TM 9–1706

WAR DEPARTMENT

TECHNICAL MANUAL

ORDNANCE MAINTENANCE

HERCULES JXD GASOLINE ENGINE FOR SCOUT CARS

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HERCULES JXD GASOLINE ENGINE FOR SCOUT CARS

SECTION I

GENERAL

1. Scope.—*a. General.*—This manual is published for the information and guidance of ordnance maintenance personnel, and is one of several maintenance manuals on these vehicles. It contains detailed instructions for removal, disassembly, inspection, maintenance, repair, assembly, and installation of the Hercules JXD gasoline engine and all its accessories for scout car M3A1. These instructions are supplementary to those in the Field and Technical Manuals prepared for the using arms. Additional descriptive matter and illustrations are included to aid in providing a complete working knowledge of the matériel.

b. Vehicle generally.—Information concerning the service maintenance, technical inspection, and lubrication of the entire vehicle will be found in TM 9–705 and 9–1705.

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c. Power train.—For maintenance information concerning the power train, refer to TM 9–1705.

d. Chassis and body.—For maintenance information concerning the chassis and body components, refer to TM 9–1709.

e. Diesel power plant.—For maintenance information concerning the Hercules Diesel engine, model DJXD, and all its accessories, see TM 9–1707.

SECTION II

SERVICE MAINTENANCE

2. Objective.—There is a decided difference between the purpose of organizational maintenance and that of service maintenance. Organizational maintenance is performed by the using arms and has for its primary objectives the routine steps in preventive maintenance, together with the care and adjustment of vehicles and their equipment, so that the matériel will be in good operating condition and there will be a minimum of time lost for repairs. Service maintenance by light and heavy maintenance units of the Ordnance Department has for its primary objectives supply, technical inspection, and corrective action and in general all repairs beyond the capacity of the using arms. This work is accomplished either by unit replacement, overhauling, rebuilding, reclaiming, manufacturing, or any other necessary expedients.

3. Scope.—The scope of maintenance and repairs by maintenance personnel is determined by the amount of time available, weather conditions, cover and concealment, shelter, proximity or exposure to hostile fire, equipment tools and parts available, and skill of the personnel. Since all these factors are variable, no exact system or rules of procedure can be prescribed or followed.

4. Allocation of repair jobs.—The operations mentioned below augment those which may be performed by the using arms.

a. Clutch.

(1) Clutch assembly---------- Replace, repair, rebuild.
(2) Clutch housing---------- Replace.

b. Cooling system.

(1) Fan assembly---------- Repair.
(2) Fan bushings or bearings----- Replace.

(3) Radiator	Repair.
(4) Water pump	Repair, replace, rebuild.
c. Electrical—generator and regulator.	
(1) Circuit breaker	Adjust or repair.
(2) Generator	Repair or rebuild.
(3) Voltage regulator	Adjust, repair, rebuild.
(4) Current regulator	Adjust, repair, rebuild.
d. Electrical—ignition system.	
(1) Ignition switch	Repair.
(2) Distributor	Repair, rebuild.
e. Electrical—starter.	
(1) Starting motor	Repair, rebuild.
(2) Starting switch	Repair.
f. Engine.	
(1) Camshaft	Replace.
(2) Connecting rods	Replace.
(3) Connecting rod bearings	Adjust and replace.
(4) Crankshaft	Grind, polish, straighten.
(5) Cylinder	Honeboring.
(6) Crankshaft main bearings	Replace.
(7) Engine	Rebuild, replace.
(8) Flywheel	Replace.
(9) Pistons	Grind and fit.
(10) Piston pins	Fit.
(11) Piston rings	Fit.
(12) Piston assembly	Replace.
(13) Timing gears	Replace.
(14) Timing gear cover	Replace.
(15) Valves	Reface, reseat, insert, and replace.
(16) Valve guides	Replace.
g. Fuel system.	
(1) Carburetor	Repair and rebuild.
(2) Fuel pump	Repair and rebuild.
(3) Fuel tank	Repair.
(4) Fuel gage	Repair.
h. Lubrication system.	
(1) Internal oil lines	Repair, replace.
(2) Oil pump	Repair, replace.

SECTION III

TECHNICAL INSPECTION

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.—W. D., Q. M. C. 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 a 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 or jerky, or slips in operation.

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

(2) Inspect supporting bracket of fan and bushings and bearings.

(3) Look at water pump and casing for cracks and leaks and make sure gear on shaft is tight and shaft rotates freely.

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.

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

(6) Examine regulator case for cracks.

d. Ignition system.—(1) Inspect all harness and terminals for damage, wear, and looseness.

(2) Examine and test ignition switch.

(3) Look over distributor. Test for loose mounting or loose connection to knob on dash. Remove upper half shield and inspect cap

for cracks. Inspect breaker points and spring, high-tension rotor, and metal inserts in cap for pitting and burning. Try cam for evidence of wear, looseness, or breakage of governor springs.

e. Starting motor.—(1) Examine all connections and terminals.

(2) Inspect and test starting switch.

(3) Inspect commutator and brushes.

f. Engine.—(1) Check crankcase, block, head, and head gasket for cracks or leaks. 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 steady and normal reading with engine running.

g. Fuel system.—(1) Inspect mounting and connections of fuel pump and check its operation. Examine fuel tanks for leaks or damage.

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

(3) Check fuel gage and switch.

h. Lubrication system.—(1) Check oil pressure at gage.

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

SECTION IV

POWER PLANT TROUBLE SHOOTING AND TUNE-UP WHILE INSTALLED

8. Trouble shooting.

Symptom	*Cause*
a. Engine skips or misses.	*a.* (1) Spark plugs cracked or dirty. (2) High-tension wires broken or shorted. (3) Distributor cap or rotor broken, damp, or dirty. (4) Faulty distributor points, condenser, or coil. (5) Valves adjusted too close or badly worn guides.

Symptom	*Cause*
	(6) Leaking head gasket.
	(7) Cracked valve seat or water jacket.
	(8) Improperly adjusted carburetor.
	(9) Air leak in intake manifold or head.
	(10) Partially plugged gas line.
b. Lack of power in engine.	*b.* (1) Skipping motor.
	(2) Motor out of time.
	(3) Needs carbon removed and valves ground.
	(4) Low or uneven compression.
	(5) Motor overheats.
	(6) Mixture too rich.
	(7) Clutch slips.
	(8) Brakes dragging.
c. Engine vibrates.	*c.* (1) Motor mountings loose or badly worn.
	(2) Bad skip in motor.
	(3) Ignition and timing too far advanced.
	(4) Idle adjustment set too rich.
d. Engine overheats.	*d.* (1) Circulation plugged in radiator, causing cool spot in core.
	(2) Radiator and block dirty, retarding circulation.
	(3) Ignition late.
	(4) Brakes dragging.
	(5) Clutch slipping.
	(6) Fan belt slipping.
	(7) Thermostat bad.
	(8) Leak or lack of air circulation.
	(9) Radiator fins bent or clogged.

Symptom	*Cause*
e. Engine knocks.	*e.* (1) Carbon deposit in head. (2) Spark advanced too far. (3) Automatic spark advance stuck. (4) Governor weights stuck or springs weak. (5) Loose wristpins. (6) Connecting rod out of alinement. (7) Loose rod bearings. (8) Loose main bearings. (9) End play in cam shaft. (10) Loose tappets. (11) Sticky valve stems. (12) Loose spark plugs. (13) Flywheel loose.
f. Grinding or scraping noise in engine.	*f.* (1) Generator bearings worn. (2) Water pump bearings bad. (3) Lower fan pulley sprung or frame sprung so trunnion hits pulley. (4) Broken ring or piston. (5) Flywheel pan bent or dirt in flywheel pan hitting flywheel. (6) Timing chain loose and rubbing case. (7) Oil pan nuts in flywheel housing hitting against flywheel.
g. Engine uses too much oil.	q. (1) Piston ring gaps lined up. (2) Piston rings worn or carbon in ring grooves. (3) Vacuum pump diaphragm cracked or porous. (4) Rod or main bearing has too much clearance. (5) Oil slinger clearance too great or oil slinger oil seal in housing worn out. (6) Excessive cylinder wear.

Symptom	*Cause*
h. Poor gas mileage.	*h.* (1) Worn-out spark plugs. (2) Timing late. (3) Carburetor dirty and out of adjustment. (4) Motor idles too fast. (5) Brakes dragging. (6) Clutch slips. (7) Erratic driving. (8) Automatic choke out of adjustment. (9) Air cleaner dirty or too full of oil. (10) Automatic heat control frozen closed.
i. Engine fails to start.	*i.* (1) Fuel system clogged or fuel supply exhausted. (2) Defective fuel pump. (3) Air vent closed. (4) No spark at spark plugs.
j. Generator fails to charge.	*j.* (1) Drive belt loose. (2) Voltage regulator out of order. (3) Generator not operating properly. (4) Poor connections in circuit.
k. Starting motion of vehicle jerky or delayed.	*k.* (1) Worn clutch linkage. (2) Worn or oil-saturated clutch parts—may also be out of adjustment. (3) Play in universal joints.

9. Tune-up.—*a. General.*—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 spark plugs from the engine. Turn ignition switch off and fully open hand throttle.

(2) Insert an accurate compression gage in spark plug 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 5 pounds.

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

(1) *Spark plugs.*—(*a*) Spark plugs should be Champion, model J8, type 14MM, or other make of same model and type.

(*b*) Clean the plugs thoroughly.

(*c*) Inspect closely for cracked porcelain.

(*d*) Set electrode gap between 0.025 and 0.028 inch. Use a round feeler gage. Bend side electrode when regapping.

(2) *Battery and ignition cables.*—(*a*) Clean both ends of each battery cable thoroughly. See that connections are tight.

(*b*) Inspect ignition system high- and low-tension cables. Terminal on each end must be clean and tight. If insulation shows evidence of deterioration, cable should be replaced.

(3) *Distributor.*—(*a*) Remove distributor cap and inspect it carefully for cracks and burned posts.

(*b*) Remove rotor, clean contact point, and make sure spring contacts secondary terminal.

(*c*) Clean distributor points with a flat point file. Inspect carefully and replace if cleaning does not remove pits and burns. Never use emery cloth to clean points.

(*d*) Adjust points with feeler gage to provide 0.018 to 0.020 inch clearance. Be sure that breaker cam is in position to have points fully separated.

(*e*) Check condenser. A weak condenser usually results in burned breaker points. A good check is the comparison test, replacing the old with a good condenser and observing for contrast in the spark. The spark from a faulty condenser will form an arc or drag between the points.

(*f*) Check ignition coil with coil tester. Replace weak coil.

(4) *Ignition tuning.*—Check ignition timing to be sure that No. 1 cylinder is firing according to flywheel markings. This is done by attaching one end of a neon timing light to No. 1 spark plug and grounding the other end. Run the engine at an idle speed and note whether the neon flashes coincide with the markings on the flywheel. Distributor can be retarded or advanced until neon flashes are perfectly synchronized with the flywheel markings.

(5) *Valve clearance.*—(*a*) Remove the valve covers and adjust the push rod screw to valve stem clearance to 0.006 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.

(6) *Carburetor.*—(*a*) Remove bottom bowl of air cleaner by loosening winged nut on each side. Clean out all old oil and dirt. Refill to oil level groove with new engine oil and install. Filtering element should never be removed from cleaner.

(*b*) Inspect carburetor flange and intake manifold gasket for leaks.

(*c*) Check carburetor float level as described in section XI.

(*d*) If necessary, adjust idling screw until engine runs evenly and steadily with leanest possible mixture. Engine should be thoroughly warmed before adjusting carburetor.

(*e*) Clean carburetor fuel filter.

(7) *Fuel pump.*—(*a*) The pressure from the fuel pump is measured with a fuel pump pressure and vacuum gage. Connect adapter tee into fuel pump outlet line and connect gage hose to adapter tee outlet (fig. 193). Normal pressure should be between 2½ and 4 pounds. This gage is also used to check the vacuum condition in the vacuum pump. Connect hose to pump inlet. When motor is running, this vacuum should pull from 8 to 10 inches.

(*b*) Remove sediment bowl and screen for cleaning.

(*c*) Inspect for worn parts and replace if necessary.

c. Vacuum tests.—A vacuum gage is a useful aid in an engine tune-up. Before testing be sure that engine is thoroughly warmed. The gage is attached at the rear of the intake manifold. Gage readings indicate condition of vacuum existing in all the space of the intake manifold between the throttle valve and the piston on the suction stroke. Take readings with engine running at 500 rpm unless otherwise specified.

(1) *Normal engine.*—A normal engine pulls a vacuum of 18 to 21 inches. The vacuum reading will drop to about 2 inches when the throttle is opened and will rebound to about 25 inches when throttle is closed.

(2) *Steady needle, slightly low vacuum.*—If the engine pulls a vacuum of 13 to 16 inches with a steady needle, it would indicate the possibility that the piston rings or oil is in poor condition. With slight needle motion it would indicate late ignition timing.

(3) *Steady needle, low vacuum.*—If the vacuum is between 8 and 12 inches, the trouble might be caused by loose valve guides, worn piston rings, poor oil, or a manifold leak.

(4) *Steady needle, very low vacuum.*—If the vacuum should drop below 5 inches with a steady needle, the trouble is undoubtedly a manifold leak.

(5) *Gradual drop.*—If a normal reading is obtained when the engine starts and the needle gradually drops, the trouble would probably be found in the exhaust system—probably a choked muffler.

(6) *Irregular drop, normal vacuum.*—If the engine pulls a normal vacuum but the needle drops at irregular intervals, the trouble might be caused by gummy valve stems, rich mixture, lean mixture, or defective spark plugs.

(7) *Regular drop, normal vacuum.*—A periodic drop or regular drop with a normal vacuum indicates a chipped valve, a burned valve, a leaky valve, or a head gasket leak.

(8) *Slow movement, low vacuum.*—A low vacuum with a slowly moving needle might indicate late valve timing, poor carburetor adjustment, defective spark plugs, poor ignition, or gummy valve stems.

(9) *Wide variations.*—An oscillating needle over a wide range with the variation increasing with increased speed indicates weak or broken valve springs.

SECTION V

CLUTCH

10. Description (fig. 1).—The clutch assembly is bolted to the engine flywheel. It is the dry disk, single plate type, incorporating a mechanical vibration dampener and automatic adjustment to compensate for wear.

a. Construction (fig. 2).—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 six crimped spring steel segments which constitute a cushioning effect for smooth operation. A circle of six coil

springs is installed in the hub of the driven plate to eliminate tortional vibration. The clutch coverplate contains the pressure plate, release levers, lever yokes with tension springs, and adjusting nuts, and 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.

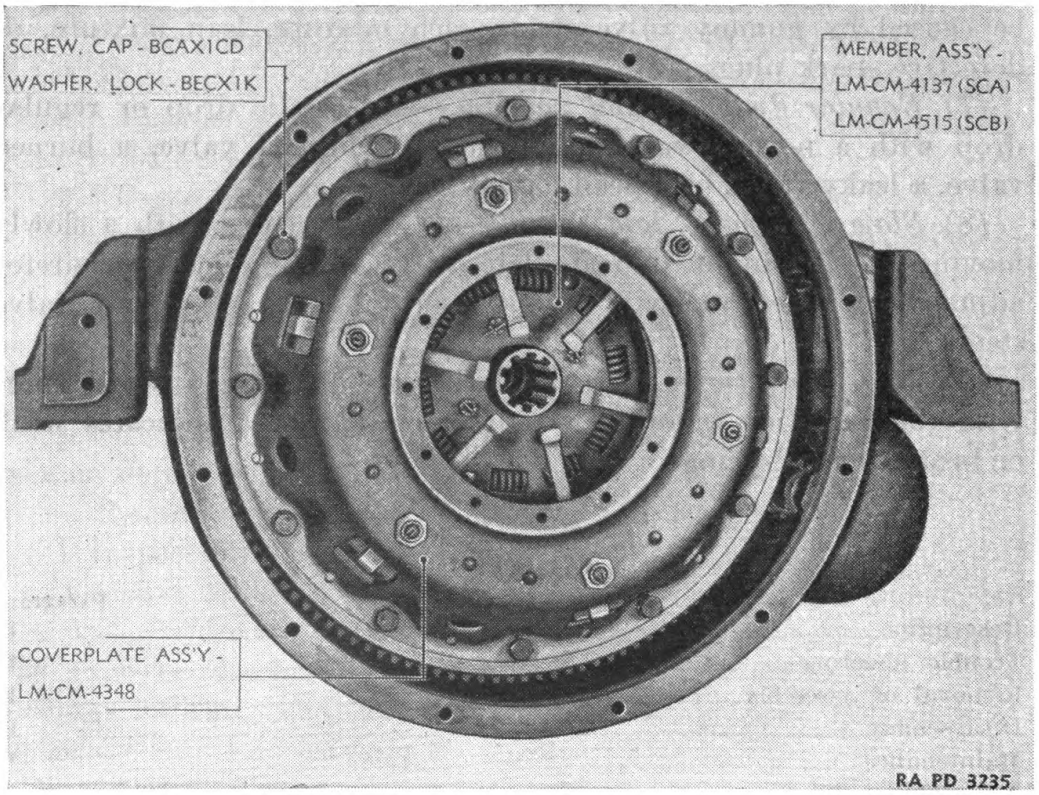


FIGURE 1.—Clutch assembly installed.

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 throwout 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.

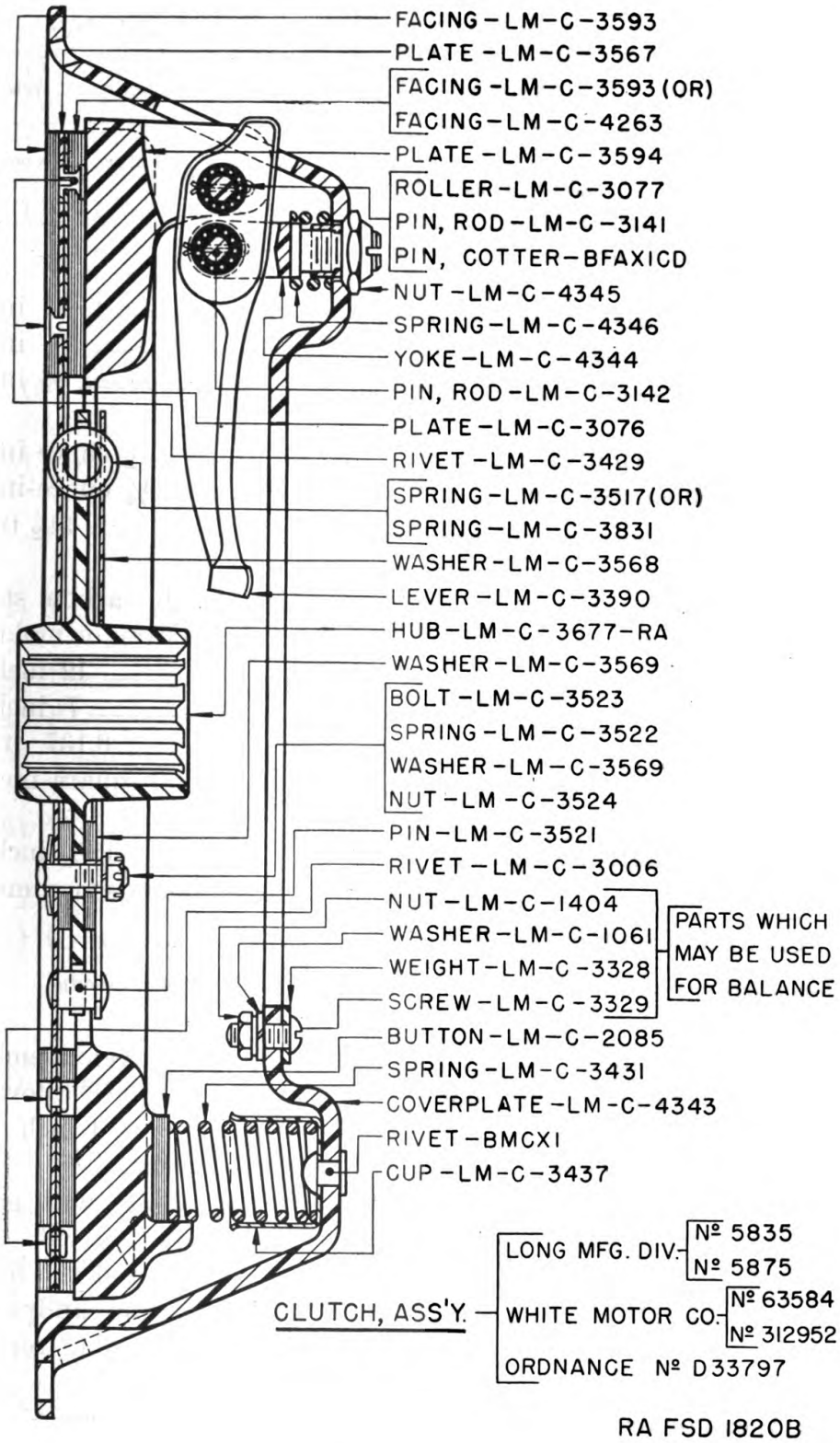


FIGURE 2.—Clutch (long), sectionalized.

c. Specifications.

Make	Model	Type	Ordnance No.	Manufacturer's No.	White No.	Weight
Borg-Warner	12 CB–CL	Dry, single plate, nonadjustable.	D33797	LM–5875	WI–312952	38½ pounds.

Lever travel:
- To release ..... 3/8 inch.
- Recommended ..... ½ inch.
- For wear ..... 5/8 inch.

Clutch balance:
- Cover plate assembly ..... ½ ounce-inch.
- Driven member assembly ..... ¼ ounce-inch.

Release levers ratio ..... 5½ to 1.

Driven disk:
- Material ..... High carbon steel.
- Friction facings ..... Woven or molded.
- O. D ..... 12 inches.
- I. D ..... 7 inches.
- Thick ..... 0.137 inch.
- Total area ..... 150 square inches

Pressure plate:
- O. D ..... 12½ inches.
- Spring press ..... 1,620 pounds maximum.

11. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
a. Slippage.	
(1) Worn facings.	(1) Replace driven member.
(2) Clutch pedal riding floor board.	(2) Adjust pedal, allowing about ¾ to 1 inch free movement.
(3) Grease on facings.	(3) Wash facings with gasoline and solvent, dry-cleaning and rub lightly with fine sandpaper. If oil-soaked, replace facings.
(4) Weak or broken pressure springs.	(4) Replace all springs.
(5) Distorted pressure plate.	(5) Replace.

Symptoms and probable cause	*Probable remedy*
b. Grabbing.	
(1) Worn facings.	(1) Replace driven member.
(2) Distorted pressure plate.	(2) Replace.
(3) Misalinement of bell housing.	(3) Check with indicator.
(4) Grease on facings.	(4) Wash with naphtha and solvent, dry-cleaning, and sandpaper lightly. Replace facings if oil-soaked.
(5) Clutch parts binding.	(5) Clean and lubricate.
c. Chatter.	
(1) Grease on facings.	(1) Wash with solvent, dry-cleaning, and sandpaper lightly. Replace if oil-soaked.
(2) Insufficient cushion or dish in driven plate.	(2) Replace.
(3) Uneven release levers.	(3) Reset on fixture.
(4) Facings worn.	(4) Replace driven member.
(5) Facings glazed.	(5) Sand lightly with fine sandpaper.
(6) Warped or grooved pressure plate.	(6) Replace.
d. Dragging.	
(1) Grease on facings.	(1) Wipe off with solvent, dry-cleaning, and sandpaper lightly. Replace if oil-soaked.
(2) Release lever out of adjustment.	(2) Check on fixture.
(3) Insufficient pedal travel.	(3) Adjust pedal, allowing about ¾ to 1 inch free movement.
(4) Clutch hub binding shaft.	(4) Free up.
(5) Separator springs on center drive plate weak or broken.	(5) Replace.
e. Noise.	
(1) Throw-out or pilot bearing needs lubrication.	(1) Lubricate.

Symptoms and probable cause	*Probable remedy*
(2) Throw-out or pilot bearing worn out.	(2) Replace.
(3) Tips of release levers worn.	(3) Replace.
(4) Splines of hub worn.	(4) Replace driven member.
(5) Splines of clutch shaft worn.	(5) Replace.
(6) Release sleeve dry or worn.	(6) Lubricate or replace if necessary.
(7) Throw-out bearing riding release levers.	(7) Adjust free movement of clutch pedal to ¾ to 1 inch.

12. Removal of assembly.—Tools:

Screw driver.
⅝-inch box wrench.
Pliers.
Hammer.
Brass drift.
9/16-inch open end wrench.
7/16-inch open end wrench.
Length of 1-inch rope.
Chain block and hook.
9/16-inch socket wrench.
Speed handle.

a. Remove floor plate over transmission. — Screw driver.

Remove transfer case shift lever ball by unscrewing. Remove six machine screws holding center floor plate, and remove plate by lifting over transfer case shift lever.

b. Disconnect propeller shaft. — ⅝-inch open end wrench.
⅝-inch box wrench.

Remove four nuts, bolts, and lock washers holding propeller shaft to companion flange on transmission.

c. Disconnect clutch release shaft lever. — Pliers.
Hammer.
Brass drift.

Remove cotter pin and drive out rod end pin holding clutch release shaft lever to adjustable yoke.

d. Disconnect clutch release shaft support. — 9/16-inch open end wrench.

Remove two cap screws, plain washers, and lock washers holding shaft support to engine support bracket. Remove shaft support shims. Support will remain hanging on clutch release shaft.

e. Disconnect transfer case shift lever from shift rod. — Pliers.
Hammer.
Brass drift.

Remove cotter pin and drive out rod end pin holding shift lever to yoke end rod.

f. Remove hand brake lever. — $\frac{9}{16}$-inch open end wrench.

Remove two nuts holding hand brake lever assembly to transmission and disconnect lever from operating linkage of drive shaft brake.

g. Disconnect throw-out bearing outer oil tube. — $\frac{7}{16}$-inch open end wrench.

Remove inverted flared tube nut from inverted flared tube elbow on inner oil tube, to disconnect outer oil tube from inner tube.

h. Remove master cylinder push rod. — Pliers. Hammer. Brass drift.

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

i. Mount sling under transmission. — 1-inch rope. Chain block and hook.

Put rope around and under transmission, making certain that assembly will be balanced in sling during removal, in order to prevent injury to splined shaft (fig. 3).

j. Disconnect transmission bell housing from flywheel housing. — $\frac{9}{16}$-inch socket wrench.

Remove 12 cap screws and lock washers holding bell housing to flywheel housing.

k. Remove transmission. — None.

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

l. Detach clutch assembly. — $\frac{9}{16}$-inch socket wrench. Speed handle.

Remove 12 cap screws and lock washers holding 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. 106).

m. Remove cover plate and driven member assemblies. — None.

Take off separately cover plate assembly and driven member assembly. Take care that driven member does not fall out while removing cover plate assembly.

13. Disassembly.—Tools:

Clutch rebuilder.	Chisel.
Hack saw.	Pliers.
Punch.	Hammer.
Spider.	Lands.
Gage.	¾-inch socket wrench.

a. Dismantle clutch cover plate assembly.	Clutch rebuilder. Hacksaw. Punch.

Place and center clutch cover plate assembly on clutch rebuilder but do not clamp it down. Saw sealing burs off release lever nuts (fig. 4).

b. Punch-mark cover and bearing lug..	Punch.

Punch-mark cover plate and lever bearing lug to assure accurate reassembly (fig. 5). Factory assembly is bored for weight balance and reassembly of the pressure plate unit must duplicate its original assembly.

c. Remove cover plate from assembly.	Spider. ¾-inch socket wrench. Lands.

Place three lands on clutch rebuilder and center assembly on lands. Place spider on clutch rebuilder shaft and compress clutch sufficiently to take spring pressure off cover plate. Remove release lever nuts (fig. 6). Release clutch rebuilder and remove spider. Lift off cover plate (fig. 7).

d. Dismantle pressure plate unit assembly (fig. 8).	Pliers. Hammer.

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.

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

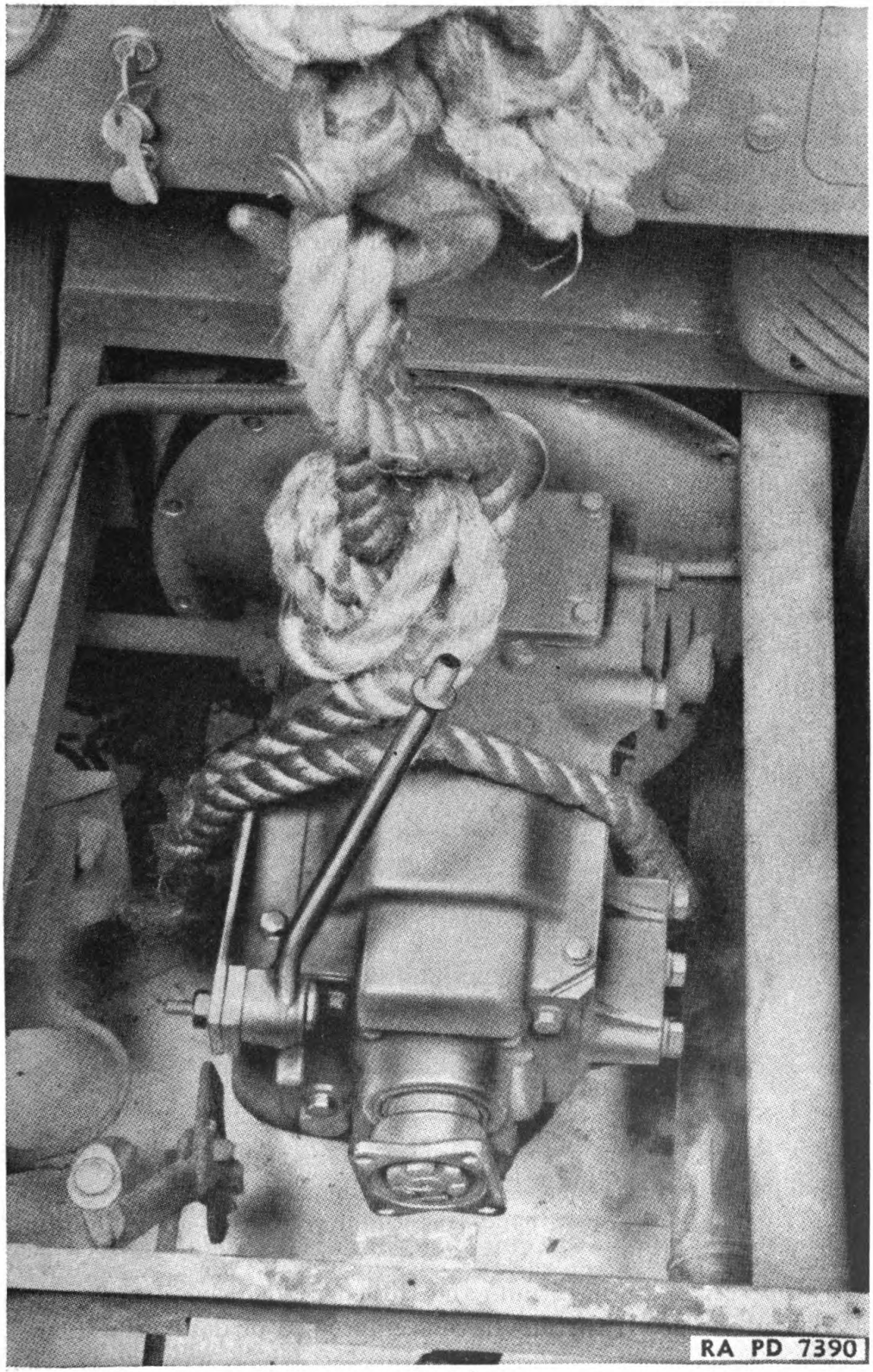


FIGURE 3.—Transmission removal.

ing nuts. Compress cover to release spring tension, and disassemble by following steps *b*, *c*, and *d* above.

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 clean solvent, dry-cleaning.

b. Pressure plate assembly.—(1) A pressure plate that has been grounded, heat-checked, or warped should be replaced.

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

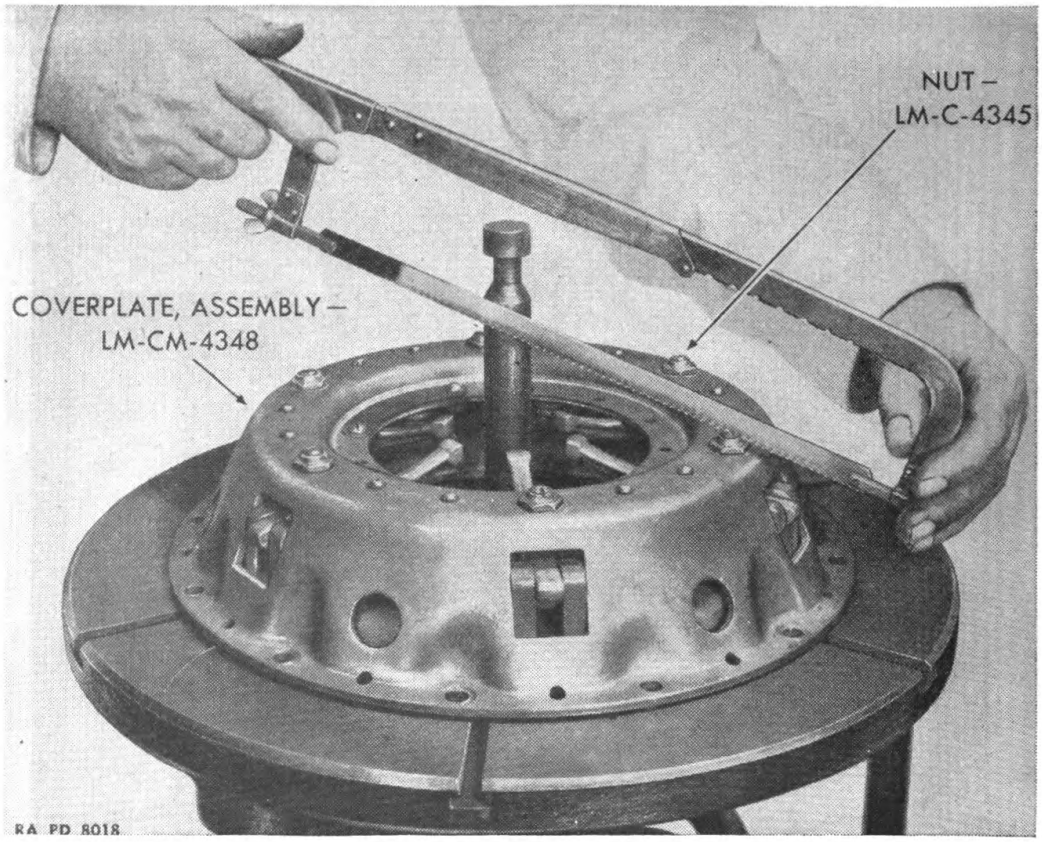


FIGURE 4.—Clutch lever adjusting nut bur removal.

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

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

(2) Inspection may be made of the friction faces, before clutch is removed, by removing transmission inspection plate and checking distance from inside rim of cover to top of lever at this point. If clearance between release levers and inner edge of cover plate is less than

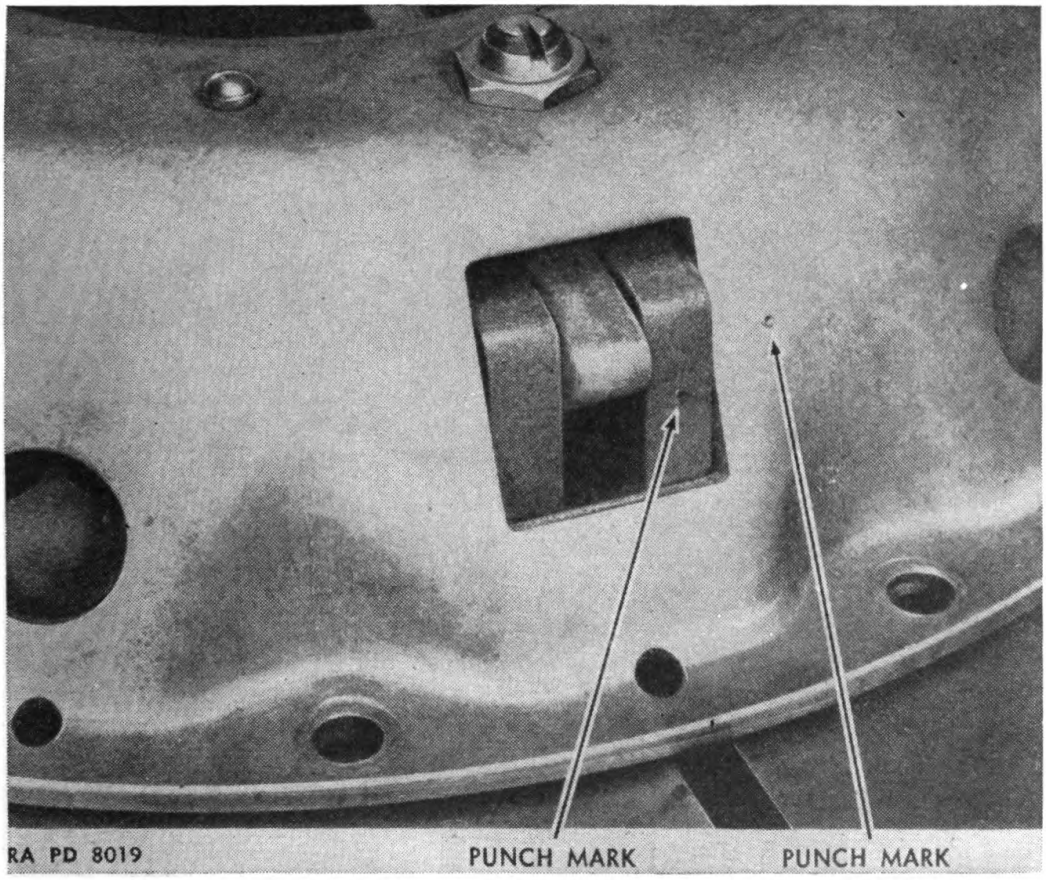


FIGURE 5.—Punch mark location.

⅛ inch, the future life of the facings will be very limited and they should be replaced by installing a new 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 drive lugs on pressure plate and sides of the windows when centered, a new cover plate stamping should be installed.

(2) Inspect pressure spring cups that are riveted to cover plate. Loose cups should be riveted tight and rivets replaced when necessary.

e. Adjustments.—(1) After clutch has been installed, clutch operating lever link should be adjusted so that there is at least ¾ to 1 inch free movement between clutch pedal arm and floor board.

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

f. Lubrication.—As clutch shaft pilot and release bearings are packed and sealed at assembly, no lubrication is necessary, other than that of clutch shaft release bearing spline. Apply a small quantity of oil, engine, SAE 30, every 500 miles in oil fitting on floor board.

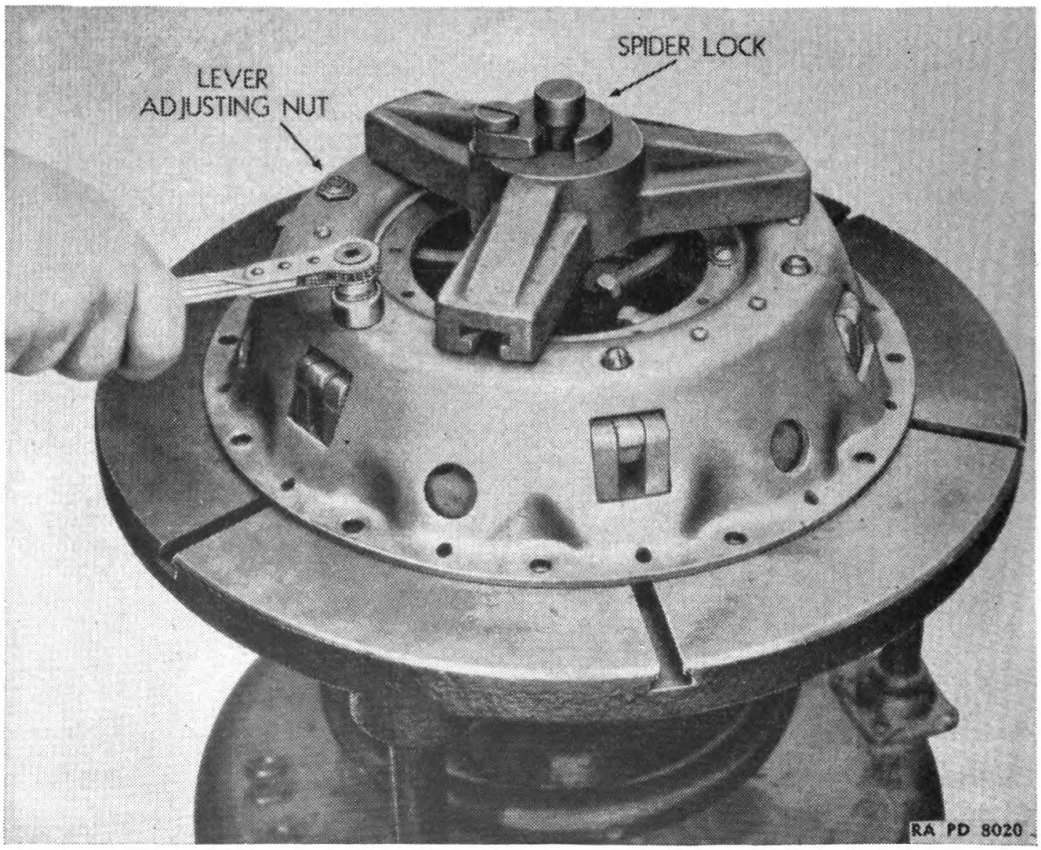


FIGURE 6.—Clutch disassembly operation.

15. Assembly.—Tools:

Hacksaw.
Pliers.
Clutch rebuilder.
Lands.
Adapter.
Weight.
Pilot bar.
Spider.
Wrench, adjustable.
¾-inch socket speed wrench.
Gage.
Punch.
Hammer.

a. Replace release lever yokes. Hacksaw.

Make a roller retainer by sawing off a short lever rod to thickness of lever. Insert this rod in lever yoke hole and push 13 needle rollers, which have been covered with heavy grease, in around this sawed-off pin. Place lever in yoke, lining up holes of each yoke with ends of roller retainer. Push retainer out with regular pin and insert cotter pin (fig. 9). Make sure slot in threaded end of yoke points outward to facilitate future disassembly. Repeat for all levers.

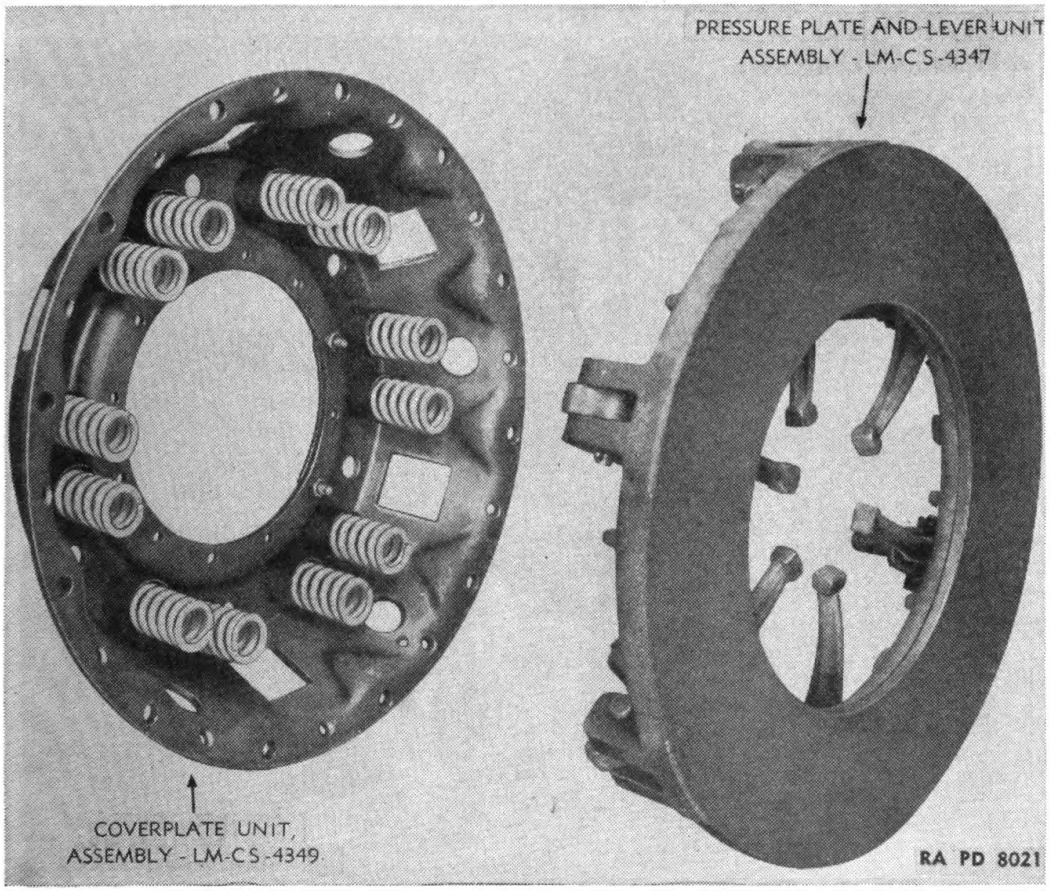


FIGURE 7.—Clutch cover plate assembly, dismounted.

b. Replace release levers. Pliers.

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

c. Assemble pressure plate. Clutch rebuilder.
Lands.
Adapter.

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. 10). Place release lever springs on threaded ends of yokes.

d. Replace cover plate. None.

Register punch-marks on cover plate and lever bearing lugs (fig. 5). Locate pressure springs in their cups in cover plate. Make sure

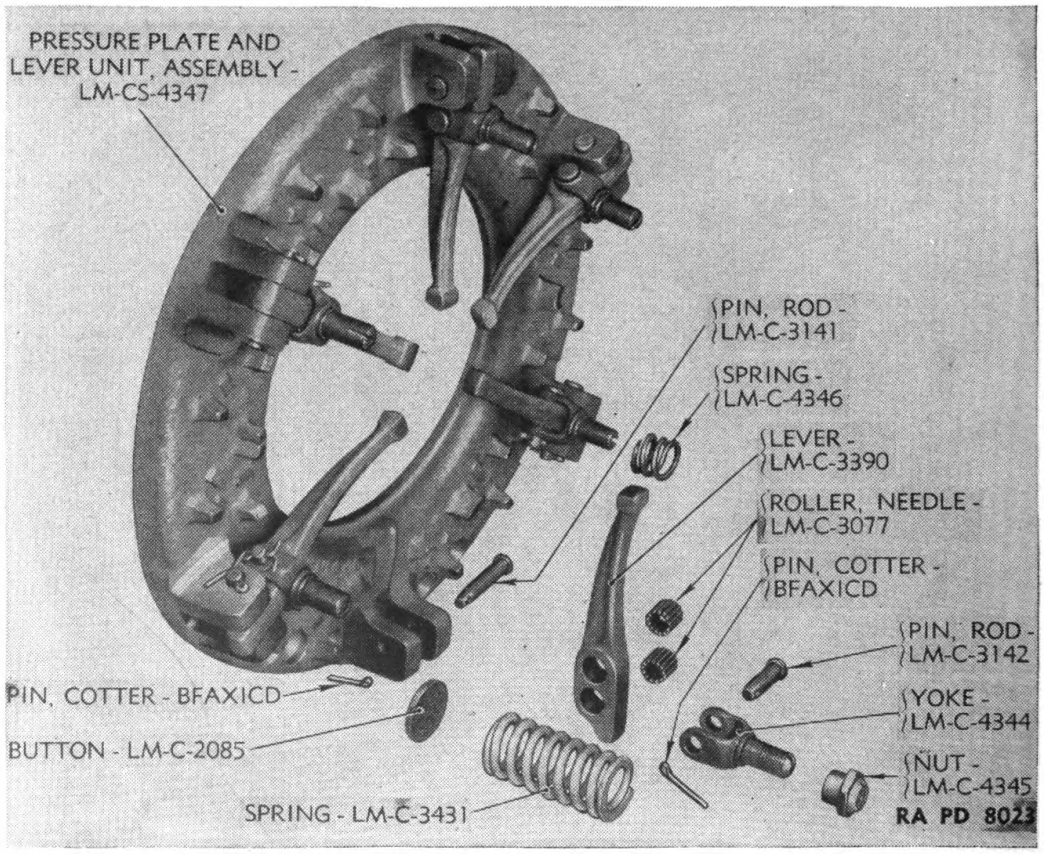


FIGURE 8.—Clutch pressure plate and lever unit assembly, exploded view.

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

e. Reconnect cover plate.

Clutch rebuilder.
Spider.
Wrench, adjustable.
¾-inch socket speed wrench.

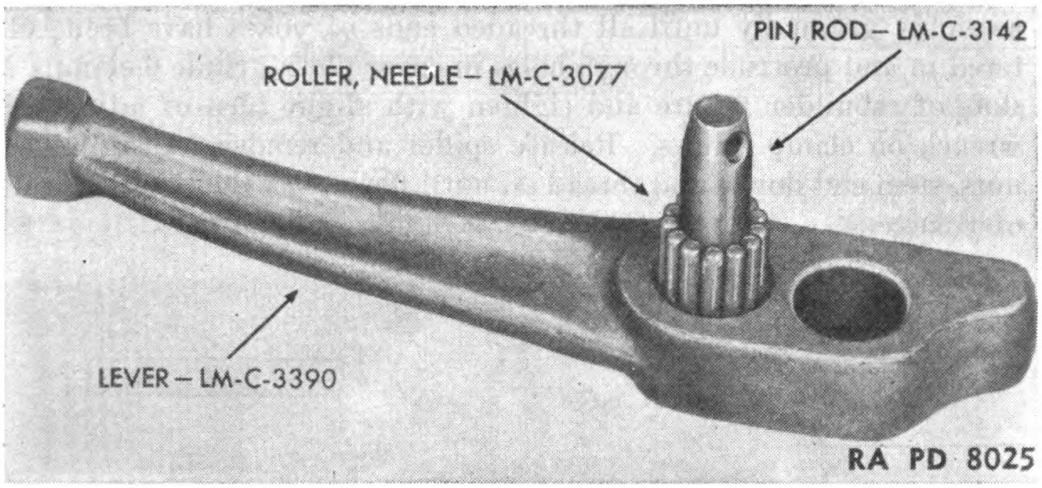


FIGURE 9.—Clutch lever bearing installation.

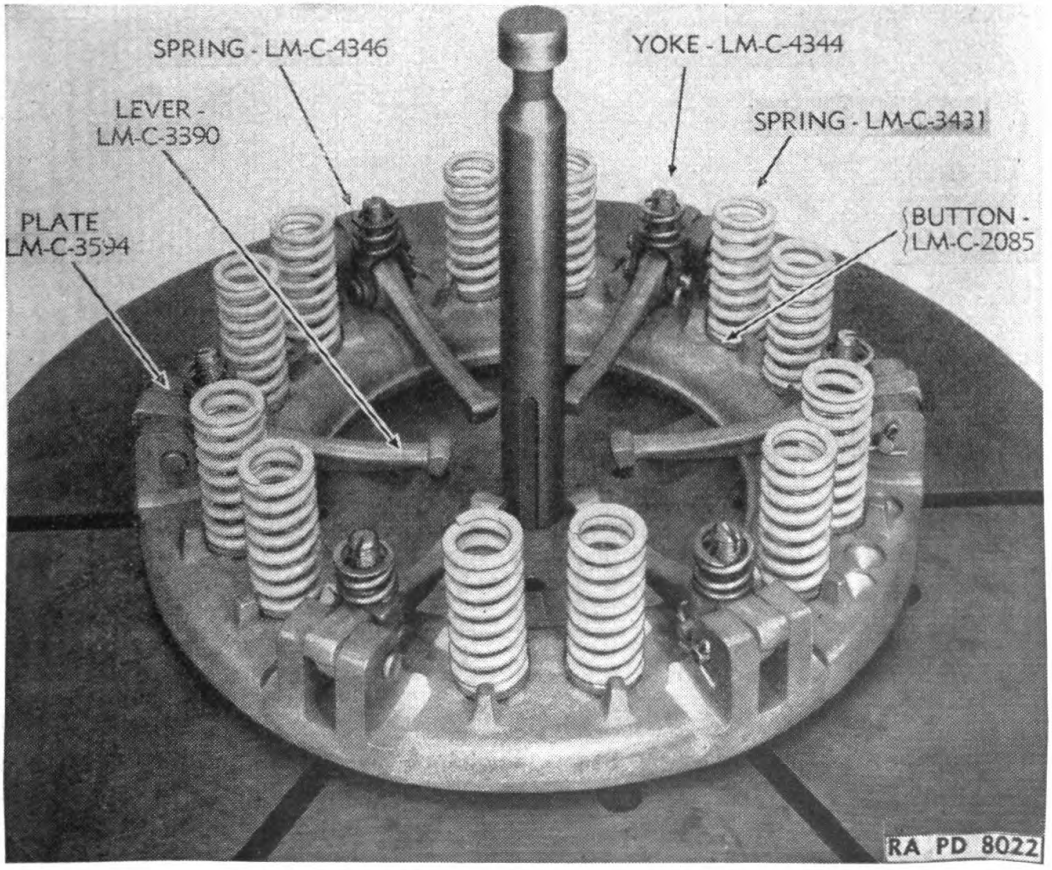


FIGURE 10.—Pressure plate lever unit assembly.

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 until all threaded ends of yokes have been centered in and protrude through holes in cover plate. Slide 6 clamps in slots of rebuilder fixture and tighten with slight turn of adjustable wrench on clamp screws. Release spider and remove. Install lever nuts, stem end down, and thread on until flush with the threaded ends of yokes.

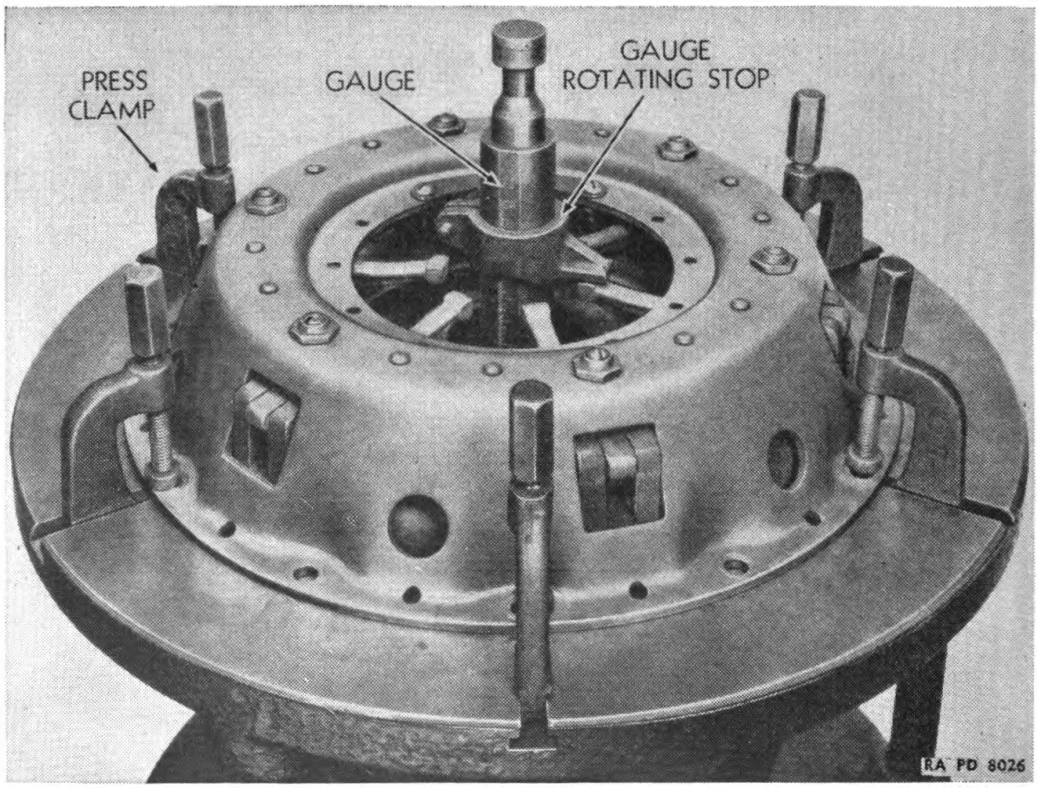


FIGURE 11.—Clutch adjustment.

f. Adjust height of levers.

Gage.
¾-inch socket speed wrench.
Rebuilder.
Weight.

Set clutch rebuilder adjustment gage at $2\frac{13}{32}$ inches and slide it onto rebuilder shaft (fig. 11). Tighten each lever nut until lever just touches 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. 12), compressing and releasing lever several times. Remove weight, re-

place gage, and retest adjustment. If several tests show one lever refuses to adjust, a weak spring is indicated and it must be replaced.

g. Lock cover plate assembly. Chisel.
Hammer.
Punch.

After final adjustment, lock lever adjustment nuts into slots of yoke stems with a blunt chisel and hammer (fig. 12). Should the

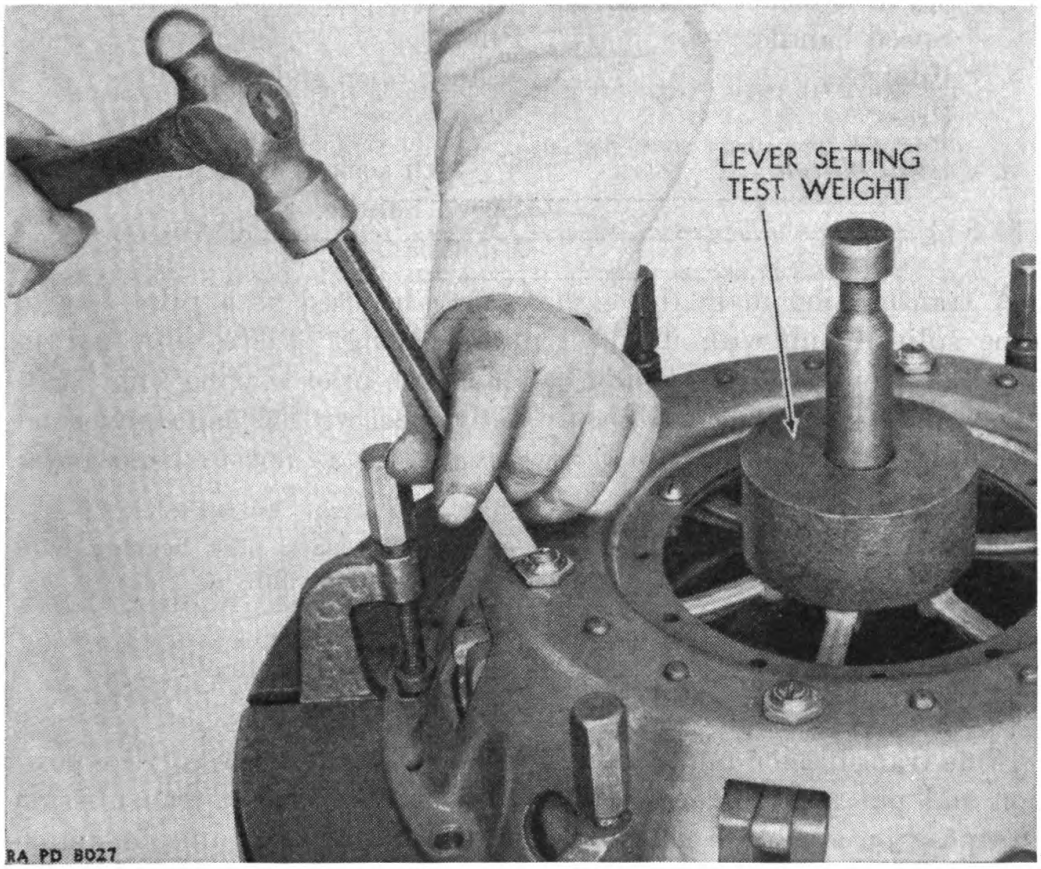


FIGURE 12.—Clutch lever adjusting nut locking.

hacksaw cut on the nut line up with the slot of the stem, make a new lock with punch and hammer at another point on the rim of the nut.

h. Remove assembly from rebuilder. Rebuilder.

Compress clutch assembly, loosen, and remove clamps. Release spider and remove clutch assembly.

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* above.

Adjustment of pressure plate levers may be made by placing a straightedge across the top surface of cover plate. Then, using a depth gage, adjust levers so that the distance from top surface of cover plate to tip of each lever is exactly $31/32$ inch.

16. Installation.—Tools:

Length of 1-inch rope.	Screw driver.
Chain block and hook.	Hammer.
Pinch bar.	$7/16$-inch open end wrench.
$9/16$-inch socket wrench.	$9/16$-inch open end wrench.
Speed handle.	Pliers.
Pilot bar.	$5/8$-inch open end wrench.
Press.	
a. Install clutch.	$9/16$-inch socket wrench.
	Speed handle.
	Pilot bar.

A transmission main drive shaft may be used as a pilot bar to aline splined hub with flywheel pilot bearing. Place pilot bar in clutch disk hub and insert pilot bar in clutch pilot bearing (fig. 172). Place clutch in position and secure to flywheel with 12 cap screws and lock washers. Tighten cap screws evenly so as not to bend cover plate.

NOTE.—Before clutch is reassembled, clean and repack pilot bearing with grease, general purpose, No. 2. Do not use excessive lubricant.

b. Install transmission.	1-inch rope.
	Chain block and hook.
	Pinch bar.

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 spline in clutch hub. Do not force spline into hub. Be sure to keep transmission in line in order to prevent injury to spline.

c. Connect bell housing to flywheel housing.	$9/16$-inch open end wrench.

Replace 12 cap screws and lock washers that hold bell housing to flywheel housing.

d. Replace master cylinder push rod.	Pliers.
	Hammer.

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

e. Connect throw-out bearing outer oil tube. 7/16-inch open end wrench.

Connect outer oil tube to inner by screwing inverted flared tube nut into elbow on inner oil tube.

f. Replace hand brake lever. 9/16-inch open end wrench.

Replace two nuts that hold lever to transmission and connect lever to operating linkage of drive shaft brake.

g. Connect transfer case shift lever to shift rod. Pliers.
Hammer.

Replace rod end pin and cotter pin holding lever to rod.

h. Connect clutch release shaft support. 9/16-inch open end wrench.

Replace shims and replace two cap screws, plain washers, and lock washers that hold shaft support to engine support bracket.

i. Connect clutch release shaft lever to linkage. Pliers.
Hammer.

Replace rod end pin and cotter pin holding release shaft lever to adjustable yoke.

j. Connect rear propeller shaft. 5/8-inch open end wrench.
5/8-inch box wrench.

Set shaft in place and replace four nuts, bolts, and lock washers holding shaft to transmission companion flange.

k. Replace floor board. Screw driver.

Set floor plate down over transfer case shift lever and replace six screws. Replace transfer case shift lever ball.

Section VI

COOLING SYSTEM (FAN AND PUMP)

17. Description (fig. 13).—The water-cooling system consists of the engine water jacket, water outlet and inlet fittings, radiator, centrifugal water pump, connecting pipes and hoses, and shroud-enclosed fan. The radiator is located in front of the engine and is

connected to the engine water outlet and the water pump inlet by brass pipes with short rubber hose connections at both ends. The water pump is bolted on the left front side of the engine block and is connected to the engine water inlet by a short rubber hose assembly. The pump is gear driven from the camshaft gear by means of the engine idler gear. The fan is bolted to the front of the pulley hub and the pulley is mounted on roller bearings on a stationary shaft. The shaft is carried by an adjustable bracket which is mounted on the engine timing gear cover. The shaft assembly can be adjusted vertically by means of the bracket handwheel and screw assembly so that the driving V-belts can be kept at the proper tension at all times. The system may be drained by removing the water pump discharge plug and opening drain cocks located in the radiator outlet pipe and in the left rear side of the engine block. Vents sealed by plugs in the engine water outlet fitting and the water pump inlet fitting are provided for installing a heater.

a. Functioning.—The pump circulates cooled water from the radiator throughout the channels in water jacket and cylinder head. The warmer liquid which rises to the top of the water jacket is forced through the radiator inlet into the upper radiator tank, flows down the radiator tubes for cooling, and is redrawn from the lower tank into the pump to repeat the cycle. Air, rushing through the radiator fins and around the tubes, cools the liquid as it descends through the tubes and is then blown back over the engine by the fan to help keep the engine cool.

b. Specifications.

Cooling capacity (quarts)	19
Water pump:	
Type	Impeller.
Make	Hercules.
Model	40170–CS.
Location	Left front side of cylinder block.
Drive	Double V-belt.
Impeller location	Pump body.
Bearings	Bushings.
Fan:	
Make	Schwitzer-Cummins Co.
Number	A–105005.
Diameter	19 inches.
Number of blades	6.

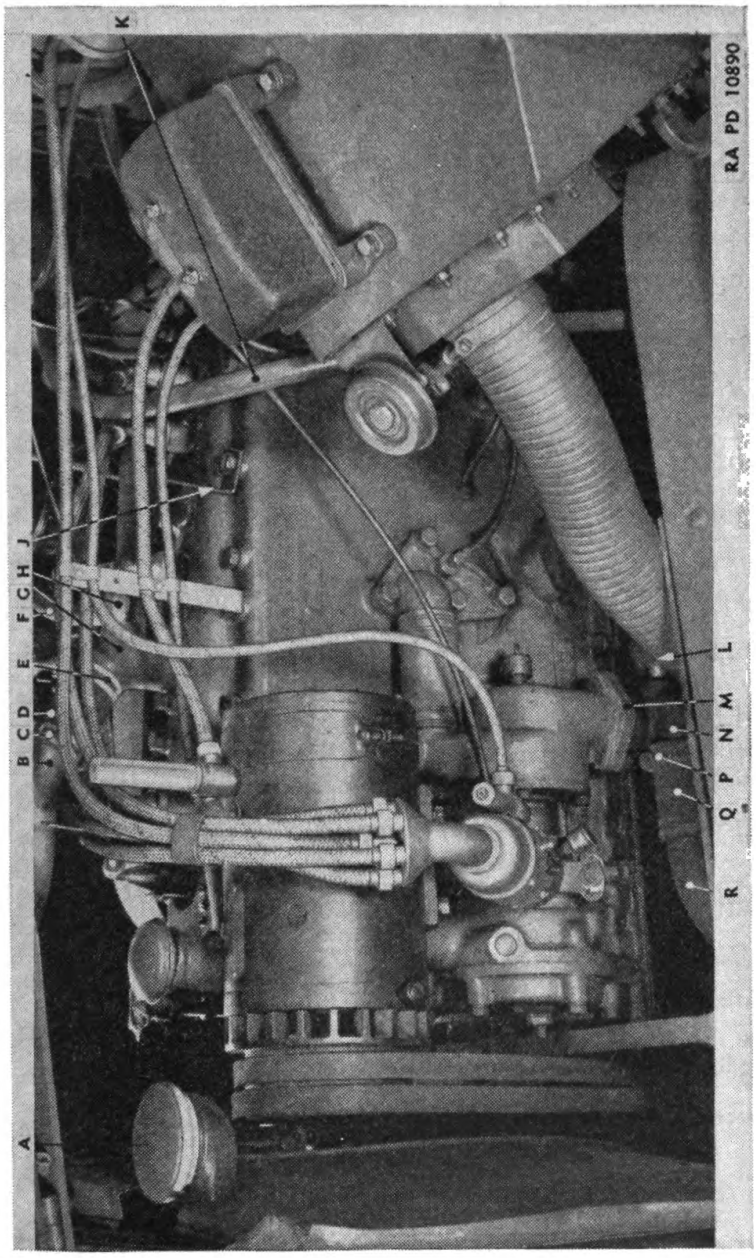


FIGURE 13.—Cooling system, installed.

A. Cap, radiator.
B. Tube, radiator inlet.
C. Clamp, hose.
D. Hose, radiator inlet.
E. Clamp, heater hose.
F. Hose, heater inlet.
G. Connection, cylinder head.
H. Valve, shut-off.
J. Support, heater hose.
K. Hose, heater return.
L. Clamp, heater hose.
M. Gasket, pump to inlet connection.
N. Connection, inlet.
P. Clamp, radiator hose.
Q. Hose, pump inlet.
R. Tube assembly, radiator to pump.

Fan belts:
- Make---------- Gates.
- Type---------- V.
- Width---------- ¾ inch.
- Length---------- 52½ inches.

Radiator core:
- Make---------- Modine.
- Numbers---------- AD3583.
- Type---------- Fin and tube.
- Frontal area---------- 555 square inches.
- Thickness---------- 3¾ inches.

18. Trouble shooting.

Symptom and probable cause	*Probable remedy*
a. Overheating.	
(1) Radiator dirty inside or out.	(1) Clean radiator thoroughly.
(2) Dirty water.	(2) Drain and refill with clean water.
(3) Engine timing wrong.	(3) Time engine correctly.
(4) Fan belts slipping on fan pulley.	(4) Take up belt slack.
(5) Restriction in system.	(5) Clean system to remove restriction.
(6) Air being drawn into system.	(6) Tighten hose connections.
b. Loss of cooling liquid.	
(1) Loose hose connections.	(1) Tighten all connections.
(2) Damaged hose connections.	(2) Replace damaged hose.
(3) Leaking water pump.	(3) Repack pump.
(4) Leaks in radiator core.	(4) Remove core and repair leaks.
(5) Loose or open drain cocks.	(5) Check and tighten.

19. Fan and belt.—*a. Description* (fig. 14).—The six-bladed fan assembly with pulleys is mounted on a bracket bolted to a pad on top of the timing gear case and is driven by dual V-belts from a pulley on the engine crankshaft.

(1) *Construction* (fig. 15).—The fan assembly is mounted on a slotted bracket bolted to a pad on top of the engine timing gear case. The fan hub spindle is held in position in the bracket slot by means of a jam nut threaded on the end of the spindle. The fan hub, with dual V-type drive pulley which rotates on two roller bearings mounted on the spindle, has a six-bladed fan attached to its flange. The fan-

adjusting screw with lock nut is threaded into the top of the mounting bracket. The fan belts are endless V-type, vulcanized, fabric rubber.

(2) *Functioning.*—The dual V-belts that drive the fan assembly and generator are driven by a pulley mounted on the engine crankshaft. The six-bladed fan, rotating at approximately 1½ times engine speed, draws air through the radiator core and blows it back over the engine and out the rear of the engine compartment.

(3) *Specifications.*

	Make	Type	Manufacturer's No.	White No.	Ordnance No.	Weight
Fan assembly	Schwitzer-Cummins	------	SZ–A–105005	WI–311965	C67496	18 pounds.
Belts	Gates	V	GC–10R44	WI–311964	B156068	1.5 pounds.

b. Trouble shooting.

Symptom and probable cause	*Probable remedy*
(1) *Overheating.*	
(*a*) Lack of water.	(*a*) Refill system.
(*b*) Fan belts loose.	(*b*) Adjust.
(*c*) *Fan belts bottoming in pulley.*	(*c*) Replace.
(*d*) Broken belts.	(*d*) Replace.
(2) *Overheated bearings.*	
(*a*) Lack of lubrication.	(*a*) Lubricate with proper lubricant.
(*b*) Tight belts.	(*b*) Adjust belts to proper tension.
(3) *Uneven belt wear.*	
Belts out of alinement.	Adjust and aline belts with pulley.

c. Fan removal from engine.—Tools:

1/16-inch open end wrench.
¾-inch open end wrench.

(1) *Loosen fan belt.*	1 1/16-inch open end wrench. ¾-inch open end wrench.

Loosen fan spindle jam nut and loosen fan belt adjusting screw lock nut (fig. 16). Then unscrew fan belt adjusting screw by hand, allowing fan assembly to drop to bottom of bracket, thereby relieving tension on belts.

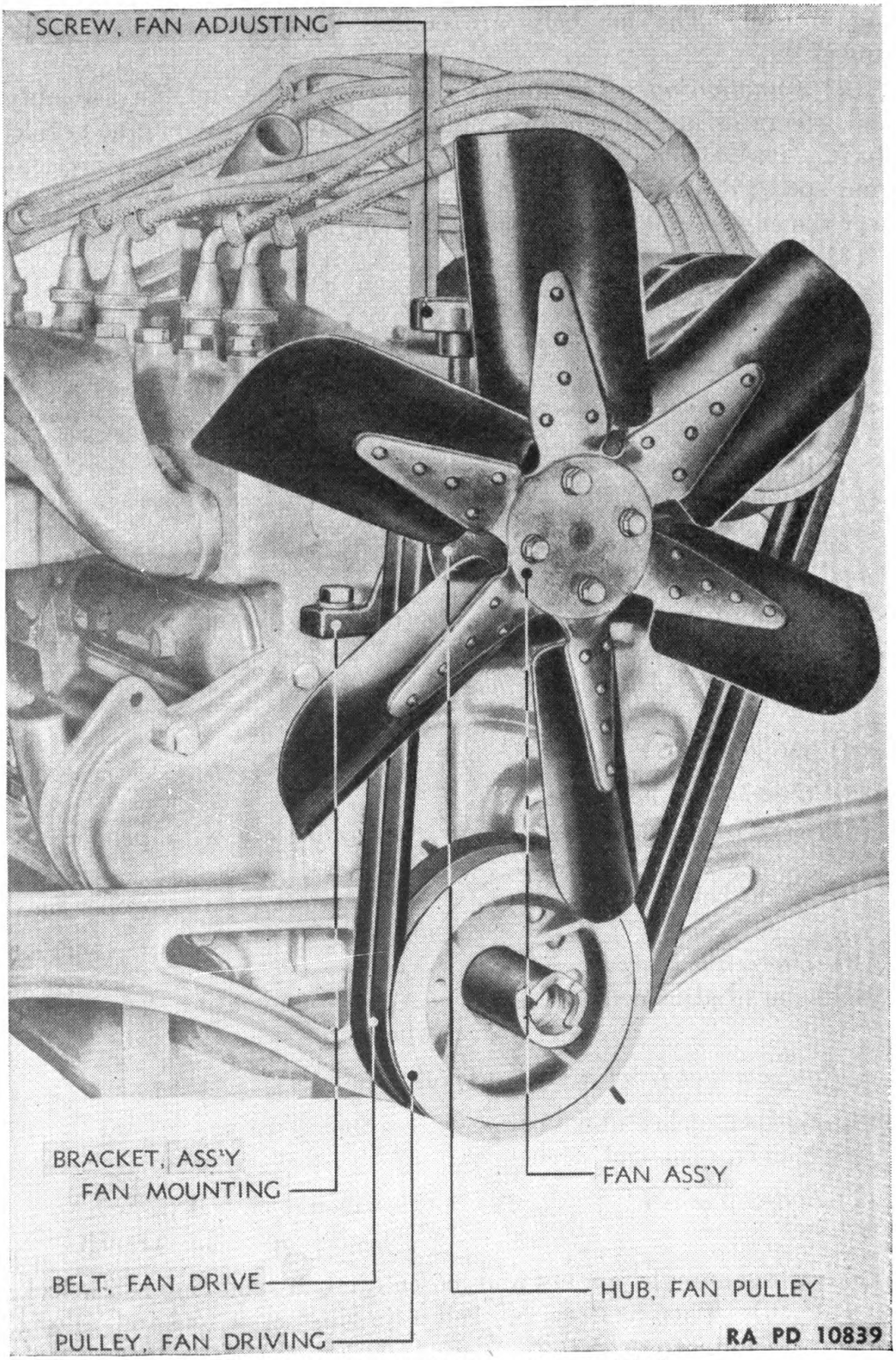
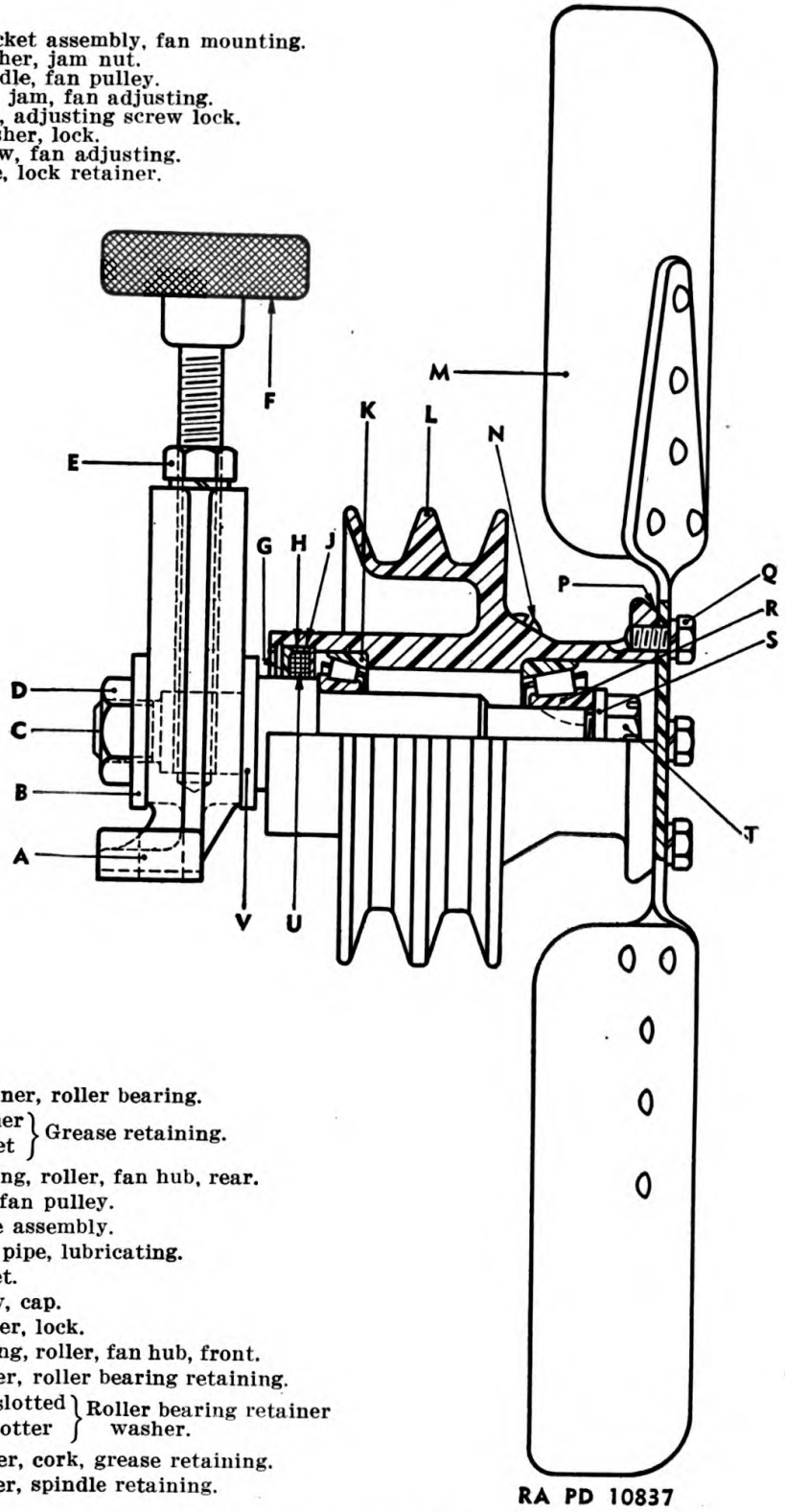


FIGURE 14.—Fan and belt assembly, installed.

A. Bracket assembly, fan mounting.
B. Washer, jam nut.
C. Spindle, fan pulley.
D. Nut, jam, fan adjusting.
E. {Nut, adjusting screw lock. / Washer, lock.}
F. Screw, fan adjusting.
G. Wire, lock retainer.



H. Retainer, roller bearing.
J. {Washer / Gasket} Grease retaining.
K. Bearing, roller, fan hub, rear.
L. Hub, fan pulley.
M. Blade assembly.
N. Plug, pipe, lubricating.
P. Gasket.
Q. {Screw, cap. / Washer, lock.}
R. Bearing, roller, fan hub, front.
S. Washer, roller bearing retaining.
T. {Nut, slotted / Pin, cotter} Roller bearing retainer washer.
U. Washer, cork, grease retaining.
V. Washer, spindle retaining.

FIGURE 15.—Fan, w/bracket assembly.

(2) *Remove screws from fan bracket.* — ¾-inch open end wrench.

Remove two cap screws and lock washers that attach fan bracket to timing gear case (fig. 17).

(3) *Remove fan belts.* — None.

Slide belts off fan drive pulley, generator pulley, and fan pulley and remove belts by lifting them up and out over fan blades.

(4) *Remove fan assembly and bracket.* — None.

Push fan assembly back against cylinder block and tilt up blade end to clear radiator shroud. Then lift out fan assembly and bracket (fig. 18).

d. Fan disassembly (fig. 19).—Tools:

1 1/16-inch open end wrench.	Soft metal drift.
15/16-inch open end wrench.	Hammer.
¾-inch open end wrench.	Screw driver.
½-inch open end wrench.	Pliers.

(1) *Remove fan assembly from bracket.* — 1 1/16-inch open end wrench.

Remove fan nut, plain washer, and shakeproof washer and pull fan assembly from bracket. Then take washer off spindle.

(2) *Remove blade assembly from fan pulley hub.* — ½-inch open end wrench.

Remove four cap screws and lock washers that attach fan to hub and lift blade assembly from hub. Gasket is shellacked to fan blade assembly.

(3) *Remove bearing retainer lock wire.* — Screw driver.

Pry out bearing retainer lock wire from groove in fan hub.

(4) *Remove front and fan spindle bearing retaining nut.* — 15/16-inch open end wrench. Pliers.

Pull cotter pin and remove nut and washer from fan hub spindle.

(5) *Remove front fan roller bearing from spindle.* — Soft metal drift. Hammer.

Drive spindle from front roller bearing and remove bearing cone assembly from fan hub.

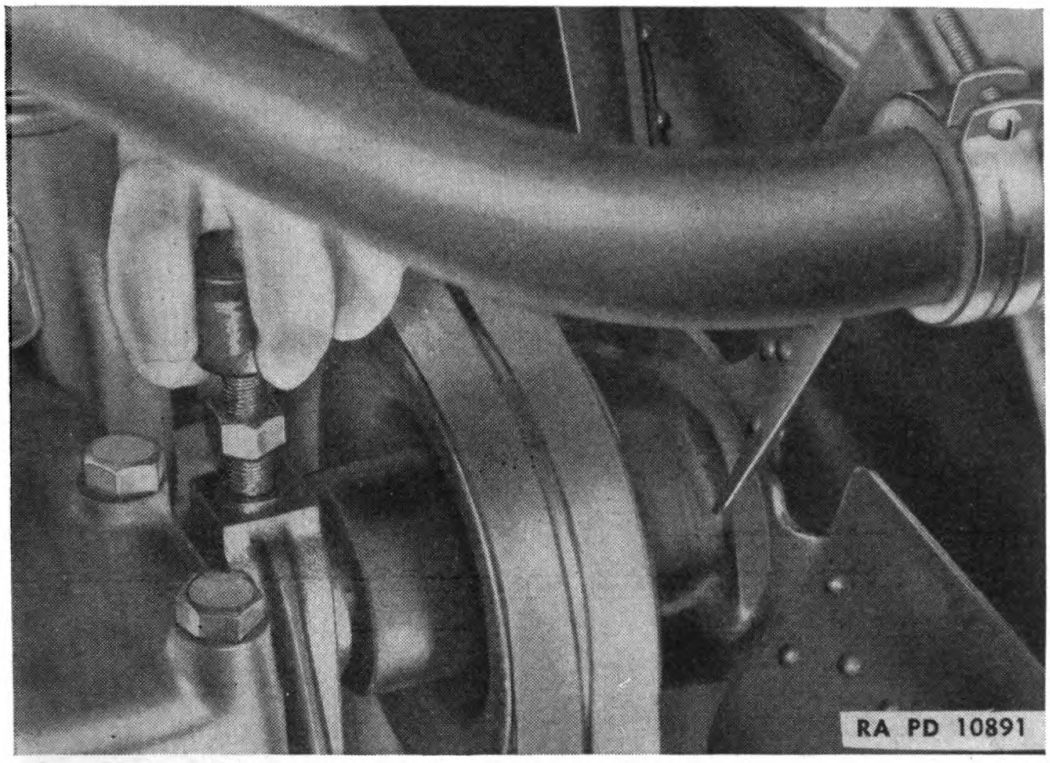


FIGURE 16.—Loosening fan belts.

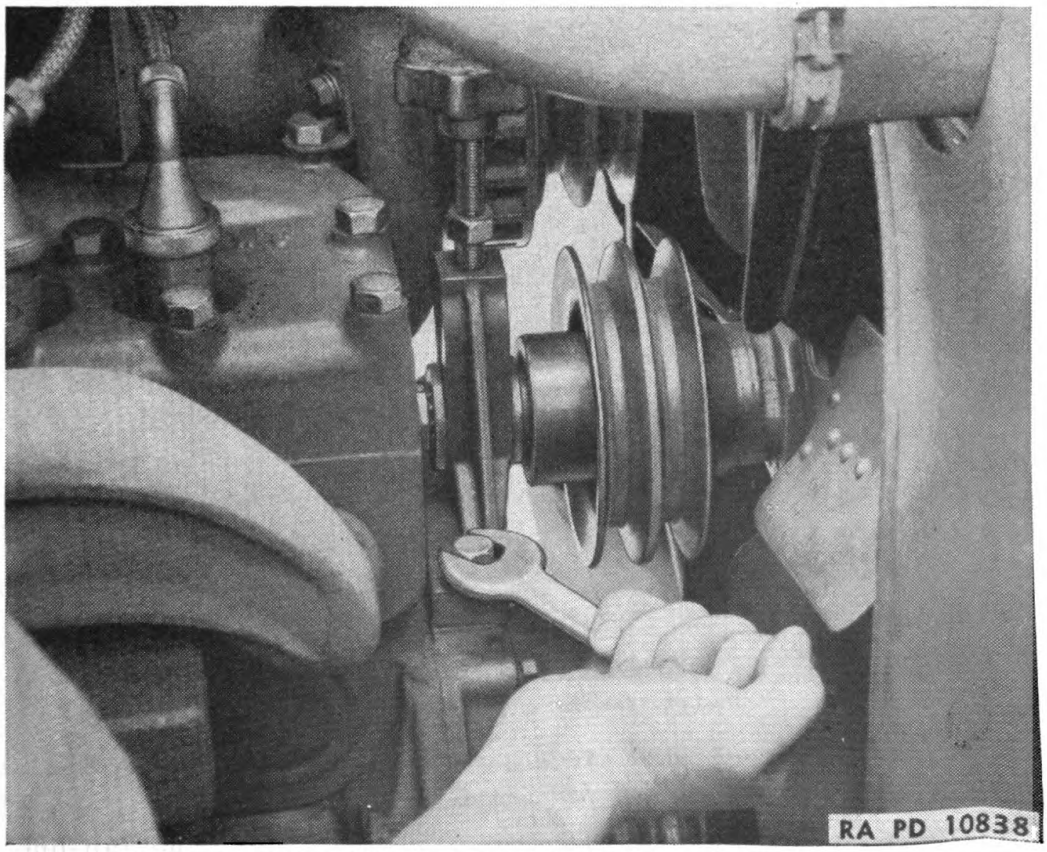


FIGURE 17.—Fan mounting bracket removal.

(6) *Remove rear roller bearing from spindle.* Soft metal drift.

Slide retainer, cork washer, and washer from spindle, in order named, and then drive rear bearing cone assembly from spindle.

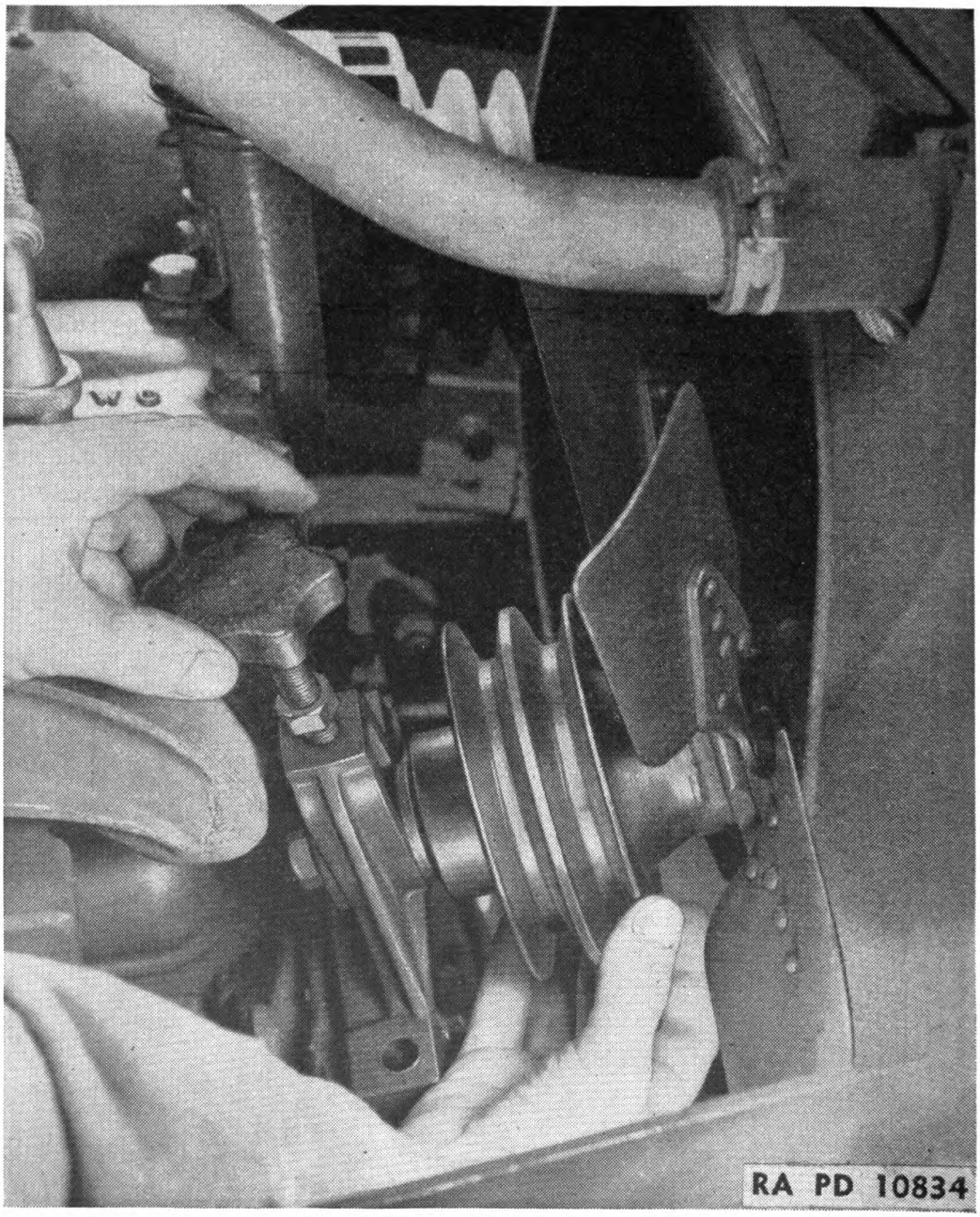
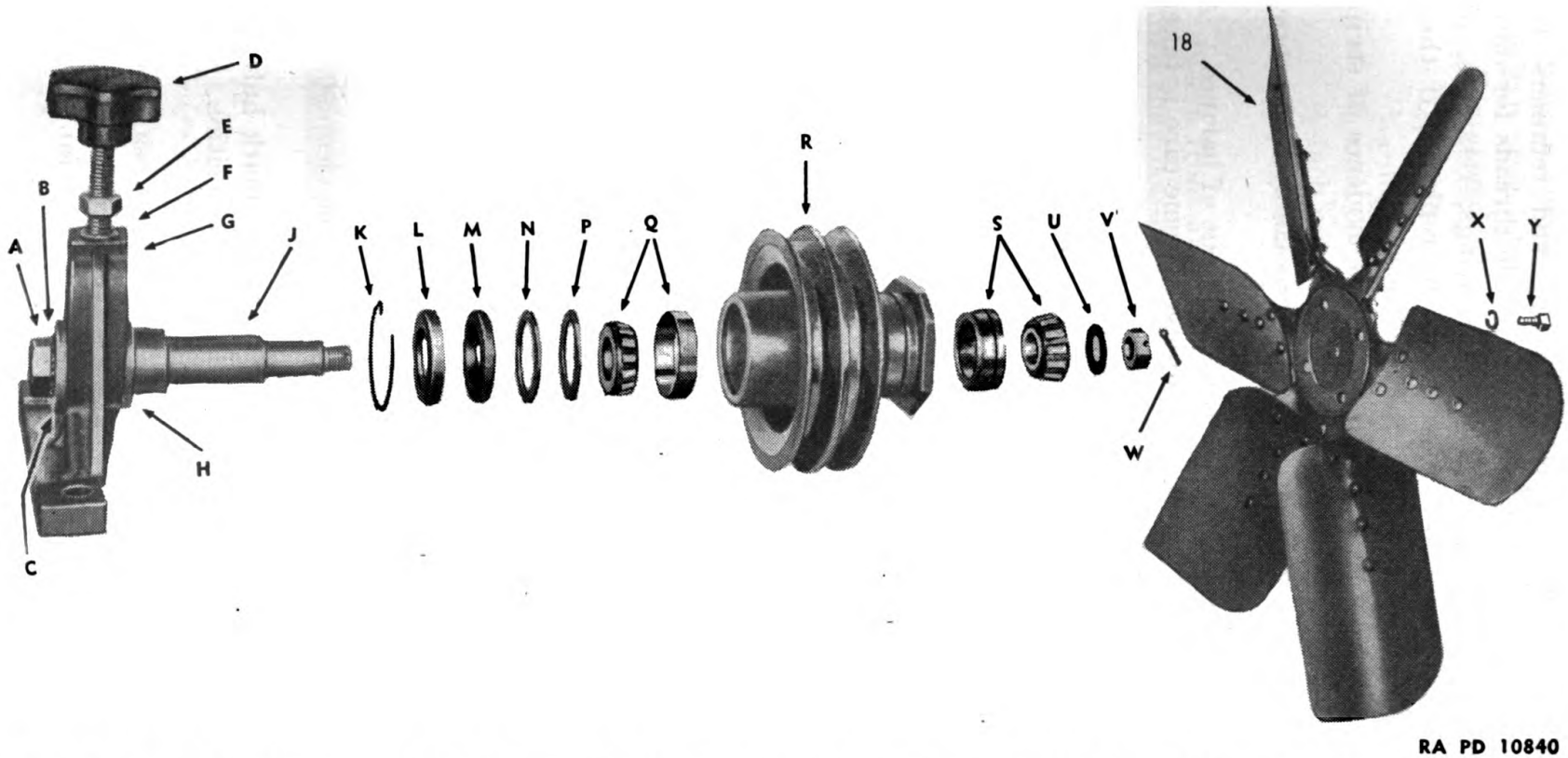


FIGURE 18.—Fan and bracket removal.

(7) *Remove front and rear roller bearing cups from fan hub.* Soft metal drift. Hammer.

Drive out front bearing cup and rear bearing cup from fan hub.



A. Nut, jam, fan adjusting.
B. Washer, shakeproof.
C. Washer, jam nut.
D. Screw, fan adjusting.
E. Nut, adjusting screw lock.
F. Washer, lock, adjusting screw nut.
G. Bracket assembly, fan mounting.
H. Washer, spindle retaining.
J. Spindle, fan pulley.
K. Wire, lock, retainer.
L. Retainer, roller bearing.
M. Washer, cork grease retaining.
N. Washer, bearing retaining.
P. Gasket, roller bearing.
Q. Bearing, roller, fan pulley.
R. Hub, fan pulley.
S. Bearing, roller, fan hub front.
T. Blade assembly.
U. Washer, roller bearing retaining.
V. Nut, slotted, roller bearing retaining washer.
W. Pin, cotter, bearing retaining nut.
X. Washer, lock, blade attaching nut.
Y. Screw, cap, blade attaching.

FIGURE 19.—Fan, with bracket assembly, exploded view.

e. Maintenance.—(1) Inspect roller bearing and retainers for wear and evidence of pitting. Inspect fan spindle threads for damage or evidence of stripping. Fan roller bearings, retainers, oil seal, and bearing retaining lock wire should be replaced, if these parts are scored or fractured and show excessive wear.

(2) Should fan spindle threads and nuts show evidence of stripping, spindle must be replaced.

(3) If threads have become burred during disassembly, run proper size die over spindle threads and use new nuts.

(4) Fan blades that have bent will throw fan out of balance. A fan with bent blades should be replaced, unless extreme care is taken in bending blades back into proper position.

(5) Inspect fan belts and replace belts that are frayed, cracked, or saturated with oil.

(6) Belts that are worn to the extent that they bottom on the pulley V should be replaced. When replacing belts always replace both belts, as dual pullers are used and one adjustment tightens both belts.

(7) To adjust fan belts, loosen fan spindle jam nut and adjusting screw lock nuts. Then, to tighten belt tension, turn adjusting screw handle to the left. Adjust belts so that there is between ½ and ¾ inch lateral movement of the belts halfway between the pulleys. With the dual V-belts, very little tension is required to drive the fan and generator. Belts that are adjusted too tightly will cause excessive wear and overheating of the fan roller bearing. After adjustments have been made, carefully check alinement of fan pulley with drive pulley. Misalinement will cause belts to ride up on the pulley flange, causing damage to the belts.

(8) Care should be taken not to mar the fan roller bearings when removing and replacing. If an arbor press is available it should be used in preference to a soft metal drift when removing and replacing bearings, bearing cups, and spindle from the fan hub.

(*a*) It is not necessary to remove the bearing cone cups from the fan hub unless they are to be replaced, as they may be cleaned without removing.

(*b*) In disassembly, before removing fan from hub, mark hub and fan flange so that they will be reassembled in the same position. This is essential because they are balanced as an assembly.

(9) Before bearing cones are installed in the fan, hub bearings and cups should be packed with lubricant, gear, universal, seasonal grade. Fan bearings are lubricated by removing the plug in the fan hub and

injecting a small quantity of lubricant every 1,000 miles (figs. 20 and 21). See lubrication chart, TM 9–1705.

f. Fan assembly (fig. 19).—Tools:

$1\frac{1}{16}$-inch open end wrench.	Soft metal drift.
$\frac{15}{16}$-inch open end wrench.	Hammer.
$\frac{3}{4}$-inch open end wrench.	Screw driver.
$\frac{1}{2}$-inch open end wrench.	Pliers.
(1) *Replace roller bearing cups.*	Hammer.
	Soft metal drift.

Insert front and rear bearing cups in fan hub and drive them in until they bottom against shoulder. Pack bearing cups and bearings with grease and place bearings in cups.

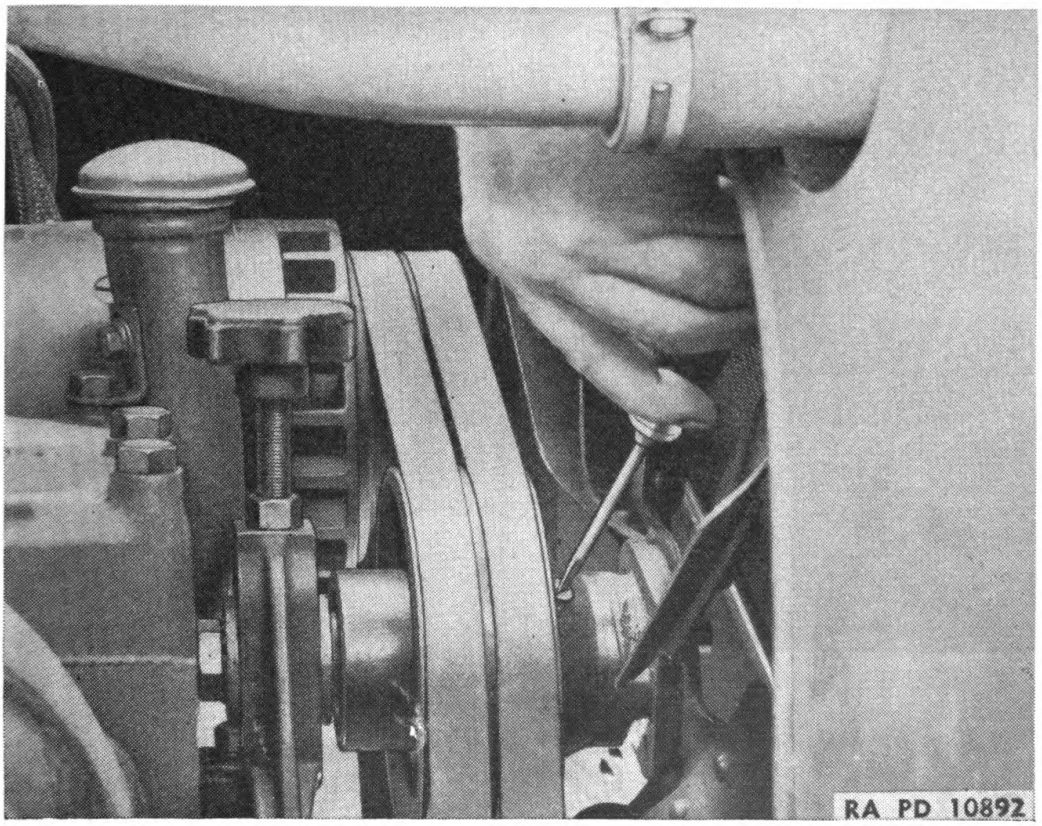


FIGURE 20.—Removing fan hub grease retaining plug.

(2) *Replace rear roller bearing retainers.*	None.

In order named, install gasket, plain washer, and retainer in fan hub, back of the rear bearing.

(3) *Replace washer retainer lock wire.* Pliers.
Screw driver.

Secure oil seal washer retainer lock wire in fan hub recess.

(4) *Install fan and spindle.* Soft metal drift.
Hammer.
$^{15}/_{16}$-inch open end wrench.

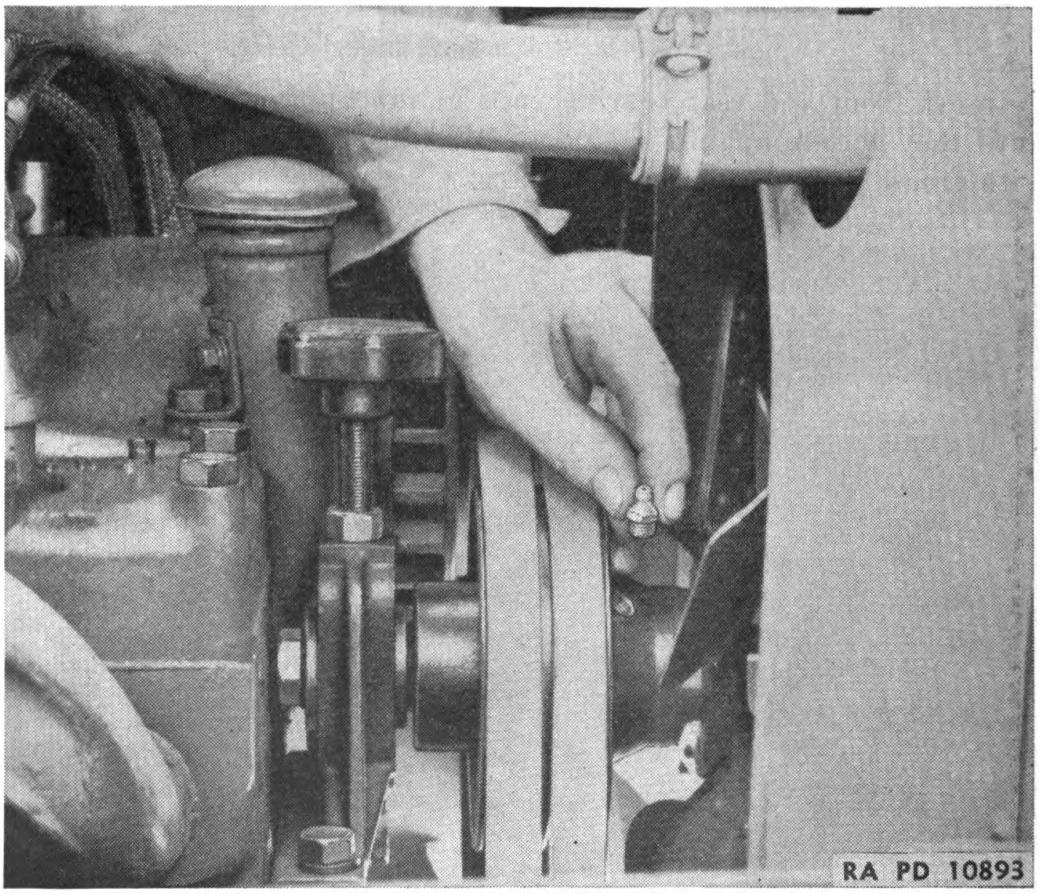


FIGURE 21.—Inserting pressure grease fitting in fan hub.

Insert spindle in fan hub and replace washer, castle nut, and cotter pin. Tighten this nut to give a loose fit with no end play and lock this adjustment with the cotter pin.

(5) *Install fan blade assembly.* ½-inch open end wrench.

Place fan blade assembly with gasket on fan hub and install fan cap screws and lock washers.

(6) *Install fan and hub assembly.* $15/16$-inch open end wrench.

Insert fan and hub assembly into slot in mounting bracket and replace plain washer and shakeproof washer and jam nut. Do not tighten jam nut, as adjustment will be made when assembly is installed.

(7) *Install fan adjusting screw.* $3/4$-inch open end wrench.

Install fan adjusting screw with lock nut in top bracket and thread screw into spindle.

g. Installation.—Tools:
$1\ 1/16$-inch open end wrench.
$3/4$-inch open end wrench.

(1) *Replace fan belt.* None.

With fan-mounting bracket resting on timing gear case, tilt fan down and slip belts over fan blades and onto drive pulley, fan pulley, and generator pulley (fig. 22).

Make	Type	Manufacturer's No.	White No.	Ordnance No.	Weight
Hercules	Impeller	HM–40170–CS	WI–316816	C65948	

(2) *Replace and line up fan-mounting bracket.* $3/4$-inch open end wrench.

Slide mounting bracket into position on timing gear case pad and insert two attaching cap screws with lock washers. Adjust bracket so that fan pulley is lined up with fan driving pulley and then tighten cap screws.

(3) *Adjust fan belts.* $1\ 1/16$-inch open end wrench.
$3/4$-inch open end wrench.

Screw down fan adjusting screw until there is approximately $1/2$ inch movement of fan belts and tighten lock nut. Check to make sure that fan pulleys are properly alined. If misalinement is visible, loosen cap screw and shift bracket to correct position.

20. Water pump.—*a. Description* (fig. 23).—The centrifugal type water pump is located at the left front of the engine block and is bolted on the rear of the timing gear case.

(1) *Construction* (fig. 24).—The water pump shaft is supported on two bushings, a large diameter bushing in the pump cover casting, just

to the rear of the drive gear, and a bushing of smaller diameter at the extreme rear of the pump body. The front bushing is lubricated by oil from the timing gears and the rear bearing by a grease cup threaded on the end of the body casting. Split ring type packing is used so that the pump can be repacked without disassembling. The impeller and distributor drive gear are keyed and pinned on the pump shaft. A bearing on the pump cover is used for mounting the engine ignition distributor.

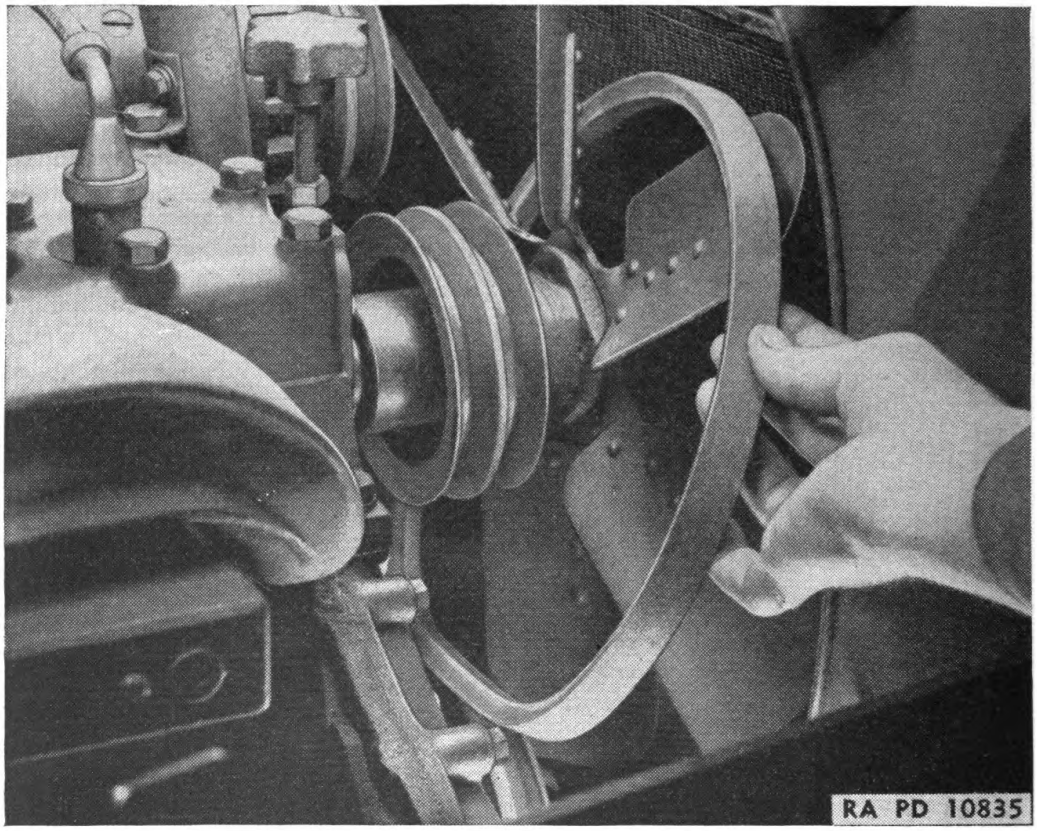


FIGURE 22.—Installing fan belt.

(2) *Functioning.*—The water pump drive gear is driven from the engine camshaft gear by means of an idler gear which rotates the pump shaft at one-half engine speed. Water is drawn from the bottom of the radiator by the rotation of the pump impeller and is forced to circulate through the engine water jackets and cylinder head, returning through the upper hose into the radiator. When the car heater is in use, return water from the heater enters the pump inlet below.

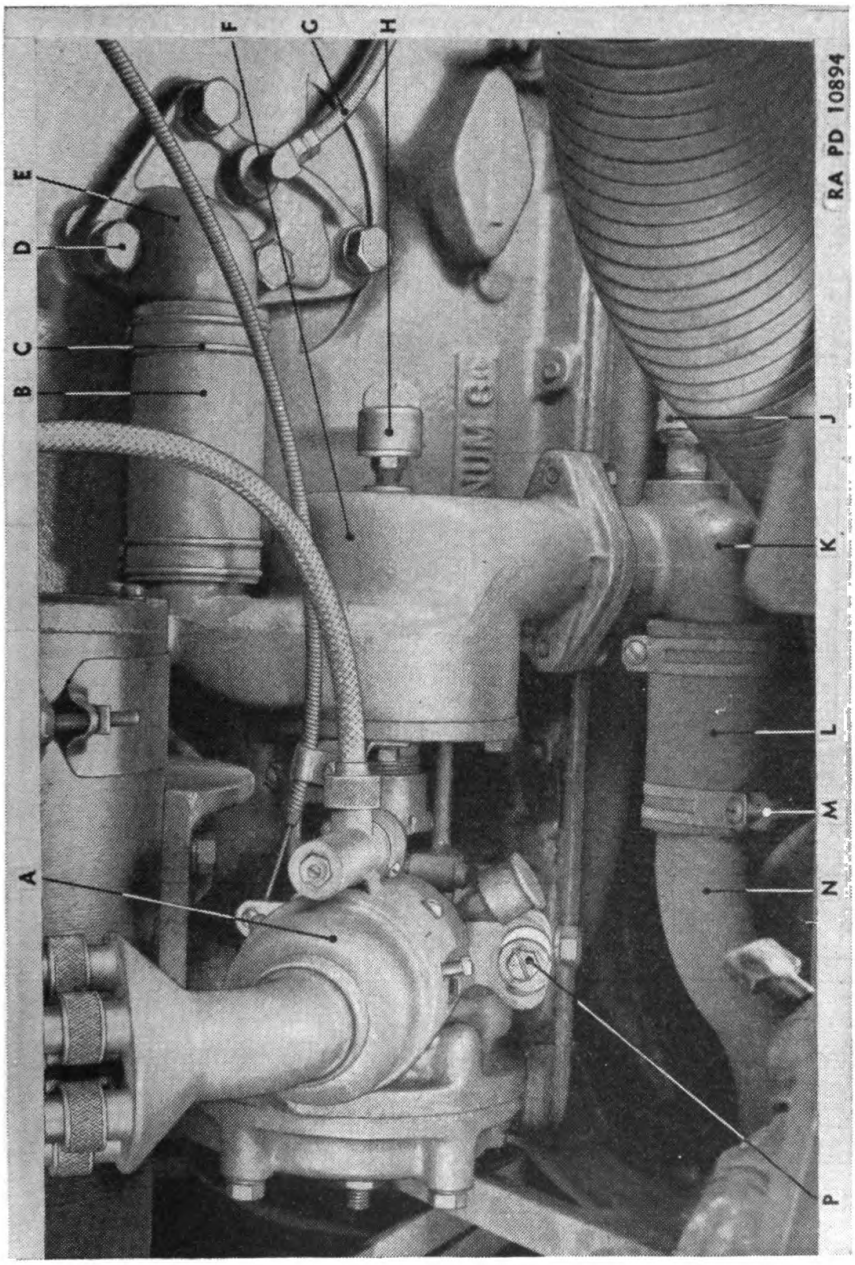


FIGURE 23.—Water pump assembly, installed.

A. Distributor, assembly.
B. Hose, pump discharge.
C. Clamp, hose.
D. Screw, cap, discharge pipe.
E. Pipe, discharge.
F. Pump, water, assembly.
G. Pipe assembly, oil filter inlet.
H. Cup, grease.
J. Hose, car heater.
K. Connection, pump inlet.
L. Hose, pump inlet.
M. Clamp, hose.
N. Pipe, radiator to pump.
P. Screw, advance control.

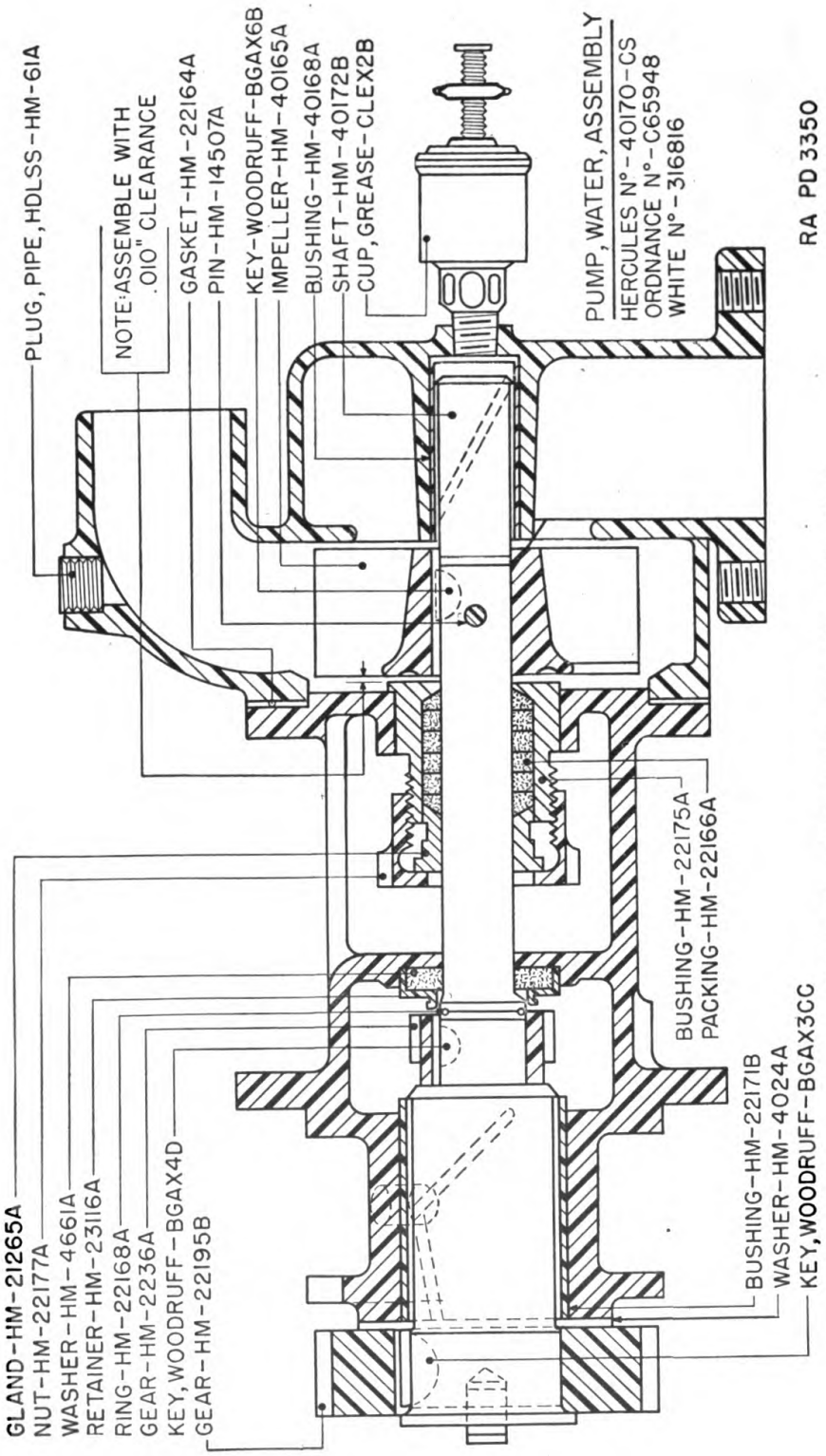


FIGURE 24.—Water pump assembly, sectionalized.

(3) *Specifications.*

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Loss of cooling water.*	
(*a*) Defective hose.	(*a*) Replace hose.
(*b*) Loose hose connection.	(*b*) Tighten connections.
(c) Defective pump packing seal.	(*c*) Replace packing.
(*d*) Defective pump shaft.	(*d*) Replace shaft.
(2) *Overheating.*	
(*a*) Lack of water.	(*a*) Refill system.
(*b*) Water pump not functioning.	(*b*) Check drive shaft bearings and impeller. Repair or replace pump.

c. Water pump removal.—Tools:

Straightedge.	Scriber.
¾-inch open end wrench.	Screw driver.
9/16-inch open end wrench.	Pliers.
7/16-inch open end wrench.	Soft metal hammer.
(1) *Drain cooling system.*	Pliers.

Open drain cock at lower left-hand radiator hose connection.

(2) *Remove distributor from water pump.* — Screw driver.

Loosen spark control wire clamping screw and remove wire. Remove distributor advance screw with two plain washers and spring washer and carefully lift distributor from its bearing so as not to move distributor shaft (fig. 25).

(3) *Mark distributor shaft timing position.* — Straightedge. Scriber.

Holding distributor, place a straightedge on shaft bearing in line over drive gear retaining pin and scribe a line on the pin and bearing which will indicate position of gear when distributor is installed (fig. 26).

(4) *Disconnect pump inlet and car heater hose.* — Screw driver.

Disconnect pump hose clamp and car heater hose clamp at water pump inlet elbow and slide hose from pipes.

(5) *Remove pump attaching screws.*

9/16-inch open end wrench.
3/4-inch open end wrench.

Remove four cap screws and lock washers from water discharge inlet pipe. Then remove three cap screws and lock washers holding pump assembly to rear of gear housing (fig. 27).

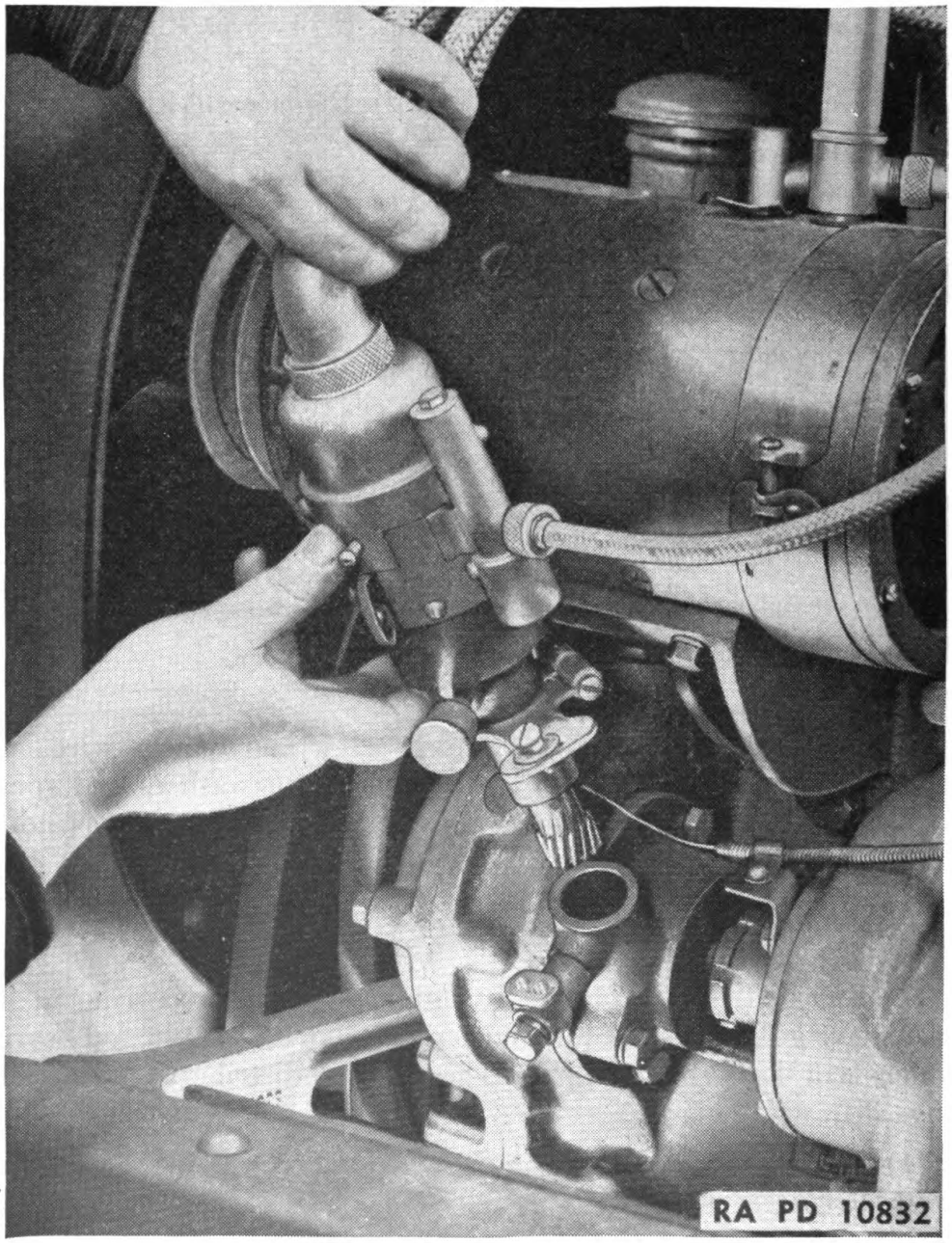


FIGURE 25. - Removal of distributor assembly.

(6) *Remove pump assembly.* Soft metal hammer.

Pull water pump back until gear is clear of timing gear housing and lift out water pump assembly (fig. 28). Then take off pump gasket and elbow gasket. It may be necessary to tap pump lightly with a brass hammer to free sleeve mounting from gear case before pump can be pulled out.

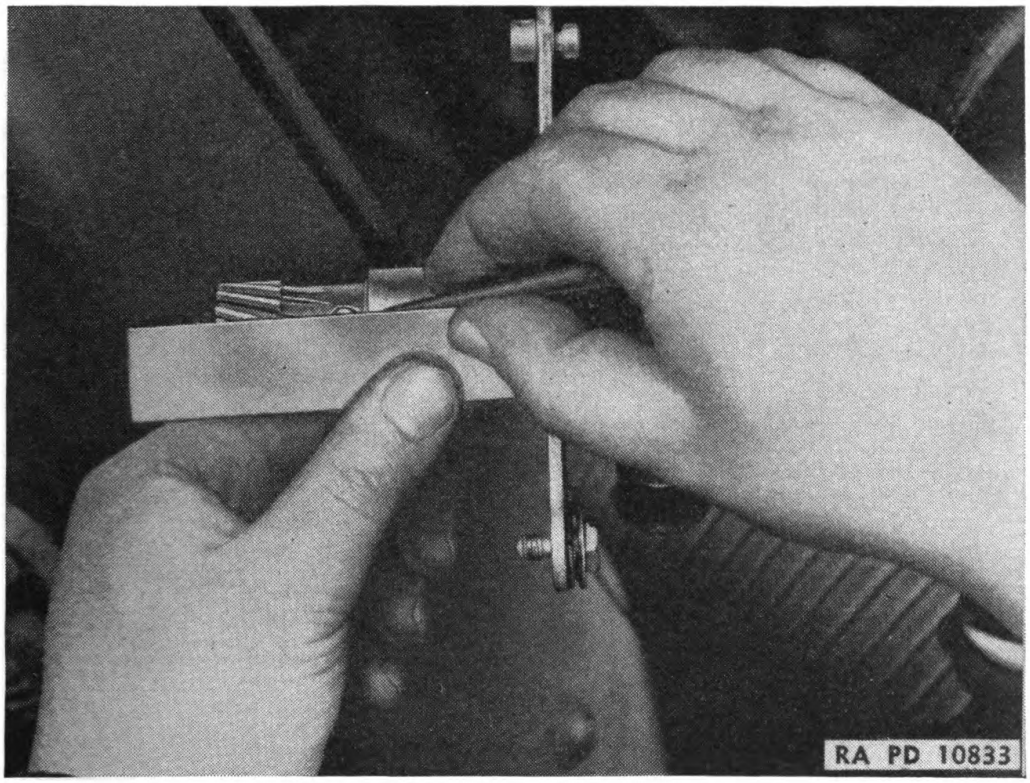


FIGURE 26.—Indicating distributor timing position.

d. Water pump disassembly (fig. 29).—Tools:

Screw driver.	Arbor press.
½-inch open end wrench.	Pliers.
Hammer.	Spanner wrench.
Punch.	Wooden mallet.
Vise.	9/16-inch open end wrench.

(1) *Remove discharge pipe and hose assembly from pump.* Screw driver.

Loosen hose clamp at pump outlet connection and pull off hose and discharge pipe assembly.

(2) *Remove water pump cover assembly.* ½-inch open end wrench.

Punch-mark pump body and cover beside one of the screws to prevent reassembling pump body in the wrong position. Then remove four cap screws and lock washers from pump cover flange and separate pump cover assembly from pump body assembly, releasing gasket.

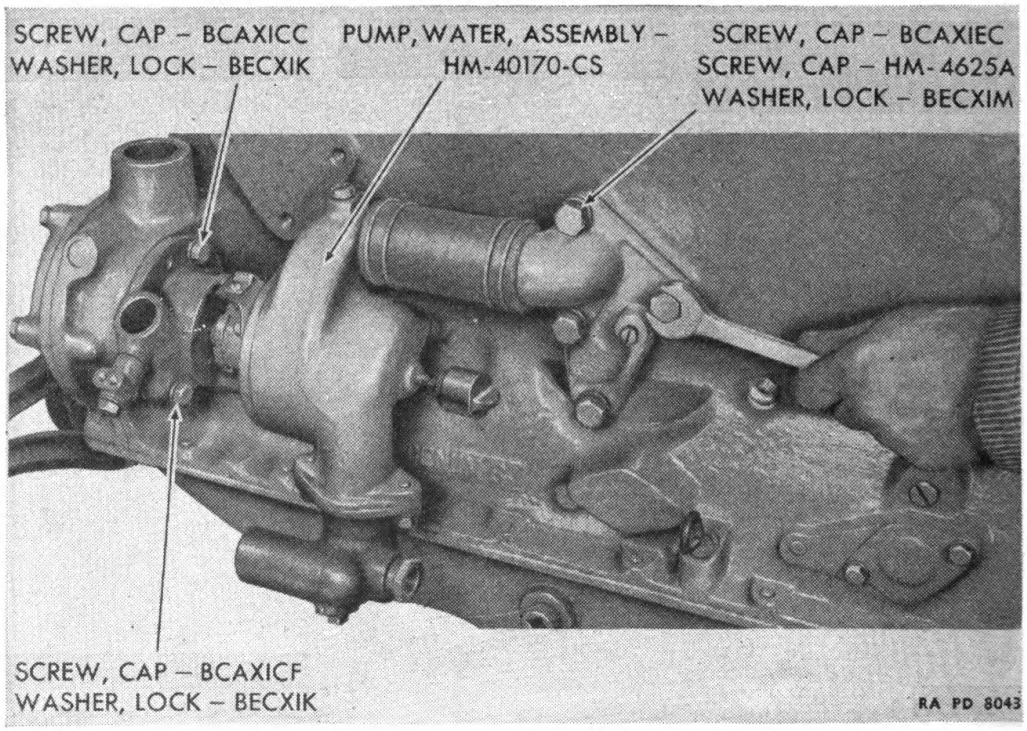


FIGURE 27.—Water pump assembly removal.

(3) *Remove water pump impeller retaining pin.* Hammer.
Punch.
Vise.

Clamp impeller shaft in a vise and drive out impeller retaining pin.

(4) *Remove water pump impeller from shaft.* Arbor press.

Place pump cover and shaft under an arbor press and pass shaft out of impeller about ½ inch. Then place a steel supporting block between impeller and cover, and press shaft out of impeller.

(5) *Remove shaft and gear assembly from pump cover.* Pliers.

Remove impeller Woodruff key from shaft, slide shaft out through front of cover, and remove thrust washer from shaft.

(6) *Remove pump packings from cover bushing.* Spanner wrench.

Remove pump packing nut from bushing and take out packing gland and four packings.

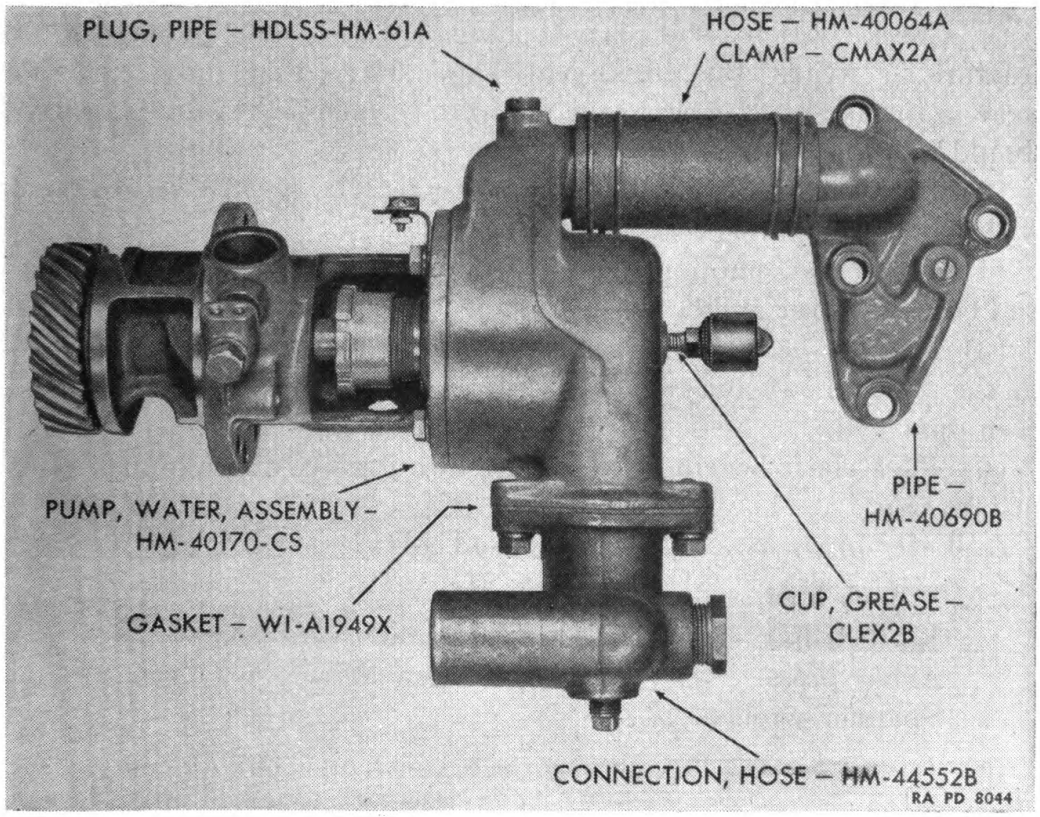


FIGURE 28.—Water pump assembly, dismounted.

(7) *Remove grease retainers from pump shaft bearings.* Pliers.

Pull out washer retainer and apply grease, water pump, to retaining washer from pump shaft bearing at front of water pump cover.

(8) *Remove distributor drive gear from pump shaft.* Wooden mallet. Pliers.

Drive pump shaft out of distributor drive gear by holding gear and tapping end of shaft with mallet. After gear is removed, pull Woodruff key from shaft.

(9) *Remove water pump drive gear from shaft.* Arbor press.

Press long end of pump shaft through drive gear and remove Woodruff key from shaft.

(10) *Remove shaft bearing grease cup.* $\frac{9}{16}$-inch open end wrench.

Remove grease cup located on back of water pump body.

e. Maintenance.—(1) Clean and inspect all water pump parts before impeller is removed.

(2) Check shaft for end play, bushings for wear, and gear teeth for fracture or wear. Bushings, gears, and shafts that show signs of wear to the extent of causing the pump to become noisy or inoperative should be replaced.

(3) Packing ring seals, if broken or brittle, should be replaced with new seals.

(4) When reassembling pump, use new gaskets on attaching flange and between cover and body.

(5) It is not necessary to remove the inlet elbow, which is attached to the pump body by two cap screws, unless the body casting has been damaged.

(6) Pack shaft bearing grease cup with grease, water pump, after installation.

f. Water pump assembly (fig. 29).—Tools:

$\frac{1}{2}$-inch open end wrench.	Punch.
$\frac{9}{16}$-inch open end wrench.	Hammer.
Arbor press.	Screw driver.
Spanner wrench.	

(1) *Install bearing grease cup.* $\frac{9}{16}$-inch open end wrench.

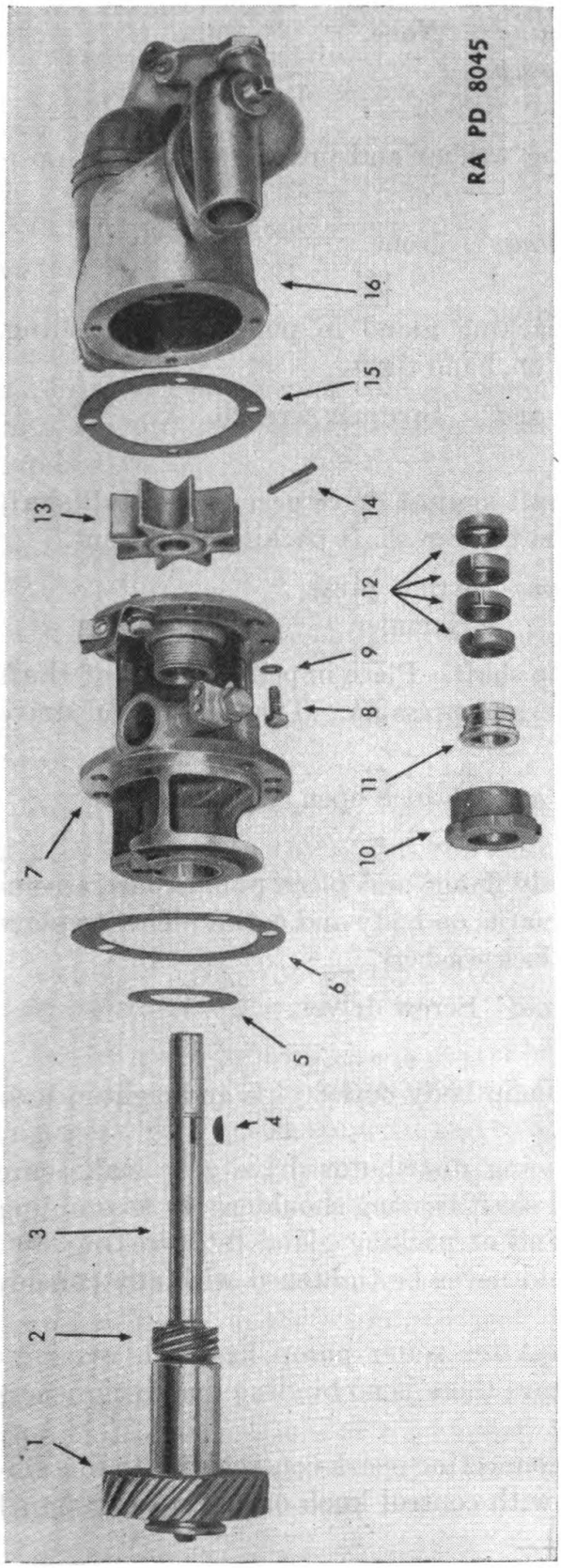
Install pump bearing grease cup in rear of pump body.

(2) *Install water pump drive gear.* Arbor press.

Insert Woodruff key in pump shaft. Slide gear down shaft until gear keyway engages key, and press on.

(3) *Install distributor drive gear on shaft.* Arbor press.

Insert Woodruff key in water pump shaft. Slide gear down shaft so keyway in gear engages key, and press on; then insert gear retaining snap ring.



1. Gear—HM–22195B.
2. Gear—HM–22336A.
3. Shaft—HM–40172B.
4. Key—BGAX6B.
5. Washer—HM–4024A.
6. Gasket—HM–22149A.
7. Cover assembly—HM–40171CS.
8. Screw, cap—BCAXIBA.
9. Washer, lock—BECXIH.
10. Nut—HM–22177A.
11. Gland—HM–21265A.
12. Packing—HM–22166A.
13. Impeller—HM–40165A.
14. Pin—HM–14507A.
15. Gasket—HM–22164A.
16. Body assembly—HM–45735CS.

FIGURE 29.—Water pump assembly, exploded view.

(4) *Install grease retaining washer and retainer in pump cover.* None.

Insert pump grease retaining washer and press retainer into position over washer.

(5) *Install packings in pump cover bushings.* None.

Place four packings and packing gland in pump cover bushing. Then screw packing gland nut on, hand tight.

(6) *Install pump shaft and gear assembly in cover.* Spanner wrench.

Place thrust washer onto shaft against drive gear and install shaft assembly in pump cover. Then tighten shaft packing gland nut.

(7) *Install impeller on pump shaft.* Arbor press.
Hammer.

Insert Woodruff key in pump shaft. Place impeller on end of shaft so keyway in impeller engages, and press on. Then insert and drive home impeller retaining pin.

(8) *Install pump cover assembly.* ½-inch open end wrench.

Position gasket on pump body flange and place pump cover assembly on body, lining up punch-marks on body and cover. Then replace four attaching cap screws and lock washers.

(9) *Connect discharge pipe and hose to pump.* Screw driver.

Slide elbow hose on water pump body outlet pipe and tighten hose clamp.

(10) *Precautions.*—In replacing distributor drive gear make sure that hub side of gear is toward shaft bearing shoulder. In assembling pump packing, place flanged end of packing gland into packing nut. Pump packing gland nut should never be tightened with any considerable force.

(11) *Inspection and tests.*—After water pump has been reassembled, spin gear shaft to make sure there is no binding due to tightness of packing gland nut.

(12) *Adjustments.*—When connecting spark control wire to distributor control arm, clamp wire with control knob on instrument panel

all the way in (down position), and distributor control arm all the way forward (advance position).

g. Water pump installation.—Tools:

¾-inch open end wrench.
9/16-inch open end wrench.
Screw driver.

(1) *Replace water pump assembly and discharge pipe.*

9/16-inch open end wrench.
¾-inch open end wrench.

Place water pump assembly in position so that pump drive gear meshes with idler gear in gear case. Use new gasket between pump assembly and gear housing and between discharge pipe and block. Secure assembly between gear housing and block with lock washers and cap screws.

(2) *Connect radiator outlet hose and car heater hose to pump inlet elbow.* Screw driver.

Slide radiator hose on elbow and heater hose on pipe elbow. Then tighten hose clamps.

(3) *Install distributor on pump cover.* None.

Make sure that scribed lines on distributor bearing and on drive gear retaining pin are in line, and slide distributor in mounting bearing on pump cover so that slot in distributor advance arm is over arm retaining screw lug.

(4) *Connect spark control wire and secure distributor.* Screw driver.

Insert spark control wire in swivel hole on advance arm and tighten clamping screw. Then replace distributor arm advance control retaining screw with one shakeproof and two plain washers.

NOTE.—If the engine is rotated for the disassembly of other parts, or for any other reason during the time that the water pump and distributor are removed from the engine, the ignition will have to be retimed (see par. 29*e*(5)).

(5) *Inspect for leaks.*—After the water pump has been installed and water replaced in the cooling system, run the engine at idling speed. Inspect hose connections, flanges, and packing gland nut for water leaks. Inspect the shaft where it comes through the pump cover and the oil line connections at the engine block elbow flange for oil leaks.

21. Radiator.—Information concerning the radiator can be found in TM 9–1709.

SECTION VII

ELECTRICAL—GENERATOR AND REGULATOR

22. Description of circuit (fig. 30).—The generator is a 12-volt, 4-brush, 4-pole heavy duty machine, supported on the left side of the engine about level with the top at the front. It is driven by V-belts from the crank shaft. The regulator consists of a cut-out relay, a voltage regulating coil, and a current regulating coil, each controlling a pair of contacts. The regulator is in the circuit between the battery and the generator and automatically keeps the voltage and current delivered by the generator within rated limits. This regulator is mounted in front of the dash, at the left, under the hood of the engine, and is inclosed in a metal casing.

23. Trouble shooting for circuit.

Symptom and probable cause	*Probable remedy*
a. Low or no generator output.	
(1) Dry battery.	(1) Refill cells.
(2) Poor battery condition.	(2) Replace battery.
(3) Fully charged battery.	(3) None (check output when battery is slightly discharged).
(4) Loose or dirty connections.	(4) Clean and tighten.
(5) Burned contacts on regulator units.	(5) Clean or replace contacts (check generator field condition).
(6) Grounded armature wires or terminal posts.	(6) Replace wires, insulate terminals.
b. High generator output.	
Short circuit between field and output circuits.	If necessary, replace field windings. Check regulator contacts.
c. High discharge on ammeter.	
Regulator circuit breaker closed.	Repair and adjust circuit breaker. Check generator for damage.

d. Quick checks to determine if units are operating properly.—The following checks can be made to determine whether or not units are operating normally. If not, the checks will indicate whether the generator or regulator is at fault so that the proper corrective steps can be taken.

(1) *Fully charged battery and low charging rate.*—This condition indicates normal voltage regulation. To check further, disconnect the

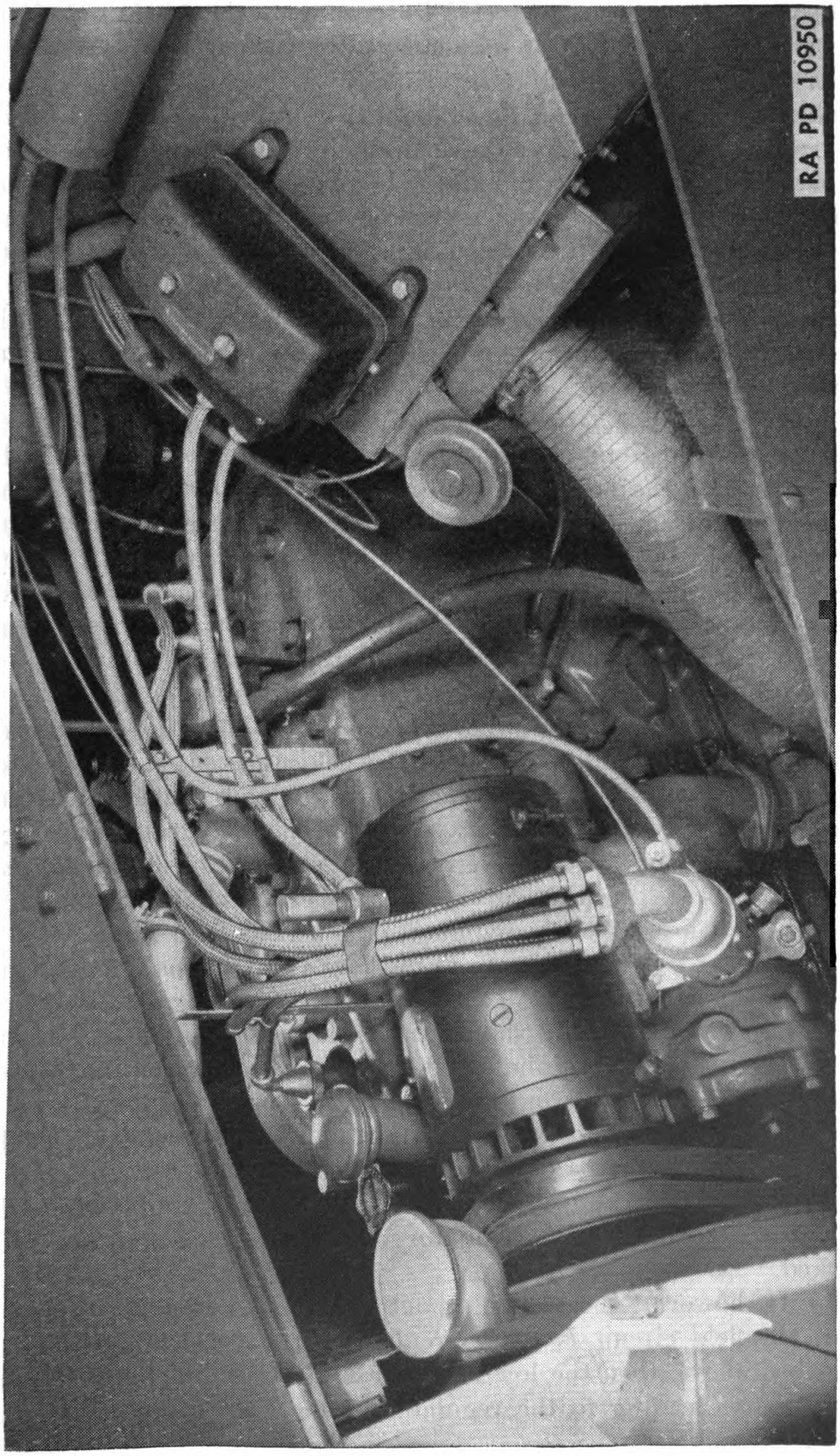


FIGURE 30.—Generator and regulator, installed.

battery wire from the battery (BAT) terminal of the regulator. Connect the positive lead of an ammeter to the battery wire. With the ignition switch in the "off" position, step on the starting switch and crank the engine for about 15 seconds; then start the engine. While it is running at medium speed turn on the lights and any other electrical accessories used on the car and note quickly the generator output, which should be very nearly (not exceed) the value at which the current regulator is set. Then turn off all electrical accessories (lights, etc.) that were on and allow the engine to continue running. As soon as the generator has replaced in the battery the current used in cranking, the voltage regulator, if operating properly, will taper the output down to a few amperes.

(2) *Fully charged battery and high charging rate.*—This condition indicates malfunctioning of generator or regulator. Disconnect the field wire from the field (F) terminal of the regulator. This opens the field circuit and the output should immediately drop off to a very few amperes. If it does not, it is an indication that a short circuit exists between the field circuit and output circuit somewhere ahead of the regulator, probably in the generator itself. If the output drops off with the field circuit disconnected at the regulator the trouble is isolated in the regulator. Remove and check the regulator.

(3) *Low battery and low or no charging rate.*—This may be caused by a number of conditions. Check the field and output circuits for loose connections. Check for corroded battery terminals, loose or corroded ground strap, and frayed or damaged wires. The high resistance resulting from these conditions will prevent the normal charge from reaching the battery. If the entire charging circuit is in good condition, either the regulator or generator is at fault.

(*a*) Connect a jumper wire from the field (F) terminal of the regulator to the generator (GEN) terminal of the regulator. This short-circuits the regulator and should cause the generator output to increase quickly as the engine speed is increased to a medium speed. (Care must be taken to avoid excessive engine speed, as this may cause the generator greatly to exceed its maximum output rating.) If the output does increase, the generator may be assumed to be in operating condition and the cause of the low charging rate would be in the regulator. To find it, the regulator would have to be removed and checked.

(*b*) If, however, the generator output remains at a few amperes when the field circuit is short-circuited to the generator circuit as described above, then the low output would be caused by an "open" in the wires leading to the regulator or by some cause within the

generator. The generator and wires leading from it would have to be removed and checked to determine the exact cause.

24. Generator.—*a. Description.*—The generator is a 12-volt, d-c, 4-brush, 4-pole heavy-duty machine. It is air-cooled by means of the fan which is part of the drive pulley.

(1) *Construction* (fig. 31).—The generator field frame has the form of a hollow cylinder. The four pole shoes and four field coils are attached on the inside of this frame. Within the frame-and-field assembly the armature is supported. One end of its shaft projects through a bearing in a head assembly secured to the extremity of the frame-and-field assembly, and carries a pulley for the drive belt. The other end, at which the commutator is located, is engaged by a bearing in a second head assembly, which holds the commutator brushes and closes the opposite extremity of the frame-and-field assembly. A bracket is screwed to the bottom of the frame-and-field assembly and to the side of the engine, fastening the generator in place with the commutator at the rear and the pulley to the front in line with the engine fan. Both head assemblies have openings and on the rear face of the drive pulley are vanes which force air through the generator from end to end to ventilate and cool it. On top of the frame-and-field assembly, near the commutator end, are insulated, shielded terminal posts to which the armature and field windings are separately attached.

(2) *Functioning.*—The generator converts a small amount of mechanical energy which is carried to the battery, where it is stored for future use. In actual operation some of the energy is used directly from the generator, but for explanatory purposes it is assumed to flow from the generator to the battery and then to be drawn from the latter.

(3) *Specifications.*

Make	Electric Auto-lite Co.
Model	12-volt.
Ordnance No.	B167664.
Manufacturer's No.	GDJ–4802–A.
White No.	344910.
Rotation	Clockwise viewed from driven end.
Type of winding	Shunt.
Voltage	12.
Ground	Negative.
Number of brushes	4.
Number of poles	4.

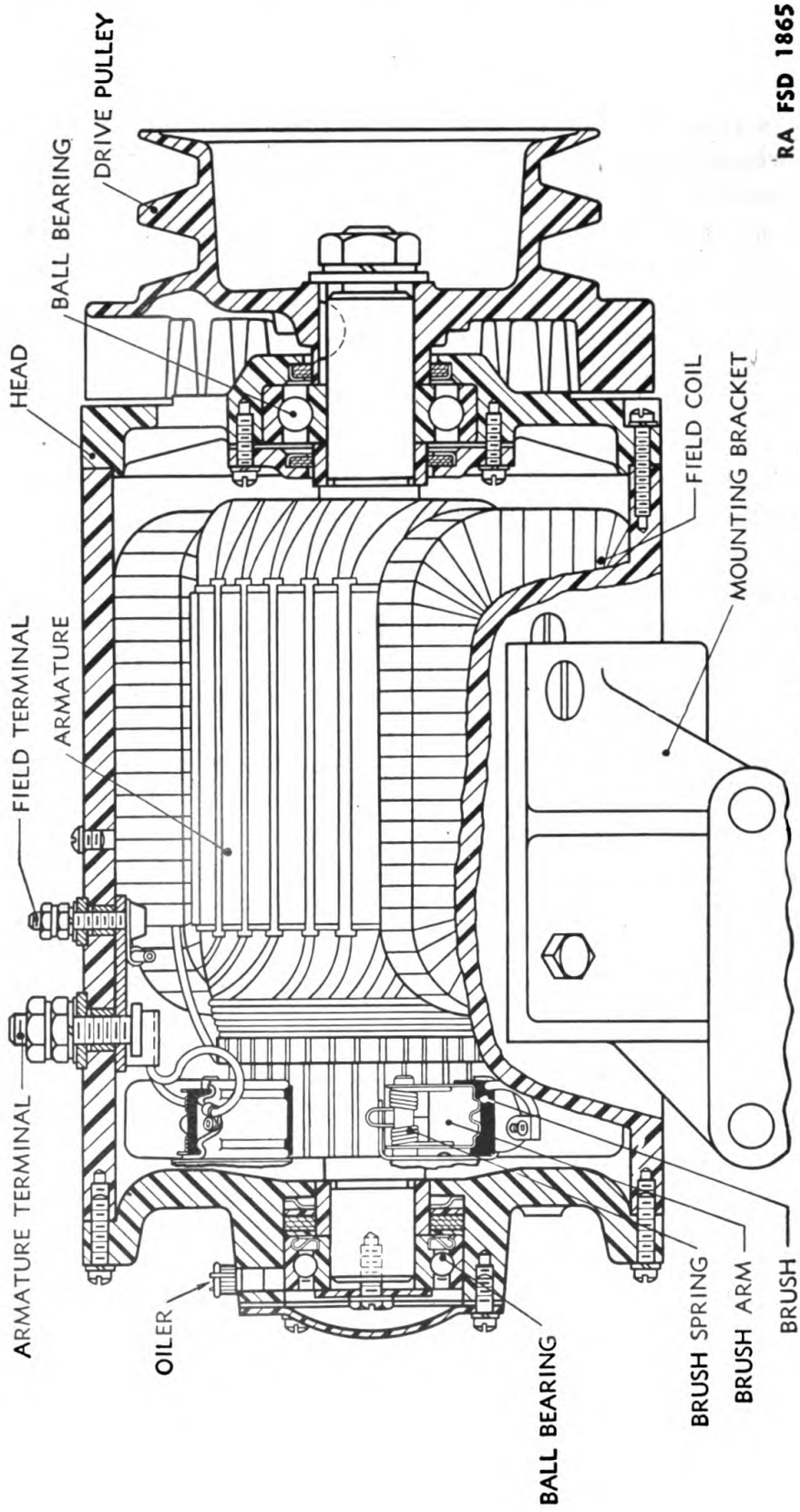


FIGURE 31.—Generator assembly, sectionalized.

Controlled output---------- 55 amperes.
Fuse---------- None.
Control---------- Voltage regulator.

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Noise at engine idle speed.*	
(*a*) Broken bearing.	(*a*) Replace.
(*b*) Loose pulley.	(*b*) Tighten.
(*c*) Loose pole piece.	(*c*) Tighten.
(*d*) Commutator damaged.	(*d*) Repair or replace.
(*e*) Bent armature shaft.	(*e*) Replace.
(2) *Low current or no current.*	
(*a*) Open circuit in brush connections.	(*a*) Check and repair.
(*b*) Brush sticking in holder.	(*b*) Loosen and place on commutator.
(*c*) Open circuit due to worn brush.	(*c*) Replace brush.
(*d*) Open circuit due to broken brush spring.	(*d*) Replace spring.
(*e*) Open circuit due to dirty commutator.	(*e*) Clean commutator.
(*f*) Open circuit in field coil.	(*f*) Replace coil.
(*g*) Short circuit or ground in commutator.	(*g*) Repair or replace.
(*h*) Short circuit or ground in armature.	(*h*) Repair or replace.
(*i*) Short circuit or ground at main terminal.	(*i*) Repair or replace.
(*j*) Short circuit or ground in brush connections.	(*j*) Repair or replace.
(*k*) Short circuit or ground in brush holders.	(*k*) Repair or replace.
(3) *Blue sparking at commutator.*	
(*a*) Flattened bars.	(*a*) Turn down commutator.
(*b*) Open circuit in armature.	(*b*) Repair or replace.
(4) *Excessive heating of armature.*	
Ground or short circuit in armature.	Repair or replace.

Symptoms and probable cause	*Probable remedy*
(5) *Field coils heat, little current produced.*	
Ground or short circuit in fields.	Repair or replace.
(6) *Generator hot or burned out.*	
Circuit breaker open.	Repair and adjust circuit breaker. Test and repair or replace generator.
(7) *Battery discharged and generator insulation damaged.*	
Circuit breaker closed.	Repair and adjust circuit breaker and repair or replace generator. Recharge battery.

c. Generator removal.—Tools:

Screw driver.	9/16-inch socket wrench.
3/8-inch thin wall socket wrench.	Channellock pliers.
	3/4-inch socket wrench.
5/8-inch open end wrench.	Ratchet extension.
(1) *Disconnect field conduit.*	Screw driver.
	3/8-inch thin wall socket wrench.
	5/8-inch open-end wrench.

Unscrew plug at top of generator field terminal shield housing (fig. 32). Detach upper terminal hex nut and plain washer. Unscrew conduit nut from field terminal housing. Disconnect terminal wire in conduit and pull terminal out of housing assembly (fig. 33).

(2) *Disconnect armature conduit.*	9/16-inch socket wrench.
	Channellock pliers.

Unscrew condenser assembly from armature terminal shield housing (fig 34). Unscrew conduit nut from armature terminal housing (fig. 35). Remove upper terminal nut and plain washer and detach terminal of wire in conduit (fig. 36). Pull terminal out of housing.

(3) *Remove generator and bracket assembly.*	3/4-inch socket wrench.
	Ratchet extension.

Remove three cap screws and lock washers holding generator frame mounting bracket to engine block (fig. 37). Tilt generator to remove fan belts and lift out generator and bracket assembly.

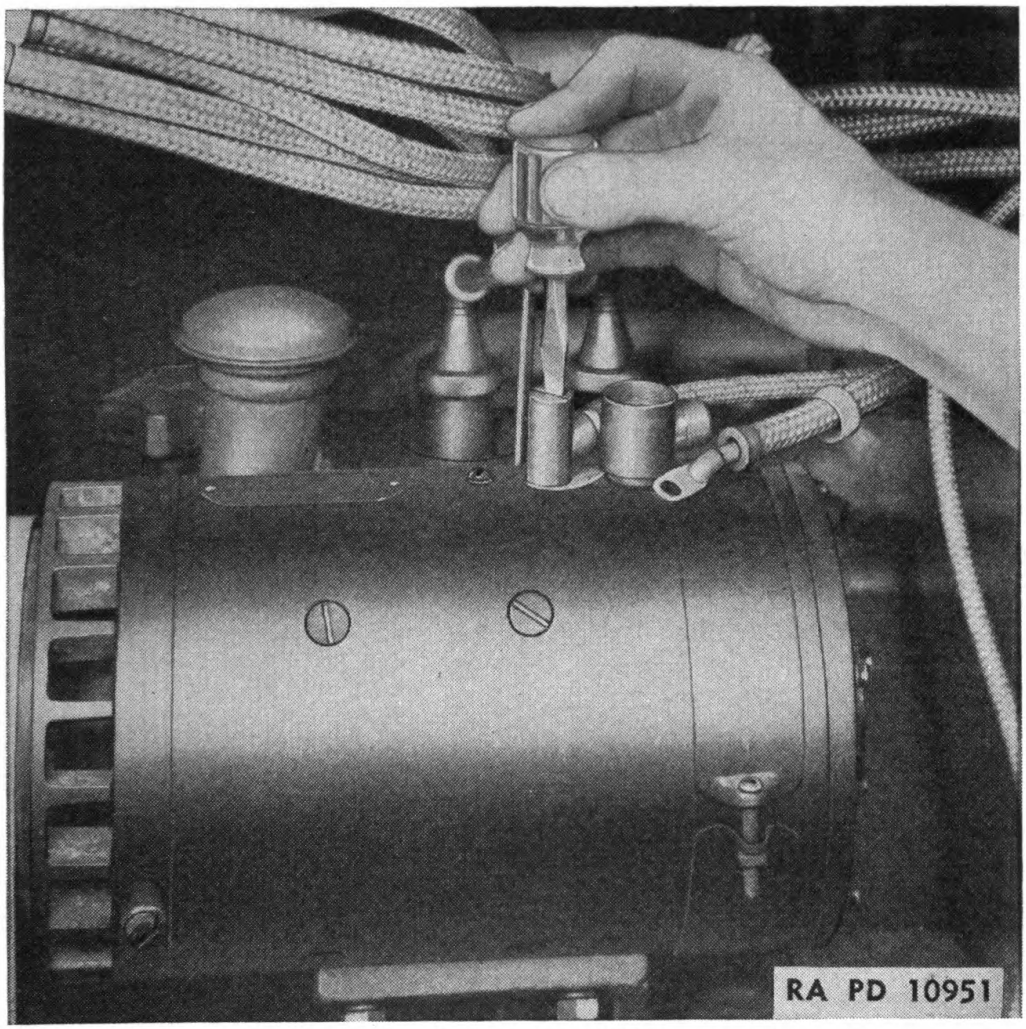


FIGURE 32.—Removing generator field terminal plug.

(4) *Remove mounting bracket.* 9/16-inch socket wrench.
Screw driver.

Remove three cap screws and lock washers and one flathead screw holding bracket to generator.

d. Generator disassembly (fig. 38 ① and ②).—Tools:

Screw driver.
Fan belt (or rope).
Length of pipe.
1-inch socket wrench.
Pulley puller.
Screw driver socket wrench, 9/16-inch face.
3/8-inch thin wall socket wrench.
9/16-inch open end wrench.

(1) *Remove cover band.* Screw driver.

Loosen roundhead machine clamp screw and remove band.

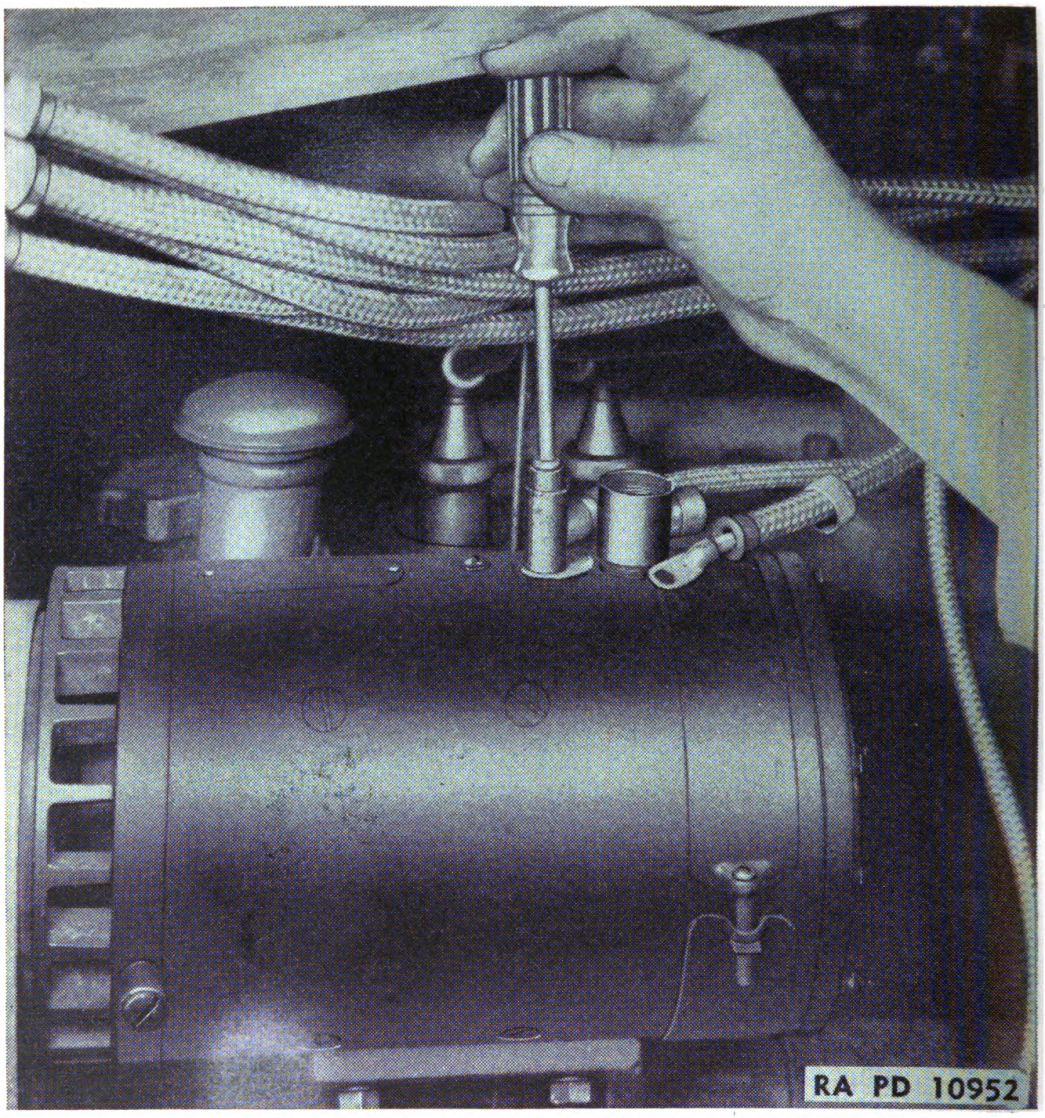


FIGURE 33.—Removing generator field terminal nut.

(2) *Remove pulley.*

Length of pipe.
Belt (or rope).
1-inch socket wrench.
Pulley puller.

Hold pulley with belt and pipe and unscrew hex nut at drive end of armature shaft (fig. 39). Take off plain washer and lock (shakeproof) washer. Remove pulley and Woodruff key (fig. 40).

(3) *Remove drive end head assembly.*

Screw driver.

Take out six oval fillister head machine screws and lock washers. Remove head assembly from frame-and-field assembly and from armature shaft.

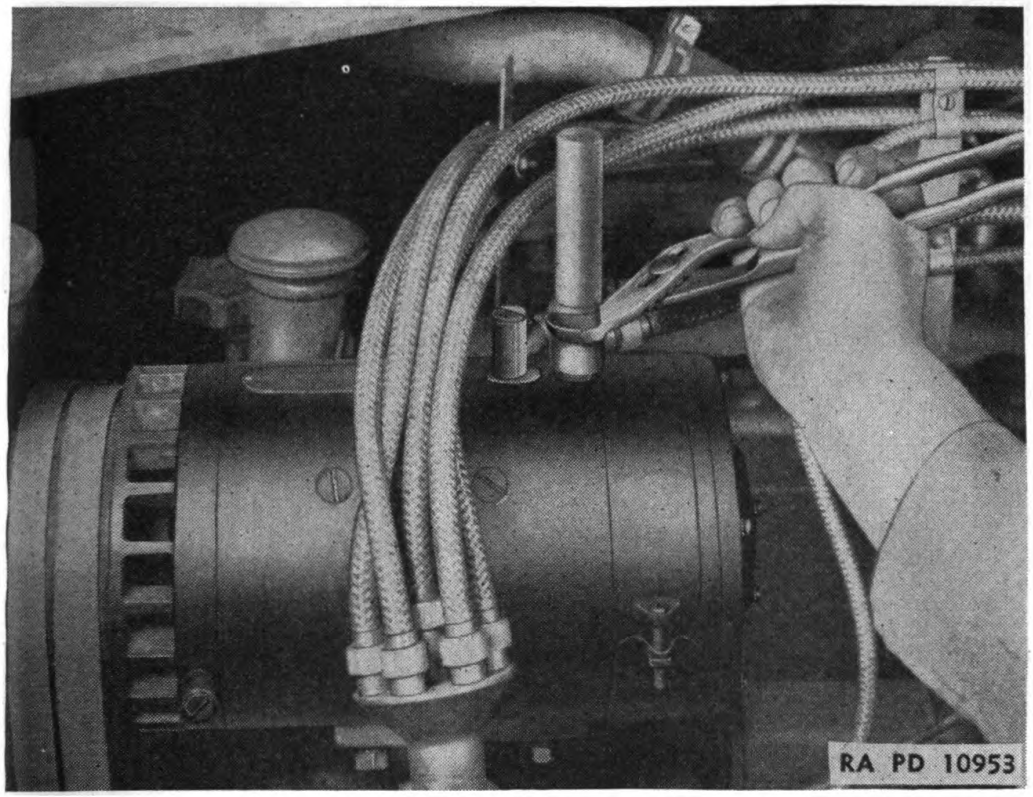


FIGURE 34.—Removing generator armature condenser.

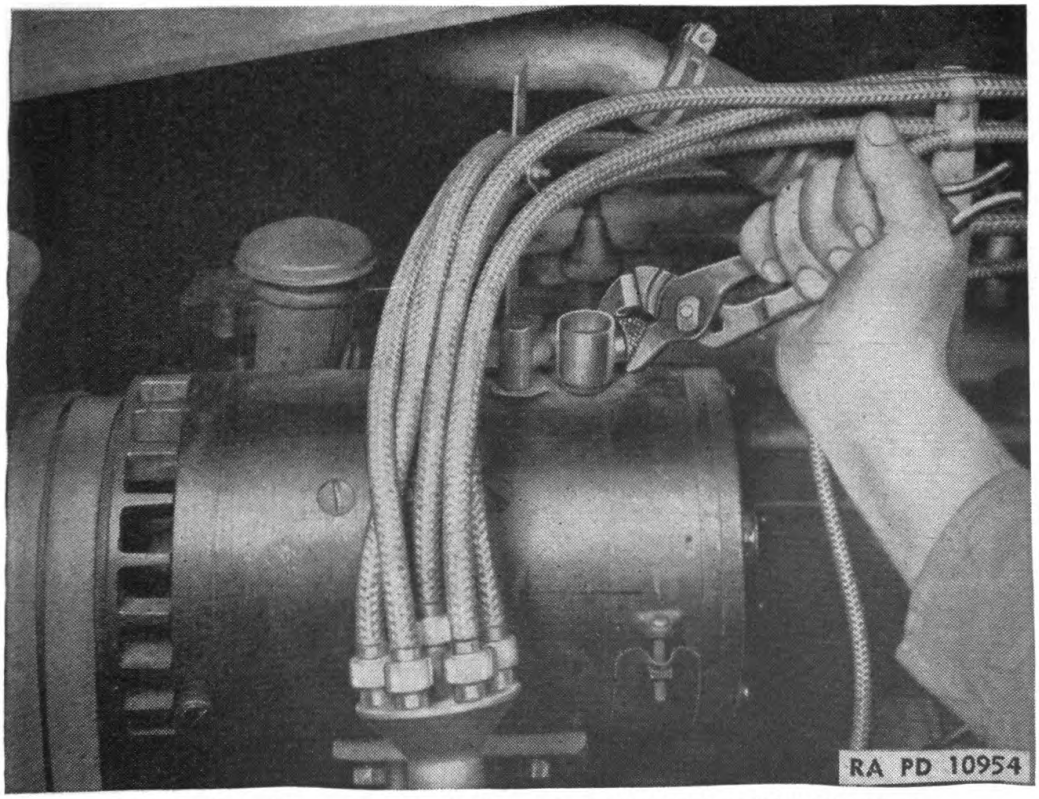


FIGURE 35.—Unscrewing conduit nut from armature terminal housing.

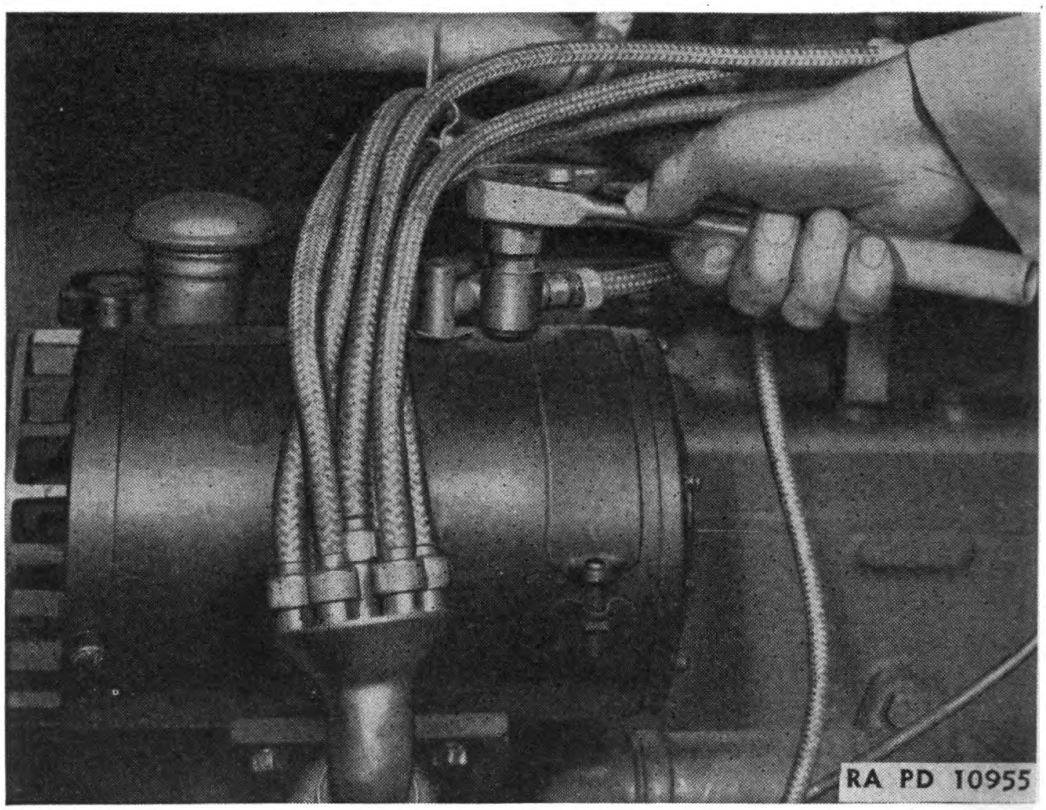


FIGURE 36.—Removing armature terminal nut.

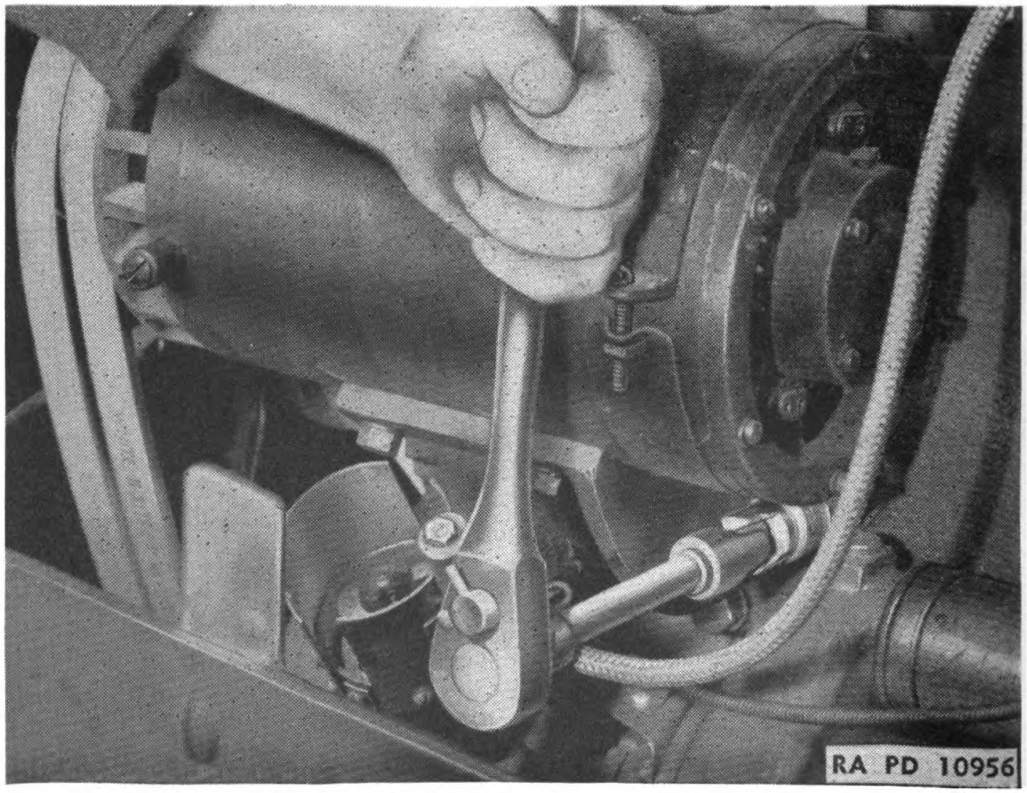


FIGURE 37.—Generator assembly removal.

(4) *Remove ball bearing from head assembly.* Screw driver.

Take out four oval fillister head machine screws and lock washers from bearing retainer. Remove bearing retainer, felt washers, retainers, gasket, and ball bearing.

(5) *Disconnect terminal of field coil and lead assembly from brush holders.* Screw driver.

Remove roundhead machine screws and lock washers from brush holders at inspection openings.

(6) *Remove commutator end head assembly.* Screw driver.

Take out four oval fillister head machine screws with lock washers at cover and remove cover and gasket. Remove hex head cap screw, large plain washer, and lock washer from armature shaft. Remove six oval fillister head machine screws and lock washers from end head. Mark head assembly and frame assembly to facilitate reassembly and remove head assembly.

(7) *Remove ball bearing from commutator end head assembly.* None.

Take out ball bearing, plain washers, felt washer, and external-tooth lock washer.

(8) *Remove brushes and holders.* Screw driver.

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

(9) *Remove armature.* None.

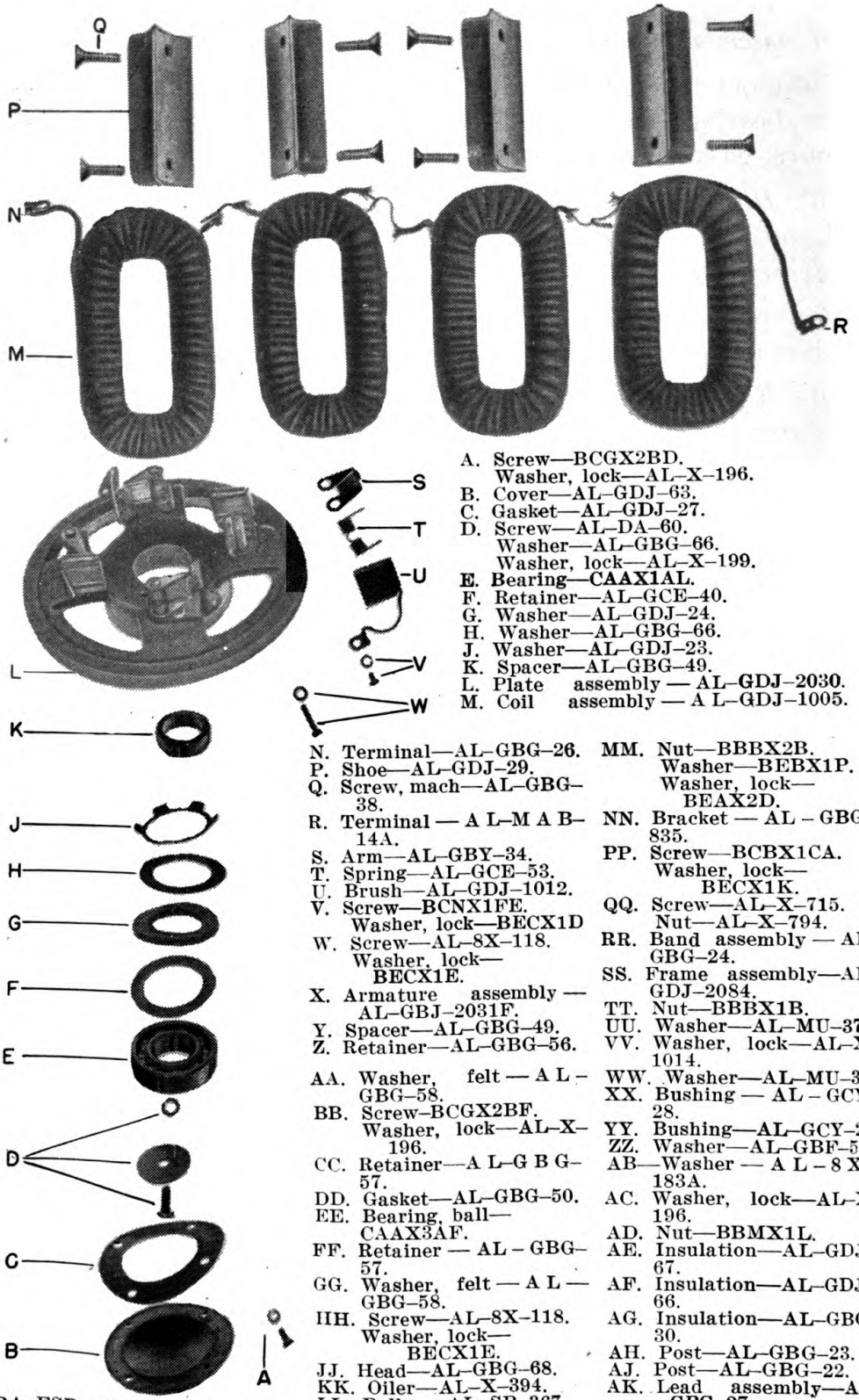
Pull armature assembly out of frame-and-field assembly by hand and slip off spacers from ends of shaft.

(10) *Remove pole shoes.* Screw driver socket wrench, $\frac{9}{16}$-inch face.

Remove flathead machine screws holding poles to frame-and-field assembly and remove pole shoes.

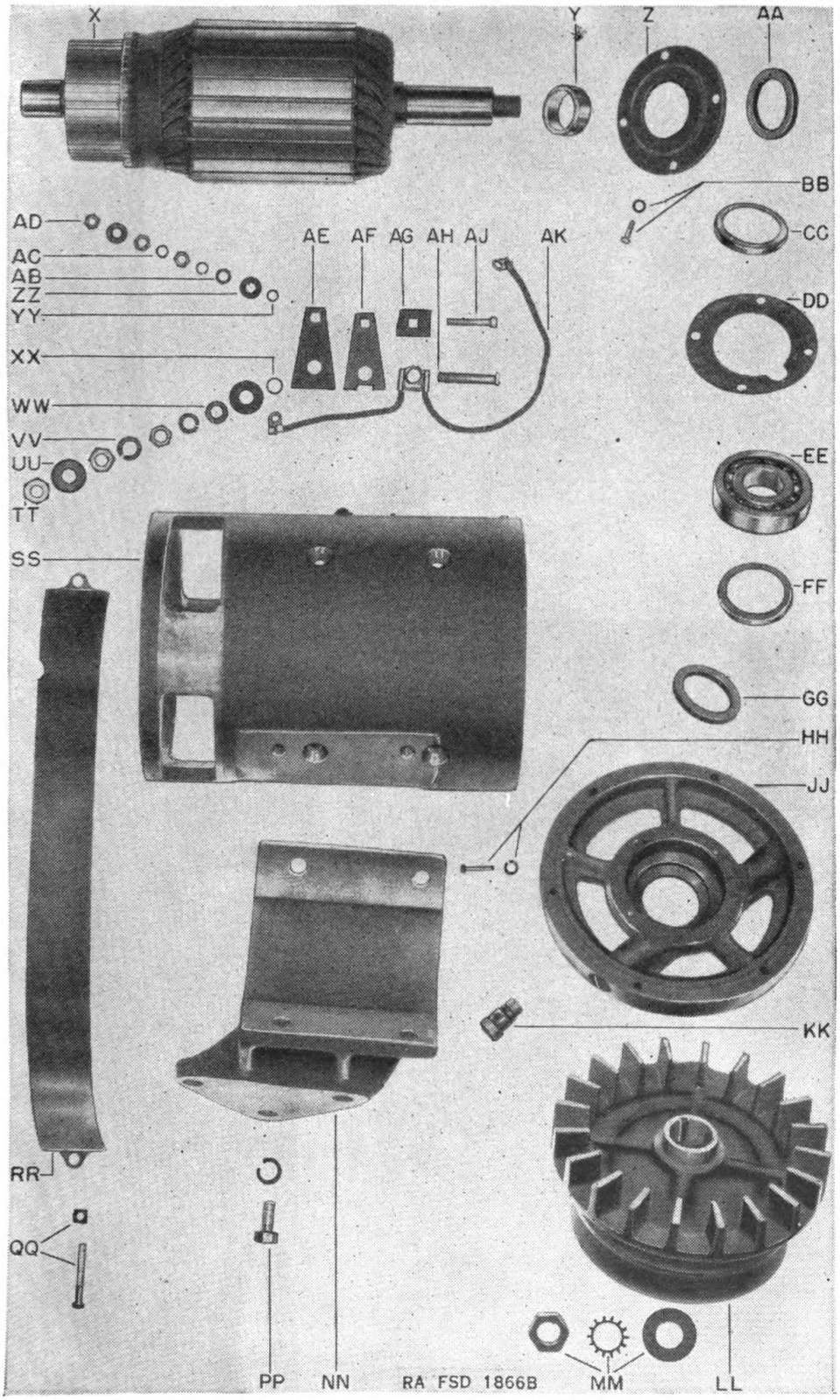
(11) *Remove field coils.* $\frac{7}{16}$-inch thin socket wrench (fig. 41).

Remove hex nuts, lock washer, terminal shield housing, plain washer, and insulating washers from generator frame stud terminal



A. Screw—BCGX2BD.
Washer, lock—AL–X–196.
B. Cover—AL–GDJ–63.
C. Gasket—AL–GDJ–27.
D. Screw—AL–DA–60.
Washer—AL–GBG–66.
Washer, lock—AL–X–199.
E. Bearing—CAAX1AL.
F. Retainer—AL–GCE–40.
G. Washer—AL–GDJ–24.
H. Washer—AL–GBG–66.
J. Washer—AL–GDJ–23.
K. Spacer—AL–GBG–49.
L. Plate assembly — AL–GDJ–2030.
M. Coil assembly — A L–GDJ–1005.
N. Terminal—AL–GBG–26.
P. Shoe—AL–GDJ–29.
Q. Screw, mach—AL–GBG–38.
R. Terminal — A L–M A B–14A.
S. Arm—AL–GBY–34.
T. Spring—AL–GCE–53.
U. Brush—AL–GDJ–1012.
V. Screw—BCNX1FE.
Washer, lock—BECX1D
W. Screw—AL–8X–118.
Washer, lock—BECX1E.
X. Armature assembly — AL–GBJ–2031F.
Y. Spacer—AL–GBG–49.
Z. Retainer—AL–GBG–56.
AA. Washer, felt — A L – GBG–58.
BB. Screw–BCGX2BF.
Washer, lock—AL–X–196.
CC. Retainer—A L–G B G–57.
DD. Gasket—AL–GBG–50.
EE. Bearing, ball—CAAX3AF.
FF. Retainer — AL – GBG–57.
GG. Washer, felt — A L — GBG–58.
HH. Screw—AL–8X–118.
Washer, lock—BECX1E.
JJ. Head—AL–GBG–68.
KK. Oiler—AL–X–394.
LL. Pulley—AL–SP–367.
MM. Nut—BBBX2B.
Washer—BEBX1P.
Washer, lock—BEAX2D.
NN. Bracket — AL – GBG–835.
PP. Screw—BCBX1CA.
Washer, lock—BECX1K.
QQ. Screw—AL–X–715.
Nut—AL–X–794.
RR. Band assembly — AL–GBG–24.
SS. Frame assembly—AL–GDJ–2084.
TT. Nut—BBBX1B.
UU. Washer—AL–MU–37.
VV. Washer, lock—AL–X–1014.
WW. Washer—AL–MU–36.
XX. Bushing — AL – GCY–28.
YY. Bushing—AL–GCY–27.
ZZ. Washer—AL–GBF–55.
AB—Washer — A L – 8 X–183A.
AC. Washer, lock—AL–X–196.
AD. Nut—BBMX1L.
AE. Insulation—AL–GDJ–67.
AF. Insulation—AL–GDJ–66.
AG. Insulation—AL–GBG–30.
AH. Post—AL–GBG–23.
AJ. Post—AL–GBG–22.
AK. Lead assembly—AL–GBG–27.

FIGURE 38①.—Generator parts.



FIGUGE 38②.—Generator parts.

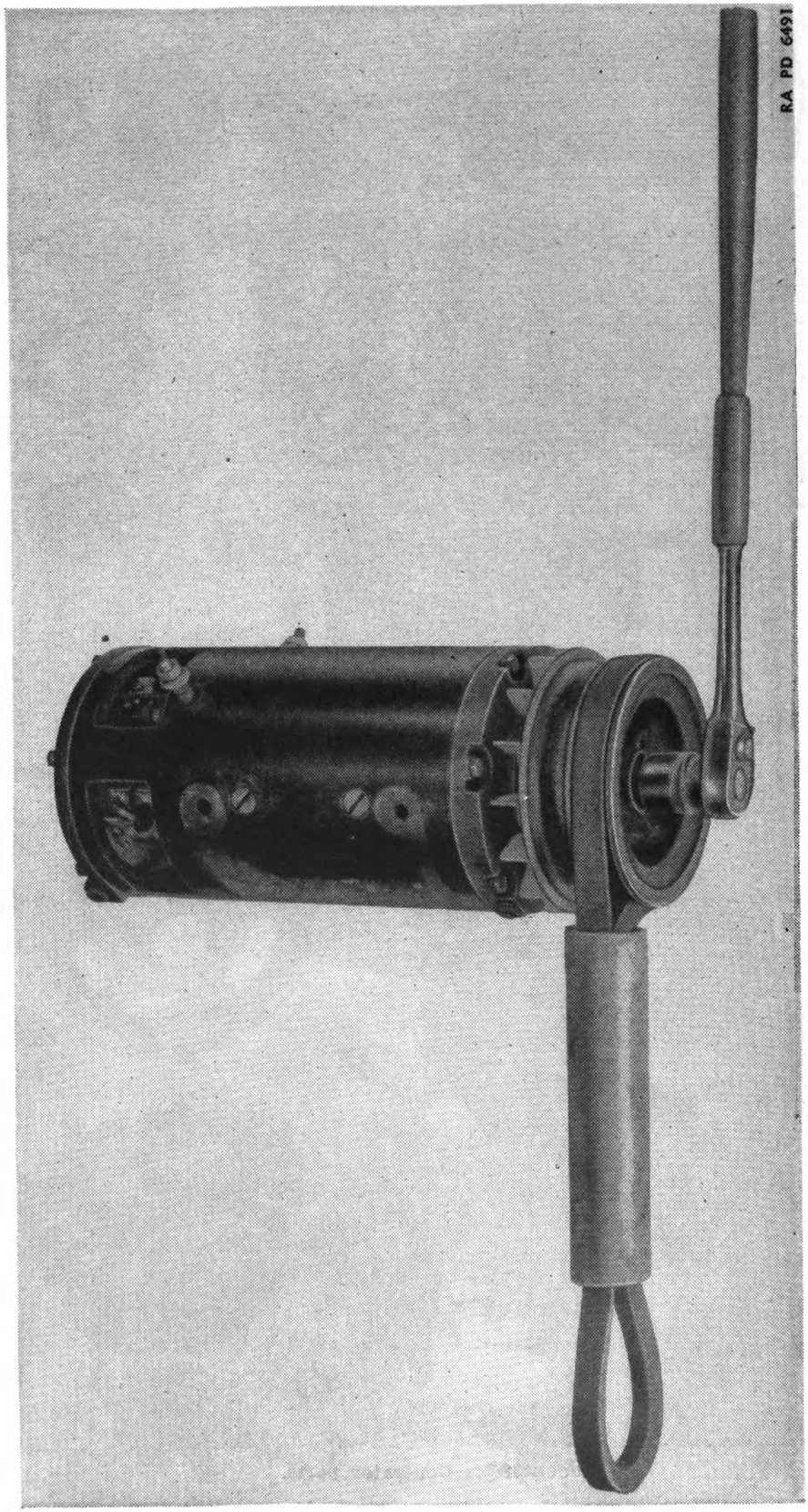


FIGURE 39.—Removing generator pulley nut.

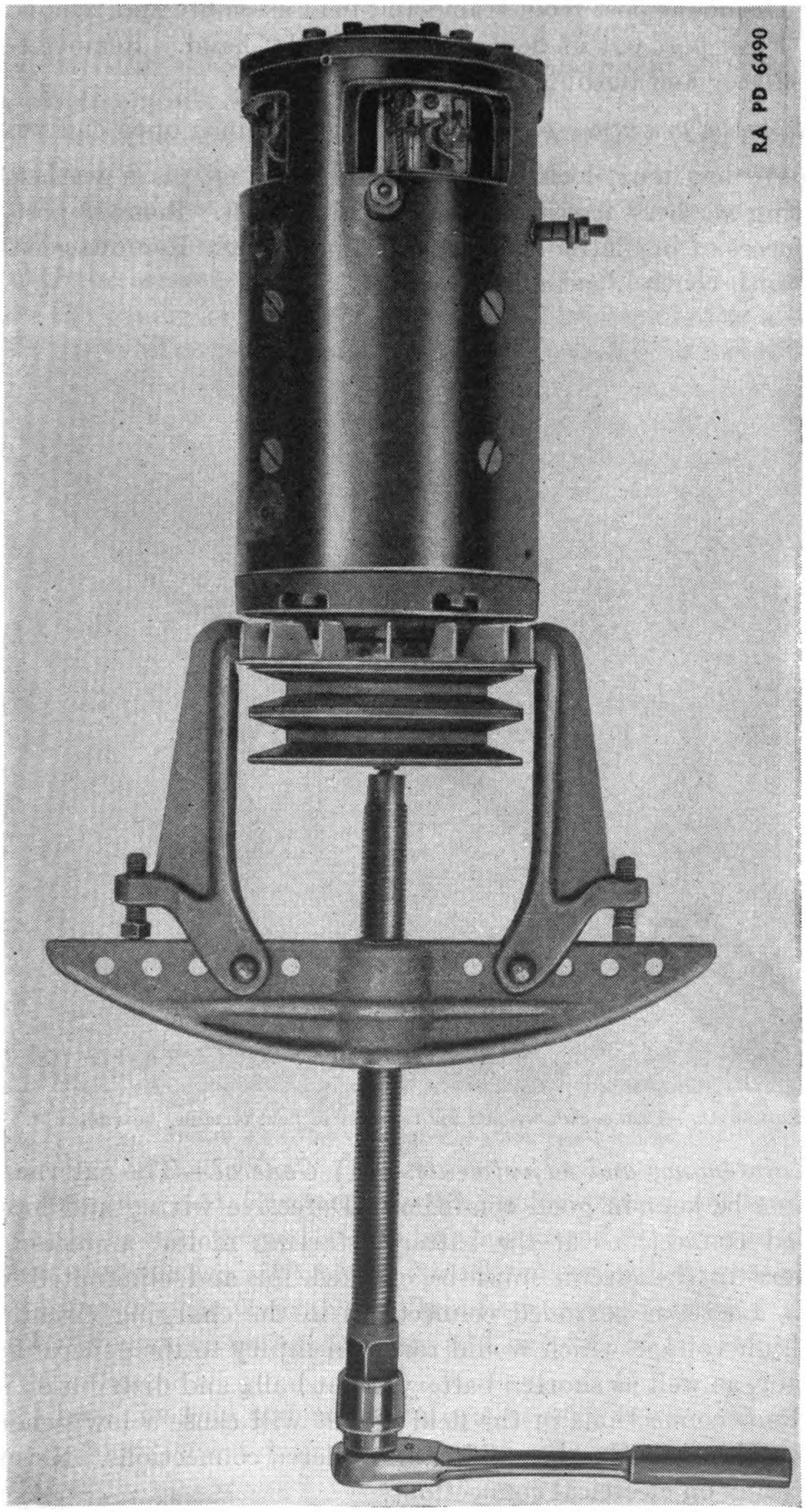


FIGURE 40.—Generator pulley removal.

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.

(12) *Remove armature terminal post.* $\frac{9}{16}$-inch open end wrench.

Remove hex nuts, lock washer, 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.

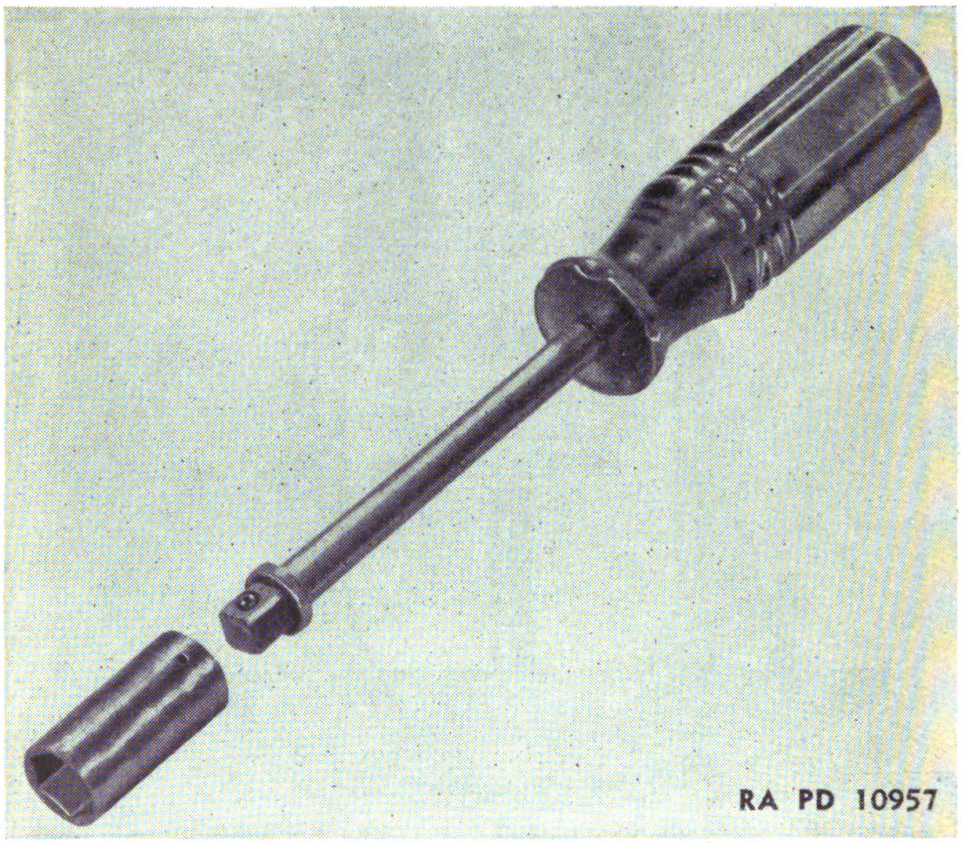


FIGURE 41.—Thin socket wrench for removal of field terminal hexagon nut.

e. Maintenance and adjustments.—(1) *General.*—The external circuit must be kept in good condition. Defective wiring and loose or corroded connections at the battery, starting 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, light bulb, and distributor point life. Poor connections in the field circuit will cause a low generator output. Use rosin flux in making all soldered connections. Never use an acid flux on electrical connections.

(2) *Lubrication.*—Ball bearings at both ends of armature are packed half full with heat-resisting grease, but should be given a few drops of oil, engine, SAE 30, every 1,000 miles.

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

(*b*) If the commutator is rough or 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 as shown in figure 42. The commutator should be inspected at least every 10,000 miles.

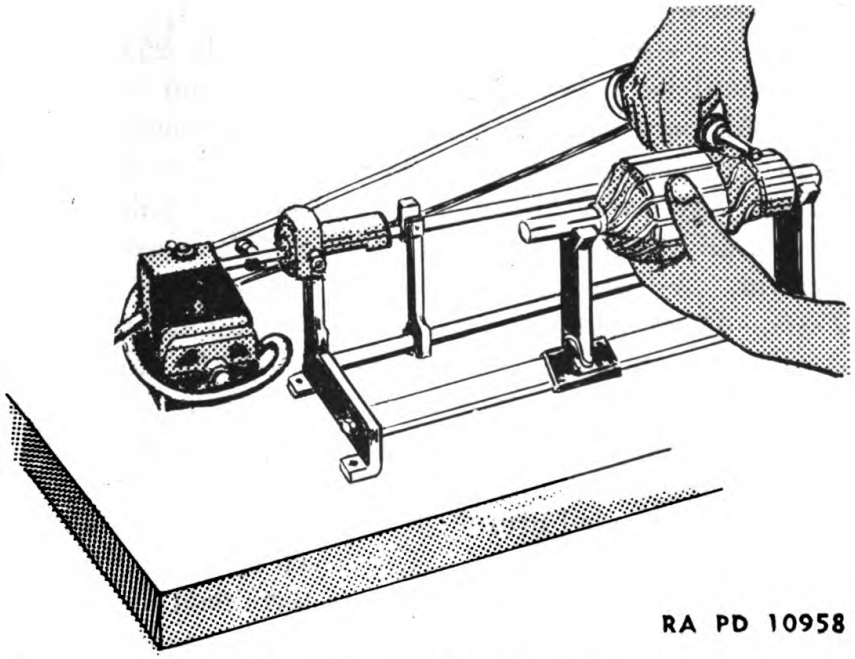


FIGURE 42.—Undercutting armature commutator.

(4) *Brushes.*—(*a*) Check the brush spring tension by hooking a scale in the hole at the end of the brush arm and take reading as the arm leaves the brush. 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.

(*b*) 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.

(*c*) Replace brushes if worn. Brushes must have 80 percent of surface in contact with commutator. To seat the brushes clean commutator with a bedding stone if available. Then wrap around the commutator a piece of No. 00 or 000 sandpaper, of the same width as the commutator, and move it back and forth along the commutator with 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.

(5) *Belt.*—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.

(6) *Generator.*—At intervals of approximately 25,000 miles, 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 and mica or enamel insulation. Ball bearings should be thoroughly cleaned and repacked with lubricant. All worn parts should be replaced.

(7) *Tests.*—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:

(*a*) Raise the grounded brushes from the commutator and insulate them with a piece of cardboard. Use a set of test points (fig. 43) and check for ground from the armature terminals 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.

(*b*) 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.

(*c*) If the field is not open, check for shorts by testing the field current. Use a battery of the proper voltage and an ammeter, con-

nected 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.

(*d*) Inspect the commutator bars, since an open circuit in the armature, which would result in 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

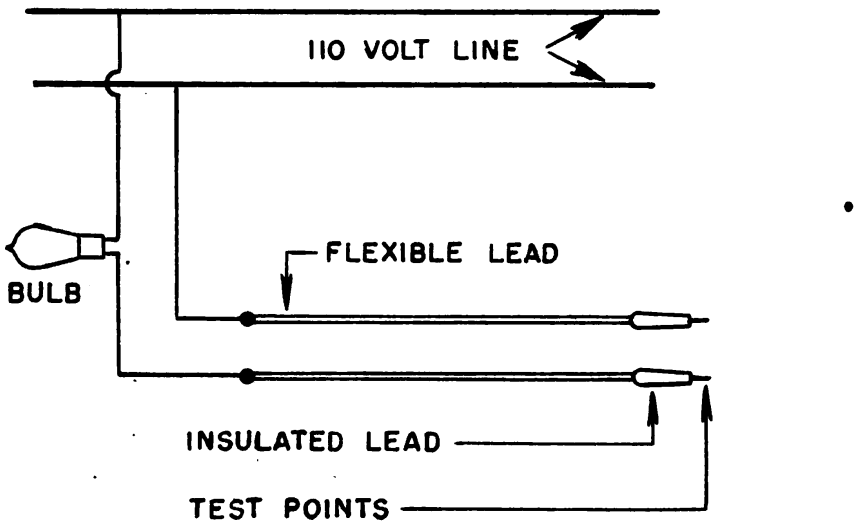


FIGURE 43.—Test point assembly.

points connected to the terminals of a volt-ammeter slowly rotate the armature, checking between adjacent bars with the test points (fig. 44). Any open-circuited coils will cause a full battery voltage reading on the voltmeter.

(*e*) If the trouble has not yet been located, check the armature for short circuit, using a test point circuit. Hold test point on alternate commutator bars. If short circuit exists lamp will light.

(*f*) 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 complete generator failure.

(8) *Service data.*

Brush spring tension	64 to 68 ounces.
End play of armature	0.010 inch maximum.

f. Generator assembly.—Tools:

9/16-inch open end wrench.	Screw driver.
7/16-inch open end wrench.	Fan belt (or rope).
Screw driver socket wrench 9/16-inch face.	Length of pipe.
	1-inch socket wrench.
	9/16-inch open end wrench.

(1) *Install armature terminal post.*

Place main brush control lead assembly, insulation, and insulating 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.

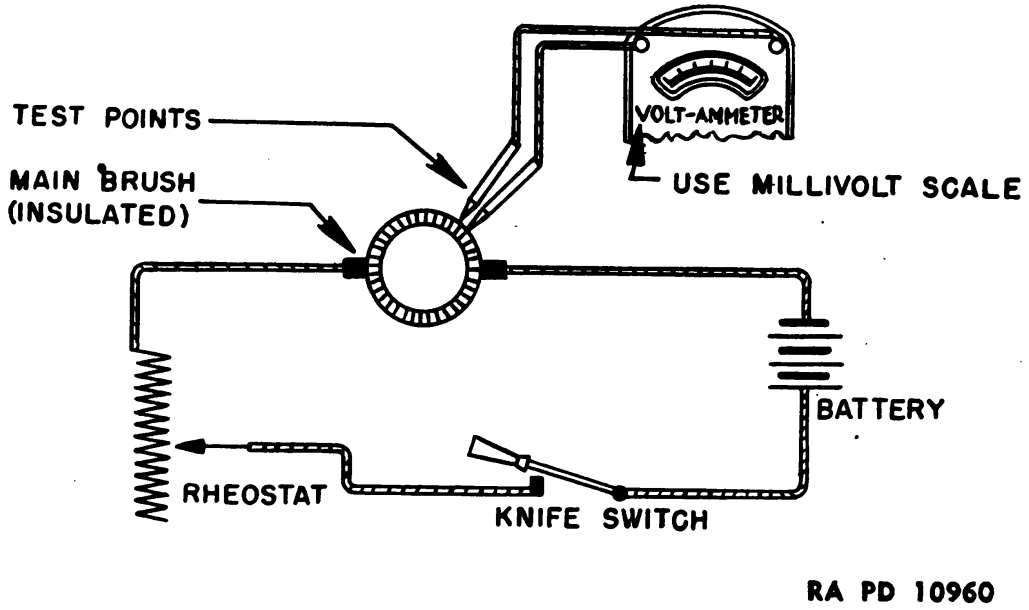


FIGURE 44.—Armature open circuit test.

(2) *Install field coils and pole shoes.* Screw driver socket wrench 9/16-inch face.

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 flathead machine screws.

(3) *Install field terminal post.* 7/16-inch open end wrench.

Place field coil terminal, 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.

(4) *Mount brush holders and brush springs on commutator end head assembly.* — None.

Assemble springs and holders and force them on pivot studs.

(5) *Install commutator end ball bearing.* — Screw driver.

Slip spacer on commutator end of armature shaft and install commutator end head. Insert external tooth lock washer, plain washer, felt washer, plain washer, and ball bearing, in order named, into end head over armature shaft. Secure end head assembly to armature shaft with plain washer, lock washer, and cap screw.

(6) *Attach outside cover to commutator and head assembly.* — Screw driver.

Place gasket and cover on outside of commutator end head assembly and secure with four oval fillister head screws with lock washers.

(7) *Mount brushes on commutator end head assembly and connect leads.* — Screw driver.

Lift spring arms and insert brushes into holders by hand. Attach each lead to holders with one roundhead machine screw and lock washer.

(8) *Install ball bearing in drive end head assembly.* — Screw driver.

Insert felt washer and retainer against seat in end head. Then install ball bearing, gasket, retainer, and felt washer, and secure bearing retainer to end head with four oval fillister head machine screws and lock washers.

(9) *Install armature assembly.* — None.

Push armature into frame-and-field assembly till commutator end head assembly fits against frame with positioning marks in register.

(10) *Connect leads to brush holders.* — Screw driver.

Connect one eyelet terminal of armature lead assembly to each insulated brush holder with roundhead machine screw and lock washer. Then connect field coil lead to grounded brush holder.

(11) *Secure commutator end head assembly to end of frame-and-field assembly.* — Screw driver.

Make position marks on both assemblies register and fasten head assembly in place with six oval fillister head machine screws and lock washers.

(12) *Install generator drive end head assembly.* — Screw driver.

Slip spacer and end head assembly over end of armature shaft and secure to frame-and-field assembly with six oval fillister head machine screws and lock washers.

(13) *Install pulley.* — Belt (or rope).
Length of pipe.
1-inch socket wrench.

Place Woodruff key into position on shaft. Then slip on pulley, plain washer, and lock washer, and secure assembly with hex nut (fig. 39).

(14) *Install cover band.* — Screw driver.

NOTE.—The generator should always be run as a motor before reinstalling in vehicle to be sure it is running correctly and to determine the direction of rotation. Run a jumper lead between the armature and field terminals and then connect the generator across a 12-volt circuit. At 12 volts the current draw should be 7.60 to 8.40 amperes.

Place band around frame over inspection openings and tighten with screw and nut.

g. Generator installation.—Tools:

Screw driver.
9/16-inch socket wrench.
¾-inch socket wrench.
Rachet extension.
Channellock pliers.
⅜-inch thin wall socket wrench.
⅝-inch open end wrench.

(1) *Install mounting bracket on generator.* — Screw driver.
9/16-inch socket wrench.

Place bracket in position on generator and secure with one flat-head screw and three cap screws and lock washers.

(2) *Install generator assembly.* — ¾-inch socket wrench.
Ratchet extension.

With fan belt adjusting screw in its slack position, place fan belts onto generator pulley and position generator and bracket assembly to engine block. Secure assembly by installing lock washers and cap screws through bracket. Adjust fan belt tension as explained in paragraph 19*e*(7).

(3) *Connect armature conduit to generator.*

9/16-inch socket wrench.
Channellock pliers.

Remove upper hex nut and lock washer from generator frame terminal post. Insert terminal of wire through shield housing, place it on armature post, and secure with washer and nut. Fasten conduit to housing with nut (fig. 35). Install condenser in housing (fig. 34).

(4) *Connect field conduit to generator.*

3/8-inch thin wall socket wrench.
5/8-inch open end wrench.
Screw driver.

Remove hex nut and lock washer from generator frame terminal stud post. Insert terminal of wire through shield housing, place it on field post, and secure with lock washer and nut. Install field terminal housing plug and fasten conduit to housing with hex coupling nut.

Caution: After generator is reinstalled on engine, or at any time after leads have been disconnected and then reconnected to generator, a jumper lead should be connected *momentarily* between *battery* and *armature* terminals of the regulator *before starting the engine.* This allows a momentary surge of current from battery to generator, which correctly polarizes generator with respect to battery it is to charge. This should always be done after any checks, adjustments, or repairs of generator or regulator.

25. Regulator.—*a. Description* (fig. 46).—The regulator contains three assemblies: the cut-out, which closes the charging circuit when the generator is charging and opens the circuit when the generator is not charging; a voltage regulator and a current regulator which connect and disconnect resistance into the generator field circuit and thereby control the generator output. The regulator is mounted in front of the dash, at the left, under the hood of the engine, and is inclosed in a metal case.

(1) *Construction* (figs. 45 to 49).—(*a*) The regulator is mounted in a case having a cover which is held on by two nuts engaging two studs fixed to the bottom of the case and projecting through holes in the cover. On the base and extending beyond one side are the battery, armature, and field terminals which connect to the circuit breaker assembly or cut-out relay, the current regulator assembly, and the voltage regulator assembly. These terminals are enclosed in a radio shield assembly at the side of the regulator case and provided with openings for the battery, armature, and field connections to terminals. On the bottom of the base are several resistance units and the circuits are such that whenever the voltage or current delivered is too high,

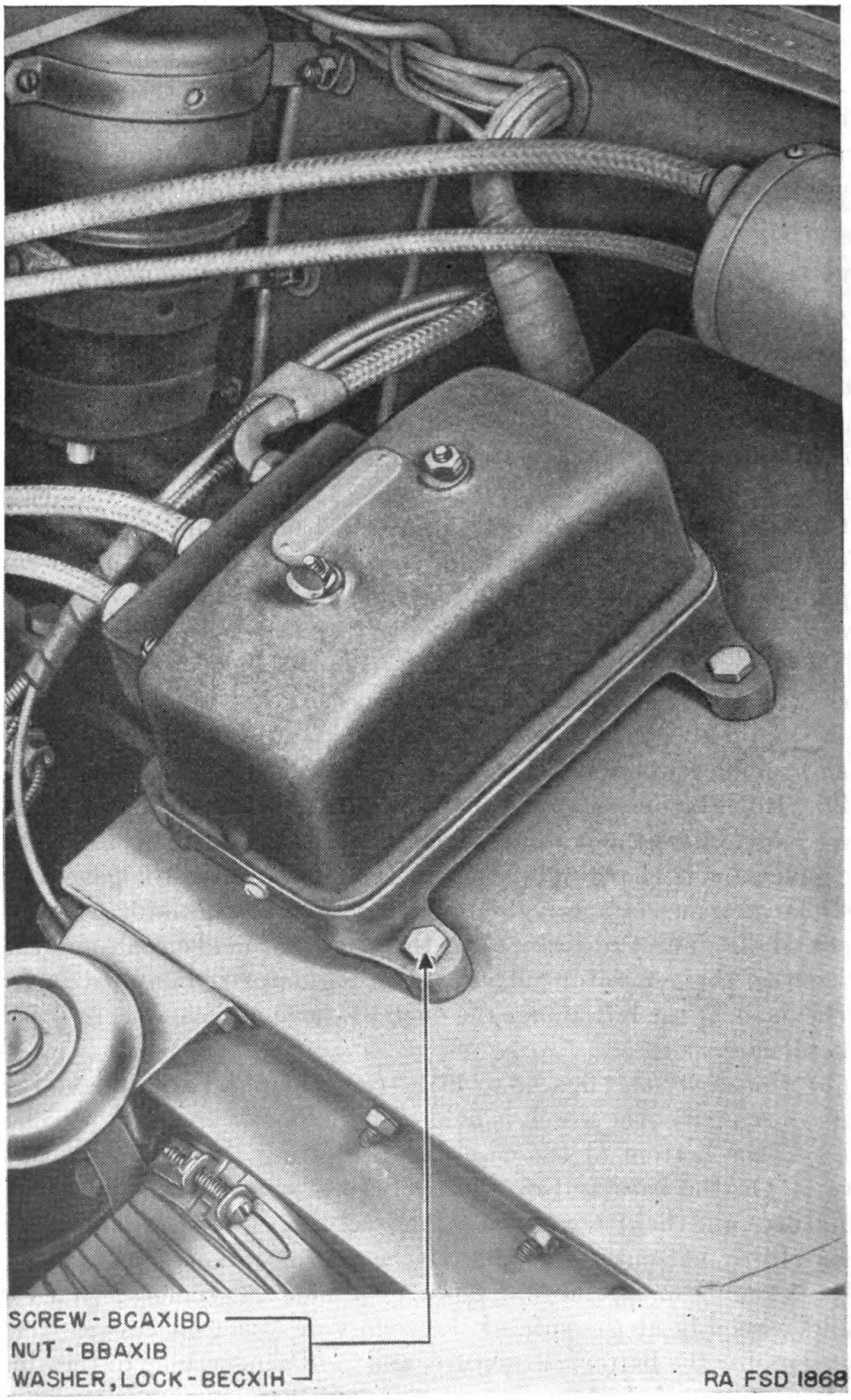


FIGURE 45.—Voltage and current regulator, installed.

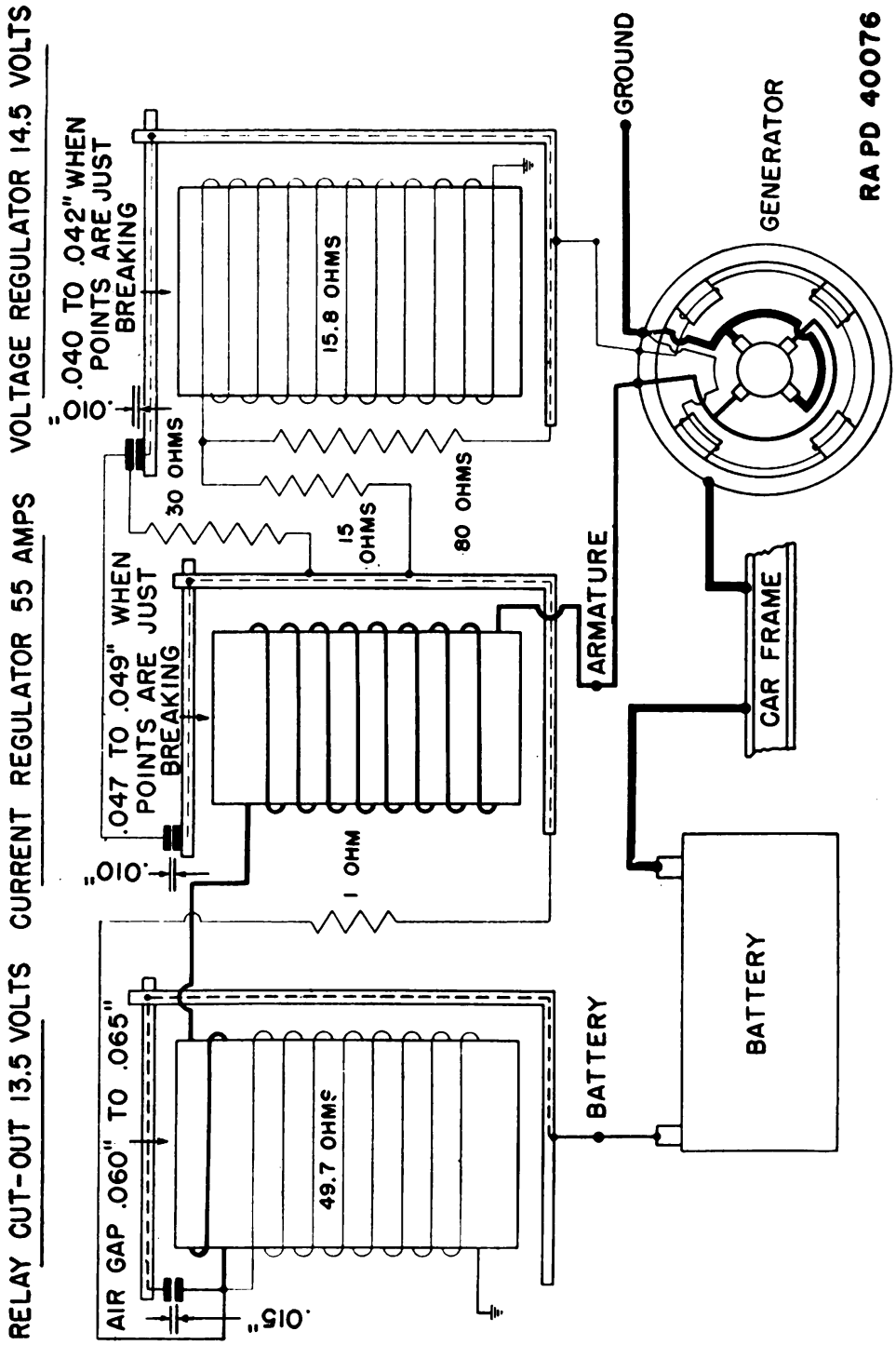


FIGURE 46.—Regulator (type VRH) and generator wiring diagram.

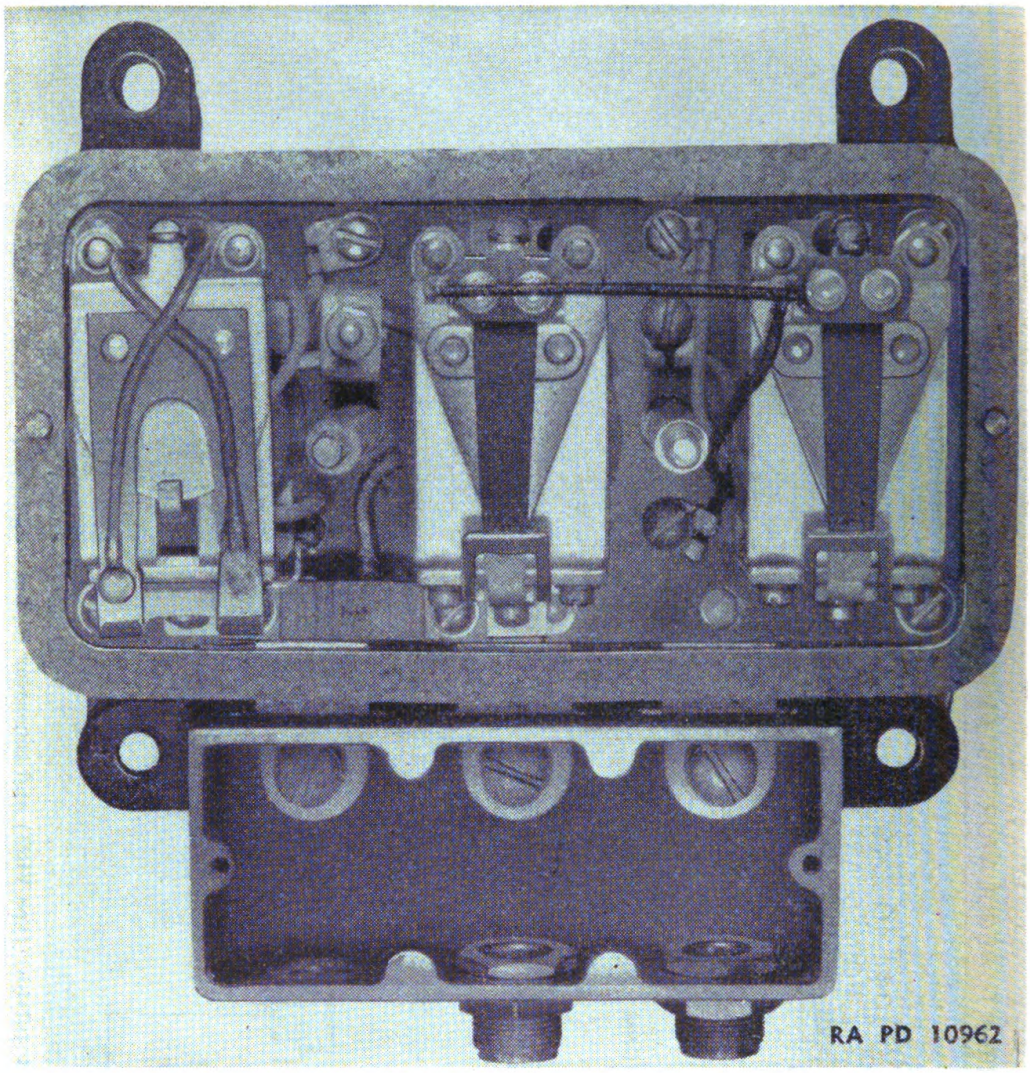


FIGURE 47.—Voltage and current regulator assembly, top view.

resistance is automatically switched into the field circuits of the generator and the output is thus reduced.

(*b*) The circuit breaker assembly, which is at the left end of the unit (viewed from the side with the three terminals), consists of an armature carrying contact points, which are connected to the battery, and controlled by an electromagnetic core on which are wound a few turns of relatively large wire, making a current coil. One end of this coil is connected to a fixed contact 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

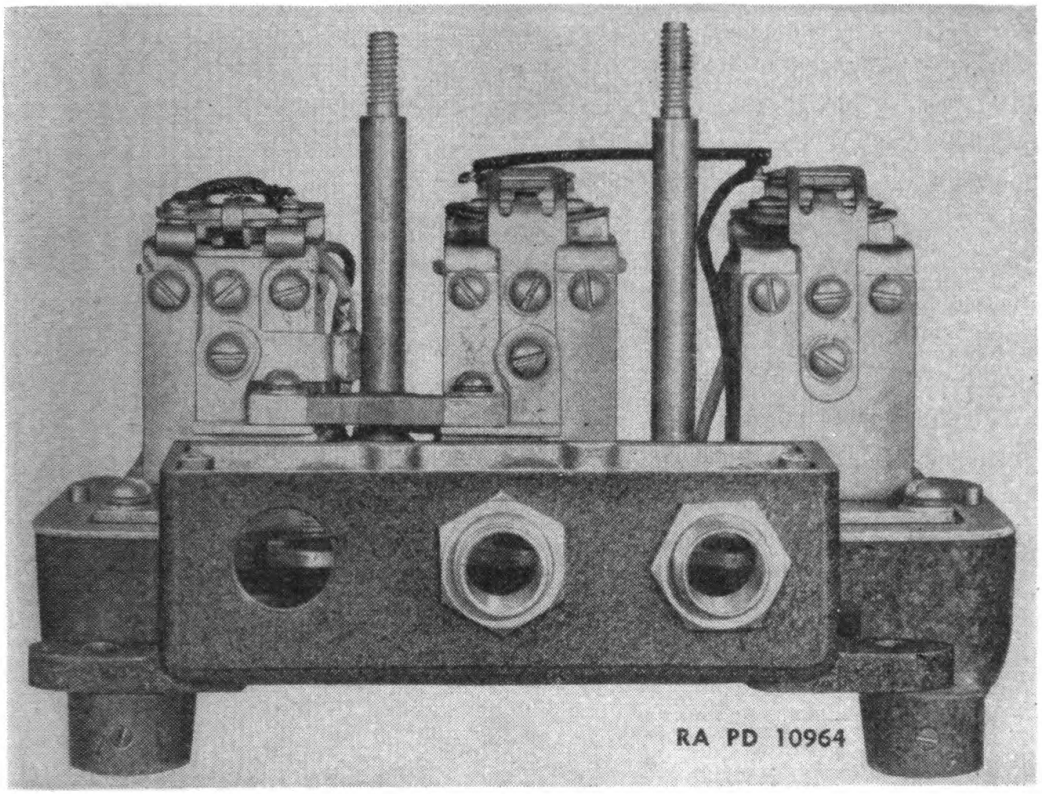


FIGURE 48.—Voltage and current regulator assembly, front view.

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) each consists of a similar magnetic core with a hinged armature carrying a contact which is held against a fixed contact by 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 are also present, but are so arranged that, as long as the contacts of both current regulator assembly and voltage regulator are closed, this resistance is not effective.

(2) *Functioning.*—(*a*) When the engine has been started by the battery and the starting motor, the battery voltage drops and the generator operates to replenish that part of the energy of the battery which has been consumed in starting. 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.

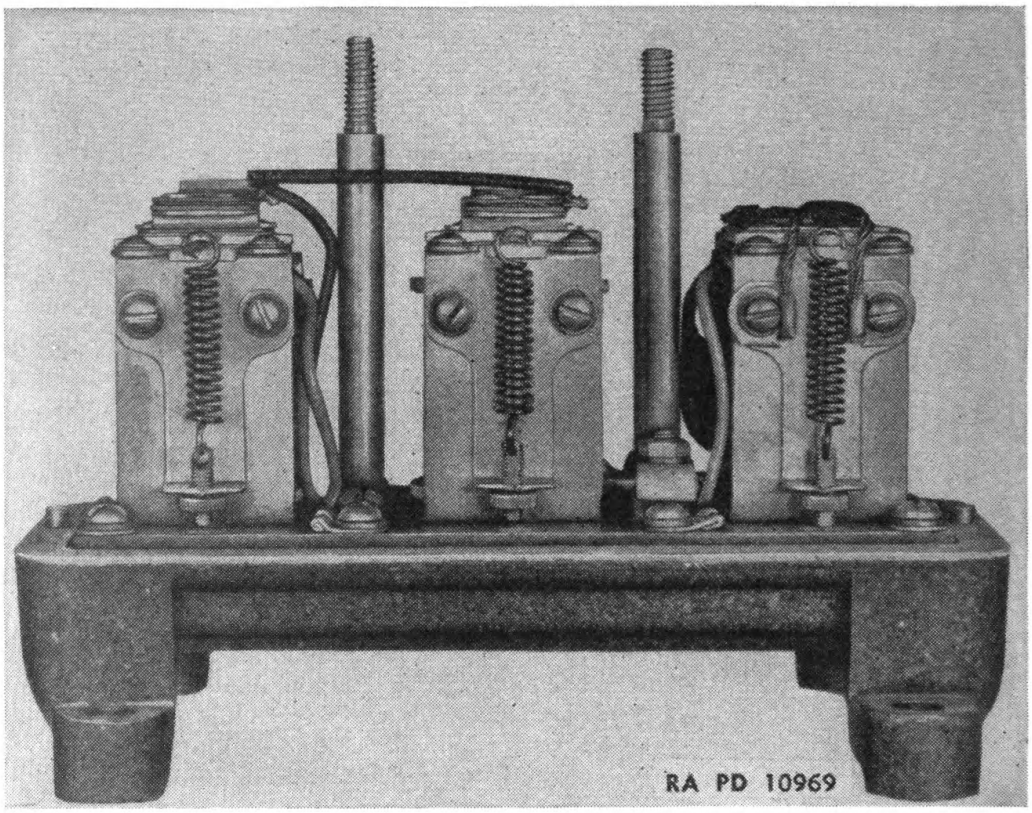


FIGURE 49.—Voltage and current regulator assembly, rear view.

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 energy to the battery. 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 the battery and generator are disconnected. As long as the battery is being charged the generator will supply the electrical system.

(*b*) While the battery is 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 battery as its 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. This is necessary, as a higher voltage is required to charge a cold battery than a hot battery.

(3) *Specifications.*

Make	Electric Auto-lite Co.
Model	Single core, vibrator.
Ordnance No	B167663.
Manufacturer's No	VRH–4102A.
White No	344909.
Ground	Negative.
Maximum current	55 amperes.

Radio shielded.

b. Quick checks (inspection of unit installed on vehicle).—If regulator is thought to be faulty, remove the cover, make a close visual inspection of the following, and make all possible corrections at once.

(1) Evidence of burning or abnormal 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, or 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.

(7) Field frame bent.

(8) Bent armature hinges.

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

(10) Corrosion due to scale or acids.

(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.

c. Trouble shooting.

Symptom and probable cause	*Probable remedy*
(1) *Overcharged battery or high charging rate.*	
(*a*) Short circuit between output circuit and field.	(*a*) Check, repair, and adjust.
(*b*) High voltage setting at regulator.	(*b*) Check and adjust.
(2) *Low battery charge and low or no charge rate.*	
(*a*) Loose connections.	(*a*) Tighten all connections.
(*b*) Frayed or damaged wires.	(*b*) Replace wires.
(*c*) Poorly soldered terminals.	(*c*) Resolder terminals.
(*d*) Circuit breaker inoperative.	(*d*) Check, repair, and adjust.
(*e*) Generator inoperative.	(*e*) Check and repair or replace.
(*f*) Low current regulator setting.	(*f*) Check, repair, and adjust.
(*g*) Low voltage regulator setting.	(*g*) Check, repair, and adjust.
(*h*) Damaged, loose, or broken regulator windings.	(*h*) Check, repair, or replace.

d. Regulator removal.—Tools:

Screw driver.
Channellock pliers.
⅝-inch open end wrench.
½-inch open end wrench.
½-inch socket wrench.

(1) *Remove shield cover.* Screw driver.

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

(2) *Disconnect generator and filter conduits at regulator.* Channellock pliers.
⅝-inch open end wrench.
Screw driver.

Remove terminal holding screws and lock washers to disconnect wires (fig. 50). Loosen conduits coupling nuts and pull away generator and filter conduit with wire assemblies. Care should be taken when removing filter terminal unless battery has been disconnected.

(3) *Remove regulator and shield assembly.* ½-inch socket wrench.
½-inch open end wrench.

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.

e. Regulator disassembly (fig. 51).—Tools:

7/16-inch open end wrench.
Screw driver.
Soldering iron.
7/16-inch socket wrench.
3/8-inch open end wrench.

(1) *Remove case cover.* 7/16-inch open end wrench.

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

(2) *Remove complete regulator base assembly.* Screw driver.

Take out roundhead machine screws and lock washers from corners of base assembly and roundhead screws with lock washers and plain washers connecting leads of circuit breaker and voltage regulator to ground. Lift the complete base assembly.

(3) *Remove three resistors under insulation.* Screw driver.

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

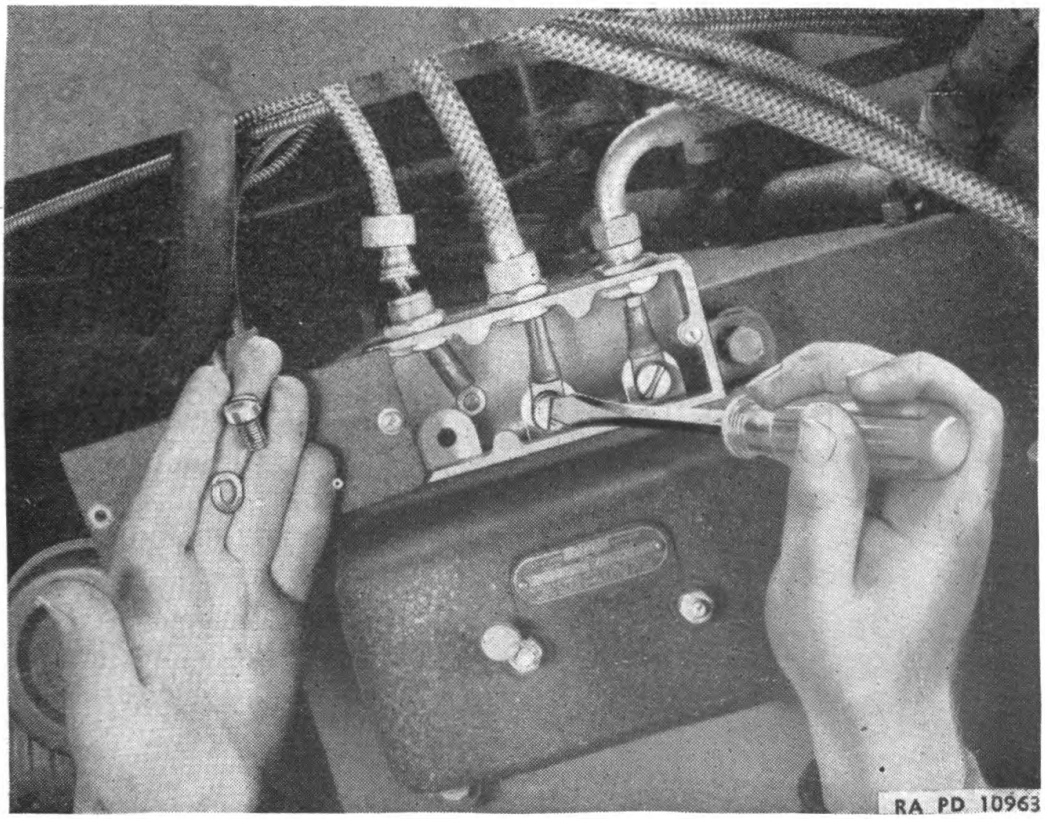


FIGURE 50.—Disconnecting regulator conduit with wire assembly.

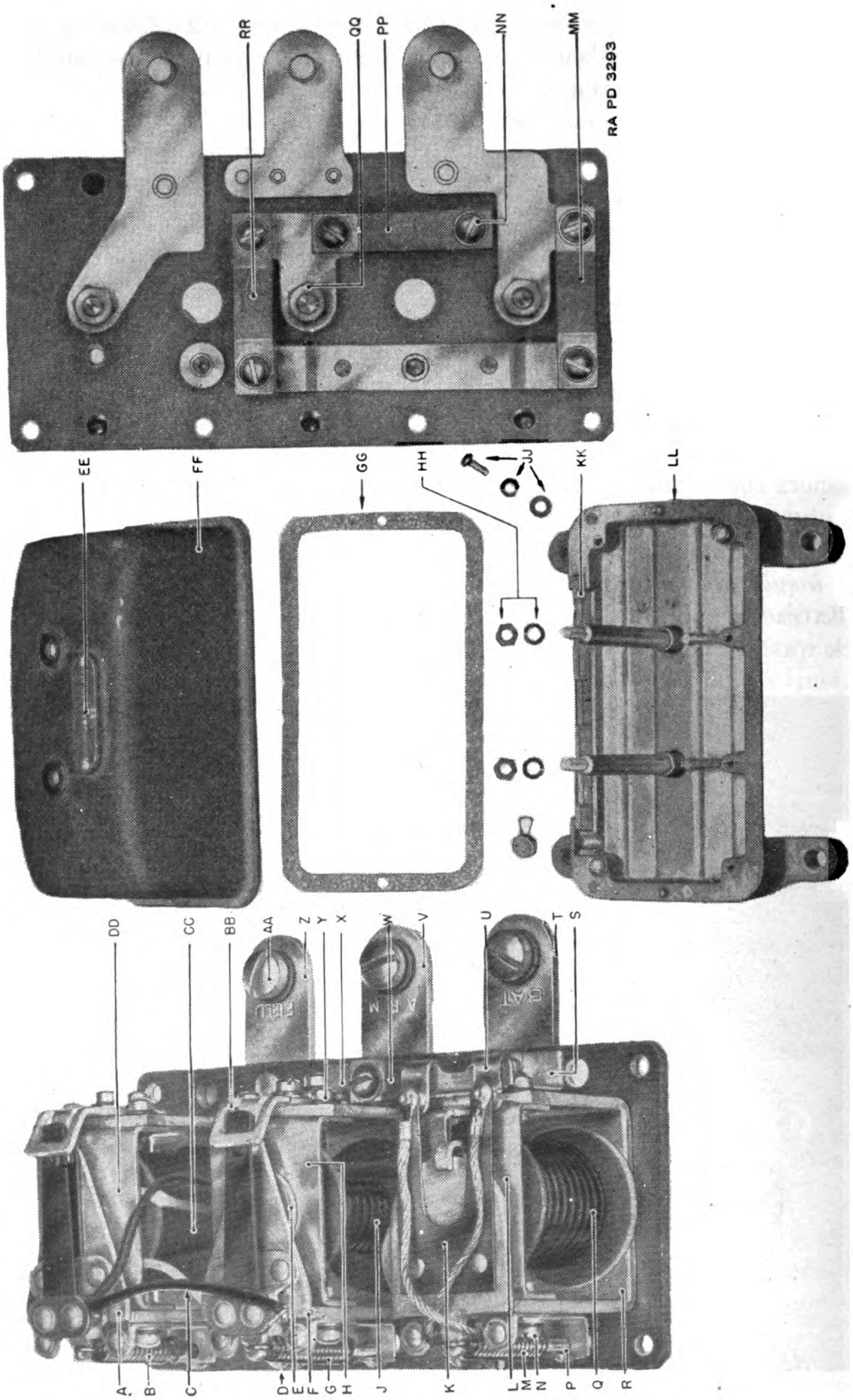


FIGURE 51.—Voltage regulator, exploded view.

A. Armature assembly—AL-VRH-1080A.
B. Spring—AL-VRA-84.
C. Jumper—AL-VRH-19.
D. Terminal—AL-X-767.
Screw—BCOX2AE.
Washer, lock—BECXIE.
E. Washer—AL-VRH-25.
F. Armature assembly—AL-VRH-1061A.
G. Spring—AL-VRA-17.
L. Support—AL-VRA-74.
J. Coil assembly—AL-VRH-2008.
K. Armature assembly—AL-VRH-1043.
L. Suport—AL-VRA-74.
M. Spring—AL-VRA-17.
N. Screw—BCFX2AE.
Washer—BEBXID.
Washer, lock—BECXID.
P. Screw—AL-VRA-15.
Nut—AL-VRA-16.
Q. Coil assembly—AL-VRH-3035A.
R. Frame—AL-VRA-68.
S. Bracket—AL-VRH-35.
Screw, Mach—BCFX2AD.
Washer—BEBXID.
Washer, lock—BECXID.
T. Terminal (bat.)—AL-VRA-5.
U. Bracket—AL-VRA-73.
V. Terminal (arm.)—AL-VRA-17.
W. Resistor—(1. OHM)—AL-TC-51A.
X. Bracket—AL-VRH-36.
Y. Screw, mach.—BCKXIFD.
Washer, lock, BECXID.
Z. Terminal (fld.)—AL-VRA-63.
AA. Screw, mach.—AL-8X-137.
Washer, lock, BECXIH.
BB. Bracket—AL-VRA-60.
Button—AL-VRA-59.
CC. Regulator assembly—AL-VRA-2071.
DD. Support assembly—AL-VRA-1057.
EE. Plate—AL-VRA-87.
Screw—AL-8X-453.
FF. Cover—AL-VRA-2.
GG. Gasket—AL-VRA-50.
HH. Nut—BBAXIA.
Washer, lock—BECXIG.
JJ. Screw—BCOX2AE.
Washer—BEBXIE.
Washer, lock—BECXIE.
KK. Gasket—AL-VRA-51.
Insulation—AL-VRA-52.
LL. Case with stud assembly—AL-VRA-1072.
MM. Resistor—(80 OHM)—AL-TC-51M.
NN. Screw—BCNXIFE.
Washer—BEBXID.
Washer, lock—BECXID.
PP. Resistor (30 OHM)—AL-TC-51L.
QQ. Nut—BBBXIA.
Washer, lock—BECXIG.
RR. Resistor (15-OHM)—AL-TC-51J.

(4) *Remove jumper between voltage regulator and current regulator assemblies.* Soldering iron.

Heat soldered ends and disconnect jumper.

(5) *Remove voltage regulator assembly.* Screw driver.
$\frac{7}{16}$-inch socket wrench.

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

(6) *Remove armature spring and adjusting screw assembly from voltage regulator assembly.* None.

Release upper end of spring from armature. Remove adjusting screw nut and lift out spring and adjusting screw assembly.

(7) *Remove voltage regulator armature assembly.* Screw driver.

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

(8) *Remove voltage regulator support assembly.* Screw driver.

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

(9) *Remove voltage regulator coil assembly.* 7/16-inch open end wrench.

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

(10) *Remove current regulator assembly.* Screw driver.
3/8-inch open end wrench.
7/16-inch open end wrench.

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. Then remove nut and lock washer from lower end of core and lift out current regulator assembly.

(11) *Remove current regulator adjusting screw and spring.* None.

Unhook upper end of spring by hand from armature. Remove adjusting screw nut and lift out adjusting screw and spring.

(12) *Remove current regulator armature assembly.* Screw driver.

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

(13) *Remove current regulator support, core, and coil.* Screw driver.

Extract three machine screws, lock washers, and plain washers holding support to frame. Remove hex 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.

(14) *Dismount circuit breaker assembly.* 7/16-inch open end wrench.

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

(15) *Remove circuit breaker adjusting screw and spring.* None.

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.

(16) *Remove circuit breaker armature assembly.* Screw driver.

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

(17) *Disconnect circuit breaker coil leads from point bracket.* Soldering iron.

Melt solder at bracket and pull out leads.

(18) *Remove circuit breaker point bracket assembly and insulation.* Screw driver.

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

(19) *Remove circuit breaker frame support.* Screw driver.

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

(20) *Remove circuit breaker coil assembly.* $\frac{7}{16}$-inch open end wrench.

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

(21) *Separate circuit breaker series coil and shunt coil assembly.* None.

Lift out shunt coil assembly, series coil, and bottom insulation.

f. Maintenance and adjustments.—(1) After any faults indicated by visual inspection have been corrected or ascertained and regulator continues to be defective, remove the unit and use the following procedure to locate defects.

(*a*) Connect test lamp in series with battery. Attach one of the test leads to BAT terminal and the other test lead to the ARM terminal of regulator. Close the circuit-breaker contacts and if lamp lights the circuit is not broken.

(*b*) Attach the test leads to the ARM 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.

(2) 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 (6) below. If the carbon resistors do not have enough resistance they may be filed until the proper resistance is obtained. Replace resistors, or make any necessary repairs.

(*a*) 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.

(*b*) Fasten each armature down with clamp, or hold by hand, and insert a piece of paper ¼ inch wide between the contact points. Connect 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 to 8 ounces.

(*c*) 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 the contacts.

(3) After the regulator assembly has been disassembled or repaired and assembled again, the armature air and point gap for the current regulator, voltage regulator, and circuit breaker should be adjusted as follows:

(*a*) *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 ARM and FIELD terminals. Place a 0.047-inch pin gage between the core and armature (fig. 52), just in front of the small brass pin, and depress the armature; the lamp should go out. Then 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 lighted. 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 contact spring so that the spring is not touched. After air gap has been correctly set, check contact point gap (fig. 53) and reset to specifications, if necessary (see (6) below).

(*b*) *Voltage regulator.*—Set the voltage regulator air gap, using the same test lamp set-up and procedure as in (*a*) above but with 0.040-inch and 0.042-inch pin gages. Check and set point gap.

(*c*) *Circuit breaker.*—Set the circuit-breaker air gap by bending armature stop on frame support. Use test lamp set and 0.060-inch and

0.065-inch flat gages as in previous adjustments (fig. 54). Then check and adjust contact points by bending the top arms of the point brackets (fig. 55).

(4) After the above adjustments have been made, proceed to make final regulator adjustments as follows:

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

(*b*) Connect regulator to generator and battery circuit.

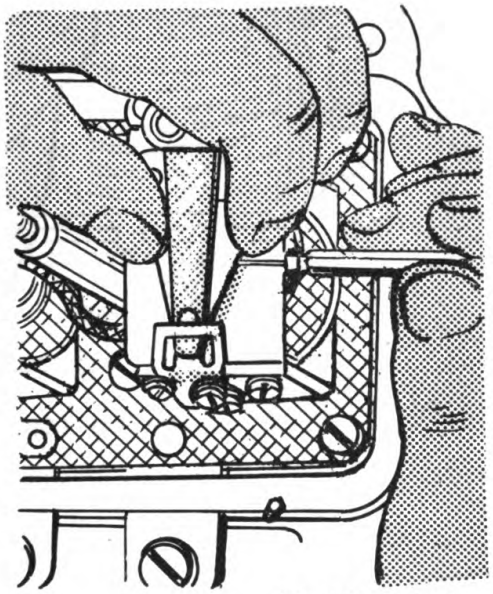


FIGURE 52.—Checking armature air gap with pin gage.

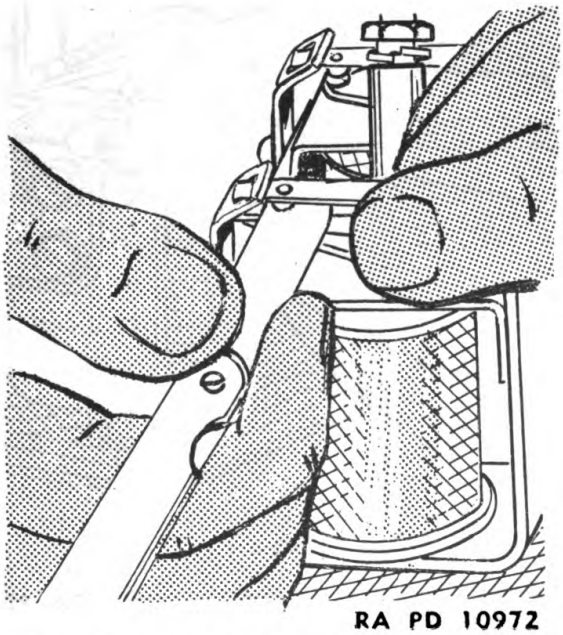


FIGURE 53.—Checking contact point gap.

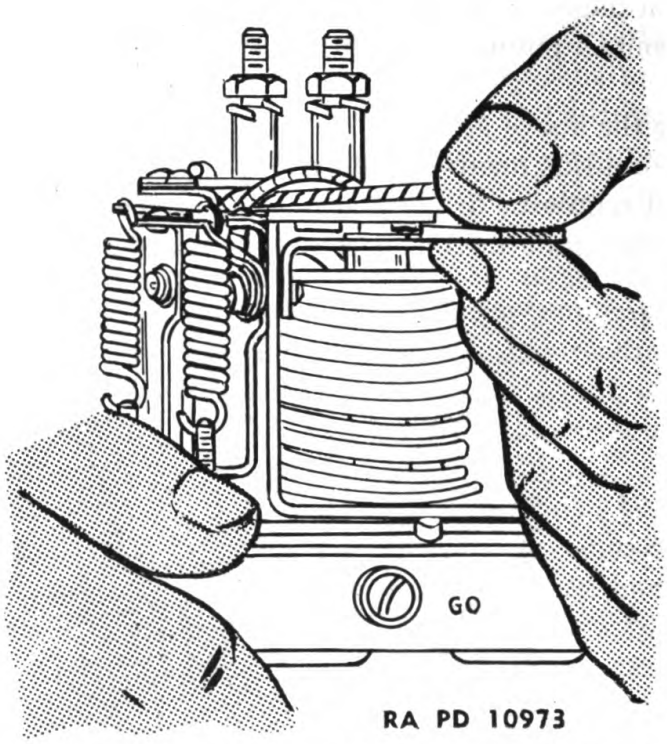


FIGURE 54.—Checking circuit breaker armature air gap.

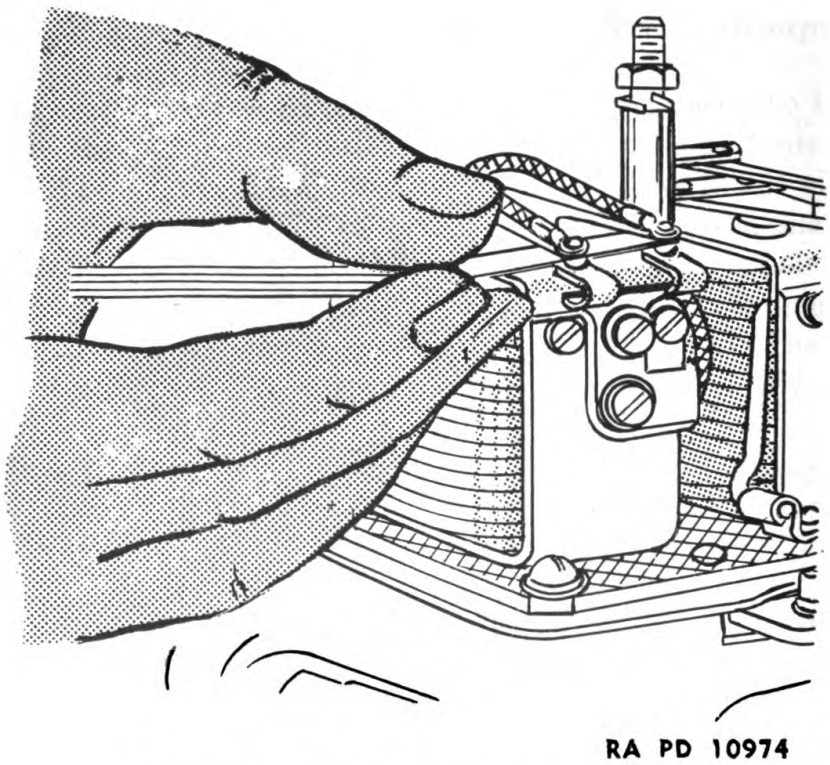


FIGURE 55.—Checking gap of circuit breaker points.

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

(*d*) With regulator cover in place heat regulator by running generator for a period of no less than 15 minutes, at sufficient speed to produce 10 amperes.

(*e*) Check temperature with thermometer approximately 2 inches from regulator case (see (6) below).

(*f*) Reduce generator speed until circuit breaker opens, then increase generator speed to equal approximately 30 mph engine speed.

(*g*) 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.

(*h*) To fix the cut-out current 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.

(*i*) After adjusting, install the regulator cover and again test the circuit-breaker operation. The voltage at which the circuit breaker closes should be 1 volt less than the voltage at which the regulator operates. After this check make a final test by stopping generator and noting the maximum voltage reading when the generator is immediately restarted (see (6) below).

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

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

(5) Check resistance of voltage regulator and current regulator.

(*a*) Disconnect both voltage regulator coil leads from base and connect them to an ohmmeter. See (6) below for correct resistance reading.

(*b*) Disconnect ground lead of current regulator and connect an ohmmeter between this point and the stationary contact. See (6) below for correct resistance reading.

(6) 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 inch.
Contact point gap	0.015 inch minimum.
Points close	13.0 to 13.5 volts.
Points open	0.5 to 4.0 amperes discharge.
Voltage regulator:	
Resistance of winding	15.8 ohms.
Armature air gap	0.040 to 0.042 inch (measured when points are just breaking).
Contact point gap	0.010 inch minimum.
Pressure of contact points	7 to 8 ounces.
Operating voltages:	
Allowable variation	Plus or minus 0.15 volt.
Temperature F	60°, 70°, 80°, 90°, 100°, 110°, 120°.
Volts	14.51, 14.48, 14.45, 14.39, 14.36, 14.33, 14.30.
Current regulator:	
Armature air gap	0.047 to 0.049 inch (measured when points are just breaking).
Contact point gap	0.010 inch minimum.
Pressure of contact points	7 to 8 ounces.
Operating amperes	54 to 56 amperes.

g. Regulator assembly.—Tools:

$\frac{7}{16}$-inch open end wrench. Soldering iron.
Screw driver.

(1) *Install circuit-breaker series coil and shunt coil assembly.* $\frac{7}{16}$-inch open end wrench.

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 frame. Secure assembly with hex nut at bottom of frame.

(2) *Install circuit-breaker frame support.* — Screw driver.

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.

(3) *Install circuit-breaker point bracket assembly.* — Screw driver.

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.

(4) *Connect circuit-breaker coil leads to point bracket assembly.* — Soldering iron.

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

(5) *Install circuit-breaker armature assembly.* — Screw driver.

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.

(6) *Install circuit-breaker adjusting spring and screw.* — None.

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.

(7) *Mount circuit-breaker assembly.* — 7/16-inch open end wrench.

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

(8) *Install current regulator support and coil assembly.* — Screw driver. 7/16-inch open end wrench

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.

(9) *Install current regulator armature assembly.* Screw driver.

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

(10) *Install current regulator adjusting spring and screw.* None.

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.

(11) *Mount current regulator assembly.* 7/16-inch open end wrench.

Place assembly next to circuit-breaker assembly, passing threaded 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.

(12) *Install resistor "1".* Screw driver.

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.

(13) *Assemble voltage regulator coil and mount in frame.* 7/16-inch open end wrench.

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.

(14) *Install voltage regulator support assembly.* Screw driver.

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.

(15) *Install voltage regulator armature assembly.* Screw driver.

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.

(16) *Install voltage regulator adjusting spring and screw.* None.

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.

(17) *Mount voltage regulator assembly on riveting base assembly.* $\frac{7}{16}$-inch open end wrench.

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

(18) *Connect voltage regulator coil lead and fixed contact lead.* Screw driver.

Fasten eyelet terminal of fixed contact lead to internally threaded tubular rivets at front of riveting base assembly with roundhead machine screws and lock washers. Connect voltage regulator coil front lead in a similar manner to rivet at rear of base.

(19) *Connect jumper to voltage and current regulator assemblies.* Soldering iron.

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

(20) *Install three resistors on bottom of riveting base.* Screw driver.

Using two roundhead 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.

(21) *Install complete regulator base assembly.* Screw driver.

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

(22) *Connect voltage regulator and circuit-breaker leads to ground.* — Screw driver.

Pass roundhead 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.

(23) *Install case cover.* — 7/16-inch open end wrench.

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

h. Regulator installation.—Tools:

1/2-inch open end wrench.
1/2-inch socket wrench.
Screw driver.
Channellock pliers.
5/8-inch open end wrench.

(1) *Install regulator assembly and shield on vehicle.* — 1/2-inch socket wrench; 1/2-inch open end wrench.

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.

(2) *Connect generator field and armature leads and filter lead to regulator.* — Screw driver; Channellock pliers; 5/8-inch open end wrench.

Insert leads through shield and connect them to respective regulator terminals with lock washers and fillister head machine screws. Care should be taken when connecting filter lead unless battery has been disconnected. Secure generator and filter conduits to shield with conduit coupling nuts.

(3) *Install shield cover.* — Screw driver.

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

SECTION VIII

ELECTRICAL—IGNITION SYSTEM

26. Description of system (fig. 56).—*a.* The ignition system comprises a coil having a primary winding for periodic connection to

the spark plugs of the engine in proper order; and a secondary winding to be energized from either the battery or generator. The connections between the active source of power and the coil are controlled by an ignition switch on the dash.

b. The primary circuit of the coil from the source of current is completed at each instant of firing in the engine by means of the distributor, which has a movable contact connected to the primary circuit and a stationary contact connected to ground. These contacts come together and are separated by the action of a cam in the distributor. At the same time the rotor in the distributor, which is joined to the secondary winding, completes a circuit to each spark plug in succession, and fires the charge in the particular cylinder where the mixture of air and gas is fully compressed. The high-voltage leads between the coil and the spark plugs consist of wires in shielded conduits attached to the plugs and the coil and to metal inserts in the cap on top of the distributor. The upper half and the lower half of the distributor are enveloped in radio shielding.

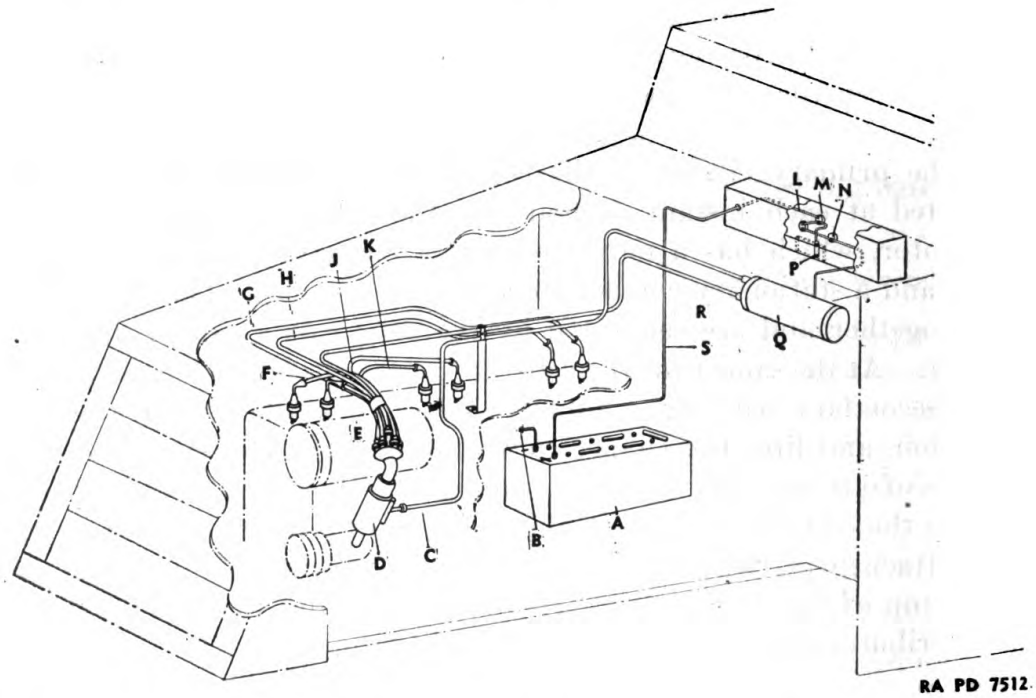
27. Trouble shooting for system.

Symptoms and probable cause	*Probable remedy*
a. Engine missing slightly or sluggish.	
Conduit defective, loose, or short-circuited.	Check and repair or replace.
b. Engine backfires.	
Crossed plug conduits.	Install in correct firing order.

28. Ignition coil and filter.—*a. Description.*—The coil is mounted in a shield assembly at the left side on the front of the dash. The coil radio filter is also mounted in the shield at the rear of the coil.

(1) *Construction.*—(*a*) The ignition coil consists of an encased primary and secondary winding in the form of a fixed unit, having three terminals at one end. The filter lead is connected to the positive terminal, the distributor high-tension lead sets into the center terminal, and the distributor breaker point lead is connected to the negative terminal. The conduits for the distributor leads are attached to the shield cover by conduit coupling nuts.

NOTE.—The internal construction of the coil is such that no attempt should be made to rebuild a faulty or damaged coil.



A. Battery assembly—WB–4376.
B. Cable assembly—WI–348739.
C. Conduit. w/wire assembly—TI–A–26378.
D. Distributor assembly—AL–IGW–4147.
E. Conduit assembly—TI–S204–1808.
F. Conduit assembly—TI–S204–1700.
G. Conduit assembly—TI–S204–3104.
H. Conduit assembly—TI–S204–2900.
J. Conduit assembly—TI–S204–2512.
K. Conduit assembly—TI–S204–2104.
L. Switch assembly—DM–2980.
M. Ammeter assembly—SW–SG96647.
N. Gage, fuel, assembly—SW–95622.
P. Fuse (50-amp.)—BZ–3730–4.
Q. Coil assembly—AL–CF–4001.
R. Conduit assembly—TI–S204–3800.
S. Cable assembly—WI–368535.

FIGURE 56.—Ignition system.

(*b*) The filter consists of a coil connected in series with the ignition coil and a condenser which is connected in the circuit at one end and grounded at the other end.

(2) *Functioning.*—(*a*) The ignition coil steps up or multiplies the voltage of the primary coil, at the instant when this circuit is broken at the distributor, to the high value needed for the electric discharge at the gaps of the spark plug. The secondary voltage is as many times as great as the primary voltage as the ratio between the large number of turns of the secondary and the small number of turns of the primary winding. The high secondary voltage is produced by electromagnetic induction, and is impressed on each spark plug in turn as the primary coil circuit is broken at the distributor.

(*b*) The filter, in circuit with the primary coil and the shield, and the shielding of the conduits reduce and shield the radio apparatus in the car against interference.

(3) *Specifications.*

Ignition coil:

Make	Electric Auto-lite Co.
Model	CF–12V.
Type	Nonvibrator.
Ordnance No	B156000.
Manufacturer's No	AL–CF–4001.
White No	62321.
Primary voltage	12 volts.

Shield and filter assembly:

Make	Tite-Flex Metal Hose Co.

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Arcing between high- and low-voltage terminals causing engine to miss.*	
Excessive moisture on end of coil.	Wipe clean and dry.
(2) *Coil will not give spark at plugs, failing to start engine.*	
(*a*) Open circuit in primary or secondary circuit or either circuit grounded.	(*a*) Check connections.
(*b*) Windings grounded inside casing.	(*b*) Replace coil.
(*c*) Short-circuited turns in primary or secondary coil or high-voltage break-down in secondary.	(*c*) Replace coil.
(*d*) Damaged filter coil or shorted filter condenser.	(*d*) Replace filter assembly.

c. Removal of assemblies.—Tools:

¾-inch open end wrench.	⅜-inch socket wrench.
5/16-inch open end wrench.	Screw driver.
7/16-inch open end wrench.	
(1) *Dismount shield assembly from dash.*	¾-inch open end wrench. ⅝-inch open end wrench. 7/16-inch open end wrench.

Remove ignition switch conduit coupling nut and remove holding nut from shield fitting at rear of dash. Then remove two nuts, plain washers, lock washers, and screws holding shield brackets to dash and pull shield assembly away from dash (fig. 57).

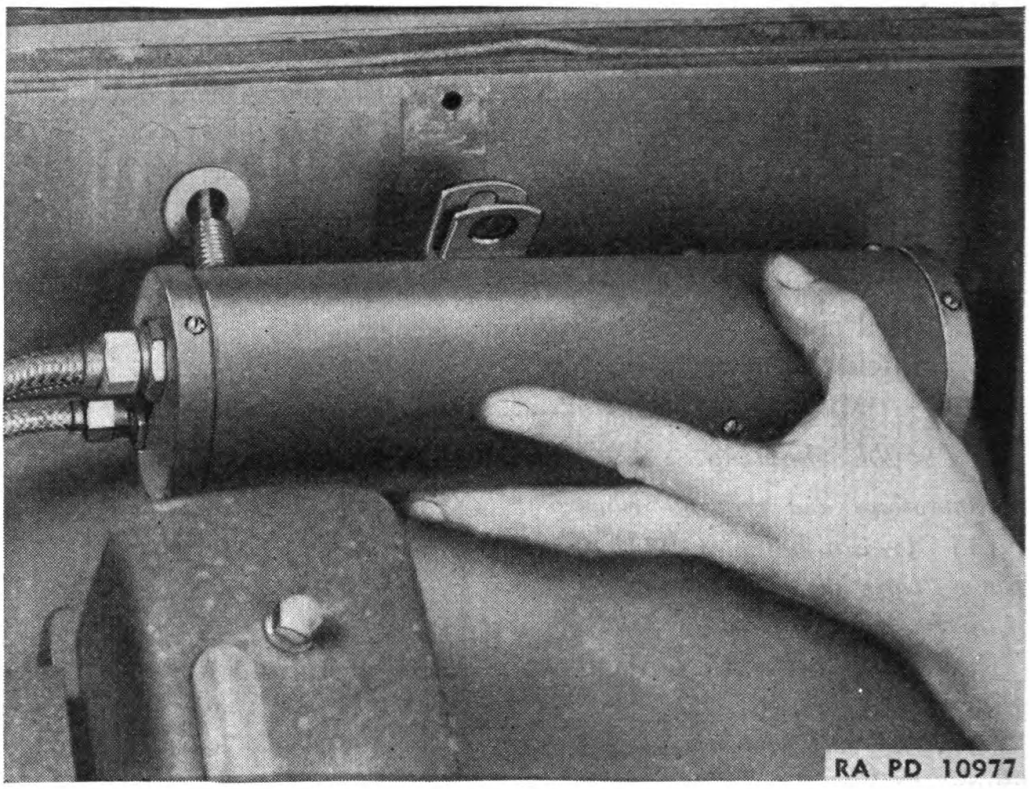


FIGURE 57.—Removing ignition coil and filter assembly.

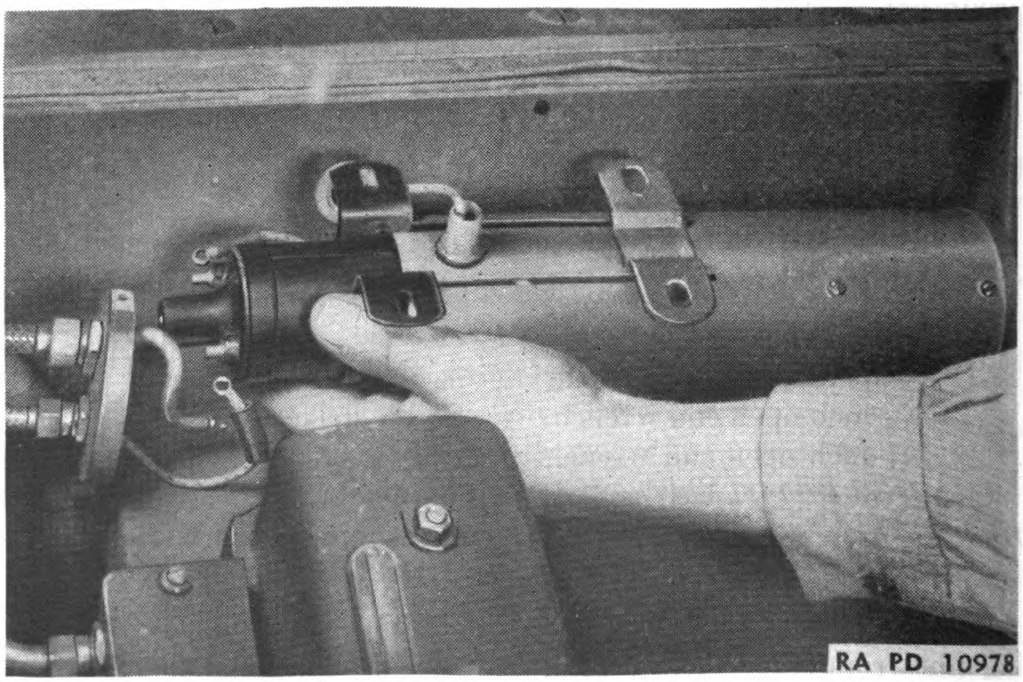


FIGURE 58.—Removing ignition coil from shielding.

(2) *Remove shield upper cap.* Screw driver.
3/8-inch open end wrench.

Remove two screws and lock washers holding upper cap to shield assembly. Pull cap away and disconnect distributor wires by pulling high-voltage wire from socket and removing nut and lock washer from negative terminal.

(3) *Remove ignition coil assembly.* 3/8-inch open end wrench.

Remove nut and lock washer from positive terminal and pull off lead. Slide coil out of shield (fig. 58).

(4) *Remove shield assembly.* Screw driver.
5/16-inch open end wrench.

Remove screws and lock washers holding shield lower cap and pull off cap. Disconnect ignition switch wire at filter coil by removing nut and plain washer from terminal post. Remove shield assembly.

d. Maintenance.—(1) Outside of shield should be kept clean by wiping periodically with a rag dampened with solvent, dry-cleaning.

(2) Remove shield upper cap periodically and inspect ignition coil terminals. Keep high-tension socket clean and dry to prevent arcing.

(3) If coil is thought to be faulty, remove it from vehicle and test in coil tester or install new coil for comparison.

e. Installation of assemblies.—Tools:

Screw driver.
5/16-inch open end wrench.
3/8-inch open end wrench.
3/4-inch open end wrench.
5/8-inch open end wrench.
7/16-inch open end wrench.

(1) *Connect ignition switch wire.* Screw driver.
5/16-inch open end wrench.

Push ignition switch wire into shielding at side fitting and fasten in position on filter coil terminal with nut and plain washer. Replace and secure lower shield cover with screws and lock washers.

(2) *Install ignition coil.* 3/8-inch open end wrench.
Screw driver.

Connect distributor wire with nut and lock washer to negative terminal and push high-voltage wire into coil center terminal. Slide ignition coil into shield and connect wire from filter coil to positive terminal. Replace upper cap and secure with screws and lock washers.

(3) *Mount shield assembly to dash.* 3/4-inch open end wrench.
5/8-inch open end wrench.
7/16-inch open end wrench.

Line up ignition coil bracket with shield bracket and place against dash with coupling passing through its hole in dash. Fasten assembly to dash with cap screws, flat washers, lock washers, and nuts. Secure coil fitting with hex nut and fasten ignition switch conduit to fitting with coupling nut.

29. Distributor.—*a. Description* (fig. 30).—The distributor is a six-cylinder, semiautomatic, single-breaker-arm type. It is supported on the water pump housing and driven by a gear from the water pump shaft.

(1) *Construction* (fig. 59).—(*a*) The distributor consists of a cup-shaped metal body which carries the main shaft. The shaft has a fixed plate near its upper end and the hollow cam-and-stop-plate assembly is mounted on the shaft above the plate. The stop plate carries pivot pins for the governor weights. The pivot pins are connected by springs to lugs on the rim of the fixed plate and the governor weights are between this fixed plate and the stop plate. They are engaged by stops on the fixed plate. The cam-and-stop-plate assembly, the governor weights, and the fixed plate are in the upper part of the base assembly, which has a bearing through which the main shaft projects at the bottom.

(*b*) The breaker plate assembly in the top of the base assembly is secured by screws to the rim. This breaker plate carries the breaker screw point and the breaker arm which is supported on a pivot. The arm is electrically connected to a post terminal in the side of the base assembly. The primary of the ignition coil is also connected to this post.

(*c*) The rotor which closes the high-voltage circuits is keyed to the cam-and-stop-plate assembly. The distributor cap of insulation fits upon the base assembly. It has six metal inserts spaced equidistantly around the inside of the top. The inserts terminate on the outside in metal sockets into which fit the terminals of the shielded conduits running to the spark plugs. A similar metal socket at the center of the cap receives the terminal of the conduit leading to the secondary of the spark coil. The insert in this socket bears at its inner end a carbon button which rests on the spring on top of the rotor.

(*d*) Spring-and-hinge assemblies on the base assembly serve as catches to hold the cap in place. Semicylindrical lower-half shields are secured to the base assembly. Another shield containing the condenser for the breaker contact points is attached to one of these. The condenser is connected at one end to the terminal post and

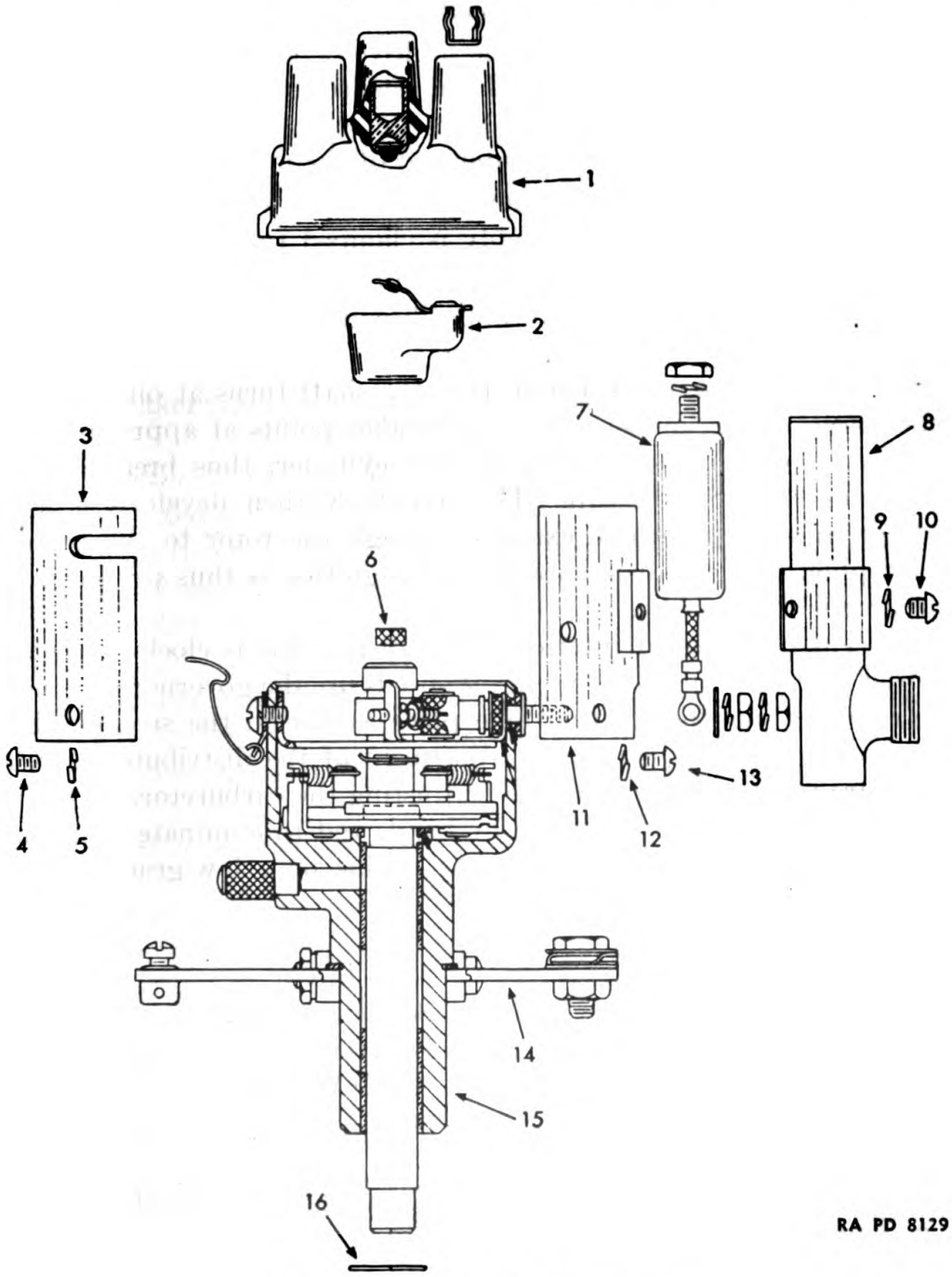


FIGURE 59.—Distributor, sectionalized.

1. Cap assembly—AL–IGB–1240.
2. Rotor assembly—AL–IGB–1239.
3. Shield—AL–XA–551.
4. Screw—BCNXIFD.
5. Washer, lock—BECXID.
6. Wick—AL–IG–495.
7. Condenser assembly—AL–IGW–3075D.
8. Shield—AL–XA–553.
9. Washer, lock—BECXIE.
10. Screw—AL–8X–1004.
11. Shield—AL–XA–552.
12. Washer, lock—BECXID.
13. Screw—BCNXIFB.
14. Arm assembly—AL–IGB–2296
15. Base assembly—AL–IGW–2123.
16. Washer—AL–IG–90.

grounded at the other. An upper-half distributor shield assembly fits over the cap. The ends of the high-voltage shielded conduits to the spark plugs enter this shield and are secured by coupling nuts to its top.

(*e*) A gear is pinned on the outer end of the main shaft, below the base assembly, to mesh with a gear on the shaft of the water pump. The advance control arm assembly is clamped to the base assembly which is united at one end by a wire to a knob on the instrument panel. This arm has a slot in its opposite end for a screw which secures the distributor adjustably in position.

(2) *Functioning.*—(*a*) The distributor shaft turns at one-half engine speed. The cam separates the breaker points at approximately the end of compression stroke in each cylinder, thus breaking the circuit of the primary coil. The secondary then develops a high voltage in a circuit which extends through the rotor to the correct spark plug. As the distributor rotates, ignition is thus produced in the proper firing order.

(*b*) The direction of rotation of the distributor is clockwise when viewed from the top. As the engine speeds up, the governor advances the cam to make the ignition take place earlier in the stroke. The purposes for which the manual adjustment of the distributor is provided are to control ignition when adjusting the carburetor, to facilitate starting in cold weather or by hand, and to eliminate knocking when carbon has accumulated in the engine or a low-grade fuel is used.

(3) *Specifications.*

Make	Auto-lite.
Model	Semiautomatic.
Ordnance No	B167666.
Manufacturer's No	AL–16W–4147.
White No	347361.
Number of cylinders	6.
Rotation	Right-hand (viewed from top).

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Engine will not start.*	
(*a*) Breaker points not closing.	(*a*) Check and adjust (see *e* (7) below).
(*b*) Breaker points defective.	(*b*) Check and replace, if necessary.
(*c*) Breaker arm grounded.	(*c*) Replace arm.
(*d*) Defective rotor or cap.	(*d*) Examine and replace.

Symptoms and probable cause	*Probable remedy*
(2) *Engine misfires in one or more cylinders.*	
Defective cap or rotor.	Replace.
(3) *Engine misses at low speed.*	
Breaker point gap too small.	Check and adjust gap (see *e* (7) below).
(4) *Engine misses at high speed under load.*	
(*a*) Breaker arm spring tension weak.	(*a*) Replace arm.
(*b*) Breaker point gap too large.	(*b*) Adjust gap (see *e* (7) below).
(5) *Engine pings excessively at high speed under load.*	
Manual setting incorrect.	Check and adjust properly.
(6) *Weak spark at plugs.*	
(*a*) Breaker cam worn.	(*a*) Install new cam-and-stop-plate assembly.
(*b*) Breaker contact points worn or defective.	(*b*) Examine and replace breaker arm and screw point.
(*c*) Condenser defective or disconnected.	(*c*) Test connection or replace condenser.
(7) *Timing incorrect or irregular.*	
Breaker cam loose or wobbly.	Check governor weights, springs, and pivots. Replace parts as needed.
(8) *Engine knocks.*	
Breaker cam too far advanced.	Readjust distributor and advance arm.
(9) *Breaker points pitted or burnt.*	
(*a*) Grease or dirt on points.	(*a*) Clean, repair, or replace.
(*b*) Defective condenser.	(*b*) Replace.
(10) *Engine lacks speed and overheats.*	
Breaker cam retarded.	Readjust distributor and advance arm.
(11) *Engine misses at all speeds.*	
(*a*) Breaker contact points too far apart.	(*a*) Check and adjust (see *e* (7) below).

Symptoms and probable cause	*Probable remedy*
(*b*) Breaker contact points pitted.	(*b*) Replace breaker arm and screw point.
(*c*) Breaker contact points uneven, burnt, or oxidized.	(*c*) Check and smooth off or replace.
(*d*) Break point screw loose.	(*d*) Tighten screw.
(*e*) Condenser defective or disconnected.	(*e*) Check connection or replace condenser.

c. Removal of assembly.—Tools:

Screw driver.
Channellock pliers.
(1) *Remove distributor cap and shields.*

⅜-inch open end wrench.
7/16-inch open end wrench.
Screw driver.

Loosen distributor cap shield locking screw. Release distributor cap holding clips, twist cap and shield counterclockwise, and remove (fig. 60).

NOTE.—High-voltage wires should not be removed from the distributor cap unless close inspection shows defective cap; then install new cap by pulling out one high-voltage wire at a time and pushing it in proper position on new cap. Hold both caps in same position.

(2) *Disconnect spark control.* Screw driver.

Loosen clamping screw holding control to arm assembly and pull out control.

(3) *Disconnect primary wire.*

Screw driver.
Channellock pliers.
⅜-inch open end wrench.

Remove distributor primary terminal shield by removing two machine screws. Unscrew conduit coupling nut from condenser shield. Remove primary wire from distributor terminal by unscrewing nut and lock washer and pull away primary wire and conduit assembly.

(4) *Remove distributor assembly.* 7/16-inch open end wrench.

Remove nut holding distributor arm to bracket on water pump and lift out assembly. Note exact position of rotor so that distributor can be installed in correct timing position.

d. Disassembly of distributor (fig. 61① and ②).—Tools:

Screw driver.
⅜-inch open end wrench.
¼-inch open end wrench.
⅛-inch drift.
Hammer.
Thin-nosed pliers.
7/16-inch open end wrench.
Punch.
Arbor press.
⅝-inch diameter.
Arbor.

(1) *Remove condenser assembly from base.* — None.

Disconnect lead of condenser by hand from terminal post. Take off condenser shield with condenser assembly inside.

(2) *Remove lower-half distributor shields from base.* — Screw driver.

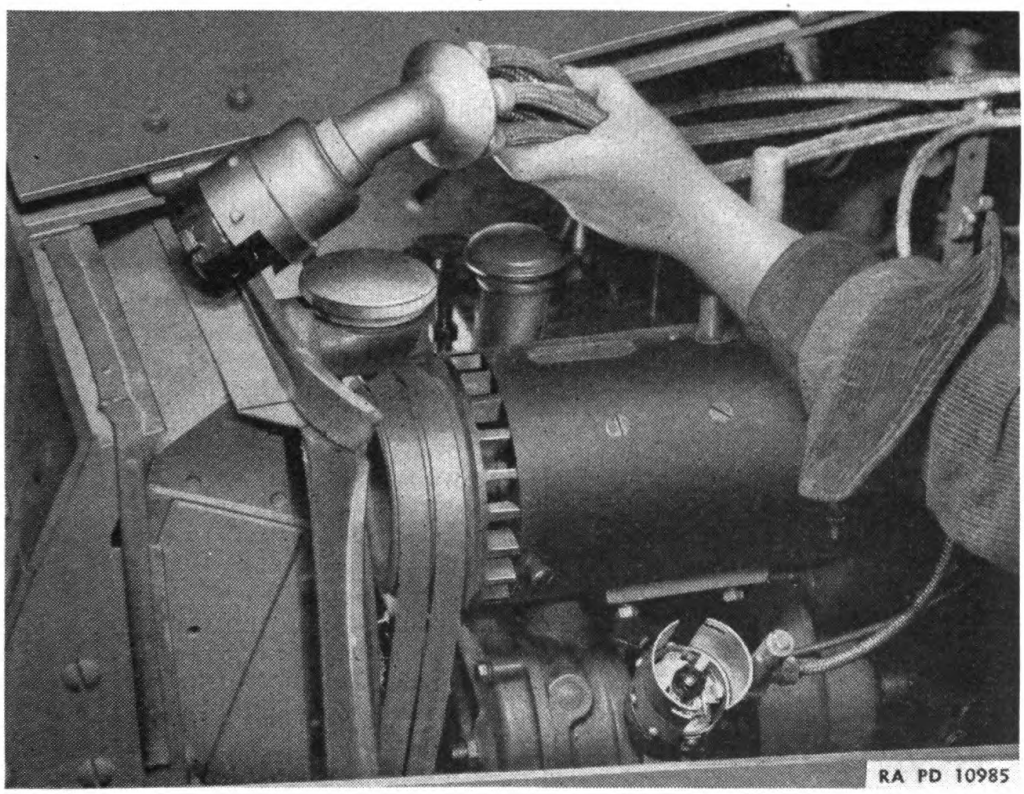


FIGURE 60.—Removing distributor cap and shielding assembly.

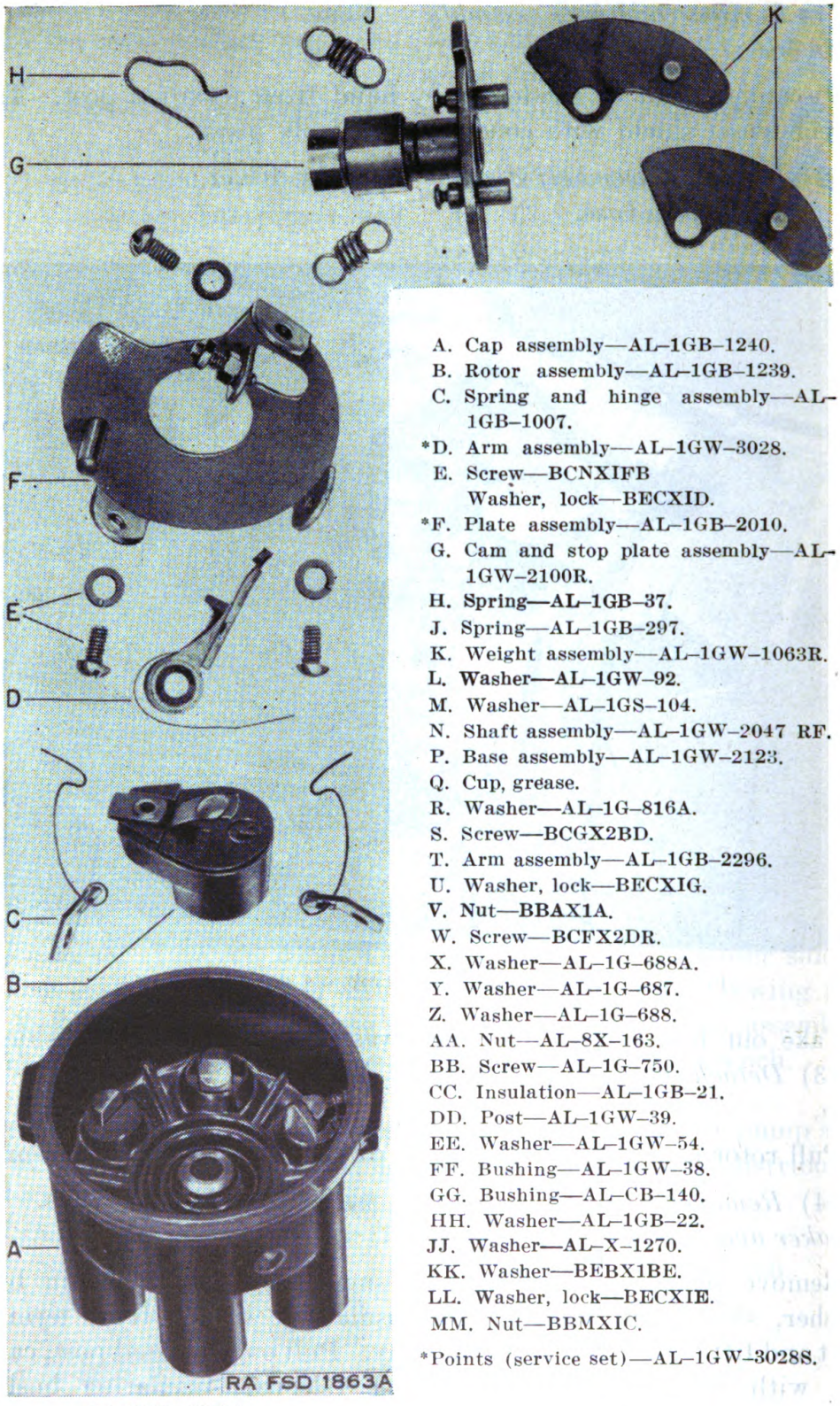
Take out four screws with lock washers. Dismount two shields.

(3) *Detach rotor assembly from cam.* — None.

Pull rotor assembly off upper end of cam-and-stop-plate assembly.

(4) *Remove terminal post and breaker arm assembly from base.* — 3/8-inch open end wrench.

Remove remaining binding nut, small lock washer, plain brass washer, shakeproof washer, and insulating washer from terminal post and lift out breaker arm assembly. Pull out terminal post, carrying with it the insulating bushing (sleeve), insulating bushing (washer), square plain metal washer, and post insulation (strip). Remove the two bushings, washer, and strip from terminal post.



A. Cap assembly—AL–1GB–1240.
B. Rotor assembly—AL–1GB–1239.
C. Spring and hinge assembly—AL–1GB–1007.
*D. Arm assembly—AL–1GW–3028.
E. Screw—BCNXIFB
Washer, lock—BECXID.
*F. Plate assembly—AL–1GB–2010.
G. Cam and stop plate assembly—AL–1GW–2100R.
H. Spring—AL–1GB–37.
J. Spring—AL–1GB–297.
K. Weight assembly—AL–1GW–1063R.
L. Washer—AL–1GW–92.
M. Washer—AL–1GS–104.
N. Shaft assembly—AL–1GW–2047 RF.
P. Base assembly—AL–1GW–2123.
Q. Cup, grease.
R. Washer—AL–1G–816A.
S. Screw—BCGX2BD.
T. Arm assembly—AL–1GB–2296.
U. Washer, lock—BECXIG.
V. Nut—BBAX1A.
W. Screw—BCFX2DR.
X. Washer—AL–1G–688A.
Y. Washer—AL–1G–687.
Z. Washer—AL–1G–688.
AA. Nut—AL–8X–163.
BB. Screw—AL–1G–750.
CC. Insulation—AL–1GB–21.
DD. Post—AL–1GW–39.
EE. Washer—AL–1GW–54.
FF. Bushing—AL–1GW–38.
GG. Bushing—AL–CB–140.
HH. Washer—AL–1GB–22.
JJ. Washer—AL–X–1270.
KK. Washer—BEBX1BE.
LL. Washer, lock—BECXIE.
MM. Nut—BBMXIC.

*Points (service set)—AL–1GW–3028S.

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FIGURE 61①.—Distributor assembly, exploded view.

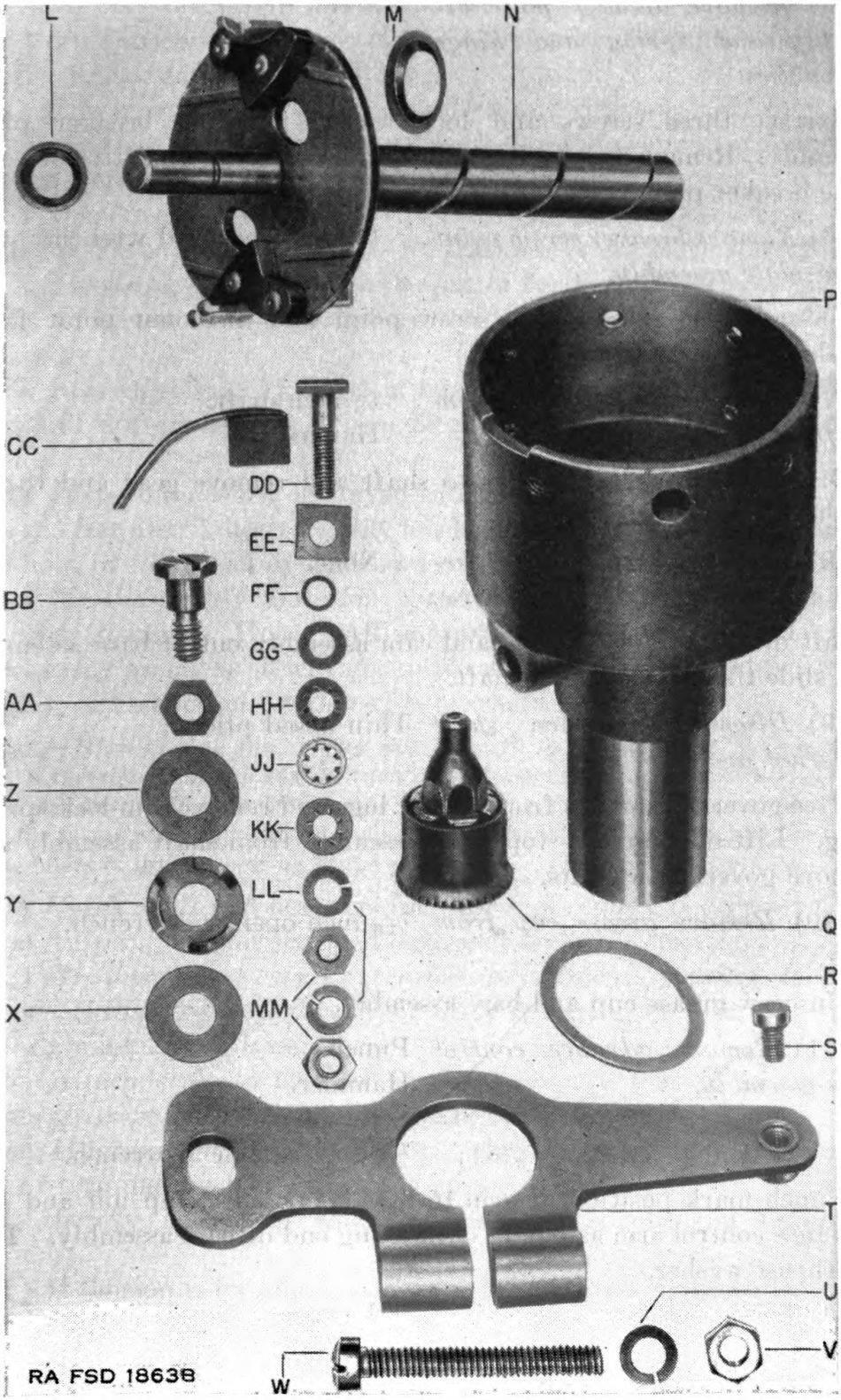


FIGURE 61②.—Distributor assembly, exploded view.

(5) *Remove breaker plate assembly and spring and hinge assemblies.*	Screw driver.

Extract three screws and lock washers holding breaker plate assembly. Remove two spring and hinge assemblies and lift out complete breaker plate assembly.

(6) *Remove breaker screw point from plate assembly.*	¼-inch open end wrench.

Unscrew nut and breaker screw point and dismount point from breaker plate.

(7) *Remove drive gear from shaft assembly.*	⅛-inch drift. Hammer.

Drive out pin holding gear to shaft and remove gear and thrust washer.

(8) *Remove drive shaft governor and cam assembly from base.*	None.

Lift drive shaft, governor, and cam assembly out of base assembly and slide thrust washer off shaft.

(9) *Disassemble drive shaft governor and cam.*	Thin-nosed pliers.

Free governor springs from anchor lugs and remove cam lock spring ring. Lift off cam-and-stop-plate assembly from shaft assembly and remove governor weights.

(10) *Remove grease cup from base.*	7/16-inch open end wrench.

Unscrew grease cup and base assembly.

(11) *Remove advance control arm assembly.*	Punch. Hammer. Screw driver. 7/16-inch open end wrench.

Punch mark position of arm to base. Loosen clamp nut and slip advance control arm assembly off bearing end of base assembly. Pull off thrust washer.

(12) *Remove bronze bushings from base.*	Arbor press. ⅝-inch diameter. Arbor.

Press bronze bushings from base assembly.

e. Maintenance.—(1) *Inspection.*—After every 2,000 miles examine the distributor carefully as follows:

(*a*) Check contact points for condition and clearance. If they are gummy or dirty, clean them well. Check cam follower and if found to be worn, replace breaker arm assembly.

(*b*) Inspect cap. Wipe away dust or oil within cap and base. If cap is not burnt at any point, or if metal inserts are burnt only at the tips and not excessively, cap can be put to further use. If cap shows cracks or carbon streaks, which are evidence of arcing, it should be replaced.

(*c*) Inspect rotor. If rotor is burnt only at outer end of metal strip and not excessively, it can be put to further use. Otherwise replace.

(*d*) Inspect for worn or frayed cables.

(*e*) After distributor assembly has been removed from water pump, take hold of lower end of shaft and rotate it. It should rotate freely in the base assembly and cam should separate contact points the required distance. Hold shaft motionless and turn cam forward (clockwise) as far as it will go, then release. It should return with no drag or restriction. Otherwise, overhaul governor.

NOTE.—When moving the breaker cam forward to test governor, it is best to remove the rotor. If the cam is turned by grasping the rotor, the key of the latter may break or chip. Pliers may be used to grip breaker cam and shaft, to hold the latter while moving the cam, provided stout paper is placed in the jaws of the pliers to prevent scoring of the parts.

(*f*) Check shaft and bearings for wear and replace if necessary.

(*g*) Inspect gear for stripped teeth and replace if necessary.

(2) *Breaker point spring tension adjustment.*—Spring tension should be adjusted periodically or after repairing or installing new contact points, as follows:

(*a*) Attach scale to breaker arm and observe tension as contact points separate. This tension should be 17 to 20 ounces pull.

(*b*) If tension is too great, ease up spring by loosening nuts on outer end of terminal post and allowing spring to uncoil slightly at pivot post, thereby increasing effective length of spring and reducing tension.

(*c*) If tension is too small, stiffen spring by pressing on coiled end, thereby decreasing effective length and increasing tension. Tighten nuts on terminal post.

(*d*) If points do not line up correctly, bend lug with pliers until they do so.

(3) *Breaker point gap adjustment.*—If engine does not run properly, check breaker point gap when points are separated fully by cam as shown in figure 62. If gap is not correct (see (7) below), make adjustments as follows:

(*a*) Loosen jam nut.

(*b*) Turn point screw in or out until 0.020 gage just fills gap when cam separates points fully (fig. 63).

(*c*) Tighten jam nut, making sure that point screw does not turn.

(4) *Contact point resurfacing.*—Dismount breaker arm and point screw. Rub both contacts with fine file or oilstone. Never use emery cloth or sandpaper.

(5) *Engine timing.*—To time the engine correctly after distributor has been removed, proceed as follows:

(*a*) Remove distributor cap and shield (see *c*(1) above).

(*b*) Unscrew No. 1 spark plug conduit shield nut and remove spark plug and shield.

(*c*) Place finger over spark plug opening and crank engine until compression in cylinder is felt.

(*d*) Remove finger and slowly crank engine until flywheel marking D. C. is in line with timing mark on flywheel housing. No. 1 cylinder is now in firing position.

(*e*) Position the distributor in mounting so that when gears engage the rotor metal strip will line up with No. 1 spark plug contact in the distributor cap.

(*f*) Fasten distributor with screw, two flat washers, spring washer, and nut to bracket on water pump.

(*g*) Loosen distributor clamp just enough so that the distributor base can be turned on its mounting.

(*h*) Turn distributor base until points are just ready to separate, with rotor pointing to No. 1 metal insert in distributor. Secure distributor by tightening clamp screw.

(*i*) Replace distributor cap and shield.

(*j*) Connect neon timing light in series with No. 1 spark plug. With the engine running at idle speed, direct the light at the timing hole in flywheel housing. The dead center mark on the flywheel should be visible and lined up with mark across timing hole. If not alined, loosen distributor clamp and turn distributor slowly until proper timing is obtained. Tighten distributor clamp.

NOTE.—To time engine when distributor has not been removed, it is only necessary to use neon light as explained above.

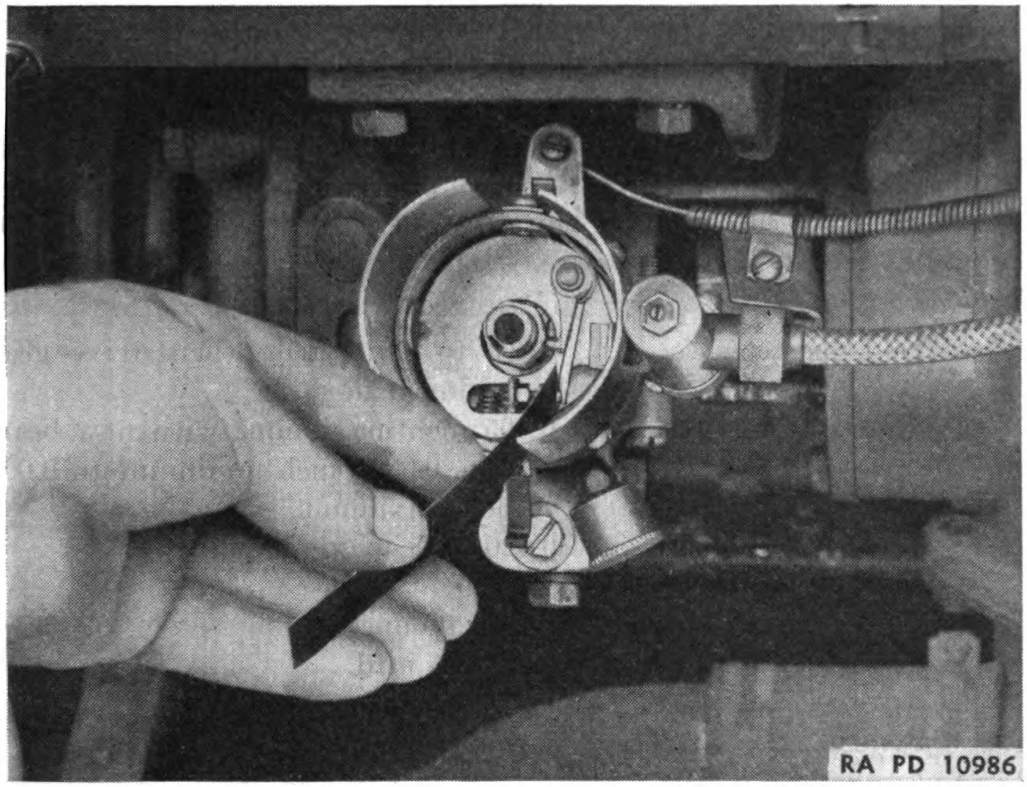


FIGURE 62.—Checking distributor point gap.

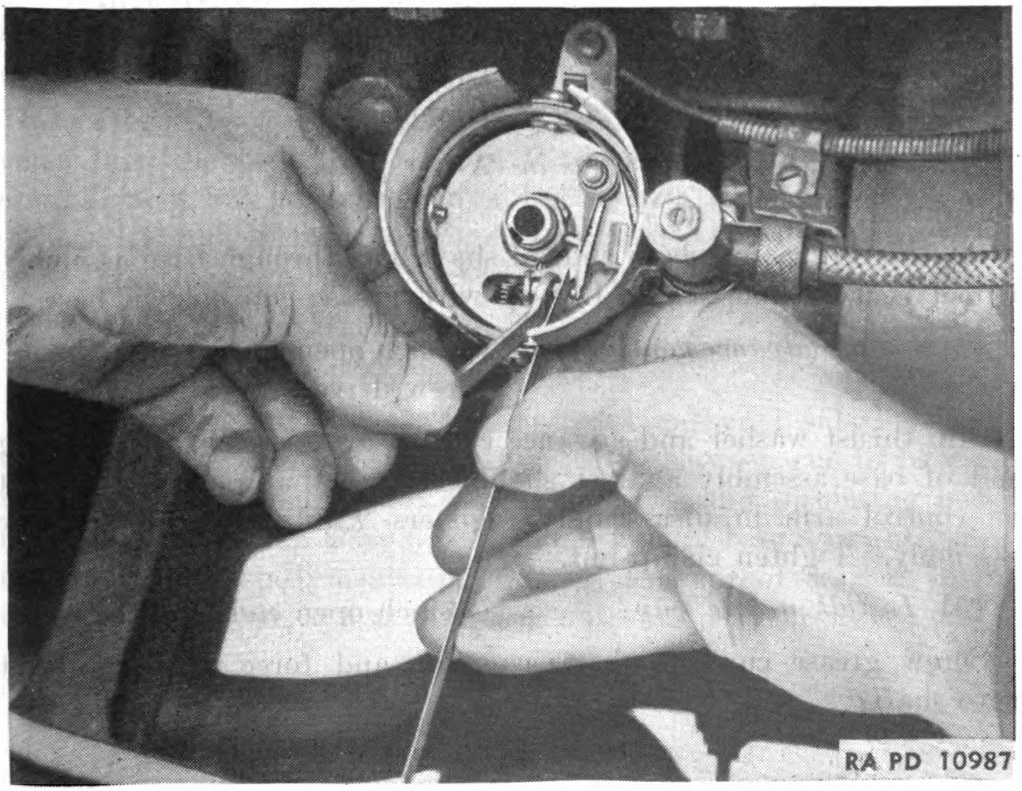


FIGURE 63.—Adjusting distributor point gap.

(6) *Overhauling.*—The distributor should be completely overhauled every 15,000 miles and the following points lubricated:

(*a*) Pivot of breaker arm—one drop of light oil and no more.

(*b*) Felt in top of breaker cam—saturate with light oil.

(*c*) Breaker cam—wipe lightly with grease, general purpose.

(*d*) Governor mechanism—two drops of light oil, one on each cam weight at cam-and-stop plate.

(7) *Service data.*

End play	0.003 to 0.010 inch when drive gear is pinned to shaft.
Side play in bearings	0.005 inch maximum; with new bearings 0.0005 inch minimum to 0.001 inch maximum.
Breaker point gap	0.020 inch maximum.
Breaker arm spring tension	17 to 20 ounces.
Condenser capacity	0.20–0.25 mfd.
Advance	10° automatic.
Retard	6° manual.

f. Assembly of distributor (fig. 61① and ②.—Tools:

Arbor press.	¼-inch open end wrench.
7/16-inch open end wrench.	⅜-inch open end wrench.
Screw driver.	Drift.
Thin-nosed pliers.	Hammer.

(1) *Replace bronze bushings in base assembly.* — Arbor press.

Press bushings into both ends of shaft bore through base assembly. Upper bearing hole should line up with grease cup hole in base.

(2) *Install advance control arm assembly.* — 7/16-inch open end wrench. Screw driver.

Slip thrust washer and advance control arm assembly on bearing end of base assembly against shoulder. See that punch mark put on control arm in disassembly registers with mark put on base assembly. Tighten clamp nut.

(3) *Install grease cup.* — 7/16-inch open end wrench.

Screw grease cup into base assembly and force some lubricant onto shaft.

(4) *Reassemble shaft, governor, and cam assembly.* Thin-nosed pliers.

Place governor weights in position on fixed plate assembly with straight ends of weights against stops. Mount cam-and-stop-plate assembly on distributor shaft assembly so that anchor pins set into weights. Attach springs to pins on cam-and-stop plate and to lugs on distributor shaft assembly. Saturate felt in top of breaker cam with light oil. Push cam lock spring ring into groove in side of cam-and-stop-plate assembly.

(5) *Install shaft and governor assembly in base.* None.

Slip thrust washer onto lower end of shaft so that flat surface rests against fixed plate. Slide shaft assembly into base.

(6) *Remount breaker screw point on plate assembly.* ¼-inch open end wrench.

Thread binding nut on screw, about one-third of the length. Thread screw into threaded hole of lug on breaker plate assembly to binding nut.

(7) *Replace breaker plate assembly in base assembly and retaining spring-and-hinge assemblies on outside of base assembly.* Screw driver.

Insert breaker plate assembly into base assembly so that hole in center lug lines up with hole in base which is directly opposite terminal post hole. Secure center lug to base with screw and lock washer. Attach spring-and-hinge assemblies to outside of base with screws and lock washers which also hold remaining two lugs of breaker plate assembly.

(8) *Install terminal post.* None.

Slip onto terminal post the square metal washer, insulating bushing (washer), end of strip insulation (to lie between rim of base assembly and pivot journal on plate assembly), and insulating bushing, in order named. Pass post through hole in base assembly from inside. Then install insulating washer, shakeproof washer, plain washer, lock washer, and one binding nut onto post, in order named.

(9) *Replace breaker arm assembly.* — ⅜-inch open end wrench.

Mount breaker arm assembly on pivot journal, using one drop of light oil on journal. Hook end of spring on terminal post between head and metal washer. With scale on end of breaker point, set spring tension (see *e*(7) above). Tighten binding nut on outer end of terminal post to clamp spring securely.

(10) *Adjust breaker points.* — ¼-inch open end wrench.

Set breaker screw point, and lock with binding nut, to have a contact gap of 0.020 inch (±0.002); cam angle setting 38°.

(11) *Install rotor assembly.* — None.

Fit key inside rotor to keyway and press rotor down upon cam.

(12) *Install lower radio shields.* — Screw driver.

Fasten two lower-half shields to outside of base assembly with two screws and lock washers each. Place shield, having condenser directly over terminal post. Slip terminal of condenser onto terminal post.

(13) *Install drive gear.* — Drift.
Hammer.

Slip thrust washer onto shaft, place gear in position on shaft, and secure with pin. Peen over end of pin. End play of shaft can be changed by using different size thrust washers.

g. Installation of assembly.—Tools:

7/16-inch open end wrench.	⅜-inch open end wrench.
Screw driver.	Channellock pliers.

(1) *Mount distributor on water pump casing.* — 7/16-inch open end wrench.

Place shaft into water pump casing so that when gear on distributor meshes with gear on water pump the rotor is in the same position as when distributor was removed. If engine has been moved while distributor was out, it will be necessary to retime distributor as explained in *e*(5) above. Place spring washer between two plain washers in position on control arm and fasten distributor to bracket on water pump with special screw.

(2) *Connect dash control wire.* — Screw driver.

Push wire through hole in machine screw in end of control arm and secure with screw.

(3) *Connect primary wire.*	3/8-inch open end wrench. Screw driver. Channellock pliers.

Remove condenser shield and place low-voltage wire over condenser lead terminal on terminal post. Secure with hex nut and lock washer. Fasten conduit coupling nut to shield. Replace condenser shield and secure with two screws and lock washers.

(4) *Install cap and upper shield.*	Screw driver.

With high-voltage wires in proper position, place cap over distributor and secure with clips. Twist upper distributor shield clockwise to clamp it, and then tighten locking screw.

30. Ignition shielding.—*a. Description* (fig. 64).—Shielding is provided for the distributor and all wires connected to it, and for the spark plugs.

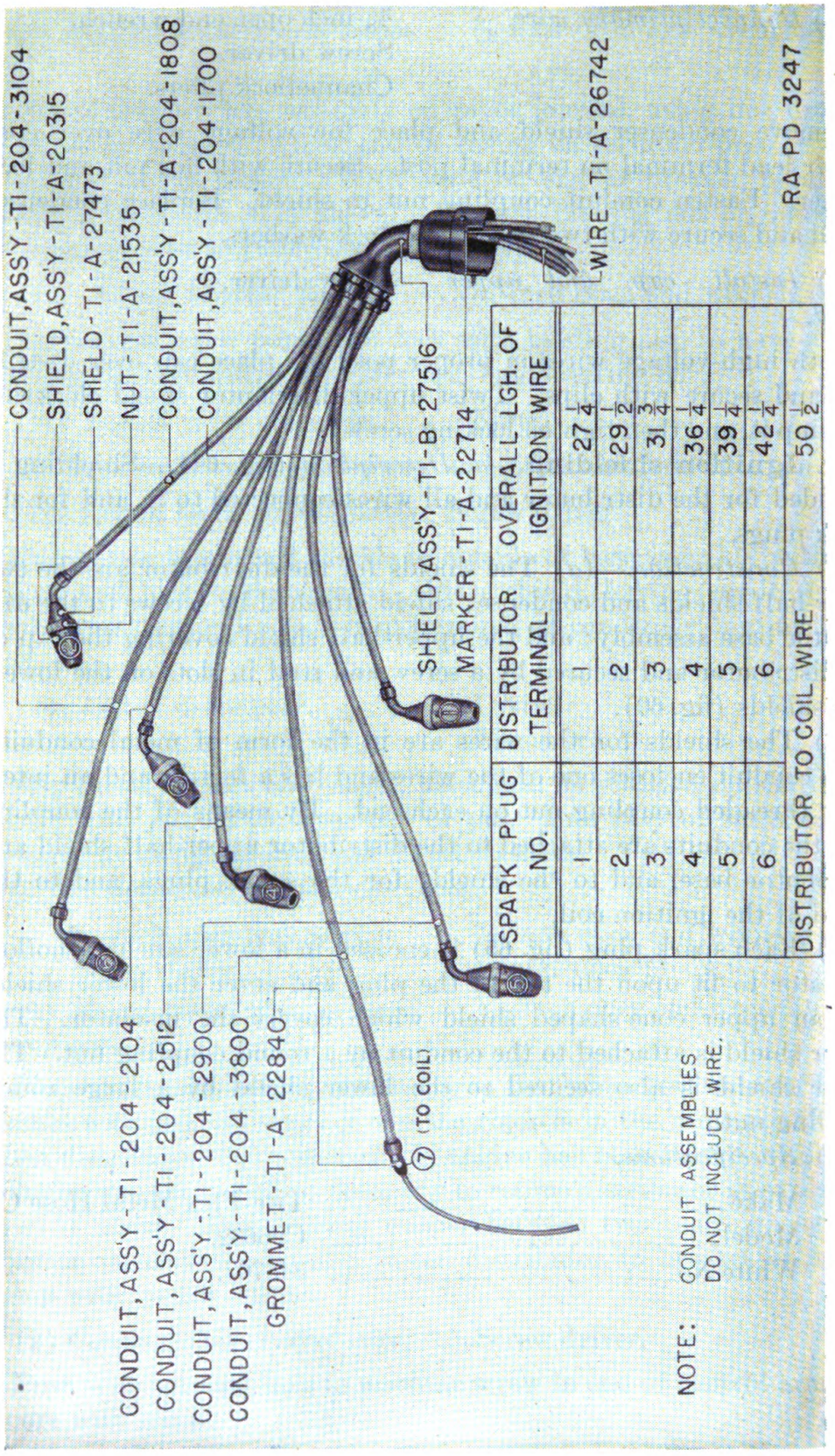
(1) *Construction.*—(*a*) The shields for the distributor are the two lower-half shields and condenser shield attached by screws to the distributor base assembly; and the upper-half shield covering the cap of the distributor and secured by a screw and stud in slots on the lower-half shields (fig. 60).

(*b*) The shields for the wires are in the form of metal conduits. Each conduit encloses one of the wires and has a ferrule and an internally threaded coupling nut on each end. By means of the coupling nuts the conduits are attached to the distributor upper-half shield and distributor base, and to the shields for the spark plugs, and to the shield of the ignition coil.

(*c*) Each spark plug (fig. 65) is encased in a lower shield, a hollow insulator to fit upon the top of the plug and enter the lower shield, and an upper cone-shaped shield which covers the insulator. The upper shield is attached to the conduit by a round coupling nut. The upper shield is also secured to the lower shield by a large round coupling nut.

(2) *Specifications.*

Make	Tite-Flex Metal Hose Co.
Model	C26632.
White No	348767.



SPARK PLUG NO.	DISTRIBUTOR TERMINAL	OVERALL LGH. OF IGNITION WIRE
1	1	27 1/4
2	2	29 1/2
3	3	31 3/4
4	4	36 1/4
5	5	39 1/4
6	6	42 1/4
DISTRIBUTOR TO COIL WIRE		50 1/2

FIGURE 64.—Ignition shielding assembly.

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Admission of oil, fuel, and water.*	
(*a*) Crushing of conduits.	(*a*) Replace.
(*b*) Looseness of coupling nuts.	(*b*) Tighten.
(2) *Loss of effectiveness.*	
(*a*) Gaps in conduits, due to abrasion.	(*a*) Replace.
(*b*) Breaks or high-resistance joints.	(*b*) Tighten joints and free them from oil, grease, and insulating substances.

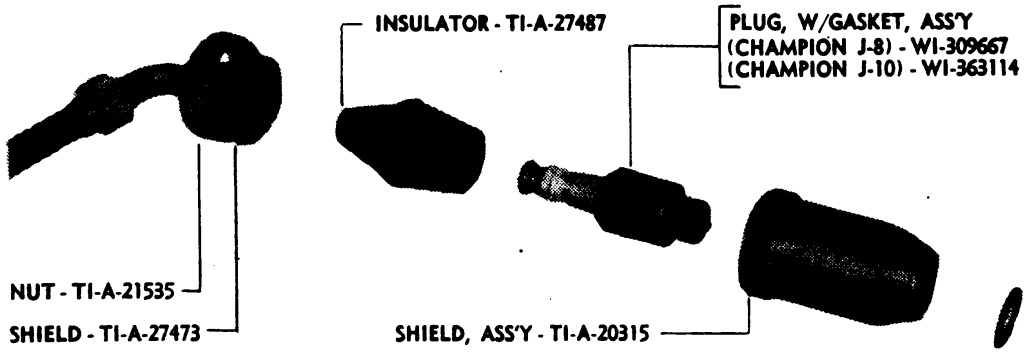


FIGURE 65.—Spark plug and shielding details.

c. Removal and disassembly of shielding (figs. 65 and 66).—Tools:

Screw driver.
7/8-inch open end wrench.
3/4-inch open end wrench.
3/8-inch open end wrench.

(1) *Remove upper-half distributor shield.* Screw driver.

Loosen screw in side of shield. Release cap from spring and hinge assemblies. Turn upper-half shield to free it from slots in lower-half shields. Lift upper-half shield and cap from distributor base.

(2) *Remove lower-half shields.* Screw driver.

Remove four screws and lock washers at bottom of shields and dismount shields.

(3) *Free ends of conduits.*
7/8-inch open end wrench.
3/4-inch open end wrench.
3/8-inch open end wrench.

Unscrew hex nuts and coupling nuts at ends. Pull or disconnect wires from distributor cap ignition coil and spark plugs.

(4) *Remove shielding of spark plugs.* None.

Unscrew coupling nut at each plug to release upper and lower shield. Remove upper shield, coupling nut, spring terminal, and insulator. Remove lower shield after plug is removed.

d. Maintenance and adjustments.—Clean all joints, tighten nuts, and replace all conduits crushed or having gaps or openings. Repair damaged insulation on wires or replace wires. Use solvent, dry-cleaning, to clean couplings or plug shields. In removing wires from conduits, tie a piece of twine to wires and pull into conduit. The twine can be used to pull through cleaning rags and facilitate replacement of wire. Use a wire brush to clean coupling threads. An insulation or resistance testing instrument will be of service in going over insulation and resistance of conduits.

e. Assembly and installation.—Tools:

⅞-inch open end wrench.
¾-inch open end wrench.
⅜-inch open end wrench
Screw driver.

(1) *Attach conduits.*

⅞-inch open end wrench.
¾-inch open end wrench.
⅜-inch open end wrench.

Push in or connect wires at distributor cap, ignition coil, and spark plug, upper shields, and insulators. Screw on hex nuts and coupling nuts at distributor cap and ignition coil. Put lower shield on spark plugs when they are mounted, with gaskets on seats at holes. Place insulators in upper shields with spring terminals at ends of wire leads to make contact with outer end of plugs, and secure upper insulator in place with coupling nut.

(2) *Attach lower-half shields to distributor.* Screw driver.

Secure each shield to side of distributor base assembly with two screws and lock washers.

(3) *Attach upper-half shield to distributor.* None.

Replace cap and secure shield by turning to bring screw and stud into slots of lower-half shields.

(4) *Mount conduits on brackets.* Screw driver.

Secure the seven conduits of the upper-half distributor shield to brackets on top of engine with clamps and screws.

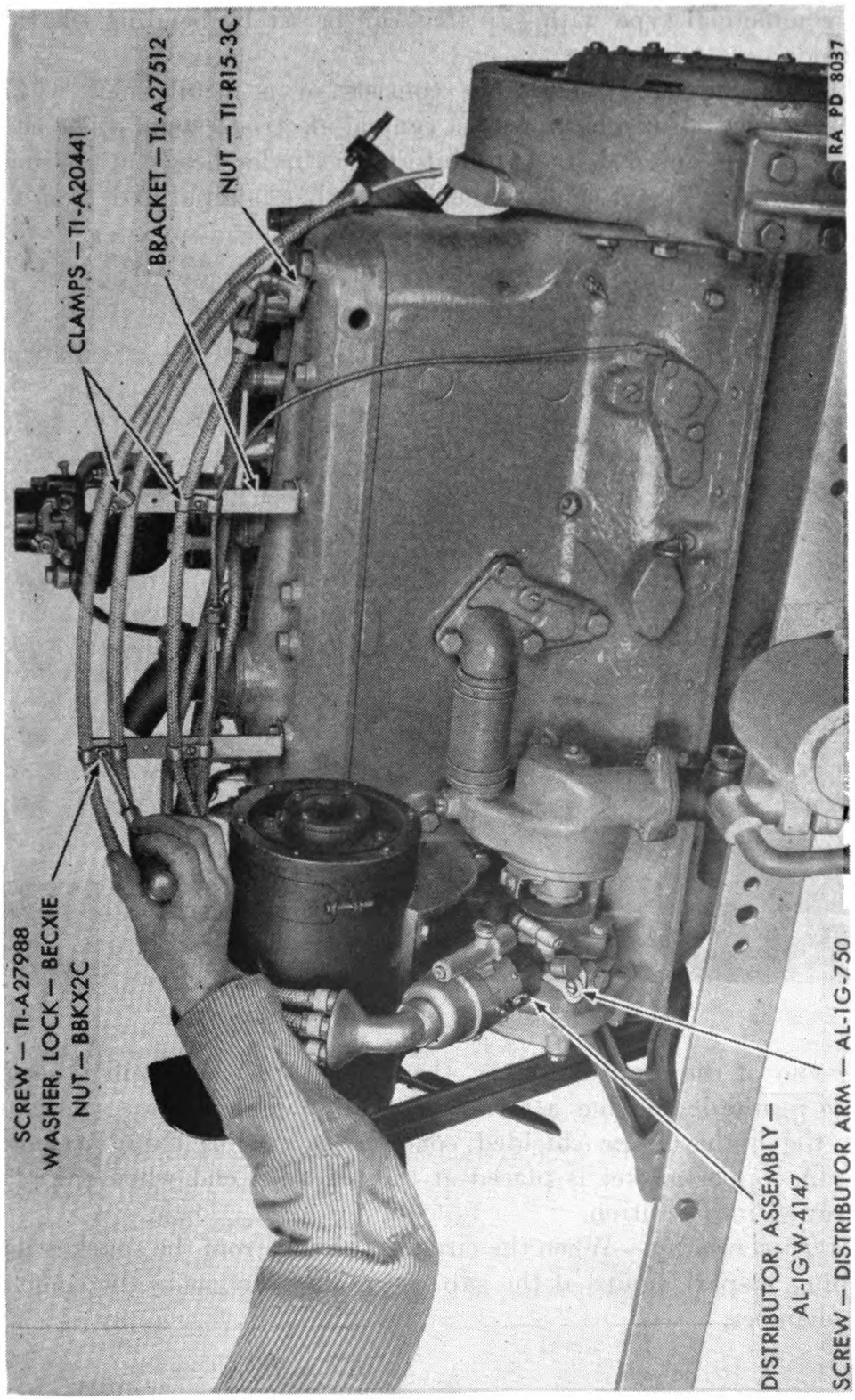


FIGURE 66.—Radio shielding, installed.

31. Spark plugs.—*a. Description* (fig. 67).—The spark plugs are of a commercial type with gap that can be set by bending the side electrode.

(1) *Construction.*—Each plug consists of a metal shell within which is fixed an insulator with a central electrode stem. The shell is threaded at one end to screw into the cylinder head; at its inner end it carries a fixed, bent, side electrode that is separated from the

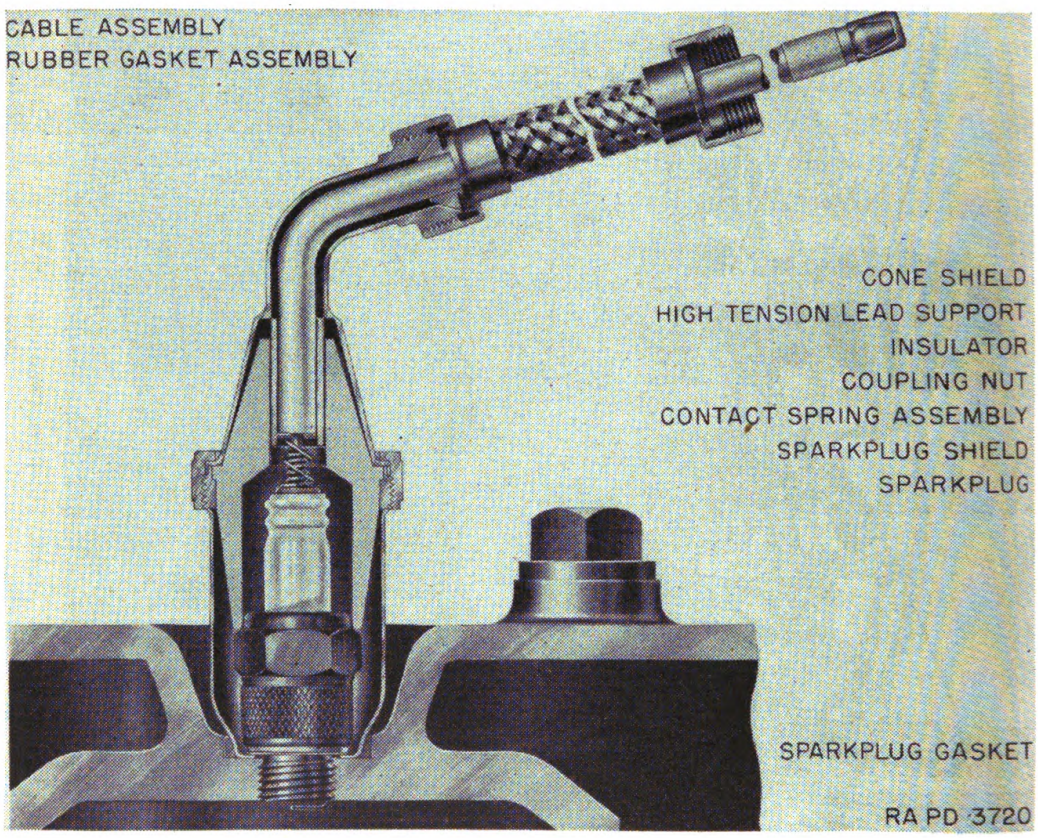


FIGURE 67.—Spark plug with shielding, installed.

inner end of the central stem by the spark gap. The stem is sealed in the insulator and has a terminal on its outer end for connection with the high-voltage shielded conduit leading to the distributor cap. A copper gasket is placed at the threaded end when the plug is screwed into position.

(2) *Functioning.*—When the circuit is closed from the spark coil to the plug, a spark jumps at the gap and ignites the gas in the combustion chamber.

(3) *Specifications.*

Make	Champion Spark Plug Co.
Model	14-mm J–8. 14-mm J–10.
Ordnance No	A186774.
White No	309667 (J–8). 363114 (J–10).

b. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
(1) *Engine missing slightly, sluggish or irregular performance.*	
(*a*) Improperly adjusted spark gap in plug.	(*a*) Check and correct to proper gap (0.025 inch).
(*b*) Loose, leaky plug threads.	(*b*) Tighten or replace plug.
(2) *Failure to give spark.*	
(*a*) Insulation broken at one end.	(*a*) Replace plug.
(*b*) Side electrode worn excessively.	(*b*) Replace plug.
(*c*) Plug carbonized at inner end.	(*c*) Clean plug.
(*d*) Plug burned at inner end.	(*d*) Replace plug.
(*e*) Insulation swollen, blistered, fused, or broken.	(*e*) Replace plug.
(*f*) Electrodes showing signs of disintegration.	(*f*) Replace plug.
(*g*) Leak around insulator, showing carbon streaks on outer part.	(*g*) Replace plug.
(*h*) Moisture on outside of plugs.	(*h*) Wipe dry.
(*i*) Electrodes contacting due to careless handling when plug was mounted.	(*i*) Separate points and adjust spark gap (0.025 inch).
(3) *Engine missing at low speed only.*	
Insulator cracked at point outside of engine.	Replace plug.

c. Removal of spark plug.—Tools:

13/16-inch socket wrench.
Ratchet extension.

(1) *Remove shielding.* None.

Unscrew shield coupling nut by hand. Push aside upper shield and remove insulator.

(2) *Remove spark plug.* 13/16-inch socket wrench.
Ratchet extension.

Place wrench on spark plug and screw it out of cylinder head (fig. 68). Remove lower shield and copper gasket.

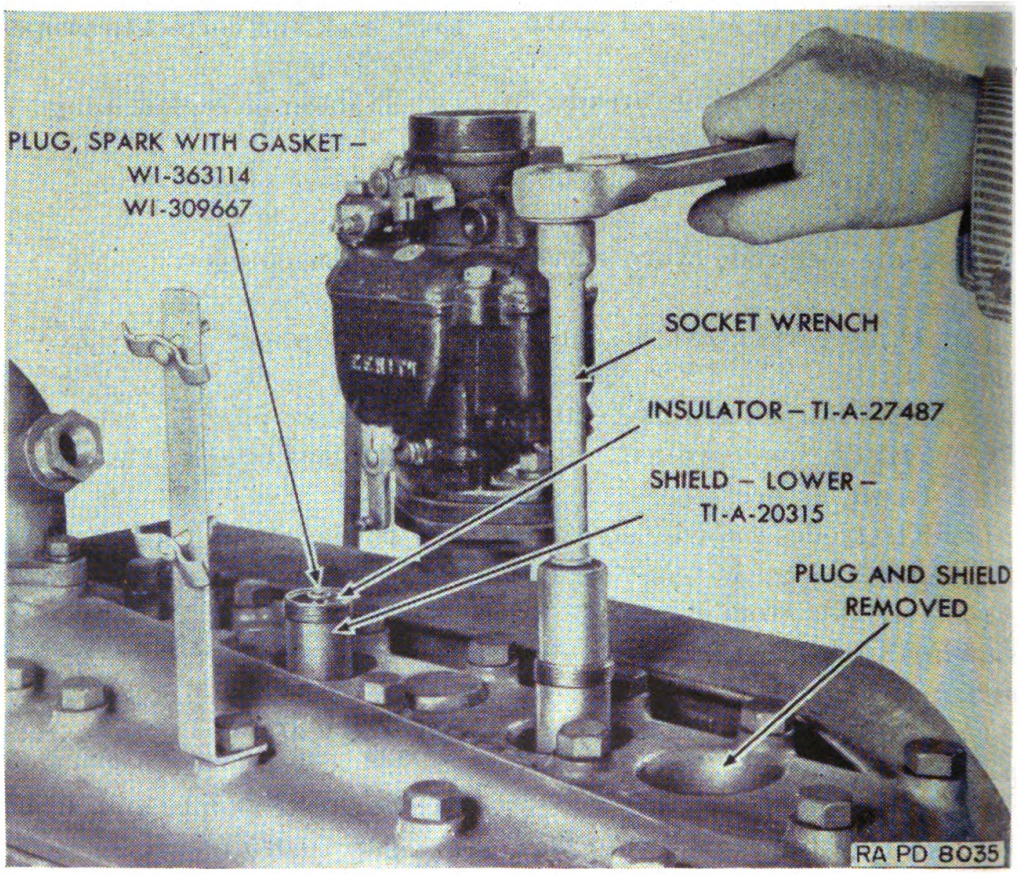


FIGURE 68.—Spark plug removal.

d. Maintenance and adjustments.—(1) After every 500 miles of operation, the spark plugs should be removed and the following checks made:

(*a*) Check for cracked or blistered insulation and replace plugs if any is evident.

(*b*) Check for dirty or worn electrodes. Clean dirty electrodes with a brush or by scraping, and replace plugs with worn electrodes.

(*c*) Check the spark gaps and if they are too large or too small, set gaps to 0.025 inch, using a gage and pliers (fig. 69).

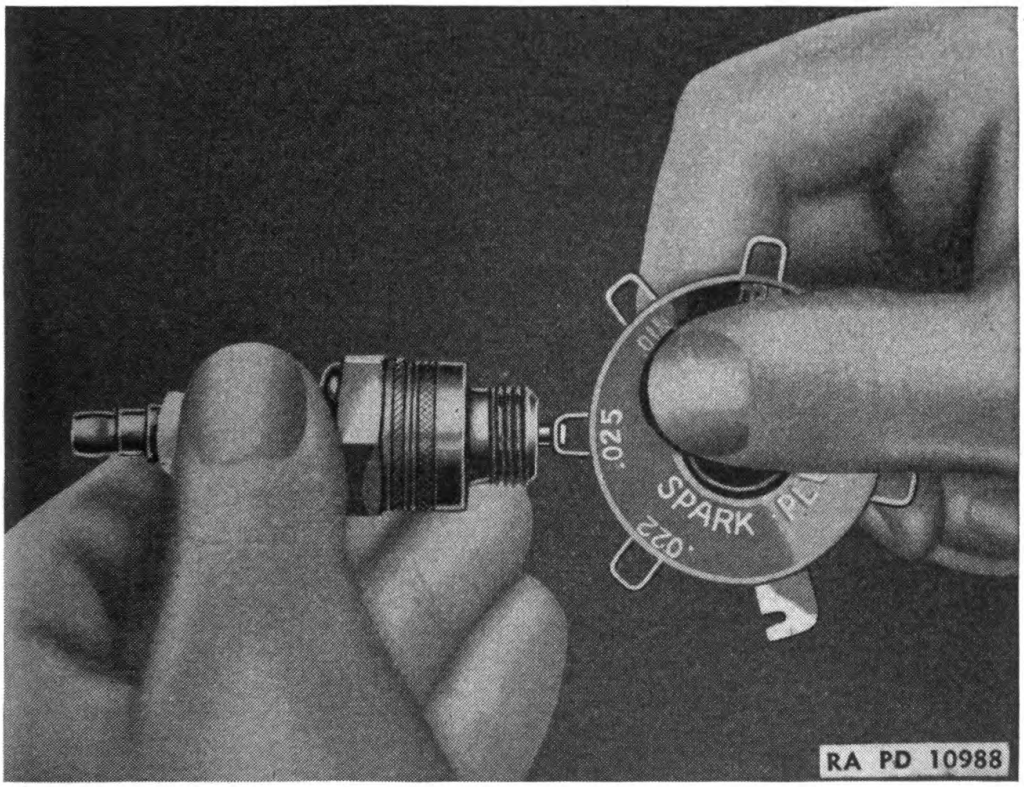


FIGURE 69.—Measuring spark plug adjustment with gage.

(2) A running engine has a certain rhythm. If a spark plug of a regularly firing cylinder is shorted out, a different rhythm is produced. Remove shield cap and short out each plug. Note the result on the operation of the engine. If a cylinder is already missing no change will be noted when its plug is shorted out. If a spark plug is thought to be faulty, it should be removed and tested in a spark plug tester.

(3) After 10,000 miles of operation, new spark plugs should be installed.

(4) For effects of different operating conditions on spark plugs, see figures 70① and ② and 71.

(5) The following cautions should be observed:

(*a*) Do not bend center electrode.

(*b*) Never touch plugs or high-voltage cables while engine is running.

FIGURE 70①.—Effects of operating conditions on spark plugs.

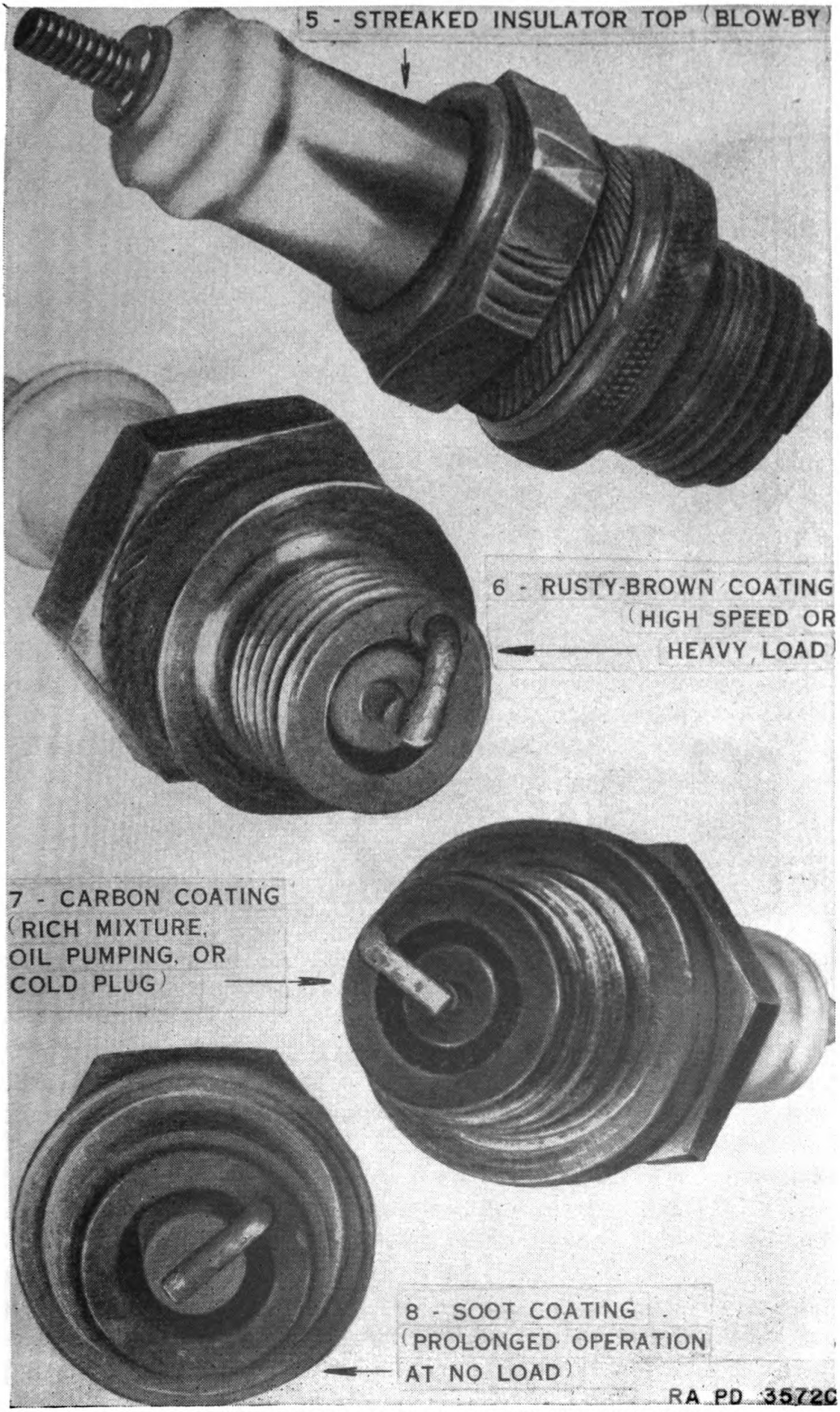


FIGURE 70.—Effects of operating conditions on spark plugs.

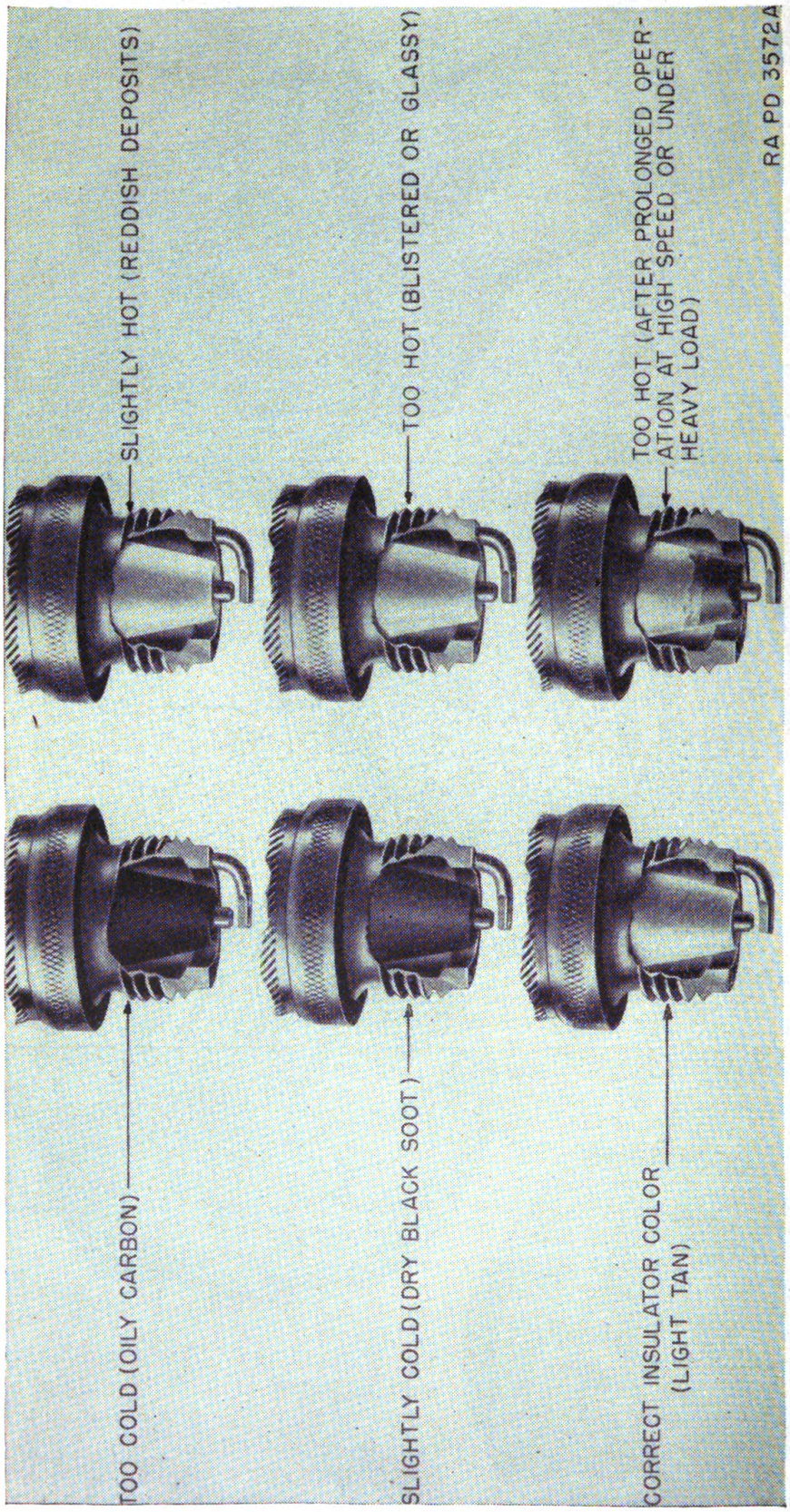


FIGURE 71.—Effects of operating conditions on spark plugs.

(*c*) Do not use graphite or other lubricants on threads of spark plugs.

(*d*) When removing or installing a plug, do not use an open end wrench. This type of wrench can slip easily and crack porcelain.

(*e*) Always use a new copper gasket when installing plugs and clean the seat around the spark plug hole in the cylinder head.

(*f*) Do not screw cold spark plug tightly into a hot cylinder head; allow head to cool first.

(*g*) Never scrape the insulation.

e. Installation of spark plug.—Tools:

$^{13}/_{16}$-inch socket wrench.
Ratchet extension.

(1) *Install spark plugs.*	$^{13}/_{16}$-inch socket wrench. Ratchet extension.

Place a new copper gasket on the seat in the cylinder head. Set plug in its lower shield and screw it into head. Avoid using excessive pressure when tightening plugs.

(2) *Install shielding.*	None.

Place insulators in upper spark plug shields so that wire terminals enter insulators. Insert lower ends of insulators into lower shields so that wire terminals engage upper ends of plug electrodes. Screw shield coupling nuts onto lower spark plug shields.

SECTION IX

ELECTRICAL—STARTING MOTOR

32. Description (fig. 72).—The starting motor is a three-bearing, four-brush motor mounted on the flywheel housing at the lower left side of the engine.

a. Construction (fig. 73).—(1) The motor consists of a frame-and-field assembly in the form of a hollow cylindrical section. The four pole pieces are mounted on the inside circumference of the frame and each is encircled by a field coil. The field coils are connected in series. The lead at one end of the coils is connected to an insulated terminal post which passes through the frame. The lead at the opposite end of the coils is connected to a brush which is mounted

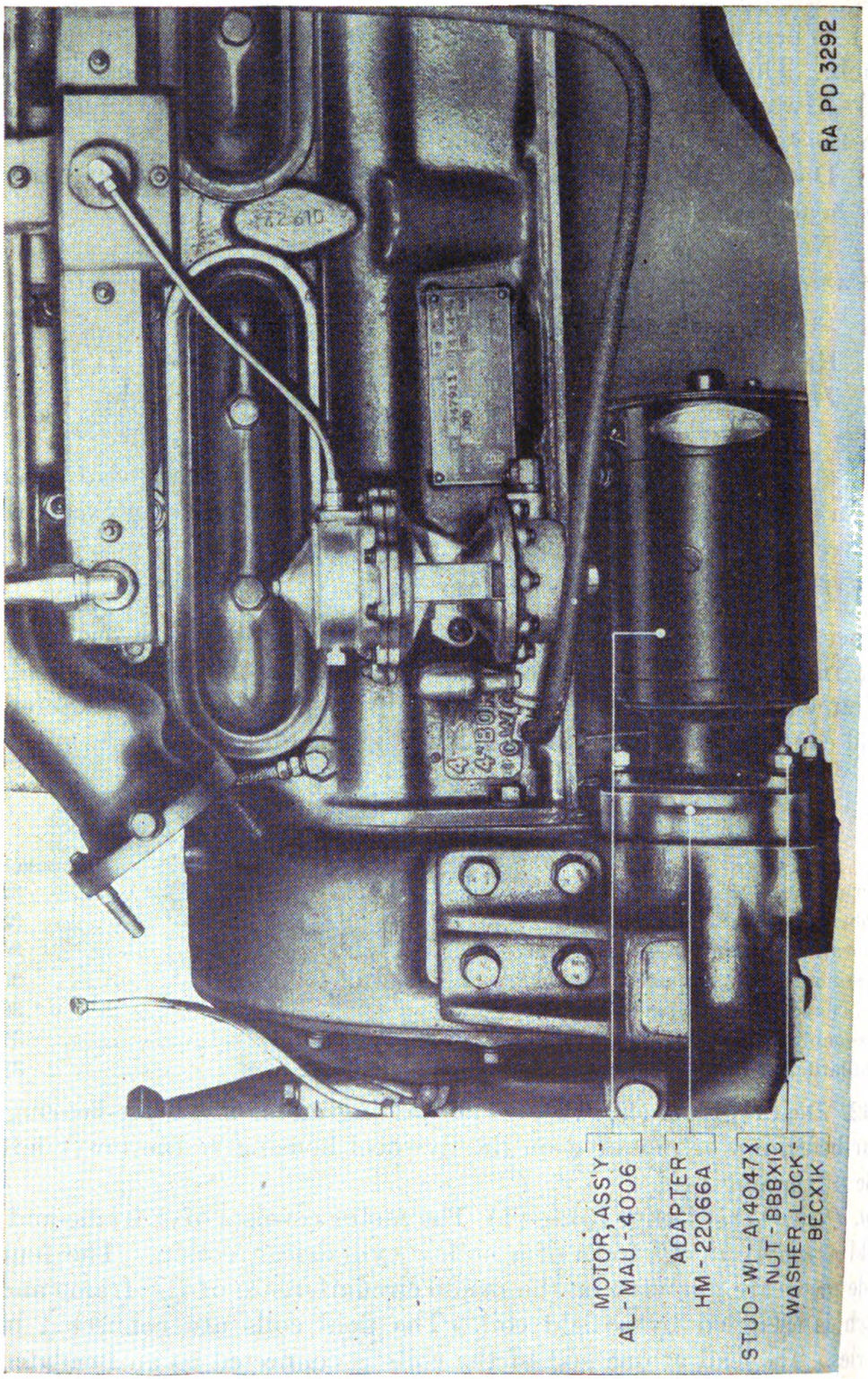


FIGURE 72.—Starting motor, installed.

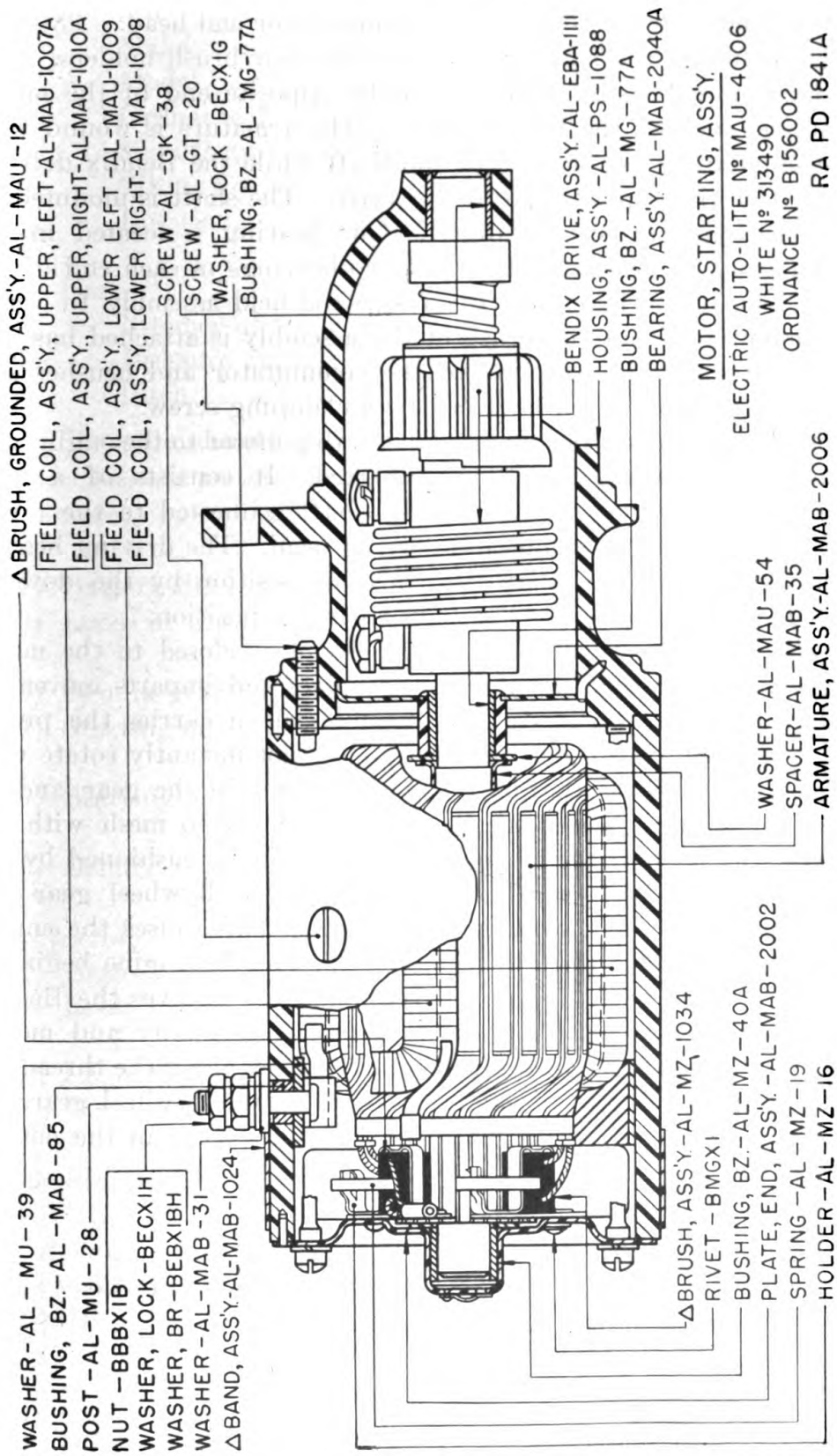


FIGURE 73.—Starting motor, sectionalized.

in an insulated brush holder on the commutator end head. This end head is bolted to the frame and carries the four brush holders. The Bendix pinion housing is bolted to the opposite end of the motor frame and encloses the Bendix drive. The armature is wound with the commutator near one end of the shaft while the Bendix drive is mounted on the opposite end of the shaft. The shaft is mounted on three bearings (bronze bushings). One bearing is located in the commutator end head and the other two bearings in each end of the pinion housing. The end of the frame-and-field assembly to which the commutator head and brush holder assembly is attached has side openings to permit inspection of the commutator and brushes and is closed by a cover band held fast by a clamping screw.

(2) The Bendix drive connects the starting motor to the engine and releases it when the engine has started. It consists of a gear mounted on a hollow spiral-threaded shaft connected to the armature shaft by a drive spring and driving head. The driving head is keyed to the armature shaft and held in position by the doweled hex bolt which also secures the drive spring in position.

b. Functioning.—When the battery circuit is closed to the motor by the starting switch, the armature revolves and imparts movement through the drive spring to the assembly which carries the pinion gear. The gear, because of its inertia, does not instantly rotate with the assembly. Hence the drive assembly turns in the gear and its threads move the gear along the drive assembly to mesh with the gear on the flywheel of the engine. The torque is cushioned by the connecting drive spring. The pinion turns the flywheel gear and the engine crankshaft, to which it is fixed. This causes the engine to turn over until it starts to run. As soon as the engine begins to run, the flywheel gear, being of large diameter, revolves the Bendix gear rapidly, forcing it to outrun the drive assembly and motor. This action causes the Bendix gear to move back along the threads of the drive assembly and disengage itself from the flywheel gear. A take-up or antidrift spring normally keeps the gear in the out-of-mesh position.

c. Specifications.

Starting motor:

Make	Electric Auto-lite Co.
Model	12-volt.
Ordnance No	B156002.
Manufacturer's No	AL-MAU-4006.
White No	313490.
Rotation	Clockwise, viewed from front.

Bendix drive:

Make	Eclipse Machine Co.
Model	Outboard R–13.
Ordnance No	B167662.
Manufacturer's No	AL–EBA–11.
White No	98320.
Rotation	Clockwise, viewed from gear end.

Gear:

Number of teeth	13.
Pressure angle	20°.
Pitch	8/10.

33. Trouble shooting.

Symptom and probable cause	*Probable remedy*
a. Starting motor fails to operate.	
(1) Battery discharged.	(1) Recharge battery.
(2) Loose or dirty connections.	(2) Clean and tighten connections.
(3) Bendix gear jammed.	(3) Free gear from flywheel.
(4) Starting motor switch faulty.	(4) Repair or replace switch.
(5) Starting motor faulty.	(5) Remove and repair, or replace starting motor.
(6) Bendix drive at fault.	(6) Remove starter and repair, or replace drive.
b. Starting motor cranks weakly.	
(1) Battery weak.	(1) Recharge battery.
(2) Loose or dirty connections.	(2) Clean and tighten connections.
(3) Commutator dirty.	(3) Remove band and clean commutator with No. 00 sandpaper.
(4) Starting motor faulty.	(4) Remove, repair, or replace starting motor.
c. Bendix drive fails to operate when starting motor revolves.	
(1) Dirty or gummy Bendix drive.	(1) Remove starting motor. Clean and lubricate drive.
(2) Drive spring broken.	(2) Remove starting motor and replace drive spring.

34. Removal of assembly.—Tools:
5/8-inch open end wrench.
9/16-inch open end wrench.

a. Disconnect motor cable. 9/16-inch open end wrench.

Detach nut and lock washer from terminal post and remove cable. Tape cable terminal to prevent possible short or ground in case starter button should be depressed accidentally.

b. Dismount motor from engine. 5/8-inch open end wrench.

Remove three nuts and lock washers which hold starting motor to studs on flywheel housing (fig. 74). Pull starting motor forward and out of vehicle (fig. 75).

35. Disassembly of components (fig. 76).—*a. Bendix drive assembly.*—Tools:
Screw driver.
Arbor press.
5/8-inch open end wrench.

(1) *Remove pinion housing.* Screw driver.

Remove two frame screws and lock washers from commutator head end of motor. Pull off pinion housing assembly from frame-and-field assembly.

(2) *Remove pinion housing end bushing.* Arbor press.

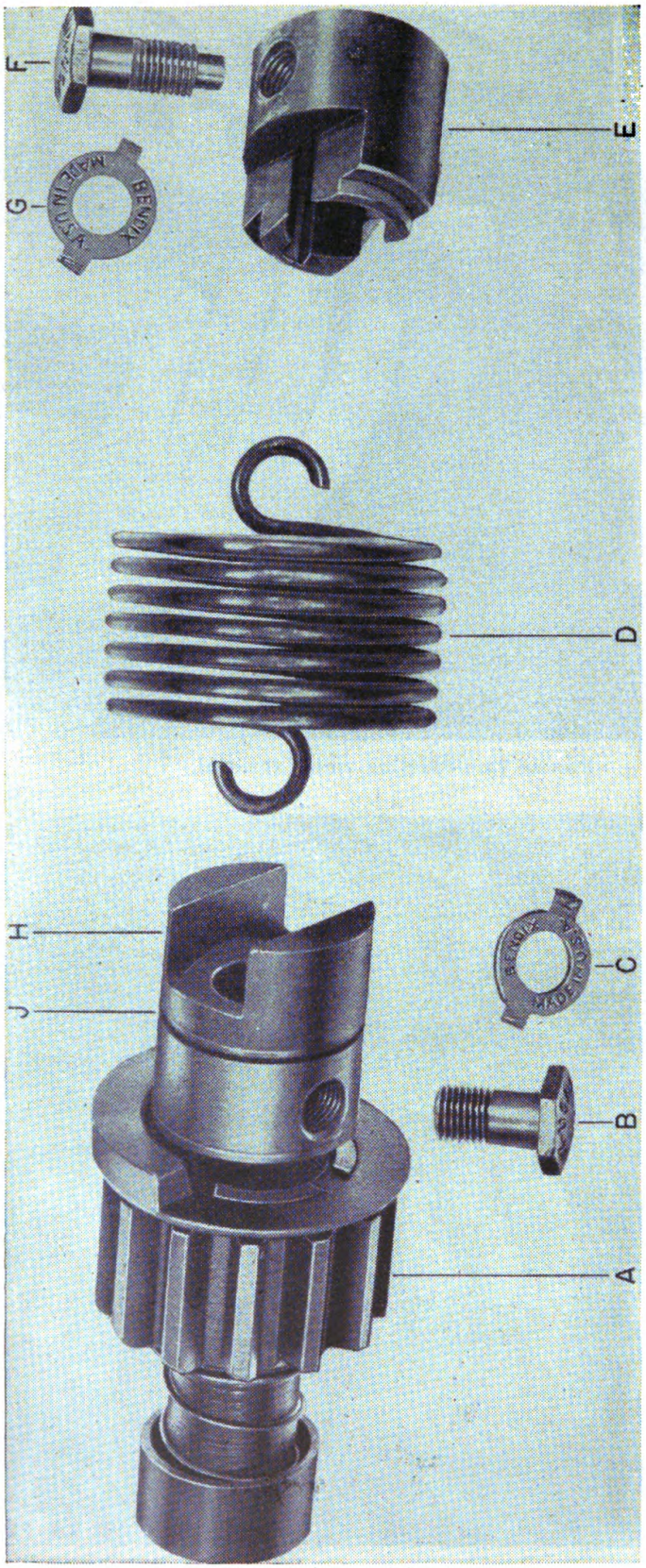
Press bushing out of pinion housing.

(3) *Detach Bendix drive assembly and take apart.* 5/8-inch open end wrench.

Remove one screw and lock washer from drive head. Pull drive assembly off armature shaft. Remove Woodruff key and drive head from armature shaft. Remove screw and lock washer from gear-and-shaft assembly. Detach drive spring.

FIGURE 74.—Starting motor removal.

FIGURE 75.—Starting motor removal.



RA FSD 1862

A. Gear-and-shaft assembly—AL–EBA1111.
B. Screw—AL–ED7807.
C. Washer, lock—AL–EB108.
D. Spring—AL–EB–8705.
E. Head—AL–EB8503.
F. Screw—AL–EB7806.
G. Washer, lock—AL–EB108.
H. Sleeve—AL–EB7819S.
J. Spring—AL–EB8734.

FIGURE 76.—Starting motor, Bendix drive, exploded view.

b. Starting motor assembly (fig. 77① and ②).—Tools:

Arbor press.	Soldering iron.
Screw driver.	Hammer.
9/16-inch screw driver socket.	Drift.

(1) *Remove intermediate bearing assembly and separate bushing.* — Arbor press.

Pull bearing assembly off end of armature shaft by hand and press out bushing.

(2) *Remove cover band.* — Screw driver.

Loosen round head machine screw and slip band off.

(3) *Remove armature assembly.* — None.

Pull armature out of frame-and-field assembly by hand. Slip off thrust washer and thrust bearing spacer from drive end and thrust washer from commutator end.

(4) *Remove commutator end head assembly with bushing.* — Screw driver. Hammer.

Lift springs from brushes connected to field and pull out brushes. Pull head assembly off frame-and-field assembly, carrying remaining two brushes with it. Knock out bushing.

(5) *Remove pole shoes and field coils.* — 9/16-inch screw driver socket. Screw driver.

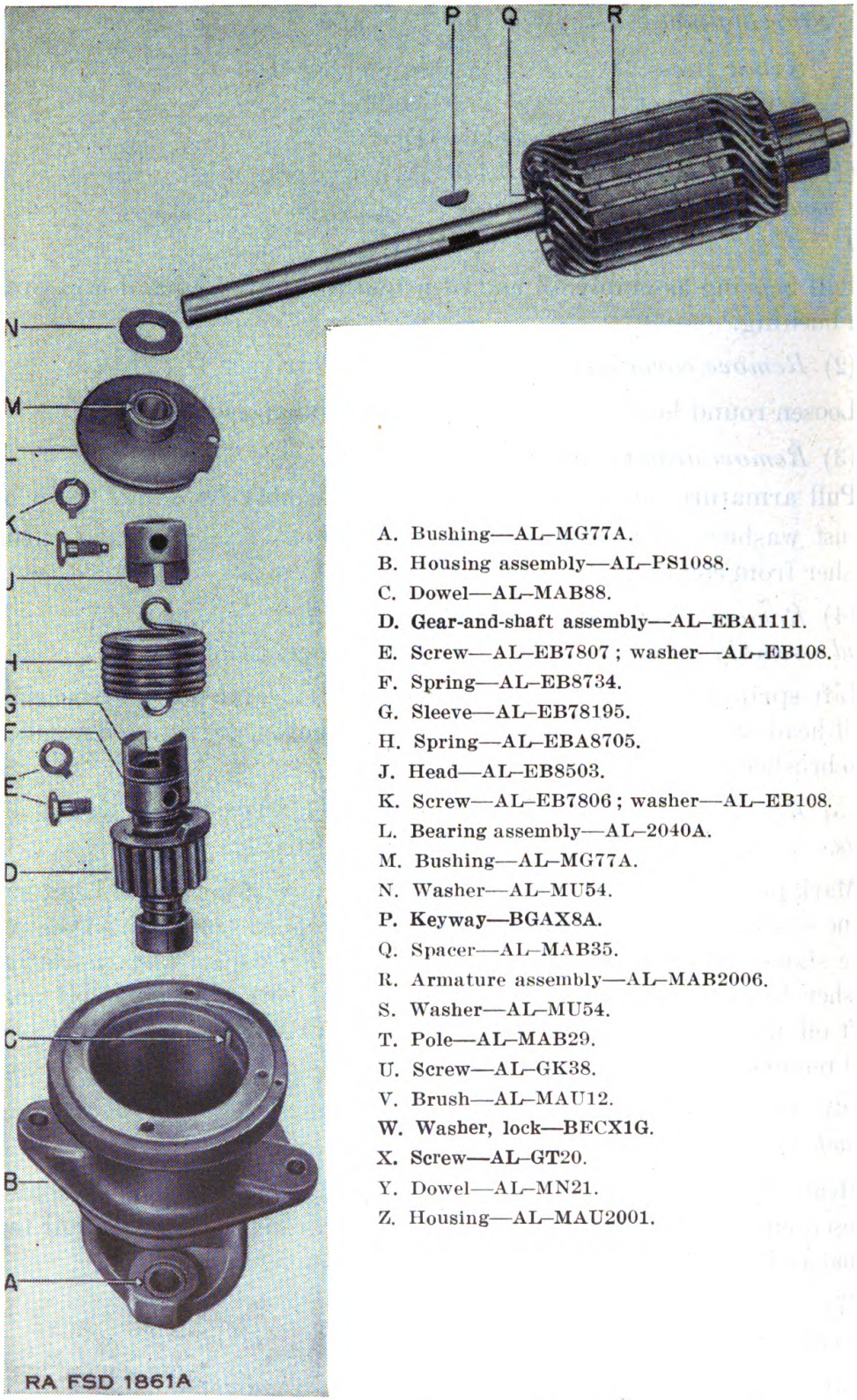
Mark position of field coils in frame. Remove four round head machine screws holding pole shoes and field coils to frame and take out pole shoes. Remove nut, lock washer, plain washer, and insulating washer from terminal post and lift out field coils and terminal post. Lift off insulating bushing and insulating washer from terminal post and remove field coil insulation from frame.

(6) *Separate field coils and detach brushes and post terminal.* — Soldering iron. Screw driver.

Heat ends of coils, coil terminal, and connectors to melt solder. Loosen ends with screw driver. Remove terminal post from coil terminal and brushes from connecter. Detach connecter.

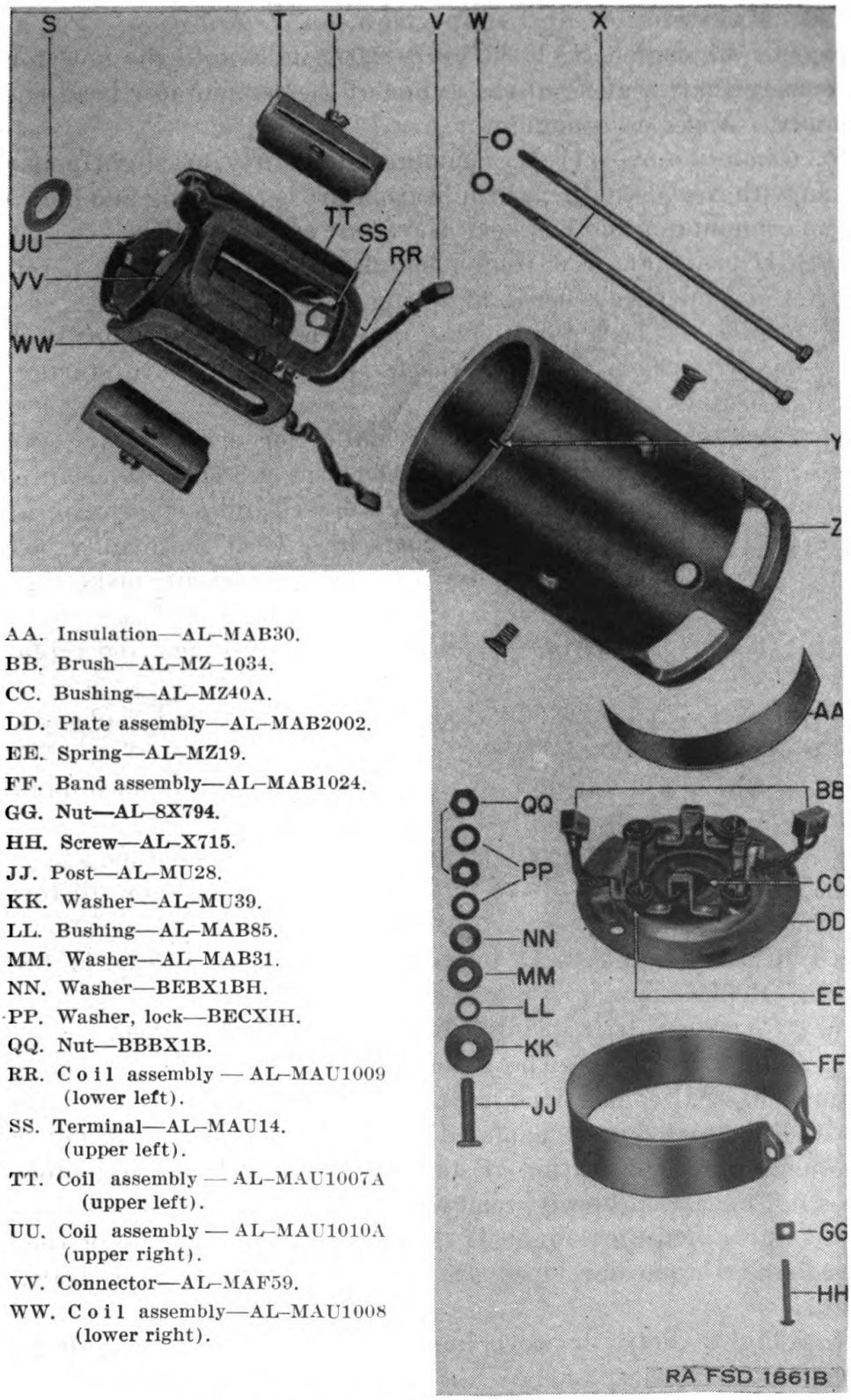
(7) *Remove brush springs from commutator end head.* — None.

Lift up springs to clear brush holders and remove.



A. Bushing—AL–MG77A.
B. Housing assembly—AL–PS1088.
C. Dowel—AL–MAB88.
D. Gear-and-shaft assembly—AL–EBA1111.
E. Screw—AL–EB7807; washer—AL–EB108.
F. Spring—AL–EB8734.
G. Sleeve—AL–EB78195.
H. Spring—AL–EBA8705.
J. Head—AL–EB8503.
K. Screw—AL–EB7806; washer—AL–EB108.
L. Bearing assembly—AL–2040A.
M. Bushing—AL–MG77A.
N. Washer—AL–MU54.
P. Keyway—BGAX8A.
Q. Spacer—AL–MAB35.
R. Armature assembly—AL–MAB2006.
S. Washer—AL–MU54.
T. Pole—AL–MAB29.
U. Screw—AL–GK38.
V. Brush—AL–MAU12.
W. Washer, lock—BECX1G.
X. Screw—AL–GT20.
Y. Dowel—AL–MN21.
Z. Housing—AL–MAU2001.

FIGURE 77①.—Starting motor, exploded view.



AA. Insulation—AL–MAB30.
BB. Brush—AL–MZ–1034.
CC. Bushing—AL–MZ40A.
DD. Plate assembly—AL–MAB2002.
EE. Spring—AL–MZ19.
FF. Band assembly—AL–MAB1024.
GG. Nut—AL–8X794.
HH. Screw—AL–X715.
JJ. Post—AL–MU28.
KK. Washer—AL–MU39.
LL. Bushing—AL–MAB85.
MM. Washer—AL–MAB31.
NN. Washer—BEBX1BH.
PP. Washer, lock—BECXIH.
QQ. Nut—BBBX1B.
RR. Coil assembly — AL–MAU1009 (lower left).
SS. Terminal—AL–MAU14. (upper left).
TT. Coil assembly — AL–MAU1007A (upper left).
UU. Coil assembly — AL–MAU1010A (upper right).
VV. Connector—AL–MAF59.
WW. Coil assembly—AL–MAU1008 (lower right).

FIGURE 77②.—Starting motor, exploded view.

36. Maintenance and inspection.—*a. Lubrication.*—Put a few drops of oil, engine, SAE 30, every 2,000 miles into the hole for the armature shaft bearing at the center of the commutator head end assembly. Never oil commutator.

b. Commutator.—(1) If 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 (fig. 78).

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. In cleaning do not use any degreasing agent such as dry-cleaning solvent on armature or fields. After all other parts have been thoroughly cleaned with clean water and blown dry with compressed air, make the following inspections:

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

(2) Check for broken or weak brush springs, and replace when necessary (see *h* below).

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

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

(5) Check Bendix drive spring for weakness or distortion. Replace faulty spring.

(6) Check Bendix drive pinion gear for wear, cracks, or broken teeth. Replace damaged parts.

(7) Check antidrift spring. Replace if weak or broken.

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.

f. Causes of failure.—(1) If the motor fails to operate or the free speed and torque developed are low, with high current draw, the cause is—

(*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 armature with test prints.

(*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 (see par. 24*e*(7) (*a*)).

(*f*) Grounded switch, terminal, or fields.

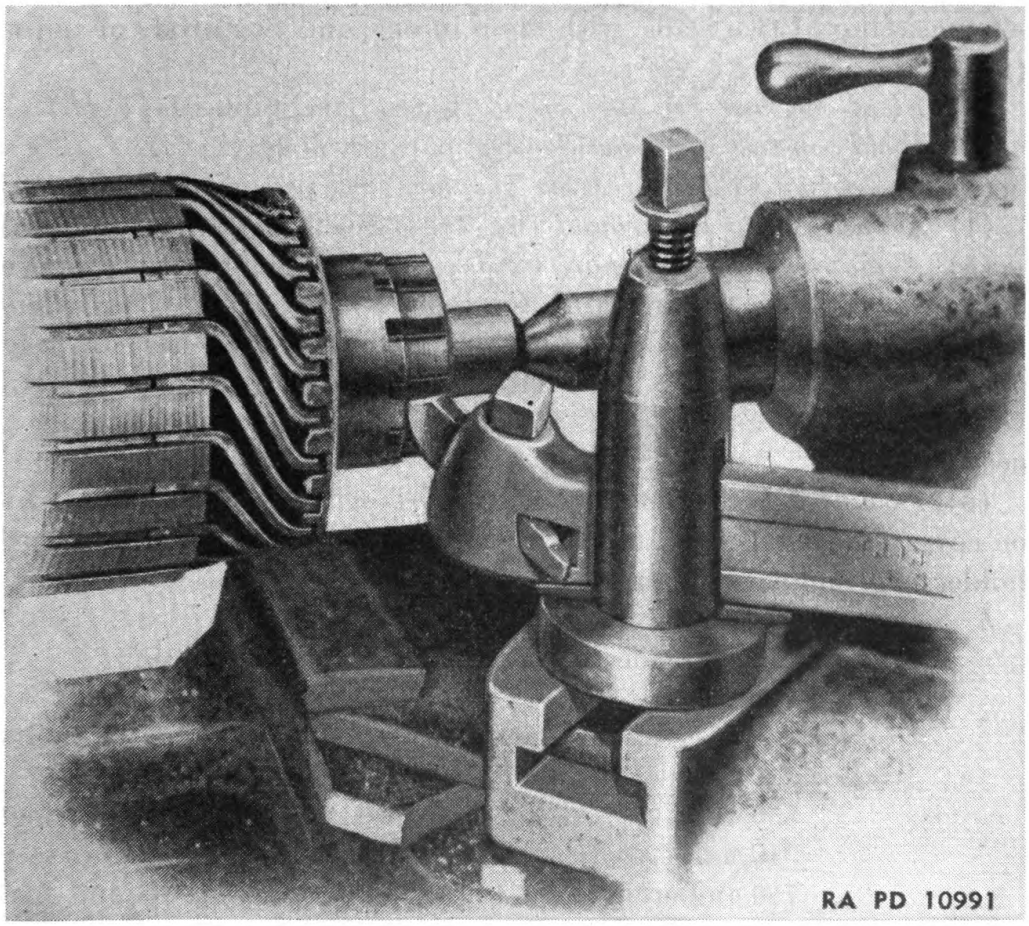


FIGURE 78.—Turning commutator.

(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. Tests.—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 (fig. 43).

(1) *Field coil test for open circuit.*—See paragraph 24*e*(7) (*b*).

(2) *Field coil test for ground.*—See paragraph 24*e*(7) (*a*).

(3) *Individual field coil test for ground.*—See paragraph 24*e*(7) (*a*).

(4) *Armature test for ground* (fig. 79).—See paragraph 24 *e*(7) (*a*).

(5) *Armature test for short circuit.*—If the trouble has not yet been located, check the armature for short circuit, using a "growler." A thin strip of steel, such as discarded hacksaw blade, held in place over the armature core as the armature is turned in the growler, will vibrate if a short circuit exists in the armature (fig. 81). Replace if necessary.

(6) *Insulated brush holder test for ground.*—Place one test prod on cover and other on insulated brush holder. If lamp lights, brush holder is grounded and should be replaced.

h. Service data.

Brush spring tension	42 to 53 ounces.
Torque tests:	
No load speed with Bendix	4,800 rpm with 11 volts and 65 amperes.
Locked torque:	
350 amperes	4 volts—11.1 pound-feet.
540 amperes	6 volts—17.3 pound-feet.
750 amperes	8 volts—23.5 pound-feet.

37. Reassembly of components.—*a. Starting motor.*—Tools:

Pliers.	9/16-inch open and wrench.
Soldering iron.	5/8-inch open and wrench.
Screw driver socket.	Screw driver.
Arbor press.	

(1) *Mount springs in commutator end head assembly.* None.

Slip inner ends of springs into split ends of brush holders and lift free end of each spring until it rests on brush holder.

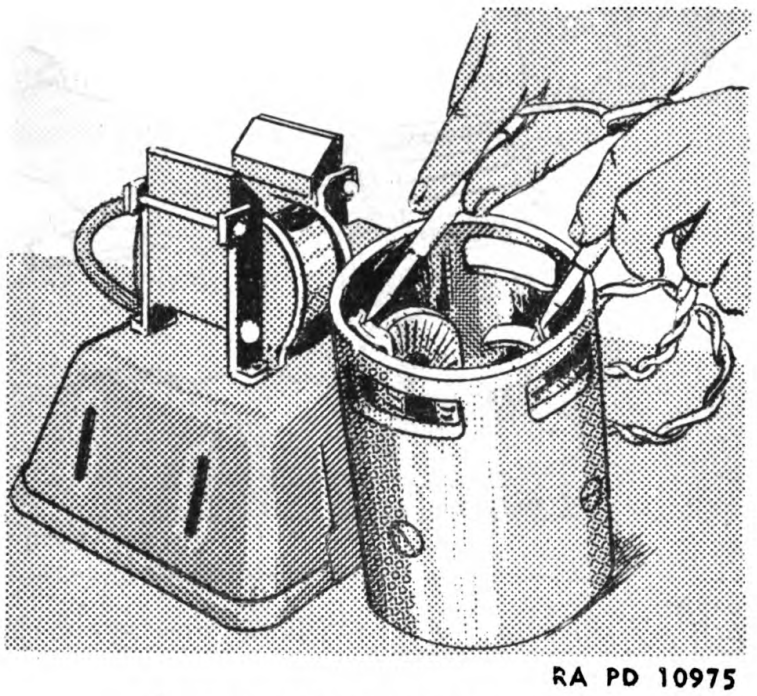


FIGURE 79.—Testing starting motor field.

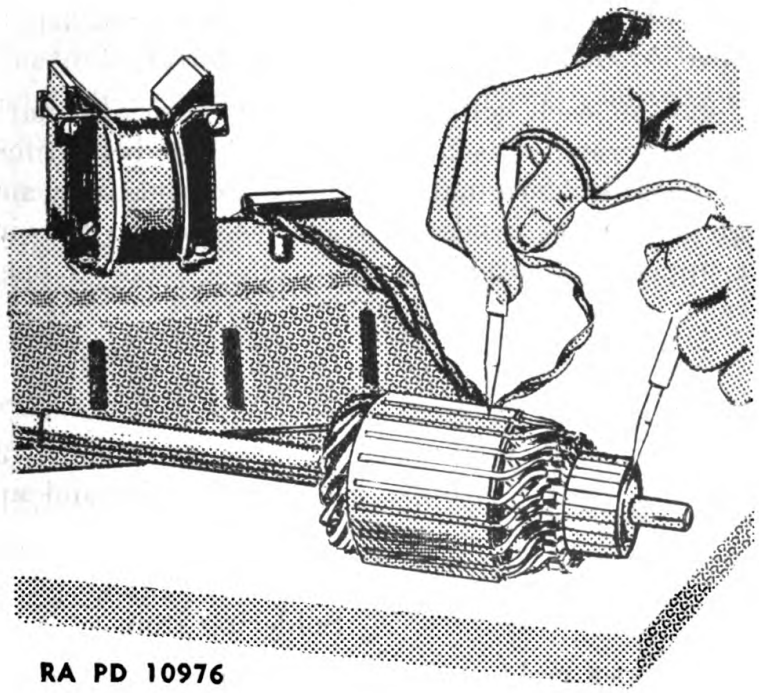


FIGURE 80.—Testing armature for ground.

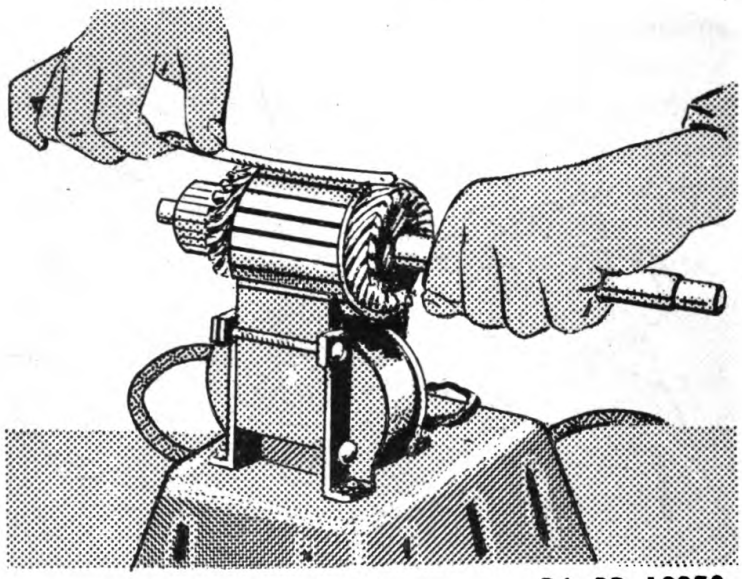


FIGURE 81.—Armature test for short circuit.

(2) *Attach terminal post and field coil terminal to upper left field coil.*	Pliers. Soldering iron.

Force post through coil terminal. Clamp one end of terminal on end of conductor at corner of coil and solder.

(3) *Mount pole shoes and field coils in field-and-frame assembly.*	Screw driver socket. Screw driver.

Put hole shoe in each coil, place coils in positions marked, and attach with one screw in each shoe. Slip large insulating washer on post over field coil terminal, add insulating bushing, and thrust post through hole from inside of frame assembly. Put insulation strip under upper and lower right coils along edge of openings in field-and-frame assembly. Tighten four screws.

(4) *Unite coils in series at drive end of field-and-frame assembly.*	Pliers. Soldering iron.

Use separate connecter for upper and lower right coils. Join and solder all ends of lower and upper right, and lower and upper left coils.

(5) *Attach two brushes to field coils.*	Pliers. Soldering iron.

Join end of upper right coil at inspection opening on field-and-frame assembly to middle of additional connector, and a complete brush and lead to each end of this connector. Pinch and solder at all points.

(6) *Insert armature into field-and-frame assembly.* None.

Pass armature into frame-and-field assembly.

(7) *Insert commutator end head bushing.* Arbor press.

Press bushing into commutator end head.

(8) *Replace commutator end head assembly.* None.

Slip thrust washer on armature shaft at commutator. Put bearing in head assembly over armature shaft. Bring notch in head assembly to receive dowel pin on frame-and-field assembly.

(9) *Mount brushes in brush holders and set springs on brushes in commutator end head assembly.* None.

Insert brushes attached to field coils through inspection openings of field-and-frame assembly into insulated holders on assembly and two additional brushes into remaining holders; then set free ends of springs upon them.

(10) *Replace intermediate bearing and bushing.* Arbor press.

Press bushing into bearing, and put bearing thrust spacer, thrust washer, and intermediate bearing assembly with bushing on armature shaft at drive end.

(11) *Secure terminal post.* $\frac{9}{16}$-inch open end wrench.

Apply insulating washer, plain washer, lock washer, hex nut, lock washer, and second hex nut to post outside of frame-and-field assembly. Tighten nuts.

b. Bendix drive.

(1) *Place drive head on armature shaft.* None.

Insert Woodruff key in slot and slip on drive head over key, lining screw hole up with hole in shaft.

(2) *Place drive spring and gear-and-shaft assembly on armature shaft.* $\frac{5}{8}$-inch open end wrench.

Slip on spring and gear-and-shaft assembly. Secure spring to drive head and drive head to shaft with dowel and hex head screw

and lock washer. Secure spring at opposite end to gear-and-shaft assembly with hex head screw and lock washer. Bend lock washer ears against screw heads.

(3) *Replace bushing in pinion housing.* Arbor press.

Force bushing into end bearing of housing.

(4) *Attach pinion housing.* Screw driver.

Slip housing over Bendix drive and insert intermediate bearing into housing. Line up dowel pin on housing with bearing. Slip long end of armature shaft through bushing. Line up hole in housing with dowel pin on field-and-frame assembly. Pass two long screws through commutator end head assembly and field-and-frame assembly into housing and tighten.

38. Installation of assembly.—Tools:

5/8-inch open end wrench.
9/16-inch open end wrench.

a. Mount starting motor on engine. 5/8-inch open end wrench.

Attach motor to flywheel housing with three studs, three nuts, and three lock washers.

b. Connect motor to battery cable. 9/16-inch open end wrench.

Remove one nut and lock washer from terminal post. Attach terminal of cable to post and secure with lock washer and nut.

SECTION X

ENGINE (STRIPPED)

39. Description (figs 82 and 93).—The engine is a model JXD Hercules gasoline unit and is a four-cycle, six-cylinder, L-head type.

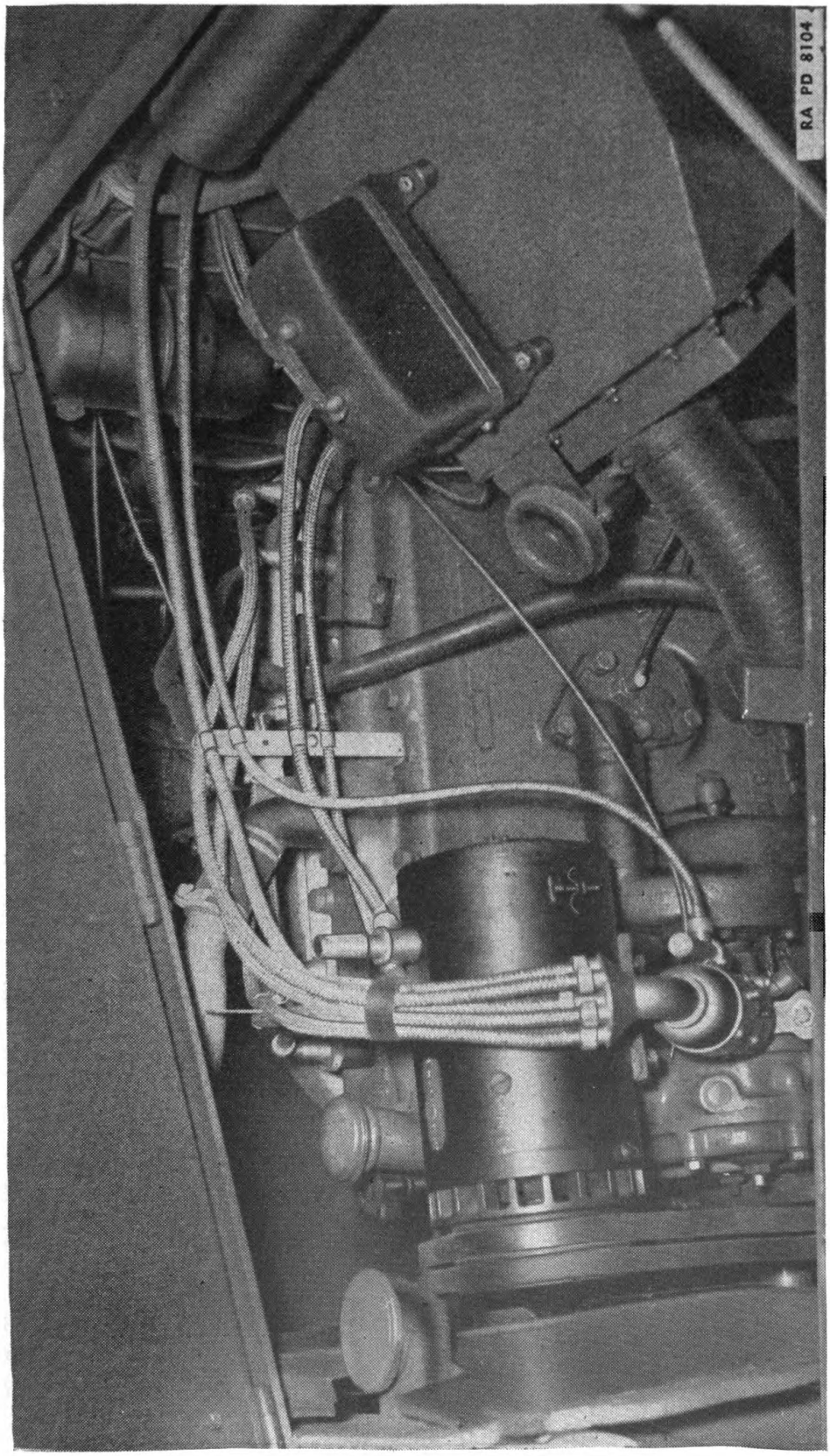


FIGURE 82.—Gasoline engine compartment, left side.

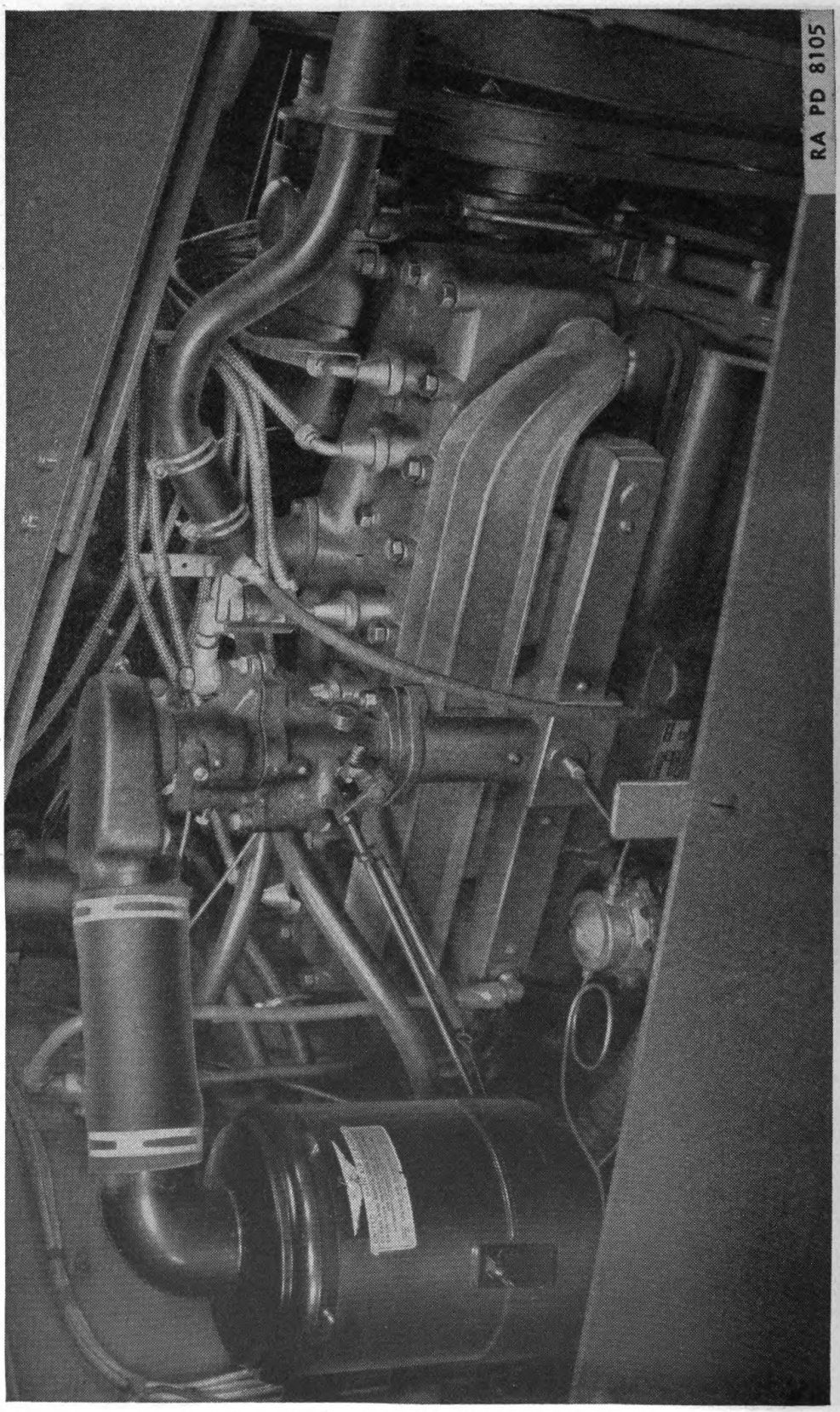


FIGURE 83.—Gasoline engine compartment, right side.

The cylinders and crankcase are cast in block with a detachable cylinder head. The inlet and exhaust manifold, carburetor, fuel pump, and starting motor are mounted on the right side (fig. 84). The water pump, distributor, generator, oil filler pipe, and oil level gage are mounted on the left side (fig. 85).

a. Construction (fig. 86).—(1) The fan is driven by dual V-type belts from a pulley keyed to an extension on the crankshaft and held

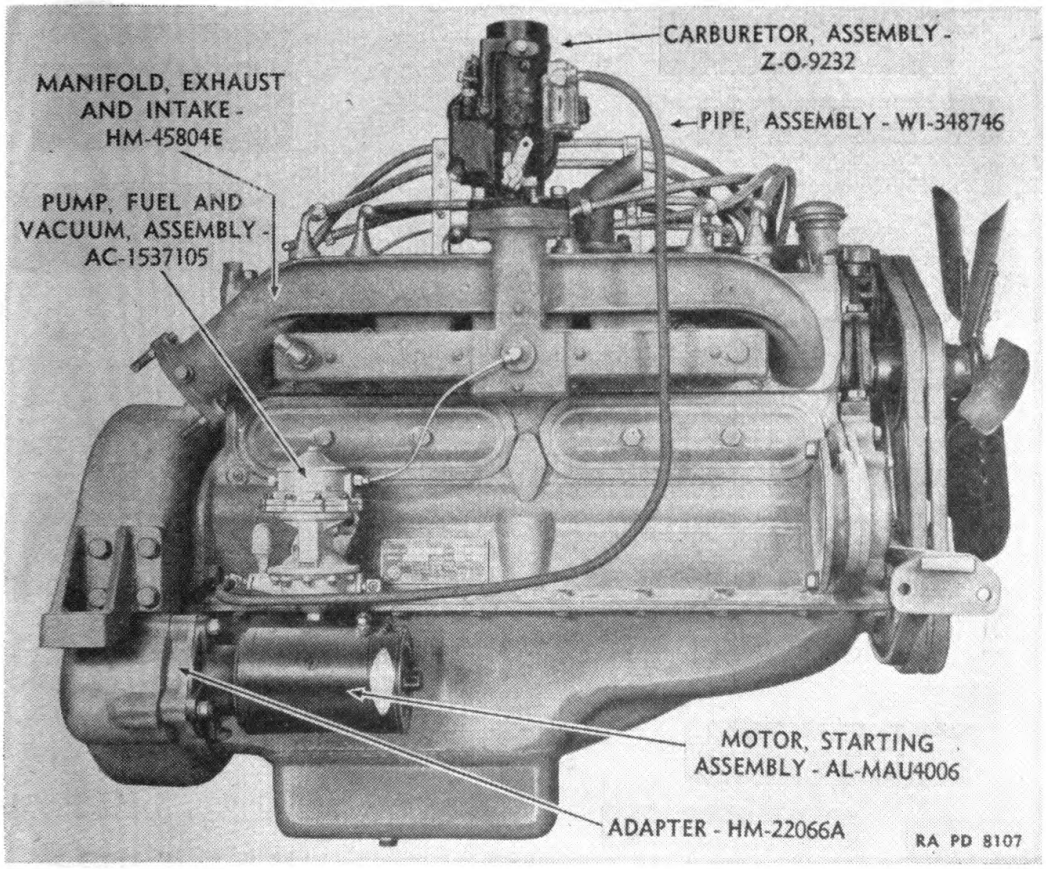


FIGURE 84.—Gasoline engine, dismounted, right side.

in place by the starting crank jaw (fig. 87). The water pump is driven directly from the gear train and is mounted on the rear of the timing gear case (fig. 88). The distributor, which is mounted on the water pump housing, is driven by a gear keyed to the water pump shaft and is held in place by a bracket and bolt.

(2) The cylinders and the upper half of the crankcase are cast in one piece and carry the seven crankshaft main bearings. The water jacket runs the full length of the cylinder bore, which provides for maximum cooling. The lubricant is forced under pressure to the seven main

bearings, connecting rod bearings, and idler gear shaft (fig. 90). Oil from the rapidly revolving crankshaft is sprayed onto the cylinder walls, pistons, and other moving parts inside the engine.

(3) The detachable cylinder head is bolted to the cylinder block with 26 cap screws. A gastight and watertight seal is maintained by means of a combination copper and asbestos gasket.

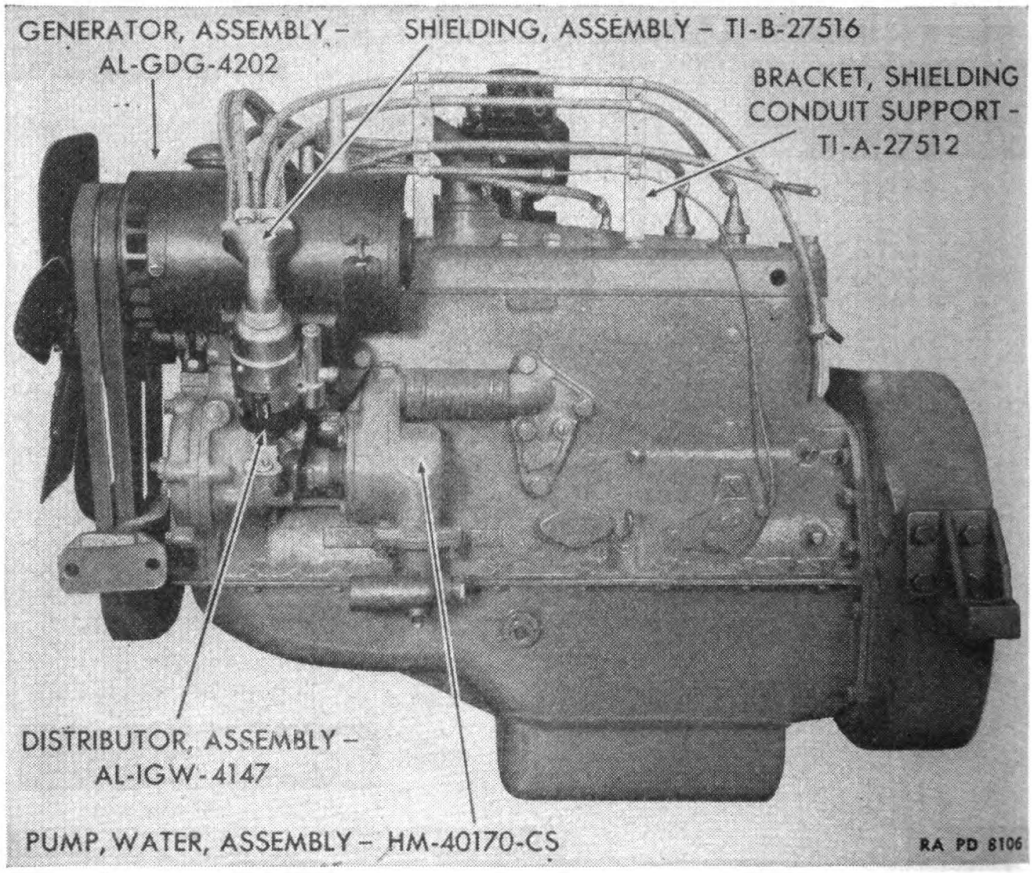


FIGURE 85.—Gasoline engine, dismounted, left side.

(4) The crankshaft is a drop forging and is both statically and dynamically balanced. Seven cadmium nickel main bearings support the crankshaft. The bearing caps are all drop forgings fitted with removable bearing shells.

(5) The pistons are made of an aluminum alloy and are of the four-ring type. All the rings are located above the piston pin. The piston pin has a very close hand-push fit in the piston and is clamped rigidly in the upper end of the connecting rod by means of a clamp screw which passes through a notch in the pin, and is locked in place with a lock washer.

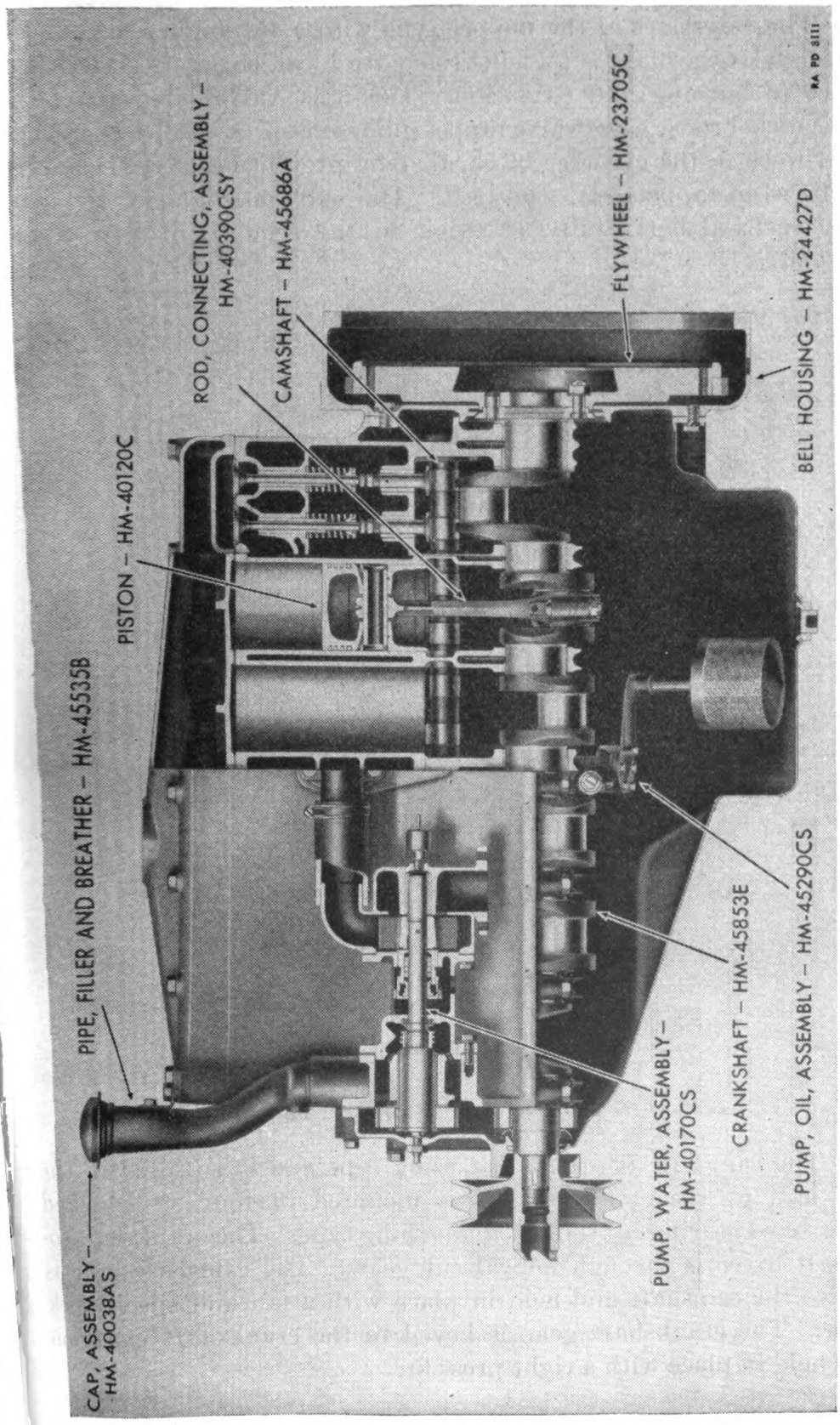


FIGURE 86.—Gasoline engine, sectionalized, side elevation.

(6) The valves are of the poppet type with a 45°-angle seat. The exhaust valves are made of silchrome steel, which offers high resistance to burning and oxidation. The inlet valves are made of chrome nickel steel. The valve tappet guides are pressed directly into special webs in the cylinder block, thereby preventing any misalinement between tappets and camshaft. The valve mechanism is completely enclosed but readily accessible by the removal of the valve cover plate.

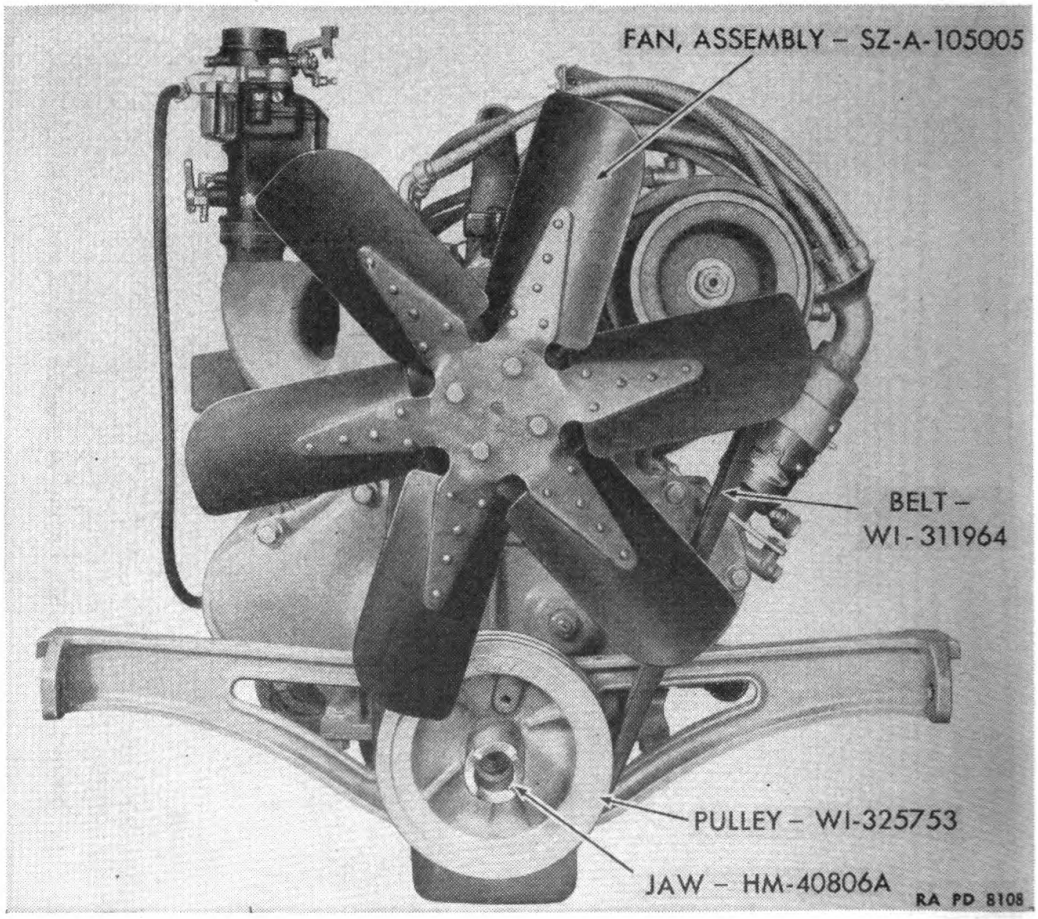


FIGURE 87.—Gasoline engine, dismounted, front view.

(7) The camshaft is of the cast alloy type and is enclosed in the upper half of the crankcase. It is mounted in four steel-backed babbitt-lined bearings of the continuous ring type. The crankshaft-to-camshaft drive is through helical cut gears. The camshaft gear is keyed to the camshaft and held in place with a nut and special lock washer. The crankshaft gear is keyed to the crankshaft extension and is held in place with a tight press fit.

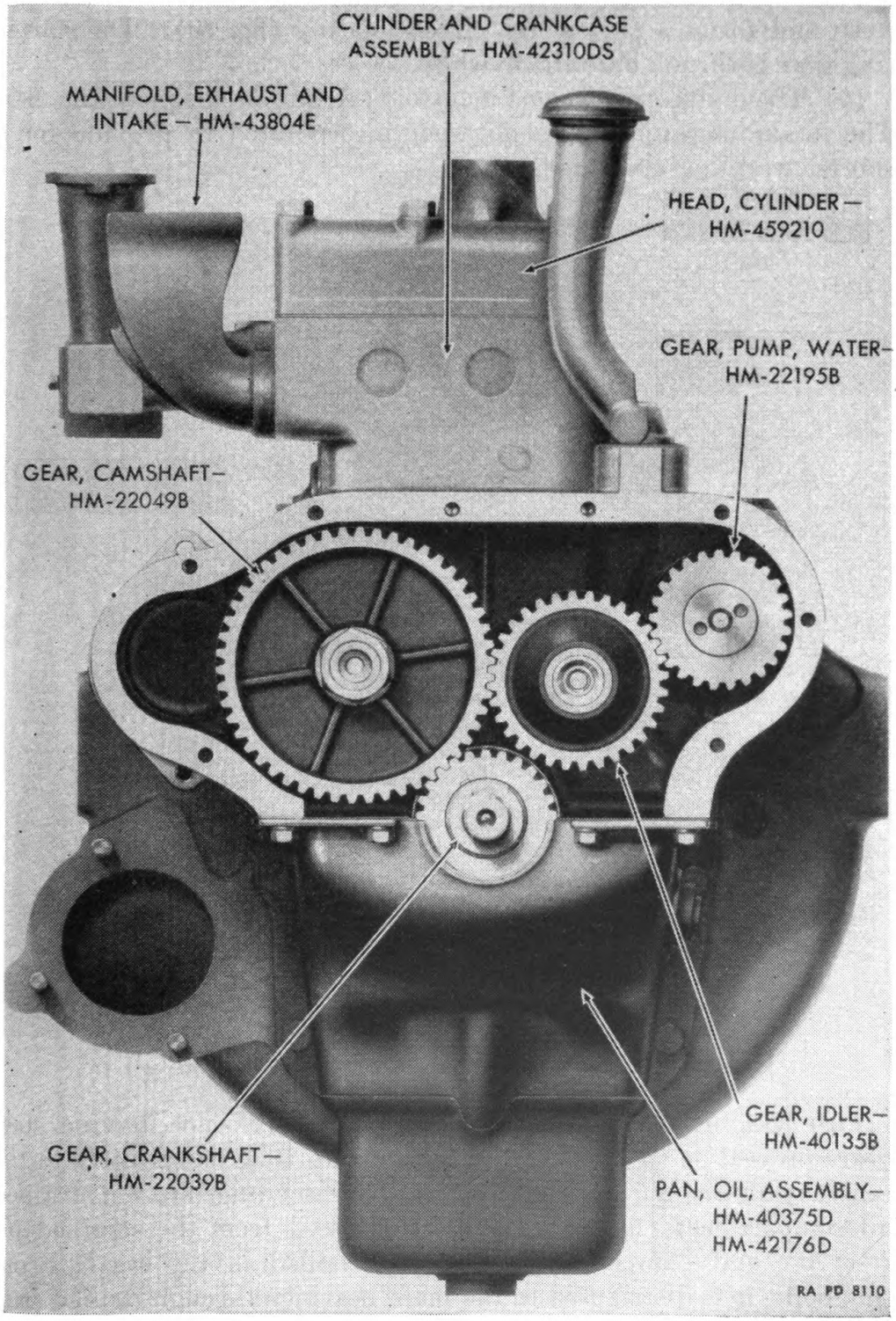


FIGURE 88.—Gasoline engine, sectionalized, front elevation.

(8) The flywheel is bolted and doweled to the flange on the crankshaft and forms a part of the clutch housing (fig. 89). The starter ring gear is shrunk onto the flywheel.

(9) The intake and exhaust manifold are cast in one piece (fig. 84). The intake manifold has a hot spot incorporated to provide for a shorter warming-up period.

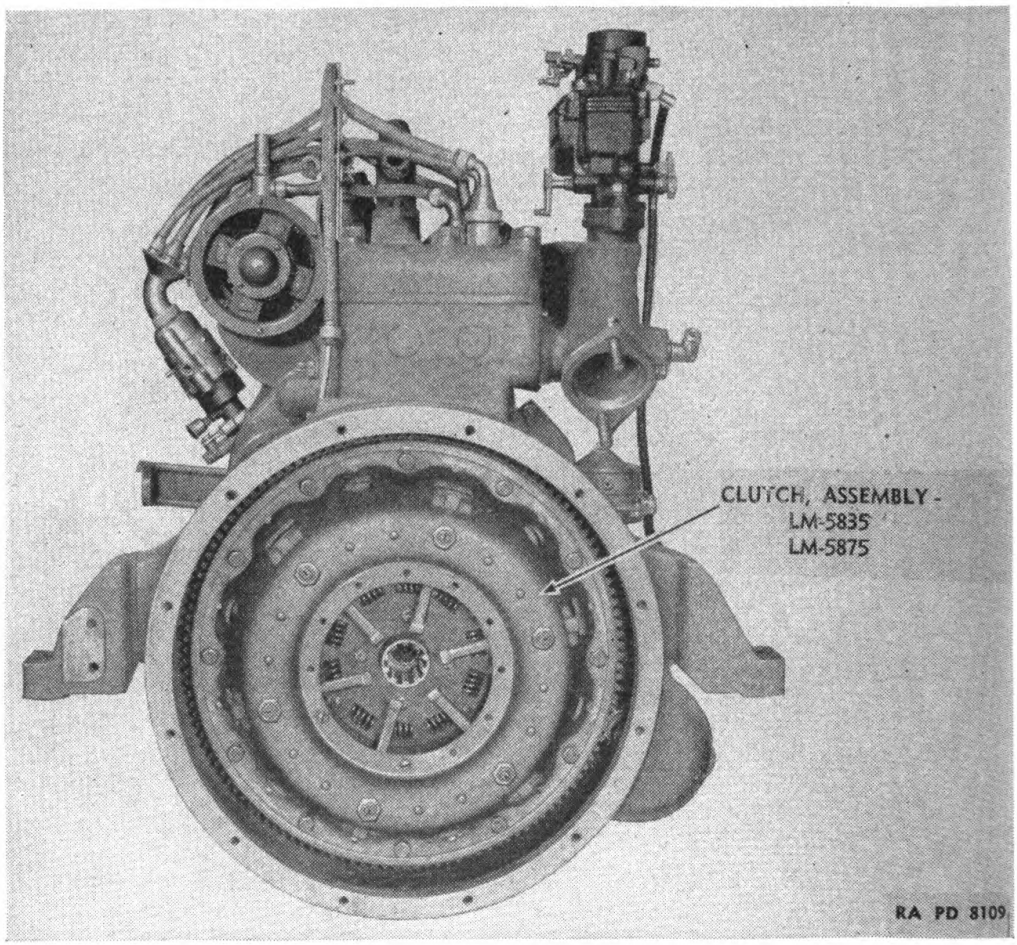


FIGURE 89.—Gasoline engine, dismounted, rear view.

(10) The oil pump is of the two-gear positive type, having steel gears pressed on steel shafts. The oil pump is bolted directly to the center main bearing web, the suction tube extending into the strained oil compartment (fig. 90). The oil is raised from the strained oil reservoir and pumped into a channel drilled in the case. From this point it is distributed to the main bearings through drilled passages and thence to the connecting rod bearings through the drilled crankshaft.

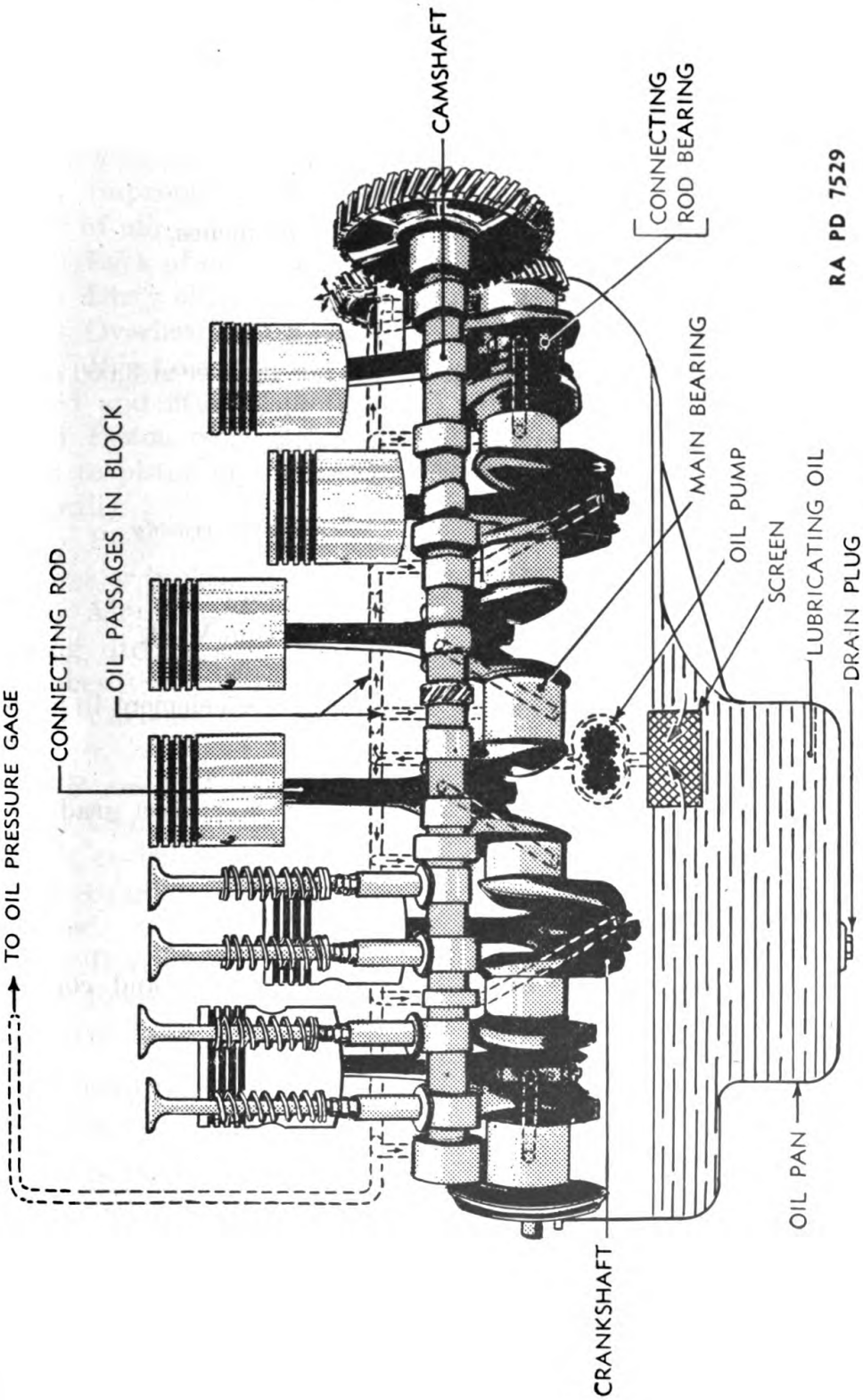


FIGURE 90.—Gasoline engine lubricating system.

b. Specifications.

Make	Hercules gasoline.
Model	JXD.
Type	L-head.
Number of cylinders	6.
Bore	4-inch.
Stroke	4¼-inch.
Piston displacement	320 cubic inches.
Compression ratio	6.5 to 1.
Rated horsepower (N. A. C. C.)	38.4.
Firing order	1–5–3–6–2–4.
Maximum bhp at maximum rpm	110 horsepower at 3,000 rpm.
Crankcase	With block.
Capacity	6 quarts.

40. Trouble shooting.

Symptoms and probable cause	*Probable remedy*
a. Lack of power.	
(1) Low or poor compression.	(1) See below.
(2) Poor ignition.	(2) See section VIII.
(3) Poor carburetion.	(3) See section XI.
(4) Air cleaner restricted.	(4) Clean mesh element in gasoline.
(5) Overheating.	(5) See section VI.
(6) Improper grade and viscosity of oil.	(6) Change to correct grade.
b. Poor compression.	
(1) Valves worn.	(1) Grind valves.
(2) Valve seats worn or pitted.	(2) Cut new seats.
(3) Piston rings weak, broken, stuck, or worn.	(3) Replace rings and correct cause of sticking.
(4) Tappets sticking.	(4) Clean guides.
(5) Tappets set too close.	(5) Set clearance at 0.006 inch.
(6) Leaky spark plugs.	(6) Tighten plugs in head.
(7) Cylinder head loose.	(7) Tighten head.
(8) Cylinder head gasket leaking.	(8) Replace gasket.
(9) Worn pistons.	(9) Replace worn parts.
(10) Worn cylinders.	(10) Rebore cylinders.
(11) Valve stems worn.	(11) Replace valves.
(12) Valve guides worn.	(12) Replace guides.

(13) Valve springs weak or broken.	(13) Replace springs.
(14) Valve timing incorrect.	(14) Correct timing.
c. Excessive cylinder and piston wear.	
(1) Improper grade and viscosity of oil.	(1) Change oil to correct grade and viscosity.
(2) Lack of oil.	(2) Keep oil at correct level.
(3) Dirty oil.	(3) Always change dirty oil.
(4) Overheating.	(4) See section VI.
(5) Piston improperly installed and fitted.	(5) Correct or replace piston.
(6) Piston rings not properly fitted to piston groove and cylinder wall.	(6) Install new rings and fit correctly.
(7) Piston rings stuck in piston grooves or broken.	(7) Clean or replace rings.
(8) Air cleaner not clean, allowing dirt to enter combustion chamber.	(8) Clean air cleaner mesh and sump.
(9) Carburetor fuel mixture too rich.	(9) Replace worn jets.
d. Bearing failures.	
(1) Crankshaft bearing journal rough or out of round.	(1) Grind or replace shaft.
(2) Crankshaft oil passage restricted.	(2) Clean passages and line.
(3) Bearings sprung.	(3) Replace sprung inserts.
(4) Bearings loose or improperly fitted.	(4) Adjust mains 0.0025 to 0.0035 inch and rods 0.0015 to 0.002 inch.
(5) Crankshaft out of alinement.	(5) Straighten, or replace if necessary.
(6) Bearings out of alinement.	(6) Aline bearings with shims, or replace if necessary.
(7) Lack of oil.	(7) Add oil or check oil pump.
(8) Low oil presure.	(8) Adjust pump to deliver 5-pound pressure at idling and at least 25-pound pressure at running speed. Fit bearings properly.

(9) Overspeeding engine.	(9) Continuous operation at maximum speed or close to it is to be avoided. Exercise caution when going down grade.
(10) Restricted oil passages.	(10) Clean oil passages and line.
(11) Bent connecting rod.	(11) Replace rod.
(12) Improper oil.	(12) Use correct oil. (See TM 9–1705.)
e. Burned valves and seats.	
(1) Tappets set too close.	(1) Set at 0.006 inch.
(2) Weak valve springs.	(2) Replace springs.
(3) Improper valve timing.	(3) Time properly (see valve timing).
(4) Excessive carbon deposits around seat and valve head.	(4) Clean carbon.
(5) Valves sticking in guides.	(5) Clean stems and guides. Replace parts as required.
(6) Improper type valves.	(6) Use genuine parts.
(7) Valve head too thin, causing hot sections.	(7) Replace valve.
(8) Valve seats too narrow.	(8) Cut seats to correct width.
(9) Lean mixture.	(9) Clean carburetor. Check float adjustment.
(10) Overheating.	(10) See section VI.
(11) Low-grade fuel.	(11) Use good quality fuel.
f. Valves sticking.	
(1) Improper valve clearance.	(1) Set at 0.006 inch.
(2) Insufficient clearance between valve stem and guide.	(2) Ream guides for proper clearance.
(3) Valve springs weak.	(3) Replace springs.
(4) Valve springs broken.	(4) Replace springs.
(5) Valve stems scored or dirty.	(5) Replace or clean valves.
(6) Gummy deposits from inferior fuels or oils.	(6) Clean. Use better grade fuel or oil.
g. Overheating.	
(1) Ineffective cooling.	(1) See section VI.
(2) Lack of oil.	(2) Add oil.
(3) Carburetor choke valve partly closed.	(3) Adjust controls.

(4) Improper valve timing.	(4) Correct timing.
(5) Exhaust line restricted.	(5) Check muffler and tail pipe.
h. Excessive oil consumption.	
(1) Piston rings worn or broken.	(1) Install new rings.
(2) Crankcase gasket loose.	(2) Tighten or replace.
(3) Front gear case loose.	(3) Tighten.
(4) Poor grade of oil.	(4) Use recommended grade oil. (See TM 9–1705.)
(5) Cylinder walls worn.	(5) Rebore cylinders.
(6) Cylinder bore out-of-round or excessive taper.	(6) Overhaul cylinders.
(7) Main or rod bearings worn or loose.	(7) Adjust or replace bearings.
(8) Ring gaps too great.	(8) Install new rings.
(9) Ring gaps lined-up.	(9) This condition will correct itself.
(10) Rings poorly seated.	(10) Replace rings.
(11) Overheating.	(11) See section VI.
(12) Oil ring slots clogged with carbon.	(12) Clean rings of carbon. Replace if necessary.
(13) Excessive oil pressure.	(13) Adjust pump pressure.
i. Low oil pressure.	
(1) Improper oil.	(1) Use correct oil. (See TM 9–1705.)
(2) Pressure regulating plunger worn or clogged.	(2) Adjust correctly. (Oil pressure 5 pounds at idling and at least 25 pounds at running speed.)
(3) Oil pump screen clogged.	(3) Clean screen.
(4) Excessive crankshaft and connecting-rod bearing clearance.	(4) Adjust crankshaft bearings to 0.0025 to 0.0035 inch and rod bearings to 0.0015 to 0.002 inch.
(5) Oil pump worn.	(5) Overhaul oil pump.
(6) Idler gear shaft worn .	(6) Replace shaft.
j. Popping, spitting, and spark knock.	
(1) Excessive carbon deposits.	(1) Clean carbon from engine.
(2) Hot spot in cylinder head (carbon formation or clogged water passage).	(2) Clean carbon from engine.

(3) Improper valve timing.	(3) Check valve timing.
(4) Ignition timing incorrect.	(4) Correct timing (see Sec. VIII).
(5) Carburetion incorrect.	(5) Check carburetor (see Sec. XI).
(6) Spark plug gaps too wide.	(6) Set plugs at 0.025 to 0.028 inch.
(7) Tappets set too close.	(7) Set at 0.006 inch.
(8) Exhaust valve head too thin, causing hot sections.	(8) Replace valve.
(9) Weak valve springs.	(9) Replace springs.
(10) Valves not seating properly.	(10) Grind valves, and cut seats if necessary.
(11) Piston and rings in poor condition.	(11) Overhaul.

41. Removal of assembly.—Tools:

Pail.
Pliers.
9/16-inch open end wrench.
Heavy-duty square shank screw driver.
Length of rope.
Hoist.
9/16-inch box wrench.
1/2-inch open end wrench.
Screw driver.
3/4-inch socket wrench.
7/8-inch socket wrench with universal attachment.
7/16-inch open end wrench.
7/8-inch open end wrench.
3/8-inch open end wrench.
5/8-inch open end wrench.
Channellock pliers.
9/16-inch socket wrench.
Thin screw driver.
3/8-inch thin wall socket wrench.
3/4-inch open end wrench.
9/16-inch socket with speed handle.
Length of 3/4-inch manila rope (at least 14 feet).
15/16-inch socket wrench.
15/16-inch open end wrench.
Wood blocks.
Hammer.

a. Drain radiator.

Pail.
Pliers.

Open drain cock or lower left-hand hose connection and drain water into pail or on ground.

b. Remove hood.

9/16-inch open end wrench.
Heavy-duty square shank screw driver.
Length of rope.
Hoist.

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.

c. Remove shutter assembly.

9/16-inch box wrench.
Heavy-duty screw driver.
1/2-inch open end wrench.
Chain hoist.

Remove bolts and nuts holding 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.

Screw driver.

Loosen clamps holding inlet and outlet radiator hoses and pull hoses loose from radiator.

e. Remove radiator.

3/4-inch socket wrench.
7/8-inch socket wrench with universal attachment.
Chain hoist.

Disconnect radiator from cross member by removing holding stud nuts, springs, washers, and pads. Then disconnect stay rods at frame by removing nuts from stay rod bolts underneath car on the bottom side of the top frame flange. Remove radiator assembly from car by lifting up and slightly forward (fig. 91).

f. Remove heater inlet and return hoses.

Screw driver.

Loosen clamp holding inlet hose to cylinder head connection and pull off hose. Then loosen clamp holding return hose to water pump connection and clip holding hose at cylinder head. Pull hose from water pump connection.

g. Disconnect battery.

9/16-inch open end wrench.

Remove cap screws and lock washers holding battery compartment cover and lift off cover (fig. 92). Loosen nuts clamping cable

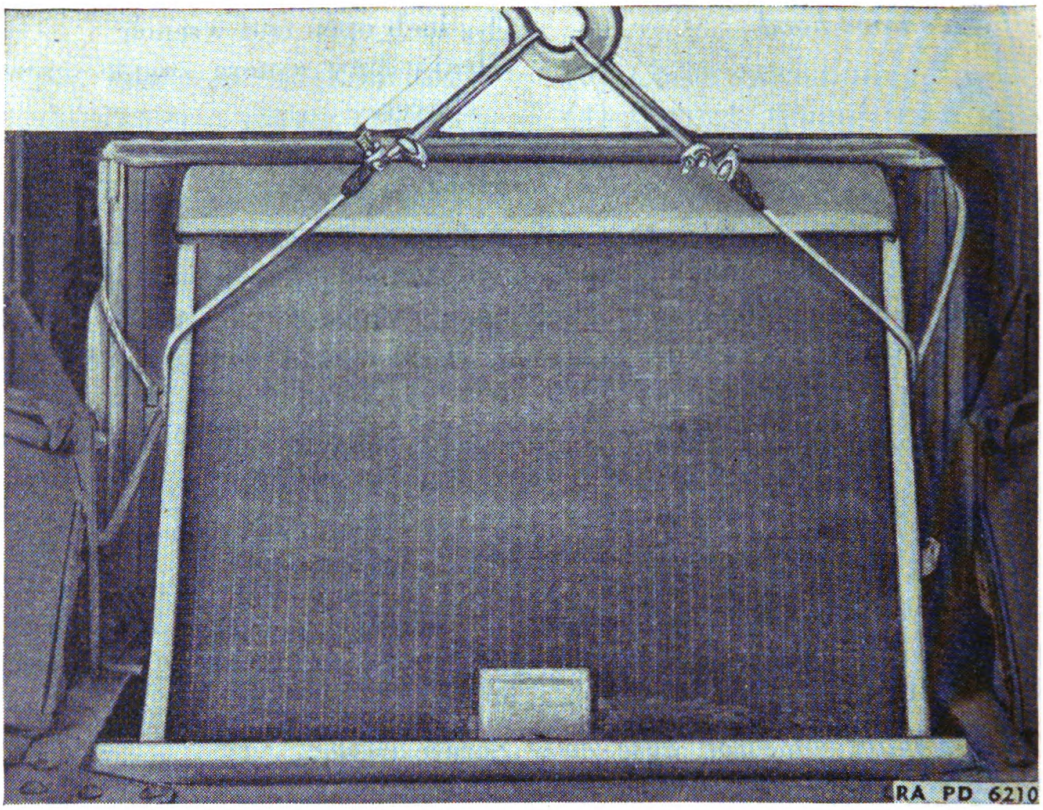


FIGURE 91.—Radiator removal.

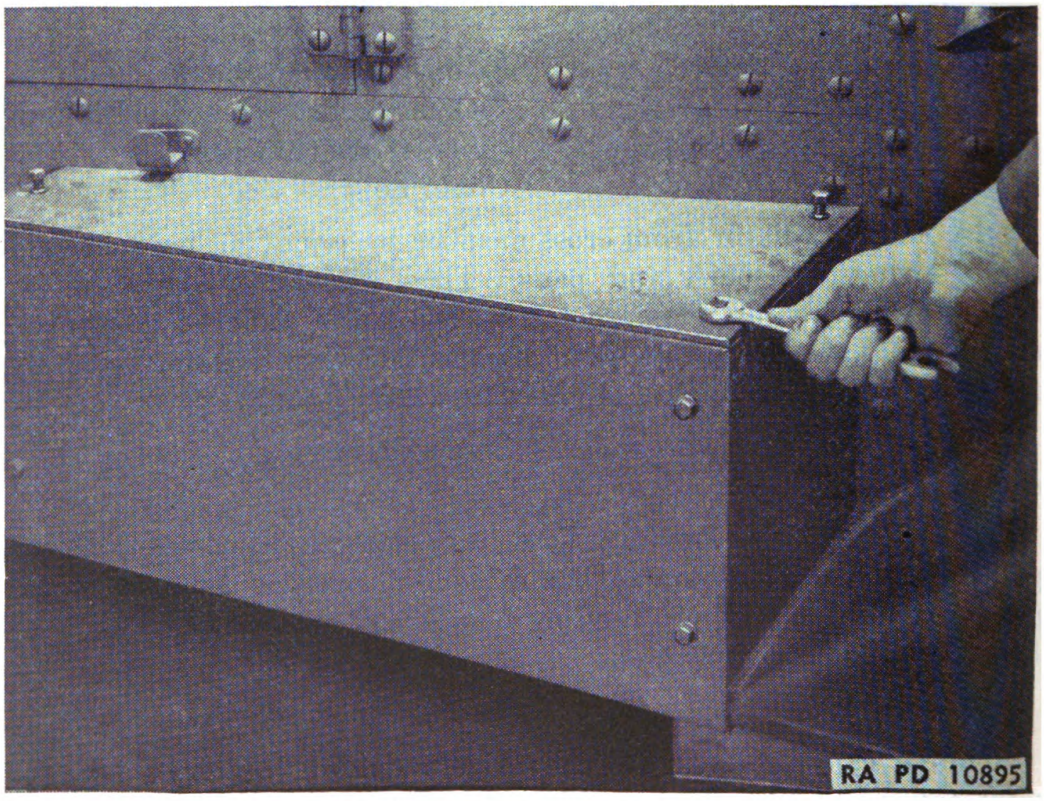


FIGURE 92.—Battery compartment cover removal.

terminals to battery terminals and pull off cables from terminals. Always pull off negative cable first (fig. 93). Tape cable terminals.

h. Remove carburetor air horn and rubber hose assembly. ½-inch open end wrench. Screw driver.

Loosen clamp holding hose to air cleaner outlet. Then loosen cap screw holding air horn to carburetor air inlet. Lift horn from carburetor and remove horn and hose assembly (fig. 176).

i. Remove pipe assembly fuel pump to carburetor. ½-inch open end wrench.

Shut off fuel tank supply at transfer shut-off valve. Disconnect flanged tube nuts at fuel filter inlet connection and at fuel pump outlet connection and remove pipe assembly.

j. Disconnect carburetor controls. 7/16-inch open end wrench. Screw driver.

Remove nut and lock washer holding throttle control rod to throttle lever and lower rod. Then loosen screws holding choke and throttle controls at carburetor and pull out controls (fig. 94).

k. Remove pipe assembly (check valve to inake manifold). ⅞-inch open end wrench.

Disconnect flared tube nuts at check valve intake fitting and at intake manifold fitting and remove pipe assembly (fig. 95).

l. Disconnect fuel feed line and windshield wiper pipe assembly at fuel pump. ½-inch open end wrench. ⅜-inch open end wrench.

Disconnect main fuel line fitting at fuel pump inlet fitting. Then disconnect inverted flared tube nut holding windshield wiper pipe assembly to vacuum side of fuel pump (fig. 190).

m. Remove right-hand funnel assembly. Screw driver. 9/16-inch open end wrench.

Loosen clamp holding funnel assembly to ventilator box. Remove cap screw and lock washer holding funnel support bracket to frame and lower funnel assembly.

n. Disconnect exhaust pipe at manifold. ⅝-inch open end wrench.

Remove two brass nuts holding exhaust pipe flange to manifold flange.

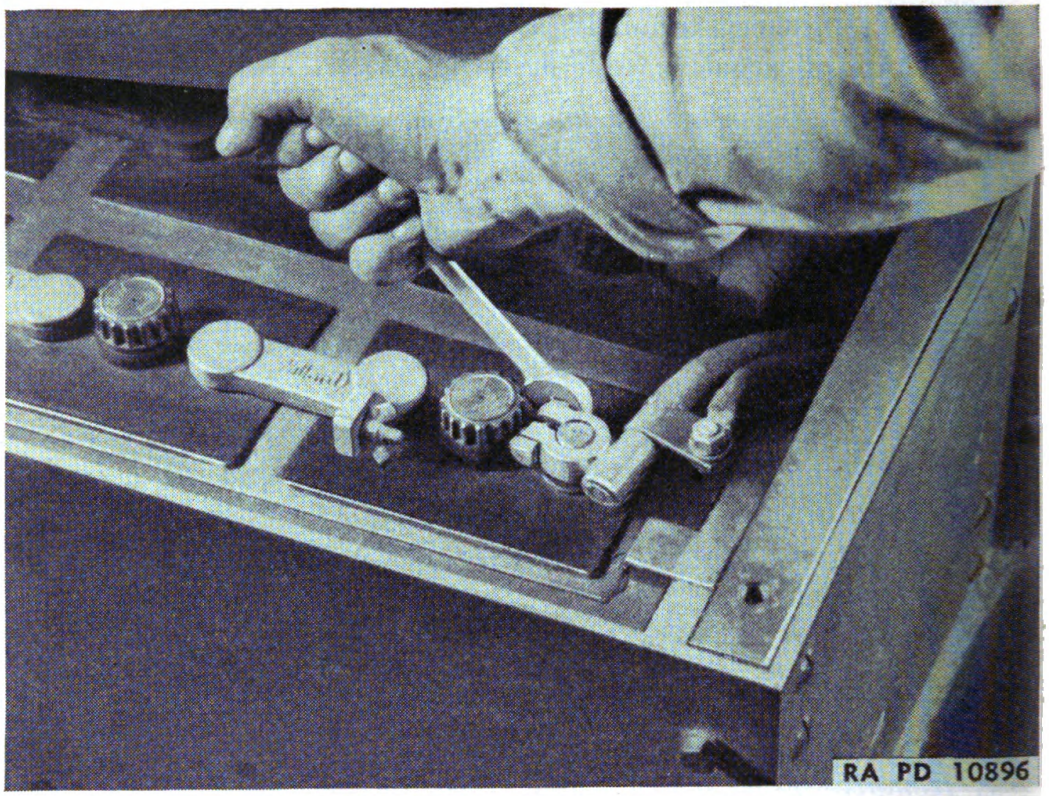


FIGURE 93.—Disconnecting battery terminal.

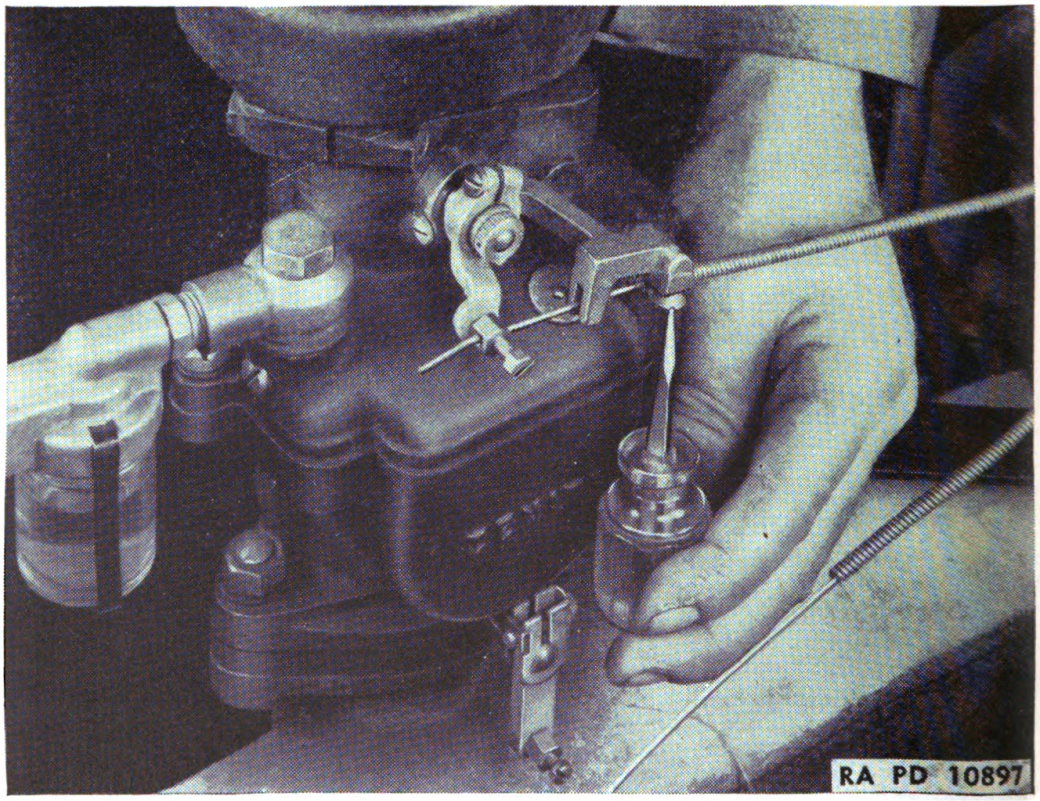


FIGURE 94.—Disconnecting choke wire assembly.

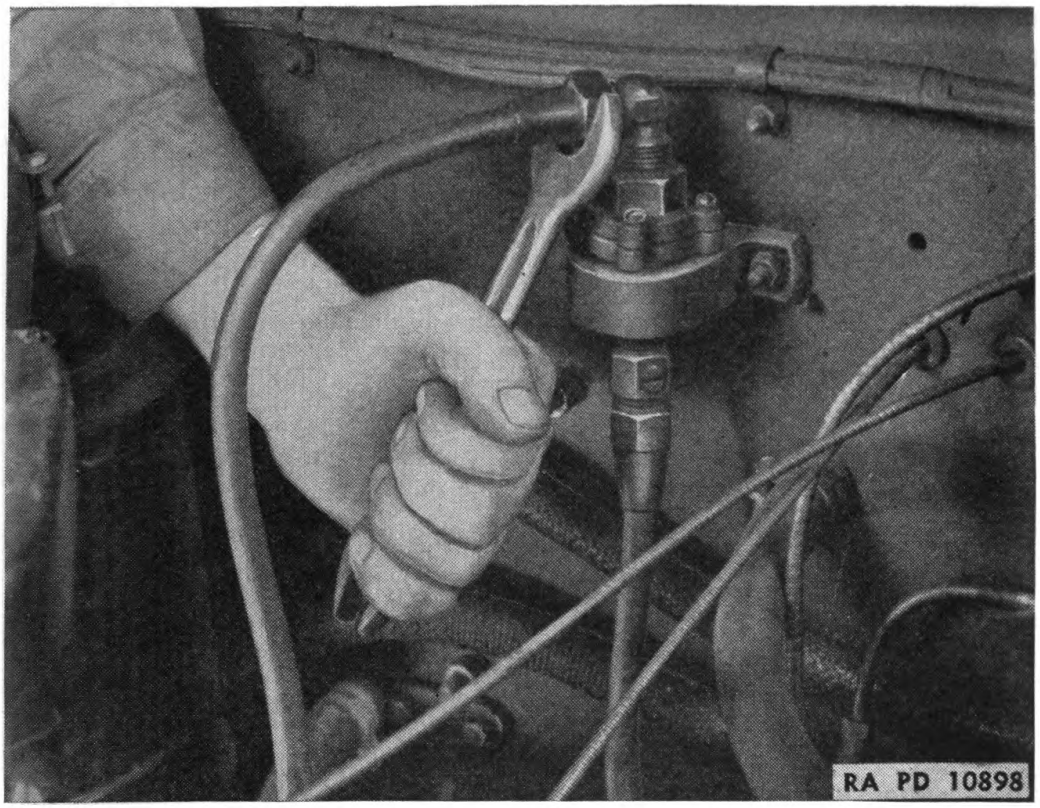


FIGURE 95.—Vacuum line removal at check valve.

o. Disconnect cable from starting motor.	9/16-inch open end wrench.

Remove terminal nut and pull cable from terminal.

p. Disconnect high-voltage and low-voltage wires from ignition coil.	Screw driver. 3/8-inch open end wrench.

Remove two coil shielding cover screws and remove cover. Pull out high-voltage wire from coil. Remove nut holding low-voltage wire to coil terminal and pull off wire (fig. 58).

q. Disconnect manual spark control.	Screw driver.

Loosen screw holding control wire to spark control arm and loosen clamp screw at bracket. Pull out spark control.

r. Disconnect armature conduit with wire assembly at generator.	Channellock pliers. 9/16-inch socket wrench. Thin screw driver.

Remove armature condenser from housing and screw off armature conduit nut from housing (figs. 34 and 35). Then remove armature

terminal post nut (fig. 36), lift off cable terminal from armature terminal post, and pull out conduit with wire assembly.

s. Remove generator field conduit with wire assembly at generator.	Screw driver. 5/8-inch open end wrench. 3/8-inch thin wall socket wrench. 3/8-inch open end wrench.

Remove generator field terminal housing plug and screw off conduit nut from housing (figs. 32 and 33). Then remove field terminal post nut and pull out conduit, with wire assembly. Loosen clamp holding generator field and armature conduits to engine bracket and free conduits (fig. 66).

t. Disconnect oil filter pressure gage line assemblies.	7/16-inch open end wrench. 1/2-inch open end wrench.

Disconnect oil filter inlet line assembly and oil pressure gage line assembly by unscrewing inverted flared tube nuts from fittings at rear left side of engine block. Break oil filter return line assembly at flared tube fitting located between rear of block and filter.

u. Remove temperature gage bulb assembly.	5/8-inch open end wrench.

Loosen temperature gage bulb adapter nut at rear left side of engine cylinder head and pull out bulb from adapter (fig. 96).

v. Remove vacuum line assembly from check valve to booster hose.	7/8-inch open end wrench. 3/4-inch open end wrench. Screw driver.

Unscrew inverted flared tube nut at check valve (fig. 95). Remove cap screw and lock washer holding line clip to rear of engine block. Loosen booster hose clamp screw and pull out line assembly.

w. Remove left-hand air funnel assembly.	Screw driver 7/16-inch open end wrench.

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

x. Disconnect brake vacuum booster and bracket assembly.	9/16-inch socket with speed handle.

Remove three cap screws and lock washers holding booster bracket to engine crankcase and lower bracket and booster assembly.

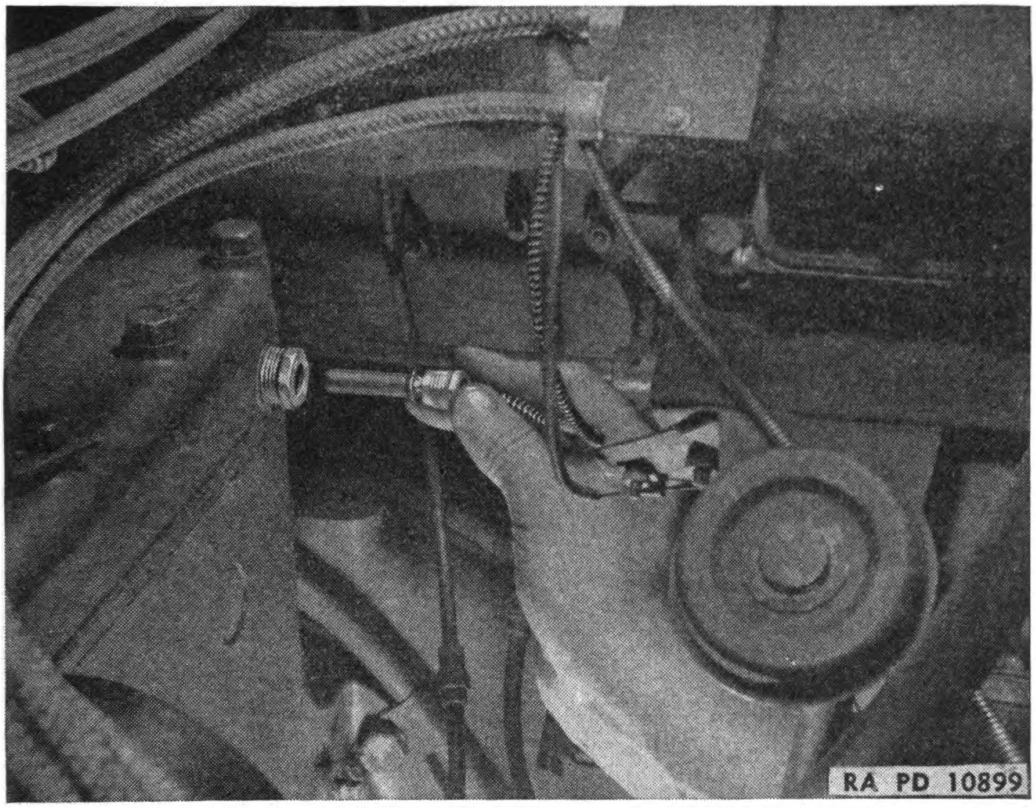


FIGURE 96.—Removing temperature gage bulb assembly.

y. Prepare engine for removal. Hoist.
Length of 3/4-inch manila rope (at least 14 feet).
9/16-inch socket wrench.
9/16-inch open end wrench.

Tie rope around engine in figure eight. Place hoist in balanced place of rope and remove slack in rope by raising hoist hook. Remove cap screws and lock washers holding transmission to engine bell housing (fig. 97).

z. Disconnect engine supports. Pliers.
3/4-inch socket wrench.
3/4-inch open end wrench.
15/16-inch socket wrench.
15/16-inch open end wrench.

Remove cotter pins from castellated nuts at rear support bolts and remove nuts, bolts, washers, and right support spring. Remove nuts, lock washers, and cap screws from front engine supports (fig. 98).

aa. Remove engine.

Wood blocks.
Heavy-duty screw driver.
Hammer.

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 car and place in stand or on blocks (figs. 99 and 100).

FIGURE 97.—Disconnecting engine bell housing from transmission.

42. Removal of accessories.—Tools:

Screw driver.
$\frac{9}{16}$-inch open end wrench.
Channellock pliers.
$\frac{3}{4}$-inch socket wrench.
$\frac{5}{8}$-inch open end wrench.
$\frac{3}{8}$-inch open end wrench.
$\frac{1}{2}$-inch open end wrench.
$\frac{9}{16}$-inch socket wrench.

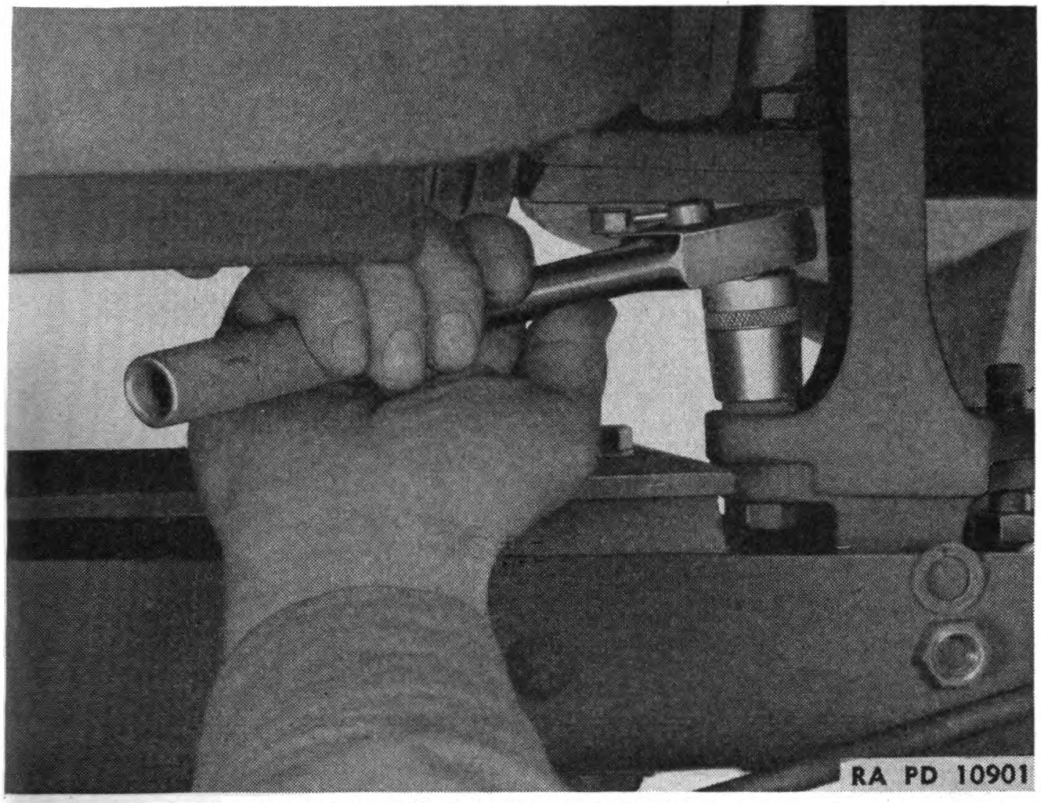


FIGURE 98.—Disconnecting front engine support.

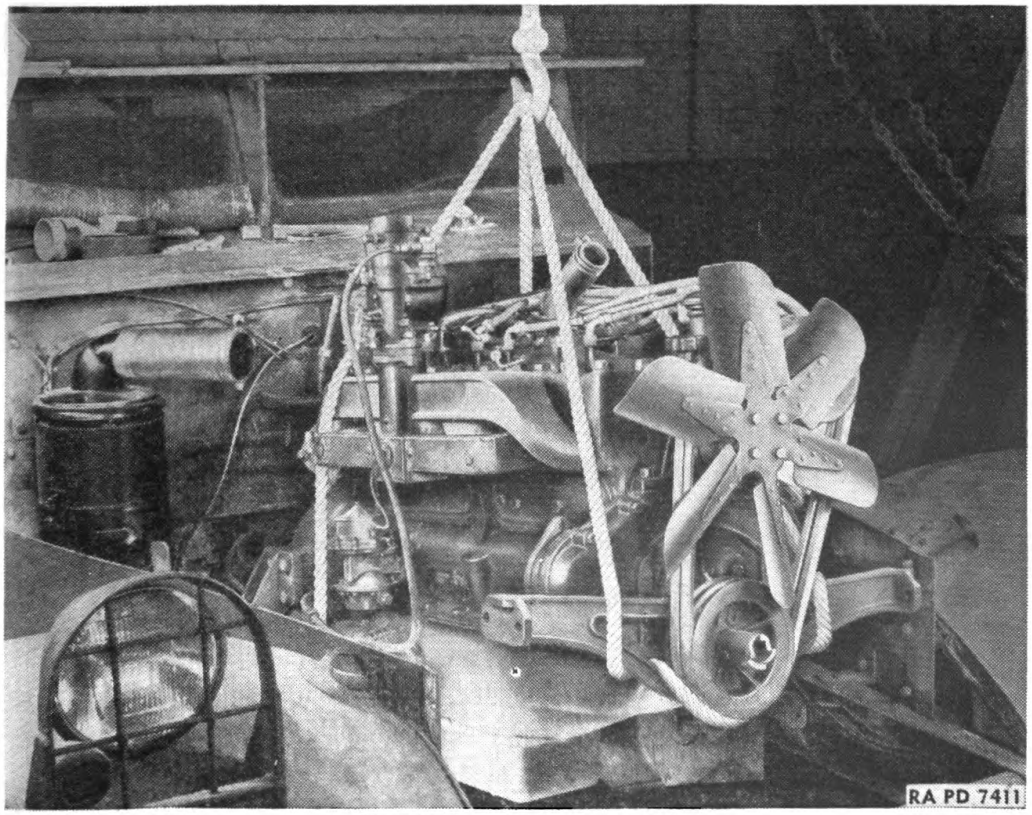


FIGURE 99.—Engine removal.