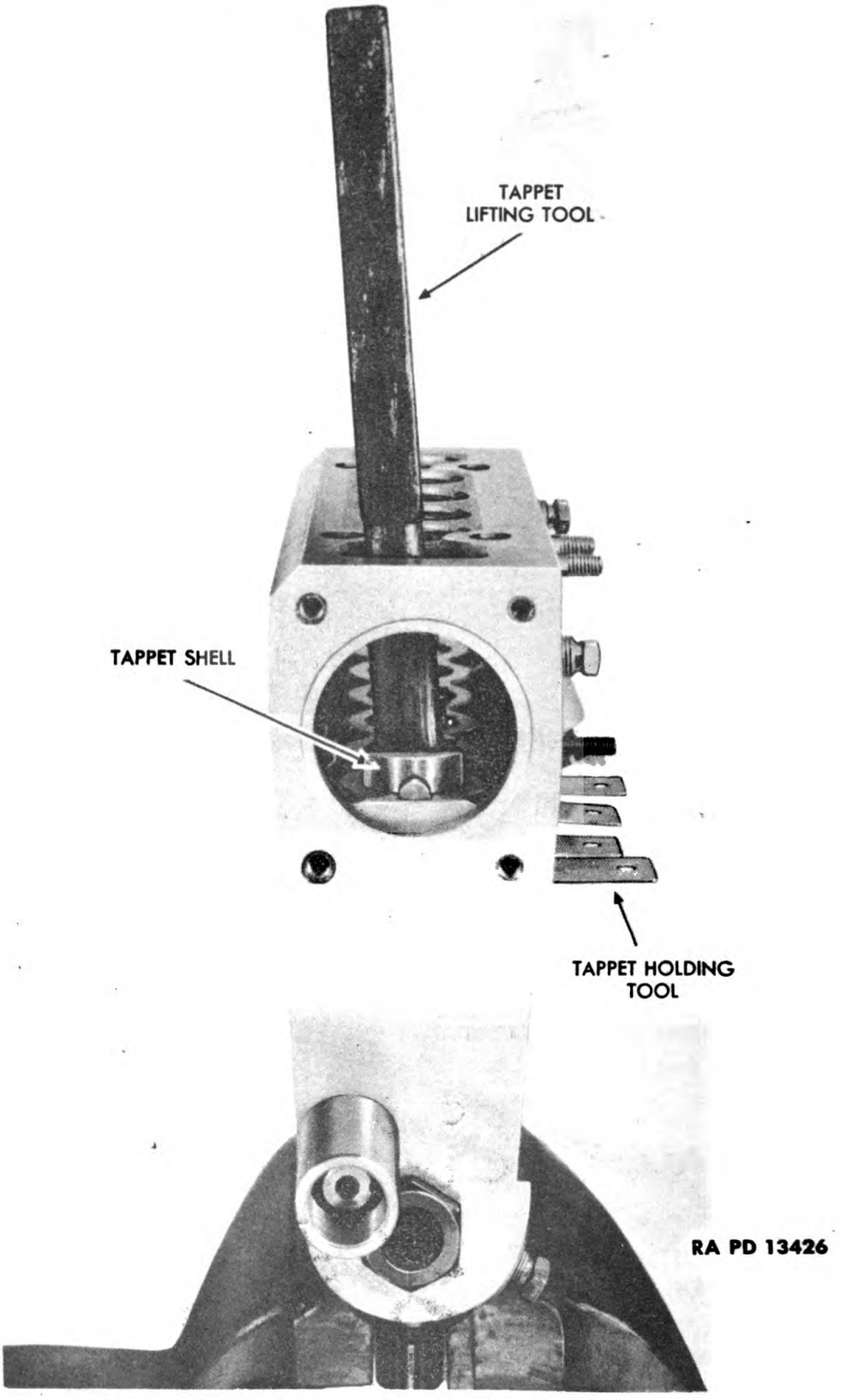


Figure 179—Removing Fuel Pump Tappets

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Figure 180—Fuel Pump Control Rod

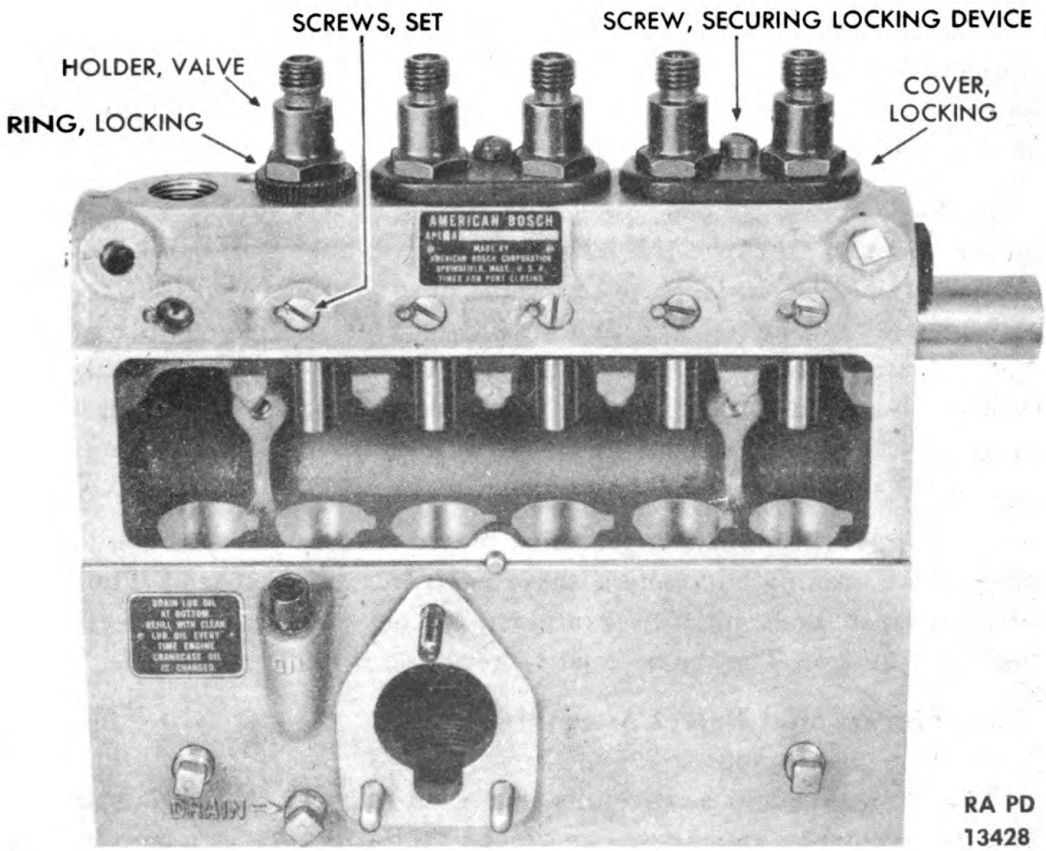


Figure 181—Removing Fuel Pump Delivery Valves

plunger barrel holding set screws. Slide the six plunger barrels (fig. 182) out of the top of the fuel pump housing.

76. INSPECTION OF FUEL INJECTION PUMP PARTS.

All parts should be carefully washed in clean fuel oil and blown dry with compressed air (free from water or dirt). Exceptionally dirty

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parts should be cleaned in SOLVENT, dry-cleaning, or paint remover. Gummy or sticky plungers should be soaked in ACETONE.

a. Housing Parts.

Reamer, line

Inspect control rod bushings in the housing. Insert the control rod and determine if wear of the bushing is excessive. Worn bushings can be pressed out and replaced. Whenever new bushings are installed, they must be line-reamed to insure proper fit with the shaft. Cracked or distorted housings must be replaced.

b. Camshaft Assembly.

Cloth, crocus

The lobes of the camshaft must be smooth and free from pit marks, scratches, rust or corrosion. If the cam lobes are not severely pitted, the surface may be polished with crocus cloth. Never use emery paper or abrasives. Inspect the threaded ends, as well as the keyway of the camshaft, for damage. Inspect the inner ball-bearing race by removing the bearing cage. Worn bearings must be replaced.

c. End Plates. Replace outer ball bearing race if worn or whenever it is necessary to exchange the inner ball bearing race and ball cage. The oil seal should be examined for possible cuts. If damaged at all, replace the oil seal or packing. The seal should be soaked for several hours in light lubricating oil to make it pliable. When pressing out the oil seal, note how it is installed in end plate so that the new seal can be installed in the same way. The new seal should be set in place with a little sealing compound.

d. Tappet Assembly. If excessive play is noticed between the tappet pins, roller bushing and rollers, these parts must be replaced. The head of the tappet screw must be examined for any wear caused by contact with the plunger. The screw must be replaced if badly damaged.

e. Plunger and Barrel Assembly.

Glass, magnifying

The plunger should be carefully inspected for wear. If the plunger has lost its mirror-like appearance and looks dull or gray, it is a sure indication that the plunger has been worn due to dirt in the fuel. The edge of the plunger helix should appear sharp under a magnifying glass and the plunger should not be nicked or scratched.

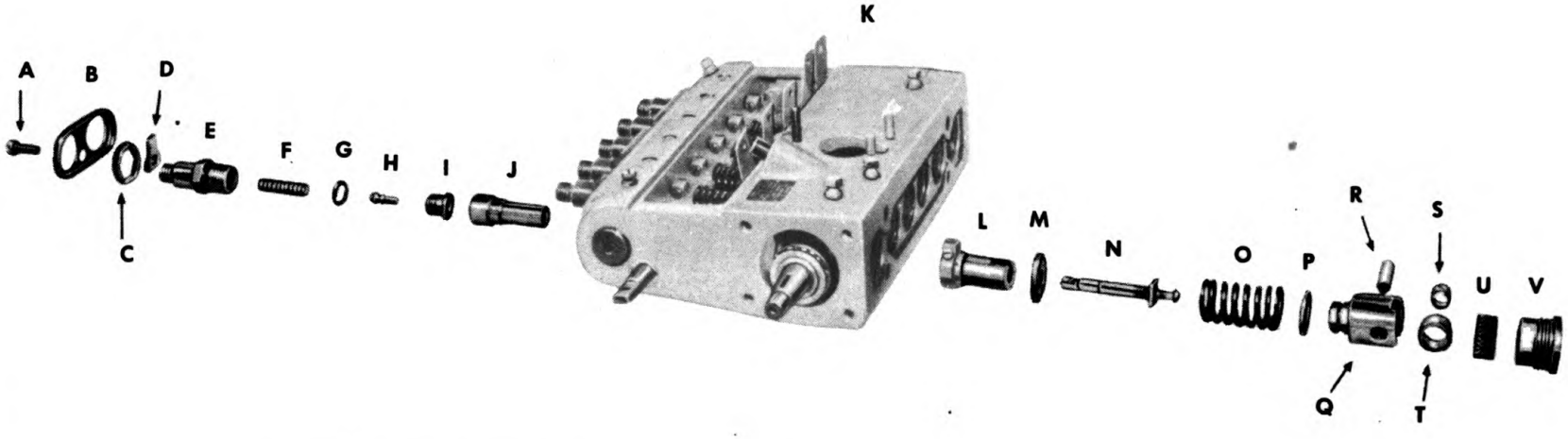
f. Delivery Valve and Seat.

Device, delivery valve checking, AEF-8258	Vise
	Wrench, open-end, ¾-in.

(1) Replace the delivery valve gasket only in an emergency. If the

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A – SCREW, LOCKING DEVICE SECURING
B – COVER, LOCKING DEVICE
C – RING, LOCKING
D – KEY, LOCKING
E – HOLDER, DELIVERY VALVE
F – SPRING, DELIVERY VALVE
G – GASKET, DELIVERY VALVE HOLDER
H – VALVE, DELIVERY
I – SEAT, DELIVERY VALVE
J – BARREL, PLUNGER
K – HOUSING, PUMP
L – SEGMENT, TOOTHED, AND CONTROL SLEEVE
M – SEAT, UPPER, SPRING
N – PLUNGER
O – SPRING, PLUNGER
P – SEAT, LOWER, SPRING
Q – TAPPET
R – PIN, TAPPET
S – BUSHING, TAPPET
T – ROLLER, TAPPET
U – PLUGS, FELT
V – PLUG, CLOSING

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Figure 182—Fuel Pump Housing Assembly—Exploded View

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gasket appears in good condition it should be re-used. After dipping the valve in clean fuel oil, it should fall freely in place in the valve seat. The bottom seating surface of the valve seat which comes in contact with the top of the plunger should be free from scratches or damage due to corrosion. The delivery valve and seat should be replaced if the valve seat appears gray or the piston on the top of the valve stem is scratched or gray.

(2) Test the fuel injection pump delivery valves for leakage.

(a) Thoroughly clean the valve and the seat in SOLVENT, dry-cleaning, or gasoline.

(b) Insert the delivery valve and seat, with gasket, in the delivery valve checking device, AEF-8258. Place the tool in a vise and tighten the delivery valve holder with a ¾-inch open-end wrench.

(c) Attach a connecting tube to the testing stand, and attach the delivery valve to the tube, using a ¾-inch open-end wrench to tighten the tube firmly to the stand and to the delivery valve.

(d) Open the valve to the pressure gage by turning the handwheel.

(e) Apply approximately 50 pounds pressure and bleed the checking device by pressing the delivery valve off its side against the spring. Release the valve as soon as fuel oil starts flowing. Blow the fuel oil from the free end of the checking device with compressed air.

(f) Operate the hand lever slowly until the pressure gage indicates 1,425 pounds. No fuel oil should escape from the free end of the delivery valve checking device, and the pointer of the gage should remain steady at the set pressure.

(g) Repeat the previous operation at 2,850 pounds pressure.

(h) Repeat the operation at 4,250 pounds pressure. Delivery valves which do not withstand these tests without leaking should be replaced.

g. Control Sleeve and Toothed Segment. The setting of these parts should not be altered unless either of the parts has to be replaced. The scratch marks on the control sleeve and on the toothed segment should line up. If the teeth on the toothed segment are damaged, the part must be replaced. Replace the control sleeve of the plunger if guide slots are badly worn.

h. Plunger Spring and Spring Seats. Plunger spring should be free of scratches or pitting which would in any way affect the strength of the spring. Spring seats must not be distorted or badly worn.

i. Barrel Set Screw and Gasket. It is advisable that the barrel set screw and gasket be replaced when assembling the pump.

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j. Closing Plugs and Felt Cushion. The felt cushions should be removed from the plugs and thoroughly washed. If the cushions are badly worn, they should be replaced.

k. Delivery Valve Holder and Spring. The holder should be inspected for damaged threads. The spring must be free from scratches and pitting.

l. Pipe Plugs. Any plugs or fittings which are damaged in any way should be replaced.

77. ASSEMBLY OF FUEL INJECTION PUMP AND GOVERNOR ASSEMBLY.

Drift, soft metal
Hammer
Hammer, fiber
Pliers
Pliers, long-nosed
Punch, small
Screwdriver
Screwdriver, small
Screwdriver, wide blade
Tool, tappet lifting
Vise, with brass jaws
Wrench, box, 3/4-in.
Wrench, open-end, 3/8-in.
Wrench, open-end, 7/16-in.
Wrench, open-end, 1/2-in.
Wrench, open-end, 9/16-in.
Wrench, open-end, 11/16-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 7/8-in.
Wrench, screwdriver socket

a. Install Delivery Valve Assemblies.

Screwdriver
Wrench, box, 3/4-in.

Install the six plunger barrels in the pump housing (fig. 181). Put them in through the top. Lock in position by installing set screws (fig. 181). Replace holder gasket around the delivery valve seat and insert the seat in position on top of the plunger barrel. Install the delivery valve and spring. Install the delivery valve holder and tighten with a 3/4-inch box wrench (fig. 182). NOTE: The delivery valve and its valve seat must always be kept together as a pair. Make sure also that the ground and lapped surface at the lower end of the valve seat is absolutely clean. Repeat the same operations for all delivery valves that have been removed. Install the six delivery valve holder locking rings and the three locking device keys and covers. Secure in place with the securing screws (figs. 181 and 182).

b. Install Tappet Assemblies. (fig. 176).

Screwdriver
Tool, tappet lifting
Wrench, open-end, 7/16-in.

Insert the control rod (figs. 176 and 180) and install the securing screw in the back of the pump housing. Place the six upper spring seats and six toothed segments in the housing (fig. 182), and insert the two

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side cover screw adapters (fig. 176). Install springs, keepers and plungers (fig. 182). With the tappet-lifting tool, insert the tappets under the spring seats (figs. 176 and 179).

c. Install the Camshaft.

Screwdriver
Wrench, screwdriver socket
Vise, with brass jaws

Place fuel pump housing top side down in a vise. Install the camshaft in the housing and install the closing plugs and felts in the bottom of the pump housing (figs. 177 and 182). Rotate the fuel injection pump camshaft, and when each spring in the fuel pump raises, remove the tappet holder tool.

d. Assemble the End Cover Assembly.

Pliers
Screwdriver
Pliers, long nosed
Wrench, open-end, $\frac{7}{16}$-in.

Insert the stop lever shaft in the end cover (fig. 175). Install a plain washer on each end of the shaft, outside of the cover, the stop lever secured on the shaft inside the cover with its retaining screw and the stop lever spring in position. Insert the cotter pin in the shaft. Install the Woodruff key in the shaft and the operating lever on the outside end of the shaft. Secure the lever in position with the clamp screw and lock washer. Place the end cover assembly in position on the pump housing and secure with the special retaining screw (fig. 174). Insert the linkage pin through the governor membrane and control rod. Install the linkage pin nut and washer. Install the linkage pin cotter pin. Place the dip stick in position in the side of the housing. Secure the side cover plate to the pump housing with the two cover plate screws.

e. Install Covers and Plate.

Pliers
Screwdriver

Place the camshaft rear bearing cover end plate in position on the pump housing (fig. 174). Fasten the rear dust cover to the housing with four retaining screws (fig. 173). Place two new felt washers in the front dust cover (fig. 167). Insert the cover locating dowels and secure the front dust cover to the housing with four retaining screws.

f. Install Control Rod Stop Assembly.

Pliers
Wrench, open-end, $\frac{7}{8}$-in.

Place the plunger and spring in position in the guide bushing and attach the lever to the plunger by inserting the pivot pin. Put the washer on the pin and secure with a cotter pin (fig. 172). Put the special lock washer back on the guide bushing and secure the control rod stop assembly to the fuel pump (fig. 165).

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FUEL SYSTEM

g. Install Fuel Inlet Angular Fitting.

Wrench, open-end, 3/4-in.

Place a copper washer on the retaining screw, insert the retaining screw in the fitting and put on another copper washer (fig. 171). Screw the retaining screw into the pump housing (fig. 165)

h. Install Check Valve.

Wrench, open-end, 9/16-in.
Wrench, open-end, 3/4-in.

Place the check valve and valve spring in the retaining screw (fig. 170) and install valve screw. Place a copper washer on the retaining screw and insert in the union. Place the other copper washer on the retaining screw and install the adapter. Attach the fuel pump check valve assembly to the fuel pump (fig. 165).

i. Install Governor Housing.

Screwdriver
Screwdriver, small
Wrench, open-end, 11/16-in.

Secure the adjusting screw into the adjusting screw bushing (fig. 169). Place the idling spring and idling control pin in position in the adjusting screw bushing. Place the end cap in position over the end of the adjusting screw and secure with a flat washer and nut. Put the stop ring on the adjusting screw and secure in place with the snap spring. Secure the end cap assembly in position on the governor housing. Install the governor housing and spring in position on the fuel pump end cover (fig. 165).

j. Install Fuel Transfer Pump.

Hammer
Pliers
Punch, small
Screwdriver
Screwdriver, wide blade
Wrench, open-end, 3/8-in.
Wrench, open-end, 3/4-in.
Wrench, open-end, 15/16-in.

Install the spring and plunger in the lever support and fasten with the snap ring (fig. 168). Screw the lever support into the transfer pump body (15/16-in. open-end wrench). Install the tappet and roller, spring and spindle. Secure the tappet and tappet roller in place in the body with the small pin (fig. 168). Push the shaft and spring into the plunger body and install the snap ring. Attach the priming handle and links with the pivot pin, flat washer and cotter pin (fig. 168). Install the two valve spring retaining screws, springs and fiber valves in the top of the fuel transfer body (fig. 168) (3/4-in. open-end wrench). Install the inlet screen in the inlet screw (fig. 168). Use a wide blade screwdriver to get it in as far as it should go. Install the fitting screws and two copper washers in position and attach the fuel inlet and outlet fittings to the

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transfer pump (fig. 168) (¾-in. open-end wrench). Place a new gasket in position and attach the fuel transfer pump assembly to the fuel injection pump with three lock washers and nuts (fig. 165) (⅜-in. open-end wrench).

k. Install the Drive Coupling.

Hammer, fiber
Pliers
Wrench, open-end, ½-in.
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, ¾-in.

Install the coupling shaft ball end in the coupling flanged shaft (fig. 166). Place the two spring steel coupling disks and spacers in position on the flanged shaft and secure with the hub flange screws, castle nuts and cotter pins (fig. 166). Place the Woodruff key in the fuel pump shaft and drive the rear hub onto the shaft. Secure with a lock washer and nut (fig. 166). Attach the coupling flanged shaft to the rear hub with two coupling screws, castle nuts and cotter pins (fig. 166). Attach the bracket to the bottom of the fuel pump with four cap screws, lock washers and plain washers.

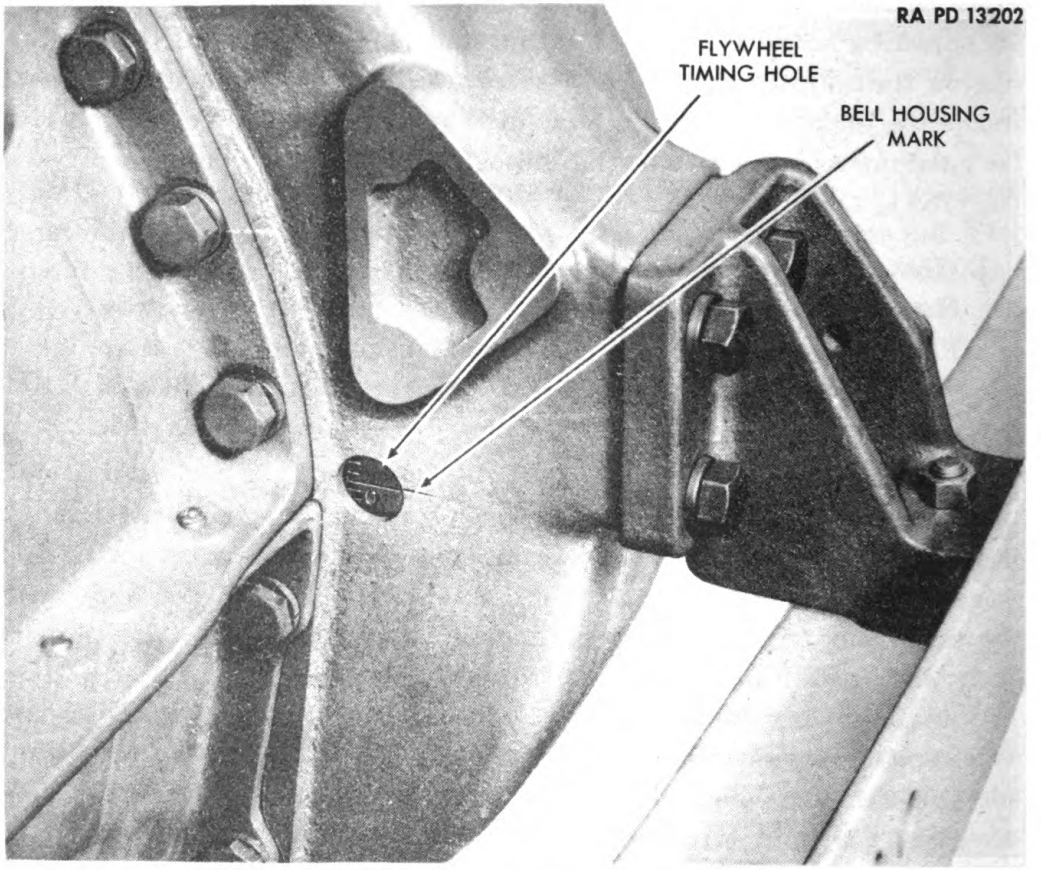


Figure 183—Timing Hole in Bell Housing

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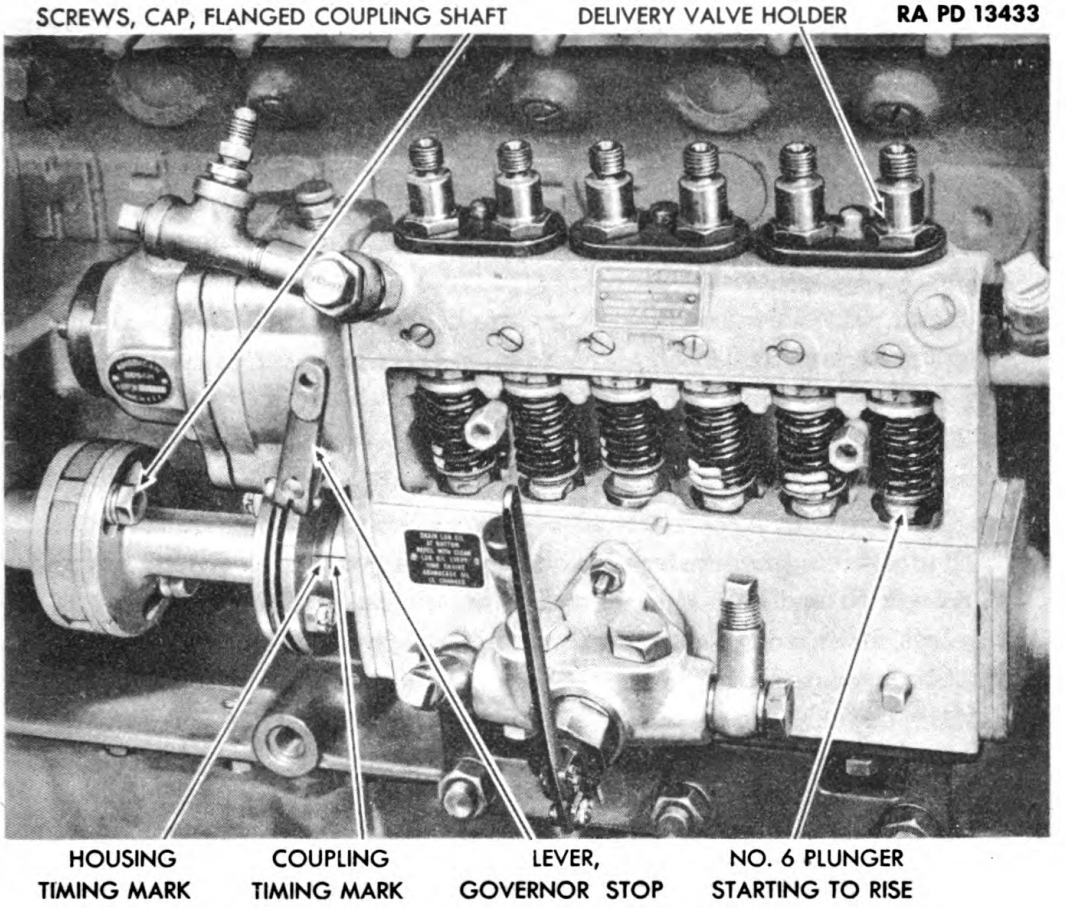


Figure 184—Mounting and Timing Fuel Injection Pump

78. INSTALLATION OF FUEL INJECTION PUMP.

Wrench, open-end, ¾-in.

Position the pump and bracket on the three studs in the side of the engine case, with the two collar dowels on the outside studs halfway in the case and in the pump bracket (fig. 164). Install lock washers and nuts on these studs. Connect the leak-off manifold at the pump union (fig. 90); attach the fuel pump fuel lines at the barrels at the top of the fuel pump; then install the lower connection of the governor vacuum line to the fuel pump (fig. 87).

79. TIMING FUEL INJECTION PUMP.

Chisel, light
Hammer
Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.

a. Loosen the four cap screws which hold the pump on the pump bracket.

b. Slide the pump back and forth until a position is obtained which does not bind the floating member of the coupling, yet does not give it too much end play.

c. Tighten the fuel pump in place on the bracket.

d. Rotate flywheel by means of the hand crank until "DC" mark

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appears in timing hole in front of the bell housing. Be sure that No. 6 piston is just completing the compression stroke and starting on the expansion stroke. This can be determined by removing No. 6 nozzle and placing the thumb or finger over the nozzle opening in the engine and feeling the pressure. The point of greatest pressure indicates when the compression stroke is ended.

e. Next, rotate the crankshaft counterclockwise until the graduation marked 24 degrees is directly in line with the mark in the center of the timing hole in the bell housing (fig. 183).

f. The crankshaft is then spotted at 24 degrees before top dead center—the point at which the fuel injection pump is set for port closing.

g. The front of the flywheel is marked with a line "DC" (dead center) and from this line are graduations designating degrees of crankshaft travel. From "DC" these graduation lines are marked 5 degrees—10 degrees, then every 2 degrees up to 30 degrees. They are numbered every 10 degrees.

h. Remove inspection cover plate from the side of the fuel pump. Rotate fuel pump coupling on the fuel pump until No. 6 plunger spring begins to rise. Now line up the heavy marking on the fuel pump coupling with the heavy marking on the fuel pump hub (fig. 184).

i. Install cap screws with lock washers and plain washers in the adjusting slots in the front end of the flanged coupling shaft (figs. 166 and 184). Plain washers are installed next to the flange. Tighten the cap screws.

j. Spotting the Flywheel. There may be times when it is necessary to install and time a new fuel pump and coupling without the timing marks on the coupling. This is done by what is known as the flow method. This procedure follows:

(1) Rotate flywheel by means of hand crank until "DC" mark appears in timing hole in bell housing. Be sure No. 6 piston is just completing the compression stroke and beginning the expansion which can be determined by observing that the No. 1 cylinder exhaust valve is nearly closed.

(2) Rotate engine counterclockwise until the graduation marked 24 degrees is directly in line with the mark in the center of the timing hole in the bell housing. This will then have the crankshaft spotted at 24 degrees before top center, at which point the fuel pump is set for port closing.

(3) Install pump assembly, tightening all attaching screws but leaving the rear half of coupling loose from front half so pump shaft can be rotated while the drive shaft remains stationary.

(4) Connect all fuel suction and discharge pipes from fuel tank to pump. Install all fuel lines except to No. 6 cylinder.

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(5) With governor stop lever in wide-open or full-load position, prime the pump.

(6) Put governor stop lever in "stop" position and remove pump delivery valve holder from No. 6 pumping unit. Remove delivery valve and spring but not the seat. Replace delivery valve holder finger tight (fig. 184).

(7) Put governor stop lever in wide-open or full-load position. Fuel now should rush out of the delivery valve holder. Rotate pump shaft toward the engine by means of the rear half of coupling until fuel flow stops. If fuel did not flow when governor stop lever was first opened, rotate shaft until it does, then back to where it is just off. Use hand-priming pump to keep fuel pump manifold supplied with oil.

(8) Very carefully rotate shaft until fuel barely flows, then back to point where flow is barely shut off. Repeat this two or three times until a movement of less than $\frac{1}{64}$ inch on the circumference of the coupling is the difference between fuel flowing and not flowing. This determines where the pump plunger just closes the fuel port and begins the period of building up pressure in the lines and nozzles so that injection can start. This adjustment must be extremely accurate.

(9) Connect the front and rear half of the coupling together with cap screws. Be sure these screws are tight so no slippage can occur yet do not strip the threads. It is not advisable to use a wrench over 6 inches long for tightening. Also observe if any slight movement, which might occur while tightening the screws, has started the fuel flowing again from the delivery valve holder. When these screws are tight, no fuel should flow. The fuel pump is now timed to close the ports at 24 degrees before top center.

(10) Put governor stop lever in "stop" position again. Remove delivery valve holder and install the delivery valve and spring. Install delivery valve holder, tightening firmly. Be careful not to get any dirt, water, or any other foreign matter in or on any of these parts. Do not tighten so tightly as to distort fuel pump case.

(11) Connect No. 6 cylinder fuel line to pump. Prime fuel lines, being sure the fuel pump, strainer and all lines are full of fuel without air.

(12) Start engine. If after checking all points, engine operation is rough, stop engine and recheck timing.

(13) After engine is operating smoothly and has been properly warmed up, stop the engine.

(14) With light chisel and hammer, enlarge the single mark on the front hub and put a corresponding mark on the other hub so these two parts can be lined up together at any future time without the necessity of flowing the pump.

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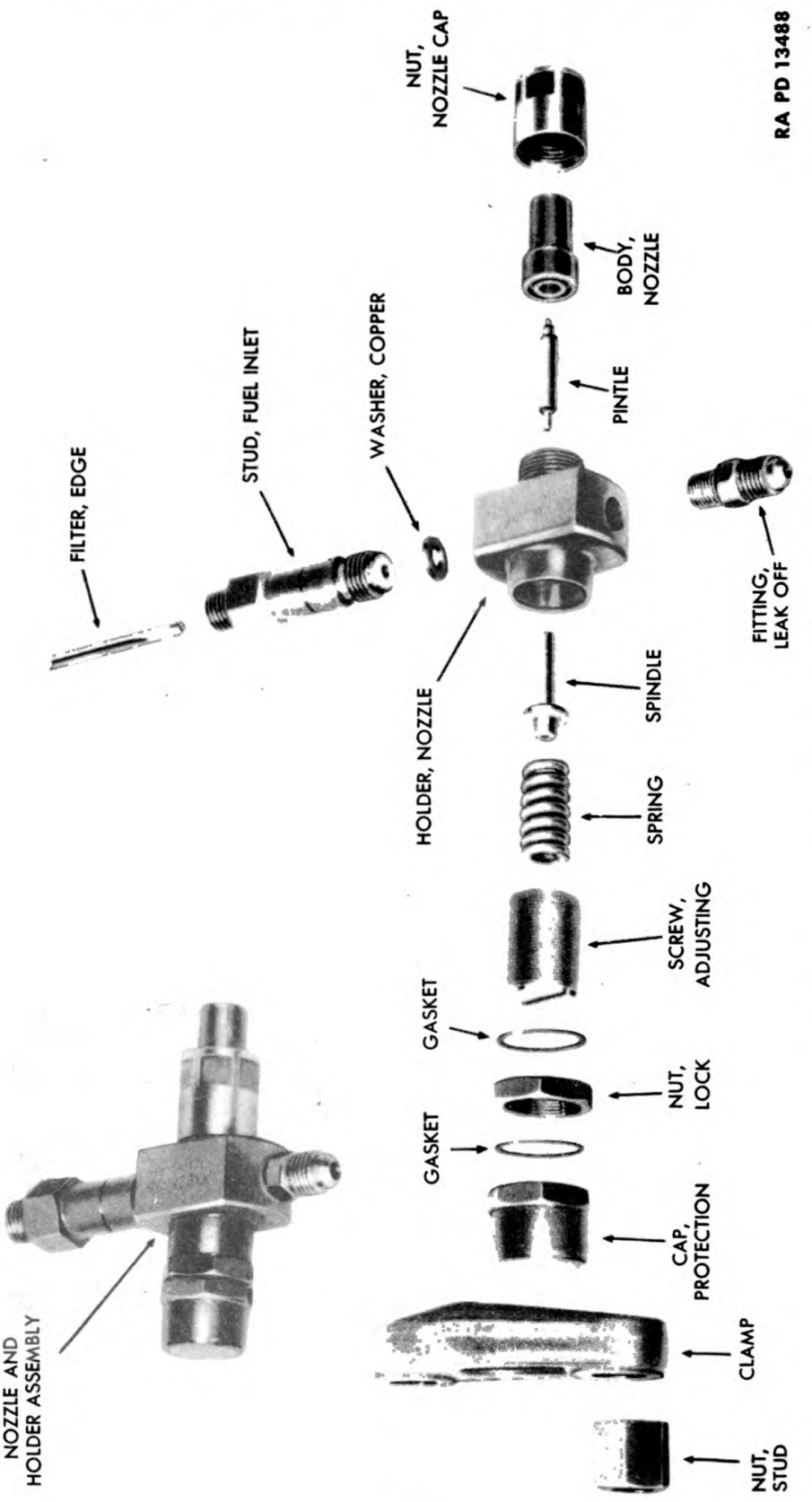


Figure 185—Fuel Nozzle and Holder Assembly—Exploded View

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FUEL SYSTEM

80. FUEL NOZZLE AND HOLDER ASSEMBLY.

a. Description. A fuel nozzle and holder assembly is provided at each cylinder to inject the fuel, forced under pressure from the injection pump, into the combustion chamber.

(1) CONSTRUCTION. The fuel nozzle and holder assembly consists of the parts shown in figure 185. The fuel nozzle body and pintle are not interchangeable with similar parts of other assemblies and should be used as pairs as originally furnished.

(2) FUNCTIONING (fig. 185). Fuel is pumped to the nozzle from the fuel injection pump through an inlet tube and an edge filter. A spring in the nozzle holder holds the pintle against its seat in the nozzle until sufficient pressure is built up to overcome the force of the spring and move the pintle back off its seat. This permits the injection of the fuel through the nozzle into the combustion chamber. With the release of the fuel, the pressure drops and the spring once more holds the pintle against the seat, shutting off the fuel injection.

b. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) FUEL KNOCK.	
Dirty injector nozzle.	Remove and clean.
Nozzle valve sticking.	Remove and clean.
Nozzle spring broken.	Replace complete holder.
Improper nozzle spring adjustment.	Adjust to 1,650 lbs per sq. in. pressure.
(2) EXCESSIVE SMOKE IN EXHAUST.	
Dirty injector nozzles.	Remove and clean.
(3) ENGINE MISSING.	
Sticking nozzle valve stem.	Remove and clean.
Dirty injector nozzles.	Remove and clean.
(4) LOSS OF POWER.	
Dirty injector nozzles.	Remove and clean.

c. Removal of Fuel Nozzle.

Screwdriver
Wrench, open-end, $\frac{9}{16}$-in.
Wrench, open-end, $\frac{11}{16}$-in.

Disconnect the fuel pump fuel line at the fuel injector nozzle by loosening the nut which holds the line to the injector nozzle (fig. 90). Disconnect the leak-off manifold from the injector nozzle by loosening the union nut which holds the manifold to the injector nozzle (fig. 90). Remove the nozzle clamp stud nuts which hold the nozzle holder and remove the nozzle holder and nozzle assembly. If the engine has been in operation for a considerable length of time, it may be necessary to pry out the nozzle holder with a screwdriver, due to carbon deposits.

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ORDNANCE MAINTENANCE—DIESEL POWER PLANT FOR SCOUT CAR M3A1 (HERCULES DJXD ENGINE)

81. DISASSEMBLY OF FUEL NOZZLE AND HOLDER ASSEMBLY (fig. 185).

Hammer
Punch
Vise
Wrench, open-end, $\frac{7}{16}$-in.
Wrench, open-end, $\frac{11}{16}$-in.
Wrench, open-end, 3/4-in.
Wrench, open end, 7/8-in.

Clamp the flat sides of the fuel nozzle holder assembly in a vise. Unscrew the nozzle cap nut (3/4-in. open-end wrench). Lift out the nozzle body and pintle (fig. 185). NOTE: The pintle is inside the nozzle body. *All pintles must be kept with their respective nozzle bodies, as they are not interchangeable.* Each pintle and nozzle body set is, however, interchangeable with any of the other sets. Remove the brass leak-off fitting (fig. 184) ($\frac{7}{16}$-in. open-end wrench). Reverse the position of the nozzle holder in the vise. Remove adjusting screw protection cap, nut and copper gasket (fig. 185) (7/8-in. open-end wrench). Loosen the lock nut on the adjusting screw (7/8-in. open-end wrench). Unscrew and remove the adjusting screw with lock nut and copper gasket (fig. 185). Lift out the spring and spindle from the nozzle holder (fig. 185). Remove the fuel inlet filter stud and copper washer (fig. 185) ($\frac{11}{16}$-in. open-end wrench). Drive edge filter from fuel inlet stud, using punch.

82. FUEL NOZZLE AND HOLDER MAINTENANCE AND REPAIRS.

a. Cleaning. The most important part of spray nozzle cleaning, testing, and examination is *cleanliness.*

(1) Spread clean paper on a workbench and have available a clean dish or open container of clean fuel oil or kerosene (approximately one pint). Also have a supply of soft (not fluffy), dry, clean, wiping cloths, a clean squirt can of clean lubricating oil or a jar of vaseline.

(2) Spray nozzles should be cleaned by first soaking them in kerosene or clean fuel oil to soften the dirt. The interior of the body can be cleaned with a small strip of wood dipped in the cleaning oil, and the spray hole with a pointed piece of wood. The nozzle valve should be rubbed with a clean oil-soaked soft rag (but not fluffy). Hard or sharp tools, emery paper, crocus cloth, grinding powder or abrasive of any kind should never be used.

(3) Before assembling, wash and rinse all parts carefully and have them perfectly clean. Smear them with good clean lubricating oil or vaseline so that the valve revolves freely.

b. Testing Spray Nozzles. Testing can be done on a hand-operated testing unit, or by running the engine, with the spray nozzle to be tested

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attached to the fuel delivery pipe, but not installed in the engine. Occasionally set the throttle in full load position momentarily, while observing the spray and possible leakage.

(1) The spray should be an 8-degree included angle and should be smooth and even. Unevenness or roughness of the stream indicates a dirty nozzle hole and pintle, which must be polished with a pointed stick and soft cloth.

(2) A dribble of oil out of the nozzle, after the spray is completed, indicates a dirty nozzle hole and pintle, which should be polished as above.

(3) CAUTION: Care must be observed in rotation of the engine with the injectors removed as fuel oil is ejected under extremely high pressure from the injectors. The fuel spray at short range will damage the skin and it is likely to cause a dry gangrenous infection.

c. Nozzle Pressure Adjustment. Fuel nozzles should be set for 1,650 pounds per square inch pressure on a fuel nozzle testing fixture. However, no adjustment is required if this pressure has dropped only to 1,600 pounds.

(1) To adjust the pressure, remove the cap nut, loosen the lock nut and turn the adjusting screw in the fuel nozzle holder.

(2) WARNING: Never attempt to adjust pressure without the proper testing fixtures.

(3) Every 1,000 operating hours or 25,000 miles, the fuel injector nozzles should be cleaned, inspected and tested for opening pressure.

83. ASSEMBLY OF FUEL NOZZLE AND HOLDER ASSEMBLY (fig. 185).

Screwdriver	Wrench, open-end, $\frac{11}{16}$-in.
Vise	Wrench, open-end, $\frac{3}{4}$-in.
Wrench, open-end, $\frac{7}{16}$-in.	Wrench, open-end, $\frac{7}{8}$-in.

Clamp the fuel inlet stud in a vise so that the end that goes into the nozzle holder is down. Drive in the edge filter. Put a new copper washer on the holder end of the stud and screw stud in the nozzle holder (fig. 185) ($\frac{11}{16}$-in. open-end wrench). Clamp the nozzle holder in the vise with the fuel nozzle opening down. Place spindle and spring in position in the nozzle holder (fig. 185). Screw the adjusting screw in place loosely. Put on a new copper gasket and screw on the lock nut. Tighten the lock nut ($\frac{7}{8}$-in. open-end wrench). Put on another new copper gasket next to the lock nut and screw the protection cap in place (fig. 185) ($\frac{7}{8}$-in. open-end wrench). Change the nozzle holder position in the vise so that the fuel nozzle opening is *up*. Screw the brass leak-off fitting in position on the holder ($\frac{7}{16}$-in. open-end wrench). Put the nozzle body and pintle in position in the holder and screw the nozzle cap nut in place ($\frac{3}{4}$-in. open-end wrench).

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84. INSTALLATION OF FUEL NOZZLE AND HOLDER ASSEMBLY.

Wrench, open-end, $\frac{9}{16}$-in. Wrench, open-end, $\frac{11}{16}$-in.

Insert the fuel nozzle in the nozzle opening in the side of the engine. The nozzle will shoulder against the copper seal in the engine nozzle opening. Place the nozzle clamp in position and secure in place loosely by screwing the clamp stud nuts on by hand. Install the fuel pump fuel line on the nozzle (fig. 90). Tighten the clamp stud nuts on the nozzle clamp. Install the leak-off manifold connection on the nozzle (fig. 90).

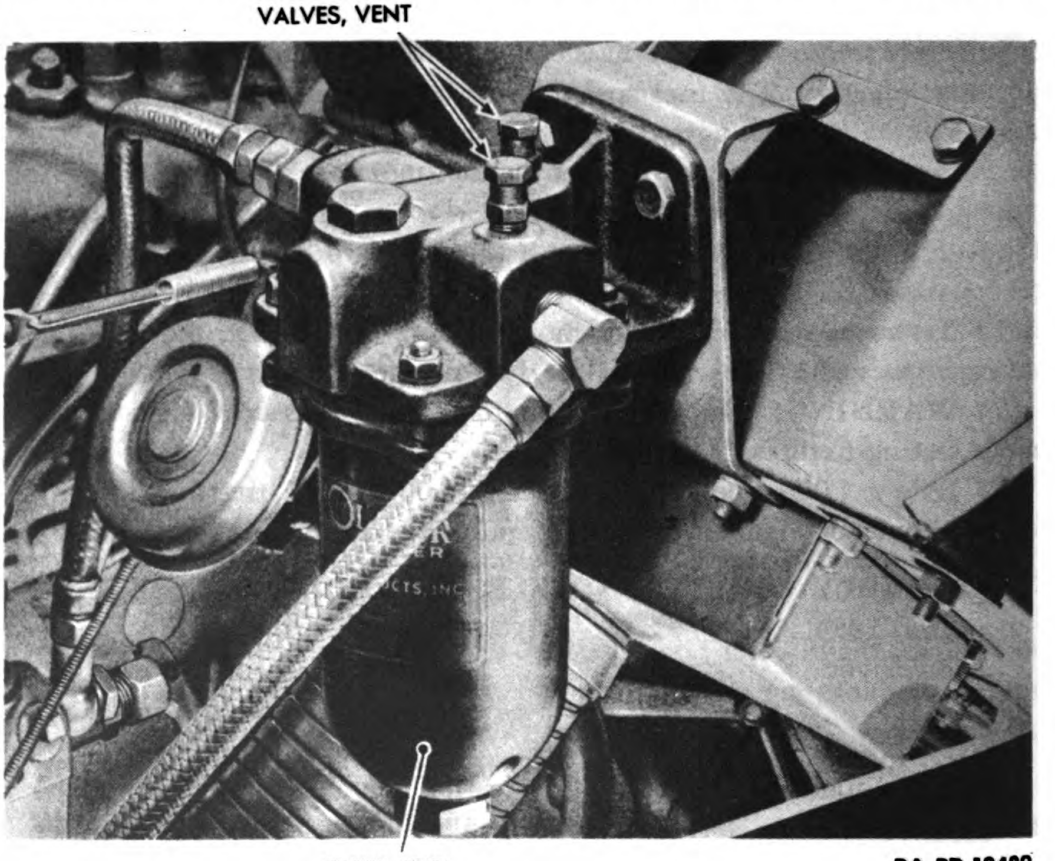


Figure 186—Final Stage Fuel Filter—Installed

85. FUEL FILTERS.

a. Description. Because of the extremely accurate construction of the various parts of the fuel injection system, a thorough filtering system is used which will reduce the wear on the accurately fitted parts of the injection system. Three filters are provided.

b. Construction and Functioning.

(1) A special metal and cloth filter, the primary filter, is located between the fuel tank and the fuel transfer pump. This unit removes the larger particles of dirt and water.

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(2) A smaller metal and cloth combination final stage filter is installed between the fuel transfer pump and the fuel injection pump.

(3) Each fuel nozzle has a stem filter as a final protection against impurities (fig. 185).

c. Trouble Shooting.

Symptom and probable cause	Probable remedy
(1) ENGINE STOPS SUDDENLY.	
Fuel filter plugged.	Clean filter, then prime lines.
Obstructed or broken line.	Check, starting with fuel tank to strainer line.
Water in fuel.	Drain fuel oil strainer sump and fuel tank of all water and sediment.
(2) ENGINE MISSING.	
Sticking nozzle valve stems or pump delivery valves.	(Caused usually from dirty fuel.) Clean entire system and refill with clean oil.
Water in fuel.	Drain fuel oil strainer sump and fuel tank of all water and sediment.
(3) FUEL KNOCKS.	
Spray nozzle valve sticking.	Clean valve with a cloth and clean body with piece of wood. Turn valve stem in body until free, then smear with good clean OIL, lubricating, engine, or vaseline and install. Clean filters.
Fuel delivery valve in pump stuck open.	Clean valve stem with cloth and valve seat with small piece of wood. Do not use abrasives or metallic tools. Clean filters.
Water in fuel oil.	Drain fuel oil strainer sump and fuel tank of all water and sediment.
(4) EXCESSIVE SMOKE IN EXHAUST.	
Dirty spray nozzles.	Remove and clean. Clean fuel filters.
Fuel delivery valve in fuel pump stuck.	Remove and clean with soft cloth. Clean filters.

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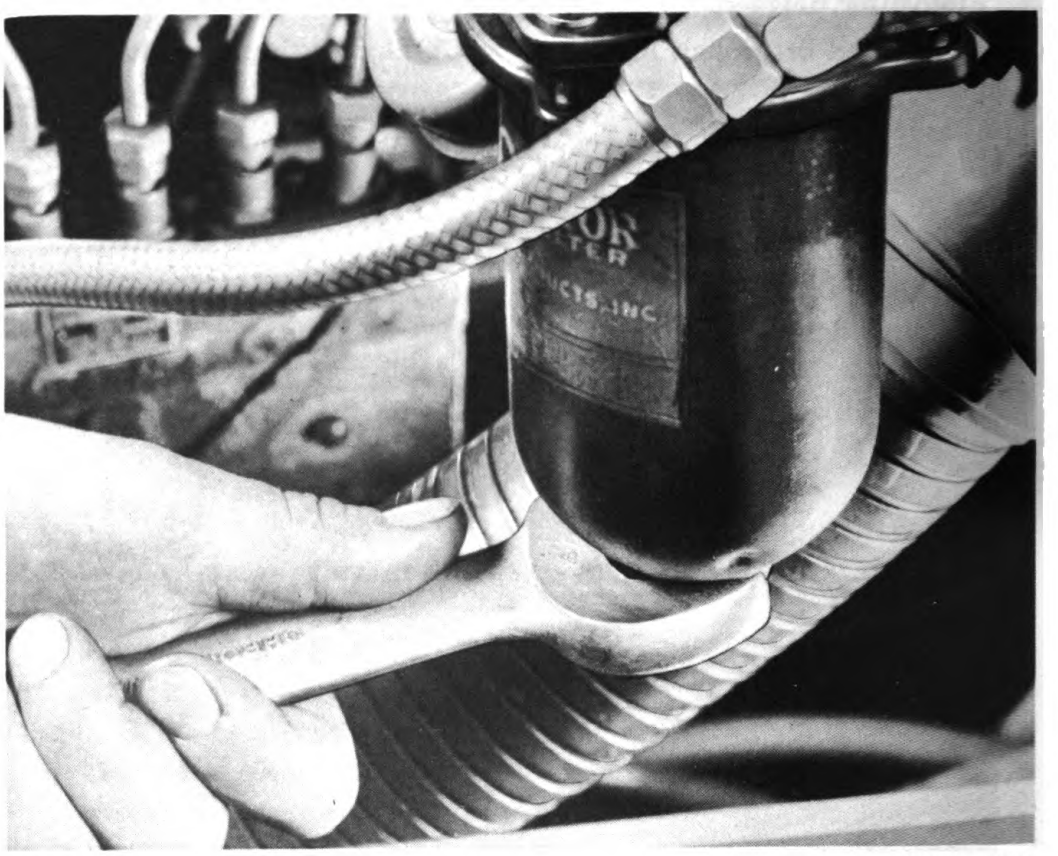
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86. REMOVAL OF FILTER ELEMENTS.

The primary and final stage fuel filters are almost identical in design and are disassembled in a similar manner. To remove the elements proceed as follows:

a. Open both vent valves in the top of the filter (fig. 186).

b. Drain the filter by removing the drain plug in the bottom of the filter (fig. 187).



RA PD 13077

Figure 187—Removal of Drain Plug from Fuel Filter

c. Remove the filter case by unscrewing the four nuts with lock washers that attach the case to the mounting flange (fig. 188).

d. Remove the cloth element by twisting it to the left to release the catch by which it is attached to the metal unit (fig. 189).

e. Remove the metal element by unscrewing it from the head casting (fig.190)

87. MAINTENANCE OF FUEL FILTERS.

Wash both elements and the case in SOLVENT, dry-cleaning, gaso-

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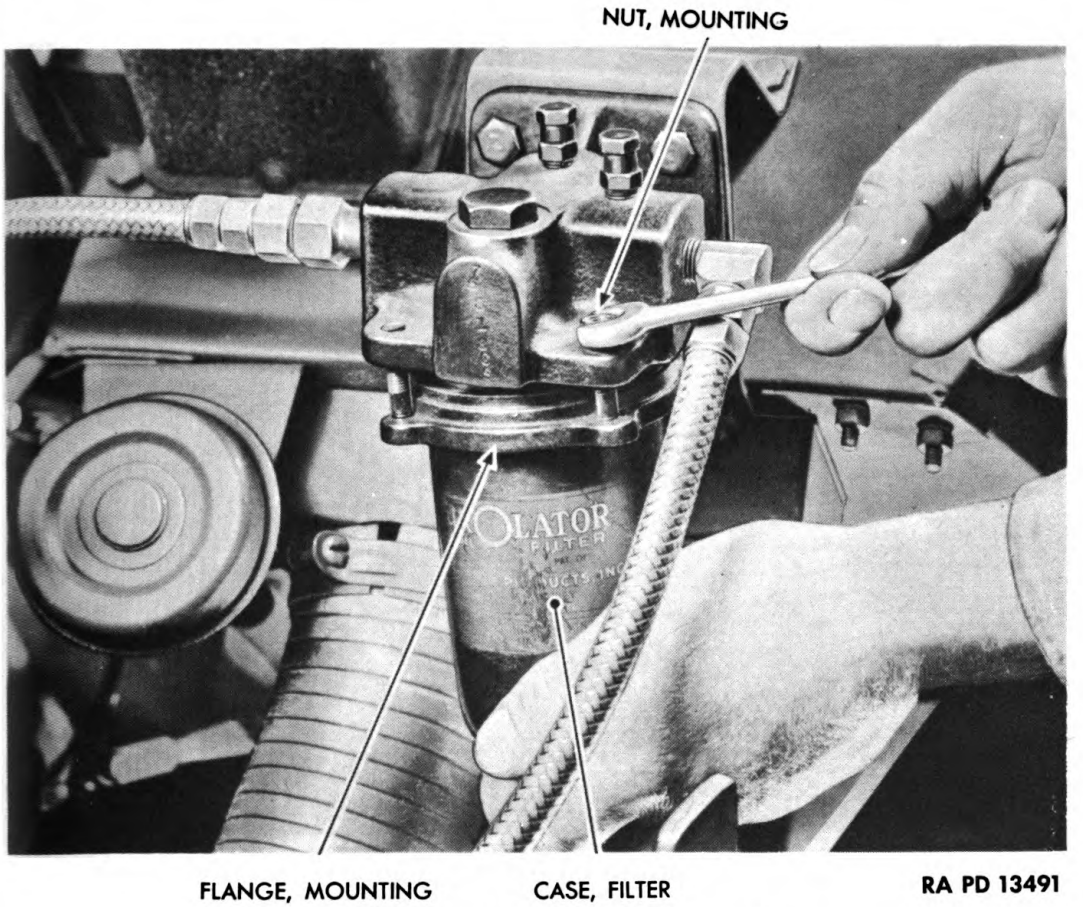


Figure 188—Removing Filter Case

line or kerosene. Do not use a wire brush or scraper. Use a soft cloth or bristle brush. The fabric element should be cleaned by placing it, open end down, in a partially filled can or bucket of cleaning fluid. Compress the element and allow it to expand. Repeat until dirt on the outside of the cloth is removed. Take care that dirt does not get on the inside of the cloth. The fabric element should be replaced if worn or torn.

88. INSTALLATION OF FUEL FILTER ELEMENTS.

a. Install the metal element by screwing it into the head.

b. Install the fabric element over the metal element and secure by turning to the right.

c. Install the case at the mounting flange and secure with nuts and lock washers.

d. Install the drain plug in the bottom of the filter.

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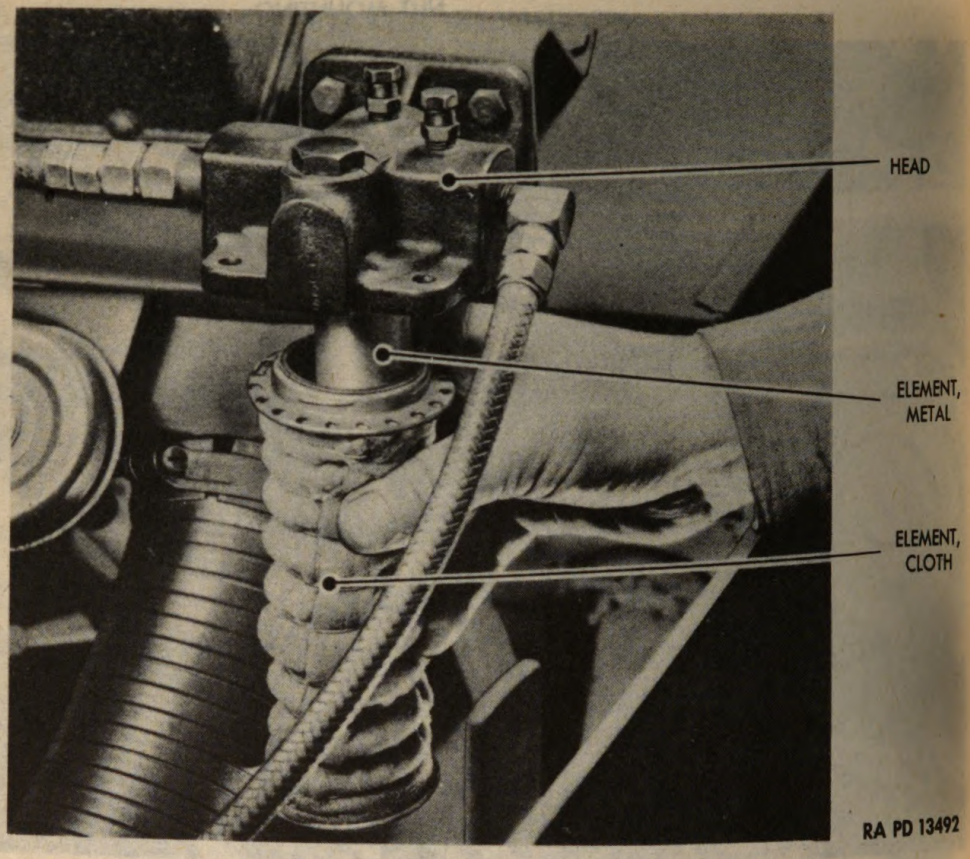


Figure 189—Removing Cloth Element from Filter

89. VENTURI CONTROLS.

a. Venturi controls consist of hand throttle and accelerator pedal and linkage.

b. The hand throttle control is a wire and flexible housing type. It is used when starting the engine or when making engine adjustments. For proper use refer to TM 9-705.

c. The accelerator operates the throttle by means of a bell crank and a cross shaft with two levers. The shaft assembly is mounted on the engine side of the dash. Return springs are provided to return throttle to closed position when the accelerator pedal is released or throttle hand control button pushed in.

d. It is important that levers and linkage work freely and do not bind.

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