TM9-1735C

WAR DEPARTMENT TECHNICAL MANUAL

ORDNANCE MAINTENANCE

MEDIUM TANKS M26 AND M45

AUXILIARY ENGINE

(W/ GENERATOR AND REGULATOR)

WAUKESHA, MODEL G-TGU

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TM 9-1735C, Ordnance Maintenance, Medium Tanks M26 and M45 Auxiliary Engine (W/Generator and Regulator), Waukesha, Model G-TGU, is published for the information and guidance of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff

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For explanation of distribution formula, see TM 38-405.

CONTENTS

CHAPTER 1
INTRODUCTION

1. Scope

a. These instructions are published for the information and guidance of personnel responsible for field and base maintenance on the auxiliary engine assembly with generator and regulator. These instructions also apply to units in use with medium tanks T26E4 and T26E5. They contain information on maintenance which is beyond the scope of the tools, equipment, or supplies normally available to using organizations. This manual does not contain information which is intended primarily for the using arm, since such information is available to ordnance maintenance personnel in 100–series TM's or FM's.

b. This manual contains a description of, and procedure for disassembly, overhaul, assembly, trouble shooting and testing of the auxiliary engine, generator, and generator regulator.

2. Forms, Records, and Reports

a. GENERAL. Forms, records, and reports are designed to serve necessary and useful purposes. Responsibility for the proper execution of these forms rests upon commanding officers of all units maintaining this equipment. It is emphasized, however, that forms, records, and reports are merely aids. They are not a substitute for thorough practical work, physical inspection, and active supervision.

b. AUTHORIZED FORMS. The forms, records, and reports generally applicable to units maintaining this equipment are listed below with brief explanations of each. No forms other than approved War Department forms will be used. Pending availability of forms listed, old forms may be used. For a current and complete listing of all forms, see current FM 21–6 (Lists and Index of War Department Publications).

(1) *War Department Lubrication Order.* War Department Lubrication Order 9–735 prescribes lubrication maintenance for this equipment. A lubrication order is issued with each vehicle and is to be carried with it at all times. Instructions contained therein are mandatory to all users of the equipment and supersede all conflicting lubrication instructions of prior date.

(2) *WD AGO Form 9–71 (Locator and Inventory Control Card).* Except when specified otherwise by the War Department, this form will

be used as a bin tag, locator card, or inventory control card by all units authorized automotive spare parts.

(3) *WD AGO Form 9–72 (Ordnance Stock Record Card).* This form is prescribed for use by ordnance maintenance and depot companies.

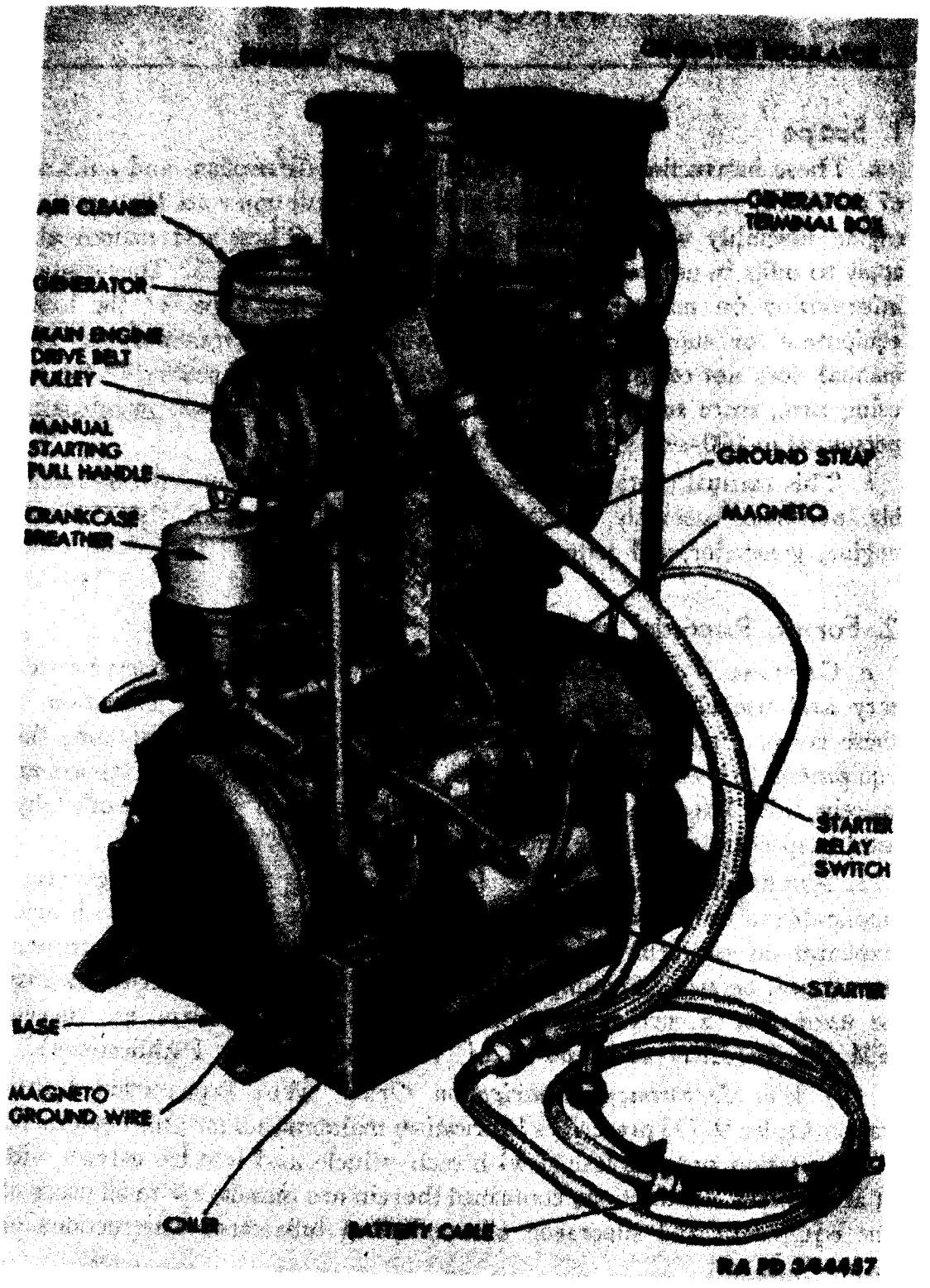


Figure 1. Auxiliary engine w/generator and regulator assembly—left front.

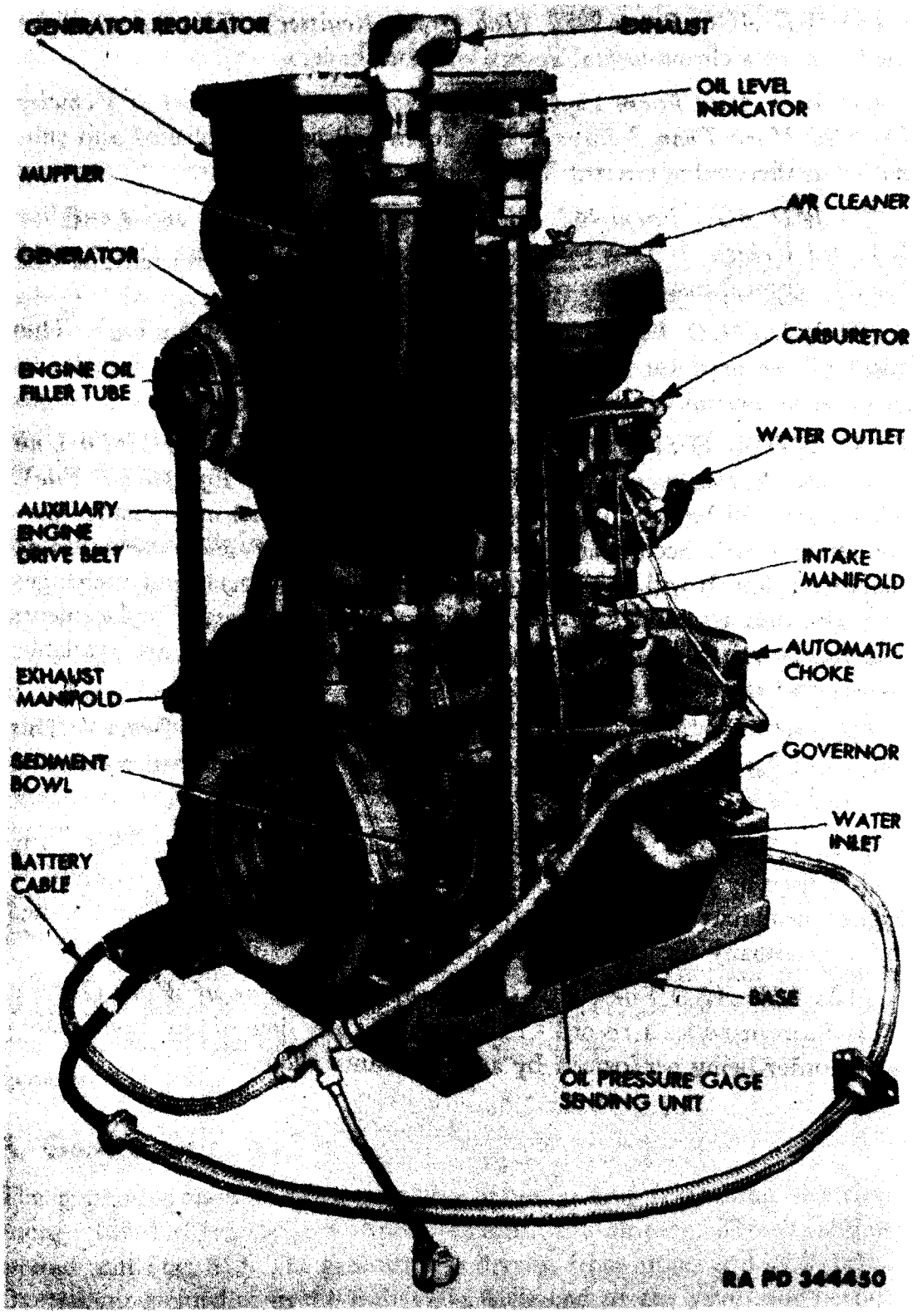


Figure 2. Auxiliary engine w/generator and regulator assembly—right rear.

(4) *WD AGO Form 9–76 (Request for Work Order)*. This form will be used for requesting repairs, alterations, or other type of work within or between organizations and departments.

(5) *WD AGO Form 9–77 (Job Order Register)*. This form will be used to keep a chronological record of work orders.

(6) *WD AGO Form 13–1 (Automotive Disability Report of Vehicles Disabled More Than 3 Days)*. This form will be accomplished and submitted as directed in current War Department instructions.

(7) *WD AGO Form 462 (Work Sheet for Full-track and Tank-like Wheeled Vehicles)*. This form will be used for maintenance services and for all technical inspections of these vehicles.

(8) *WD AGO Form 461–5 (Limited Technical Inspection)*. This form will be used for limited technical inspections to classify vehicles as to general over-all condition.

(9) *WD AGO Form 478 (Modification Work Order and Major Unit Assembly Replacement Record and Organizational Equipment File)*. This form will be kept in possession of organizational maintenance personnel and will accompany vehicles upon transfer and evacuation to higher echelon. It will be a record of all modifications made and exchanges of major unit assemblies. Minor repairs, parts and accessory replacements will not be recorded. In the field, where no filing facilities are available, this form will be kept in a filing jacket.

(10) *WD AGO Form 811 (Work Request and Job Order)*. This form will be used by organizational maintenance units when requesting repair by a higher maintenance unit.

(11) *WD AGO Form 866 (Consolidation of Parts)*. This form will be used by a maintenance company for the periodic report required by higher headquarters showing the parts and materials used and issued by the company for a given period.

(12) *WD AGO Form 867 (Status of Modification of Work Order)*. This form provides a record of the status at any time of any modification work order being performed by a maintenance shop.

CHAPTER 2
DESCRIPTION

3. General

The auxiliary engine assembly consists of a liquid-cooled gasoline engine which drives an electric generator through one V-belt. The engine, generator, and generator regulator are mounted as a unit on a base provided with vibration dampers (figs. 1 and 2). The timing gear end of the engine is to be considered the "front." The magneto and starter side of the engine is the "left" side, and the exhaust and intake manifold side of the engine is the "right" side.

4. Auxiliary Engine

a. The auxiliary engine is a 4-cylinder, 4-stroke cycle, 13.6 horsepower, liquid-cooled, gasoline engine. The cylinder head, crankcase, cylinder block, and pistons are of aluminum. The cylinder head and crankcase are detachable and the crankcase houses the ball bearing supported crankshaft and the camshaft, and mounts a timing gear plate at one end. Lubrication is by pressure and spray from oil carried in the crankcase sump. The intake and exhaust manifolds, carburetor, automatic choke, governor and water pump, fuel pump, and oil filler are mounted on the right side of the engine (fig. 2). The magneto and electric starter are mounted on the left side of the engine (fig. 1). A rope-type starter is attached to the front end of the crankshaft for emergency starting.

b. In normal use the vehicle's engine drives the generator through a V-belt and pulley mounted at one end of the generator but if the vehicle's engine is not in operation, the auxiliary engine can be started to maintain generator output.

5. Generator

The generator used for charging the batteries and furnishing electrical energy for the vehicle is a direct current, 150-ampere, 24-volt, shunt-wound unit (fig. 31). The generator is driven from either end by V-belts. Overrunning clutches in the pulleys at each end of the generator permit operation by either the auxiliary engine or the vehicle engine. The clutches prevent the driving engine from transmitting its torque through the generator to the nondriving engine. The generator is grounded by a strap attached to the hull. The output of the generator is fed through a

generator regulator and a control panel to the electrical system of the vehicle.

6. Generator Regulator

a. The generator regulator is composed of three units, a regulating unit, a voltage rheostat, and a reverse current cut-out relay (fig. 38). These assemblies are mounted in an aluminum case and are protected from dust and moisture by a cover sealed with a rubber gasket. Rubber vibration dampers secure the base to the mounting bracket on top of the generator.

b. The function of the generator regulator is to hold the generator voltage to 29.2 volts over the entire speed range of the generator at no-load and to prevent the battery from discharging through the generator when the generator output is less than about 24 volts.

CHAPTER 3
SPECIAL TOOLS

7. Purpose

The list of special tools in paragraph 8 is for information only. It is not to be used as a basic for requisition.

8. List of Special Tools

Item	*Identifying Number*	*References* Fig.	Par.	*Use*
Handle, replacer, length 6⅛ in.	41-H-1395-988 A411984	3	48*a*.(2)	To replace generator oil seal.
Replacer, oil seal, generator, drive pulley.	41-R-2392-685 A7080283	3	48*a*.(2)	To replace generator oil seal.

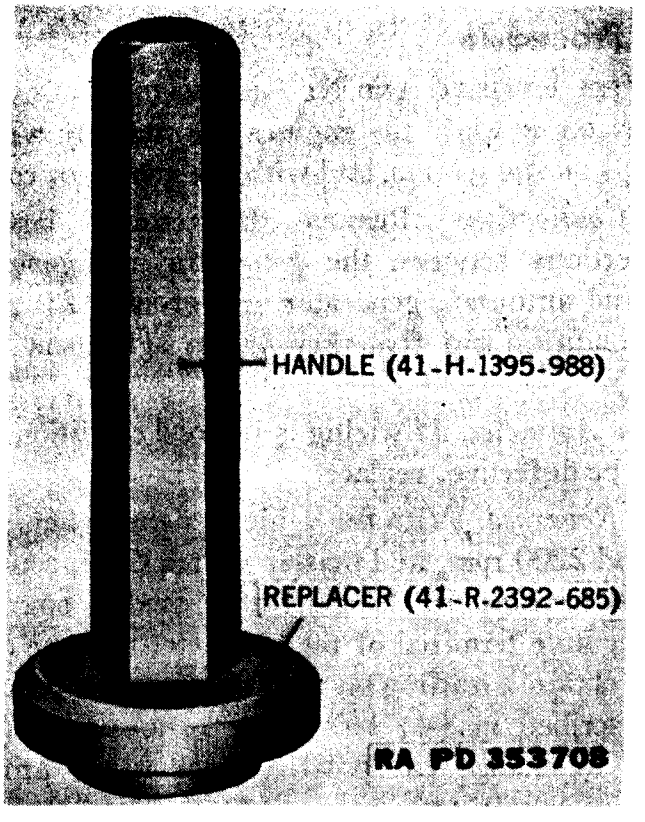


Figure 3. Generator oil seal replacer.

CHAPTER 4
TROUBLE SHOOTING

9. General

a. The first evidence of trouble in the generating circuit is failure to keep batteries charged and is usually noted by the ammeter on the vehicle instrument panel showing a discharge or no charge while the engine is running. The generating circuit consists of three elements—generator, generator regulator, and wiring. All troubles which occur can be located in one or more of these elements. The trouble shooting and repairs required can be accomplished with the auxiliary engine assembly either in or out of the vehicle.

b. Because of the presence of high current do not under any condition close the main contacts of the reverse current cut-out relay. To do so will cause arcing and probable welding of the contacts.

10. Detailed Procedure

a. No Ammeter Reading and No Generator Voltage. The following troubles may occur while the engines are running, with batteries and all electrical loads on the system, and with the generator control switch on.

(1) *Faulty Connections.* Remove the terminal board covers and check all connections between the generator and generator regulator, terminal strip and ammeter, generator and ground, for good mechanical and electrical condition and that they are in agreement with the wiring diagram (fig. 4).

(2) *Defective Ammeter.* If wiring is in good condition, check ammeter and if found to be defective, replace.

(3) *Polarity Reversed.* With the vehicle engines running at a speed of between 2000 and 2200 rpm, and master switch OFF, connect a voltmeter between the G+ terminal in the generator conduit box and the vehicle frame. If the negative terminal of the voltmeter must be connected to the G+ terminal to obtain a reading on the voltmeter, the polarity is reversed. The remedy described in (4) below for restoring residual magnetism should be used to change the polarity back to its proper position.

(4) *Loss of Residual Magnetism.* If no reading is obtained while making the test outlined in (3) above, the residual magnetism may be lost. This can be rectified in the following manner: First make sure that the ground stud on the generator and the negative post on the vehicle battery

are both grounded to the vehicle. Disconnect the F+ wire either at the regulator or in the generator conduit box (later models have an F+ terminal in the generator conduit box). Connect one end of a small wire to the positive side of the battery and touch the other end briefly to the F+ wire of the generator. Remove this wire and reconnect the generator. The residual magnetism will now be restored. If no reading is indicated on the ammeter after this procedure, short out the regulator by connecting wires BR+ and F+ together. If there is no voltage reading, the generator is faulty and must be overhauled (pars. 47 through 50).

b. No Ammeter Reading and Either Low or No Generator Voltage. If the voltage build-up is not satisfactory, the reverse current relay will not close. This may result from any of the following causes:

(1) *Loose Connections.* Check all connections for mechanical and electrical fitness, while the vehicle engines are at a standstill and with the master switch OFF. Make any necessary repairs. Start either one of the engines and run at sufficient speed to rotate the generator at 3200 or 3500 rpm. Check the voltage between the G+ terminal in the generator conduit box and the frame of the vehicle. If trouble still persists, either the regulator or the generator is at fault. Stop the engine.

(2) *Improperly Adjusted or Defective Regulator.* Install a temporary connection between the G+ and the F+ terminals. Start one of the vehicle engines and slowly increase the speed. If voltage builds up to normal at approximately 1700 rpm engine speed, the regulator is out of adjustment or defective. Stop the engine and remove the temporary connection. Restart the engine and bring the speed up to 2100 rpm. Adjust the regulator to hold 29.2 volts. If this cannot be done, stop the engine and install a serviceable regulator. Start the engine again and bring the speed up to 2100 rpm. Check the voltage.

(3) *Grease, Oil, or Dirt on Brushes and Commutator.* Clean brushes, brush holders, and commutator of any dirt by wiping with clean, dry, nonlinting cloth. If there is any evidence of oil or grease, clean commutator and brush holders with clean, dry, nonlinting cloth and install new brushes.

(4) *Loose Brush Terminal Screws.* Tighten any loose brush terminal screws.

(5) *Insufficient Spring Pressure.* If the brush spring tension is less than 1 to 1.5 pounds, replace the brush as a worn brush will register lighter spring pressure. If the brush cannot be replaced, the spring may be bent slightly to produce the proper pressure. If the spring does not come within this range, install a new spring. If this does not correct the trouble, remove the generator for complete overhaul and install a serviceable generator.

c. No Ammeter Reading and Normal Generator Voltage. If a voltmeter across the G+ terminal and the ground indicates normal gen-

erator voltage, any one of the following may be causing this trouble:

(1) *Battery Fully Charged and No Load, or Very Little Load on the System.* Check for satisfactory operation by connecting a load to the system.

Note. Do not attempt to load the generator or increase its voltage by adjusting the voltage regulator.

(2) *Faulty Connections or Defective Ammeter.* Check as outlined in *a* (1) above.

(3) *Reverse Current Cut-out Relay Does Not Close—Defective Connections or Defective Relay.* Stop the engine and turn the master switch to OFF. Check all connections to the regulator. Make any necessary repairs. Turn the master switch to ON. Start the engine and bring the speed up to 2100 rpm. The relay should close and stay closed. If it does not stay closed, a complete overhaul of this unit must be performed as outlined in paragraph 58.

d. Low Voltage at Minimum Generator Speed (3200 Revolutions Per Minute). Adjust the voltage adjusting rheostat (par. 59 *d*) if the adjustment is not correct. If this does not change the voltage, check the generator speed to see if it is too low. If the speed is correct, short out the generator regulator by connecting terminals F+ and BR+ together. If the voltmeter registers 28 volts or over, the generator regulator is defective and should be overhauled as outlined in paragraphs 56 through 61. If the voltage is still low, the generator is not functioning properly and should be tested as outlined in paragraph 50.

e. High Voltage at Maximum Generator Speed (4500 Revolutions per Minute). Adjust the voltage adjusting rheostat (par. 59 *d*) if the adjustment is not correct. If this does not change the voltage, check the generator speed to see if it is too high. If the speed is correct, overhaul the generator regulator as outlined in paragraphs 56 through 61.

f. Rapidly Fluctuating Ammeter Reading, and Fluctuating Voltage. This condition is caused by the reverse current cut-out relay closing, reopening, and then reclosing. This, in turn, may result from any of the following causes:

(1) *Improperly Adjusted, or Defective Voltage Regulator.* With the engine running at 2100 rpm and the master switch turned OFF, check the voltage at the generator terminal G+ and vehicle frame. If necessary, adjust the regulator. If it cannot be made to hold 29.2 volts it may be defective. Stop the engine and install a serviceable regulator. Connect the battery and a little load. Turn master switch to ON. Start the engine and bring up to 2100 rpm. The relay should close and stay closed.

(2) *Improperly Adjusted, or Defective Reverse Current Cut-out Relay.* If the trouble still persists after the above test is made, reduce the speed until the relay stays open. Then slowly increase the speed and check the voltage at which it closes. This should be 20 volts. If it does not close

at 20 volts it is defective, or out of adjustment, and should be overhauled as outlined in paragraph 58.

Note. If this test was made with a replaced serviceable regulator, the generator is probably at fault.

(3) *Faulty Connections.* Check all connections and make any necessary repairs.

(4) *Electric Defects in Generator.* Check position of the brush rigging. The paint mark on the yoke should be in line with the paint mark on the endshield. If the paint mark is missing, set brushes as outlined in paragraph 50 *c*. Connect the battery and put a little load on the system. Set the master switch to ON. Run the engine at 2100 rpm. Relay should close and stay closed. If trouble still persists, install a serviceable generator.

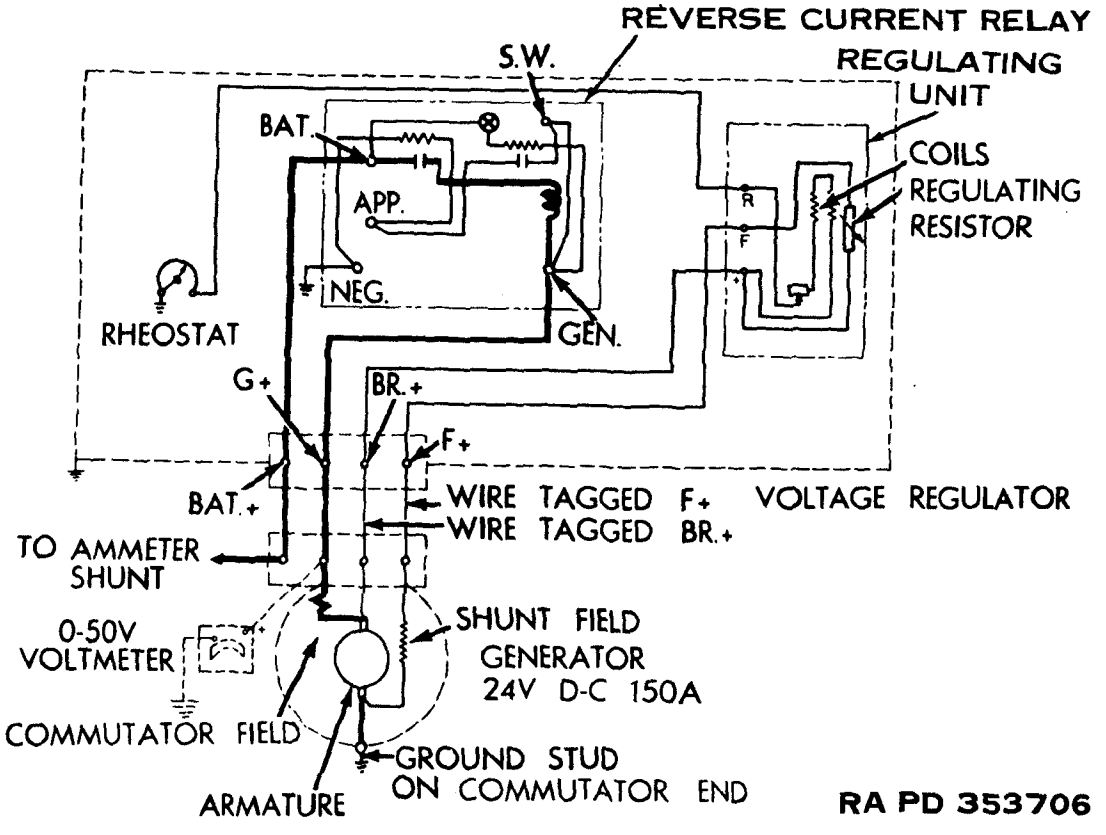


Figure 4. Wiring diagram of generator regulator and generator.

CHAPTER 5
ENGINE

Section I. DESCRIPTION AND DATA

11. Description

a. The auxiliary engine is a 4-cylinder, 4-stroke-cycle, liquid-cooled, gasoline engine (figs. 1 and 2). The cylinder head, crankcase, cylinder block and pistons are of aluminum. The cylinder block has alloy-iron dry liners. The pistons have two compression rings and one oil ring. The cylinder head and crankcase are detachable and the crankcase houses the ball bearing supported crankshaft and the camshaft, and mounts a timing gear plate at one end. Lubrication is by pressure and spray from oil carried in the crankcase sump. The intake and exhaust manifolds, carburetor, automatic choke, governor and water pump, fuel pump, and oil filler are mounted on the right side of the engine. The magneto and electric starter are mounted on the left side of the engine. A rope-type starter is attached to the front of the crankshaft for emergency hand starting.

b. The vehicle's engine, when running, drives the generator. The auxiliary engine may be used to maintain generator output when the vehicle engine is not operating.

12. Data

Make	Waukesha
Model	G-TGU-2, ICK-81-B
Type	Gasoline, 4-stroke-cycle, liquid-cooled
Number of cylinders	4
Bore and stroke	2.500 in. x 3.125 in.
Firing order	1-2-4-3
Piston displacement	61 cu. in.
Compression ratio	5.7 to 1
Speed (governed at full load)	1,800 rpm
Rated horsepower	13.6
Rotation of crankshaft	clockwise
Spark plug type	aircraft 14 mm
Oil capacity	3 quarts
Oil pressure (at 1,800 rpm)	15-35 lb
Fuel	Gasoline
Over-all height (including generator regulator)	28.5 in.

Over-all length	27 in.
Over-all width	24 in.
Dry weight of entire auxiliary equipment	297 lb
Dry weight of engine and accessories only	190 lb

Section II. DISASSEMBLY INTO SUBASSEMBLIES

13. Preliminary Instructions

a. DRAIN THE OIL. Remove the plug in the ridge of the oil pan and drain all the oil from the crankcase.

b. DRAIN THE FUEL PUMP SEDIMENT BOWL. Loosen the thumb screw at the bottom of the sediment bowl, swing the yoke away from the bowl and empty the bowl of fuel. Reinstall the bowl on the pump.

c. REMOVE GENERATOR REGULATOR AND GENERATOR. Disconnect and remove the generator regulator and generator from the auxiliary engine assembly as outlined in TM 9–735.

d. REMOVE ENGINE ACCESSORIES. Remove the following items from the auxiliary engine assembly as outlined in TM 9–735: muffler assembly, automatic choke, carburetor, oil filler pipe and gage, oil pressure sending unit, fuel pump, spark plugs, intake and exhaust manifolds, water pump and governor assembly, electric starter, starter relay, magneto, hand starter assembly, and crankcase breather assembly.

14. Disassembly

a. GENERATOR SUPPORT. Remove the two cap screws and internal-toothed lock washers from the side of the generator support (fig. 5). Remove the nuts and washers holding the support and cylinder head to the cylinder block. Carefully lift the generator support from the studs and the cylinder head.

b. CYLINDER HEAD. Remove the remaining nuts and washers holding the cylinder head to the cylinder block. Carefully lift the cylinder head from the cylinder block studs. Remove and discard cylinder head gasket.

c. OIL PAN. Lay the engine on its side with the valve door down. Remove the 18 nuts and lock washers from the bottom of the crankcase and remove the oil pan and oil pan gasket (fig. 6). Discard the oil pan gasket.

Note. Inspect the inside of the crankcase and oil pan for sediment, shavings, and steel chips as a clue to wear and bearing failure.

d. OIL PUMP SUCTION PIPE AND SCREEN. Unscrew and remove the suction pipe and screen from the oil pump (fig. 6).

e. CYLINDER BLOCK-TO-CRANKCASE NUTS. Remove five of the elastic stop nuts that hold the cylinder block to the crankcase from the left side of the cylinder block (fig. 6). Remove the elastic stop nuts from each end

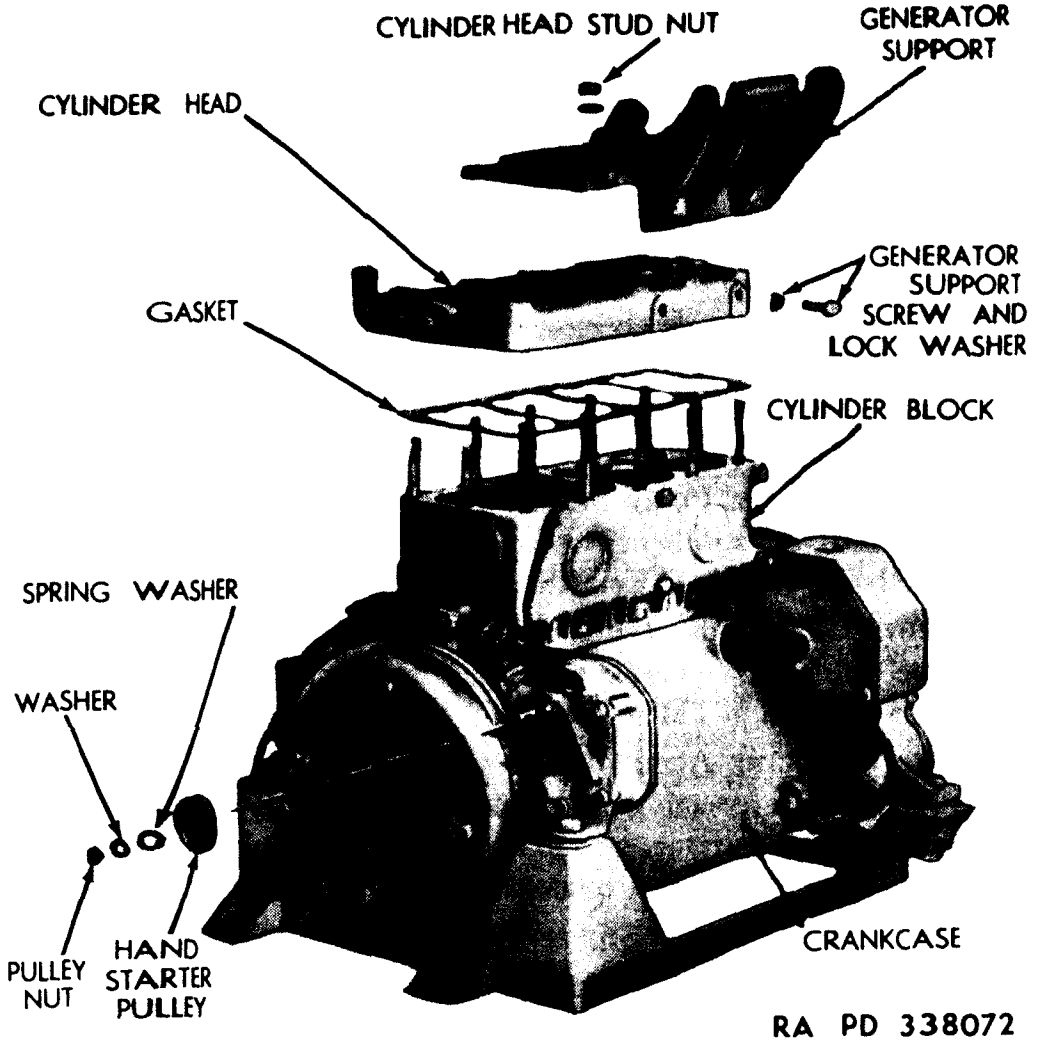


Figure 5. Cylinder head removed from engine.

of the cylinder block; one of the bolts holding the gear case cover to the crankcase must be removed to allow access to the nut on the front of the engine.

f. CONNECTING RODS FROM CRANKSHAFT (FIGS. 6 AND 12). Lay the engine on its left side, valve door up. Remove the cotter pins and nuts from the bearing caps of each connecting rod. Remove the bearing caps, connecting rod bearings, and any shims present. Be sure to mark pistons, rods, caps, and shims to facilitate the proper placement at assembly. Push the pistons toward the top of the cylinder block.

g. CYLINDER BLOCK (FIG. 6). Remove the two long cap screws and copper washers that hold the valve door to the cylinder block and remove the valve door and the gasket to gain access to the four remaining elastic stop nuts holding the cylinder block to the crankcase. Remove the four nuts and carefully separate the cylinder block and crankcase.

h. VALVE LIFTERS (FIG. 6). Remove eight valve lifters from the cylinder block and mark or store in numerical order to assure assembly in the original position in relation to the cylinders.

i. PISTONS (FIG. 6). Pull the four pistons from the bottom of the cylinder block.

j. VALVES. With a valve lifter, compress the valve springs and spring

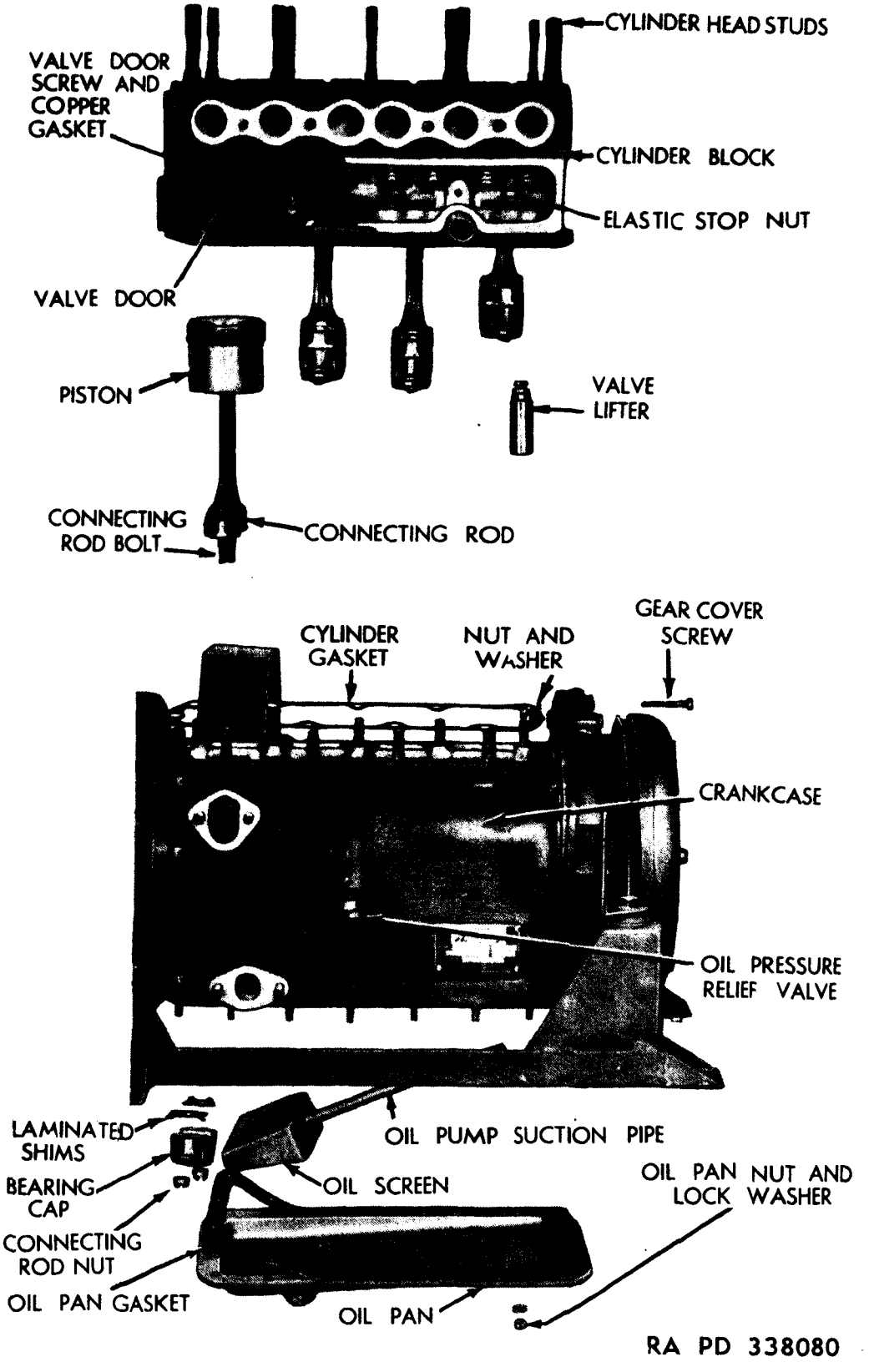


Figure 6. Cylinder block and pistons removed from crankcase.

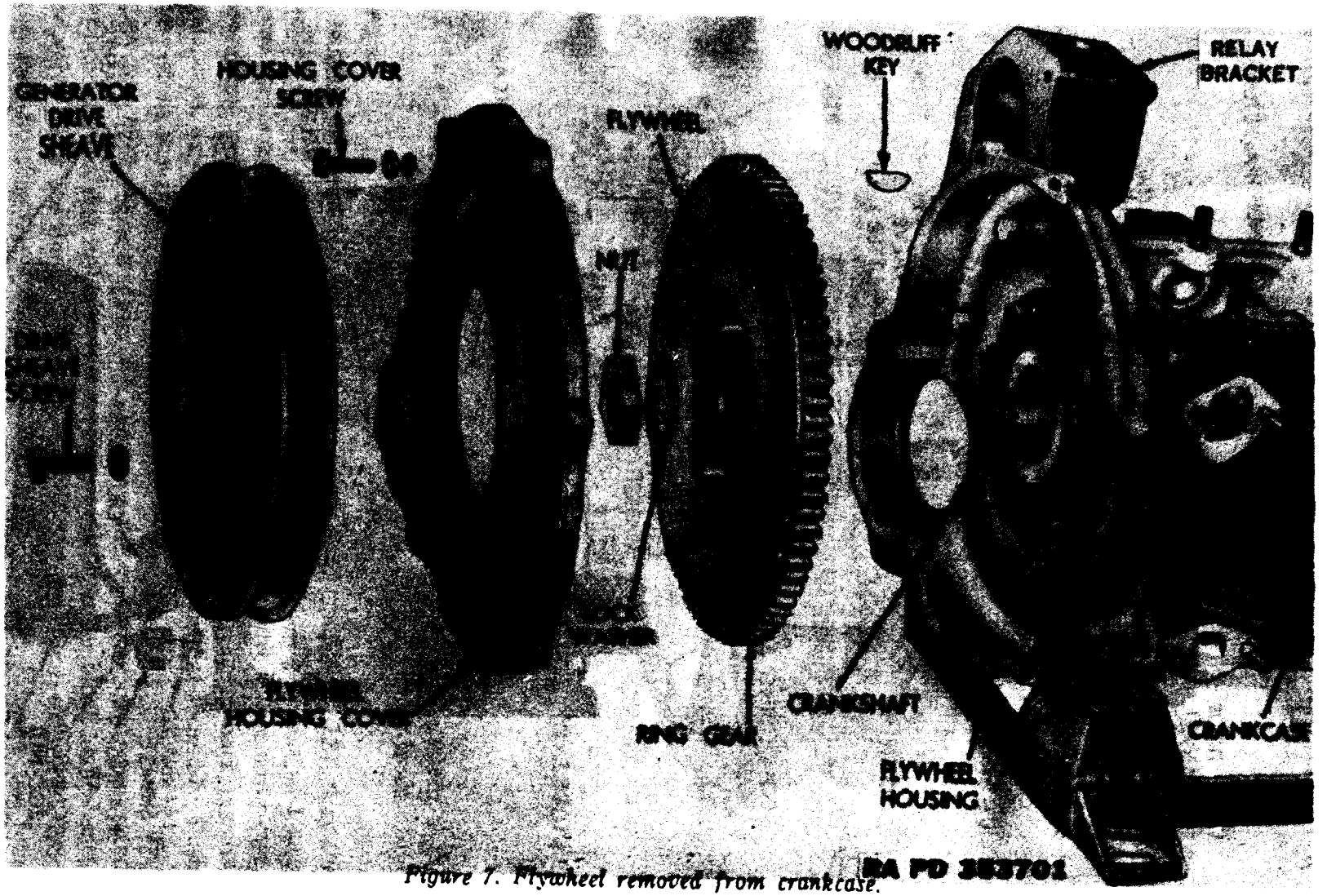
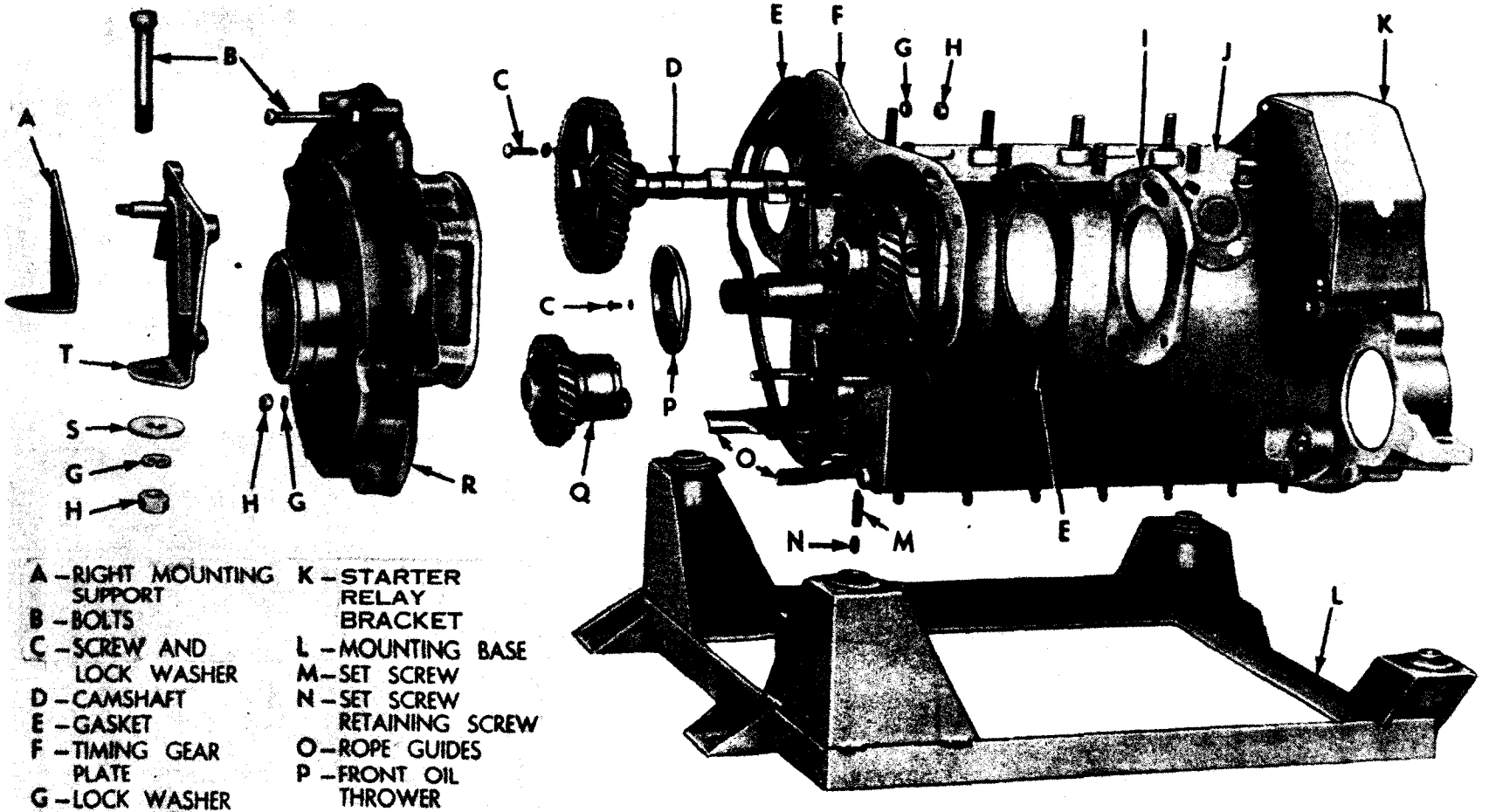


Figure 7. Flywheel removed from crankcase.



A – RIGHT MOUNTING SUPPORT
B – BOLTS
C – SCREW AND LOCK WASHER
D – CAMSHAFT
E – GASKET
F – TIMING GEAR PLATE
G – LOCK WASHER
H – NUT
I – MAGNETO ADAPTER PLATE
J – CRANKCASE
K – STARTER RELAY BRACKET
L – MOUNTING BASE
M – SET SCREW
N – SET SCREW RETAINING SCREW
O – ROPE GUIDES
P – FRONT OIL THROWER
Q – OIL PUMP
R – GEAR COVER
S – WASHER
T – ROPE GUIDE

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Figure 8. Camshaft and gears removed from crankcase.

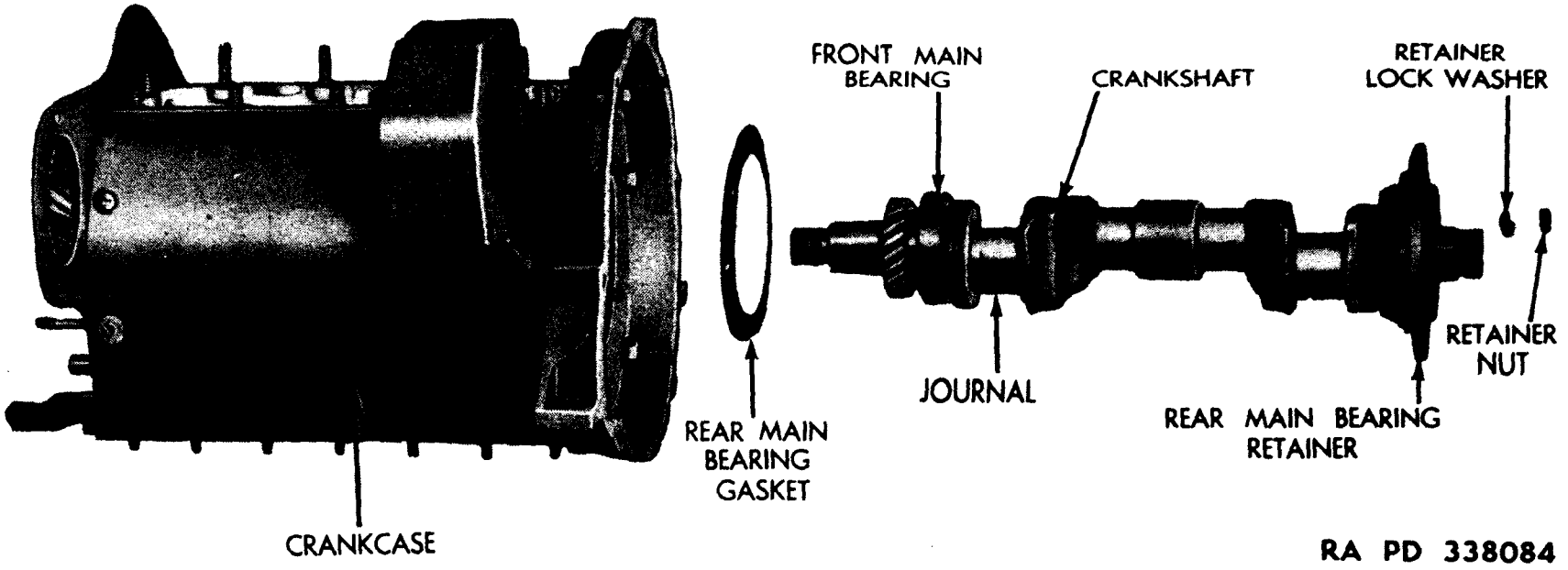

Figure 9. Crankshaft removed from crankcase.

retainers and remove the retainer clips, valves, spring retainers, and valve springs from the cylinder block (fig. 10). Store or mark the valves and other parts so that they may be reinstalled in their original positions in relation to the cylinders.

k. GENERATOR DRIVE SHEAVE. Remove the four screws and lock washers that hold the generator drive sheave to the flywheel and remove the drive sheave from the flywheel (fig. 7).

l. FLYWHEEL ASSEMBLY. Remove the two large and four small cap screws, internal-toothed lock washers, and plain washers that hold the cover to the flywheel housing and remove the flywheel housing cover. Remove the large nut and internal-toothed lock washer that holds the flywheel to the crankshaft. With a suitable puller, pull the flywheel from the crankshaft. Remove the Woodruff key from the end of the crankshaft.

m. MOUNTING BASE. Remove the four long bolts, nuts, washers, and lock washers from the corners of the mounting base and lift the crankcase assembly from the mounting base (fig. 8).

n. GEAR COVER. Remove the six nuts and lock washers that hold the gear cover to the crankcase and pull the cover from the crankcase studs (fig. 8). Strip off and discard the gasket.

o. FRONT OIL THROWER. Remove the three screws and internal-toothed lock washers that hold the front oil thrower to the crankshaft gear and remove the thrower from the gear (fig. 8).

p. CAMSHAFT. Rotate the camshaft to expose the two screws that hold the camshaft thrust plate to the crankcase, remove the two screws and lock washers, and carefully pull the camshaft from the crankcase (fig. 8).

q. OIL PUMP. Remove the set screw retaining screw and the set screw from the front bottom edge of the crankcase directly under the oil pump and remove the oil pump from the crankcase (fig. 8).

r. CRANKSHAFT (fig. 9). From the rear main bearing retainer, remove four nuts and lock washers that hold the retainer to the crankcase. Turn the crankshaft so that No. 2 and No. 3 crankshaft journals are on the right side of the crankcase as illustrated in figure 9. Drive the crankshaft to the rear with a soft-faced hammer, being careful to keep the journals from wedging against the sides of the crankcase. After the bearings are disengaged from the crankcase, shift the crankshaft as necessary to prevent wedging and remove it from the crankcase. Strip off and discard the rear main bearing retainer gasket.

Section III. REBUILD

15. Cylinder Head

a. CLEANING. Remove all dirt and carbon from the cylinder head by brushing and scraping. Pressure flush all water passages. Immerse the cylinder head in dry cleaning solvent and remove all remaining dirt.

Caution: *Do not use caustic soda bath for aluminum cylinder heads.* Dry with compressed air.

b. INSPECTION. Check the cylinder head for cracks, breaks, and stripped threads. Place the cylinder head on a surface plate and test for warpage with a feeler gage. Inspect the gasket surfaces for nicks, burs, and channeling.

c. REPAIR. Replace cracked or broken cylinder head. Retap holes having stripped threads or if impractical, replace the cylinder head. The maximum permissible amount of channeling is 0.003 inch. The maximum permissible amount of warpage is 0.005 inch per foot of length. Reface warped or channeled cylinder heads exceeding the above maximum figures by surface grinding. Do not grind more than 0.010 inch from the original surface to correct warpage or channeling. The manufacturer's dimension for the head thickness is 1.5625 inch measured from the gasket surface to the milled face of cylinder head nut bearing surface.

16. Generator Support

a. CLEANING. Clean the generator support with dry cleaning solvent and dry with compressed air.

b. INSPECTION. Inspect the generator support for cracks and breaks. Inspect the generator adjusting screw pivot to see that it is free to pivot on the screw. Replace a damaged support and/or broken pivot and install a new screw if it binds.

17. Oil Pan

a. CLEANING. Clean the oil pan with dry cleaning solvent.

b. INSPECTION. Inspect the oil pan for cracks, dents, and other obvious damage.

c. REPAIR. Repair the oil pan by welding or straightening if possible. Straighten the pan if warped so that the gasket surface is flat and true as determined by using a surface plate.

18. Cylinder Block

a. GENERAL. The aluminum cylinder block (fig. 10) is of the dry sleeve type. These sleeves or liners are not to be replaced. A letter is stamped on the face of the cylinder block near each sleeve to denote the original size of the sleeve.

b. CLEANING. Scrape the carbon from the ports and chambers of the cylinder block and flush the water passages with hot water (110° F. at 75 pounds pressure). Immerse the cylinder block in dry cleaning solvent and remove all remaining dirt, paying particular attention to valve stem guides and oil passages. Oil the cylinder walls to prevent rusting.

c. INSPECTION. (1) *Visual.* Inspect studs and replace bent studs or studs having stripped thread. Inspect cylinder block for cracks, breaks,

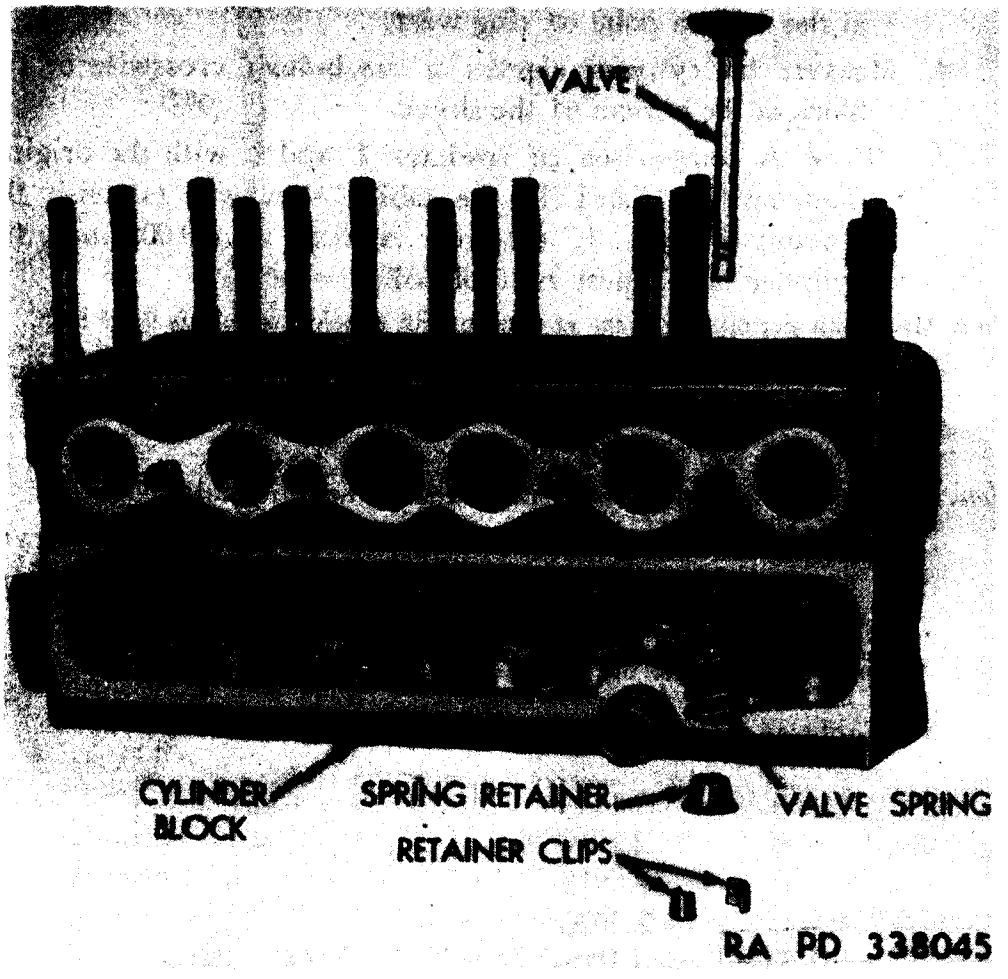

Figure 10. Cylinder block and valves.

and signs of leakage at the core plugs. Replace cracked or broken cylinder block. Inspect cylinder sleeves for pitting and scoring. Replace cylinder block having scored or pitted sleeves. Inspect valve seats for looseness, warpage, and burning. Inspect water and oil channels to see that they are clean and unrestricted.

(2) *Measurement.* (*a*) *Face warpage.* On a surface plate, check the warpage of the face of the cylinder block. Discard cylinder block that is warped more than 0.005 inch per foot of length.

(*b*) *Valve stem guides.* Determine the wear of the valve stem guides. The manufacturer's dimensions are 0.8125 to 0.8135 inch. If guides are worn more than 0.002 inch, replace the cylinder block.

(*c*) *Cylinder sleeves.*

1. Measure the cylinder sleeves at the top, lengthwise of the block at the deepest point of ring wear.
2. Measure the cylinder sleeves at the bottom, lengthwise of the block at the bottom of the sleeve.

3. Measure the cylinder sleeves at the top, crosswise of the block at the deepest point of ring wear.

4. Measure the cylinder sleeves at the bottom, crosswise of the block at the bottom of the sleeve.

5. *Wear.* A comparison of readings *1.* and *2.* with the original diameters as listed in the table below will establish the amount of wear. If the wear is more than 0.008 inch, the cylinder block must be replaced.

Note. Maximum permissible wear at time of 5th echelon rebuild is 0.004 inch.

6. *Taper.* A comparison of the readings *1.* with *2.* and *3.* with *4.* will indicate the taper. If the taper is more than 0.008 inch, replace the cylinder block.

Note. Maximum permissible taper at time of 5th echelon rebuild is 0.004 inch.

7. *Out-of-round.* A comparison of readings *1.* with *3.* and *2.* with *4.* will indicate the out-of-round. If the sleeve is out-of-round more than 0.004 inch, replace the cylinder block.

Note. Maximum permissible out-of-round at time of 5th echelon rebuild is 0.002 inch.

8. *Table of original cylinder size.*

Size	*Skirt diameter (inches)*
A	2.5010
B	2.5015
C	2.5020
D	2.5025

d. REPAIR. (1) *Cylinder sleeves.* Cut the ridge from the top of the cylinder sleeves with a ridge reamer. Polish sleeves with a 400-grit stone, and wash with hot soapy water. Rinse with clear cold water and dry thoroughly. Oil polished surfaces to prevent rusting.

(2) *Valve seats.* Reface valve seats to an angle of 45 degrees, and, if after facing, the width of the seat is more than 1/16 inch, narrow the seat with a 1-degree angle of relief. Valve seat width is 3/64 to 1/16 inch.

(3) *Valve guides.* The manufacturer's dimensions for the valve guides are 0.311 to 0.312 inch. If exhaust valve guides are worn more than 0.003 inch or intake valve guides are worn more than 0.002 inch, replace the cylinder block.

19. Valves and Springs (fig. 11)

a. CLEANING. Scrape the carbon from the valve heads and stems. Clean the springs and other parts with dry-cleaning solvent and dry with compressed air.

b. INSPECTION AND REPAIR. (1) *Valves.* Replace valves that are warped, pitted, or burned. Measure the intake and exhaust valve stems. The manufacturer's dimensions are 0.310 to 0.311 inch for both intake

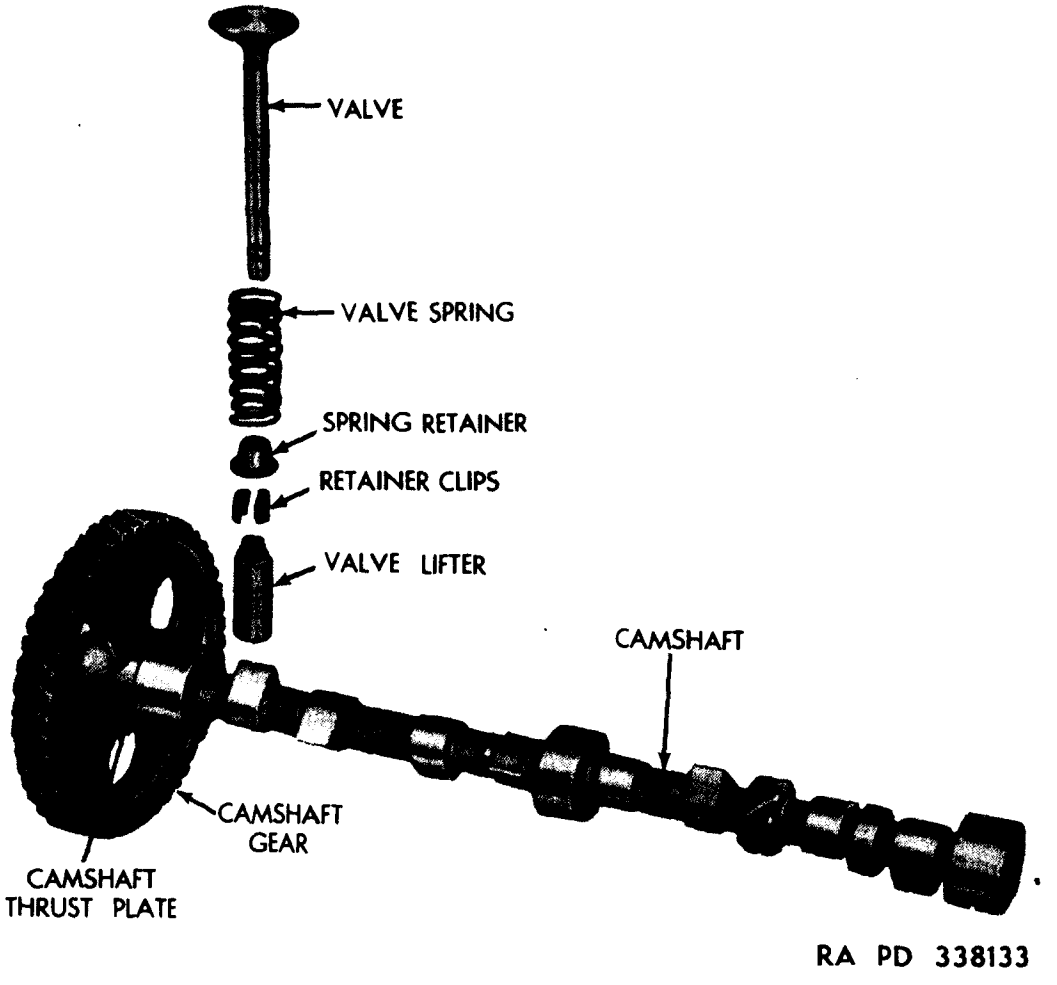

Figure 11. Camshaft and valve.

and exhaust valve stems. Replace intake valves that have worn stems and measure less than 0.308 inch, and exhaust valves that have worn stems and measure less than 0.307 inch. Reface serviceable valves to an angle of 45 degrees, 30 minutes. If after refacing, the thickness from the top of the head to the edge of the refaced outer circle is less than 1/64 inch, replace the valve.

(2) *Valve springs.* Inspect valve springs for cracks and rust spots. Replace springs having rust spots or cracks. Check valve springs on a spring tester. The manufacturer's specifications are 39±3 pounds at 31/32 inch and 25±2 pounds at 1 7/32 inches. Springs having a free length of less than 1 5/8 inches and a tension of less than 29 pounds at 1 inch are considered weak and must be replaced.

(3) *Clips and retainers.* Replace all clip halves and spring retainers that are damaged.

20. Connecting Rod and Piston Assemblies (fig. 12)

a. DISASSEMBLY. Remove the two compression rings and oil ring from each piston and discard. Remove and discard the expander from

the oil ring groove. Remove two piston pin retaining rings and push the piston pin from the piston and connecting rod, and separate the piston and rod.

b. CLEANING. Scrape the carbon from the top of the piston, ring grooves, and underside of piston head. Remove the carbon from the holes in the oil ring groove with a 1/8-inch drill. Check to see that the oilhole in the upper end of the connecting rod is open.

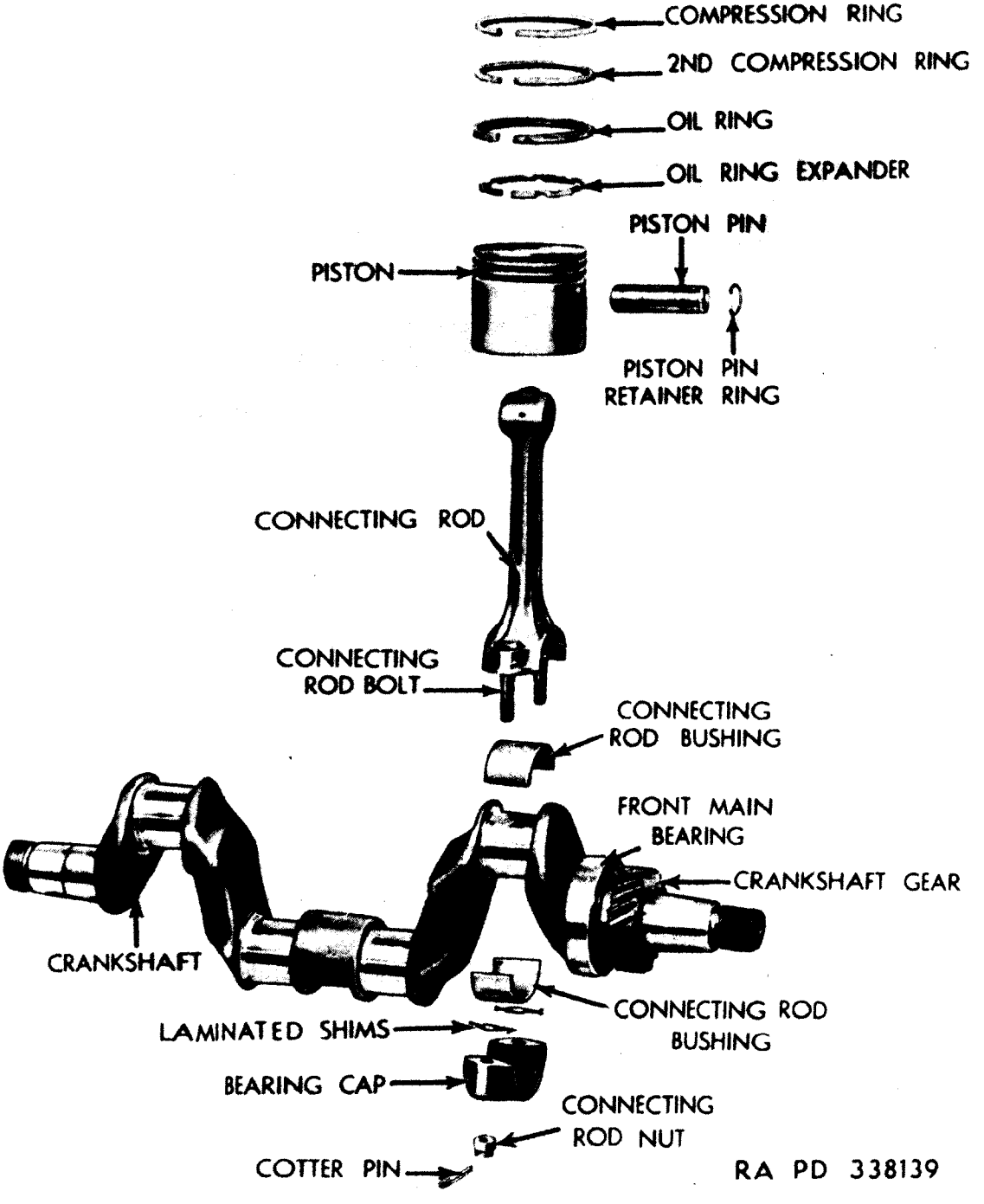

Figure 12. Piston and crankshaft.

c. INSPECTION AND REPAIR. (1) *Connecting rods and caps.* Check the connecting rod for alinement on a connecting rod aliner. If possible, straighten misalined or twisted connecting rods. Replace connecting rods that cannot be straightened. Measure the inside diameter of the piston pin bushing in the connecting rod. The manufacturer's dimensions are 0.6250 to 0.6253 inch. If the bushing is out-of-round or worn more than 0.0015 inch, press out the bushing and press a new bushing in its place. Drill an oilhole in the new bushing using the hole in the top of the connecting rod as a guide. Ream the new bushing to fit as described in step *d* (1) below. Install the bearing cap and shims on the connecting rod and draw the bolts to a tightness of 375 to 400-inch pounds. Measure the inside diameter of the connecting rod and cap assembly to determine the out-of-round. The manufacturer's dimensions for this diameter are 1.6680 to 1.6685 inches. If the bore is out-of-round more than 0.0005 inch, replace the connecting rod and cap assembly. Disassemble serviceable connecting rod and cap. Examine the bolts and nuts to see that the threads are not damaged. Replace damaged bolts and nuts.

(2) *Connecting rod bearings.* Replace connecting rod bearings that are scarred, pitted, or discolored (due to overheating). Measure the bearing at the center. The manufacturer's dimension for thickness is 0.05225 inch maximum for standard size. The manufacturer's dimensions for the bearing length is 0.990 to 1.000 inch. If less than 0.986 inch, replace the bearing.

(3) *Pistons.* Check pistons for cracks, scores, or worn ring grooves. Check each piston with a micrometer to determine wear on the skirt. Measure the skirt on the piston at the bottom and at right angles to the piston pin. The manufacturer's dimensions are 2.4980 inches for size A pistons; 2.4985 inches for size B pistons; 2.4990 inches for size C pistons; and 2.4995 inches for size D pistons. The size letter is stamped on the top of the piston. Replace pistons having a skirt worn more than 0.002 inch from the original size. With a new piston ring and a feeler gage, measure the wear in each ring groove. Replace pistons having a top ring groove wear of 0.002 inch from the original manufactured size of 0.1255 to 0.1265 inch. Replace pistons having a center ring groove wear of 0.001 inch from the original manufactured size of 0.125 to 0.126 inch. Replace pistons having an oil ring groove wear of more than 0.001 inch from the original manufactured size of 0.156 to 0.157 inch. Measure the piston pin bore. If the piston bore is worn more than 0.001 inch from the manufactured bore of 0.6245 to 0.6248 inch, replace the piston and pin assembly.

(4) *Piston pins.* The manufacturer's dimensions for piston pins are 0.6246 to 0.6248 inch. Replace piston and pin assembly if piston pin is worn more than 0.001 inch at piston pin bushing bearing surface.

(5) *Fitting pistons to cylinders.* Clean cylinder and piston thoroughly and wipe dry with a clean cloth. Use a piston fitting spring scale with a ½-

inch feeler gage 0.003 inch thick. Insert the feeler gage on the side of the cylinder wall at right angles to the piston pin. Completely insert the piston upside down in the cylinder bore. Withdraw the feeler gage and observe the reading on a spring scale. A pull of 4 to 8 pounds indicates the correct fit. The correct clearance between piston and cylinder is between 0.003 and 0.0035 inch for new pistons in a new cylinder block. However, when fitting new pistons in an old block or other combination not using all new parts, the maximum wear or clearance must not exceed 0.008 inch. If it is anticipated that the clearance will exceed 0.008 inch through wear before the next overhaul period, use a new piston or cylinder block.

Note. At time of rebuild, clearance between cylinder and piston must not exceed 0.005 inch.

(6) *Fitting piston rings.* (*a*) *Fitting rings to cylinders.* Place a new ring in the cylinder, pressing it down about halfway into the bore with the top of a piston so that the ring will be square with the cylinder wall. Measure the gap between the ends of the piston ring with a feeler gage. If the gap is less than 0.007 inch, place the ring in a jig and file until the correct gap of 0.007 to 0.015 inch is obtained.

(*b*) *Fitting rings to pistons.* Measure the clearance between the ring and the ring groove of the piston by holding the ring and a feeler gage in the groove of the piston. If side clearance between ring and piston groove is more than 0.0025 inch, use a new piston. The desired side clearance for a new piston and ring combination is 0.001 inch. Check each ring with its particular groove in the piston as above.

d. ASSEMBLY. (1) *Connecting rod to piston.* Select a piston pin to fit the bore in the piston from 0.0001 inch tight to 0.0001 inch loose. Check this pin and ream or burnish the piston pin bushing to give a fit of 0.0005 inch loose. Thoroughly clean connecting rod and pin. Lubricate the piston pin. Place the connecting rod in the piston so that marks are

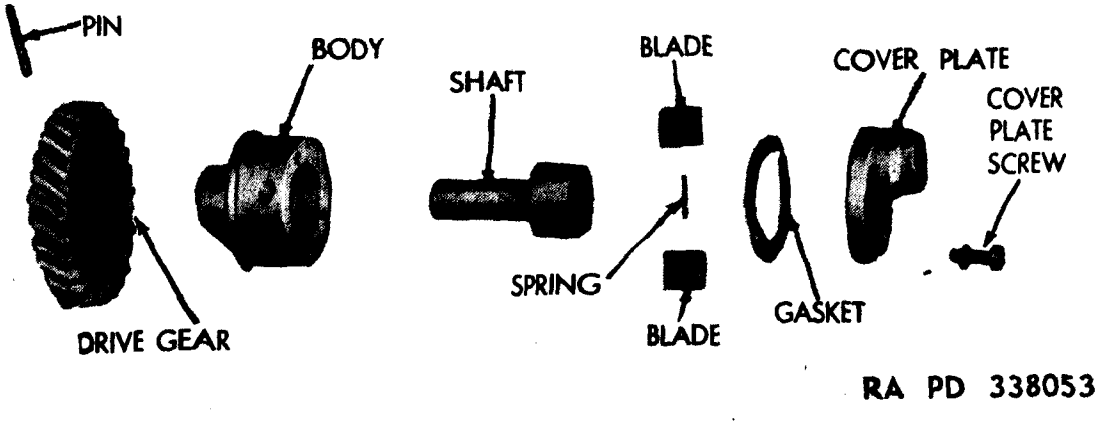

Figure 13. Oil pump—disassembled.

alined and install piston pin through piston bore and piston pin bushing. Install a piston pin retaining ring in the bore at each end of the piston pin.

(2) *Rings to piston.* Use a piston ring applier to install the rings on the pistons. Install a piston ring expander in the oil, or third groove. Install the oil control ring (beveled edge toward the top) in the third groove on top of the expander. Install the middle, or second ring, in the middle groove so that the beveled edge is toward the bottom. Install the first or compression ring in the top groove of the piston. Lubricate the rings and grooves as assembly proceeds.

21. Oil Pump and Screen

a. DISASSEMBLY (fig. 13). Before disassembly, scribe-mark the gear and shaft to aid in assembly. Drive out the pin holding the oil pump gear to the shaft and pull the gear from the shaft. Remove three screws and lock washers, cover plate, and paper gaskets from the body of the pump. Remove the shaft from the body and lift two blades and a spring from the shaft.

b. CLEANING. Clean all parts with dry-cleaning solvent and dry with compressed air. Be sure that oil passages are clear. Clean the screen and oil pump suction pipe with dry-cleaning solvent and compressed air. If the assembly cannot be well cleaned, replace the assembly.

c. INSPECTION AND REPAIR. Replace the oil pump drive gear if excessively worn or if teeth are chipped or missing. Pitted tooth flanks do not necessarily indicate that replacement is necessary. Check to see that the cover plate is not warped or worn. If wear or warpage is not extensive, reface cover plate inner surface by lapping on fine aluminum oxide abrasive cloth held flat on a surface plate. Examine the pump shaft for wear. The manufacturer's dimensions for the shaft diameter are 0.4990 to 0.4995 inch. If the shaft is worn more than 0.003 inch, replace the shaft. Determine the wear and out-of-round of the the shaft bore in the pump body. The manufacturer's dimensions for the diameter of the pump body bore are 1.7476 to 1.7480 inch. The pump body bore depth dimensions are 0.561 to 0.563 inch. Replace the pump body if the diameter of the bore is more than 1.7495 inch, or if the bore is more than 0.563 inch deep. Inspect the blades for scores on the rounded edge. Replace scored blades. The manufacturer's dimensions for the blade length is ½ inch. The manufacturer's dimensions for the width are 0.562 to 0.564 inch. The manufacturer's dimensions for the blade thickness are 0.119 to 0.122 inch. Replace blades that are worn more than 0.002 inch from any of the above dimensions. Examine the blade slot in the pump shaft and if worn more than 0.003 inch from the manufacturer's dimensions of 0.124 to 0.127 inch, replace the shaft. Inspect the spring for rust spots and distortion and replace if rusted or distorted. Spring tension is

not critical. Inspect the screen for obvious damage. Repair by straightening or by soldering. Replace badly damaged screen and pipe assembly.

d. ASSEMBLY. Install two pump blades and spring in the shaft (fig. 13). Make certain that the blades are free to slide in the shaft slot. Place the shaft and blade assembly in the pump body. Install the cover plate with enough gaskets between cover plate and pump body to allow a maximum clearance of 0.002 inch between the edge of blades and inner surface of cover plate. This can best be determined by comparing the blade width with the depth of the pump body. Secure the cover plate to the pump body with three screws and lock washers. Place the drive gear over the pump shaft so that the previous marks are alined and secure by pinning gear to shaft.

22. Flywheel Housing Cover and Gear Cover

Clean the flywheel housing cover and gear cover with dry-cleaning solvent and blow out all oil passages with compressed air (figs. 7 and 8). Inspect the covers for breaks, cracks, warpage and stripped threads. Check warpage on a surface plate. Breaks and cracks may be welded if excessive warpage does not result. The gasket surfaces must be true. If necessary, surface grind to remove warpage in excess of 0.010 inch provided not more than 0.015 inch is removed. Stripped threads may be plugged and tapped. Inspect the felt insert in the flywheel housing cover to see that it hugs the flywheel hub. If loose, replace the felt.

23. Flywheel

Clean the flywheel with dry-cleaning solvent (fig. 7). Inspect the flywheel and ring gear for broken teeth, stripped threads, breaks and cracks. A damaged ring gear may be removed from the flywheel by heating the ring gear and pressing from the flywheel. Install a new ring gear by heating and applying on chilled flywheel with a press. Check repaired ring gear and flywheel for run-out. The maximum permissable run-out is not more than 0.012 inch total indicator reading. The difference of interference diameters of ring gear and flywheel is 0.011 to 0.019 inch.

24. Camshaft

Clean the camshaft with dry-cleaning solvent, blowing out the oil passages with compressed air (fig. 14). Inspect the cam lobes and bearing surfaces for wear. If the cam lobes are worn more than 0.020 inch from heel to toe, the camshaft must be replaced. The manufacturer's dimensions for the lobes at this point are 0.999 inch for intake lobes and 0.975 inch for exhaust lobes. The manufacturer's dimensions for the three journals (bearing surfaces) are 1.248 to 1.249 inches. If worn more than 0.003 inch, replace the camshaft. Check the center journal for run-out while

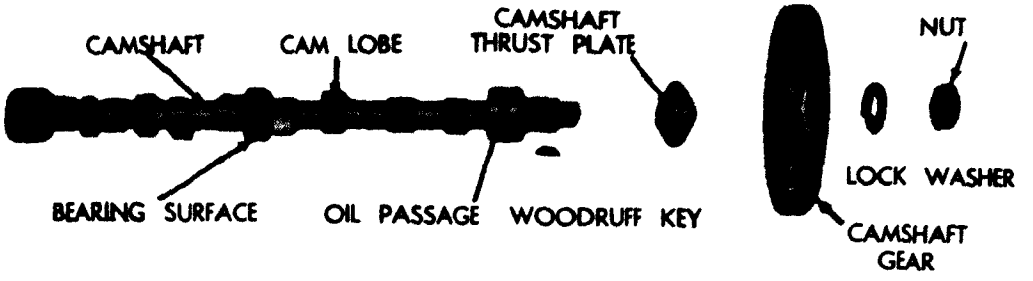

Figure 14. Camshaft—disassembled.

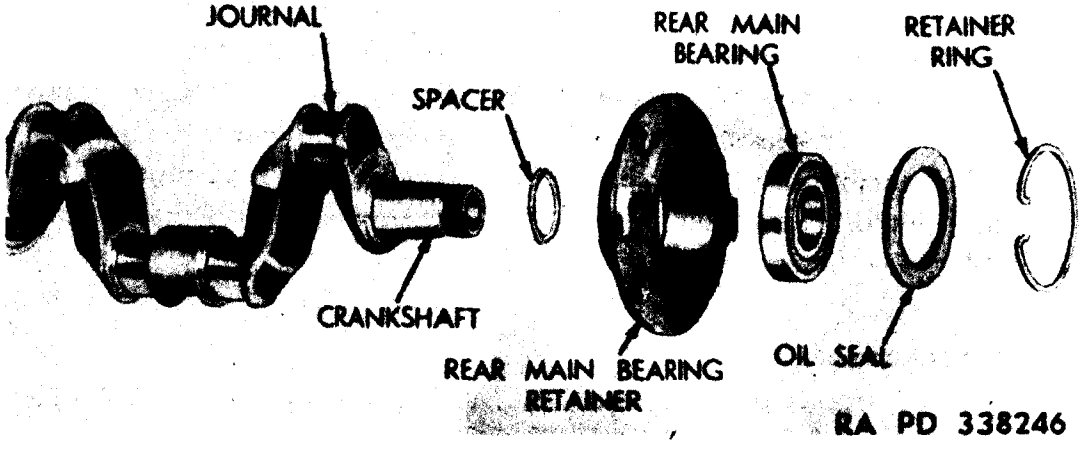

Figure 15. Crankshaft—disassembled.

supporting the camshaft by the end journals. The maximum allowable run-out is 0.003 inch. Inspect the camshaft gear for chipped and broken teeth. Replace the gear if chipped or broken. Inspect the camshaft thrust plate and if it allows end play of more than 0.006 inch, replace the thrust plate. This end play is measured with a feeler gage placed between the thrust plate and the end of the journal.

25. Crankshaft (fig. 15)

a. CLEANING. Clean the crankshaft with dry-cleaning solvent and dry with compressed air. Blow out the oil passages with air and solvent.

b. INSPECTION. Inspect the crankshaft connecting rod journals for wear and scores. The manufacturer's dimensions for a standard crankshaft are 1.562 to 1.563 inches. Crankshafts with connecting rod journals that are worn and measure less than 1.560 inches or are out-of-round more than 0.0015 inch must be replaced. Light scores or scratches may be polished out with crocus cloth. Inspect the crankshaft for burred and damaged keyway and stripped threads. Clean up keyways and threads if possible or replace the crankshaft. Examine the teeth of the crankshaft gear (fig. 12) for damage and excessive wear and if worn or if

teeth are damaged or missing, replace the gear (step *c* (1) below). Rotate the main bearings by hand; if they feel gritty, are noisy, do not run true or seem loose, replace the bearings (step *c* (2) and (3) below).

c. REPAIR. (1) *Crankshaft gear.* The crankshaft gear (fig. 12) is removed and replaced by using a press. Take precautions to support the work properly, to avoid springing the crankshaft.

(2) *Front main bearing.* Remove and replace the crankshaft front main bearing (fig. 12), when defective, by using a press. When pressing a new bearing on the crankshaft be sure to apply the pressure on the inner race.

(3) *Rear main bearing.* Press the crankshaft rear main bearing and the rear main bearing retainer from the crankshaft as a unit. Pry the oil seal from the retainer, remove the retainer ring and press the bearing from the retainer (fig. 15). Remove the bearing spacer. Place the bearing spacer on the crankshaft with the beveled edge toward the journals. Press the bearing into the bearing retainer and secure with retainer ring. Install a new oil seal in the bearing retainer. Press the rear main bearing assembly onto the crankshaft.

26. Crankcase

a. DISASSEMBLY. Unscrew and remove the oil pressure relief valve, copper gasket, spring and ball from the center of the right side of the crankcase (fig. 6). The flywheel housing, timing gear plate, starter relay bracket, and magneto idler gear need not be removed except for replacement.

(1) *Removal of flywheel housing.* Remove six cotter pins, castellated nuts, plain washers, and bolts that hold the flywheel housing and starter relay bracket (fig. 16) to the crankcase and separate the housing, relay bracket, and crankcase.

(2) *Removal of timing gear plate.* Remove three cap screws and internal-toothed lock washers that hold the timing gear plate to the crankcase and carefully pull the timing gear plate from the crankcase. Strip off and discard the gasket.

(3) *Removal of magneto idler gear.* From inside the crankcase, remove the cotter pin, castellated nut and plain washer from the idler gear spindle. Pull the spindle from the crankcase. Unscrew the cap screw and remove locking plate, thrust plate and magneto idler gear from spindle (fig. 17).

b. CLEANING, INSPECTION AND REPAIR. Clean all parts with dry-cleaning solvent. Flush the oil passages from the oil pump recess to the camshaft bushings and oil pressure relief valve with dry-cleaning solvent and air, blocking outlet holes at the camshaft bushings as necessary to produce pressure at required holes. Be sure oilhole in magneto idler gear spindle is open. Inspect the crankcase for cracks and breaks, stripped

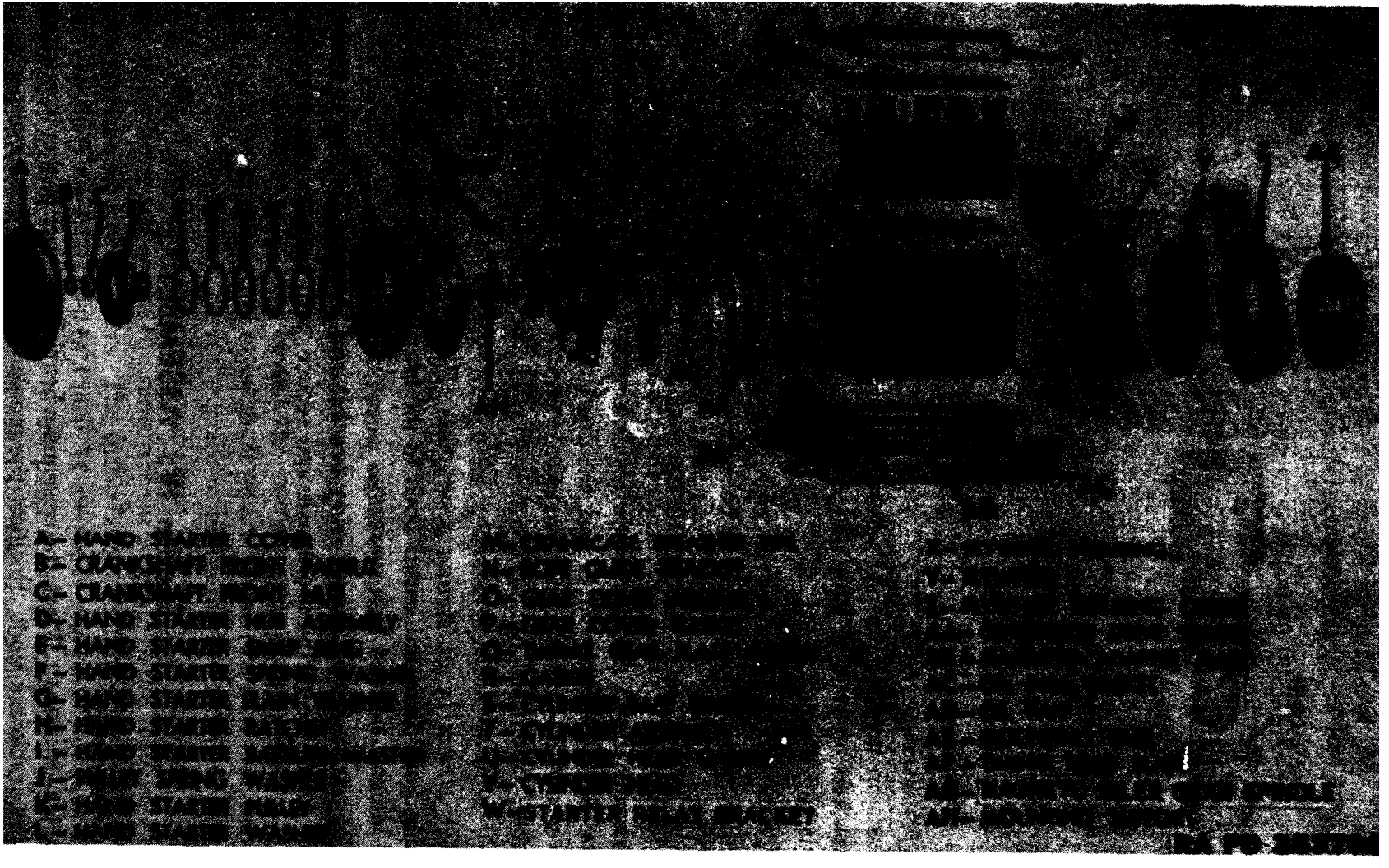

Figure 16. Engine, right side—disassembled.

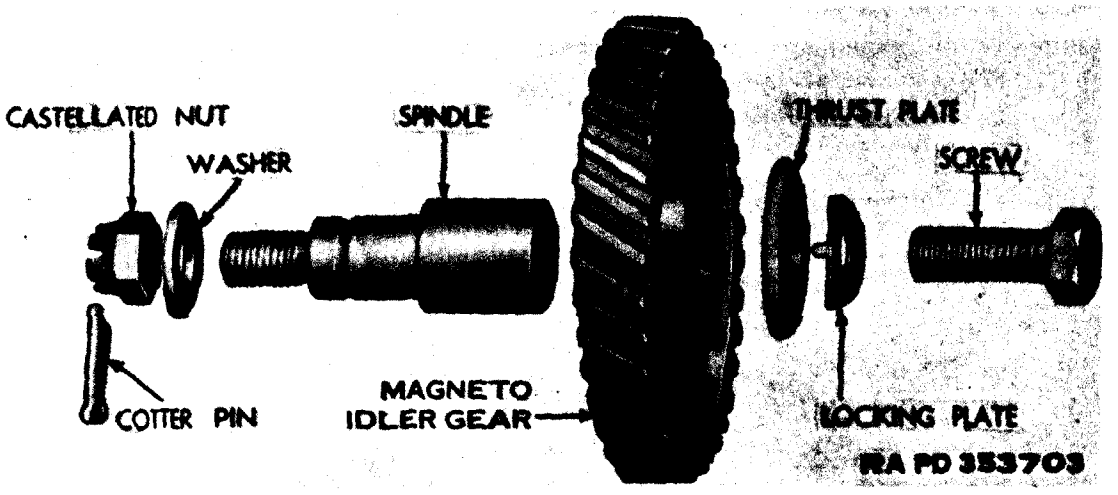

Figure 17. Magneto idler gear—disassembled.

threads in tapped holes, and bent or damaged studs. Replace crankcase if cracked or broken. Plug and tap damaged tapped holes. Replace bent or damaged studs.

c. ASSEMBLY. If any of the following items were removed for replacement purposes, they should be reassembled in the following manner:

(1) *Assembly of magneto idler gear.* Place the magneto idler gear over the idler spindle (fig. 17). Install the locking plate and thrust plate on the cap screw. Bend the tab of the locking plate into the hole in the thrust plate. Secure this assembly and the gear to the spindle by tightening the cap screw. From inside the crankcase secure the spindle with the plain washer, castellated nut, and cotter pin. If the end play does not equal 0.020 to 0.025 inch, add shims between the gear and the thrust plate.

(2) *Assembly of timing gear plate.* Place a new gasket under the timing gear plate and secure both to the crankcase with three cap screws and internal-toothed lock washers.

(3) *Assembly of starter relay bracket and flywheel housing to crankcase.* Assemble to the crankcase and secure with six plain washers, castellated nuts, and cotter pins.

Section IV. ASSEMBLY

27. Assembly

a. CRANKSHAFT. Place the rear main bearing retainer gasket in position on the crankcase studs. Position the crankshaft in the same manner as in disassembly (par. 14*r*), (fig. 9). Before tapping the crankshaft into the crankcase with a soft-faced hammer, make certain that the rear main bearing retainer is alined with the retainer mounting studs on the crank-

case. Tap the crankshaft into the crankcase and secure the bearing retainer to the crankcase with four nuts and lock washers. The manufacturer's limits for end play are 0.002 to 0.012 inch. If end play is excessive, replace the rear main bearing retainer assembly.

b. OIL PUMP. Place the oil pump in position in the crankcase so that the locating hole is alined to receive the screw (dog point type) (fig. 8). The pump inlet will be toward the oil pan. Install the set screw in the edge of the crankcase and secure with a retaining screw.

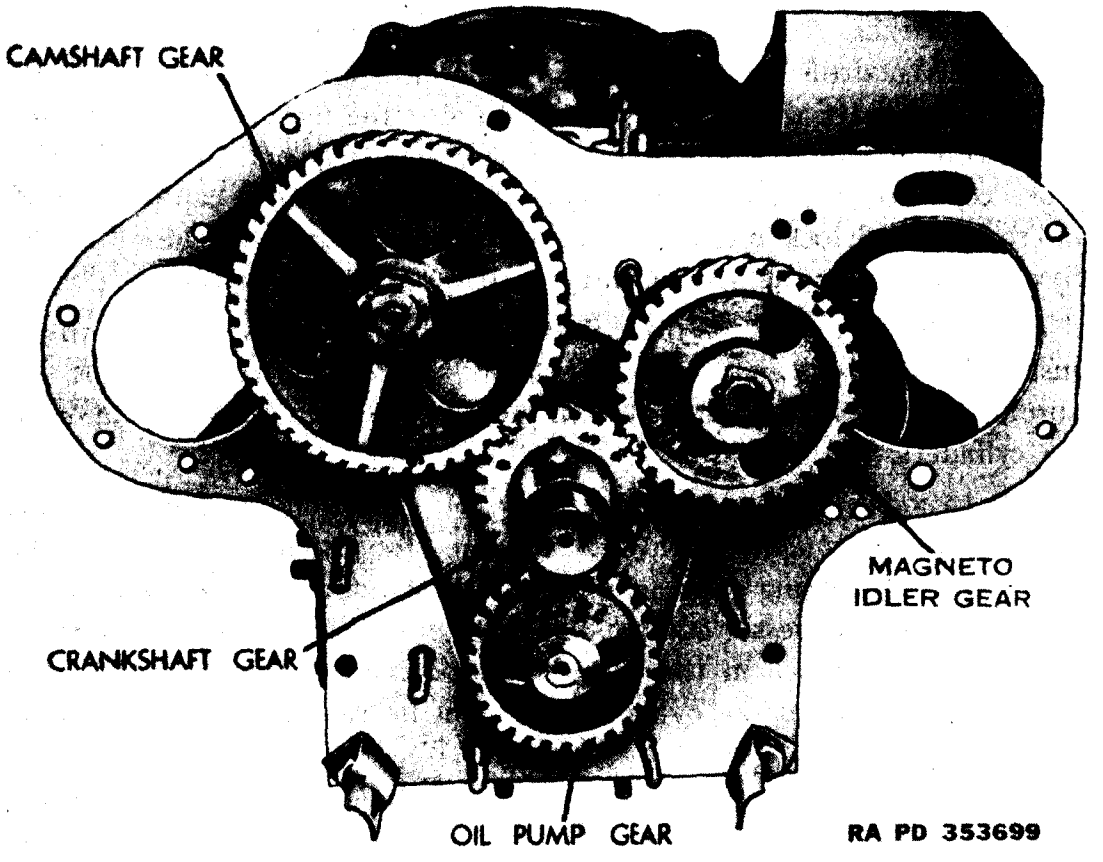

Figure 18. Timing marks on gears.

c. CAMSHAFT (fig. 8). Install the camshaft in the crankcase but do not mesh the camshaft and crankshaft gears. These two gears are marked with a "C" for timing. Turn the gears until the marked teeth are in mesh (fig. 18). Turn the camshaft thrust plate (fig. 14) as necessary to aline the screw holes and secure the camshaft thrust plate to the crankcase with two screws and lock washers. The manufacturer's limits for end play in the camshaft are 0.002 to 0.003 inch. If excessive end play is present after assembly, replace the camshaft thrust plate or if replacing the thrust plate does not correct the end play to 0.003 inch or less, replace the camshaft.

d. FRONT OIL THROWER (fig. 8). Secure the front oil thrower to the crankshaft gear with three screws and internal-toothed lock washers.

e. GEAR COVER (fig. 8). Place the gear cover gasket and the gear cover over the mounting studs and secure the cover to the crankcase with six nuts and internal-toothed lock washers. Secure the cover to the timing gear plate with three bolts, nuts, and internal-toothed lock washers.

Note. It is important that the right front mounting support be bolted to the gear cover only temporarily as the bolts which secure it to the gear cover are also used for the mounting of the governor and water pump.

f. CRANKCASE ON BASE (fig. 8). Place the crankcase assembly on the mounting base and secure the two rear and front left corners with three bolts, nuts, plain washers, and lock washers.

g. FLYWHEEL ASSEMBLY AND GENERATOR DRIVE SHEAVE (fig. 7). Place the Woodruff key in the end of the crankshaft and tap the flywheel on the crankshaft with a brass drift. Secure the flywheel to the crankshaft with an internal-toothed lock washer and large nut. Secure the flywheel cover to the crankcase with two small and four large cap screws and internal-toothed lock washers. Secure the generator drive sheave to the flywheel with four cap screws and internal-toothed lock washers.

h. VALVES (fig. 10). With a valve lifter compress the valve springs, install the valve springs, spring retainers, valves, and retainer clips. Be sure that these parts are installed in their original positions in relation to the cylinders.

i. PISTONS IN CYLINDER BLOCK (fig. 6). Lubricate the cylinder walls and pistons thoroughly with oil. Arrange the piston rings around the piston so that the ring gaps are staggered and not over piston pins. With a piston ring compressor compress the piston rings and install the pistons in their proper place in the cylinder block from the bottom. Push the pistons to the top of the cylinder block but be careful not to push them through.

j. VALVE LIFTERS (fig. 6). Lay the cylinder block on its side with the valve chamber up to prevent valve lifters from falling out. Install the valve lifters in their proper places in the cylinder block.

k. CYLINDER BLOCK TO CRANKCASE (fig. 6). Place the cylinder block-to-crankcase gasket over the crankcase studs. Place the crankcase on its side, camshaft up. Position the cylinder block assembly so that the stud holes are alined with the crankcase studs and assemble the cylinder block and crankcase, being careful to engage the connecting rod bearings with the crankshaft journals. Push the block down onto the studs and place the assembly in an upright position. Secure the block to the crankcase with eleven elastic stop nuts.

l. CONNECTING RODS TO CRANKSHAFT (fig. 12). With crankshaft journals and bearings well lubricated, assemble bearing caps to connecting rods according to previous markings and with the proper shims in place. The desired clearance between the crankshaft journal and the connecting rod bearing is 0.0015 inch. The permissible clearance is 0.0005 to 0.0025

inch. The manufacturer's dimensions for the thickness of the connecting rod bearing is 0.05225. Replace connecting rod bearings that are scarred, pitted, discolored (due to overheating) or worn to less than 0.05075 thickness. The permissible side clearance between bearing and crankshaft journal is 0.006 to 0.010 inch. To obtain the proper clearance between the connecting rod bearing and the crankshaft journal, shims are added or removed from the connecting rod bolts. These shims are built up of laminated stock 0.002 inch thick. Always add or remove the same amount of stock from each side of the connecting rod to avoid cocking the bearing cap. When assembling the connecting rod care must be exercised to prevent shims from extending out between the mating edges of the bearing. Do not remove any material from the back, front or mating edges of the bearing. When the correct clearance between bearing and crankshaft journal has been established, tighten the nuts on the connecting rod bolts to a torque of 375-to-400-inch pounds. Turn the crankshaft after each connecting rod is tightened to be sure there is no binding. Secure the nuts with cotter pins.

m. Oil Pump Suction Pipe and Screen (fig. 6). Screw the oil pump suction pipe and screen into the oil pump until the pipe is tight and the screen is parallel and facing the bottom of the crankcase.

n. Oil Pan (fig. 6). Place the oil pan and gasket in position over the crankcase studs so that the drain plug is located at the right rear. Secure the pan to the crankcase with 18 nuts and lock washers.

o. Cylinder Head and Generator Support (fig. 5). Place the cylinder head gasket, with the part number on top and on the side away from the valves, over the studs. Place the cylinder head over the studs. Place the generator support over the studs and on top of the cylinder head so that the side screw holes line up. Secure the cylinder head and the generator support to the cylinder block with 12 nuts and plain washers. Secure the generator support to the cylinder head with two cap screws and washers. Tighten the cylinder head nuts to a torque of 350-inch pounds.

p. Valve Adjustment. The clearance between the end of the intake valve stem and the valve lifter should be 0.009 inch, and the corresponding exhaust valve clearance 0.013 inch. These clearances can be obtained by the adjustment at the top of the valve lifter. After the engine run-in test has been completed, the intake valves must be reset (cold) to 0.007 inch and the exhaust valves reset (cold) to 0.011 inch. Replace the valve door and gasket. Secure with the two long cap screws and copper washers.

28. Final Instructions

a. Install Engine Accessories. Install the following items as outlined in TM 9–735: Crankcase breather assembly, hand starter assembly, magneto, starter relay, electric starter, water pump and governor as-

sembly, intake and exhaust manifolds, spark plugs, oil pressure sending unit, fuel pump, oil filler pipe and gage, carburetor, automatic choke, and muffler assembly.

b. INSTALL GENERATOR REGULATOR AND GENERATOR. Install and connect the generator regulator and generator to the auxiliary engine assembly as outlined in TM 9–735.

Section V. TESTS AND ADJUSTMENTS

29. Preliminary Instructions

a. FUEL SUPPLY. Connect the fuel pump inlet to a fuel supply of 70 (or higher) octane nonleaded gasoline.

b. FILL THE CRANKCASE. Fill the crankcase with oil as specified in LO–735.

c. AIR CLEANER AND BREATHER. Service the crankcase breather and the carburetor air cleaner as outlined in TM 9–735.

d. COOLING SYSTEM. Connect the water pump inlet and the cylinder head outlet water connections to a suitable test standard radiator.

e. BATTERIES. Connect two 12-volt batteries in series. Connect the negative terminal to the engine ground strap. Connect the positive terminal to the large battery terminal of the starter relay.

f. OIL PRESSURE SENDING UNIT. Connect the oil pressure sending unit to the oil pressure gage and battery, or if more practical, remove the oil pressure sending unit (electrical) and install an oil pressure gage of the bourdon tube type.

g. MAGNETO GROUND. Connect the magneto grounding terminal to ground through a switch.

30. Starting and Stopping the Engine

a. CHOKING. During starting, the engine may be choked by pulling the choke-to-carburetor rod toward the choke.

b. STARTING. Touch a jumper wire from the large battery terminal of the relay to the small ungrounded terminal of the starter relay. This will energize the starter relay and starter. Do not run the starter for periods of more than 30 seconds.

c. STOPPING. The engine is stopped by grounding the magneto through the magneto switch.

31. Tests and Adjustments

a. GENERAL. Start the engine. If the engine races, stop the engine and make a temporary adjustment of the governor as outlined in TM 9–735.

b. OIL PRESSURE. With the engine running, check the oil pressure. The maximum oil pressure should be 35 pounds per square inch. Adjust the screw of the oil pressure relief valve until the correct pressure is reached and tighten lock nut. The pressure will drop off as the oil becomes heated.

c. CARBURETOR. With the engine warmed up, adjust the carburetor systems, idle and high speed, as outlined in TM 9–735.

d. GOVERNOR. The governor is adjusted as outlined in TM 9–735. However, the final adjustment will be made with the engine running under load.

e. VALVES. After the engine run-in test has been completed, adjust the valves as outlined in paragraph 27 *p*.

f. HAND STARTER. Work the hand starter several times to see that the rope is returned to the spool and that the pawls and clutch are working properly.

CHAPTER 6
FUEL SYSTEM

Section I. DESCRIPTION

32. General

Fuel (gasoline) is supplied from the right fuel tank of the vehicle and is pumped from the tank to the carburetor through the fuel lines by a diaphragm-type fuel pump located on the right side of the auxiliary engine and driven by the camshaft. The fuel is filtered in the fuel pump by a sediment bowl. Fuel is supplied to the engine through the carburetor and the intake manifold. The carburetor is controlled by a centrifugal governor driven by the camshaft gear and connected by linkage to the carburetor accelerator lever. For cold weather starting, the carburetor is choked by an automatic choke located on the exhaust manifold beneath the carburetor. Information on the fuel pump and carburetor can be found in appropriate technical manuals.

Section II. GOVERNOR AND WATER PUMP

33. Description

a. GOVERNOR. The governor is of centrifugal type, gear driven by the camshaft gear, and is self oiling. The main bearing (ball bearing) is lubricated by spray from the camshaft gear. The governor and water pump (fig. 19) are mounted on the same shaft. A pair of weights (fig. 21), are used to actuate the control lever which is connected by linkage to the carburetor throttle plate. When the engine speed is increased, the weights fly out from the main shaft and press against the ball thrust bearing assembly which in turn moves the shifter and lever, closing the throttle. Spring tension, adjustable from the outside of the governor (fig. 19), restrains the movement of the weights and returns them toward the mainshaft when at rest; therefore the spring tension directly controls the engine speed.

b. WATER PUMP. The impeller type water pump (fig. 22), circulates the coolant from the radiator to the engine. The mainshaft is sealed to prevent water from entering the governor section. A drain plug is provided in the bottom of the impeller housing for drainage. Telltale

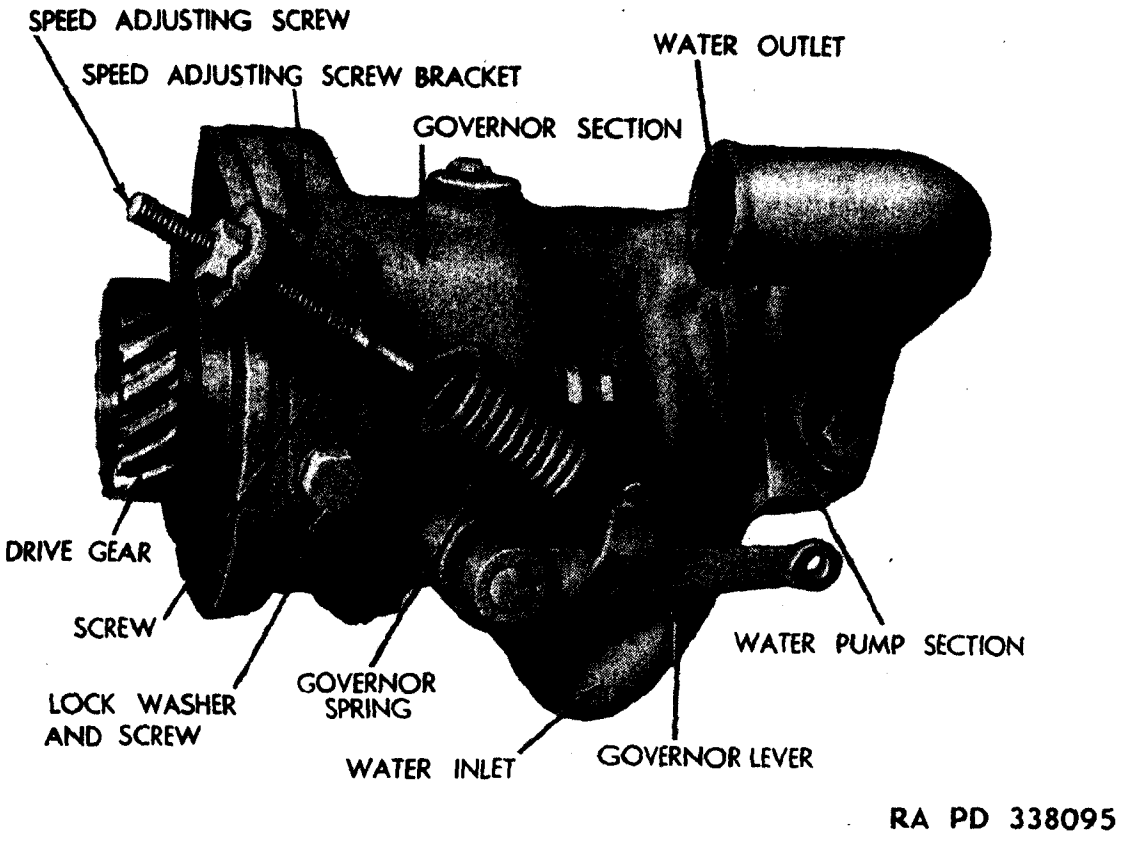

Figure 19. Governor and water pump.

holes are provided in back of the water seal to allow coolant to drain out before it can reach the governor section and to warn the operator that the seal is wearing out.

34. Disassembly

a. Water Pump Section (fig. 22). Remove six cap screws and lock washers that hold the water pump cover to the body. Separate the cover and water pump body and strip off the gasket. Support the mainshaft to avoid springing and drive the grooved taper pin from the vane (impeller). Pull the vane from the mainshaft and remove the spring seal and carbon washer from the mainshaft.

b. Governor Section. Remove the cap screw and lock washer and slotted-head screw and lock washer from the speed adjusting screw bracket (fig. 19). Unhook the governor spring from the governor lever and remove the spring, speed adjusting screw, and bracket as an assembly. Pull the drive gear and mainshaft assembly from the body (fig. 23). Remove the ball thrust bearing assembly from the mainshaft.

c. Body. Drive the pin from the shifter shaft and shifter and pull the shifter shaft from the body (fig. 24). Drive the oil seal and needle bearing

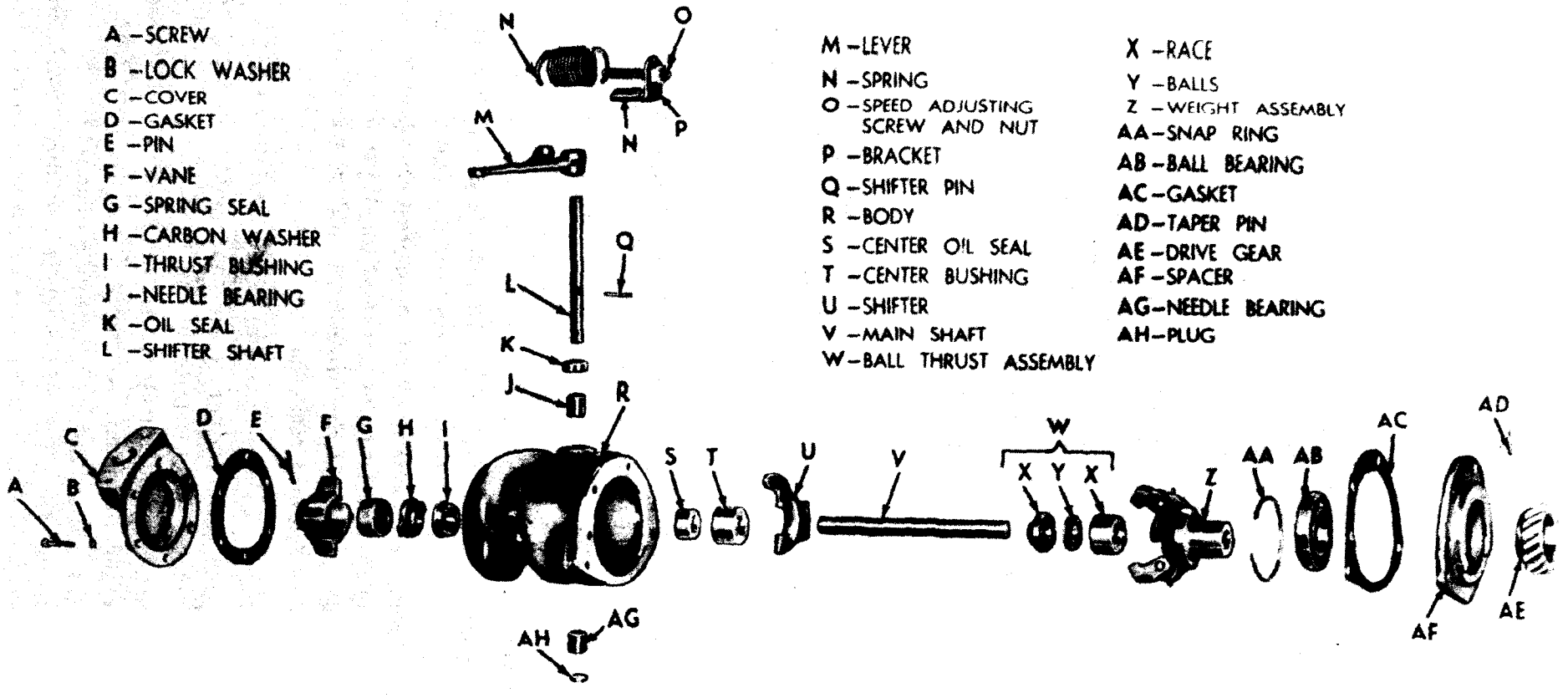

Figure 20. Governor and water pump—disassembled.

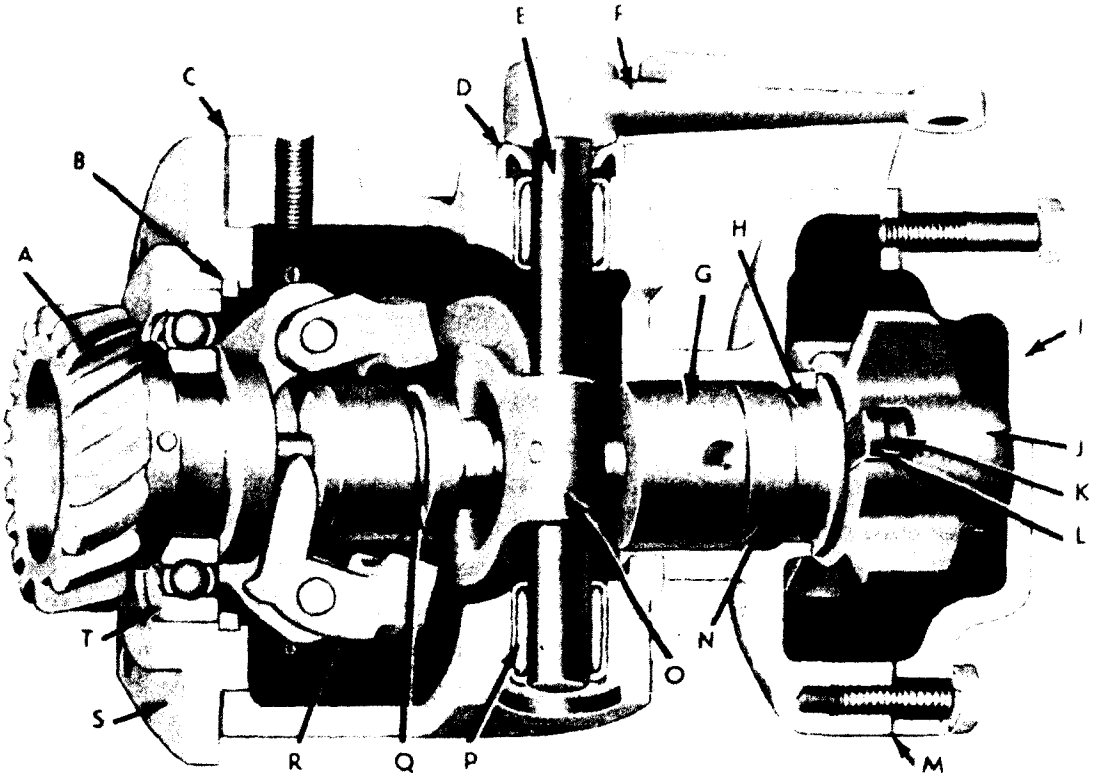

Figure 21. Governor and water pump—cross sectional view.

from the body. Pick the remaining needle bearing from the body. Drive mainshaft center bushing, thrust bushing, and oil seal from the body.

35. Cleaning

Clean the body and all other parts with dry-cleaning solvent, remove rust or corrosion by scraping, and dry with compressed air.

36. Inspection and Repair

a. Body (fig. 24). Inspect the body and cover for cracks, breaks, and stripped threads. Replace the body or cover if cracked or broken, or if tapped holes cannot be repaired by plugging and retapping. If the gasket surfaces are not true, remove the warp by cutting with aluminum oxide abrasive cloth held flat on a surface plate.

b. Governor (fig. 24). Inspect the shifter, shifter shaft, and needle bearings for obvious defects such as breaks, cracks, and wear. The manufacturer's dimensions for the shifter shaft diameter are 0.3745 to

0.3750 inch. The dimension for the internal diameter of the needle bearings is 0.3750 inch. Replace the shifter shaft if worn more than 0.005 inch. Replace the needle bearings if worn more than 0.005 inch, or if they seem to have flat spots when the shaft is turned in them. Replace the shifter if damaged. Inspect the mainshaft, weights, bearing, and gear as an assembly. The manufacturer's dimensions for the mainshaft diameter are 0.437 to 0.438 inch. If the mainshaft bearing surface is worn more than 0.005 inch, replace the mainshaft. To disassemble the mainshaft assembly, proceed as follows: Scribe gear, shaft, and weight assembly for ease in assembly. Drive the pin from the gear and shaft, and press the shaft from the weight assembly. Press the weight assembly from the gear and bearing. Examine the weight assembly for obvious damage and if the pivots are worn or rusted, replace the pivots. Inspect the gear for burred, worn, and missing teeth. Replace the gear if worn or damaged. Inspect the bearing for looseness, side play, and grit or worn bearing balls by turning in the hands, by feeling, and by listening. Replace the bearing if defective by removing the snap ring from the spacer and pressing the bearing out of the spacer. Lightly oil serviceable bearing. Replace spacer if broken or cracked. If bearing or races of ball thrust bearing assembly are pitted, or grooved, replace the assembly. Inspect the stop screw and if defective, replace.

c. WATER PUMP (fig. 22). Inspect the vane for cracks and breaks, and replace if cracked or broken or if badly rusted. If the carbon washer shows a worn groove or is chipped, replace. Examine the mainshaft center bushing for wear. The manufacturer's dimensions for the internal diameter are 0.439 to 0.4395 inch. If worn more than 0.003 inch, replace the bushing. Inspect the face of the thrust bushing to see that it is smooth.

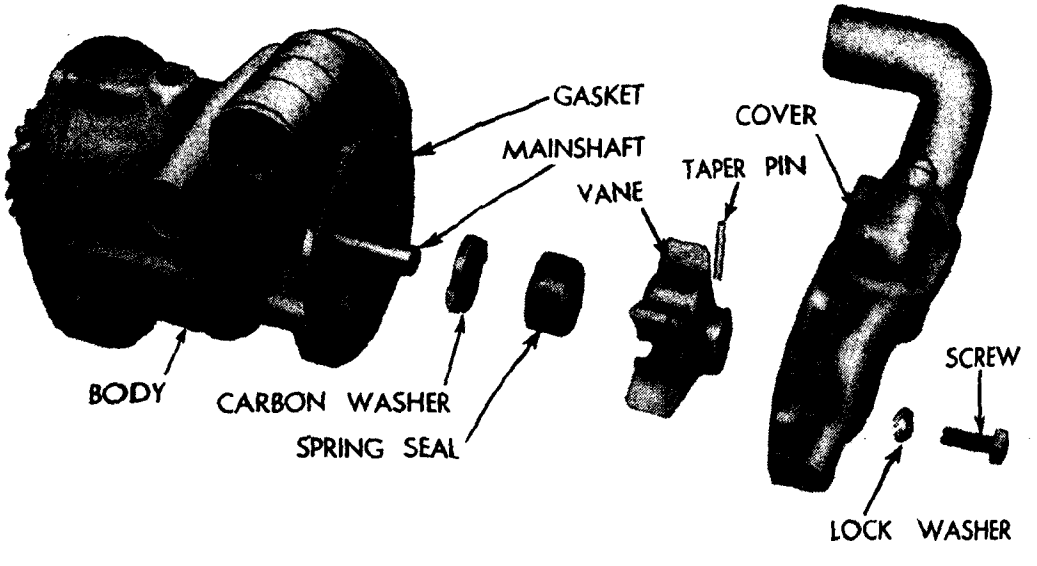

Figure 22. Water pump section—disassembled.

If this surface is not smooth, the carbon washer will wear rapidly. Smooth the face of the thrust bushing with crocus cloth held flat on a surface plate. Inspect the oil seals to see that they grip their respective shafts and that the leather is not deteriorated. Replace any defective oil seals. Inspect the rubber spring seal. If the rubber is deteriorated or if the tension is less than 12 pounds when compressed to 0.463 inch (tension of new spring is 12 pounds when compressed to 0.463 inch), replace the seal.

37. Assembly

a. BODY (fig. 24). Press the thrust bushing into the housing in the water pump section of the body so that the drain cut-out is toward the bottom. Install the center oil seal in the body from the governor side. Press the mainshaft center bushing in place so that the drain hole is toward the bottom. Place two needle bearings in shifter shaft recesses of the body and install oil seal. Place shifter in position inside of body and install shifter shaft through oil seal, needle bearing, and shifter. Aline the pinholes and pin shifter and shaft together. Place lock nut on stop screw and press spring on tip of screw. Place gasket over screw and install screw in pump body. Adjust the stop screw so that the shifter is not allowed to touch the body. Tighten lock nut.

b. GOVERNOR. Install the bearing (fig. 20) in spacer and secure by installing snap ring in recess of spacer. Press the weight assembly through the bearing. Press the gear onto the protruding end of the weight assembly so that scribe marks are alined. Press the mainshaft through the weight assembly and when the pinholes are alined, secure by driving the pin through gear, weight assembly, and mainshaft. Place races and bearing of ball thrust assembly over the mainshaft as indicated.

c. WATER PUMP. Place gasket in position on governor spacer and push mainshaft through center bushing in body (fig. 23). Place carbon washer and spring seal over mainshaft in water pump section (fig. 22). Place vane over mainshaft with pinholes alined and secure with a grooved taper pin. The clearance between the vane and the pump rear body wall should be 0.0625 inch. If necessary, to obtain this clearance, drill a new hole through the vane at right angles to the original hole. The mainshaft is very hard and brittle and will chip or break if drilling is attempted. Install gasket between cover and body and secure cover to body with six cap screws and lock washers. The screw passing through the water inlet has a copper gasket under the head to prevent leakage. Hook the free end of the governor spring in the governor lever and position the speed adjusting screw bracket to the body (fig. 19). Secure the speed adjusting screw bracket to the body with a cap screw and lock washer and a slotted-head screw and lock washer.

d. ADJUSTMENT. The initial adjustment of the governor is as follows: Adjust the nut so that 7/8 inch of the screw projects past the bracket. Final adjustment of the governor on the engine is covered in TM 9–735.

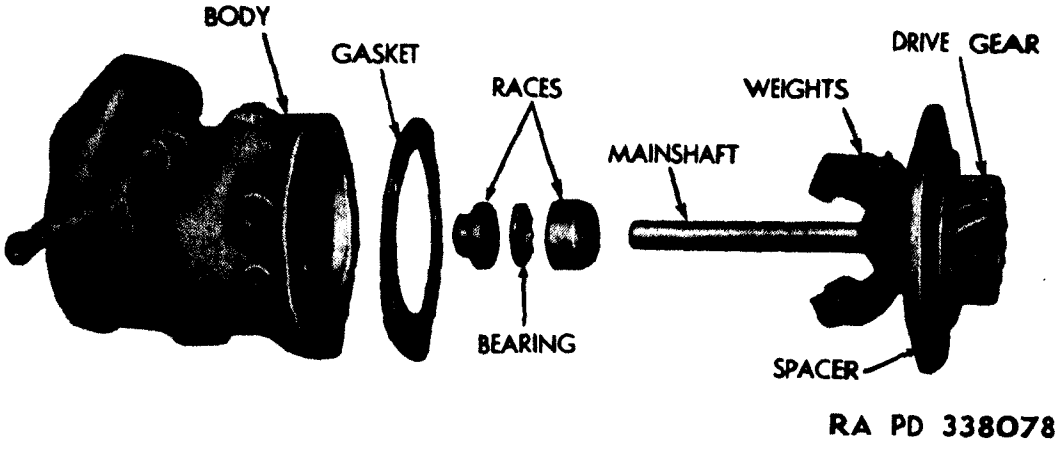

Figure 23. Governor assembly removed from housing.

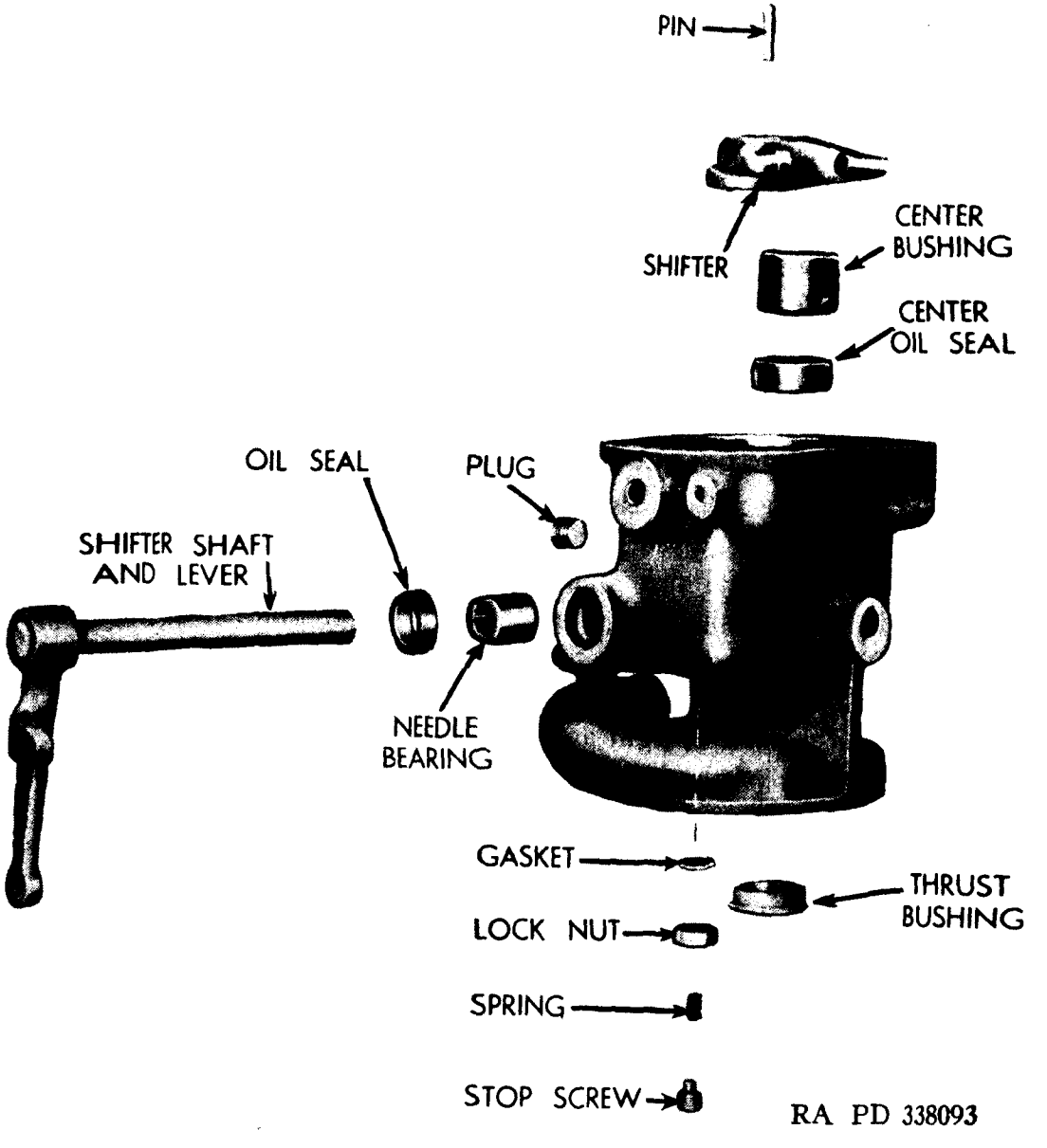

Figure 24. Throttle lever and shifter removed from housing.

Section III. AUTOMATIC CHOKE

38. Automatic Choke

a. DESCRIPTION. The automatic choke (fig. 2) is mounted on the exhaust manifold with two cap screws. The choke is composed of two parts, an electromagnet and a bimetallic strip. When the electric starter is energized, the electromagnet pulls the choke lever (connected to the choke lever of the carburetor) to close the choke plate in the carburetor. The bimetallic strip is U-shaped and when cold tends to hold the choke in the closed position. When heated by the exhaust manifold, the bimetallic strip changes shape and pulls the choke lever, opening the choke.

b. CLEANING, INSPECTION AND REPAIR. Clean the choke bimetallic strip with a brush, and dry-cleaning solvent. ***Caution:*** *Do not soak.* Pull the cover from the electromagnet section and clean with compressed air. The choke can best be inspected by observing the action of the choke plate in the carburetor when in operation. There is no repair or adjustment of the automatic choke; if damaged or out of adjustment, replace the unit.

CHAPTER 7
STARTING SYSTEM

39. Hand Starter

a. DESCRIPTION. The hand starter is a rope-turned sheave, mounted on the front of the crankshaft (fig. 25). When the rope is pulled, the sheave turns, causing the ratchet pawls to act through a clutch, forcing the pawls to engage notches in the clutch. The clutch is mounted on a hub which is keyed to the crankshaft and is turned by action of the pawls. A large, clocklike spring is mounted on the backside of the sheave and returns the sheave and pawls to the original position when the rope is released.

b. DISASSEMBLY. Disassemble the hand starter assembly as described in TM 9-735.

c. CLEANING, INSPECTION, AND REPAIR. Clean all parts of the hand starter assembly with dry-cleaning solvent. Remove rust from steel parts with fine aluminum oxide abrasive cloth or crocus cloth. Examine all parts for signs of wear and obvious damage. If any parts are worn or damaged, replace the parts.

d. LUBRICATION. Apply a graphite grease to the seal surface of the rear side of the sheave and to the counterbore spring washer seat at the front of the sheave. The pawl pivots should be oiled very sparingly with a light oil, such as aircraft instrument oil or machine gun oil. Wipe all surfaces of steel parts with an oily cloth to prevent rusting. The bakelite washer and associated parts must be free to move at low temperatures and not be slowed by sticky oil or grease.

e. ASSEMBLY. Assemble the hand starter assembly as outlined in TM 9-735.

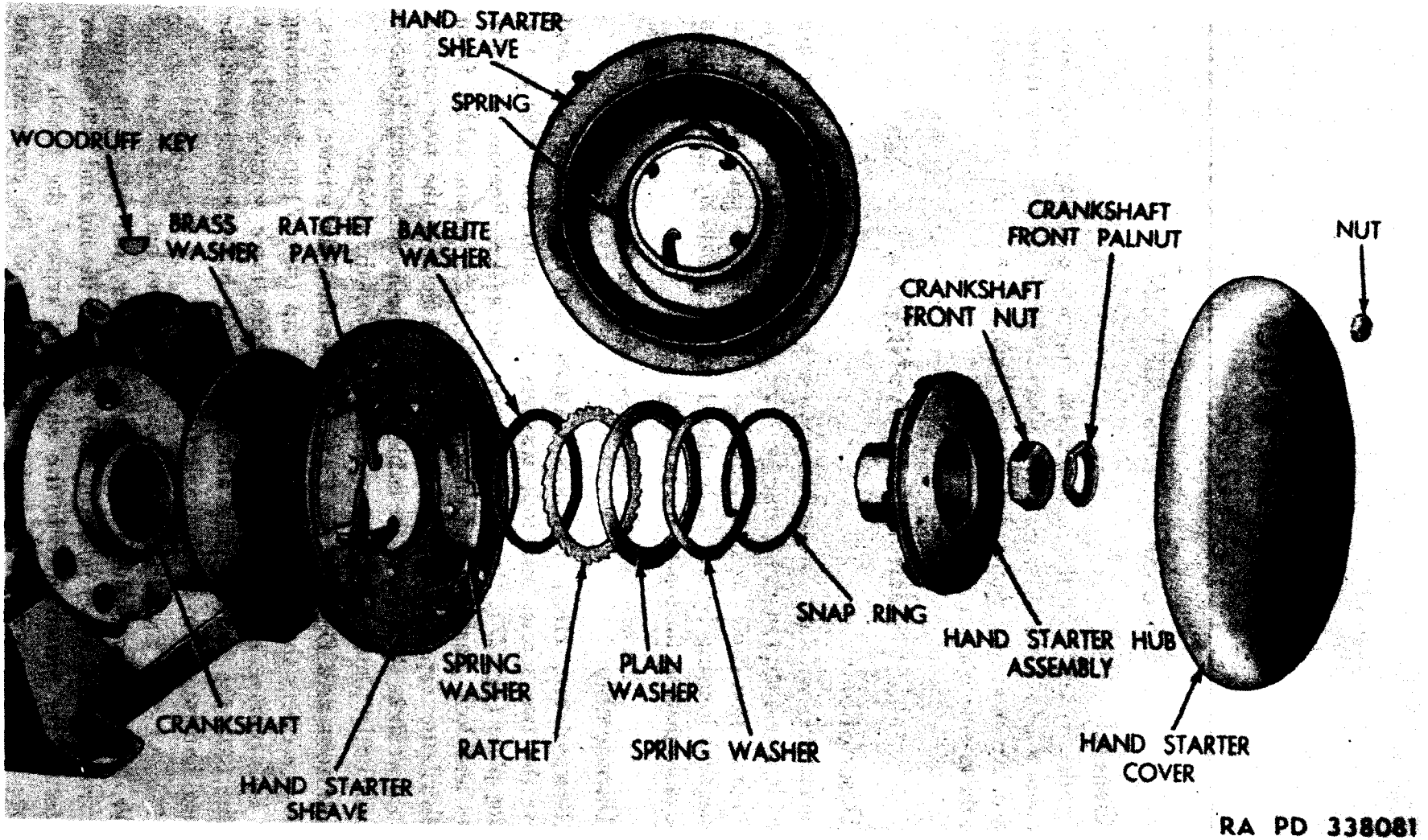

Figure 25. Hand starter—disassembled.

CHAPTER 8
IGNITION SYSTEM

Section I. DESCRIPTION

40. General

The ignition system is of the high-tension, magneto type and utilizes four Champion C88S aircraft-type spark plugs. The system is fully radio-shielded. An ignition switch on the control panel shorts out the magneto when the engine is not in use.

Section II. MAGNETO

41. Description

The armature, winding, bearings, impulse starter, and distributor are housed in a cast aluminum housing with integral mounting plate (fig. 26). The high tension cables are connected to the distributor and are held to the magneto housing by the cable shield which is held by knurled nuts to the cable plate at the top of the housing.

42. Disassembly

a. REMOVE THE HIGH TENSION CABLES. Cut the locking wire and remove the two screws and lock washers that secure the cover to the housing plate (fig. 27). Remove the cover and gasket. Remove the four screws and lock washers, and disconnect the high tension cables from the distributor cap. Cut the locking wire and remove the four screws and lock washers that secure the cable outlet plate to the housing. Remove the cable outlet plate with cables attached. Strip off the gasket.

b. REMOVE THE DISTRIBUTOR CAP. Remove the four screws, washers, and lock washers that secure the distributor cap (fig. 27) to the housing plate and remove the distributor cap. Remove three screws and lock washers from the housing plate and remove the housing plate from the magneto housing. Strip off the gasket.

c. REMOVE THE END PLATE. Remove the round nut, and copper lock washer, and spacing bushing from the condenser, and release the three leads from the condenser post (fig. 30). Remove the nut and lock washer that secure the pinion gear to the shaft and remove the pinion gear. Remove two screws and copper lock washers from the condenser and remove the condenser. Remove the five screws and lock washers that secure the end plate to the housing (fig. 29), and remove the end plate.

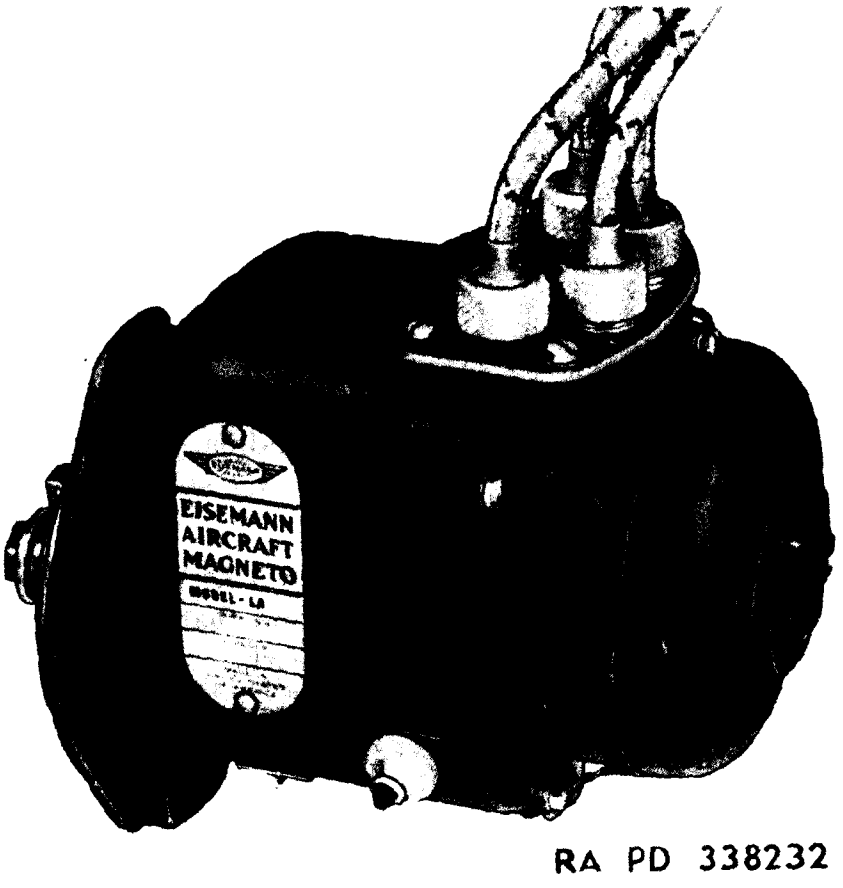

Figure 26. Eisemann magneto—model LA-4.

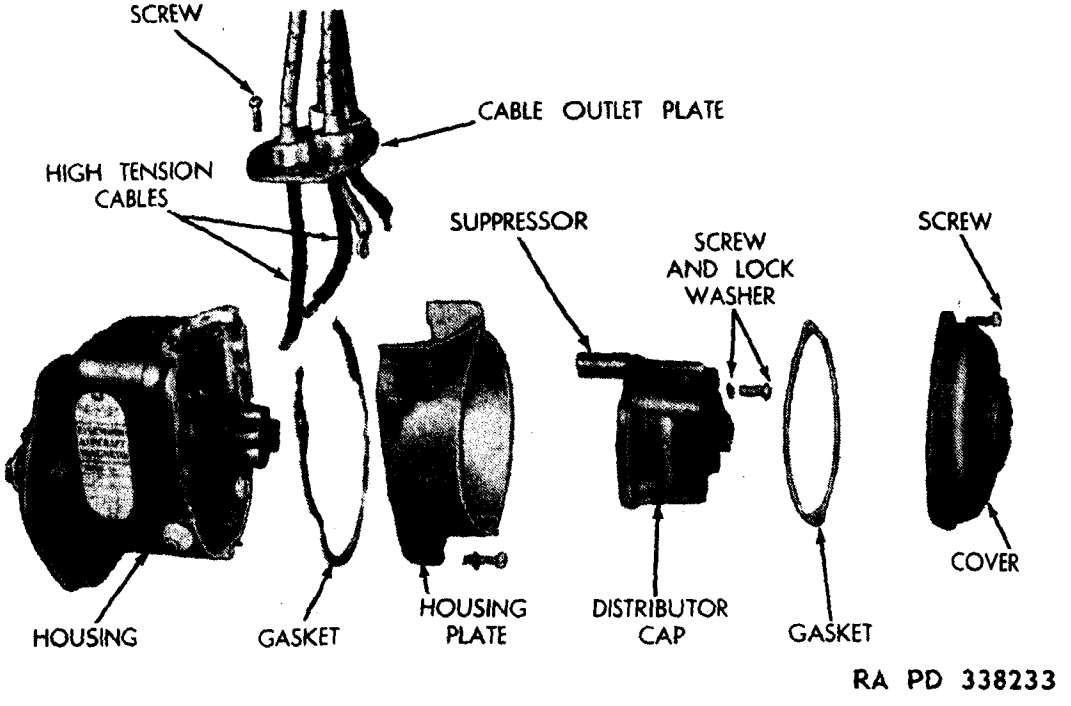

Figure 27. Magneto—Partially disassembled.

d. REMOVE THE IMPULSE STARTER. With a suitable puller, remove the impulse starter from the shaft (fig. 28). Be certain to locate the puller on the solid edge of the flange and not on the pawls.

e. REMOVE THE MAGNET ROTOR (fig. 29). Tap the magnet rotor from the housing, removing the oil slinger at the same time.

f. REMOVE THE WINDING. Remove four screws and copper lock washers from the winding clamps (fig. 29) and pull the two clamps from the coil. Remove the winding from the housing, tapping the housing if winding sticks.

43. Overhaul

a. CLEANING. With the exception of the winding, condenser, and end plate, clean the magneto parts with dry-cleaning solvent and dry with compressed air.

b. INSPECTION AND REPAIR. (1) *Impulse starter.* Inspect the impulse starter to see that the spring is not broken and that the pawls are free on the pivots. Replace any damaged or worn parts.

(2) *Magnet and rotor shaft.* Inspect the magnet and rotor shaft for straightness, bearing and cam wear. If the shaft is not straight or if the

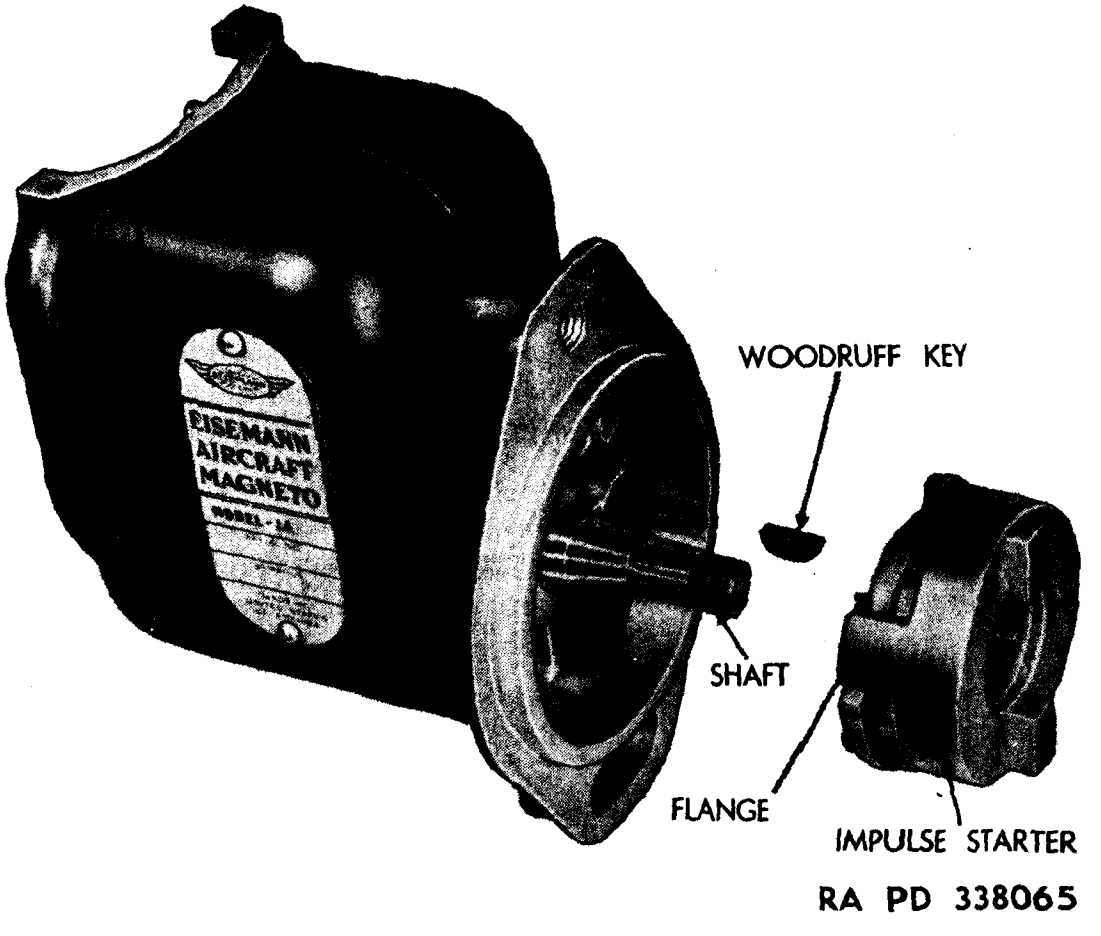

Figure 28. Magneto impulse starter removed.

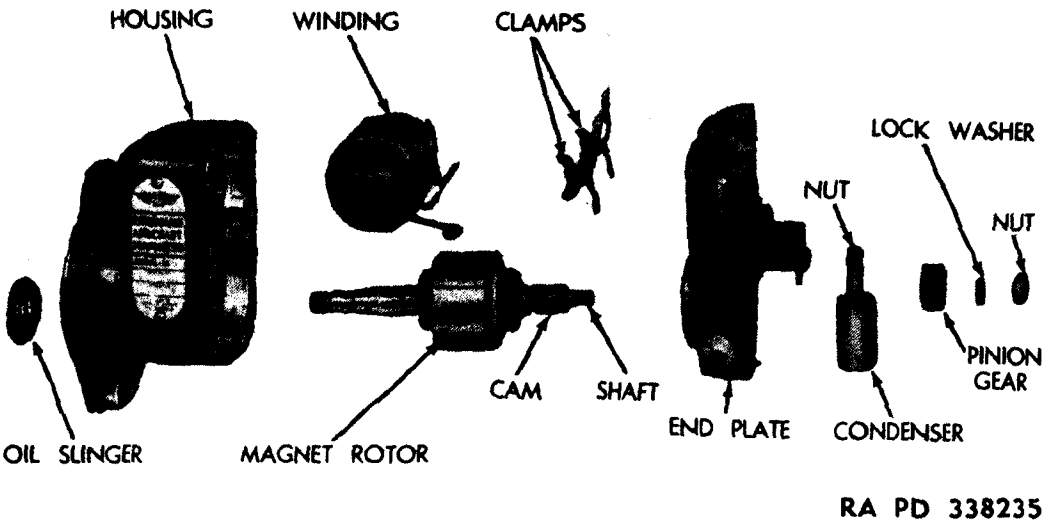

Figure 29. Magneto—disassembled.

magnet has lost its magnetism, replace the magnet and rotor assembly. Replace bearings and races if loose, or if the feel is gritty.

(3) *Housing.* Inspect the housing for cracks, breaks, stripped threads, worn bearing races, damaged impulse starter catch pin, and oil seal. Replace the housing if cracked or if threads are stripped. The oil seal will be replaced if damaged or leaking, using a suitable replacer. Check between the bearing race and the housing with an ohmmeter to determine if insulation has been broken or damaged; if the race is worn so that a groove is evident or if not insulated from the housing, replace the bearing race, being sure to insulate it properly from the housing. Replace a damaged impulse starter catch pin with a suitable puller and press.

(4) *End plate.* Clean the end plate assembly, except for the bronze distributor rotor bushing, with dry-cleaning solvent and dry with compressed air. Inspect the assembly for breaks, cracks, stripped threads and wear. Replace the magnet shaft bearing race if worn or not insulated from the end plate. Check to see if the insulation on the contact lead is damaged or if the lead is not grounded. Reinsulate the lead with tape if necessary or replace the contact assembly. If the end plate is broken or threads are stripped, replace. If the distributor rotor bushing or gear is worn or teeth are damaged, replace, being careful to limit the end play to about 0.002 inch.

(5) *Winding.* Test the winding on an ignition coil tester and replace if defective.

(6) *Condenser.* Test the condenser on a condenser tester and replace if defective.

(7) *Pinion gear.* Inspect the magnet rotor pinion gear for wear and stripped teeth, and replace if worn or damaged.

(8) *Distributor cap.* Inspect the distributor cap for burned contacts cracks, carbonizing and stripped threads, and replace the cap if any such defects are found. Replace the carbon brush if worn to less than ¼ inch. Clean the contacts of a serviceable cap with fine flint paper to remove corrosion.

(9) *Cover and housing plate.* Inspect the cover and the distributor housing plate for cracks, breaks, and stripped threads and replace if damaged. Disassemble and clean the vent in the cover and install clean new filter element.

(10) *High tension cables.* Check the high tension cables with a megger and inspect them visually to see that the insulation is not deteriorated and that good electrical contact is being maintained. If cables or shielding are defective, replace. Mark the cable shield with the spark plug identification number.

44. Assembly

a. INSTALL THE WINDING. Place the winding firmly in its seat so that the leads are on the right-hand side (fig. 29). Place the lead with the pear-shaped lug (ground connection) at the upper right and place the right-hand clamp in position at the coil end. Secure the winding and the ground lead to the housing with two screws and copper lock washers. Secure the left side of the winding to the housing with the left clamp and two screws and copper lock washers.

b. INSTALL THE MAGNET ROTOR. Pack the bearings of the rotor with special grease (high temperature). Install magnet rotor in the housing (fig. 29).

c. INSTALL THE IMPULSE STARTER. Place the oil slinger (fig. 29) over the shaft so that the shoulder is toward the magnet and with a suitable driver, press the slinger up to the oil seal. Insert a Woodruff key in the shaft (fig. 28) and press the impulse starter over the shaft. Temporarily secure the starter to the shaft with a nut.

d. INSTALL THE END PLATE. Secure the end plate (fig. 29) to the housing with five screws and lock washers (the longer screws at the top). Fasten the condenser to the end plate with two screws and copper lock washers. Install the spacing bushing over the condenser terminal and connect the three remaining leads to the terminal, securing with a copper lock washer and round nut. Make sure the magnet rotor rotates freely and that the end play is not excessive.

e. INSTALL THE CAM. If it is necessary to replace the cam, turn the magnet rotor until the keyway is up and install key in keyway (fig. 29). Hold the cam with lobes vertical and with the keyway toward the upper left; press the cam onto the shaft in this position.

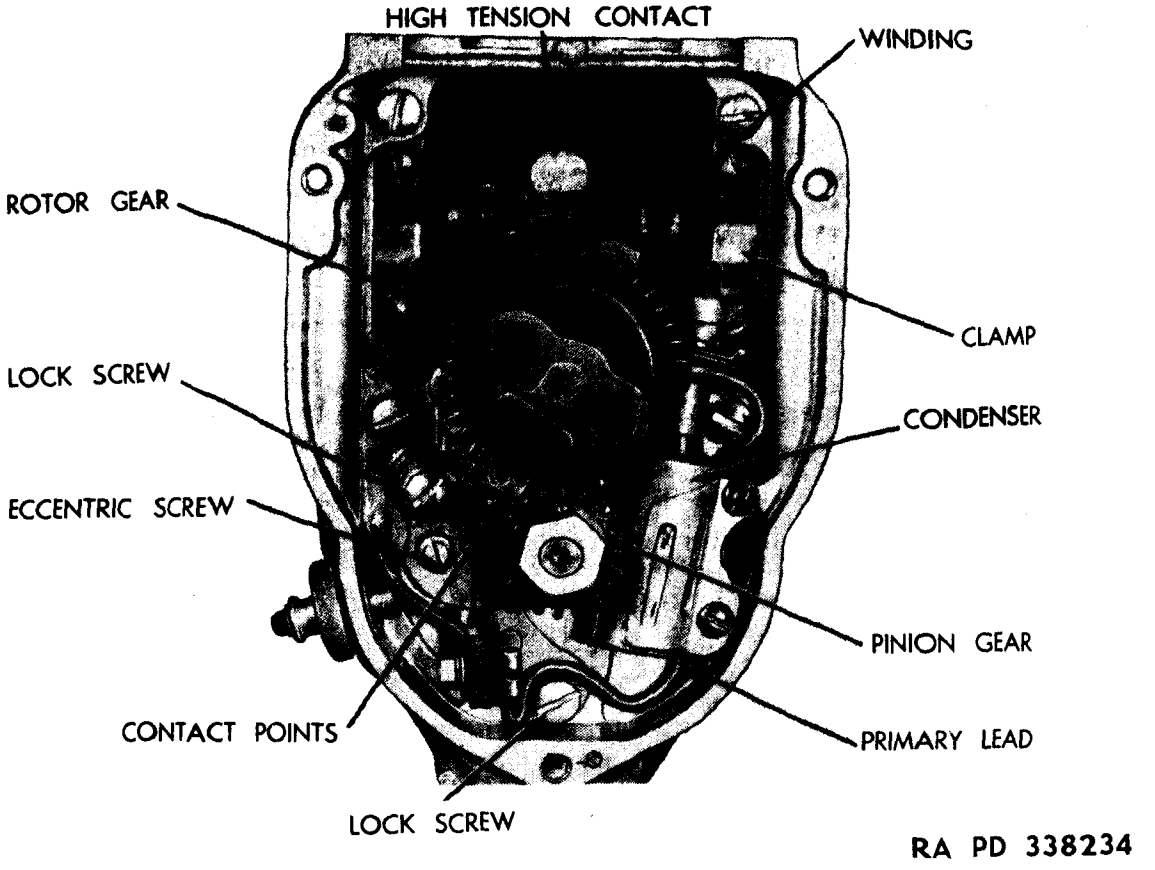

Figure 30. Magneto—timing marks on gears.

f. TIME THE MAGNET AND DISTRIBUTOR. With the tooth marked "c" of the rotor gear directly over the magnet rotor shaft, place the pinion on the magnet rotor shaft so that the punch-marked tooth of the pinion gear is meshed with the tooth marked "C" of the rotor gear (fig. 30). Turn the meshed gears until the pinion gear can be pushed over the Woodruff key on the shaft. Secure the pinion gear to the shaft with a lock washer and nut.

g. ADJUST THE CONTACT POINT OPENINGS. Rotate the magnet rotor counterclockwise until the cam lifts the fiber lever to its maximum position (contacts open). Loosen the locking screws (fig. 30) and turning the eccentric screws, set the contact points so that the opening measures 0.019 to 0.021 inch as measured with a round feeler gage. Lock by tightening the locking screws. Wipe the contact points with a clean cloth moistened with carbon tetrachloride.

h. INSTALL THE HOUSING PLATE. Place a gasket over the locating pins of the end plate (fig. 27) and install the housing plate on the end plate, securing with three screws and lock washers.

i. INSTALL THE DISTRIBUTOR CAP. Place distributor cap (fig. 27) over locating pins and secure with four screws, washers, and lock washers.

j. INSTALL THE HIGH TENSION CABLES. Place the gasket over the housing opening (fig. 27). Feed the high tension cables through the opening and to the distributor cap. Secure the cable outlet plate to the housing with four screws and lock washers. Position the cables of the distributor cap terminals and secure with four screws, and lock washers.

k. INSTALL THE COVER (fig. 27). Secure the cover and gasket to the housing with two screws and lock washers.

45. Testing

a. Test the magneto on a magneto test stand to see that the impulse starter is functioning properly (below 200 rpm) and that the spark is intense enough to fire consistently across a gap of 7 millimeters.

b. Safety-wire all external screws of the magneto.

CHAPTER 9
GENERATOR

Section I. DESCRIPTION

46. Description and Data

a. GENERAL. The generator (fig. 31) is shunt wound with four main and four commutating fields and is used for charging the vehicle batteries. The generator double shaft extension allows double end drive through the overrunning clutches. The generator is provided with two fans which are an integral part of the overruning clutches and provide ventilation.

b. OPERATION. Voltage output depends on the current through the shunt field winding, speed of rotation of the armature and the electrical load imposed by lights, motors etc. The output voltage increases or decreases directly with an increase or decrease in field current. It also increases or decreases directly with an increase or decrease in speed, but varies inversely with an increase or decrease in load. Since the speed and load cannot be varied to suit the voltage, a generator regulator is used in conjunction with the generator in order to compensate for changes in voltage due to changes in speed and load.

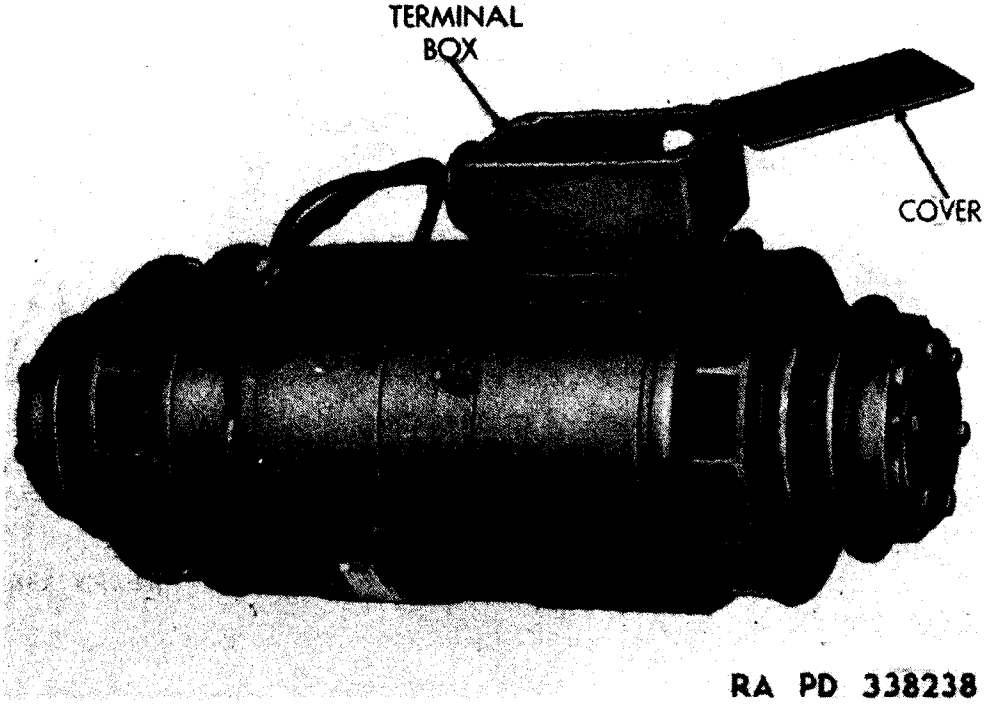

Figure 31. Generator.

c. DATA.

Make	General Electric
Model	5BY168A4
Type	shunt wound, direct current
Capacity	3.6 kw
Amperes	150
Volts	24
Regulated voltage (no load)	29.2
Regulated voltage (full load)	28.5
Speed	3,200–4,500 rpm
Rotation (viewed from brush end)	clockwise
Pulley ratio (main engine end)	1.57 to 1
Pulley ratio (auxiliary engine end)	1.80 to 1
Diameter	7 in.
Length	20 in.
Weight	96.5 lb

Section II. REBUILD

47. Disassembly

a. REMOVE THE DRIVE PULLEYS. Remove six screws and lock washers that secure the dust cover to the end of the pulley (fig. 32), and remove the dust cover. Remove the cotter pin from the end of the armature shaft and remove the castellated nut. With a suitable puller, remove the drive pulley assembly from the armature shaft. Remove the drive pulley from the opposite end of the armature shaft in like manner.

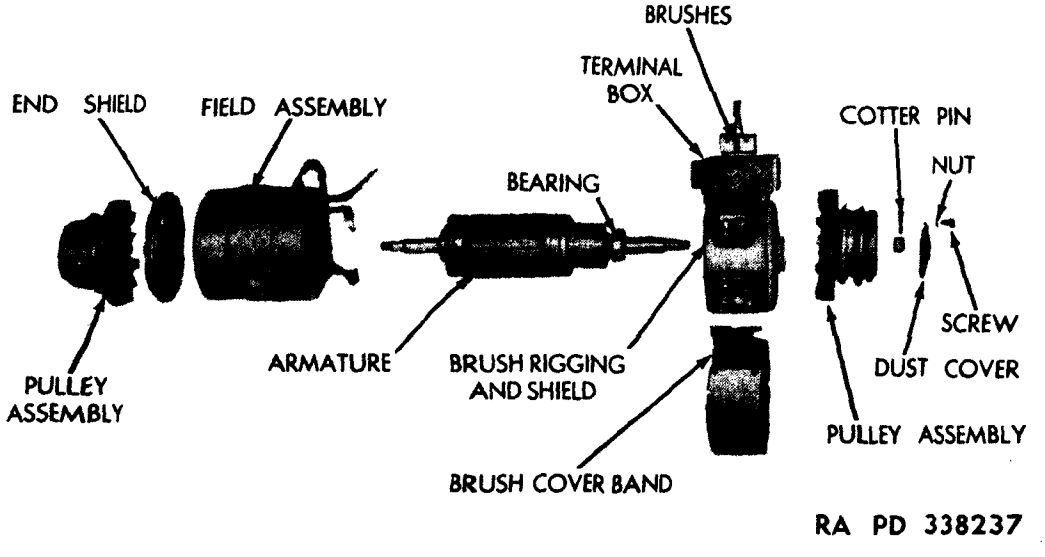

Figure 32. Generator—disassembled.

b. DISCONNECT THE LEADS. Remove the large nut, internal-toothed lock washer, and plain washer from the G+ terminal in the terminal box (fig. 32), and disconnect the braided lead from the terminal. Remove two nuts, internal-toothed lock washers (where present) from the F+ and BR+ terminals and disconnect the field and brush leads. Some generators have no terminals for the field and brush leads but have extra long leads to go directly to the generator regulator.

c. REMOVE THE BRUSHES. Remove four screws and internal-toothed lock washers from the ends of the brush cover band and slide the brush cover band from the shield (fig. 32). Remove each brush terminal screw and disconnect the leads. Lift the brush springs and carefully pull out the four pairs of brushes. Note the position of the brushes in their holders and the lead connections.

d. REMOVE THE BRUSH RIGGING AND SHIELD (fig. 32). Remove the four hollow-head screws and internal-toothed lock washers that secure the shield and brush rigging assembly to the field assembly and separate the shield and brush rigging assembly from the field assembly. Be careful not to damage the leads.

e. REMOVE THE ARMATURE. Carefully pull the armature out of the field assembly (fig. 32).

f. REMOVE THE END SHIELD (fig. 32). Remove the four hollow-head screws and internal-toothed lock washers that secure the remaining end shield to the field assembly and separate end shield from field assembly.

48. Cleaning, Inspection, Repair and Testing

a. DRIVE PULLEY ASSEMBLIES. One drive pulley is left-hand and one is right-hand.

(1) *Disassembly.* Cut the locking wire and remove six bolts and nuts from around the drive pulley and separate the fan and pulley (fig. 33). Tap lightly and remove the cover from the pulley. Pressing on the hub at the fan end, press the hub from the pulley. Strip off the gaskets and remove the spacer from the hub.

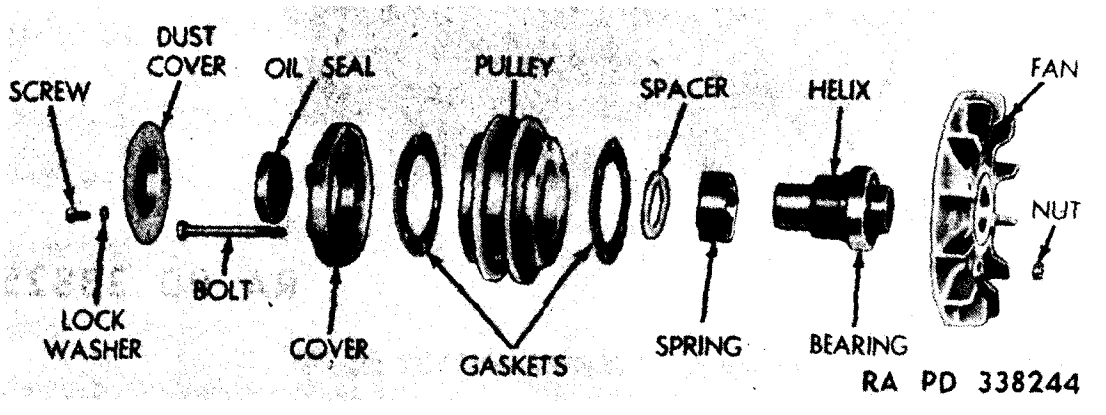

Figure 33. Drive pulley—disassembled.

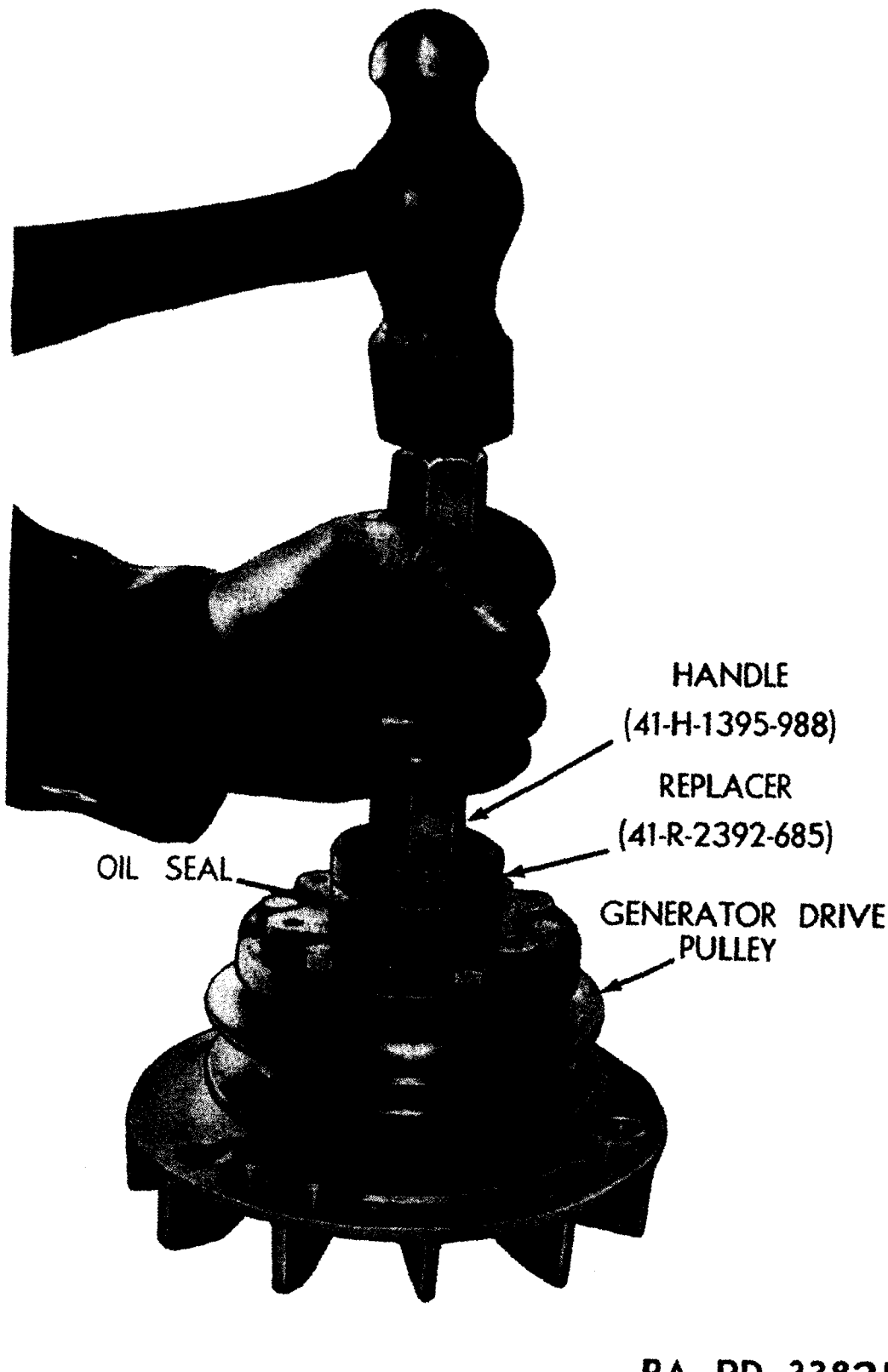

Figure 34. Replacing generator oil seal.

(2) *Cleaning and inspection.* Clean all parts with dry-cleaning solvent and dry with compressed air.

Caution: Do not spin bearings.

Inspect all parts for defects such as breaks, cracks, and wear. Inspect the bearings for looseness, flat spots and side play. Inspect the helix for obvious wear. Inspect the spring for obvious wear and damage. If necessary, pry the drive lug from the recess in the helix and remove the spring. Replace any damaged parts. Inspect the oil seals for wear and leakage. Replace damaged oil seals with replacer (41–R–2392–685) (fig. 34).

(3) *Assembly.* Press the helix (with spring, spacer and bearing on helix) into the pulley. Install gasket and cover with oil seal onto the end of the helix that has the cut-in keyway, being careful not to damage the oil seal. Pour 10 cubic centimeters of SAE 10 engine oil (5 cubic centimeters for each bearing) through the open side. Do not use more oil or the oil seals will blow out. Too little oil will damage the bearings. Secure the fan and gasket to the other end of the helix with six bolts and nuts. Secure the nuts with locking wire.

b. Brush Rigging, Shield and Brushes. (1) *Disassembly.* Remove the four special bolts and elastic stop nuts securing the brush rigging, consisting of yoke, springs, brushes and brush holders, to the shield (fig. 35). Remove the brush rigging from the shield.

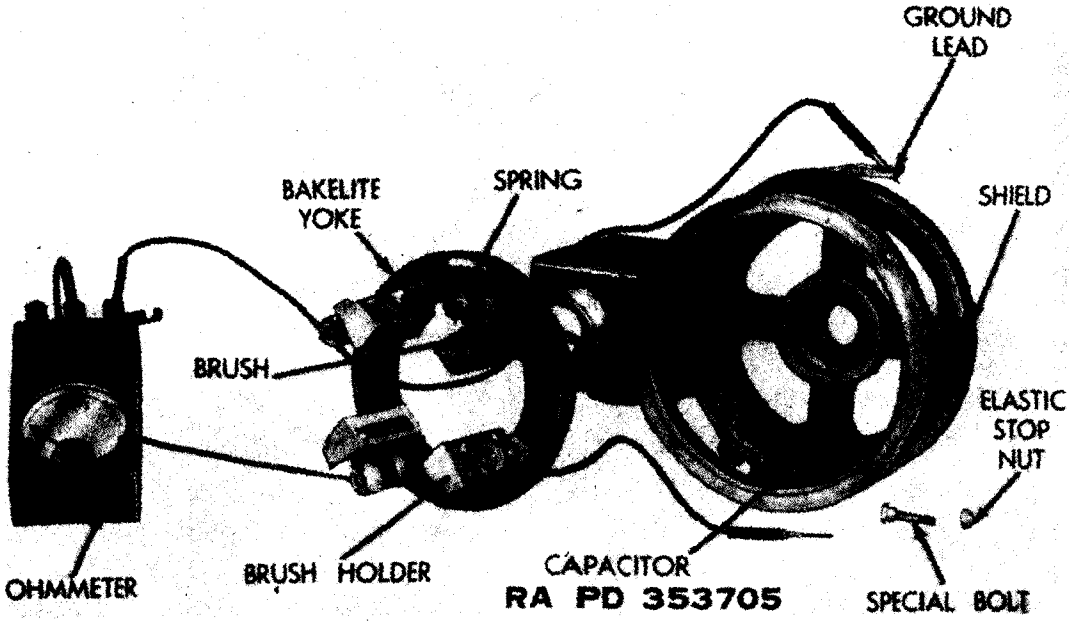

Figure 35. Testing brush rigging.

(2) *Cleaning, inspection, and repair.* Clean the shield assemblies and the brush rigging with dry-cleaning solvent and dry with compressed air. Inspect the shields for breaks, cracks, stripped threads and damaged ground lead. Test the capacitor on a condenser tester, and replace it if it is open, shorted, or leaking. Test the brush holders with a megger or ohmmeter to determine if they are well insulated from each other. Replace any damaged brush holders by removing the securing screws. Check the brush spring tension; it should be between 1 and 1.5 pounds. Measure the brushes on the long side; if worn to $\frac{1}{4}$ inch or less, if chipped or if leads are broken, replace the brushes. New brushes must be "sanded in" to the contour of the armature with No. 00 flint paper.

(3) *Assembly.* Install the brush rigging in the shield alining the white paint marks, if present, and secure with four special bolts and elastic stop nuts (fig. 35). If the paint marks are not present, set the brushes at induction neutral after assembly as outlined in paragraph 59 *c*.

c. FIELD ASSEMBLY. Clean the field assembly with dry-cleaning solvent and dry with compressed air. Inspect the assembly for obvious defects such as broken leads, breaks and stripped threads, and damaged or punctured field windings. Test the shunt field coils and commutating coils with an ohmmeter (fig 36). The shunt field must have a resistance of 4.2 ohms ±10 percent. The commutating field has practically no resistance. If the resistance of the field coils varies more than 10 percent from the values stated, replace the field assembly.

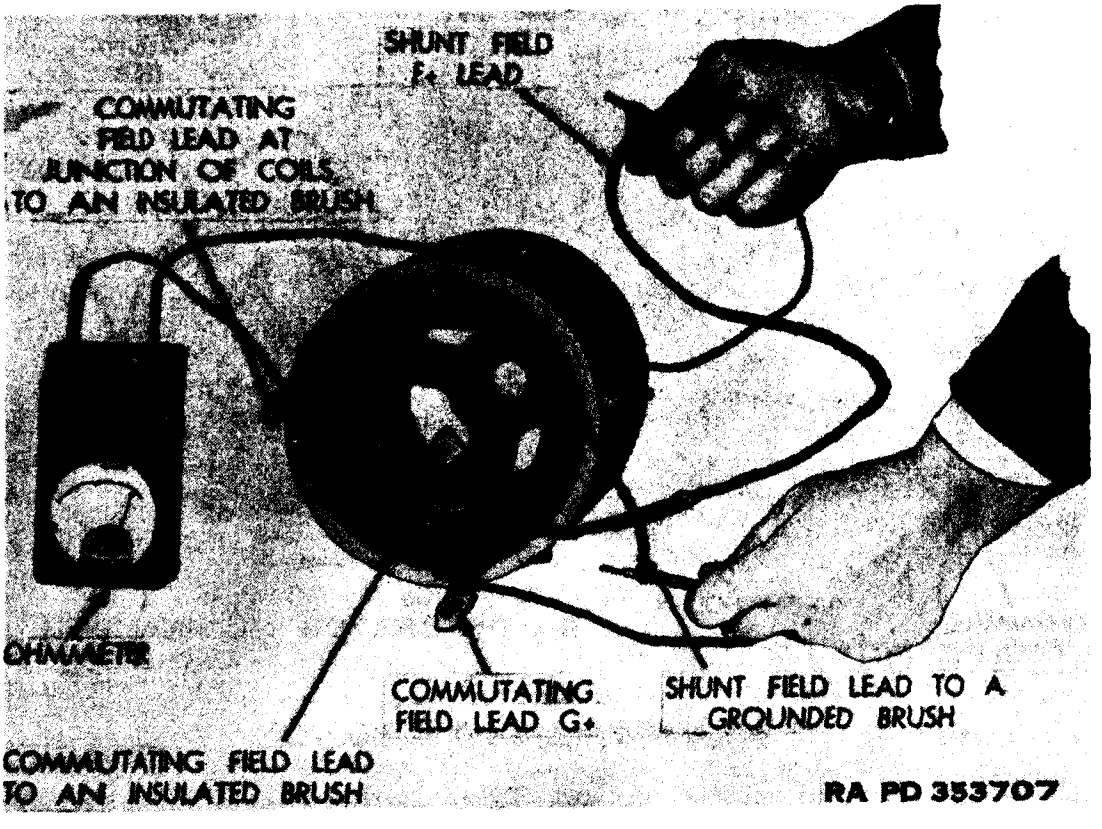

Figure 36. Testing field assembly.

d. ARMATURE. (1) *Cleaning, inspection, and repair.* Clean the armature (fig. 32) with compressed air. Inspect the commutator for scoring, thrown solder and wear. If the commutator segments are scored or worn down to the mica, turn the armature down and undercut the mica on a lathe. Resolder leads if solder is thrown or leads are loose. If the armature has been previously undercut and the diameter is less than 2.612 inches, replace the armature. The manufacturer's dimension for the armature diameter is 2.737 inches. Inspect the bearings for looseness, flat spots and side play, and, using a press, replace worn or damaged bearings.

(2) *Testing.* Test the armature on a growler for shorts, open circuits and grounds, if any such defects are indicated, replace the assembly.

49. Assembly

a. INSTALL THE END SHIELD. Place the end shield (fig. 32) on the field assembly, opposite the field leads, and secure with four hollow-head screws and internal-toothed lock washers.

Note. Before the end shield is installed, the chamber on the inside should be partially filled with special lubricating grease.

b. INSTALL THE ARMATURE. Install the armature in the field assembly being sure to hold the front bearing in alinement.

c. INSTALL THE BRUSH RIGGING AND SHIELD. Place the brush rigging and end shield over the armature shaft (fig. 32) so that the terminal box is alined with the field leads.

Note. End shield should have the chamber on the inside partially filled with special lubricating grease.

Feed the BR+, F+ and G+ leads into the terminal box. Secure the brush rigging and end shield to the field assembly with four hollow-head set screws and internal-toothed lock washers. Connect the braided G+ lead to the G+ terminal in the terminal box with a washer, nut, and internal-toothed lock washer. Where short leads are employed, connect the BR+ and F+ leads to their respective terminals with washers, internal-toothed lock washers, and nuts.

d. INSTALL THE BRUSHES. Holding the brush springs out, place a pair of brushes in each holder so that the brush springs bear against the slope of the metal brush contacts and brush slant fits the commutator. Connect each brush lead, and other leads, to the brush holders with a screw and internal-toothed lock washer according to the wiring diagram (fig. 37).

e. INSTALL THE DRIVE PULLEYS. With the Woodruff key in the end of the armature shaft, press the rear drive pulley onto the armature shaft at the commutator end (fig. 32). This pulley is marked "rear" and must drive the armature clockwise as viewed from the commutator end. Secure the pulley assembly to the armature shaft with a castellated nut and cotter pin, and a dust cover to the pulley assembly with six screws and lock washers. Install the front pulley assembly in like manner.

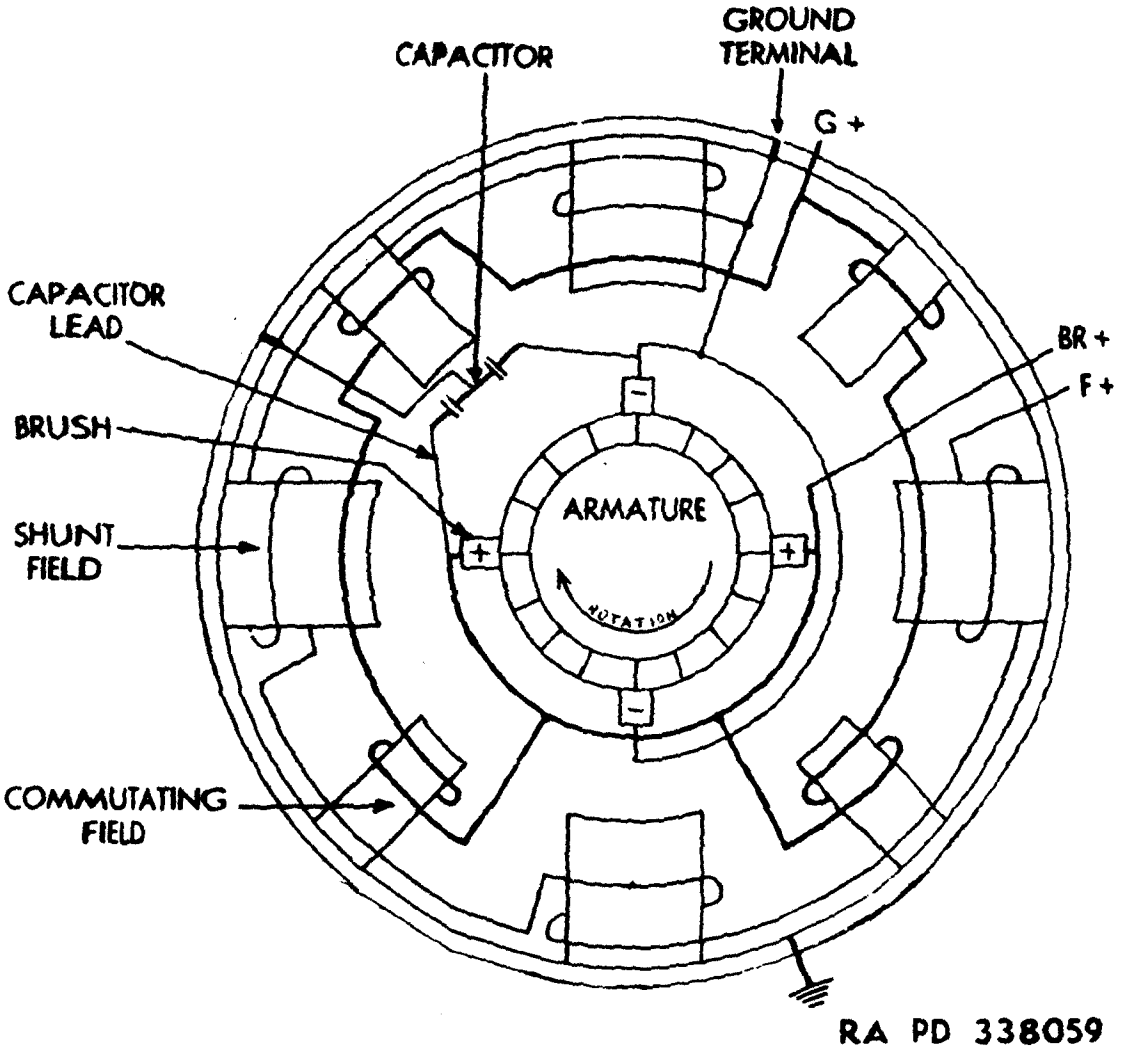

Figure 37. Brush rigging wiring diagram.

50. Testing Assembled Generator

a. Pulley Assemblies. The pulley assemblies are to be tested by running them in the free wheeling direction (opposite to normal, so that armature does not turn) at approximately 4,100 revolutions per minute for 15 minutes. At the end of this time, the temperature of the pulley assembly must not exceed 200°F. and the static drag must not exceed 2 pounds pull tangential to the bottom of the pulley groove. If either of these specifications are exceeded the pulley assembly must be overhauled.

b. Magnetism. The residual magnetism is usually lost when a generator is overhauled. Restoration of this magnetism is accomplished by following the procedure in *d* below. The test procedures outlined in *e* and *f* below are not to be used for trouble shooting, but as a check on the overhaul.

c. Set the Brushes at Induction Neutral. Disconnect the ground strap and the BR+, G+, and F+ wires so that there are no circuits to the vehicle. Disconnect the capacitor leads from the brushes and connect

a low scale voltmeter (0 to 20 millivolts) to these brushes. Connect the negative side of a 6-volt battery to the ground terminal, and the positive side of this battery to the F+ terminal through a knife switch. Close the knife switch and note that the meter needle swings on scale and back to zero. Open the switch as soon as possible. Loosen the four special brush rigging bolts and move the brush rigging slightly in either direction and take another reading on the meter. Repeat this procedure until the lowest reading is obtained. Tighten the special bolts. Make a paint mark from the shield to the bakelite brush rigging yoke for future reference.

d. MOTORIZE THE GENERATOR. Mount the generator on a generator test stand. Connect the battery negative lead to the generator frame or ground (fig. 37). Disconnect the F+ wire either at the regulator or in the generator conduit box (later models have an F+ terminal in the generator conduit box). Connect one end of a small wire to the positive side of the battery and the other end briefly to the F+ wire of the generator. Remove the small wire and reconnect the generator. If the generator runs in the reverse direction, does not run, or draws too much current, the brush rigging is probably wired wrong and the wiring must be corrected.

e. TEST THE GENERATOR. (1) *Output voltage.* Drive the generator at a speed of about 3,200 revolutions per minute with a voltmeter connected to BR+ and generator frame or ground. An output of 28 to 30 volts should be observed. If voltage is lower than specified, check the armature and overrunning clutches to see if speed is transmitted to the armature. Recheck the armature (par. 48 *d*).

(2) *Capacity.* Connect the generator and a serviceable generator regulator to a 24-volt direct current source (par. 61 *a*). Run the generator and take readings as outlined in paragraph 61 *d*. If output readings are not as specified, recheck the generator regulator and generator.

CHAPTER 10
GENERATOR REGULATOR

Section I. DESCRIPTION AND DATA

51. General

a. DESCRIPTION. The generator regulator is principally composed of three units, a regulating unit, a voltage rheostat and a reverse current cut-out relay, (fig. 38). These assemblies are mounted in an aluminum case and are protected from dust and moisture by a cover sealed with a rubber gasket. Rubber vibration dampers secure the base to the mounting bracket on top of the generator. Two models of the generator regulator are used. The earlier model is piece marked GE–3GBD1M12 and the later model is marked GE–3GBD1M13. In the early model, the terminal boxes on the generator regulator and generator, with their connection loom of cables, are on the same side of the unit as the engine carburetor; on the later model the terminal boxes are on the opposite of the unit. With the covers removed from the regulator unit, the component parts of both appear identical, except for the bus bars and lead running to opposite side as necessitated by the different location of the terminal boxes. However, among the component parts of the early and late model regulator assemblies, only the rheostats are identical, the current regulating unit and relay assemblies being designed to have different current capacities as noted in paragraph 57*b* (2) (*a*).

b. FUNCTION. The function of the generator regulator is to hold the generator voltage to 29.2 volts over the entire speed range of the generator and to prevent the battery from discharging through the generator.

c. DESIGN. The generator regulator is designed for use on tanks in conjunction with a direct current generator of 24-volt, 150-ampere output.

d. CONNECTIONS. All connections to the regulator, except the ground are made through a sealed terminal board on the side of the case (fig. 38). It is not necessary to remove the main cover for access to the terminals. It is only necessary to remove the small terminal board cover on the side.

52. Regulating Unit

a. DESCRIPTION (figs. 39 and 40). The regulating unit is mounted inside the watertight aluminum case. The regulating resistor has two

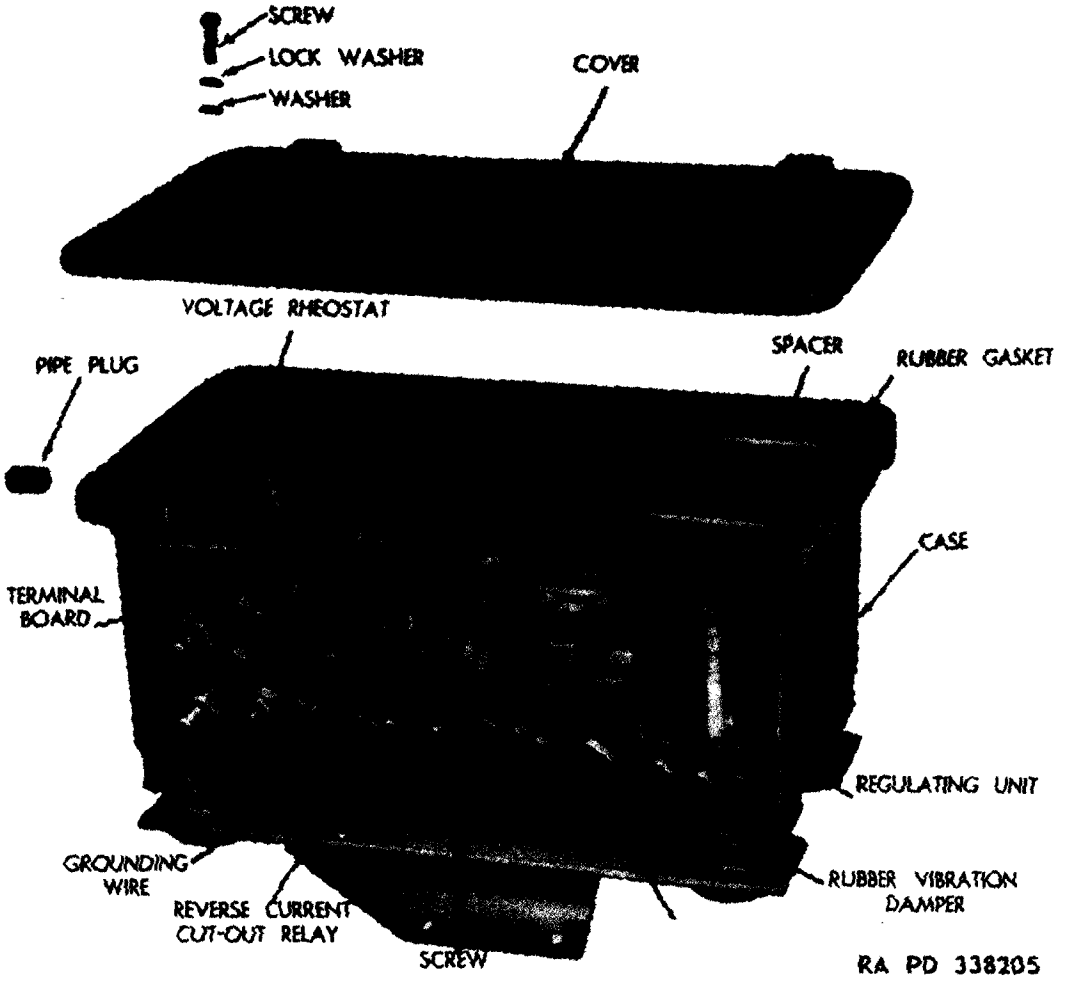

Figure 38. Generator regulator model 3GBD1M13—cut-away view.

identical sections, each section having 13 taps located in opposite rows in the embedding material. The 13 taps divide each section into 12 resistance steps. The two 7.5 ohm sections are connected in series, providing a total regulating resistance of 15 ohms. A control winding (two coils), which is energized from the generator, is located on a U-shaped core. A pivoted lever which has an armature attached to one end and a spring to the other functions as a resistance switch. Twenty-four silver-tipped contact fingers rest on a silver contact bar when the regulator is de-energized. A fiber finger lifter, attached to the armature, lifts the fingers when the armature is operated in the air gap of the magnetic circuit. A dash pot is fastened between the end of the lever and the support at the bottom, and is composed of a stationary graphite piston inside of a close fitting cylinder. This dash pot provides a damping action to all armature movements, thus providing stable operation. The voltage-adjusting nut regulates the tension of the control spring. The temperature compensator is a U shaped, bimetallic strip to which the spring is fastened. When opening or closing with temperature change, it changes the tension of the spring to maintain the proper regulated voltage over a wide temperature range.

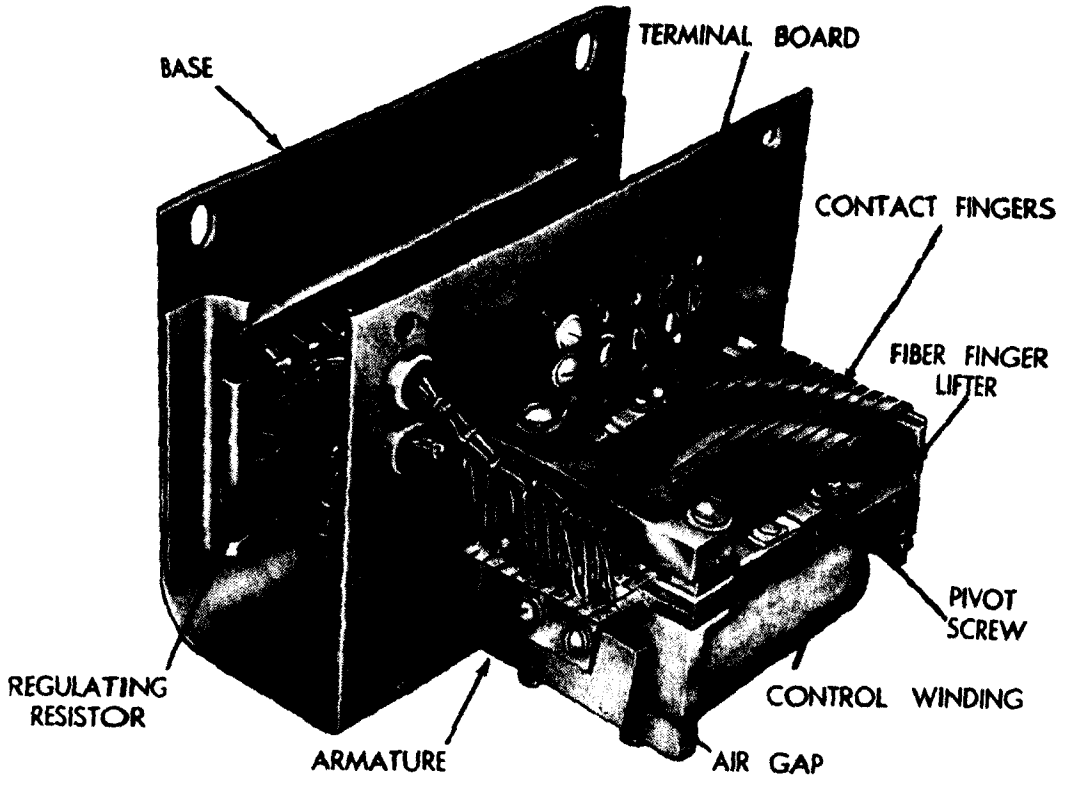

Figure 39. Regulating unit.

b. FUNCTION. The regulating unit holds the generator output voltage at 29.2 volts ±2½ percent over the speed range of the generator (3,200 to 4,500 rpm) at no load. The design and connections of the regulator are such that the voltage drops with the load approximately 0.6 volt from no load to full load.

c. OPERATION. Voltage regulation is accomplished by means of the regulating resistor (fig. 39) connected in the generator shunt field circuit, and the voltage sensitive (control winding) element connected between the generator positive brush and ground. The voltage sensitive element responds to an increase or decrease in generator voltage and causes the pivoted lever and armature (figs. 39 and 40) to move, thereby varying the regulating resistance in the generator shunt field circuit. When the generator output voltage rises, the regulator immediately inserts more resistance in the generator shunt field circuit, decreasing generator output voltage. When the generator output voltage decreases, the regulator acts to short out resistance from the generator shunt field circuit thus restoring the voltage to normal. Each contact finger is connected at its stationary end to a lug at the top of the regulating resistor. When all of the fingers rest on the silver contact bar, the regulating resistance in the generator shunt field circuit is zero. When the control winding is energized sufficiently to overcome the pull of the control spring,

the armature moves in a direction to cause the fiber finger lifter to press against and lift the contact fingers from the contact bar. When part of the fingers have been lifted, part of the resistance has been inserted in the shunt field circuit; this is the normal operating condition. When the strength of the magnetic field is such as to cause the fiber finger lifter to lift all of the fingers, the entire amount of resistance has been inserted in the shunt field circuit. When the lever moves in the other direction in response to a weaker magnetic field, the action is just the reverse, and the resistance is decreased.

53. Reverse Current Cut-Out Relay

a. DESCRIPTION (figs. 41 and 42). The reverse current cut-out relay is composed principally of a contactor assembly and a differential relay mounted on a molded plastic base. A resistance ballast (lamp) connected in series with the differential coil is mounted on top of the differential relay. The purpose of this resistance is to prevent the differential coil from overheating when full battery voltage is applied to the differential coil circuit, as when the generator is not running and the battery switch is closed. A relatively high current in the differential coil circuit increases the resistance of the filament, thus limiting the current and protecting the differential coil.

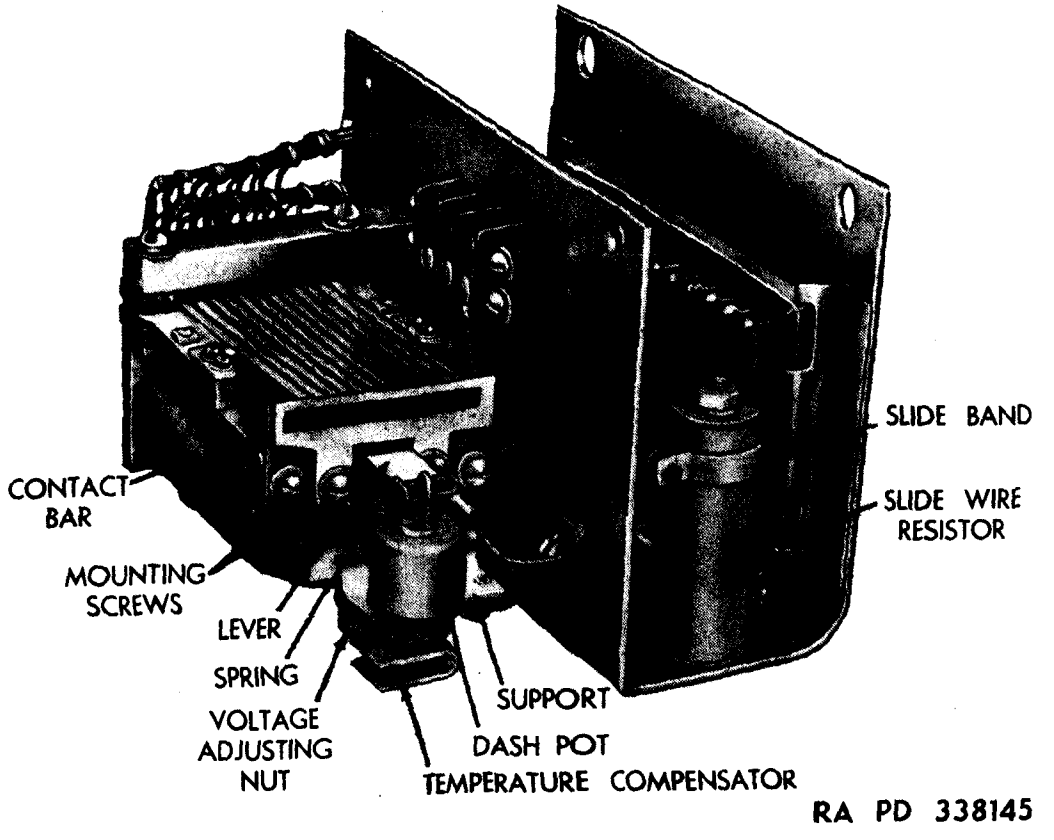

Figure 40. Regulating unit.

b. FUNCTION. The differential-type, reverse current cut-out relay acts as a switch to automatically connect the generator to the electrical system whenever the generator voltage is at least 20 volts, or is higher than the system voltage by about ½ volt. The relay disconnects the generator from the electrical system when reverse current flowing from the battery to the generator, reaches a predetermined value.

c. OPERATION. The cut-out operation is as follows:

(1) The generator comes up to speed and its voltage builds up to battery voltage.

(2) When the generator voltage across the differential coil circuit reaches approximately ½ volt above battery voltage and of the proper polarity, the differential contacts close. If the battery is not connected, the relay will close on the application of a load.

(3) The closing of the differential relay contacts applies generator voltage to the contactor coil.

(4) The contactor closes, connecting the generator to the line.

(5) If the generator slows down sufficiently to allow the reverse current to flow through the current coil, it causes a change in the polarity of the armature of the differential relay. When the reverse current reaches a value of two or three amperes, the armature flips over, opening the differential relay contacts, allowing the contactor to open and disconnect the generator from the line.

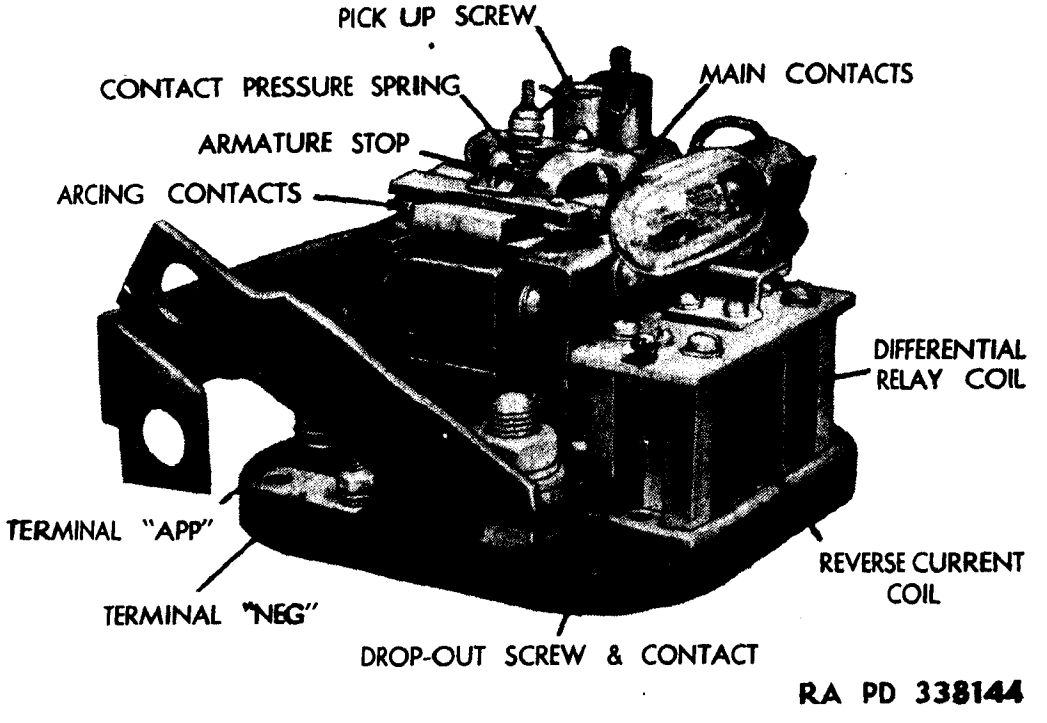

Figure 41. Reverse current cut-out relay.

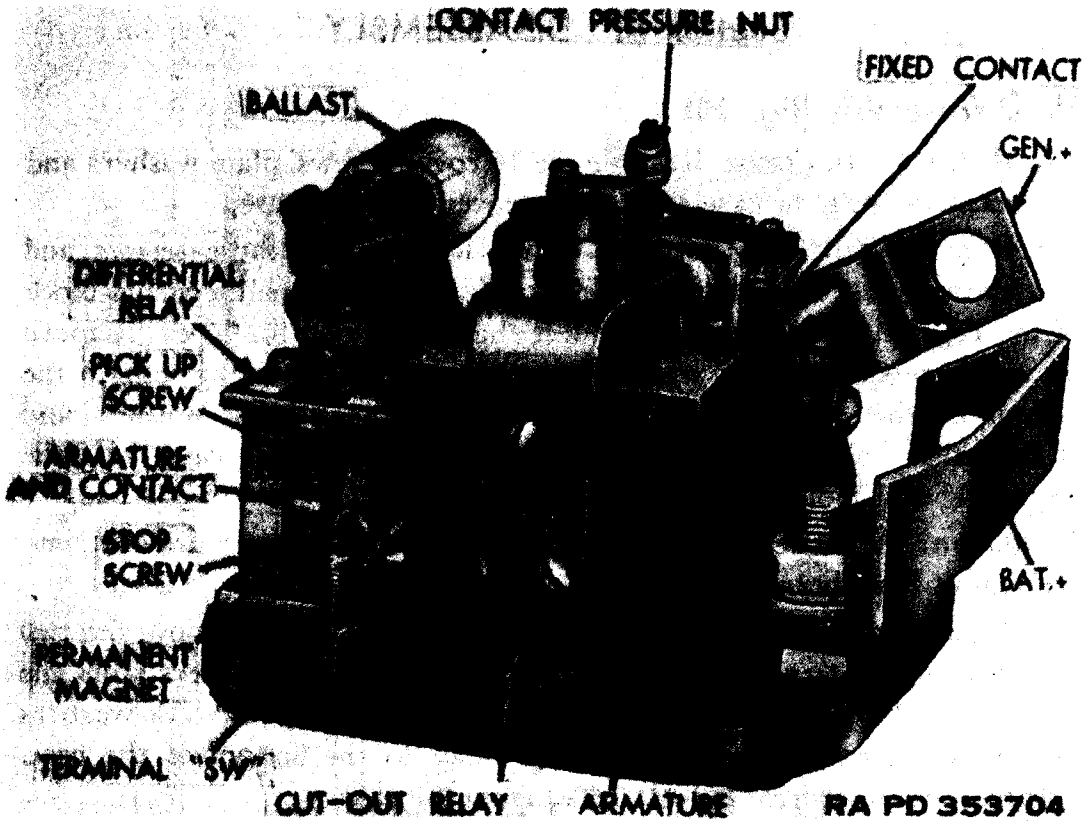

Figure 42. Reverse current cut-out relay.

54. Voltage Adjusting Rheostat

a. DESCRIPTION. The voltage adjusting rheostat is mounted at the nameplate end of the case (fig. 38). A pipe plug is provided so that adjustment of the rheostat may be made without removing the main cover. The rheostat consists of a resistance element wound on a circular form and a movable contact which slides over the element to provide adjustment.

b. FUNCTION. After the regulating unit and reverse current cut-out relay have been adjusted, the voltage rheostat may be used to make minor adjustments of the voltage as required to meet field conditions.

55. Data

Make	General Electric
Model	3GBD1M13
Voltage Input	28–30 volts direct current
Regulated voltage output	29.2 volts direct current
Length	12 in.
Width (including terminal box)	$8\frac{13}{16}$ in.
Height	5 in.
Height (including mounting bracket)	8 in.
Weight	19 lb

Section II. DISASSEMBLY

56. Disassembly (fig. 38)

a. REMOVE THE COVER. Remove the 16 cover screws, plain washers and lock washers from the case and lift the cover from the case.

b. REMOVE THE REGULATING UNIT. Remove the three screws and lock washers that connect the regulating leads to the small terminal block of the regulating unit and disconnect the leads from the block. Remove the two screws and lock washers that secure the regulating unit to the bottom of the case. Remove the two long screws, lock washers and spacers that hold the regulating unit to the end of the case. Lift the regulating unit from the case.

Caution: When setting the unit down, keep the temperature compensating unit from bearing the weight of the regulating unit.

c. REMOVE THE REVERSE CURRENT CUT-OUT RELAY. Remove the two terminal nuts, internal-toothed lock washers and plain washers from the terminal studs. Remove the four screws, plain washers and lock washers that hold the reverse current cut-out relay to the bottom of the case. Lift the reverse current cut-out relay from the case.

Section III. CLEANING, INSPECTION, REPAIR, AND ADJUSTMENT

57. Regulating Unit (figs. 39 and 40)

a. CLEANING. Clean the regulating unit with carbon tetrachloride and dry with air. A small brush is helpful in removing dust.

b. INSPECTION. (1) *Mechanical.* (*a*) *Armature movement.* With the fingers, check armature of the regulating unit to see that it is free and not binding. Check to see that the dash pot is not sticky in its movement.

(*b*) *Finger contacts.* Check to see that the tips of the silver contact fingers are clean and that the silver bar and fingers are not pitted or burned from arcing.

(*c*) *Finger sequence.* With the fingers pressing on the armature, check the lifting sequence of the silver fingers. The first fingers (both upper and lower) should start lifting from the contact bar as soon as the armature is moved inward. The remaining fingers should pick up in succession until, at the end of the armature travel, the last fingers should just barely lift from the contact bar. When the armature is returned to its normal position, all the fingers should again make contact with the contact bar. This is to utilize the maximum available travel of the armature in sequencing the fingers.

(*d*) *Overheating.* Check for signs of overheating such as burned wire insulation, charred coil coverings, cracks in resistor enamel or melted solder.

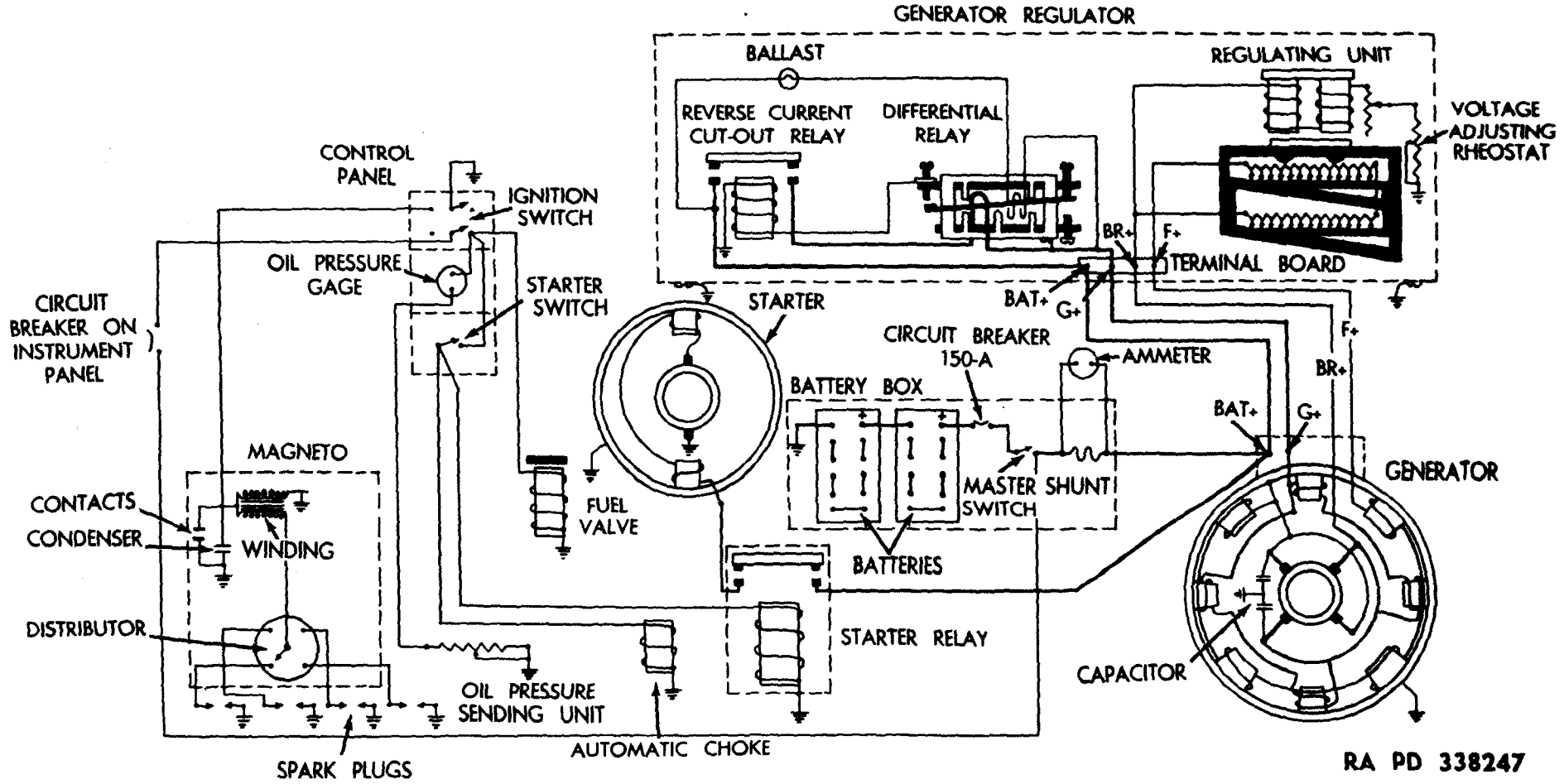

Figure 43. Wiring diagram—battery charging circuit.

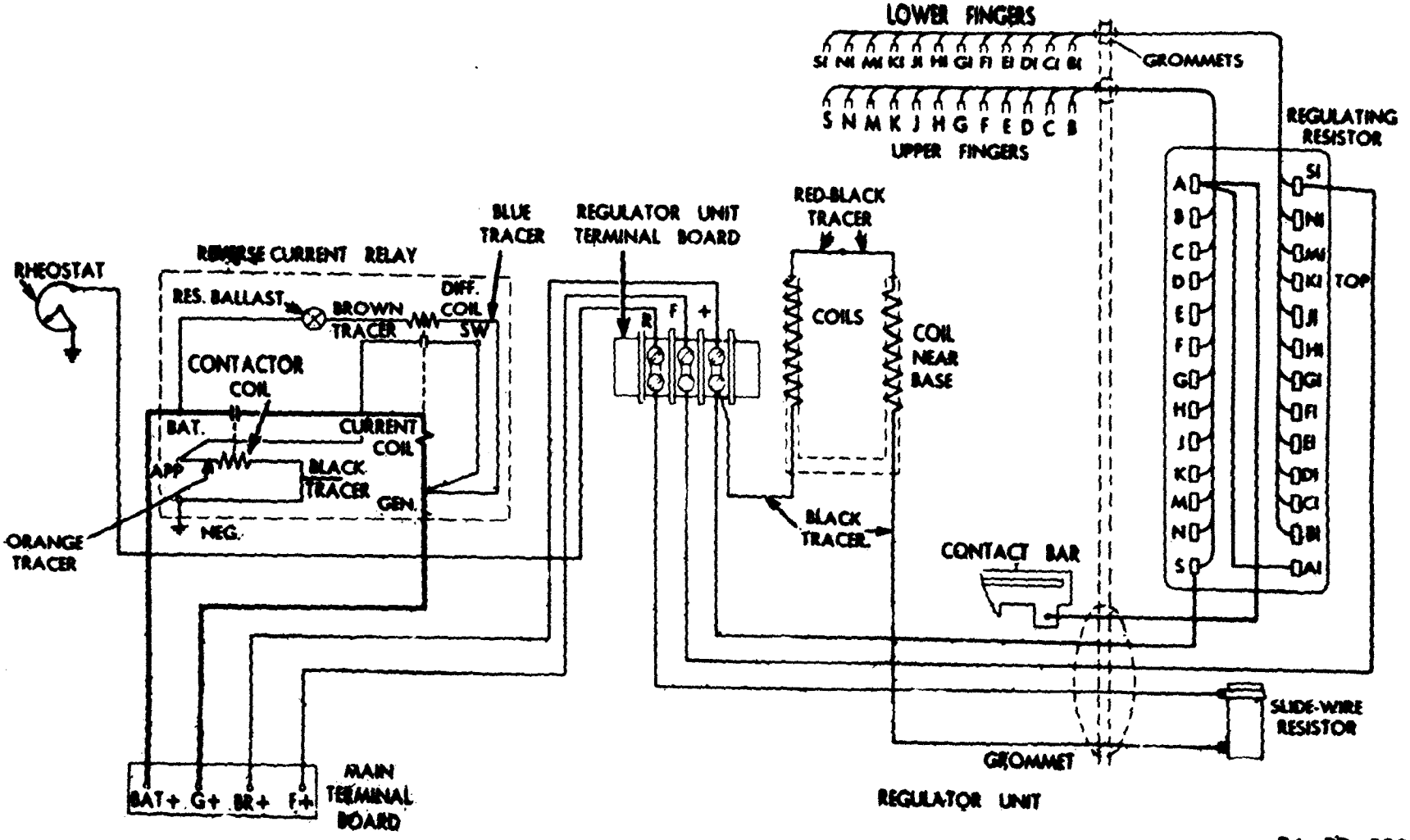

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Figure 44. Wiring diagram of generator regulator.

(2) *Electrical* (figs. 43 and 44). (*a*) *Test the regulating resistors.* Insulate both rows of contact fingers from the contact bar with a small piece of paper (inserted between the fingers and the contact bar). Measure the total resistance (F and + on the three-point terminal block). The resistance should be 15 ohms ±12 percent; however some early models have a resistance of 13.2 ohms. The individual finger resistors may be checked to isolate defects by measuring with an ohmmeter between the first and second finger of each row, the second and third finger, and so on, starting with the fingers farthest from the base. The last step of each row is measured between the twelfth finger, which is nearest the base, and the contact bar. The resistance of individual steps may vary ±20 percent from the values given in the following tables:

Individual resistor values of early model regulating units

Step	*Resistance*	*Step*	*Resistance*
1	0.2	7	0.5
2	0.2	8	0.6
3	0.3	9	0.7
4	0.3	10	0.8
5	0.4	11	1.0
6	0.4	12	1.2

Total per row of fingers is 6.6 ohms.

Individual resistor values of later model regulating units

Step	*Resistance*	*Step*	*Resistance*
1	0.2	7	0.50
2	0.2	8	0.65
3	0.3	9	0.80
4	0.3	10	1.00
5	0.4	11	1.25
6	0.4	12	1.50

Total per row of fingers is 7.5 ohms.

(*b*) *Test the slide wire resistor.* The total available resistance of the slide wire resistor is between 36 and 42 ohms. Measure the value of the resistance between the slide band and the bottom terminal of the resistor with an ohmmeter. This should be at least 27 ohms. Move the slide band toward the top of the resistor to increase the reading to at least 27 ohms.

(*c*) *Test the regulating unit coils.* Measure the total resistance of the regulating unit coils (+ to bottom of slide wire resistor) with an ohmmeter. The resistance of the coils should be between 7.0 and 7.8 ohms.

c. REPAIR. (1) *General.* Replace any parts that appear to be damaged or that cannot be readjusted or that do not meet the electrical specifications as stated in the test procedure.

(2) *Soldering.* Hard soldering is used on the regulating unit. Clean the flux from the joints after soldering.

d. ADJUSTMENTS. (1) *Mechanical* (figs. 39 and 40). (*a*) *Finger sequence.* Both the silver contact bar and the fiber finger lifter have slotted mounting holes. By loosening the mounting screws it is possible to shift

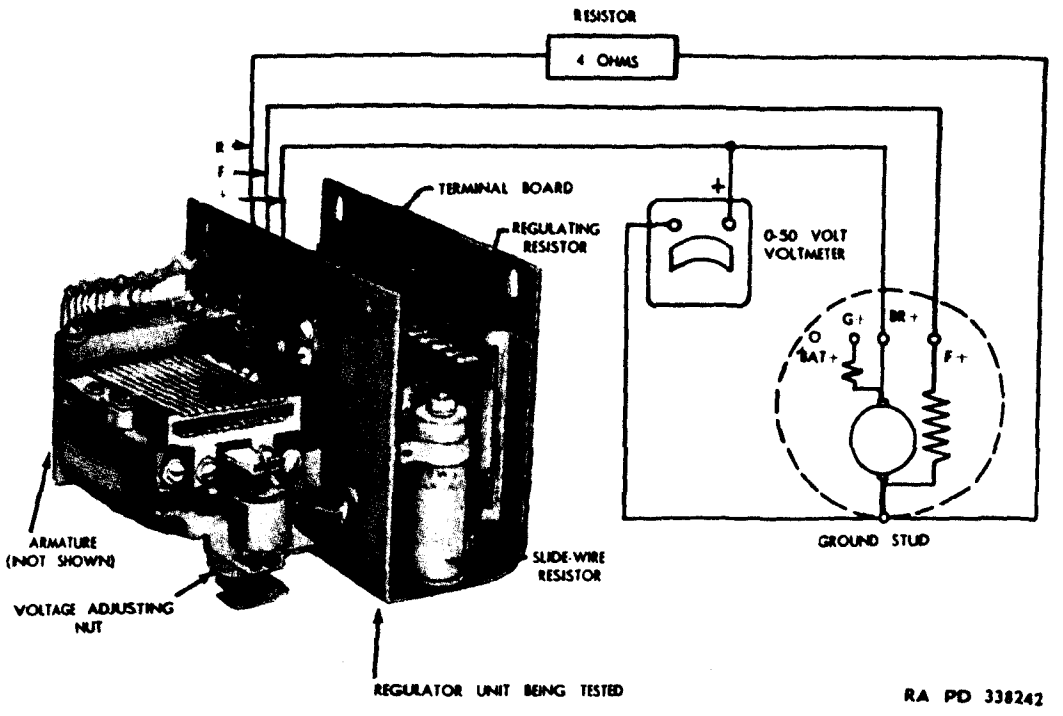

Figure 45. Wiring diagram for testing the regulating unit alone.

either the lifter section alone or both the lifter and contact bar as required. Adjust the lifter or contact bar or both by this method until the finger sequence is as described in step 57*b* (1) (*c*).

(*b*) *Armature gap.* The gap between the brass stops on the armature and the pole piece should be between 0.045 and 0.052 inch. Loosen the four pivot screws and set the air gap to 0.047 inch as measured with a round feeler gage.

(2) *Electrical* (fig. 45). (*a*) *General.* Do not allow the weight of the regulating unit to rest on the temperature compensator. Connect the regulating unit as specified in the diagram, figure 45. If after testing and adjustments are made, the unit does not function within the specified limits, replace the unit.

(*b*) *Voltage range.* Run the generator at a speed of 3,200 to 4,500 revolutions per minute. Adjust the regulating unit by means of the voltage adjusting nut located at the end of the temperature compensating spring until the voltage is about 29.2 volts. Read the voltage at several points in the speed range. The regulating unit should be adjusted until the voltage remains between 28.7 and 29.7 volts (29.2 volts ±0.5 volt). The voltage should remain the same or rise slightly with speed. A drop in voltage with increasing speed is not desirable.

(*c*) *Voltage adjustment.* If voltage decreases as speed is increased, increase the resistance of the slide wire resistor by raising the slide band, then readjust the voltage adjusting nut until the proper voltage is

obtained. Conversely, if the voltage increases excessively as speed is increased, decrease the resistance of the slide wire resistor. Final setting of the slide wire resistor should be 27 ohms or more. Do not turn the slide band or it will touch the case after installation.

(*d*) *Sluggishness.* After the regulating unit has been adjusted to regulate at 29.2 ±0.5 volt, check for sluggishness which may be caused by a sticky dash pot, misalined moving part or rubbing of parts. Check at some intermediate point of the speed range. Push the armature in by hand and release slowly; also pull the armature out and release. In either case, the regulated voltage should return to within ±0.3 volt of the original value.

(*e*) *Fluctuations.* When the voltage fluctuates continuously more than 0.2 volt, check for excessively loose dash pot or dash pot pins, poor finger contacts, poor finger sequence or wrong regulating resistance connections (producing sparking at the fingers).

58. Reverse Current Cut-Out Relay (figs. 41 and 42)

a. CLEANING. Clean the reverse current cut-out relay with carbon tetrachloride and dry with air. Be certain that there are no metal filings clinging to permanent magnets of differential relay (figs. 41 and 42).

b. INSPECTION. (1) *Mechanical.* (*a*) *Contactor assembly.*

1. *Contacts.* Inspect the main and arcing contacts for damage due to arcing.
2. *Sequence.* Move the armature down with the fingers; both arcing contacts should close, leaving a slight gap under the main contacts. Further downward movement should close both main contacts, leaving a gap of about $\frac{1}{32}$ inch between end of armature and the pole piece in order to assure a good wiping contact action and firm pressure on the main contacts.
3. *Armature bearings.* The contactor armature should move freely, but check to see that the bearings are not excessively worn. Side play (in direction of pin) should be $\frac{1}{32}$ inch or less. The up and down play (at right angles to the pin) should be $\frac{1}{64}$ inch or less.

(*b*) *Differential relay.*

1. *Armature.* Check to see that the differential relay armature moves freely to make and break the contacts. The armature should remain in either position when moved by hand, due to the permanent magnets.
2. *Contacts.* Inspect differential relay contacts to see that they are not pitted or burned and that alinement is correct.

(*c*) *Ballast.* Inspect resistance ballast (lamp) to see that filament is not badly sagging or misshapen from excessive heat. The filament must not be broken. Discoloration of the glass is not objectionable.

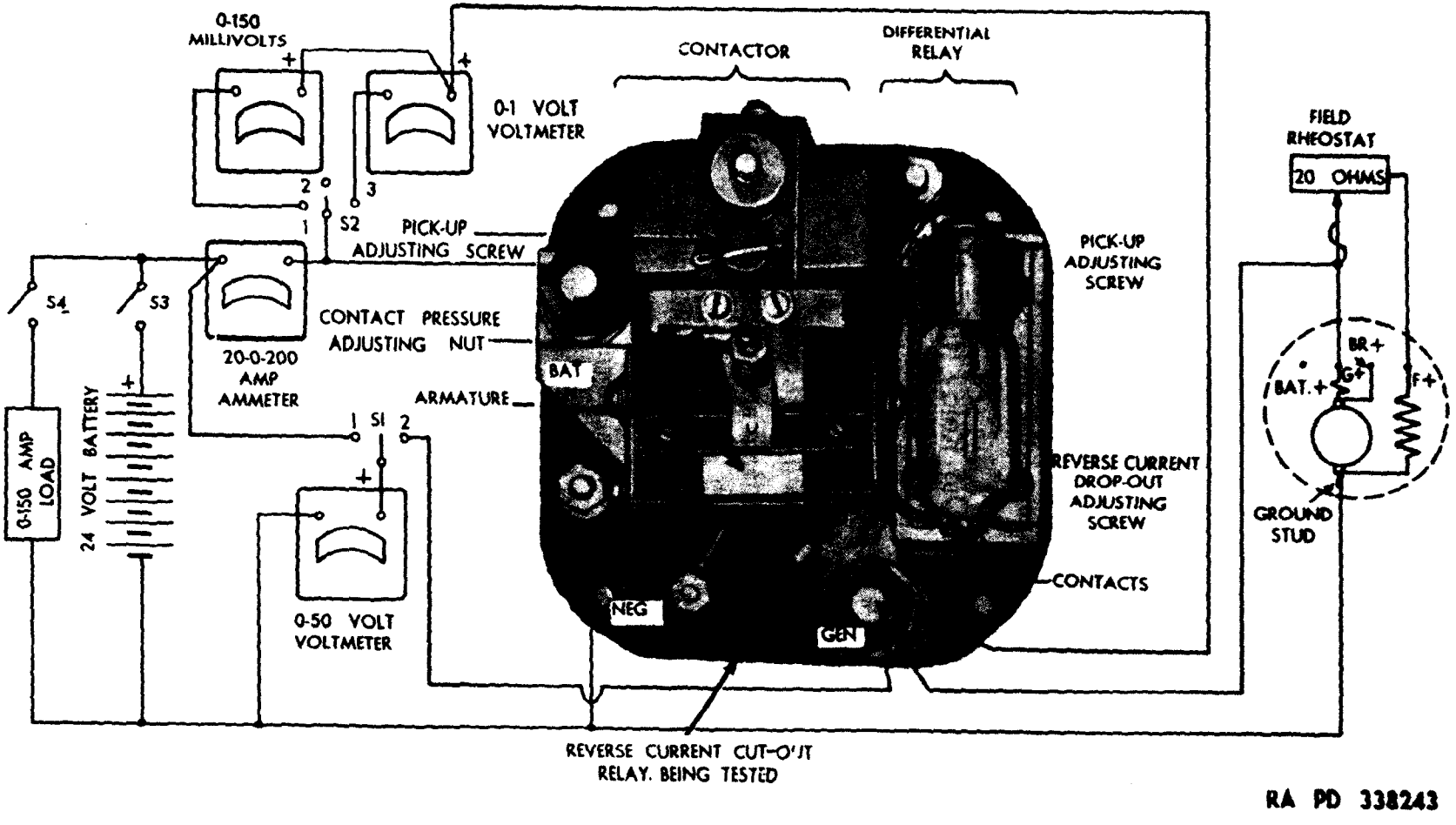

Figure 46. Wiring diagram for testing the reverse current cut-out relay alone.

(*d*) *Relays.* Check the relays for signs of overheating such as charred coil coverings and burned insulation.

(2) *Electrical* (figs. 43 and 44). (*a*) *Contactor coil.* Measure the resistance of the contactor coil (APP and NEG) with an ohmmeter. The resistance should be less than 80 and more than 72 ohms.

(*b*) *Differential coil.* Disconnect the blue-covered lead of the differential coil from the generator side of the contactor. Using an ohmmeter, measure the resistance between this lead and the lamp lead having a brown tracer. The resistance should be between 11.0 and 12.2 ohms.

(*c*) *Ballast.* Disconnect the two leads from the base of the ballast (lamp). Connect the lamp in series with a storage battery and an ammeter so as to apply two volts to the circuit. The current draw of the ballast should be between 0.4 and 0.5 ampere. Due to varying resistance of the filament when hot, a resistance test is not reliable.

c. REPAIR. Replace any parts that appear to be damaged or that cannot be readjusted or that do not meet the electrical specifications as stated in the test procedure.

d. ADJUSTMENTS. (1) *Mechanical* (figs. 41 and 42). The arcing contacts should touch the fixed contacts when the gap between the end of the armature and the pole piece is 0.057 to 0.068 inch as measured with a round feeler gage at a point $\frac{1}{16}$ inch from the edge. The main contacts should touch the fixed contacts at 0.032 to 0.043 inch. If the contact gaps are not within these specifications, free the contact with a large soldering iron and turn contact with a screwdriver until proper gap is obtained.

(2) *Electrical* (fig. 46). (*a*) *General.* Connect the reverse current cut-out relay as specified in the diagram, figure 46. If, after testing and adjustments are made, the unit does not function within the specified limits, replace the unit.

(*b*) *Contactor pick-up and drop-out.* Place switch S1 in position 2, switch S2 in position 2, and leave switches S3 and S4 open. Close the differential relay contacts by hand by moving the armature upward. Start the generator and increase the output until the contactor picks up. Adjust the pick-up adjusting screw until the contactor picks up at 19 volts (18–20 volts), then fasten the screw with a cotter pin. Reduce the generator output until the contactor drops out. This should occur between 2 and 7 volts.

(*c*) *Contactor seal-in.* Place switch S1 in position 2, switch S2 in position 2 and leave switches S3 and S4 open. Adjust the generator output to 1½ volts below the pick-up value and tap the armature lightly. If the armature seals in, adjust the contact pressure adjusting nut so that the armature will not seal in at this setting but will seal in at 1 volt below the pick-up value.

(*d*) *Voltage drop across contacts.* Increase the generator speed until the contactor picks up. Close switch S4 and apply a load of 150 amperes.

Close switch S2 in position 1 and read the voltage drop, reopen switch S2 and then remove the load and slow the generator. The voltage drop should not exceed 120 millivolts at 150 amperes and proportionately less for lower loads. If the millivolt drop is excessive, clean the contacts with a clean, dry cloth or a fine file, and see if more contact pressure is possible in the adjustment for the seal-in as explained in step (2) (*c*) above. If there is any doubt concerning the voltage drop, measure the drop directly at the copper bars of the relay. In this case the drop should not exceed 100 millivolts at 150 amperes.

(*e*) *Differential relay pick-up.* Place switch S2 in position 2, open switch S4, open the differential contacts and close switch S3. Increase the generator output to 1 volt below the battery voltage. This is measured with switch S1 in position 1 and 2 (50-volt scale).

Note. Be sure that the battery and generator voltages are within 1 volt of each other before closing switch S2 to avoid damage to the voltmeter (0–1 volt scale).

Close switch S2 in position 3 and slowly increase the generator output until the relay picks up. Read the voltage on the zero-to-one volt voltmeter. Open switch S2. Adjust the pick-up adjusting screw, located over the armature of the differential coil and at the opposite end from the contacts, until the relay picks up at 0.5 volt. Turn the screw clockwise to lower the voltage.

(*f*) *Differential relay drop-out.* Close switch S1 in position 2. Decrease the generator output until the reverse current flows from the battery to the generator. Adjust the drop-out adjusting screw until the relay opens at the value given in the following table for the generator voltage at which the relay opens:

Generator Voltage (Volts)	*Reverse Current Drop-out (Amperes)*
23	3.25
24	3.00
25	2.75
26	2.50
27	2.25

The drop-out adjusting screw is located at the same end of the armature as the contacts.

(*g*) *Stop screw adjustment.* Adjust the stop screw from beneath the differential relay so that when the contacts are tightly closed, the clearance between the stop screw and the armature is 0.003 inch.

59. Case and Voltage Rheostat (fig. 38)

a. CLEANING. Clean the voltage adjusting rheostat and the case and cover with carbon tetrachloride and dry with compressed air. Remove any loose paint by scraping.

b. INSPECTION. (1) *Mechanical.* Examine the case and cover for breaks, cracks, and other obvious defects. Check to see that the grounding

wires from the bottom of the case to the mounting bracket are tight. Inspect for stripped threads. Turn the movable arm of the voltage adjusting rheostat to see that it is free and that the resistance element is not worn thin.

(2) *Electrical* (fig. 44). Turn the movable arm to the extreme counterclockwise position. Measure the total resistance with an ohmmeter. The resistance should be between 7.2 and 8.8 ohms.

c. REPAIR. Replace any parts that appear to be damaged or that do not meet the electrical specifications.

d. ADJUSTMENTS. Adjust the voltage adjusting rheostat so that the resistance, measured from the lead to the case, is 4 ohms. This is accomplished by sliding the contact over the resistance element until the proper setting is found.

Section IV. ASSEMBLY

60. Assembly (fig. 38)

a. INSTALL THE REVERSE CURRENT CUT-OUT RELAY. Secure the reverse current cut-out relay to the bottom of the case with four screws, washers and lock washers. Connect the heavy busses to the terminals with two nuts, washers and internal-toothed lock washers.

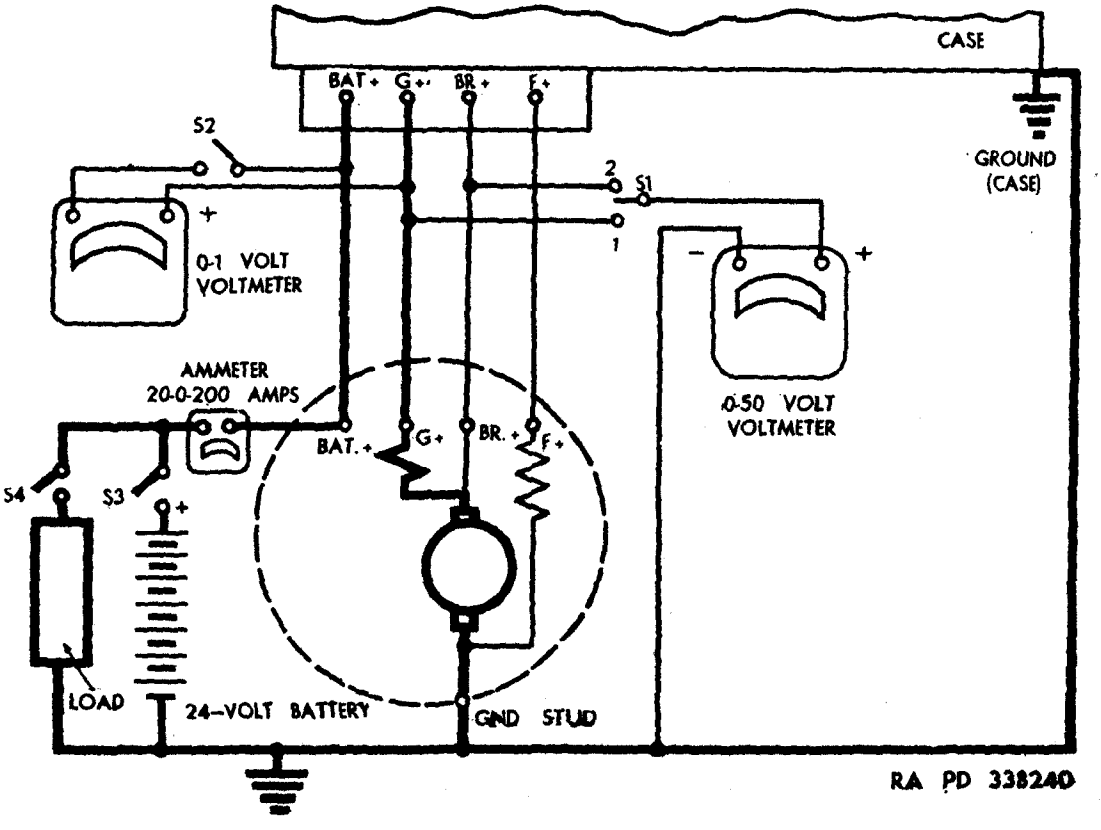

Figure 47. Wiring diagram for testing the complete generator regulator.

b. INSTALL THE REGULATING UNIT. Install the regulating unit in the case and secure with two spacers, long screws and lock washers to the end of the case. Secure the unit to the bottom of the case with two screws and lock washers. Connect the three-wire lead from the rheostat and terminals to the three-point terminal block.

c. INSTALL THE COVER. Place the cover on the case and secure with 16 screws, washers and lock washers.

Section V. TESTING RECONDITIONED GENERATOR REGULATOR

61. Testing Generator Regulator (fig. 47)

a. CONNECTIONS. Connect the generator regulator to the generator according to the diagram, figure 47. If any of the readings are not within the prescribed limits, refer to previous overhaul paragraphs and make the necessary corrections or adjustments.

b. RELAY PICK-UP. Increase the generator output until the output is about 1 volt lower than the battery voltage. Close switches S3 and S2. Increase the generator output slowly and read the differential voltage on the low scale voltmeter. When the differential voltage drops to zero the generator voltage should exceed the battery voltage by 0.3 to 0.7 volt. Open switch S2.

c. RELAY DROP-OUT. Reduce the speed of the generator until reverse current starts to flow from the battery to the generator. When the current reaches the value in the following table, for the generator voltage at which the relay opens, the reverse current cut-out relay should open:

Generator Voltage (*Volts*)	*Reverse Current* (*Amperes*)
23	2.75–3.75
24	2.50–3.50
25	2.25–3.25
26	2.00–3.00
27	1.75–2.75

d. REGULATED VOLTAGE. Open switches S2 and S4. Close switch S1 in position 2. Increase the generator speed to 3,200 revolutions per minute and read the voltage. Increase the generator speed and note the voltage at various speeds; all voltage readings should be between 28.5 and 30.0 volts. The voltage may rise slightly as the speed is increased, but must not drop off. By closing switch S1 in positions 1 or 2, check the voltage at BR+ and G+ at no load; the voltage should be the same. Measure these voltages with a load of 150 amperes. The voltage at BR+ should be the same as at no load but at G+ the voltage should be lower. With a load of 150 amperes the voltage difference should be between 0.60–0.70 volt.

CHAPTER 11
SERVICEABILITY STANDARDS

62. Engine

a. CYLINDERS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Normal bore	2.5010 to 2.5025	0.008
Base rebuild		0.004
Out-of-round		0.004
Base rebuild		0.002
Taper		0.008
Base rebuild		0.004

Note 1. Standard size available only.

Note 2. Cylinder will have a fine smooth (original) finish.

Note 3. Test block with hot (110°) water backed up with 75 lb air pressure.

b. MAIN BEARING BORES, CAPS AND BEARINGS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Two deep grooved annular ball bearings are used. Check condition.		

c. CRANKSHAFT.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Main bearing journals	1.3782 to 1.3787	(*)
Connecting rod journals	1.562 to 1.563	0.002
(1) Authorized undersizes	None	
(2) Allowable out-of-round		0.0015
Straighten if runout is more than		0.003
Runout of flywheel mounting face		0.002
Runout of flywheel face		0.003

Note 1. Crankshaft is Steel, forged.

Note 2. Balance crankshaft with flywheel and pulley to 0.4″ ounces.

d. TIMING GEARS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Total blacklash of camshaft gear	0.002 to 0.0105	0.010

Note 1. Check gears for wear and defects.

* Wear limit is not required.

e. CAMSHAFT.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Diameter of journals:		
(1) No. 1 journal	1.248 to 1.249	0.003
(2) No. 2 journal	1.248 to 1.249	0.003
(3) No. 3 journal	1.248 to 1.249	0.003
Allowable runout of center journal or nearest center, when journals are supported		0.003
Permissible wear of lobes from heel to toe		0.020
Dimensions of lobes from heel to toe	0.999 to 0.975	0.020

f. CAMSHAFT BUSHINGS AND BEARINGS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Nominal dimension and maximum wear:		
(1) Bearing—front	1.250 to 1.2505	0.005
(2) Bearing—center	1.250 to 1.2505	0.005
(3) Bearing—rear	1.250 to 1.2505	0.005
Clearance between camshaft journal and bushings	0.0010 to 0.0025	0.002
Replacement bushing (semi-finish) (nominal diameter)	1.225 to 1.227	(*)
Interference O.D. bushing to I.D. of case	0.004	(*)
End play of camshaft when installed	0.002 to 0.003	0.006

Note 1. If replacing of the camshaft thrust plate does not correct end play to 0.003 or less, replace camshaft.

g. TAPPET GUIDE (OR BUSHING).

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Nominal dimension and maximum wear	0.8125 to 0.8135	0.002
Clearance, tappet to bushing	0.0005 to 0.0020	0.004
Diameter of tappet	0.8115 to 0.8120	0.002

h. VALVE SEATS (INSERTS).

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
(1) Exhaust valve seat:		
(*a*) Interference O.D. of insert to I.D. of bore	0.004 to 0.0045	(*)
(*b*) Clearance between tappet and valve	0.013	(*)

Note 1. After engine run-in has been completed, set to 0.011 (cold).

* Wear limit is not required.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
(*c*) Width of valve seat	$\frac{3}{64}$ to $\frac{1}{16}$ inch	(*)
(*d*) Angle of seat	45°	(*)
(*e*) Angle of relief (for narrowing width of seat)	1°	(*)
(2) Intake valve seat:		
(*a*) Interference O.D. of insert to I.D. of bore	0.0035 to 0.005	(*)
(*b*) Clearance between tappet and valve	0.009	(*)
Note 1 After engine run-in has been completed, set to 0.007 (cold).		
(*c*) Width of valve seat	$\frac{3}{64}$ to $\frac{1}{16}$ inch	(*)
(*d*) Angle of seat	45°	(*)
(*e*) Angle of relief (for narrowing width of seat)	1°	(*)

i. VALVE GUIDES.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
(1) Exhaust:		
(*a*) Nominal dimension of bore and maximum wear	0.311 to 0.312	0.003
(*b*) Interference O.D. of valve guide bushing to I.D. of bore	0.002 to 0.004	(*)
(2) Intake:		
Nominal dimensions of bore and maximum wear	0.311 to 0.312	0.002

j. VALVES.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
(1) Intake:		
(*a*) Angle of seat	45°–30′	(*)
(*b*) Stem diameter	0.310 to 0.311	0.002
(*c*) Stem to guide clearance	0.001 to 0.003	0.002
Note 1. After refacing valve, if thickness from top of head to the edge of refaced outer circle is less than $\frac{1}{64}$", replace.		
Note 2. Replace if diameter of stem is less than 0.308.		
(2) Exhaust:		
(*a*) Angle of seat	45°–30′	(*)
(*b*) Stem diameter	0.310 to 0.311	0.003
(*c*) Stem to guide clearance	0.001 to 0.003	0.003
Note 1. After refacing valve, if thickness from top of head to the edge of refaced outer circle is less than $\frac{1}{64}$", replace.		
Note 2. Replace if diameter of stem is less than 0.307.		

* Wear limit is not required.

k. VALVE SPRINGS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Free length	1 1/32 inch	(*)
Compress to	1 inch	(*)
Pressure	29 to 30 lbs.	(*)

Note 1. Same valve spring used for both intake and exhaust.

l. CONNECTING ROD.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Torque tightness of connecting rod bolts	0.375 to 0.400 inch	(*)
I.D. of large (crankshaft) end	1.6680 to 1.6685	(*)
I.D. of connecting rod bearing	1.5635 to 1.5645	0.0015
Thickness of connecting rod bearing —standard	0.05225	0.0015
Clearance connecting rod bearing to crankshaft	0.0005 to 0.0025	0.003
Side clearance of connecting rod bearing to crankshaft	0.006 to 0.010	0.006 (sum of both sides)
Fit of piston pin to piston pin bushing	0.0005	0.001
Allowable twist of connecting rod		(Must be free from twist)

m. PISTONS.

Point of Measurement	*Dimensions of New Parts*		*Wear Limits*
(1) Diameters of piston skirts (standard size available only):	Top of Skirt	Bottom of Skirt	
(*a*) Size A	2.4980	2.4975	(*)
(*b*) Size B	2.4985	2.4980	(*)
(*c*) Size C	2.4990	2.4985	(*)
(*d*) Size D	2.4995	2.4990	(*)
(2) Allowable wear from nominal diameter of skirt			0.002
(3) Width of ring groove:			
(*a*) Groove No. 1 (top)	0.1255 to 0.1265		0 002
(*b*) Groove No. 2	0.125 to 0.126		0.001
(*c*) Groove No. 3	0.156 to 0.157		0.001
(4) Piston pin diameters (standard)	0.6246 to 0.6248		0.001
(5) Piston pin bore diameter in piston	0.6245 to 0.6248		(*)
(6) Clearance, piston to bore	0.003 to 0.0035		0.010
Base rebuild			0.005

* Wear limit is not required.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
(7) Piston pin bushing:		
(*a*) Inside diameter	0.6140 to 0.6160	(*)
(*b*) Outside diameter	0.6810 to 0.6820	(*)
(*c*) Finish ream inside	0.6250 to 0.6253	0.0015

n. RINGS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Gap clearance (when fitted in cylinder)	0.007 to 0.015	(*)
Clearance of ring in groove of piston:		
(1) Groove No. 1	0.0015 to 0.0025	0.002
(2) Groove No. 2	0.0015 to 0.0025	0.002
(3) Groove No. 3	0.0015 to 0.0025	0.002

o. FACE OF CYLINDER HEAD.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Maximum allowable warpage per foot of length		0.005

Note 1. Surface grind not more than 0.010 from original surface to correct warpage or roughness.

Note 2. Check for channeling and check all tapped holes.

Permissible amount of channeling before refacing		0.002
Thickness from gasket surface to cylinder head nut bearing surface	1.5625	(*)
Surface grind to not less than	1.5525	(*)

p. BOTTOM AND TOP FACE OF BLOCK.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Maximum allowable warpage per foot of length		0.005

q. OIL PUMP, GEAR TYPE.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Output of pump 5 gal/min at 100 rpm at 3 lb/sq in:		
(1) Pump body bore diameter	1.7476 to 1.7480	0.002
(2) Pump body bore depth dimensions	0.561 to 0.563	0.002
(3) Shaft diameter	0.4990 to 0.4995	0.003
(4) Blade length	½ inch	0.002
(5) Blade width	0.562 to 0.564	0.002
(6) Blade thickness	0.119 to 0.122	0.002
(7) Blade slot in pump shaft	0.124 to 0.127	0.003

Note 1. Spring tension is not critical.

* Wear limit is not required.

r. FLYWHEEL AND RING GEAR.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Runout of ring gear (total indicator reading)		0.012
Interference of I.D. of ring gear to O.D. of flywheel	0.011 to 0.019	(*)

s. STARTING MOTOR: DELCO-REMY MODEL 1108566.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Length of brushes	5/8 in.	1/16 in.
Spring tension of brushes	24 oz to 28 oz	22 oz.
Diameter of commutator	1.671 to 1.687	(*)
Maximum permissible wear or amount to be turned down		0.125
End play	0.005 to 0.050	0.010
Shaft diameter (*both ends*)	0.5595 to 0.5605	0.002
Bushing I.D. (commutator end)	0.5625 to 0.5635	0.006
Bushing I.D. (drive end)	0.562 to 0.564	0.004
Commutator (runout)	0.005	(*)

63. Governor and Water Pump

a. SHIFTER SHAFT.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Diameter	0.3745 to 0.3750	0.005

b. MAIN SHAFT.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Diameter	0.4370 to 0.4380	0.005

c. NEEDLE BEARINGS.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Internal diameter	0.3750	0.005

d. MAIN SHAFT CENTER BUSHING.

Point of Measurement	*Dimensions of New Parts*	*Wear Limits*
Inside diameter	0.4390 to 0.4395	0.003

* Wear limit is not required.

APPENDIX
REFERENCES

1. Publications Indexes

The following publications indexes should be consulted frequently for latest changes or revisions of reference given in this section and for new publications relating to matériel covered in this manual:

a. Ordnance Supply Catalog Index ..... ORD 2
b. Ordnance Major Items and Combinations, and Pertinent Publications ..... SB 9–1
c. List and Index of War Department Publications ..... FM 21–6
d. List of War Department Films, Film Strips and Recognition Film Slides ..... FM 21–7
e. Military Training Aids ..... FM 21–8

2. Standard Nomenclature Lists

a. MATÉRIEL.

Tanks, medium, M26, M45, and T26E4 ..... ORD 9 SNL G–226

b. MAINTENANCE.

Cleaning, preserving, and lubricating materials; recoil fluids, special oils, and miscellaneous items... ORD 3 SNL K–1
General tools and supplies for ordnance base armored vehicle maintenance company ..... ORD 10 SNL N–317
General tools and supplies, ordnance base automotive maintenance company (engine rebuild) ..... ORD 10 SNL N–327
Soldering, brazing, and welding material; gases and related items ..... ORD 5 SNL K–2
Tools and supplies for ordnance base armament maintenance battalion ..... ORD 10 SNL N–315
Tools and supplies for ordnance base automotive maintenance battalion ..... ORD 10 SNL N–325
Tools and supplies for ordnance heavy automotive maintenance company ..... ORD 10 SNL N–197
Tool sets (common) specialists and organizational ..... ORD 6 SNL G–27, Section 2
Tool sets (special) motor vehicles ..... ORD 6 SNL G–27, Section 1

Antifriction bearings and related items .....ORD 5 SNL H-12
Oil seals .....ORD 5 SNL H-13

3. Explanatory Publications

a. Fundamental Principles.

Automotive electricity .....TM 10-580
Basic maintenance manual .....TM 38-650
Dictionary of United States Army terms .....TM 20-205
Drivers manual .....TM 21-305
Driver training, half-track and full track vehicles .....TM 21-301
Electrical fundamentals .....TM 1-455
Military motor vehicles .....AR 850-15
Ordnance service in the field .....FM 9-5
Precautions in handling gasoline .....AR 850-20
Standard military motor vehicles .....TM 9-2800
Storage batteries—lead-acid type .....TM 9-2857

b. Maintenance and Repair.

Cleaning, preserving, sealing, lubricating and related materials issued for ordnance matériel .....TM 9-850
Instruction guide care and maintenance of ball and roller bearings .....TM 37-265
Instruction guide: Welding—theory and application.....TM 9-2852
Maintenance and care of hand tools .....TM 9-867
Maintenance and care of pneumatic tires and rubber treads .....TM 31-200
Motor vehicle inspection and preventive maintenance services .....TM 37-2810
Ordnance maintenance: Azimuth indicators, M20 and M21 for tanks and gun motor carriages .....TM 9-1731D
Ordnance maintenance: Carburetors (Stromberg) .....TM 9-1826B
Ordnance maintenance: Carburetors (Zenith) .....TM 9-1826C
Ordnance maintenance: Electrical equipment (Delco-Remy) .....TM 9-1825A
Ordnance maintenance: Electrical equipment (Autolite) .....TM 9-1825B
Ordnance maintenance: Ford tank engine (GAA-V8, GAF, GAN) .....TM 9-1731B
Ordnance maintenance: Fuel pumps .....TM 9-1828A
Ordnance maintenance: Medium tank M26—Tracks, suspension, hull and turret .....TM 9-1735B
Ordnance maintenance: Hydraulic traversing mechanism (oil gear) for medium tanks M4 and Modifications...TM 9-1731G
Ordnance maintenance: Speedometers, tachometers and recorders .....TM 9-1829A

Ordnance maintenance: Vehicle maintenance equipment:
Grinding, boring, valve reseating machines and lathes..TM 9–1834A

c. Operation of Matériel.

Medium tanks M26 and M45 .....TM 9–735

d. Protection of Matériel.

Camouflage, basic principles .....FM 5–20
Chemical decontamination company .....FM 3–70
Decontamination .....TM 3–220
Decontamination of armored force vehicles .....FM 17–59
Defense against chemical attack .....FM 21–40
Explosives and demolitions .....FM 5–25
Military chemistry and chemical agents .....TM 3–215
Ordnance maintenance: Fire extinguishers .....TM 9–1799

e. Storage and Shipment.

Ordnance company depot .....FM 9–25
Ordnance packaging and shipping .....TM 9–2854
Ordnance storage and shipment chart, group G—Major items .....SB 9–OSSC–G
Preparation of unboxed ordnance matériel for shipment...SB 9–4
Protection of ordnance matériel in open storage .....SB 9–47
Registration of motor vehicles .....AR 850–10
Rules governing the loading of mechanized and motorized army equipment, also major caliber guns, for the United States Army and Navy, on open top equipment published by Operations and Maintenance Department of Association of American Railroads
Storage of motor vehicle equipment .....AR 850–15

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