TM 9-1731B

WAR DEPARTMENT TECHNICAL MANUAL

See Sig C 3B

ORDNANCE MAINTENANCE

FORD TANK ENGINES

(MODELS GAA, GAF, AND GAN)

WAR DEPARTMENT • *4 JUNE 1945*

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TM 9-1731B

This TM supersedes TM 9-1731B, dated 15 Jul 43; OFSTB 1731B-1, dated 24 Nov 43; WDTB 9-1731B-2, dated 6 Jan 44; and WDTB 9-1731B-3, dated 18 Mar 44. This TM, together with TM 9-1825B, dated 20 Jan 44; TM 9-1826B, dated 1 Apr 44; and TM 9-1828A, dated 9 Mar 45, supersedes TM 9-1731C, dated 23 Aug 43. This TM supersedes portions of WDTB ORD 215, dated 30 Oct 44, and WDTB ORD 288, dated 12 Apr 45, which apply to the materiel covered by this TM; however, those TB's remain in force until incorporated in all other TM's or specifically rescinded.

ORDNANCE MAINTENANCE

FORD TANK ENGINES

(MODELS GAA, GAF, AND GAN)

WAR DEPARTMENT *4 JUNE 1945*

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WAR DEPARTMENT
Washington 25, D. C., 4 June 1945

TM 9-1731B, Ordnance Maintenance: Ford Tank Engines (Models GAA, GAF, and GAN), is published for the information and guidance of all concerned.

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(Refer to FM 21-6 for explanation of distribution formula.)

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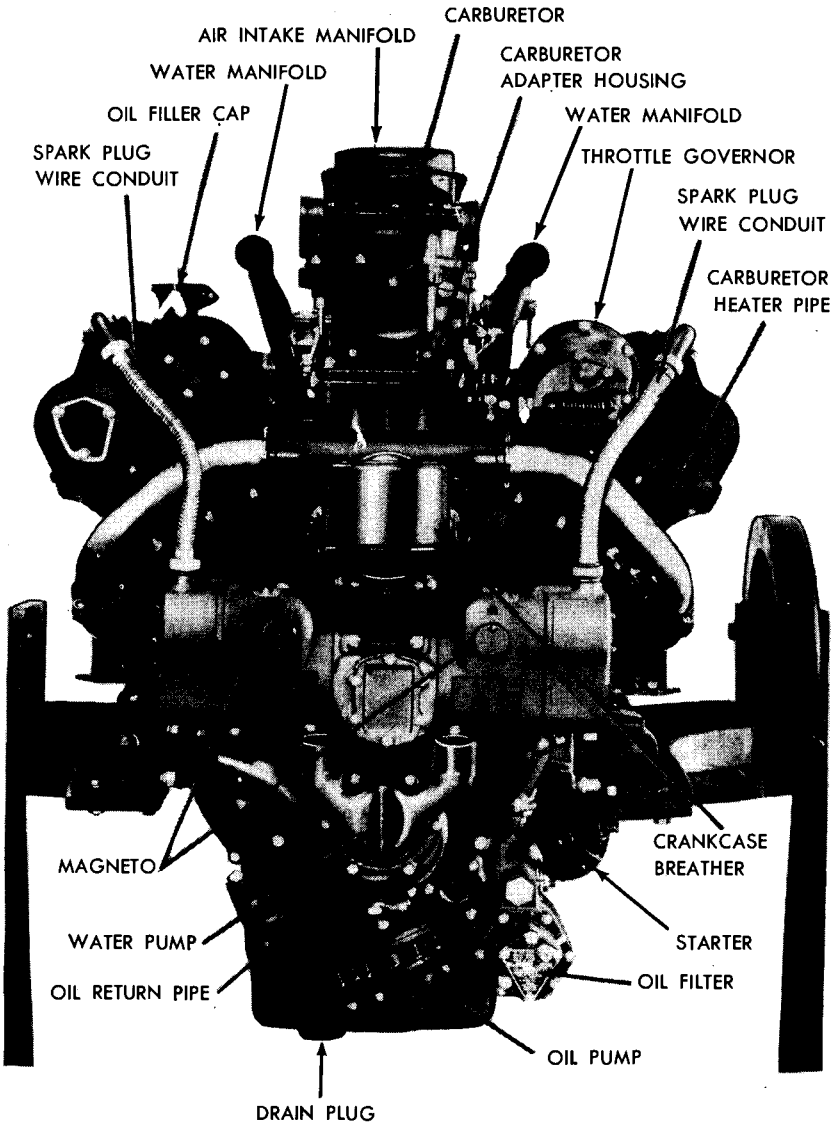


RA PD 329615

Figure 1 — GAA Engine — Rear View

This TM supersedes TM 9-1731B, dated 15 Jul 43; OFSTB 1731B-1, dated 24 Nov 43; WDTB 9-1731B-2, dated 6 Jan 44; and WDTB 9-1731B-3, dated 18 Mar 44. This TM, together with TM 9-1825B, dated 20 Jan 44; TM 9-1826B, dated 1 Apr 44; and TM 9-1828A, dated 9 Mar 45, supersedes TM 9-1731C, dated 23 Aug 43. This TM supersedes portions of WDTB ORD 215, dated 30 Oct 44, and WDTB ORD 288, dated 12 Apr 45, which apply to the materiel covered by this TM; however, those TB's remain in force until incorporated in all other TM's or specifically rescinded.

CHAPTER 1 — INTRODUCTION

1. SCOPE.

a. These instructions are published for the information and guidance of personnel charged with the maintenance and repair of the Ford tank engines, models GAA, GAN, and GAF. These instructions are supplementary to field and technical manuals prepared for the using arms. This manual does not contain information which is intended primarily for the using arms, 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 removal, disassembly, inspection, repair, and assembly of the Ford tank engines, models GAA, GAN, and GAF.

c. TM 9-1826B contains information for the maintenance of the Stromberg carburetor used on these engines.

d. TM 9-1828A contains information for the maintenance of the A-C fuel pump used on these engines.

e. TM 9-1825B contains information for the maintenance of the Auto-Lite electrical equipment used on these vehicles.

f. TM 9-1734A contains information for the maintenance of the General Electric governor used on vehicles using the GAN engine.

2. RECORDS.

a. Forms and records applicable for use in performing prescribed operations are listed below with a brief explanation of each:

(1) WAR DEPARTMENT LUBRICATION ORDER. War Department Lubrication Orders prescribe lubrication maintenance for vehicles using this engine. A lubrication order is issued with each vehicle and is to be carried with it at all times. Instructions on the order are binding on all echelons of maintenance and there shall be no deviations.

(2) W.D., A.G.O. FORM NO. 462, PREVENTIVE MAINTENANCE SERVICE AND TECHNICAL INSPECTION WORK SHEET FOR FULL-TRACK AND TANK-LIKE WHEELED VEHICLES. This form will be used for all 50-hour (500-mile) or 100-hour (1,000-mile) services and for technical inspections of these vehicles.

(3) W.D., A.G.O. FORM NO. 468, UNSATISFACTORY EQUIPMENT REPORT. This form will be used for reporting manufacturing, design, or operational defects in materiel with a view to improving and correcting such defects, and for use in recommending modifications on materiel. This form will not be used for reporting failures, isolated materiel defects, or malfunctions of materiel resulting from fair wear and tear or accidental damage; nor for the replacement, repair, or the issue of parts and equipment. It does not replace currently authorized operational or performance records.

(4) W.D., A.G.O. FORM NO. 478, MWO AND MAJOR UNIT ASSEMBLY REPLACEMENT RECORD. This form, carried with vehicle, will be used by all personnel completing a modification or major unit assembly (engine, transmission, transfer case, tracks, etc.) replacement to record clearly the description of work completed, date, vehicle hours and/or mileage, and MWO number or nomenclature of unit assembly. Personnel performing the operation will initial in the column provided. Minor repairs, parts, and accessory replacements will not be recorded.

(5) W.D., A.G.O. FORM NO. 10-144 (TALLY SHEET, INCOMING). This form may be used to record all incoming materials or supplies pending negotiation of a final voucher. It may also be used in exchanging vehicles, parts, or tools, or in lieu of shipping ticket.

(6) W.D., A.G.O. FORM NO. 10-145 (TALLY SHEET, OUTGOING). This form may be used to record all outgoing materials or supplies pending negotiation of the final voucher. It may also be used in exchanging vehicles, parts, or tools, or in lieu of shipping ticket.

(7) W.D., A.G.O. FORM NO. 9-71 (LOCATOR AND INVENTORY CONTROL CARD). This form may be used as a bin tag, locator card, or inventory control card in maintaining spare parts stocks. This form is for tactical units only.

(8) W.D., A.G.O. FORM NO. 9-76 (REQUEST FOR JOB ORDER). This form may be used by any officer or authorized person requiring production, repair, alteration, inspection, or any other type of work from another organization, department, or echelon. Not required for second or third echelon repairs.

(9) W.D., A.G.O. FORM NO. 9-77 (JOB ORDER REGISTER). This form will be prepared, when job orders are used, in single copy only, by service echelons to furnish a chronological order and record of job order numbers and related information.

(10) W.D., A.G.O. FORM NO. 9-78 (JOB ORDER). This form, properly executed, may be used as an authority for work. No work of any nature will be performed in a service echelon shop keeping a cost accounting-type record system without a properly authenticated job order.

(11) W.D., A.G.O. FORM NO. 9-79 (PARTS REQUISITION). This form will be used as an interdepartmental shop requisition to request parts where job orders are required.

(12) W.D., A.G.O. FORM NO. 9-80 (JOB ORDER FILE). This folder may be used to hold under one cover all shop papers and records incident to a particular job order or to a particular vehicle.

(13) W.D., A.G.O. FORM NO. 9-81 (EXCHANGE PART OR UNIT IDENTIFICATION TAG). This tag, properly executed, may be used when exchanging unserviceable items for like serviceable assemblies, subassemblies, parts, vehicles, and tools.

CHAPTER 2 — ENGINE

Section I

DESCRIPTION AND DATA

3. DESCRIPTION.

a. General. The Ford tank engines, Models GAA, GAN, and GAF, are so similiar in appearance and construction that all information, data, and illustrations in this manual will be considered as applying to all three engines, except where specifically designated as applying to the one particular engine. In most installations these engines are installed with the flywheel toward the front of the vehicle, and throughout this manual the flywheel end of the engine is referred to as the front. The terms "right" or "left" refer to the side of the engine as viewed from the rear. Direction of rotation is determined by looking from the rear toward the front of the engine. The cylinders are numbered 1, 2, 3, 4, on the right and left blocks. No. 1 cylinder is the rear cylinder on each block.

b. Type of Engines. The Models GAA, GAN, and GAF, V-8 Ford tank engines are the 60-degree, 4-cycle type. The cylinders and crankcase are cast in block and consist of an aluminum casting with hard steel, dry-type sleeves in each cylinder bore. Four overhead camshafts are used; one exhaust and one intake for each bank of cylinders. Two exhaust and two intake valves are used in each cylinder. Figure 7 shows the valve arrangement, and figure 9 shows the camshafts and accessory drives. Two 4-cylinder magnetos provide the ignition. These are mounted one at each end of a cross shaft at the rear of the engine and are driven by spiral gears (fig. 9). The engine is water-cooled with the water jackets extended the full length of the cylinders (fig. 8). The water pump is driven by the accessory drive gear assembly at the rear of the engine. Throughout this manual more detailed description of parts and units appear in the particular section devoted to the specific part or unit.

c. Differences Among Models.

(1) GAA engines (figs. 1 and 2) have two Model NA-Y5G Stromberg carburetors, a mechanical governor, a conventional-type flywheel, and a double-disk clutch. The oil pan on the engines, prior to engine No. 2000, also is different in that it does not contain the scavenger pump feature, and the oil pressure and oil relief valve are located inside of the pan and are not accessible for adjustment or removal from the exterior of the pan.

(2) GAN engines (figs. 3 and 4) have two Model HD-5 or HH-5 Stromberg carburetors, a hydraulic electric governor, and a special flywheel which acts as a driving plate for the propulsion generator.

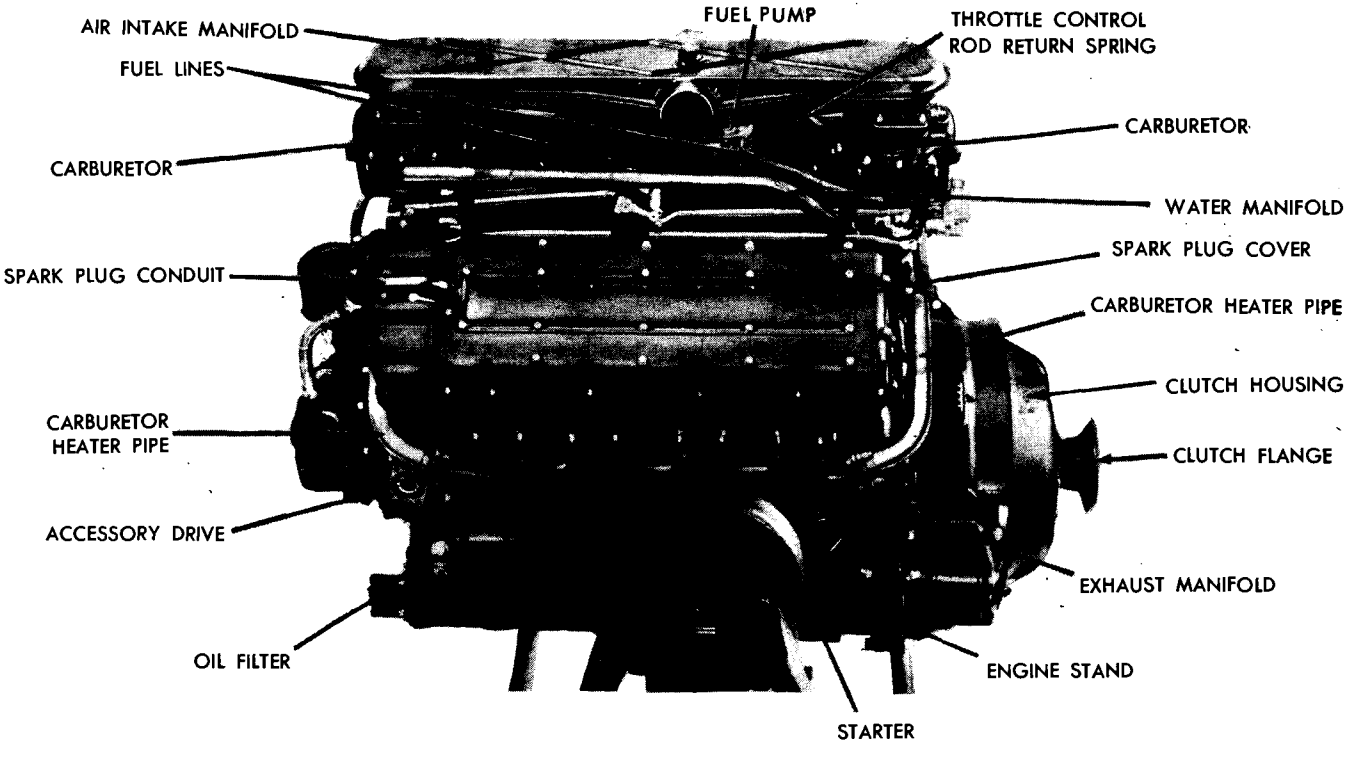


Figure 2 — GAA Engine — Right Side View

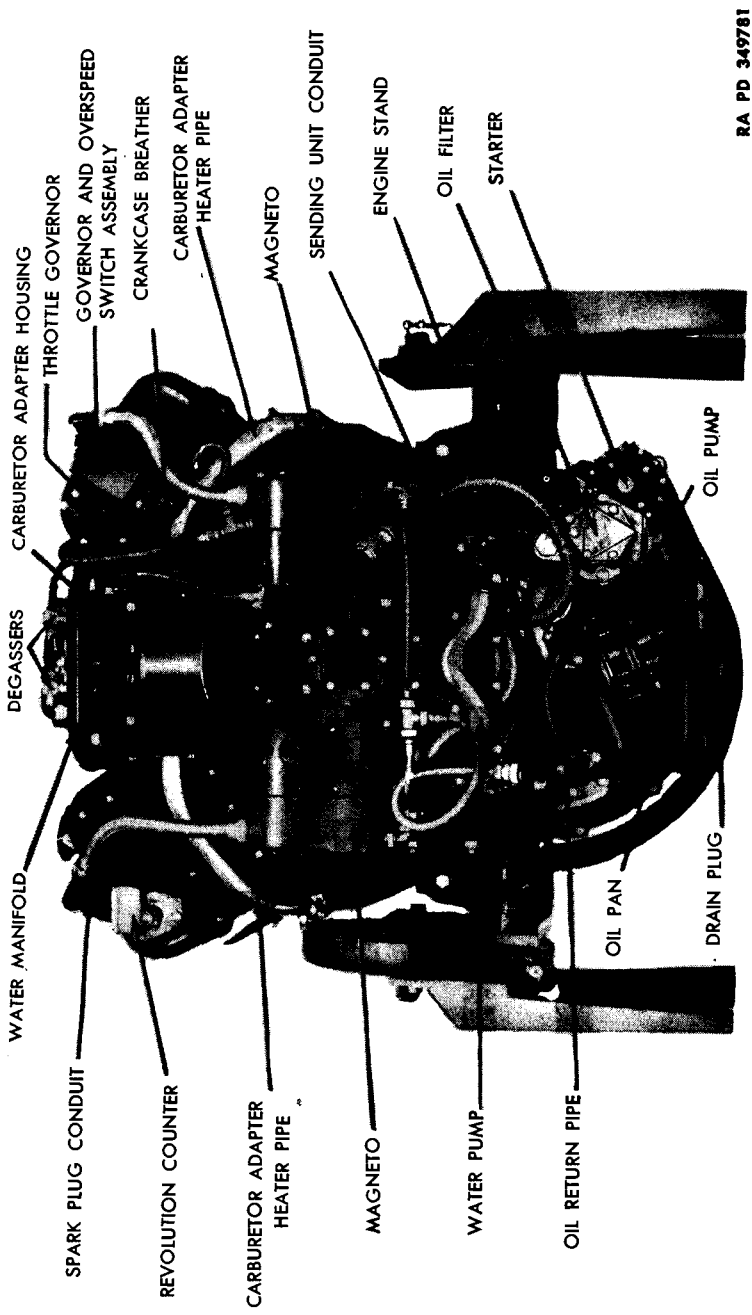


Figure 3 — GAN Engine — Rear View

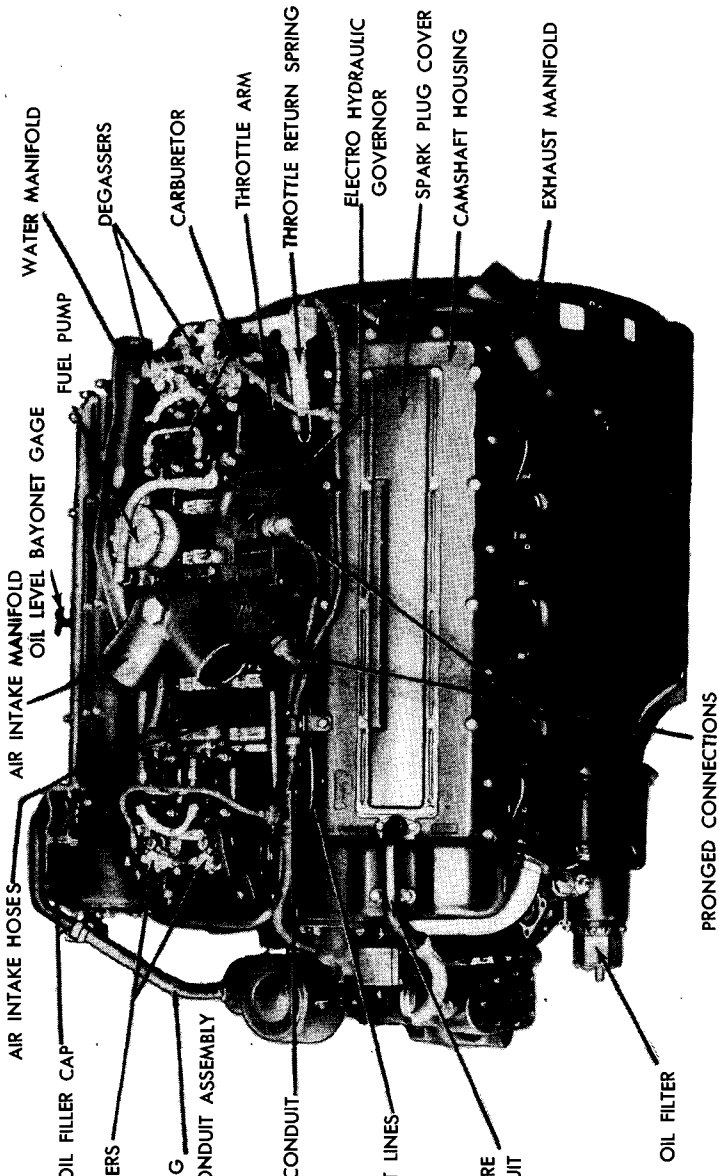


Figure 4 — GAN Engine — Right Side View

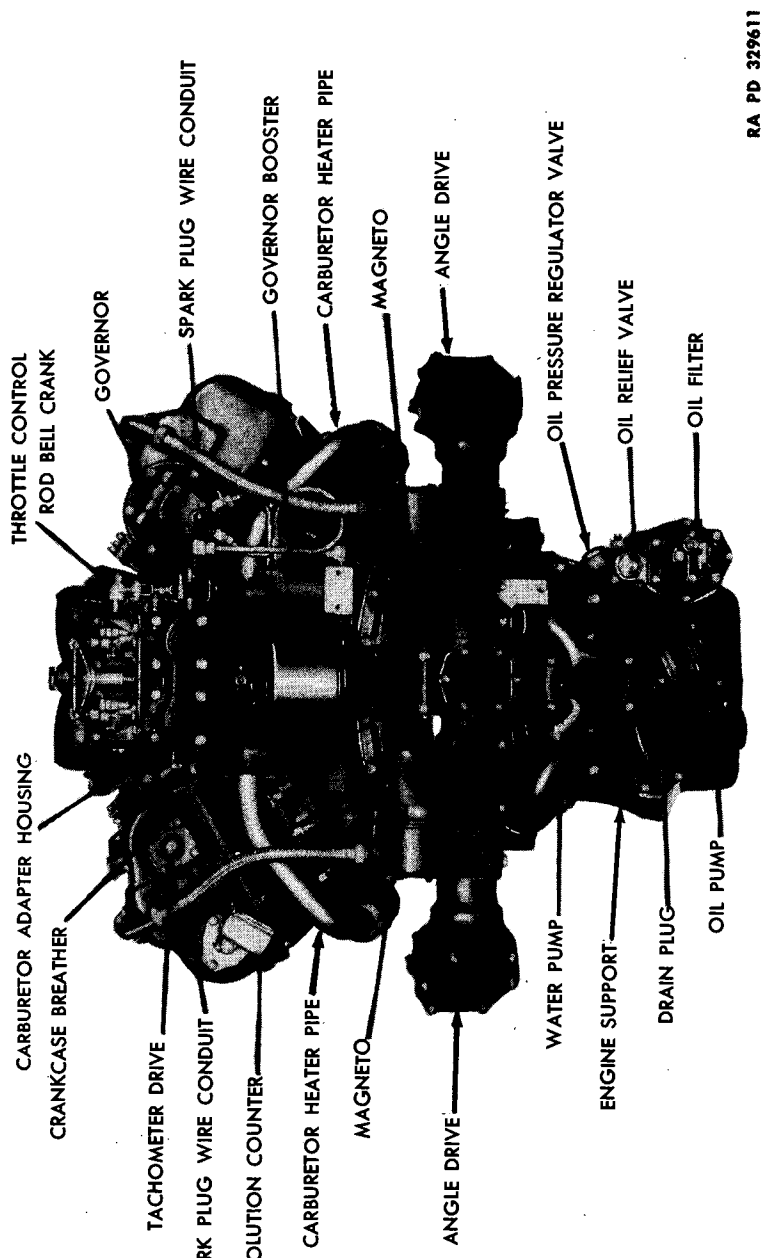


Figure 5 — GAF Engine — Rear View

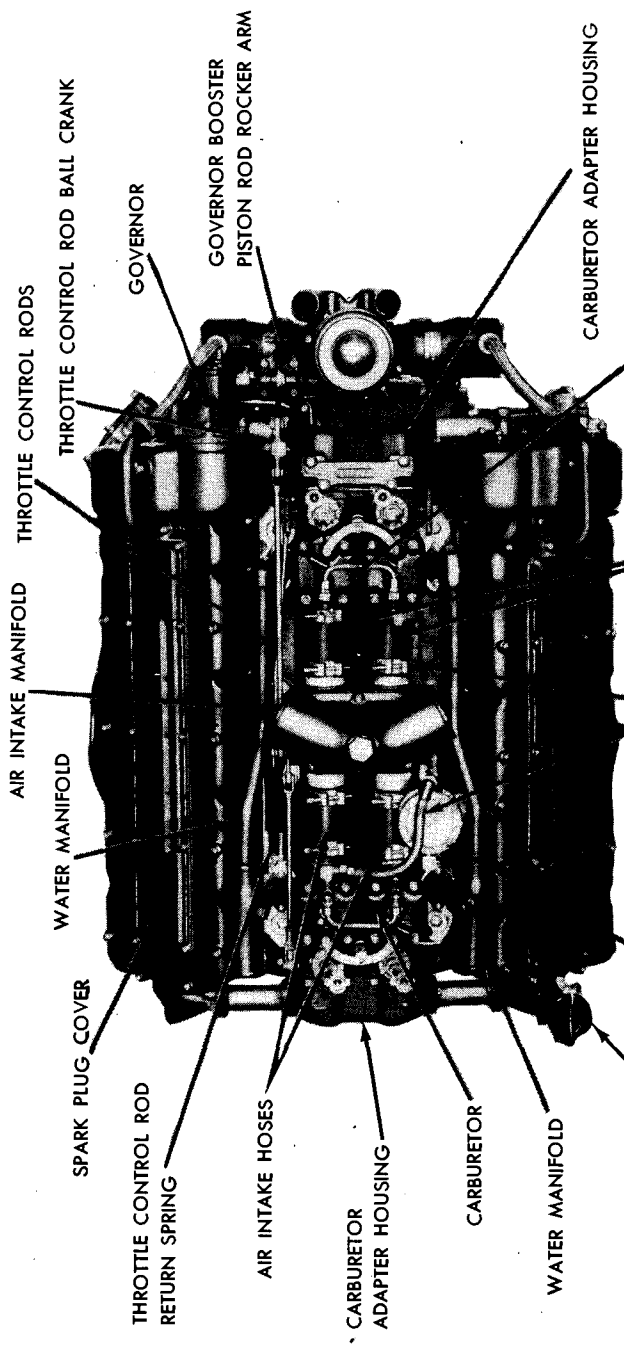


Figure 6 — GAF Engine — Top View

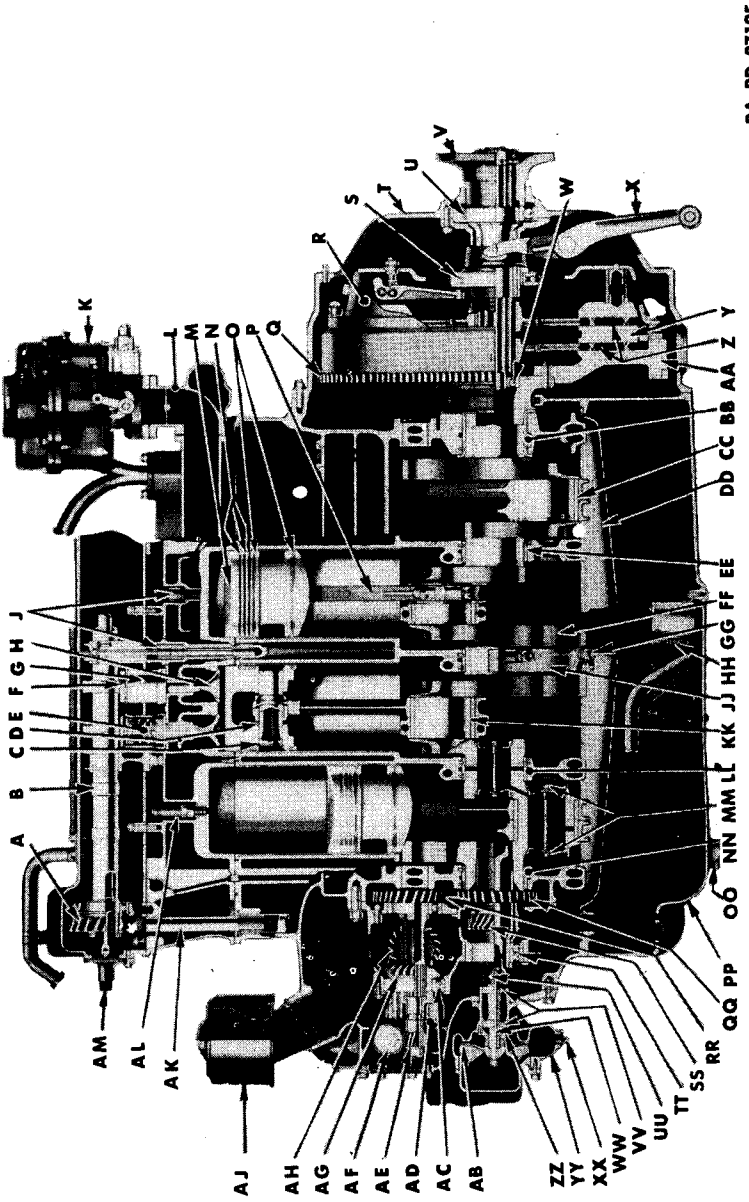


Figure 7 — Early Type GAA Engine — Longitudinal Sectional View

A—CAMSHAFT GEAR
B—CAMSHAFT
C—PISTON PIN RETAINER
D—PISTON PIN
E—VALVE SPRING
F—PUSH ROD
G—PUSH ROD GUIDE
H—VALVE
J—CYLINDER HEAD NUTS
K—CARBURETOR
L—CARBURETOR ADAPTER HOUSING
M—PISTON
N—COMPRESSION RINGS
O—OIL RINGS
P—CONNECTING RODS
Q—STARTER RING GEAR
R—CLUTCH PRESSURE PLATE ASS'Y.
S—CLUTCH RELEASE BEARING
T—CLUTCH HOUSING
U—BEARING, CLUTCH MAINSHAFT
V—FLANGE, CLUTCH MAINSHAFT
W—CLUTCH SHAFT PILOT BEARING
X—CLUTCH THROW OUT ARM
Y—CENTER DRIVE PLATE
Z—DRIVEN DISKS
AA—FLYWHEEL
BB—FRONT MAIN BEARING
CC—CONNECTING ROD BEARING LINER
DD—OIL PAN BAFFLE
EE—NO. 4 MAIN BEARING
FF—CRANKSHAFT
GG—MAIN BEARING STUD AND NUT
HH—OIL PUMP SCREEN
JJ—NO. 3 MAIN BEARING
KK—MAIN BEARING LINER
LL—NO. 2 MAIN BEARING
MM—CRANKSHAFT OIL PASSAGE SEALS
NN—NO. 1 MAIN BEARING
OO—OIL PAN DRAIN PLUG
PP—OIL PAN
QQ—CRANKSHAFT HELICAL GEAR
RR—HELICAL DRIVEN GEAR AND SHAFT, ACCESSORY DRIVE
SS—CRANKSHAFT WORM GEAR
TT—BEARING
UU—WATER PUMP DRIVING QUILL
VV—WATER PUMP BEARINGS
WW—WATER PUMP SHAFT
XX—WATER PUMP DRAIN PLUG
YY—WATER PUMP HOUSING
ZZ—WATER PUMP SEAL
AB—WATER PUMP IMPELLER
AC—BEARING
AD—MAGNETO ADVANCE GOVERNOR
AE—MAGNETO DRIVE GEAR
AF—MAGNETO DRIVEN GEAR
AG—ACCESSORY SHAFT BEVEL DRIVEN PINION
AH—ACCESSORY SHAFT BEVEL DRIVEN GEAR
AJ—CRANKCASE BREATHER
AK—UPPER CAM DRIVE SHAFT
AL—SPARK PLUG
AM—TACHOMETER DRIVE

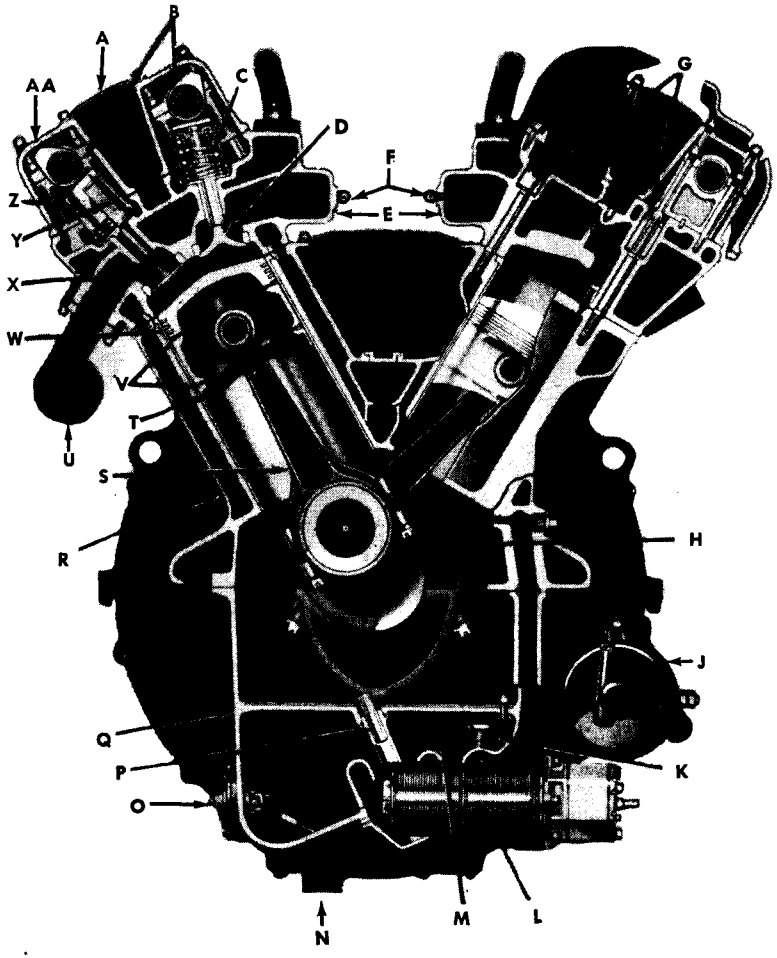
RA PD 27195B

Legend for Figure 7 — Early Type GAA Engine — Longitudinal Sectional View

(3) GAF engines (figs. 5 and 6) have two Model HD-5 Stromberg carburetors, and a mechanical flyball governor with a hydraulic booster. The flywheel is designed to accommodate the torque converter which serves as a fluid clutch.

4. DATA.

Make and type	Ford V-type, 8-cylinder tank engine
Models	GAA, GAN, and GAF
Over-all dimensions (including clutch, GAA engines only):	
Length	59.02 in.
Width	33.25 in.
Height	47.78 in.
Weight (including accessories)	1,470 lb
Horsepower	500 at 2,600 rpm
Torque	1,050 lb-ft at 2,200 rpm
Number of cylinders	8
Bore	5.4 in.
Stroke	6 in.
Piston displacement	1,100 cu in.
Compression ratio	7.5 to 1
Direction of rotation (viewed from rear of engine):	
Crankshaft	Clockwise
Starter	Counterclockwise
Magnetos:	
Right-hand rotor	Clockwise
Left-hand rotor	Counterclockwise
Make	Bosch
Breaker point gap	0.014 in. to 0.016 in.
Accessory speeds:	
Fans	1.4 crankshaft speed
Tachometer	½ crankshaft speed
Generators	1.75 crankshaft speed
Magneto rotors	½ crankshaft speed
Three-prong early-type spark plug gap	0.011 in. to 0.014 in.
Two-prong late-type spark plug gap	0.014 in. to 0.017 in.
Valve clearance (nonadjustable):	
Intake	0.028 in. to 0.031 in.
Exhaust	0.029 in. to 0.033 in.
Carburetors:	
GAA engines	Bendix-Stromberg NA-Y5G
GAN and GAF engines	Bendix-Stromberg HD-5 or HH-5
Numbering of cylinders from rear to front:	
Right bank	1-2-3-4
Left bank	1-2-3-4



A—SPARK PLUG COVER
B—CAMSHAFTS
C—VALVE SPRINGS
D—INTAKE VALVE
E—INTAKE MANIFOLDS
F—PRIMER NOZZLES
G—CYLINDER HEAD NUTS
H—CRANKSHAFT
J—STARTER
K—OIL RELIEF VALVE
L—OIL FILTER ASS'Y
M—OIL PAN BAFFLE
N—OIL DRAIN PLUG
O—OIL GAGE UNIT
P—OIL PUMP SHAFT
Q—OIL PAN
R—BLOCK
S—CONNECTING ROD
T—PISTON
U—EXHAUST MANIFOLD
V—OIL RINGS
W—COMPRESSION RINGS
X—EXHAUST VALVES
Y—PUSH ROD GUIDE
Z—PUSH RODS
AA—CAMSHAFT HOUSING

RA PD 329661

Figure 8 — Early Type GAA Engine Showing Valve and Piston Arrangement — Cross Sectional View

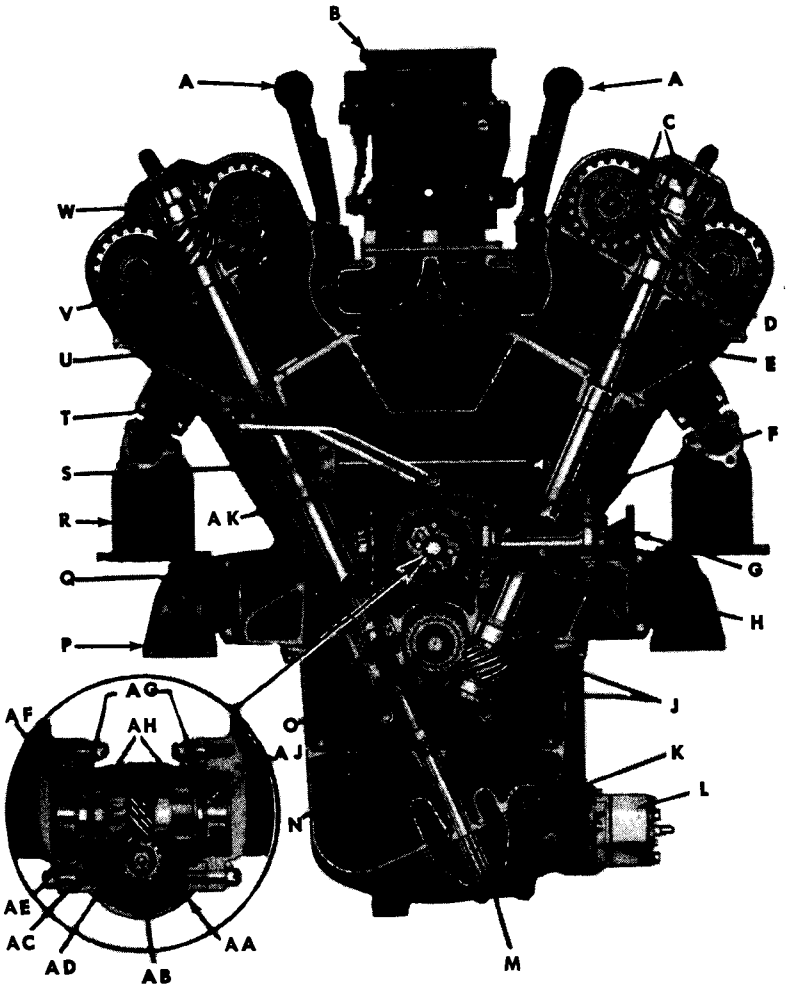


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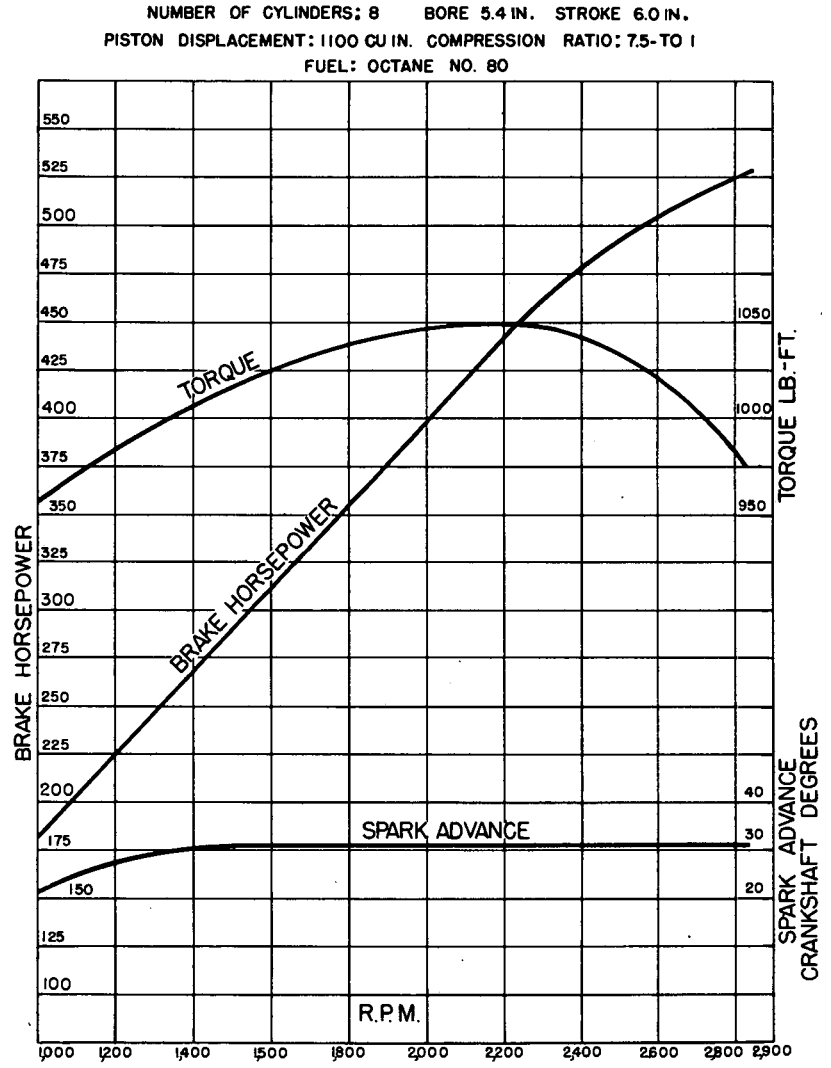
Figure 9 — Early Type GAA Engine Showing Camshaft Drive — Cross Sectional View

A—WATER OUTLET MANIFOLD
B—CARBURETOR
C—CAMSHAFT GEARS
D—CAMSHAFT DRIVE GEAR
E—CARBURETOR ADAPTER HOUSING
F—ACCESSORY SHAFT BEARINGS
G—ACCESSORY SHAFT DRIVE FLANGE
H—MAGNETO ADVANCE GOVERNOR
J—LOWER CAM DRIVE BEARING
K—OIL PRESSURE GAGE CONNECTION
L—OIL FILTER
M—OIL PUMP
N—OIL PUMP DRIVE QUILL
O—LOWER CAMSHAFT DRIVE GEARS
P—ENGINE MOUNTS
Q—CAMSHAFT DRIVE, LOWER SHAFT
R—EXHAUST MANIFOLD
S—OIL PIPE ASS'Y
T—CAMSHAFT DRIVE LOWER SHAFT BEARING
U—CAMSHAFT DRIVE, UPPER SHAFT
V—CAMSHAFT SUPPORT BEARING
W—CAMSHAFT UPPER DRIVE WORM BEARING
AA—ACCESSORY COVER
AB—MAGNETO DRIVE GEAR
AC—TIMING ADJUSTMENT
AD—MAGNETO DRIVEN GEAR
AE—KEY
AF—MAGNETO DRIVEN FLANGE
AG—DRIVING FLANGES
AH—MAGNETO DRIVE BEARINGS
AJ—MAGNETO DRIVE FLANGE

RA PD 329662B

Legend for Figure 9 — Early Type GAA Engine Showing Camshaft Drive — Cross Sectional View



RA PD 350555

Figure 10 — Engine Power Curve

Firing order R-1, L-2, R-3, L-1, R-4, L-3, R-2, L-4

Valve timing:

Intake opens ..... 5 deg BTC

Intake closes ..... 55 deg ABC

Exhaust opens ..... 50 deg BBC

Exhaust closes ..... 10 deg ATC

Type of valves used:

Exhaust valve ..... Stellite, reinforced seats, sodium-cooled stems, for types GAN and GAF, and part production GAA

Intake valve ..... 2112-W-731 steel

Section II

PREPARATION OF ENGINE FOR OVERHAUL

5. GENERAL.

a. Because of some differences in the procedures for removing the accessories on the GAA, GAN, and GAF engines, a separate paragraph is provided for each of the engines for the removal of the accessories only. Engines removed from vehicles for overhaul purposes are to be stripped of the accessories. Transmit the accessories removed from the engine to the proper department for inspection and repair.

6. CLEANING AND INSPECTION OF REMOVED ENGINE.

a. Cleaning. The outside of the engine must be thoroughly cleaned of all mud, grease, or other foreign matter. This can best be done when the engine to be cleaned is placed on a suitable stand (fig. 2). Use water under pressure to loosen and remove as much foreign matter as possible. Use a stiff brush and dry-cleaning solvent to remove the remaining grease and dirt. Exercise extreme care to see that all openings are covered while cleaning.

b. Inspection.

(1) INSPECTION REPORT. The inspection report made at the monthly inspection before engine is removed from the vehicle must accompany the engine. It will assist in correcting any abnormal condition during the course of repairs.

(2) PROCEDURE. CAUTION: *If engine is to be returned to repair depot, be sure the magnetos are grounded.* Inspect camshaft housings and spark plug cover plates for holes or other damage. Inspect cylinder block and heads for cracks which will be indicated

by leakage of the cooling solution. Inspect oil pan, crankcase, and accessory drive gear cover for cracks and dents which may cause oil leakage. Inspect manifolds and heater pipes for cracked or broken parts. Inspect oil and fuel lines and connections for leakage of oil or fuel. Inspect oil and water pump gaskets for evidence of leakage.

(3) DRAIN ENGINE. Remove drain plug from bottom of oil pan to see that oil is drained. Remove the water drain plug, and drain water from water jackets of the engine. On early production engines, the water drain plugs are located between each of the rear engine mounts and the cylinder block. The drain plugs on later production engines are approximately 3 inches forward of the rear engine mounts at the bottom of the water jackets on each side of the cylinder block.

7. GAA ENGINE ACCESSORY REMOVAL.

a. Remove Carburetors (fig. 2). Remove the five nuts at the top of each carburetor which secure the carburetor air intake manifold to the carburetor, and remove the carburetor air intake manifold. Disconnect the fuel feed line at each carburetor. Disconnect the degasser electrical connections at each carburetor. Remove the four nuts holding each carburetor. Remove the four nuts holding each carburetor to the adapter housings. Disconnect the throttle rod ball joint at each carburetor throttle arm, and remove the carburetors.

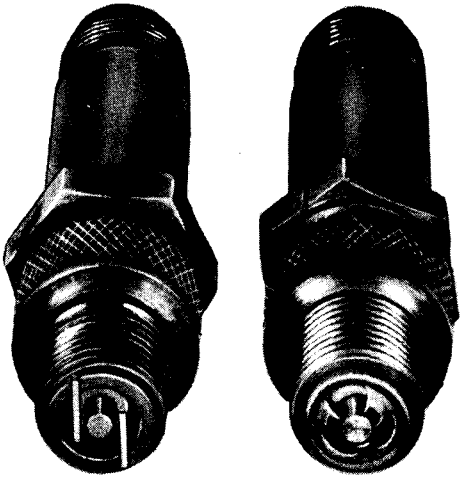
b. Remove Fuel Pump (fig. 2). Disconnect the fuel lines from the fuel pump. Remove the two nuts which secure the fuel pump to the camshaft housing, and remove the pump.

c. Remove Throttle Governor (fig. 1). Remove the cotter pin from the ball joint connection on the governor arm, unscrew the ball seat plug from the ball connection on the governor arm, and disconnect the connecting link. Remove the six nuts which hold the governor to the camshaft housing, and remove the governor.

d. Remove Tachometer Drive Assembly. On engines equipped with a tachometer, remove four nuts from the mounting flange and pull the assembly and driving quill from the camshaft housing.

e. Remove Magnetos (fig. 1). Remove the four screws from the circular inspection plate, and remove the plate. Remove the four screws securing the four ignition (high-tension) wires to the distributor plate. Unscrew the knurled nut which secures the ignition conduit from the magneto. Remove the lock wire and the upper and lower nuts from the magneto mounting flange, and lift the magneto from the accessory gear cover.

f. Remove Spark Plug Wires and Conduit Assembly (fig. 2). Remove the 10 nuts from each cover over the spark plugs, and remove the covers. Remove the two clamps which secure the spark



NEW TYPE
SPARK PLUG 7058742

OLD TYPE
SPARK PLUG A296664

RA PD 345303

Figure 11 — New and Old Type Spark Plugs

plug wires to the side of the camshaft housing. With special wrench (41-W-3336-300) (fig. 12), unscrew the spark plug terminal nuts from the spark plugs. Remove the two nuts holding each conduit to the camshaft housing, and lift the wire and conduit from the housing.

g. Remove Spark Plugs. With special wrench (41-W-3336-300) (fig. 13), remove the spark plugs from the cylinder heads.

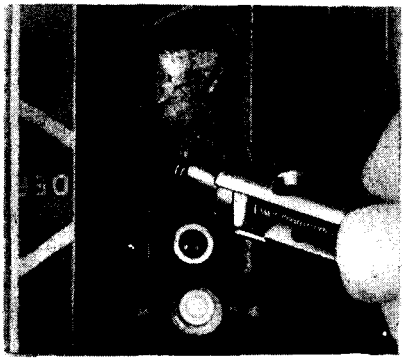
h. Remove Oil Filter (fig. 1). Remove the six nuts from the mounting flange of the oil filter, and remove the oil filter from the engine oil pan. On the early type engines the oil filter was mounted on the side of the oil pan instead of on the rear of the pan.

i. Remove Oil Level Gage Used on Early Type Engine Only (Engine Unit). Remove the lock wire from the six screws at the mounting flange and remove the screws. Remove the gage assembly from the oil pan.

j. Remove Starter Assembly (fig. 1). Remove the two nuts and one bolt which hold the starter to the crankcase, and remove the assembly.

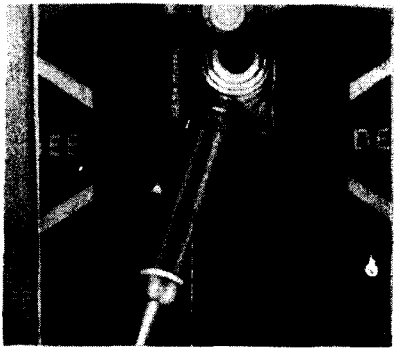
k. Remove Crankcase Breather (fig. 1). Unfasten the clamps that hold the crankcase breather cover, and remove the cover and element. Remove the four nuts that hold the breather tube to the accessory gear cover and remove the breather.

REMOVING SPARK PLUG TERMINAL NUT



RA PD 349783

Figure 12 — Removing Spark Plug Terminal Nut With Wrench (41-W-3336-300)



REMOVING SPARK PLUG

RA PD 349789

Figure 13 — Removing Spark Plug With Wrench (41-W-3336-300)

8. GAN ENGINE ACCESSORY REMOVAL.

a. Remove Sending Unit Conduit (figs. 3 and 4). Remove the screws that attach the conduit shielding caps to the degassers at each carburetor. Remove the caps from the degassers, and pull the wires out of the connectors. Disconnect the two pronged connectors at the electric governor and at the overspeed switch at the governor located on the camshaft housing. Remove the nuts from the clamps that hold the sending unit conduit at the top of the camshaft housing and to the accessory gear cover, and remove the sending unit conduit.

b. Remove Water Manifold (fig. 4). Remove the nuts and washers that secure each water manifold flange to the cylinder block, and remove the water manifold and gaskets from the engine.

c. Remove Electro Hydraulic Governor (fig. 4). Remove the cotter pin and clevis pin that secure the throttle arm leading from the governor to each carburetor. Disconnect the throttle rod return spring. Disconnect the oil inlet line at the governor and at the accessory gear cover. Remove the brace from the top of the governor. Remove the two bolts that secure the governor to the engine, and remove the governor.

d. Remove Carburetor (fig. 4). Loosen the clamps and disconnect each carburetor connecting manifold air intake hose from each carburetor. Push the hose as near to the center of the engine as possible. Disconnect the fuel feed lines leading from the fuel pump to each carburetor. Remove the lock wire and eight cap screws that hold each carburetor to the adapters, and remove the carburetors and insulating spacers.

e. Remove Carburetor Air Intake Manifold (fig. 4). Remove the four nuts that secure the air intake manifold to the cylinder block, and remove the manifold.

f. Remove Governor and Overspeed Switch Assembly (fig. 3). Remove the six nuts which hold the governor to the camshaft housing, and remove the governor and switch assembly.

g. Remove Revolution Counter (fig. 3). Remove the four nuts which hold the revolution counter to the camshaft housing, and remove the counter and driving quill.

h. Remove Magnetos (fig. 3). Remove the four screws from the circular inspection cover on the magnetos, and remove the cover. Remove the four screws securing the four ignition (high-tension) wires to the distributor plate. Unscrew the knurled nut that secures the ignition conduit from the magneto. Remove the lock wire and the upper and lower nuts from the magneto mounting flange, and lift the magneto from the accessory gear cover.

i. Remove Spark Plug Wires and Conduit Assembly (fig. 4). Remove the 10 nuts from each cover over the spark plugs, and remove the covers. Remove the two clamps which secure the spark plug wires to the camshaft housing. With special wrench (41-W-3336-300) (fig. 12), unscrew the spark plug terminal nuts from the spark plugs. Remove the nuts holding each conduit to the camshaft housing, and lift the wire and conduit from the housing.

j. Remove Spark Plugs. With special wrench (41-W-3336-300) (fig. 13), remove the spark plugs from the cylinder heads.

k. Remove Oil Filter (fig. 3). Remove the six nuts from the mounting flange on the oil filter, and remove the oil filter from the engine oil pan.

l. Remove Starter Assembly (fig. 3). Remove the two nuts and the bolt which hold the starter to the crankcase, and remove the assembly.

m. Remove Crankcase Breather (fig. 3). Unfasten the clamps which hold the crankcase breather cover, and remove the cover and element. Remove the four nuts which hold the breather to the accessory gear cover, and remove the breather.

9. GAF ENGINE ACCESSORY REMOVAL.

a. Remove Water Manifolds (fig. 6). Remove the four nuts and washers which hold the water manifold flanges to the cylinder head. Remove the water manifolds and gaskets.

b. Remove Throttle Rod Assembly (figs. 5 and 6). Remove the throttle control rod return spring. Remove the cotter pin and clevis pin that secure the rocker arm link to the

throttle control rod bell crank. Remove the cotter pin and clevis pin that secure the throttle control rod to the bell crank. Remove the cotter pin and the clevis pin that secure the throttle rods to each carburetor. Remove the nut from the throttle control rod arm support bracket to the air intake manifold base. Remove the throttle rods and support brackets as an assembly.

c. **Remove Carburetors** (fig. 6). Disconnect the fuel lines at each carburetor. Remove the lock wire and loosen the hose clamp at the air intake hose. Work the hose away from the carburetors, back against the air intake manifold. Remove the locking wire and eight cap screws that secure each carburetor to the carburetor adapter, and remove the carburetors.

d. **Remove Fuel Pump** (fig. 6). Remove the two nuts that secure the fuel pump to the camshaft housing, and remove the pump.

e. **Remove Throttle Governor and Booster Governor** (fig. 5). Disconnect the two oil lines leading from the booster to the governor. Disconnect the oil line leading from the governor to the cylinder block. Remove the three nuts that secure the booster to the cylinder block and remove the booster. Remove the six nuts that secure the throttle governor to the camshaft housing. It may be necessary to tap the governor lightly in order to free the splines on the govenor drive shaft from the camshaft.

f. **Remove Revolution Counter** (fig. 5). Remove the three nuts which hold the revolution counter to the camshaft housing, and remove the counter and driving quill.

g. **Remove Magnetos** (fig. 5). Remove the three screws from the circular inspection cover, and remove the cover. Remove the four screws securing the four ignition (high-tension) wires to the distributor plate. Unscrew the knurled nut which secures the ignition conduit to the magneto, and lift the ignition wires and conduit from the magneto. Remove the lock wire and the upper and lower nuts from the magneto mounting flange, and lift the magneto from the accessory gear cover.

h. **Remove Spark Plug Wires and Conduit Assembly** (fig. 6). Remove the 10 nuts from each cover over the spark plugs, and remove the covers. With special wrench (41-W-3336-300), unscrew the spark plug terminal nuts from the spark plugs (fig. 12). Remove the two nuts holding each conduit to the camshaft housing. Remove the two clamps which secure the spark plug wires to the camshaft housing, and lift the wire and conduit from the housing.

i. **Remove Spark Plugs.** With special wrench (41-W-3336-300), remove the spark plugs from the cylinder heads (fig. 13).

j. Remove Oil Filter (fig. 5). Remove the six nuts from the mounting flange of the oil filter, and remove the oil filter from the engine oil pan.

k. Remove Starter Assembly. Remove the two nuts and one bolt which hold the starter to the crankcase, and remove the assembly.

l. Remove Crankcase Breather (fig. 5). Unfasten the clamps that hold the crankcase breather cover, and remove the cover and element. Remove the four nuts that hold the breather to the accessory gear cover, and remove the breather.

m. Remove Angle Drives (fig. 5). Support the angle drive housing, and remove the four safety nuts which attach the angle drive to the engine. Pull the angle drive straight out until the drive shaft has cleared the internal bevel gear.

Section III

DISASSEMBLY OF STRIPPED ENGINE INTO SUBASSEMBLIES

10. GENERAL.

a. In this section it is assumed that all accessories have been removed from the engine. The procedure as outlined in the following text describes the disassembly of the GAA, GAN, or GAF engine.

11. DISASSEMBLY OF STRIPPED ENGINE INTO SUBASSEMBLIES.

a. Remove Camshaft Housing (fig. 14). Remove all the nuts from the top and lower edge of each camshaft housing, and lift the camshaft housings evenly off the cylinder heads to prevent damaging the studs.

b. Check Push Rod Clearance (fig. 15). Before removing the camshafts, check the push rod clearance. The proper clearance is 0.026 to 0.030 inch on the intake and 0.028 inch to 0.032 inch on the exhaust. This measurement is taken between the top of the push rod and the heel of the cam. If any are found that are not within the recommended limits, correction must be made during process of repair.

c. Remove Camshaft (fig. 16). Remove the two nuts from each bearing cap, and remove the caps from the camshaft bearings. Remove the snap ring at the top of the camshaft drive worm gear on each block and lift the upper drive shaft from the gear, using adapter (41-A-18-226) and a 3-jawed puller. Remove the five nuts holding

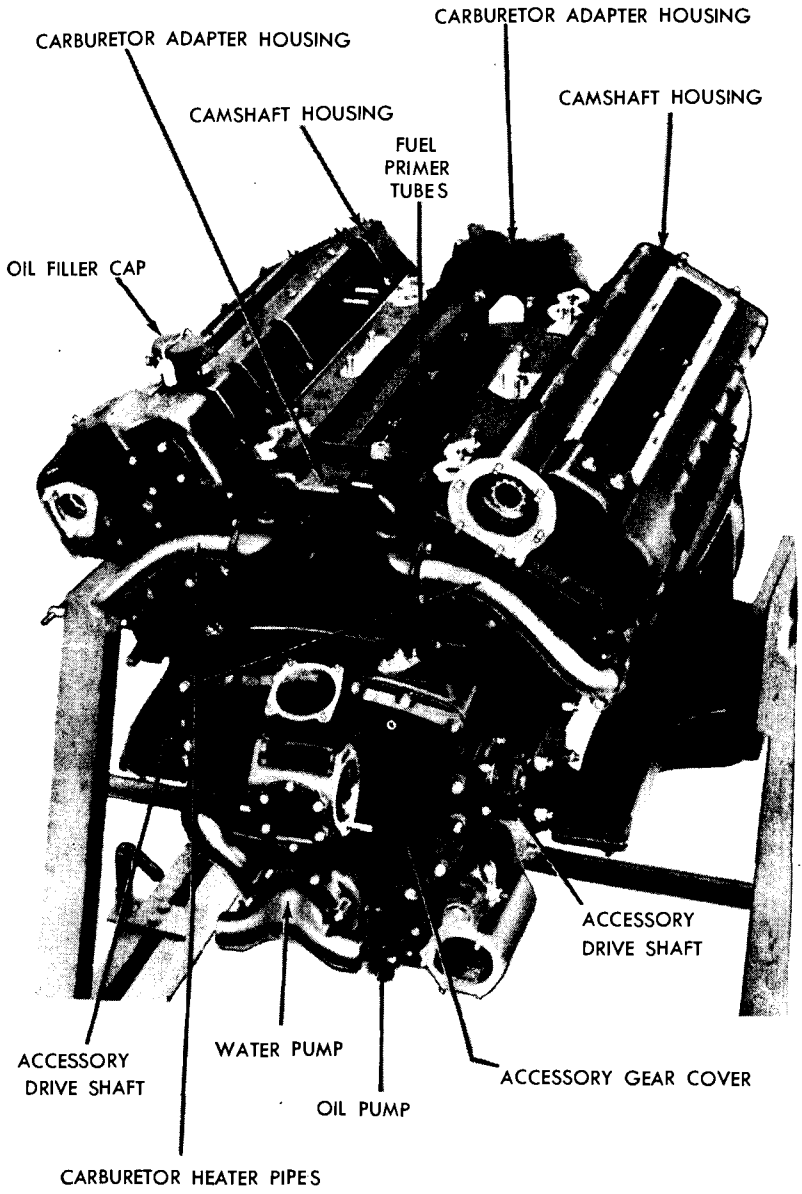


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Figure 14 — Engine Stripped of Accessories

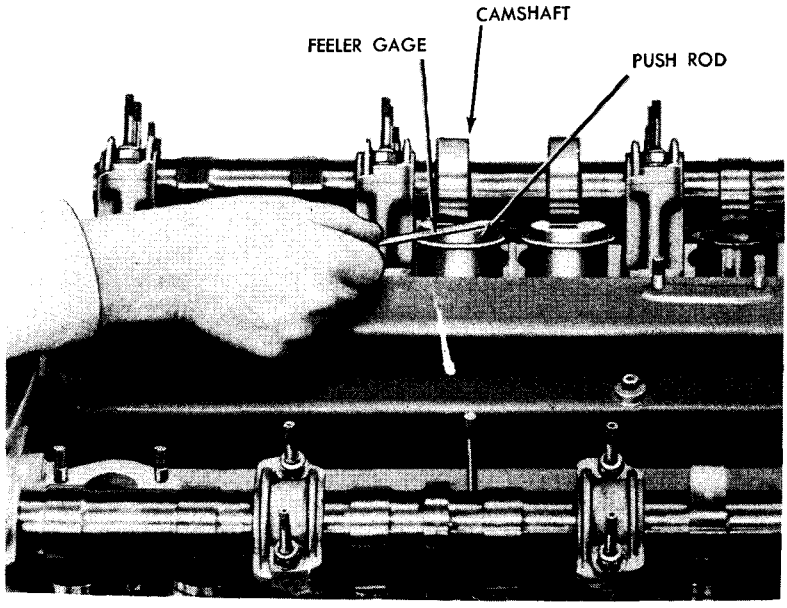

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Figure 15 — Checking Push Rod Clearance

the camshaft support to the cylinder head. NOTE: *Nuts from the bearing caps and the supports must be loosened evenly to prevent undue strain on the camshafts due to the valve spring pressure.* Lift the camshaft and gear assembly from the cylinder heads as an assembly. Lift the camshaft bearings from the studs.

d. Remove Push Rods. Lift the push rods from the guides. A tray should be provided for holding the push rods as they must not be mixed but kept in order so they can be assembled in their original location.

e. Remove Carburetor Heater Pipes and Adapter Housings (fig. 14). Remove the two cap screws from the upper flange and the two nuts from the lower flange of each heater pipe, and remove the four heater pipes which connect the exhaust manifold to the carburetor adapter. Remove the six nuts securing each of the carburetor adapter housings to the cylinder head inlet manifold, and remove the adapter housings. A special offset wrench (41-W-639-850) is provided for removing the nuts on each side which are located behind the heater pipe flanges.

f. Remove Cylinder Heads (fig. 16). Remove the 18 nuts securing each cylinder head to the cylinder block. Use special wrench

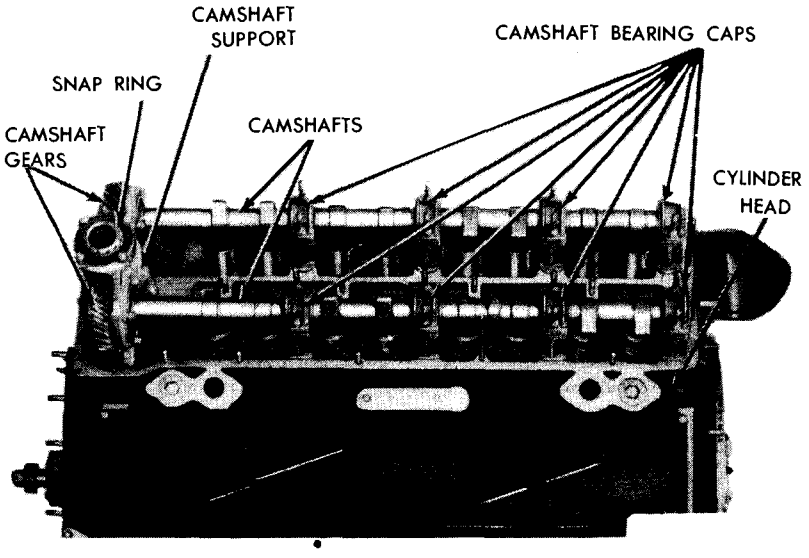

Figure 16 — Engine With Camshaft Housing Removed

(41-W-866-200) for removing the long cylinder head nuts. The long nuts are the eight nuts on each head which have the camshaft bearing studs screwed into them. Use special wrench (41-W-866-250) for the balance of the cylinder head nuts (short nuts). Remove the heads from the cylinder block.

g. Remove Clutch Shaft Flange (GAA Engines) (fig. 17). Remove the cotter pin from the clutch shaft flange nut, and remove the nut from the clutch mainshaft. Pull the clutch shaft flange from the clutch mainshaft. It may be necessary to tap the flange with a rawhide hammer in order to free the flange from the shaft.

h. Remove Clutch Housing Assembly (GAA Engines) (fig. 17). Remove the six nuts and six bolts from the cylinder block and oil pan. Remove the clutch housing assembly, using a heavy rawhide hammer to loosen the housing from the dowel pins.

i. Remove Clutch Pressure Plate Assembly (GAA Engines) (fig. 18). Install the special clutch disk alining tool (41-T-3083-75) through the clutch disk splines and into the pilot bearing in the crankshaft (fig. 18). This will prevent the clutch from falling from the flywheel when the pressure plate is removed. To hold the clutch springs compressed while the pressure plate is removed, place six ⅜-inch 16-thread cap screws, 1½ inches long, in the holes provided in the pressure plate assembly, and run them in until their heads

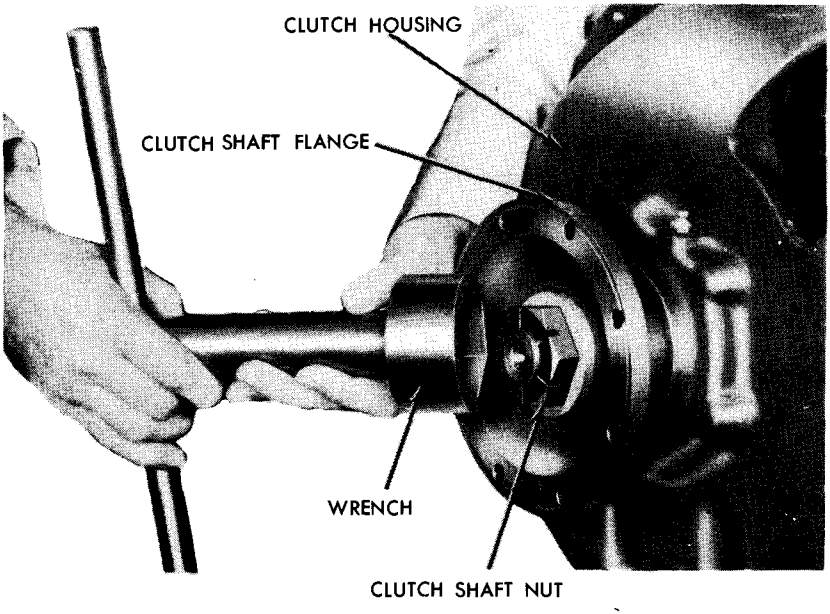

Figure 17 — Removing Nut Securing Clutch Shaft Flange to Clutch Shaft on GAA Engine

just bottom (fig. 18). These cap screws remain in the assembly until the assembly is again bolted to the flywheel during assembly procedure. Remove the lock wire and the 18 cap screws which hold the pressure plate to the flywheel and remove the pressure plate assembly.

j. Remove Clutch Disk and Pilot Bearing (GAA Engines) (fig. 79). Remove the two driven disks and the center drive disk from the flywheel. Remove the clutch pilot bearing from the end of the crankshaft.

k. Remove Water Pump (fig. 14). Remove the two nuts which secure the water pump housing flange, and the two nuts which secure the outlet flange to the accessory gear cover. Tap the body of the pump lightly to release the driving quill, and remove the pump.

l. Remove Accessory Gear Assembly Cover (fig. 14). Remove the 10 nuts which secure the cover to the cylinder block and the four cap screws which hold the cover to the oil pan, and remove the cover. NOTE: *On early type GAA engines the cover is located by two dowel pins. Starting with engine No. 5232 and all GAN and GAF engines, the accessory cover does not have the dowel pins as*

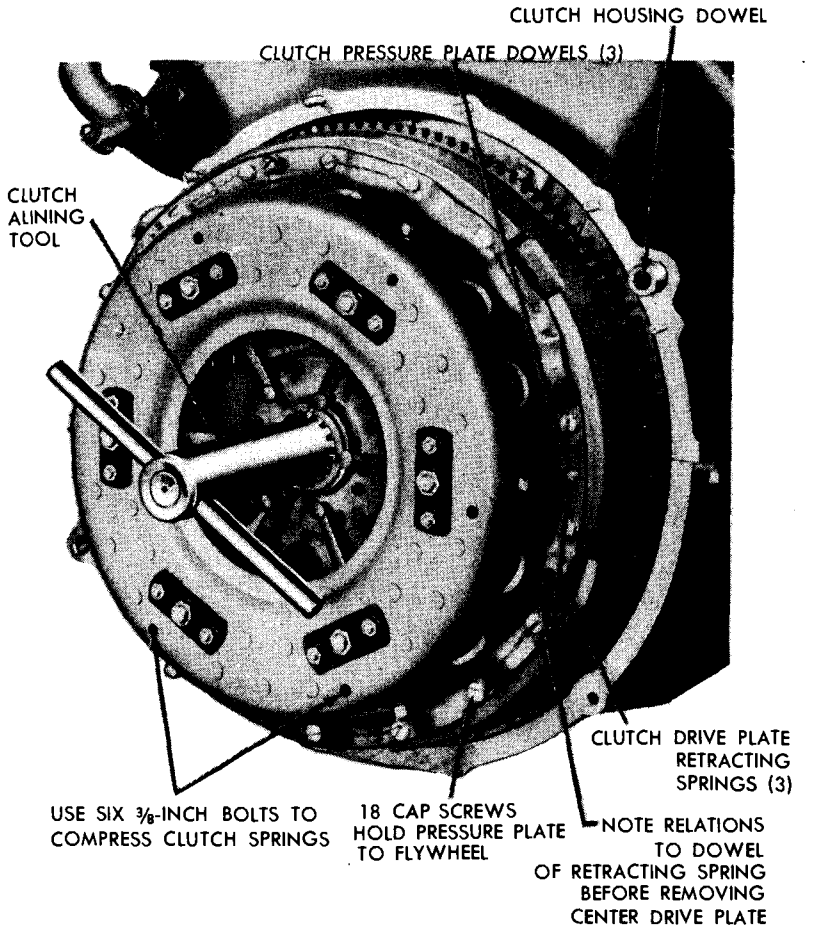

Figure 18 — Lining Up Clutch on GAA Engine, Using Clutch Pilot Tool (41-T-3083-75)

they are self-piloting on the accessory gear housing. Tap the cover lightly to release it from the dowel pins or the pilot, and remove the cover.

m. Remove Oil Pump (fig. 14). Remove the nuts which hold the oil pump to the oil pan. Tap the body of the pump lightly to release it from the gasket and the driving quill, and remove the pump.

n. Remove Oil Pan. Remove the nuts which hold the pan to the cylinder block and remove the pan. Always remove the oil pan

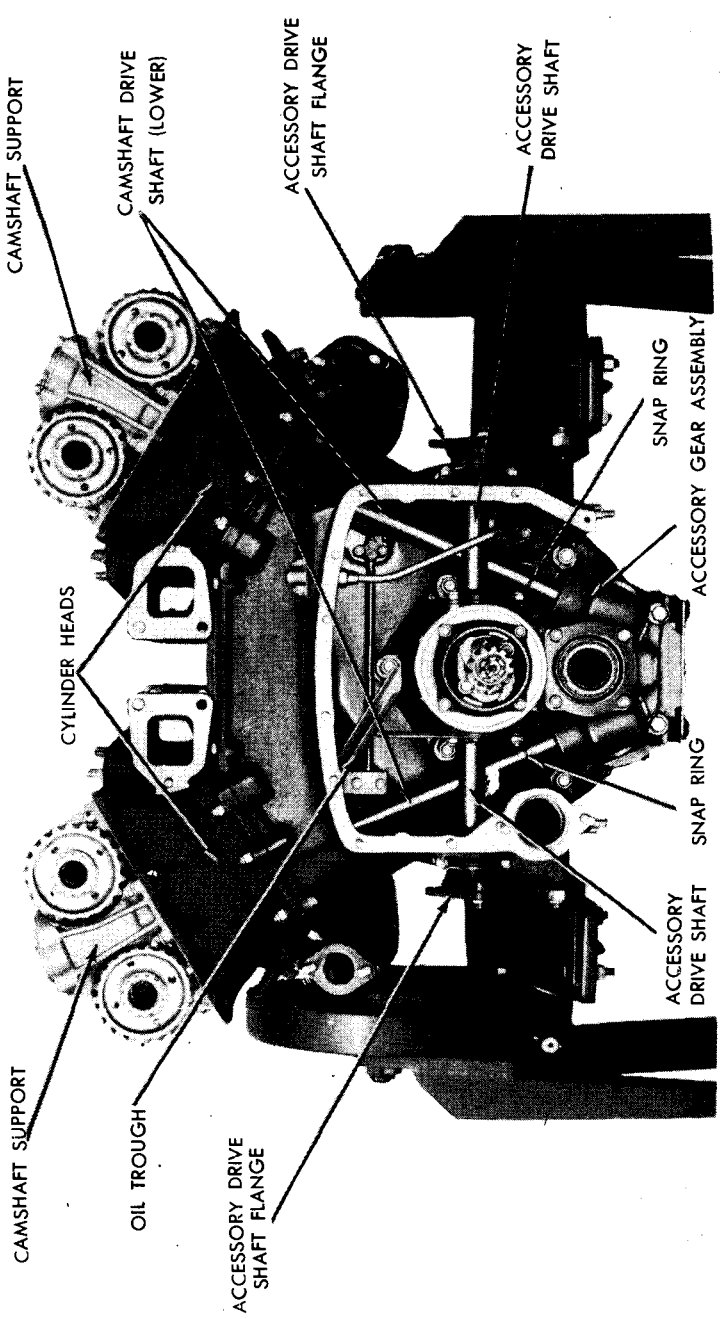

Figure 19 — Engine Showing Accessory Gear Assembly — Rear View

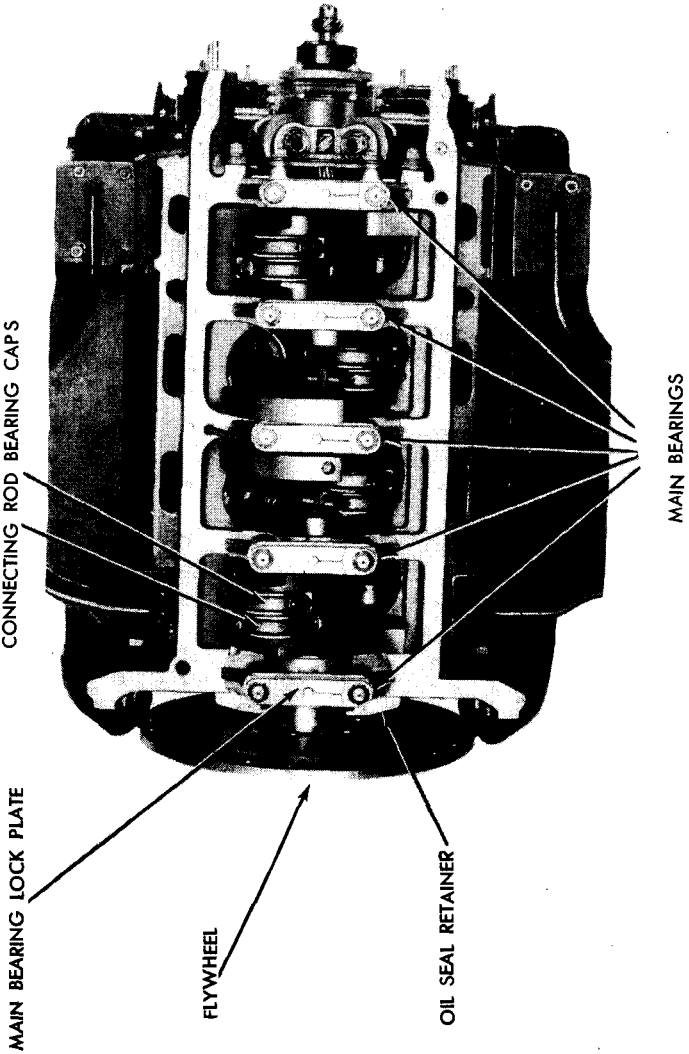

Figure 20 — Engine Showing Crankshaft and Connecting Rods in Later Type Engines — Bottom View

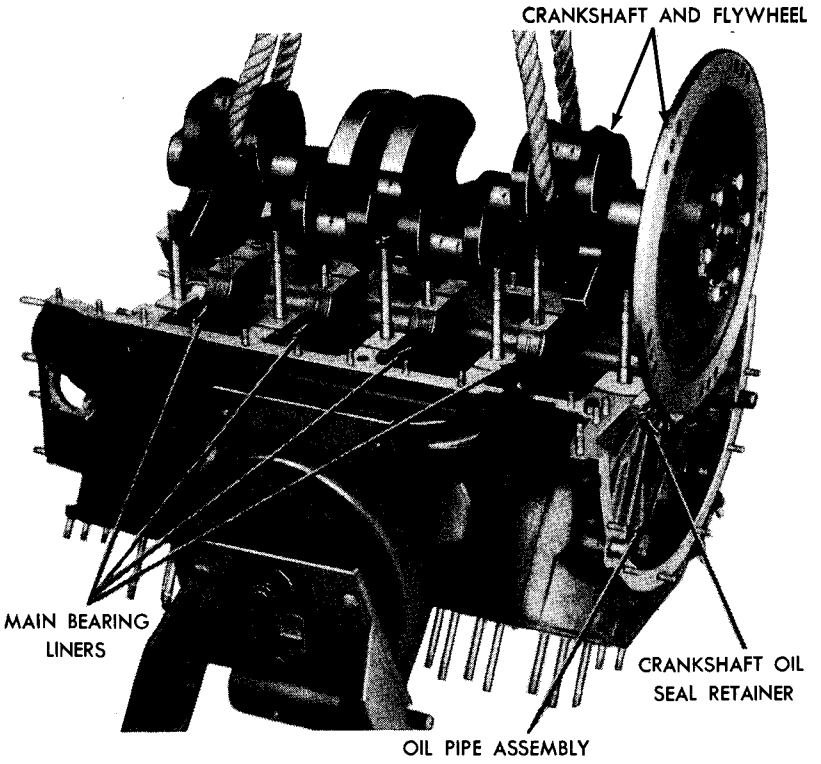

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Figure 21 — Removing Crankshaft and Flywheel From Engine

with the engine right side up to prevent the dirty oil from getting in the upper parts of the engine. NOTE: *If working on a GAF engine, it is very important that the oil pan be installed on the cylinder block from which it was removed. Tag the oil pan, indicating the engine number to which it belongs.*

o. Remove Camshaft Drive Shaft (Lower), Accessory Drive Shaft, and Accessory Gear Assembly (fig. 19). Remove the snap ring retainer at each camshaft drive shaft, and lift out the shafts. To remove the accessory drive shafts on the GAA and GAN engines, remove the four nuts from each of the bearing retainers. Use adapter (41-A-18-226) and a 3-jawed slide-hammer puller to remove the accessory drive shaft. Remove the nuts that secure the oil feed trough to the accessory gear assembly and to the block and remove the trough. It will be necessary to remove the oil line leading from the main oil passage to the cylinder block on the GAN and GAF engines. Remove the five nuts and the two cap screws which secure the ac-

cessory gear assembly to the cylinder block, and remove the accessory gear assembly.

p. Remove Connecting Rod and Piston Assembly (fig. 20). Remove the cotter pins and castellated nuts which secure the bearing caps to the rods, and remove the connecting rod caps. NOTE: *Bearing caps and rods are etched with corresponding numbers.* Tape each connecting rod bolt to prevent the threads on the connecting rod bolts from damaging the connecting rod liners. Remove the ridge, if present, from the cylinder sleeve, using a ridge reamer and push the rod and piston assemblies from the cylinders. Install the rod caps on the proper rods after removal to facilitate assembly. Remove the connecting rod liners from the crankshaft journals. Tag the liners so they can be assembled in their original position if they are still serviceable. Pistons and rods are numbered as follows: L1, L2, L3, L4, and R1, R2, R3, R4. No. 1 cylinders are the rear cylinders on the engine.

q. Remove Crankshaft and Flywheel.

(1) EARLY-TYPE GAA ENGINES UP TO ENGINE NO. 11084. Loosen main bearing cap nuts and unscrew the studs from the anchor nuts. Use a square socket wrench to remove studs. CAUTION: *Do not tip bearing caps from side to side when removing them from crankcase as it will damage the keyways which anchor the caps.* Main bearing caps are numbered as follows: 1-2-3-4-5; No. 1 is the rear bearing cap. Bearing caps also have the engine number stamped on them and are not interchangeable to another cylinder block. Main bearing liners should be tagged so they may be assembled in their original positions if they are still serviceable. With a suitable hoist and lifting hook, lift the crankshaft from the cylinder block (fig. 21).

(2) GAA ENGINE STARTING WITH ENGINE NUMBER 11084 AND ALL GAF AND GAN ENGINES. Remove the cap screws securing the main bearing nut lock plate at each bearing (fig. 20). Remove the nuts from the main bearing studs and lift each of the main bearing caps off the studs. Main bearing caps are numbered as follows: 1-2-3-4-5; No. 1 is the rear bearing cap. Bearing caps also have the engine number stamped on them and are not interchangeable to another cylinder block. Main bearing liners should be tagged so they may be assembled in their original position if they are still serviceable. With a suitable hoist and lifting hook, lift the crankshaft from the cylinder block (fig. 21).

r. Remove Crankshaft Oil Seal Retainer. Remove the cap screws securing oil seal retainer to the cylinder block (fig. 21).

s. Remove Oil Pipe Assembly. Remove the nuts from each flange and remove the oil pipes from the front and rear of the cylinder block.

Section IV

DISASSEMBLY, CLEANING, INSPECTION, REPAIR AND ASSEMBLY OF SUBASSEMBLIES

12. CYLINDER BLOCK.

a. General. During the inspection of engine parts, the inspection should record the condition of each part and make recommendations regarding the repair or disposition of each part. In this section, wherever reference is made to fits and tolerances, they will be indicated by the type of fit such as shrink fit, press fit, slip fit, or running fit. Specific values for the various types of fits are covered in the text and also in the table of fits and tolerances (Chapter 2, Section VIII).

b. Cleaning. Remove all dirt, carbon, and sludge by brushing or scraping. Flush out all water jackets with a high-pressure hose. Immerse the cylinder block in dry-cleaning solvent and remove all remaining dirt. CAUTION: *Do not use a caustic soda bath for aluminum cylinder blocks.* Thoroughly clean all oil passages in the cylinder block, using a rifle brush wherever possible and dry-cleaning solvent under pressure. Blow out all oil passages with compressed air, making sure all oil passages are open. Dry the entire block with compressed air. Coat the cylinder walls with a slight film of engine oil to prevent rusting. Figure 22 shows all the oil passages in the cylinder block that must be cleaned.

c. Inspection.

(1) CHECK CONDITION OF STUDS. Bent studs or studs with damaged threads must be replaced. Removal of broken studs is covered in subparagraph d (1) below.

(2) INSPECT WATER AND OIL FERRULE. Replace any water or oil ferrules in the cylinder block that are damaged or missing (subpar. d (2) below).

(3) INSPECT CYLINDER SLEEVES.

(a) Visual. Check the inside diameter of all sleeves for corrosion, scores, and warpage.

(b) Measurements.

1. Lengthwise of block at the top. With a micrometer caliper and a telescope gage, measure the diameter of the cylinder lengthwise of the block at the deepest point of the ring wear.

2. Lengthwise of block at the bottom. Measure the diameter of the cylinder lengthwise of the block at the bottom of the sleeve.

3. Crosswise of the block at the top. Measure the diameter of the cylinder crosswise of the block at the deepest point of the ring wear.

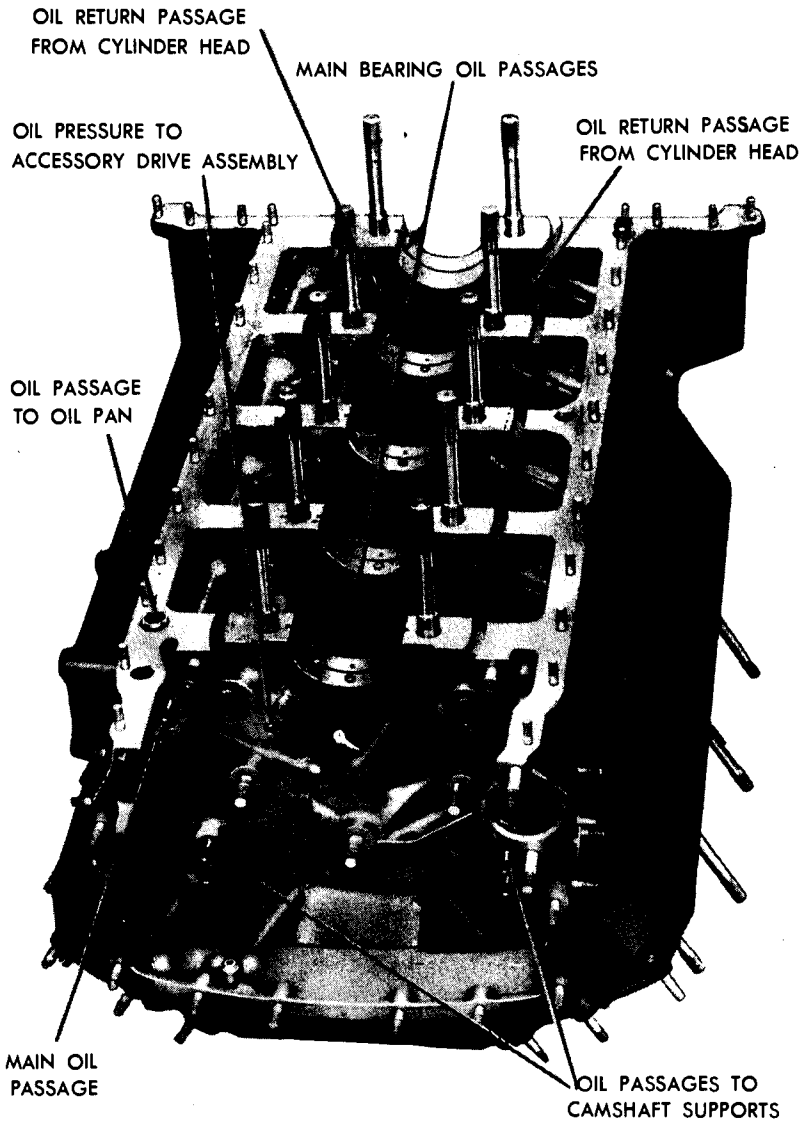

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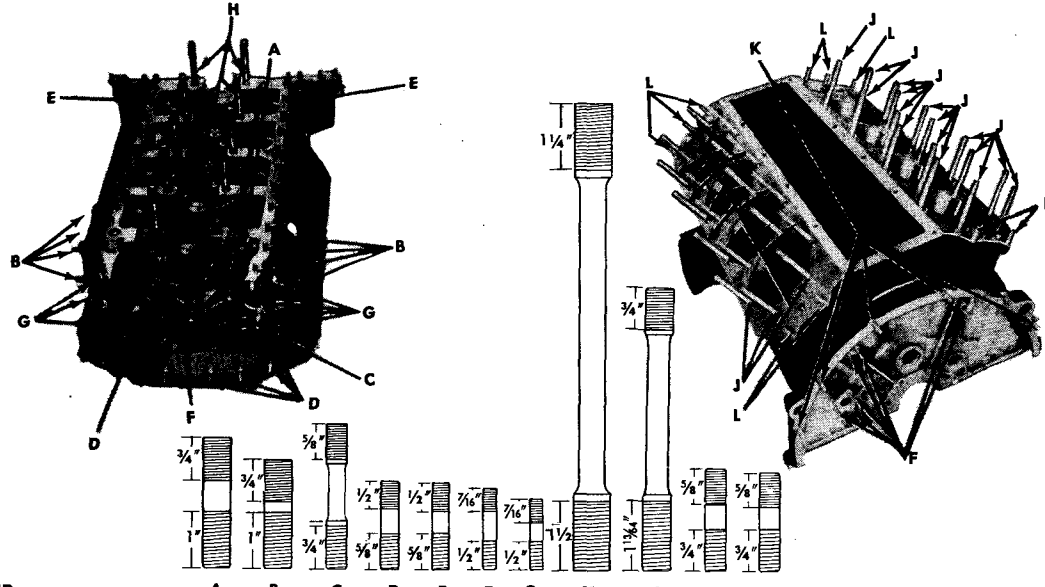
Figure 22 — Oil Passages in Cylinder Block



STUD	A	B	C	D	E	F	G	H	J	K	L
TOTAL LENGTH	2 5/16"	1 15/16"	2 9/16"	1 9/16"	1 1/2"	1 7/16"	1 1/4"	8 21/32"	5"	1 13/16"	1 3/4"
PROTRUDING LENGTH	1 11/32"	17/32"	1 13/16"	1"	7/8"	1"	25/32"	5 1/4"	3 3/4"	15/16"	19/32"
DIAMETER	1/2"	1/2"	3/8"	5/16"	5/16"	1/4"	1/4"	1 1/16"	1/2"	3/8"	1/4"
NUMBER USED	5	8	2	10	30	13	8	10	36	6	10

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Figure 23 — Identification of Cylinder Block Studs

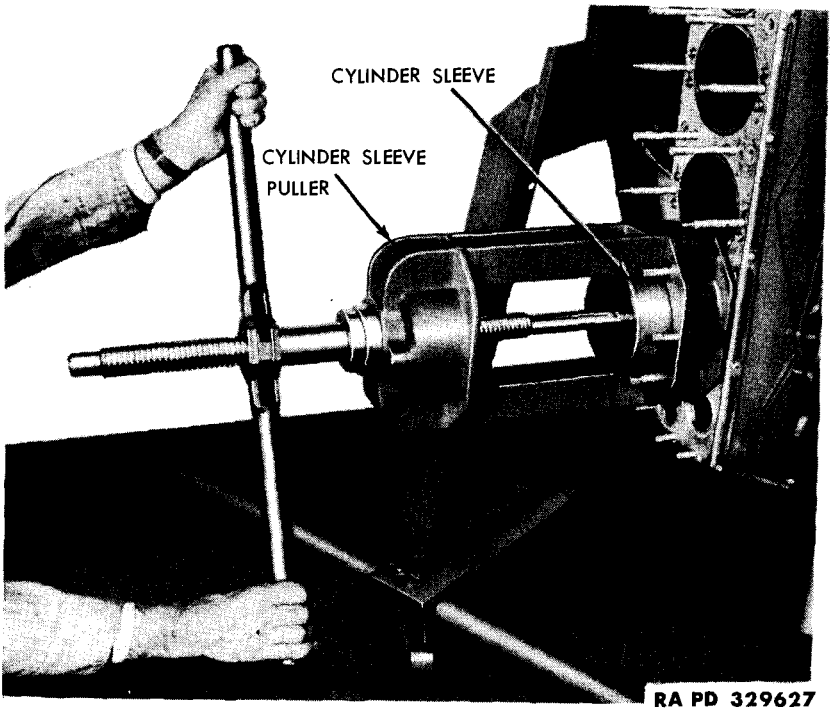

Figure 24 — Removing Cylinder Sleeves, Using Replacer (41-P-2907-117)

4. Crosswise of block at the bottom. Measure the diameter of the cylinder crosswise of the block at the bottom of the sleeve.

(c) Diagnoses.

1. Wear. A comparison of readings *1* with *2* with the original diameter of 5.401 to 5.402 inches will establish the amount of wear. If the wear is more than 5.412 inches, the sleeve must be reground to 5.421 inches to 5.422 inches oversize. Cylinder sleeves which have previously been reground must be replaced if worn to more than 5.417 inches, measured at any point. All sleeves must be reground if it is anticipated that the maximum wear limit of 0.010 inch will be reached before the next overhaul period.

2. Taper. A comparison of the readings *1* with *2* and a comparison of *3* with *4* above will indicate the taper. If the taper exceeds 0.003 inch, regrind the sleeve to 5.421 inches to 5.422 inches oversize.

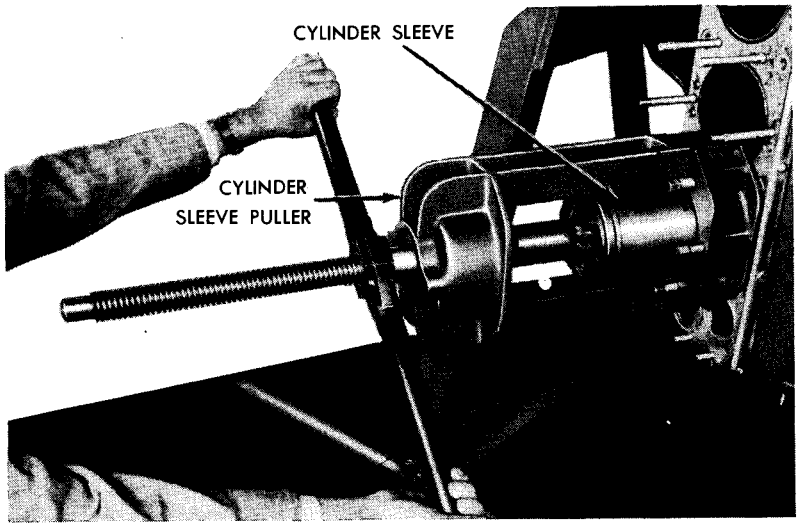

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Figure 25 — Installing New Cylinder Sleeves, Using Replacer (41-P-2907-117)

3. Out-of-round. A comparison of the readings *1* with *3* and a comparison of *2* with *4* will indicate the out-of-round of the sleeve. If the sleeve is out-of-round more than 0.003 inch, regrind the sleeve to 5.421 to 5.422 inches oversize.

d. Repair.

(1) CYLINDER BLOCK STUD REPLACEMENT. CAUTION: *Careful segregation of all studs is important when these parts are stocked, since proper selection of a stud to be used in the engine is essential.* The cylinder block can be damaged beyond further use by attempts to install other than the correct stud in any particular location. Refer to figure 23 for identification of the various studs.

(a) Remove Old Studs. Use a standard stud remover of the proper size to accommodate the particular stud to be removed.

(b) Install New Studs. Apply a thin coat of joint and thread compound on the threads of the studs to be installed in holes which are drilled through to the water jacket or crankcase. With a standard stud driver, drive all studs until the correct protruding length is obtained. See figure 23 for the type of stud and also the specified protruding length. If the stud is too tight or too loose in the stud hole, select another stud.

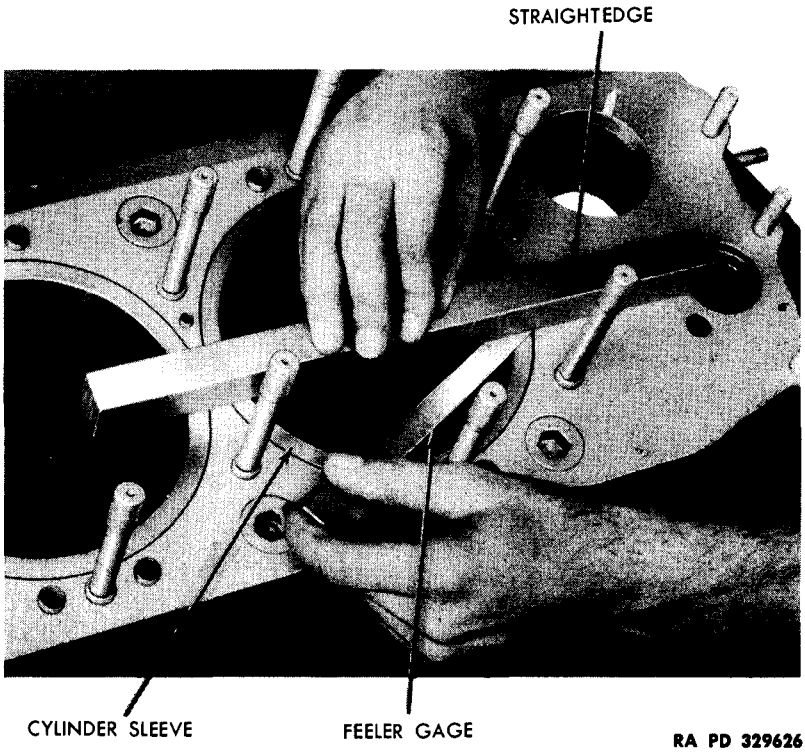

Figure 26 — Checking Clearance at Top of Cylinder Sleeve

(2) WATER OR OIL FERRULE REPLACEMENT. To remove damaged water or oil ferrules, drive on the outer side of the ferrule with a chisel until the ferrule is loose in its recess; then use a pair of pliers to pull the ferrule out of the recess. To install a new ferrule, place the ferrule in its recess. Select a ferrule driver of the proper size from the ferrule driver set (41-D-2980-150) and drive the ferrule in its recess. Be sure the ferrule is not tilted while being installed.

(3) CORE PLUG REPLACEMENT. The procedure for replacing core plugs is covered in paragraph 25 e (6).

(4) CYLINDER BORE RECONDITIONING. Cylinder bores which are not badly scored, tapered, or out-of-round, but which need cleaning, may be reconditioned with a hone to put them in a satisfactory condition. If previous inspection calls for regrinding the cylinder sleeve, approximately 0.002 inch should be left for honing. Sleeves that will not clean up when ground to 5.421 inches to 5.422 inches oversize must be replaced (step (5) below). After any of the above machin-

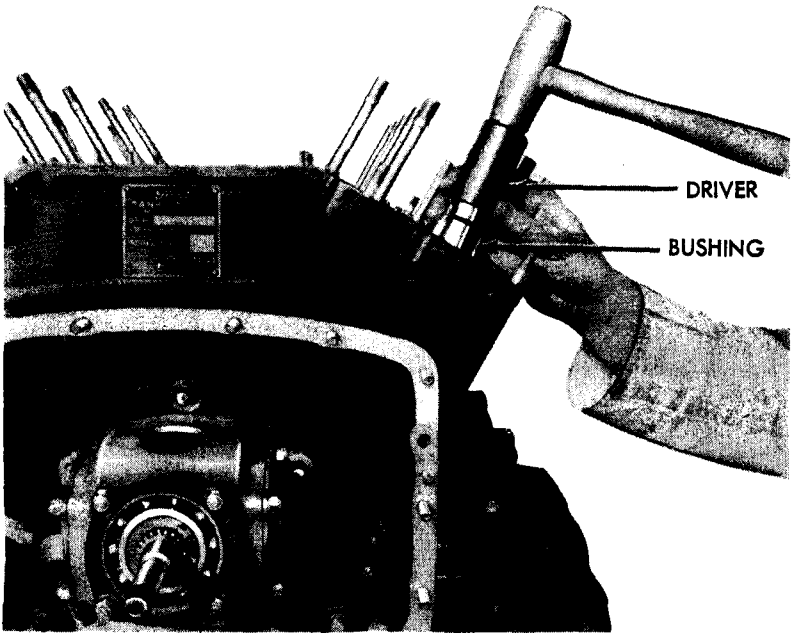

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Figure 27 — Driving Lower Camshaft Drive Shaft Bronze Bushing in Cylinder Block

ing operations are completed, it is essential that the cylinder block be thoroughly cleaned to remove all traces of abrasive materials. Particular attention should be given to all drilled oil passages.

(5) CYLINDER SLEEVE REPLACEMENT. Install the cylinder sleeve replacer (41-P-2907-117) in the cylinder block (fig. 24), and pull the sleeves out of the block. To install a new sleeve, place the sleeve in position on the block and install the sleeve, using the replacer (41-P-2907-117) (fig. 25). Be sure the sleeve is seated firmly in the recess of the cylinder block. A sleeve properly seated should be from 0.013 inch to 0.015 inch below the surface of the cylinder block, and can be measured as shown in figure 26.

(6) LOWER CAMSHAFT DRIVE SHAFT BRONZE BUSHING REPLACEMENT (IN CYLINDER BLOCK). To remove lower camshaft drive shaft bushing, insert a suitable driver in the bottom of the bushing and drive the bushing upward. To install new bushings, use a suitable driver and drive the bushings until they are firmly seated in each cylinder block (fig. 27). These bushings are bored to size and do not require reaming after installation.

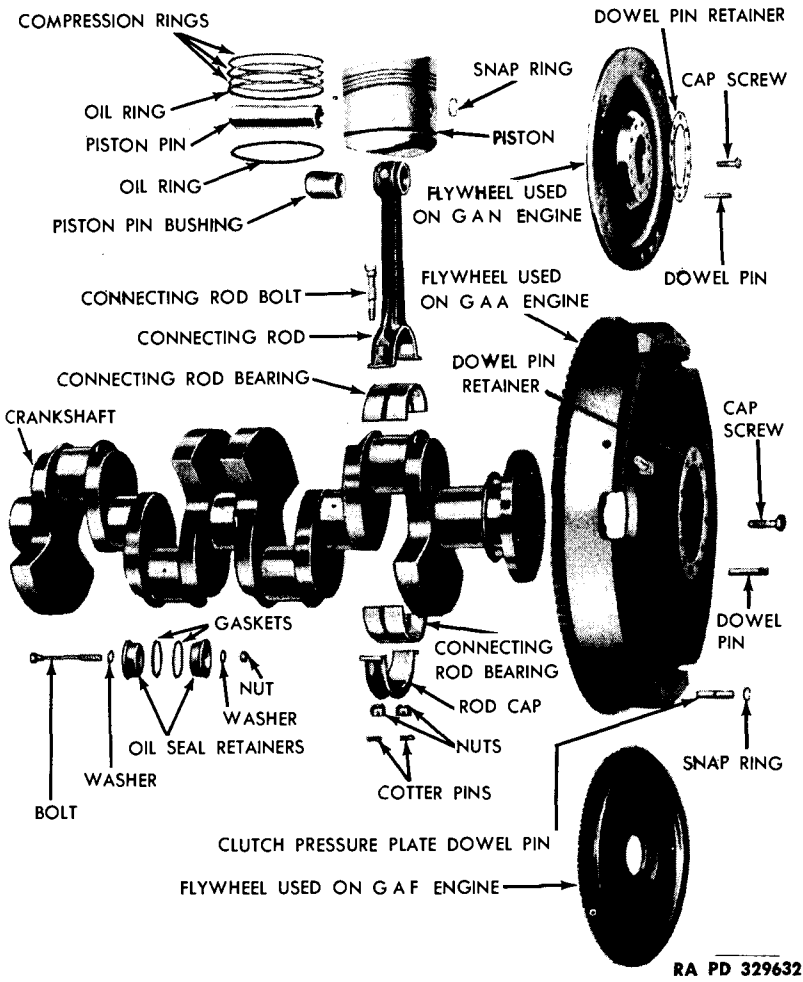
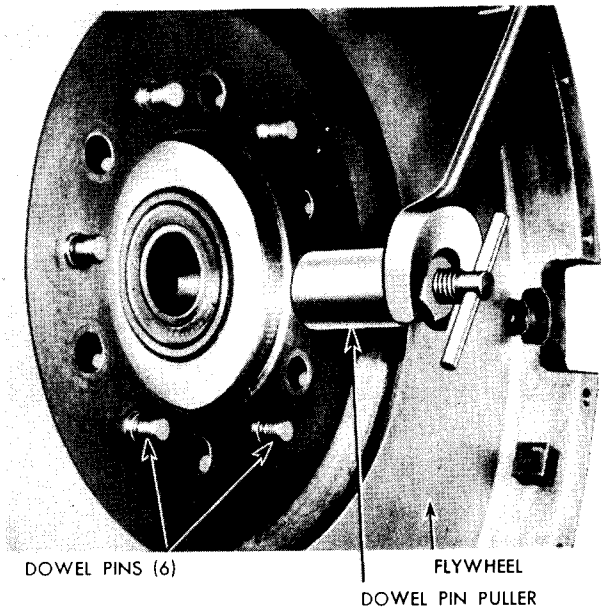


Figure 28 — Crankshaft, Connecting Rod, and Flywheel Used on GAA, GAN, and GAF Engines, Disassembled

13. CRANKSHAFT AND FLYWHEEL.

a. Description (fig. 28). The crankshaft is cast steel and has four counterweights cast integral with the crankshaft. Nos. 1 and 4 crankpins are positioned directly opposite (180 deg) from Nos. 2 and 3 crankpins. Each crankpin is hollow to reduce its weight and to provide an oil passage to the connecting rod bearing. These passages contain removable seals at the ends for holding the oil in



RA PD 28071

Figure 29 — Pulling Dowels From Flywheel on GAA and GAN Engines, Using Puller (41-P-2907-190)

the passages. Oil passages having removable seals for holding the oil are likewise provided at Nos. 2, 3, and 4 main bearings. Oil is supplied under pressure to the five main bearings through drilled holes in the crankcase leading to the main oil manifold in the crankcase. Oil is supplied to the passages in crankpins through holes drilled on an angle which lead to the oil passages in Nos. 2, 3, and 4 main bearings. The early type GAA engines up to engine No. 11084 do not contain seals at No. 3 main bearing.

b. Disassembly.

(1) REMOVE FLYWHEEL FROM CRANKSHAFT FLANGE ON GAA AND GAN ENGINES. Take out the six screws which secure the flywheel to the crankshaft flange, and remove the dowel pin retainer (fig. 28). Screw the dowel pin puller (41-P-2907-190) (fig. 29) on the threaded end of a dowel pin, and pull the dowels from the flywheel by tightening the hexagonal nut on the puller. Remove the flywheel from the crankshaft flange.

(2) REMOVE FLYWHEEL FROM CRANKSHAFT FLANGE ON GAF ENGINE. Indent the end of each dowel exactly in the center with a center punch. Drill a $^{21}/_{64}$-inch hole approximately $^{3}/_{4}$ inch deep in the center of each dowel. Tap a $^{3}/_{8}$-inch, 24-thread hole, $^{5}/_{8}$ inch

deep, in each dowel. Install a dowel puller (41-P-2907-122) in the threaded hole. Hold the puller bolt stationary and tighten the nut, and at the same time tap the head of the bolt with a soft-faced hammer to assist in loosening the dowel.

(3) REMOVE OIL SEAL RETAINERS FROM CRANKSHAFT OIL PASSAGES. Remove the cotter pin and nut from the oil seal retainer bolt (fig. 28) and take out the bolt. The retainers and gaskets (fig. 28) can now be lifted out of the crankshaft. This same procedure applies for removing the oil seal retainer from each of the crankpins and main bearing journals.

c. Cleaning. Clean the main oil passages and the angular drilled holes, using a rifle brush and dry-cleaning solvent under pressure. Blow out all oil passages with compressed air, making sure all oil passages are open.

d. Inspection.

(1) CRANKSHAFT. Inspect connecting rod journals for wear and scores. The manufacturer's dimensions for a standard crankshaft are 3.2505 inches to 3.2510 inches. Connecting rod journals that are worn and measure less than 3.2495 inches must be reground to 3.2305 inches to 3.2310 inches to accommodate a 0.020 inch undersize bearing. Any crankshafts that have connecting rod journals showing wear to 3.2295 inches must be discarded as additional grinding will not be permitted. Connecting rod journals that are out-of-round more than 0.002 inch must be reground or the crankshaft must be replaced. Inspect the main bearing journals for wear or scores. The manufacturer's dimensions for main bearing journals on a standard crankshaft are 3.3755 inches to 3.3760 inches. Main bearing journals that are worn and measure less than 3.3745 inches must be reground to 3.3555 to 3.3560 inches and renitrited to accommodate a 0.020-inch undersize main bearing. Crankshafts that have main bearing journals showing wear of less than 3.3545 inches must be discarded as additional grinding will not be permitted. Main bearing journals that are out-of-round more than 0.001 inch must be reground or the crankshaft must be replaced. Light scores and scratches can be removed by polishing journals with crocus cloth (subpar. e (1) below).

(2) BEARING LINERS. Replace main bearing liners that are pitted or scored. Check the wear of the thickness of the main bearing liners. This can be done by placing a round piece of accurately ground or rolled bar stock on the inside surface of the bearing. Measure the thickness of the two pieces with a micrometer and deduct the thickness of the bar from the total reading. The manufacturer's dimensions for the thickness of the main bearings are 0.1972 inch to 0.1975 inch. If the bearings are worn and measure less than 0.1905 inch, replace the bearings.

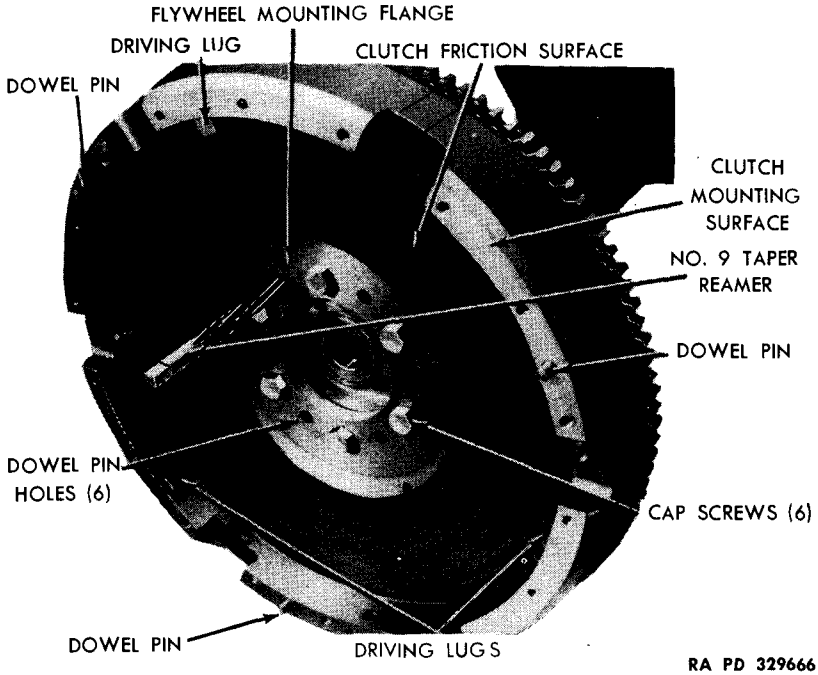
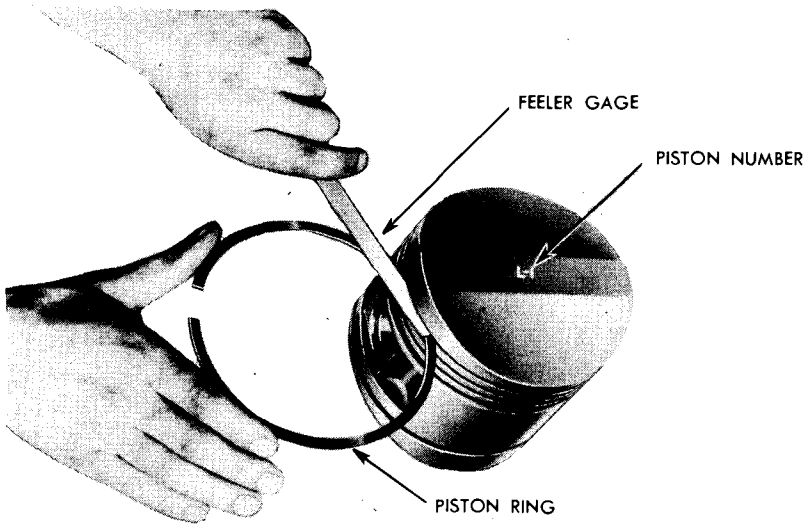


Figure 30 — Reaming Flywheel to Crankshaft Dowel Holes, Using Reamer (41-R-2307-500)

(3) FLYWHEEL. Examine the starter ring gear for cracked or damaged teeth. If damaged, it will be necessary to install a new gear on the flywheel (subpar. e (2) *(a)* below). If working on the GAA engine, check the clutch friction surface on the flywheel. If it is excessively worn or badly scored, it must be refaced. Measure from the face of the clutch mounting surface to the clutch friction surface (fig. 30). If it is anticipated that the refacing operation will reach a minimum depth of 2.909 inches before the flywheel surface will clean up, the flywheel must be discarded. Check the width of each driving lug. The manufacturer's dimensions are 0.7375 inch to 0.7385 inch. Driving lugs that are worn and measure less than 0.730 inch must be replaced. Any driving lugs found scored must also be replaced.

e. Repair.

(1) CRANKSHAFT. Remove the light scores and scratches on the journals by polishing with a crocus cloth. Bearing material that has fused to otherwise undamaged journals and the metal that has raised up around small nicks can be removed by careful honing with a fine sharpening stone. After honing, the journal must be polished



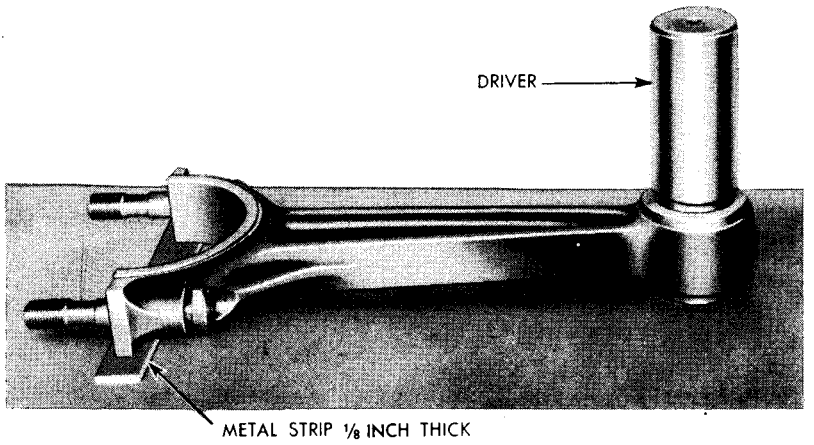
RA PD 27859

Figure 31 — Checking Piston Ring Side Clearance

with a crocus cloth. Thoroughly clean the crankshaft, making sure that all abrasives are removed from the oil passages. Do not regrind crankshaft unless facilities are available for hardening crankshaft journals to a Vickers hardness of 670 to 750 or superficial Rockwell hardness of 86.5 to 90. The crankshaft may be ground to exactly 0.020 inch undersize, then hardened by subjecting it for 40 hours at 960° F to a 20 percent ammonium dissocation atmosphere. After this treatment polish the journals of the crankshaft with crocus cloth. Remove all abrasives from oil passages and coat journals with light engine oil.

(2) FLYWHEEL.

(a) Starter Ring Gear Replacement on GAA and GAN Engines. To remove, drill a $^{3}/_{16}$-inch hole nearly through the ring gear on the engine side of the gear. Cut the remaining portion of the ring gear with a chisel and hammer until it separates, and lift the ring gear off the flywheel. To install a new ring gear, clean the starter ring gear surface on the flywheel and apply heat evenly to 360° F on the ring gear to cause it to expand. When the ring gear is thoroughly heated, place it on the cold flywheel, making sure it is firmly seated on the flywheel. The ring gear on early production GAA engines is spot-welded to the flywheel. The flywheel must be replaced when the ring gear is damaged on these engines.



RA PD 350556

Figure 32 — Driving Connecting Rod Piston Pin Bushing, Using Replacer (41-R-2369-550)

(b) Refacing the Flywheel. The clutch friction surface on the flywheel (fig. 30) should be gone over with fine flint paper to remove corrosion and light scratches. If the flywheel clutch friction surface requires refacing, remove the driving lugs and three dowel pins from the clutch mounting surface and machine the clutch friction surface until all evidence of scores is removed. The same amount of material must be machined from the clutch mounting surface to obtain the original depth of 1.560 inches to 1.564 inches from this point to the clutch friction surface (fig. 30). If the refacing of the clutch friction surface does not clean up when it reaches a minimum depth of 1.909 inches when measured from the clutch mounting surface to the flywheel mounting flange, the flywheel must be discarded. If new driving lugs are to be installed, they can be squared up with the face of the flywheel by turning them with a wrench. Use a new center driving plate and slip it over the lugs to check them for squareness. The driving plate should slip over them freely with a slight looseness. The flywheel should be thoroughly cleaned after the machining operations, and the surface very lightly coated with oil to prevent rusting if the clutch is not to be assembled immediately.

f. Assembly.

(1) INSTALL OIL SEAL RETAINERS IN CRANKSHAFT OIL PASSAGES. Use new copper gaskets and washers (fig. 28). Install the parts in the order shown in figure 28, and tighten the nut on the bolt with a torque wrench to 6 foot-pounds pull. The same procedure applies to installing the seals in each of the oil passages.

(2) REINSTALL OLD FLYWHEEL ON OLD CRANKSHAFT FLANGE. Clean the crankshaft flange and the recess in the flywheel. See that the surfaces are free from nicks. The holes for the dowel pins are unequally spaced so the flywheel can be assembled only in its original position. Set the flywheel on the crankshaft flange, and line up the dowel pin holes. Insert the cap screws and tighten lightly. Drive in the six dowel pins, using a brass drift and a hammer. Remove the cap screws and place the retainer (fig. 28) over the dowel pins; then screw in the cap screws. This retainer is not used on the GAF engine. Use a torque wrench and tighten to 90-foot pounds tension. Lock the cap screws with wire.

(3) INSTALL FLYWHEEL ON CRANKSHAFT FLANGE WHEN EITHER PART IS NEW. If a new crankshaft or a new flywheel is to be used, it will be necessary to ream the dowel holes. To ream the holes, place the flywheel on the crankshaft flange and screw the six cap screws in snugly; but do not tighten at this time. Use a No. 9 taper reamer, (41-R-2307-500) (fig. 30) and ream one hole. Use a new taper pin for a gage. The proper size for the reamed hole on the GAA and GAN engines is when the shoulder on the taper pin extends out of the hole approximately $\frac{1}{16}$ inch, and $\frac{1}{32}$ inch on the GAF engine when the pin is properly in place. Ream the opposite hole in the same manner. With a brass drift and a hammer, drive the two dowel pins in securely. The cap screws must be tightened securely. Ream the balance of the holes and drive in the dowel pins. Remove the cap screws and install the retainer (fig. 28); then replace the cap screws. This retainer is not used on the GAF engines. Use a torque wrench and tighten to 90 foot-pounds tension. Lock the cap screw with wire.

14. CONNECTING ROD AND PISTON ASSEMBLIES.

a. Description.

(1) CONNECTING RODS. The connecting rods (fig. 28) are steel forgings with an I-beam-type cross section. A bronze bushing in the upper end of the rod provides a bearing for the piston pin. A silver bearing surface is fused on one side of the rod at the crankpin end. This silvered surface acts as a bearing surface for connecting rod side thrust. Each pair of rods is assembled on a crankpin with the silvered edge facing outward. Connecting rods are numbered to identify them by cylinder numbers.

(2) PISTONS. The pistons are aluminum alloy, with cam-ground solid skirt. Pistons are stamped to identify them by cylinder number. Three compression rings and two oil rings are used on each piston. One of the oil rings is located below the piston pin (fig. 28).

(3) PISTON PINS (fig. 28). The piston pin floats in both the piston and the connecting rod bushing. The piston pins are held in the piston by a snap ring retainer at each end of the piston pin hole.

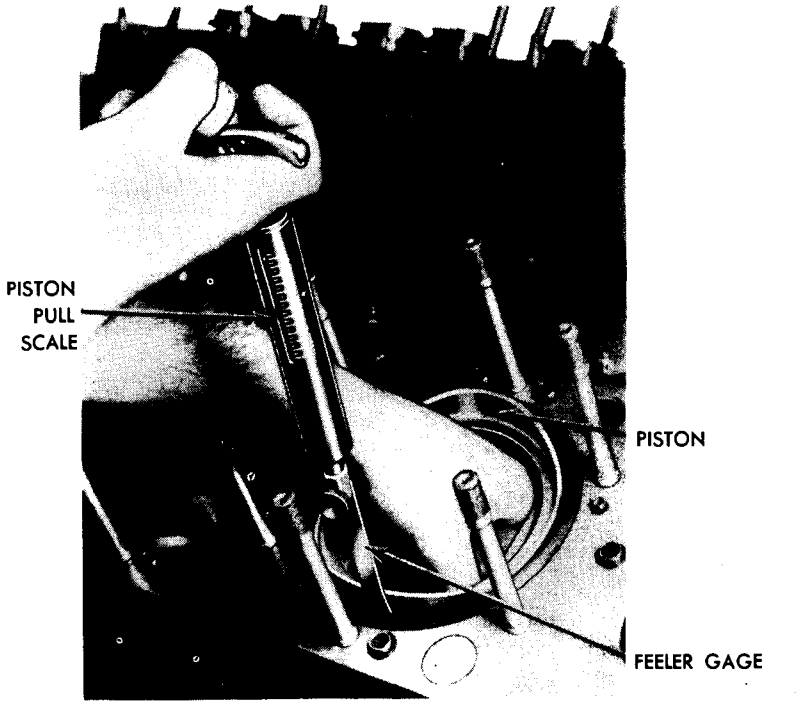


Figure 33 — Fitting Piston in Cylinder

b. Disassembly (fig. 28). Remove the piston pin retainers and push the pin from the connecting rod and piston. With a universal piston ring expander, lift the rings from the grooves in the piston.

c. Cleaning. Remove carbon from the top of the pistons and piston ring grooves. Be sure the oilholes in the oil ring groove are not plugged with carbon. Wash all parts, using dry-cleaning solvent.

d. Inspection.

(1) CONNECTING RODS. Check connecting rods for alinement. Do not attempt to straighten or use a bent or twisted rod. Install the rod bearing cap on the connecting rod; be sure the numbers on the rod and cap are numbered the same. Install the nuts on the connecting rod bolts and tighten to 54 to 60 foot-pounds. Check the inside diameter of the rod at the lower end. The manufacturer's dimensions are 3.7510 inches to 3.7515 inches. Some very early production rods were made 0.001 inch less than these dimensions. Any connecting rod which has an inside dimension less than 3.7510 inches must be honed out to 3.7510 inches to 3.7515 inches to be serviceable. If the inside diameter of the rod is worn to more than

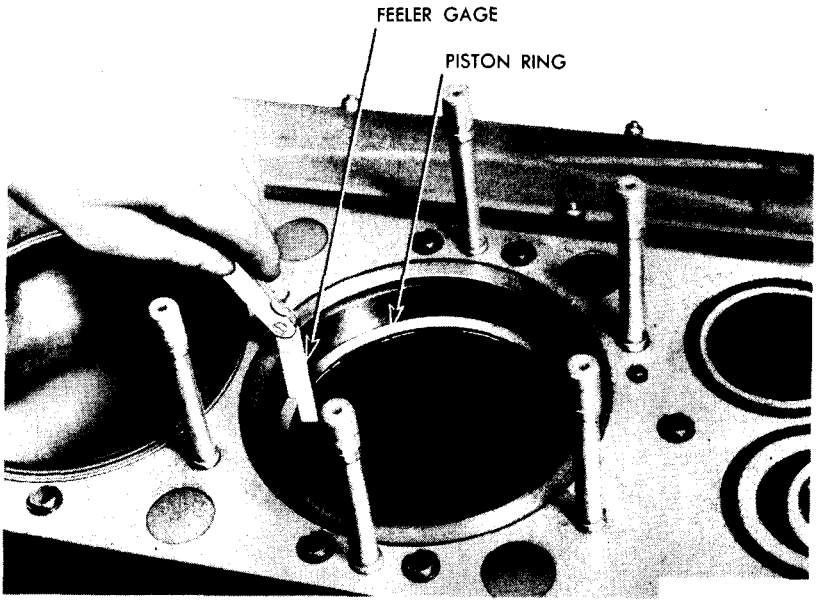


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Figure 34 — Checking Piston Ring Gap

3.753 inches, the rod must be replaced. Check the inside diameter of the bronze bushing at the upper end of the rod. The manufacturer's dimensions are 1.3750 inches to 1.3753 inches. If the bronze bushing is worn to more than 1.3763 inches, it must be replaced with a new bushing (subpar. e (1) below).

(2) CONNECTING ROD BEARING LINERS. Replace connecting rod bearing liners that are pitted or scored or which have poor adhesion between bearing metal and steel back. Check the wear of the bearing liners by measuring the thickness. This can be done by placing a round piece of accurately ground or rolled bar stock on the inside surface of the bearing. Measure the thickness of the two pieces with a micrometer and deduct the thickness of the bar from the total reading. The manufacturer's dimensions for the rod bearing thicknesses are 0.2467 inch to 0.2471 inch. If the bearing liners are worn and measure less than 0.246 inch, replace the liners.

(3) PISTONS. Check pistons for cracks, scores, or worn ring grooves, or damage of any kind. Check each piston with a micrometer to determine the wear on the skirt. Measure the skirt on the piston at the bottom at right angles to the piston pin. The manufacturer's dimensions for a standard piston are 5.389 inches to 5.390 inches. A standard piston that is worn and measures less than 5.382

inches must be replaced. The manufacturer's dimensions for an oversize piston are 5.404 inches to 5.410 inches. An oversize piston that is worn and measures less than 5.402 inches must be replaced. An oversize piston can be identified by letters "OS" stamped on the piston. Check the clearance between the piston rings and ring grooves, using a standard ring with a feeler gage (fig. 31). If the clearance is more than 0.005 inch at the three top ring grooves or more than 0.004 inch at the two bottom ring grooves, the piston must be replaced. Check the diameter of the piston pin hole. The manufacturer's dimensions are 1.3739 inches to 1.3747 inches. If the piston pin hole diameter is worn to more than 1.3757 inches, replace the piston.

(4) PISTON PINS. Check the diameter of the piston pins. The manufacturer's dimensions are 1.3737 inches to 1.3740 inches. If the diameter of the piston pin is worn to less than 1.373 inches, replace the piston pin.

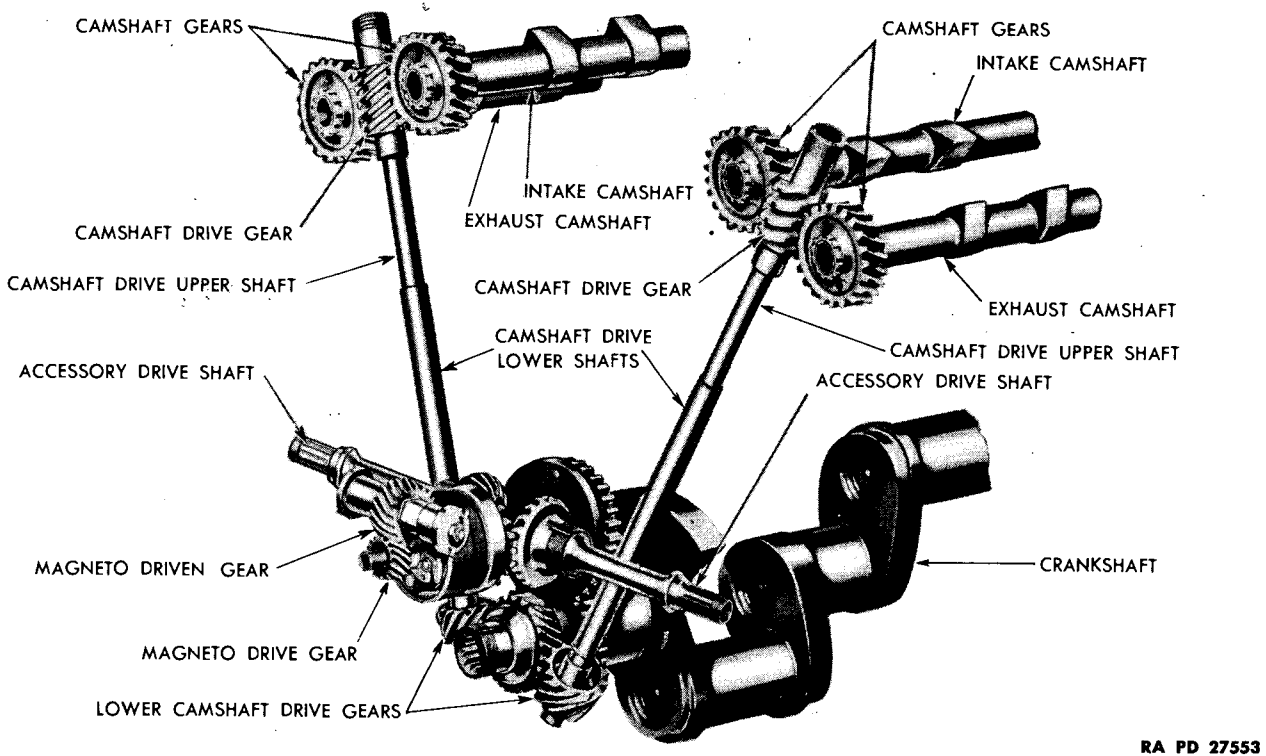
(5) PISTON RINGS. Piston rings are always replaced at overhaul periods. Discard old piston rings without inspection.

e. Repair.

(1) PISTON PIN BUSHING REPLACEMENT. If previous inspection calls for replacement of the bushing, remove and press in a new bushing using the piston pin bushing remover (41-R-2369-550) (fig. 32). This tool is used in connection with an arbor press. Rest the large end of the rod on a strip of metal ⅛-inch thick to level the connecting rod on the arbor press. With a bushing reamer, ream and burnish the bushing to 1.375-0 inches to 1.3753 inches.

(2) FITTING NEW PISTON TO CYLINDER ON ENGINE WITH NEW OR REGROUND CYLINDER BLOCK. Clean cylinder wall and piston thoroughly and wipe dry with a clean cloth. Use piston-fitting scale with three ½-inch wide, 0.004-inch feeler gage blades, 10 inches long. Never use a 0.012-inch blade in place of the three 0.004-inch blades as it will not readily adapt itself to the shape of the piston and a false reading will result. The feeler blades must be inserted on the side of the piston which is at right angles from the piston pin hole. Insert the feeler blades the full length of the cylinder bore. Then completely insert the piston upside down in the cylinder bore (fig. 33). Withdraw the feeler gage and observe the reading on the scale. A pull of 4 to 8 pounds indicates the correct fit.

(3) FITTING A USED PISTON TO A CYLINDER NOT REQUIRING REGRINDING. With a micrometer caliper, measure the diameter of the piston skirt at right angles to the piston pin hole. If a piston is suitable for use in a particular cylinder, measure the cylinder as outlined in paragraph 12 c (3) (b). Subtract the diameter of the piston from the diameter of the cylinder at its largest point. This difference



RA PD 27553

Figure 35 — Accessory Gear Assembly Showing Camshaft Drive, Accessory Drive Shafts, and Magneto Governor and Drive Gear

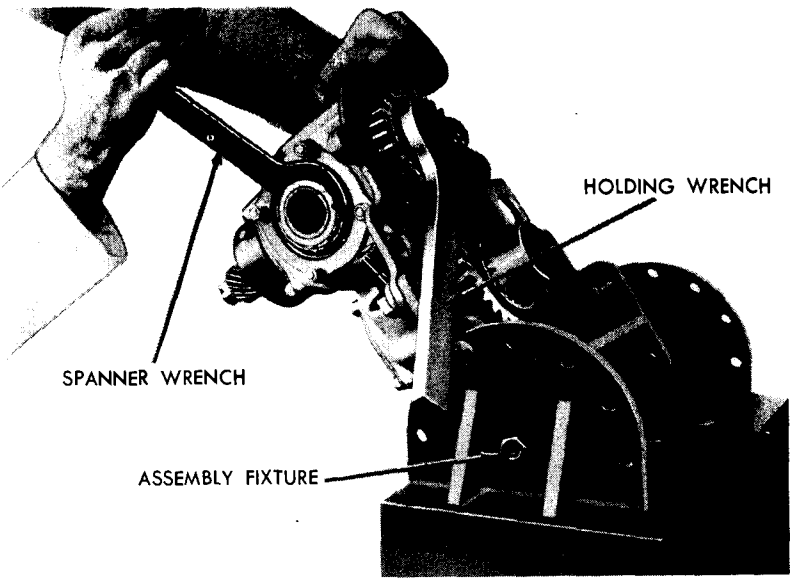


Figure 36 — Accessory Gear Assembly Attached to Fixture (41-F-2987-300)

should not exceed 0.020 inch. If it is anticipated that it will exceed 0.020 inch through wear before the next overhaul period, use a new piston.

(4) FITTING NEW PISTON RINGS IN NEW CYLINDER BLOCK. Place a new ring in the cylinder, pressing it down about halfway into the bore with the bottom of a piston so that the ring will be square with the cylinder wall (fig. 34). Measure the gap between the ends with a feeler gage. If the gap is less than 0.022 inch to 0.027 inch, remove the ring and file with a fine-cut file until the correct gap of 0.022 inch to 0.027 inch is obtained. The above dimension will be proportionately greater on a worn cylinder block.

(5) FITTING RINGS IN PISTON GROOVES. Clean the ring grooves thoroughly. Roll the new ring around its particular groove in the piston (fig. 31). Check its fit in the ring grooves (step (3) above) and install the ring on the piston. Repeat the above procedure for all piston rings.

(6) INSTALL PISTON RINGS ON PISTON. Install each ring on the piston as soon as the gap and its fit in the groove of the piston have been established. The three compression rings are etched with the word "TOP." The side marked "TOP" must be installed toward the

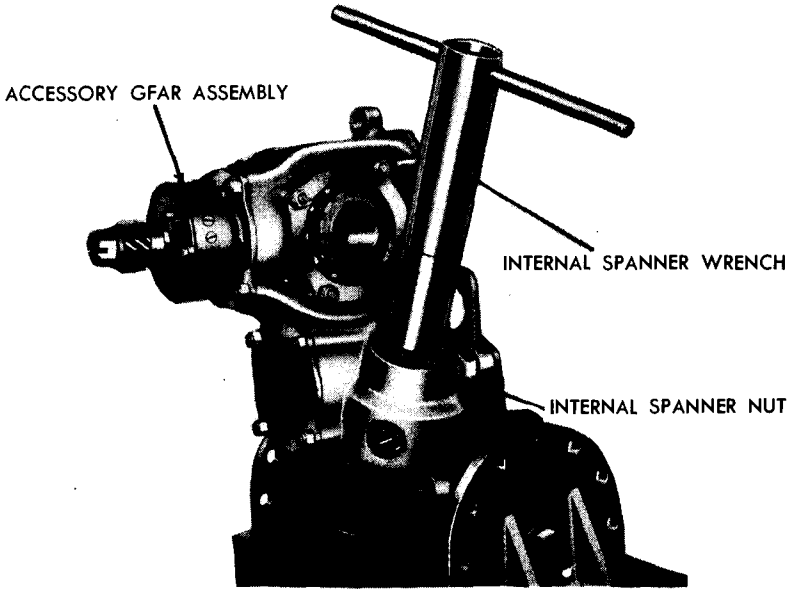


Figure 37 — Removing or Installing Internal Spanner Nut, Using Wrench (41-W-871-28)

top of the piston. The top compression ring is chromium-plated and is easily identified. The two oil rings are identical and may be installed with either side up in the two lower grooves in the piston.

f. Assembly. Install the piston which was previously fitted for the particular cylinder to the connecting rod numbered for that cylinder. If the piston is cold (below 70° F), heat the piston by immersing it in hot water to a temperature of 70° F or higher to expand the piston pin hole. The piston pin can be inserted in the piston by finger-pressure. Install a snap ring retainer in the groove provided in the piston at each end of the pin (fig. 28). NOTE: *If a new piston or connecting rod is used, it is to be numbered; the number will correspond with the cylinder number.*

15. ACCESSORY GEAR ASSEMBLY AND ACCESSORY DRIVE SHAFTS.

a. Description.

(1) GENERAL. The accessory gear assembly is a six-way drive unit (fig. 35) which drives two generators and two fans, a water pump, an oil pump, two magnetos, and four camshafts. The assem-

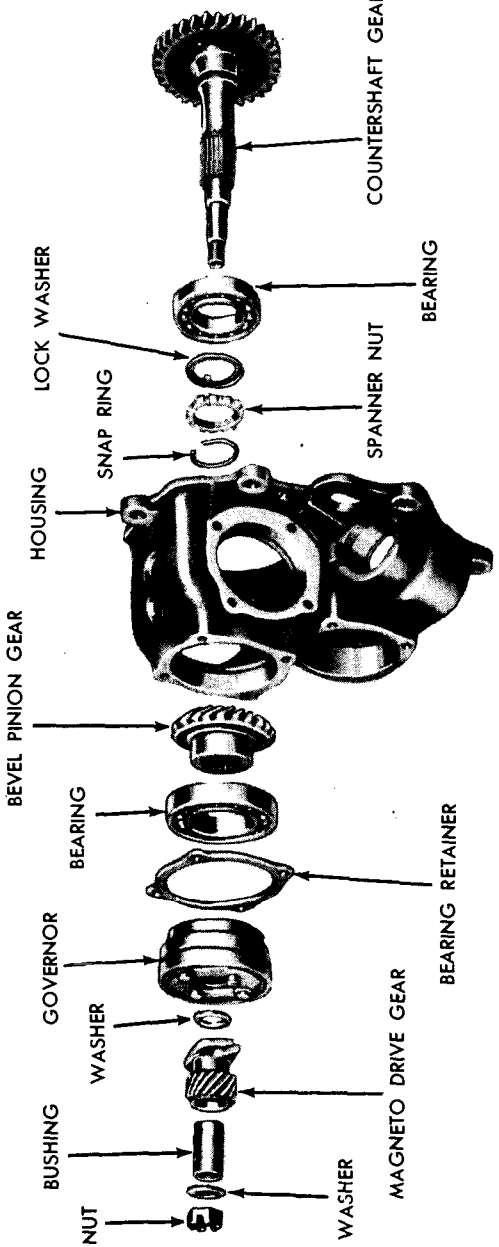


Figure 38 — Countershaft Gear and Governor, Disassembled

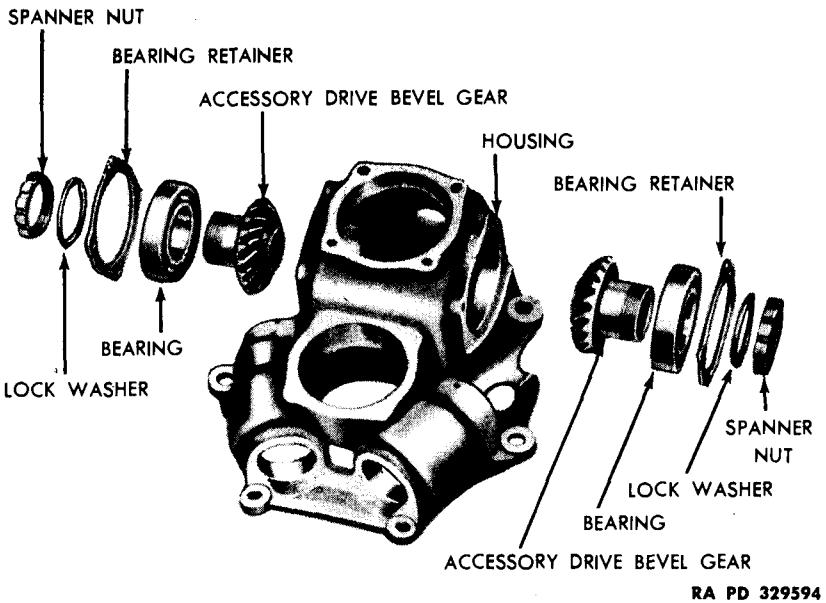


Figure 39 — Accessory Drive Bevel Gears, Disassembled

bly is attached to the rear end of the engine, and is driven by means of a splined driving quill connecting the main driving hub with the crankshaft.

(2) MAIN DRIVING HUB AND GEARS. A helical gear and a worm gear are pressed on the main driving hub (fig. 35). The helical gear meshes with the countershaft gear. The worm gear meshes with two worm gears which drive the camshafts.

(3) UPPER CAMSHAFT GEARS. The intake and exhaust camshafts for each cylinder block are driven by worm gears (fig. 35), and are connected by shafts to the lower cam drive worm gear shafts.

(4) WATER PUMP AND OIL PUMP DRIVES. The water pump is driven off the end of the main driving hub by a splined quill. The oil pump is driven by a splined quill which engages with a spline in the bottom of the lower left camshaft drive shaft.

(5) COUNTERSHAFT AND GEAR. The countershaft gear is integral with the countershaft. The countershaft, through bevel gears, drives the two accessory shafts (fig. 35), which in turn drive the fans. The magneto governor and drive gear are also driven off the end of the countershaft.

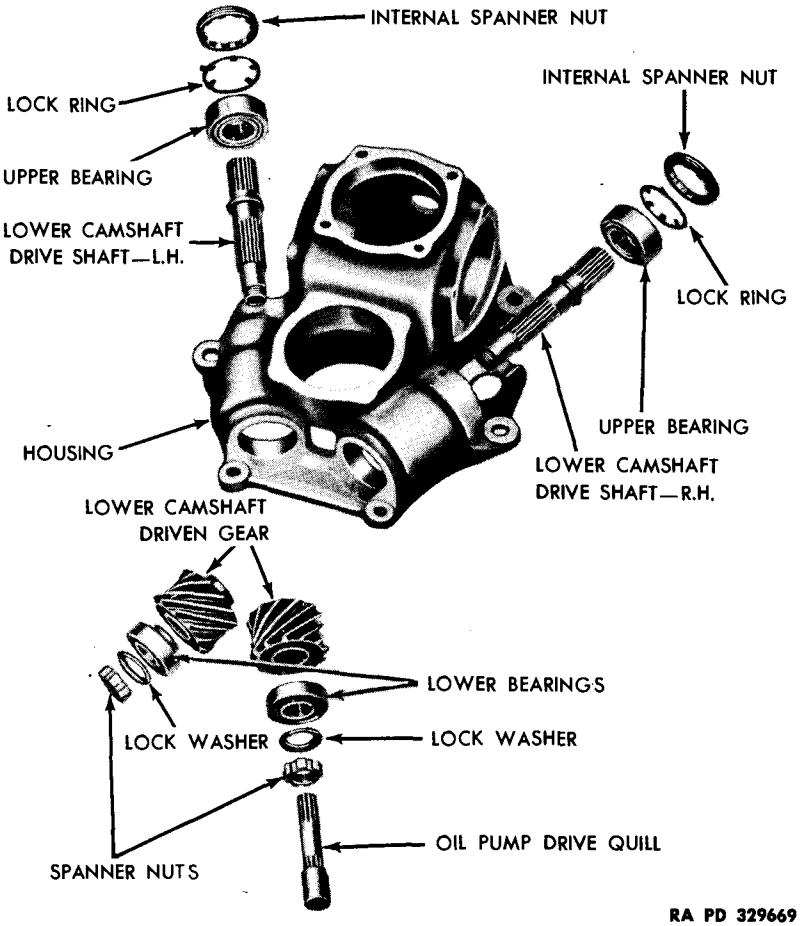


Figure 40 — Lower Camshaft Drive Shafts, Disassembled

b. Disassembly.

(1) INSTALL ACCESSORY GEAR ASSEMBLY ON FIXTURE OR A VISE. Attach the accessory gear assembly to the fixture (41-F-2987-300) as shown in figure 36 if available or use a vise. A holding wrench, as shown in the illustration, is useful for preventing the gears from turning during disassembly and assembly of the unit.

(2) REMOVE ALL SPANNER NUTS. Release all the lock washers from all the spanner nuts. Remove all the spanner nuts, using a suitable spanner wrench or a brass drift and a hammer. Remove the worm gear shaft upper internal spanner nut, using wrench (41-W-871-28) (fig. 37).

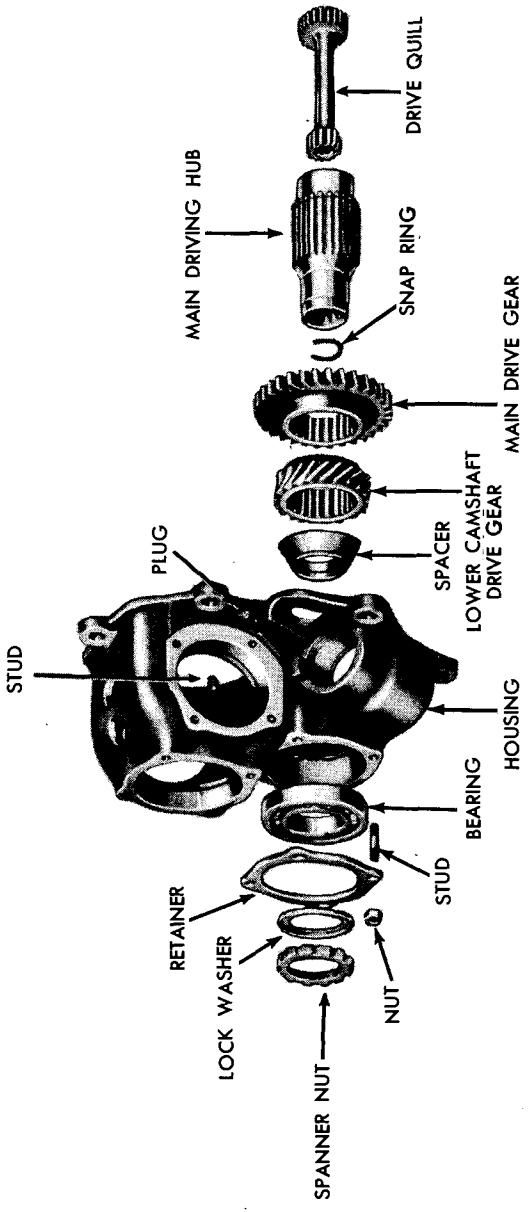


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Figure 41 — Main Drive Gear, Disassembled

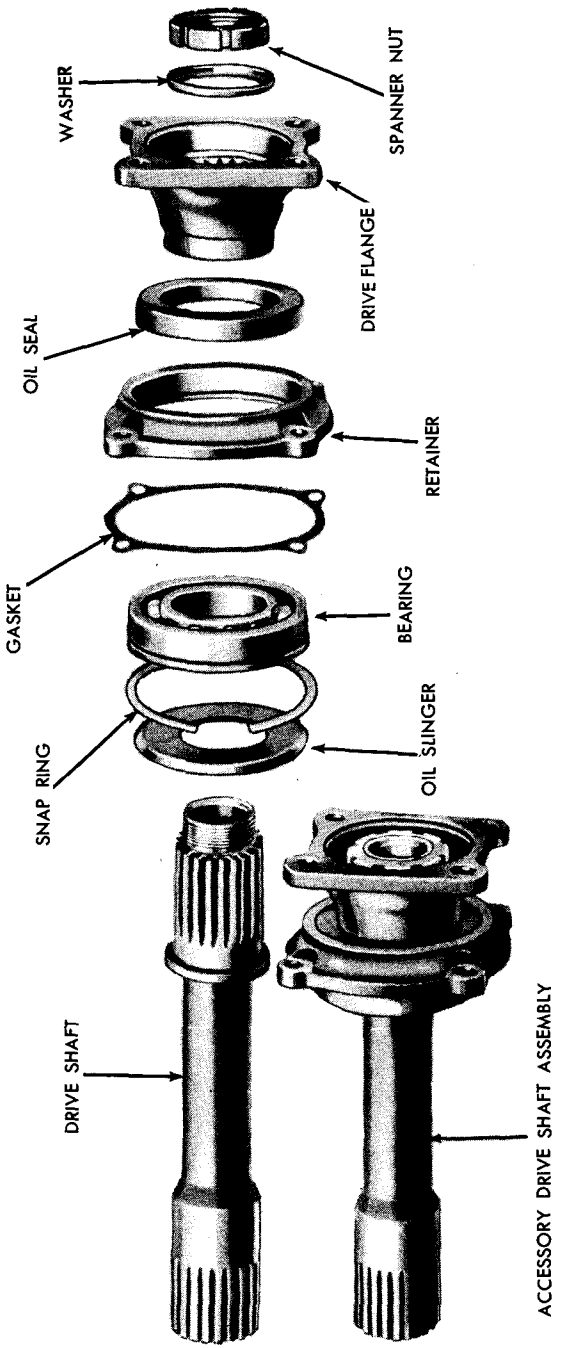


Figure 42 – Accessory Drive Shaft, Disassembled

(3) REMOVE COUNTERSHAFT GEAR AND GOVERNOR (fig. 38). Remove the countershaft nut, and pull the magneto drive gear and the magneto governor from the shaft. After the magneto governor has been removed, the countershaft and gear can be driven from the housing by pushing or tapping on the end of the shaft with a soft-faced hammer.

(4) REMOVE BEVEL PINION GEAR AND BEARING FROM THE HOUSING (fig. 38). Take off the four nuts that secure the bearing retainer to the housing, and remove the retainer. The bevel pinion gear and bearing can be removed from the housing by placing a brass drift through the opening on the other side of the housing and driving on the hub of the gear.

(5) REMOVE ACCESSORY DRIVE BEVEL GEARS FROM HOUSING (fig. 39). Drive the hub of each bevel gear, driving toward the inner side, out of the ball bearing assembly with a brass drift and a hammer. Remove the gears from the housing.

(6) REMOVE LOWER CAMSHAFT DRIVE SHAFTS (fig. 40). Drive each shaft and upper bearing upward from the housing. Use a brass drift and a hammer and drive on the threaded end of the shaft, leaving the lower bearing in the housing.

(7) REMOVE THE MAIN DRIVING HUB FROM THE HOUSING (fig. 41). Drive the hub from the housing with a brass drift and a hammer, driving on the end of the hub from which the spanner nut has been removed. The main drive gear and lower camshaft drive gear can be disassembled from the hub by pressing the hub out of the gears.

(8) REMOVE ALL BEARINGS FROM THE HOUSING. Remove the four nuts from each of the bearing retainers, and remove the retainers and bearings from the housing.

(9) DISASSEMBLE ACCESSORY DRIVE SHAFTS (fig. 42). Release the lock washer, and remove the spanner nut from the shaft. To pull the hub from the shaft, place the shaft in a vise equipped with brass jaws. Using a brass drift and a hammer, drive the shaft out of the drive flange. Slip the bearing and bearing retainer from the shaft. Remove the oil seal from the bearing retainer, and discard the seal.

c. Cleaning. Wash all parts in dry-cleaning solvent. Remove the two ⅛-inch pipe plugs from the housing, clean out the oil passage, and see that the small oilholes are open. A good method for cleaning ball bearings is to dip them in a container of dry-cleaning solvent. The container must be free from metal clips and dirt. Rotate the bearing while immersed in the dry-cleaning solvent, until all trace of lubricant is removed. Hold both races to prevent spinning, and blow the bearing dry with compressed air. Direct the air

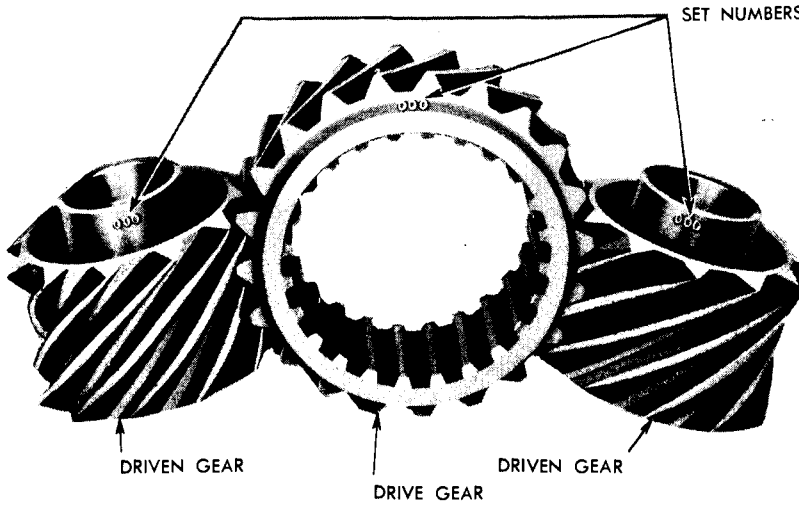


Figure 43 — Lower Cam Drive Worm Gears (Matched Sets)

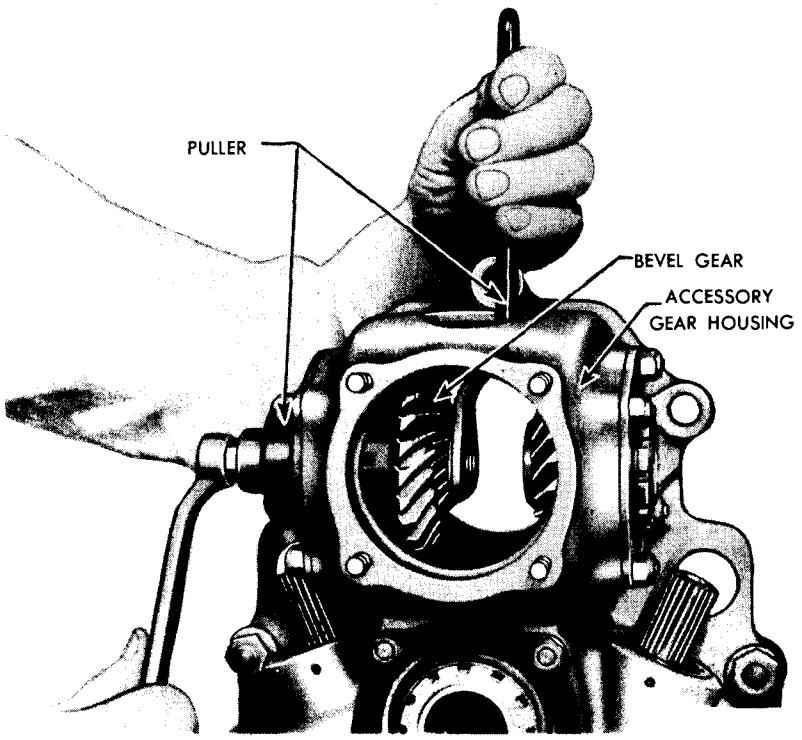
squarely at the side or face of the bearing, that is, so the nozzle is parallel with the bearing bore. Never allow the bearing to spin while drying with compressed air. To do so may cause scratching or scoring by any abrasive material which may not have been washed out. If the bearing is very dirty, rinse it a second time in clean kerosene or dry-cleaning solvent and blow dry. Oil the bearing immediately with clean engine oil to prevent corrosion of the highly polished surfaces. Rotate the bearing so as to distribute the lubricant to all surfaces. Wrap each cleaned bearing in oiled paper if not to be used at once.

d. Inspection.

(1) ACCESSORY GEAR HOUSING. Inspect the housing for cracks or damage of any kind. With a $\frac{3}{16}$-inch socket-head set screw wrench, remove the two $\frac{1}{8}$-inch pipe plugs from the housing and check the metered oil passages to make sure they are free from dirt.

(2) GEARS AND SHAFTS. Gears showing excessive wear or damage are to be discarded. Any shafts showing excessive wear at the splines are also to be discarded.

(3) BEARINGS. The inspection of a ball bearing is best performed after the bearing is washed, dried, and dipped in light oil. The condition of a ball bearing is best determined by the surface condition of the balls and races and the looseness in its races. Check for pits caused by corrosion. Check for discoloration of the balls, races, or retainers, as this may be evidence of overheating. Bearings



RA PD 350557

Figure 44 — Pulling Accessory Bevel Gear Through Bearing, Using Replacer (41-R-2389-400)

that have been overheated must be discarded. Spinning a bearing while holding it in the hands is not an accurate check of its running qualities, although this test will indicate presence of dirt or foreign matter in the bearing. Bearings in this condition are to be rewashed, lubricated, and rechecked.

e. **Assembly.**

(1) GENERAL. Any parts which previous inspection has proven unfit for further use must be replaced. The lower cam drive worm gears are supplied in sets and must be installed in sets. The set number is stamped on each gear (fig. 43). Lubricant must be applied on all spanner-type nuts at the point where the nuts contact the lock washers. This will prevent the locks turning with the nuts when tightening, thus avoiding the inner tabs being sheared off the lock washer.

(2) INSTALL ACCESSORY DRIVE BEVEL GEAR BEARINGS IN HOUSING (fig. 39). Attach the accessory gear housing to the assembly

fixture (41-F-2987-300) (fig. 36) if available or use a vise. Place the bearing in the recess in the housing. Place the bearing retainer over the studs, and secure with four boot-type nuts. The same procedure applies when installing the bearing on the opposite side of the housing.

(3) INSTALL ACCESSORY BEVEL GEARS IN HOUSING (fig. 39). Start the hub of the bevel gear into the bearing through the inner side of the housing, attach the replacer (41-R-2389-400) as shown in figure 44, and pull the hub of the gear through the bearing. The same procedure applies when installing the gear on the opposite side of the housing.

(4) INSTALL BEVEL PINION GEAR AND BEARING ASSEMBLY IN HOUSING (fig. 38). Place the bearing on the hub of the bevel pinion gear and drive the gear and the bearing assembly into the recess in the housing, using a brass drift and a hammer. Install the bearing retainer over the bearing, and secure the four boot-type nuts.

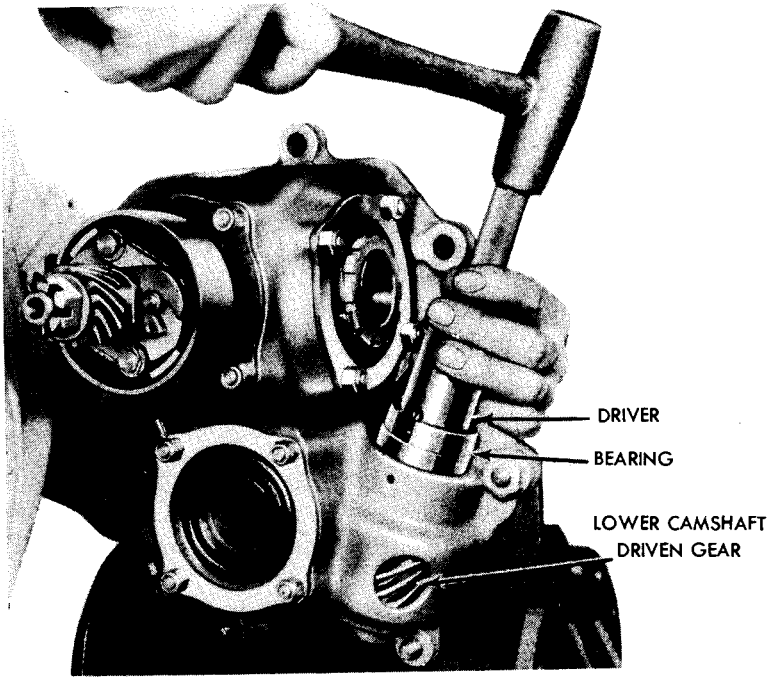
(5) ASSEMBLE BEARING ON COUNTERSHAFT (fig. 38). Press the bearing on the countershaft and secure it in place with a spanner nut and lock washer. Indent the lock washer in the notches of the spanner nut at three points, using a round-nosed punch.

(6) INSTALL COUNTERSHAFT GEAR ASSEMBLY IN HOUSING (fig. 38). Install the retainer ring (two halves) in the groove provided on the countershaft. Use heavy grease on this retainer ring to keep it from falling out of the groove during assembly. Insert the countershaft through the housing and through the spline of the bevel pinion gear; be sure the mark on the spline of the bevel pinion gear and countershaft are in line with each other. Tap the shaft through the gear until the retainer ring is firmly seated in the recess in the pinion gear.

(7) ASSEMBLE GEARS ON MAIN DRIVING HUB (fig. 41). Insert the snap ring in the groove provided on the inside of the main driving hub. Slide the main drive gear and the lower camshaft drive worm gear on the hub. Place the spacer on the hub with the large end against the lower camshaft drive worm gear.

(8) INSTALL MAIN DRIVING HUB BEARING IN HOUSING (fig. 41). Insert the bearing in the recess in the housing. Tap the bearing lightly with a brass drift and a hammer until the bearing is seated firmly in the housing. Place the bearing retainer over the studs and secure with four boot-type nuts.

(9) PLACE LOWER CAMSHAFT DRIVEN GEARS IN HOUSING. NOTE: *The lower camshaft drive gear and the two driven gears are supplied in matched sets. The set number is stamped on each gear as shown in figure 43. The driven gears (small gears) are also*



RA PD 329671

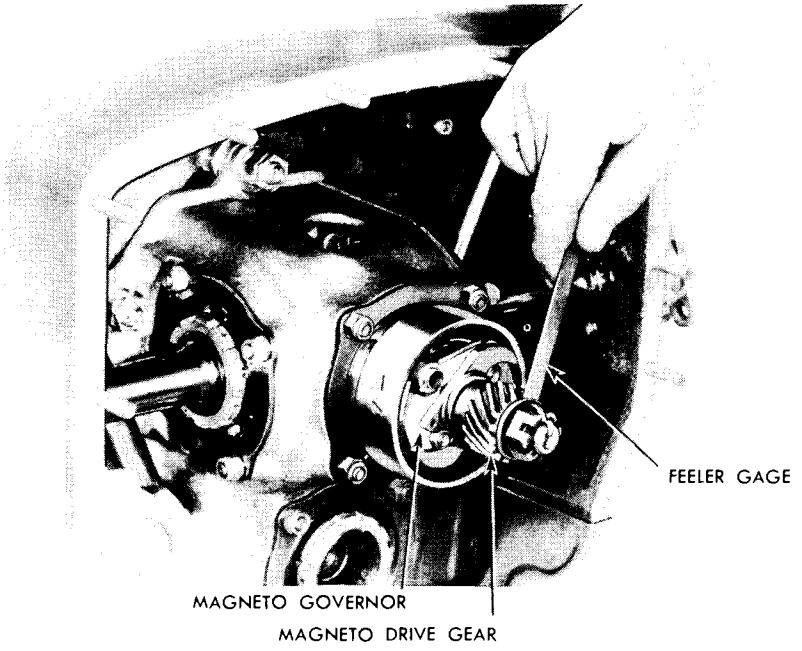
Figure 45 — Installing Lower Camshaft Drive Shaft and Bearing in Housing, Using Replacer (41-R-2380-6)

stamped with the numbers "1" and "2." The gear stamped "1" is to be assembled in the left side of the housing and the gear stamped "2" on the right side of the housing. Place the two driven gears in their proper location in the housing. The long end of the hub on the gears goes to the top.

(10) INSTALL MAIN DRIVING HUB AND GEAR ASSEMBLY IN HOUSING. Insert the main driving hub and gear assembly in the bearing in the housing. Place a fiber block on the end of the driving hub and drive the assembly into the bearing.

(11) INSTALL BEARING ON LOWER CAMSHAFT DRIVE SHAFT (fig. 40). Install the bearing on the top end of the shafts and the drive bearing against the shoulder on the shaft.

(12) INSTALL LOWER CAMSHAFT DRIVE SHAFTS AND BEARINGS IN HOUSING (fig. 40). NOTE: *The lower camshaft drive shaft having a spline on the inside of the shaft which is provided for the oil pump drive quill must be installed on the left side of the housing.*



RA PD 27726

Figure 46 — Checking End Play at Magneto Drive Gear

The shaft not having this spline is to be installed on the right side. Insert the shafts through the lower camshaft driven gears (fig. 40) which were previously set in the housing. With the replacer (41-R-2380-6), drive the shafts through the gears until the bearings are seated in the recess in the housing (fig. 45).

(13) INSTALL BEARINGS IN THE HOUSING AT THE LOWER END OF LOWER CAMSHAFT DRIVE SHAFTS (fig. 40). Insert the bearing over the lower end of one of the shafts with the shoulder on the inner race of the bearing at the top. Tap the bearing in the housing with a brass drift and a hammer. The same procedure applies when installing the bearing on the opposite side.

(14) INSTALL LOCK WASHER AND SPANNER NUT IN HOUSING AT TOP OF EACH LOWER CAMSHAFT DRIVE SHAFT (fig. 40). Insert the lock washer in the housing with the tab on the outer edge of the washer in the drilled hole at the side of the nut recesses. Install the spanner nut and tighten with the special internal spanner wrench (41-W-871-28) (fig. 37). Lock the nuts by bending a tab of the lock washer into a notch on the nuts.

(15) INSTALL SPANNER NUTS ON ACCESSORY DRIVE BEVEL GEARS. Install the lock washer and the spanner nut on each of the accessory drive bevel gears. Tighten the nuts, using a suitable spanner wrench (fig. 36) or a brass drift and a hammer. Indent the lock washers in the notches of the nut at three points, using a round-nosed punch.

(16) INSTALL SPANNER NUT ON THE MAIN DRIVING HUB (fig. 41). Install the lock washer and spanner nut on the main driving hub. Tighten the nut, using a spanner wrench or a brass drift and a hammer. Indent the lock washer in the notches of the nut at three points, using a round-nosed punch for indenting the lock washer.

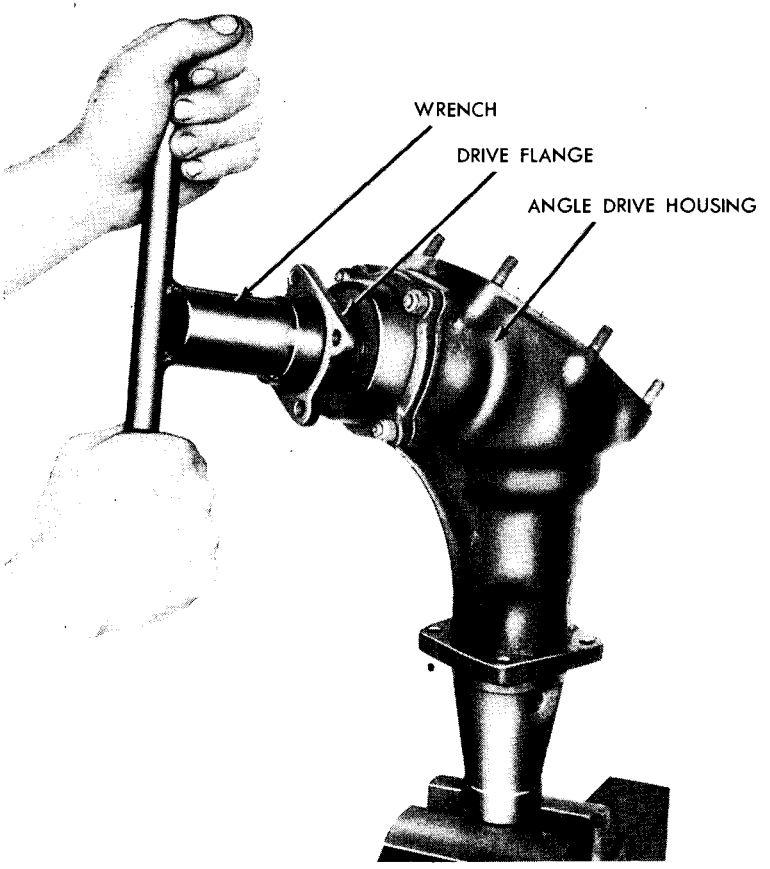
(17) INSTALL SPANNER NUTS ON LOWER END OF LOWER CAMSHAFT DRIVE SHAFTS (fig. 40). Install the lock washers and the spanner nuts on the lower end of the shafts. Tighten the nuts, using a holding wrench or a brass drift and a hammer. To hold the gears from turning while tightening the nuts, use a fiber block or a spanner wrench as shown in figure 36. Indent the lock washers in the notches of the nuts at three points. Use a round-nosed punch for indenting the lock washers.

(18) INSTALL MAGNETO GOVERNOR AND MAGNETO DRIVE GEAR. NOTE: *If previous inspection has shown the magneto governor assembly unfit for further use, it must be replaced as this unit is supplied for service as an assembly.* Slip the governor on the spline of the countershaft, then install washer, bushing, and magneto drive gear in the order shown in figure 38. The magneto drive gear (fig. 38) is of the floating type, and must be free on the bushing. Be sure the rollers on the governor weights are in the slots of the magneto drive gear flange. Secure the assembly on the shaft with the castellated nut and flat washer (fig. 38). Lock the nut with a cotter pin.

(19) CHECK MAGNETO DRIVE GEAR FOR END PLAY. The end play for the magneto drive gear must be 0.003 inch to 0.010 inch. To check the end play, place a feeler gage between the washer and the gear as shown in figure 46. This end play is controlled by the length of the bushing. To increase the end play, select a longer bushing. To decrease the end play, select a shorter bushing.

(20) INSTALL OIL SEAL IN ACCESSORY DRIVE SHAFT RETAINER (fig. 42). Place a new oil seal on the accessory drive shaft retainer, being sure the nonmetallic part of the seal goes toward the accessory housing, and tap it lightly into place, using a brass drift and a hammer. The same procedure applies to each of the retainers.

(21) ASSEMBLE ACCESSORY DRIVE SHAFTS. Assemble the parts on one accessory shaft in the order shown in figure 42. Secure the hub on the shaft with a lock washer and a spanner nut. Tighten the nut, using a spanner wrench or a brass drift and a hammer. Indent



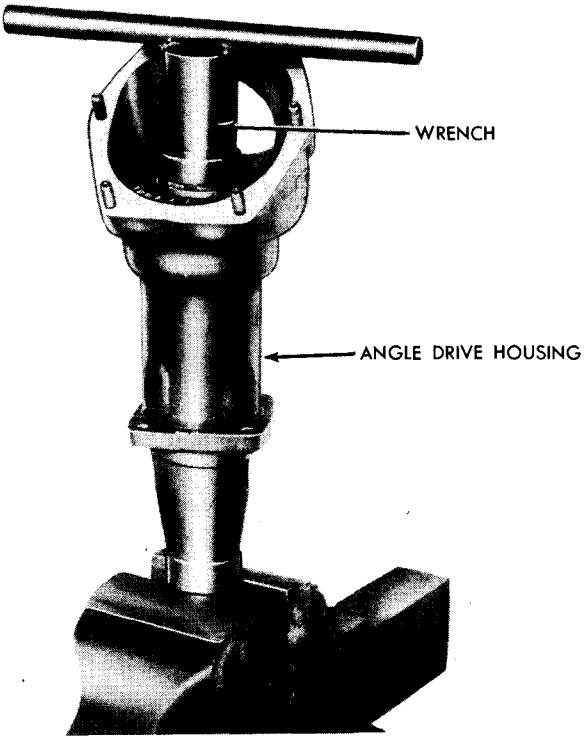
RA PD 329647

Figure 47 — Removing Spanner Nut From Driving Gear, Using Spanner Wrench (41-W-3736-155)

the lock washer in the notches of the spanner nut at three points, using a round-nosed punch. The same assembly procedure applies to each of the accessory shafts.

16. ANGLE DRIVES (USED ON GAF ENGINES ONLY).

a. Description. Power to drive the fans, generator, and differential oil pump is supplied by the main engine through the angle drives (fig. 5) on each side of the engine. The angle drives are driven by the crankshaft through the accessory drive gear assembly inside the engine at the magneto end. The angle drives are used to transmit



RA PD 329648

Figure 48 — Removing Spanner Nut From Driven Shaft, Using Wrench (41-W-3736-155)

the power at the proper angle so the propeller shafts can be connected in nearly a straight line with the fan drive hubs.

b. Disassembly.

(1) REMOVE DRIVING GEAR ASSEMBLY (fig. 49). Place the angle drive assembly in a vise equipped with brass jaws. Remove the six nuts that secure the cover to the housing and remove the cover. Release the lock washer from the spanner nut that secures the drive flange to the driving gear and remove the spanner nut, using wrench (41-W-3736-155) (fig. 47). Remove the lock washers. Remove the four nuts that secure the bearing cage to the housing. Using a brass drift and a hammer, drive the driving gear and bearing cage out of the housing. Remove the bearings and spacer from the driving gear. Tap the oil seal out of the bearing cage.

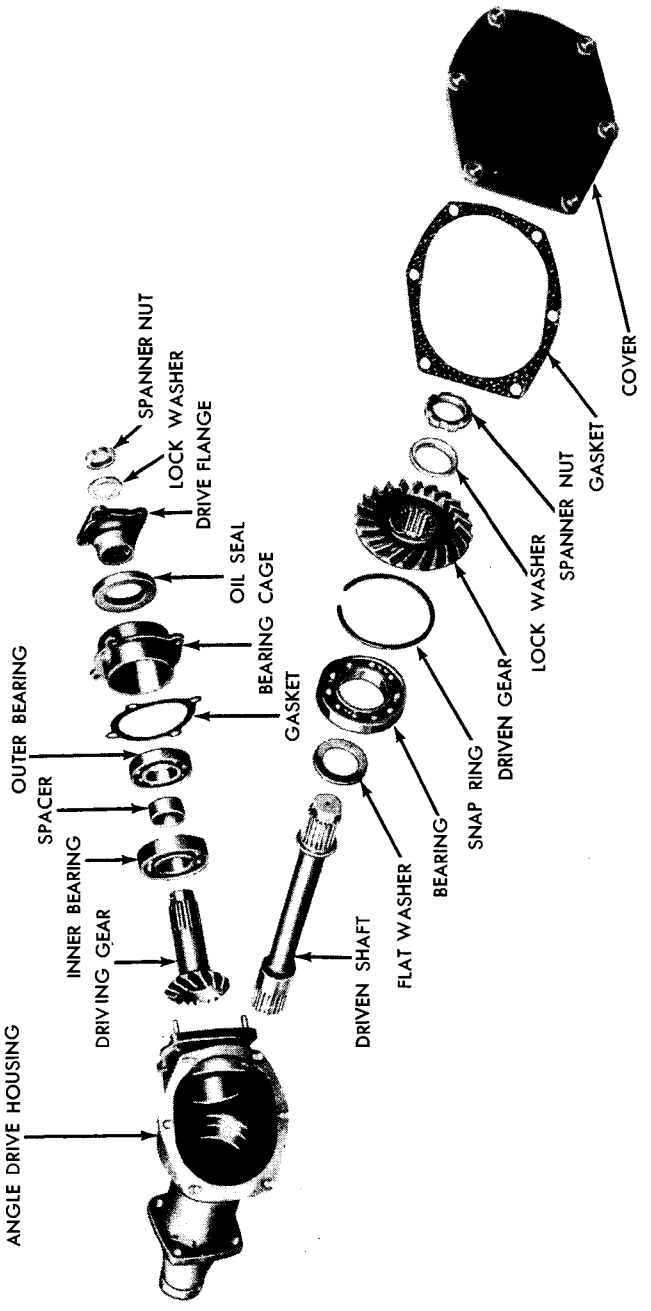
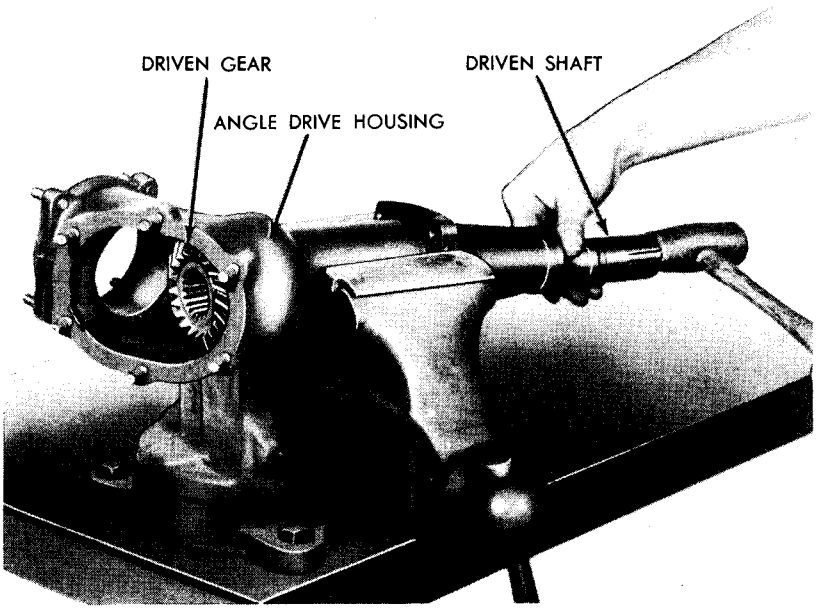


Figure 49 — Angle Drive, Disassembled



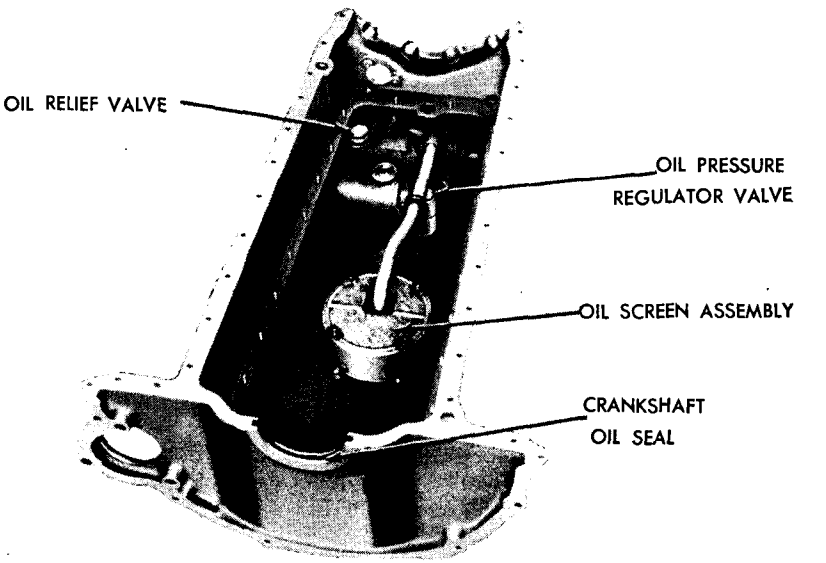
RA PD 329637

Figure 50 — Removing Driven Gear From Bearing

(2) REMOVE DRIVEN SHAFT FROM HOUSING (fig. 49). Release the lock washer from the spanner nut that secures the driven gear to the shaft. Remove the spanner nut from the drive shaft, using wrench (41-W-3736-155) (fig. 48). Remove the lock washer from the shaft. Using a brass drift and a hammer, drive the shaft out of the gear. Using the driven shaft as a driver, drive the gear out of the bearing (fig. 50). Remove the snap ring that secures the bearing in the housing. Remove the bearing using a suitable puller. Pull the shaft out of the housing.

c. Cleaning. Clean all parts in dry-cleaning solvent. Discard all old gaskets and oil seals. To clean bearings thoroughly, rotate them while immersed in dry-cleaning solvent until all trace of lubricant has been removed. Oil the bearings immediately after cleaning to prevent rusting of the highly polished surfaces.

d. Inspection. Replace the angle drive housing if it is cracked. Replace any studs that are damaged (par. 12 **d**). Replace any gears that are excessively worn or that have chipped or missing teeth. Replace the driven shaft if the splines are excessively worn. Replace



RA PD 329625

Figure 51 — Engine Oil Pan Assembly (Used on Early Type GAA Engines)

any bearings that are discolored due to overheating or if the bearings bind or show looseness from wear when rotated by hand.

e. Assembly.

(1) ASSEMBLE DRIVEN SHAFT IN HOUSING (fig. 49). Place the flat washer on the driven shaft and insert the shaft into the housing. Oil the bearing, and place the bearing in position in the housing. Tap the outer race of the bearing until the bearing is seated firmly in the housing. Install the snap ring that secures the bearing in the housing. Place the housing in a vise equipped with brass jaws. Tighten the jaws of the vise on the splines of the driven shaft. Place the driven gear on the shaft and tap it onto the shaft, using a brass hammer. Install the lock washer and spanner nut. Tighten the nut, using wrench (41-W-3736-155) (fig. 48). Indent the lock washer at three points in the notches of the spanner nut, using a round-nosed punch.

(2) INSTALL DRIVING GEAR IN HOUSING (fig. 49). Place a new oil seal in position on the bearing cage, being sure the nonmetallic part of the seal is toward the inner side of the cage. Place the inner bearing, spacer, and outer bearing on the driving gear and place this assembly into the bearing cage. Place a new gasket and the bearing cage on the housing, and install the four nuts that secure the cage on the housing. Place the drive flange on the driving gear splines, and

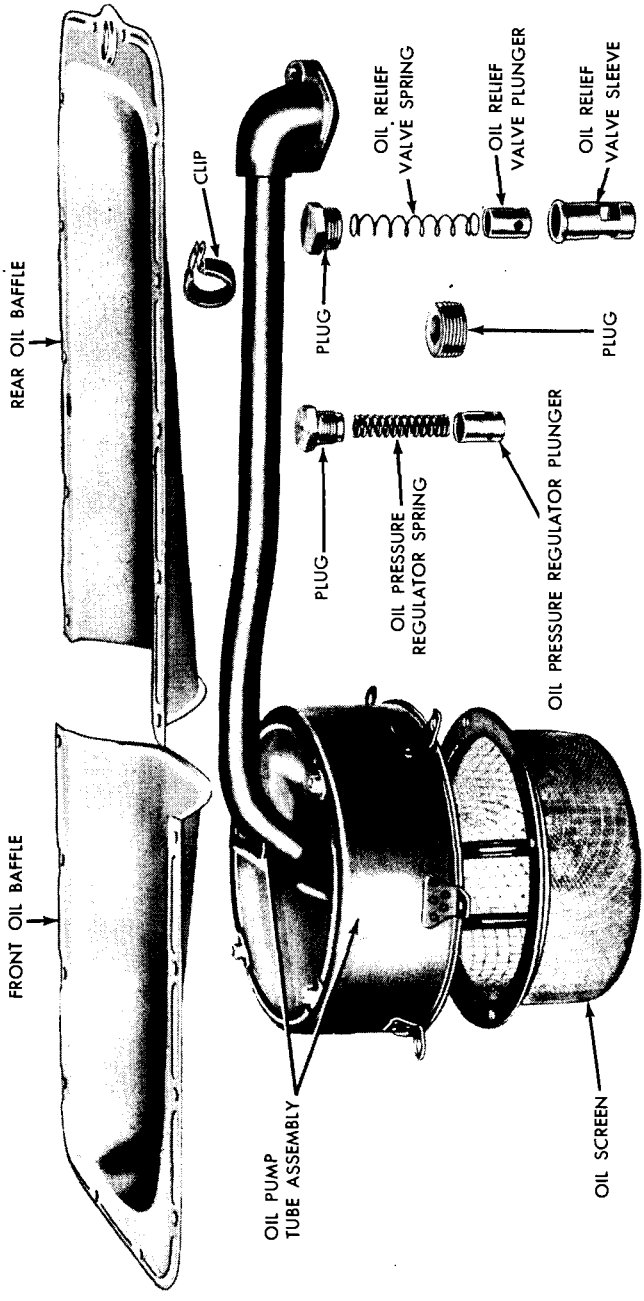


Figure 52 — Oil Pressure Regulator, Oil Relief Valve, Oil Screen and Oil Pan Baffles, Disassembled (Used on Early Type GAA Engines)

install the lock washer and spanner nut. Tighten the nut, using wrench (41-W-3736-155) (fig. 47). Install a new gasket and the cover on the housing, and install the six nuts that secure the cover to the housing.

17. OIL PAN ASSEMBLY (USED ON EARLY TYPE GAA ENGINES).

a. Description. The engine oil pan is an aluminum casting, and the assembly includes an oil screen secured to the bottom of the pan, an oil pressure regulator, and an oil relief valve, all of which are accessible only when the pan is removed from the engine (fig. 51). Two oil baffles are provided in the oil pan. A disk-type oil filter (hydraulically operated by means of the engine oil pressure) is located on the oil pan. The filter is accessible for removal from the outside of the pan. NOTE: *If working on the late type oil pan, refer to paragraph 18.*

b. Disassembly.

(1) REMOVE FRONT AND REAR OIL BAFFLE FROM OIL PAN (fig. 52). Remove the nuts which secure the front and rear oil baffle in the pan, and lift the baffles from the oil pan.

(2) REMOVE OIL SCREEN FROM OIL PAN (fig. 52). Take out the six screws which hold the oil screen assembly in the bottom of the oil pan. Remove the nut from the clip, and lift the screen assembly out of the pan. Remove the four screws securing the screen to the cover, and lift the screen from the cover.

(3) REMOVE OIL PRESSURE REGULATOR SPRING AND PLUNGER (fig. 52). Remove the nut from the top of the pressure regulator, and remove the spring and plunger from the cylinder in the oil pan.

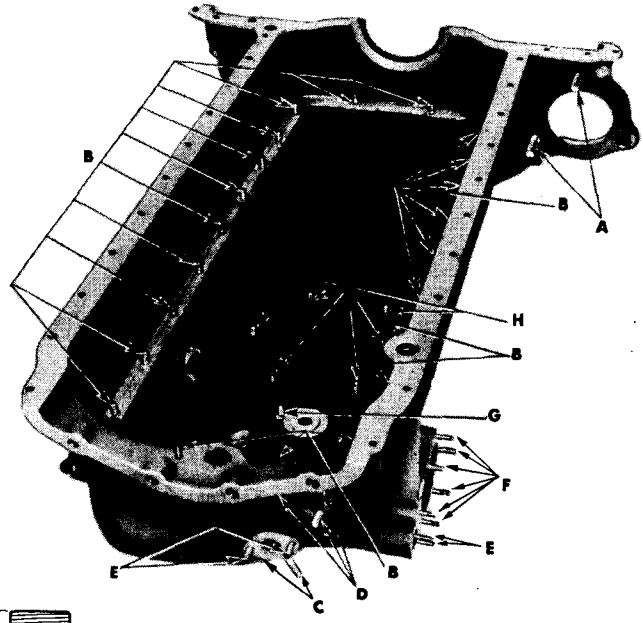
(4) REMOVE OIL RELIEF VALVE SPRING, PLUNGER, AND SLEEVE FROM OIL PAN (fig. 52). Remove the nut from the top of the oil relief valve and lift the spring, plunger, and sleeve from the recess in the oil pan.

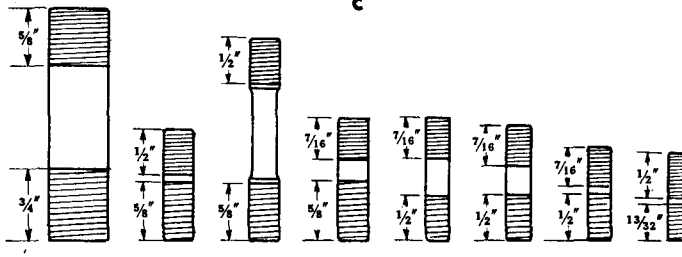
(5) REMOVE TWO PLATES COVERING OIL PASSAGES. Remove the two plates covering the oil passages on the outside of the oil pan so the oil passages can be cleaned. Do not remove any of the screw plugs from the oil passages in the pan. These are usually difficult to remove, and their removal is not necessary for cleaning the pan.

c. Cleaning. Remove all dirt and sludge by brushing and scraping. Immerse the oil pan in dry-cleaning solvent and remove all remaining dirt. CAUTION: *Do not use a caustic soda bath for cleaning as it will be injurious to the aluminum. Blow out all oil passages and dry the entire oil pan with compressed air.*

d. Inspection.

(1) OIL PASSAGES AND CASTING CRACKS. Examine the oil pan for casting cracks. Check all oil passages to see that they are open and clean.





STUD	A	B	C	D	E	F	G	H
TOTAL LENGTH	2 1/2"	1 13/16"	2 9/64"	1 5/16"	1 3/16"	1 1/4"	1"	1 5/16"
PROTRUDING LENGTH	1 5/16"	9/16"	1 13/32"	13/16"	3/4"	1 1/16"	13/32"	1/2"
DIAMETER	5/8"	5/16"	5/16"	5/16"	1/4"	1/4"	1/4"	1/4"
NUMBER USED	2	22	2	3	4	6	1	6

RA PD 329642

Figure 53 — Identification of Oil Pan Studs (Used on Early Type GAA Engines)

(2) OIL SCREEN (fig. 52). Check all parts of the oil screen assembly. Examine the screen and tube assembly to make sure it is clean. Check for broken welds and for improperly soldered joints on the tube assembly.

(3) CONDITION OF STUDS. Bent studs or studs with damaged threads must be replaced. Replacement of broken studs is covered in paragraph 12 **d** (1).

(4) OIL PRESSURE REGULATOR AND OIL RELIEF VALVE PARTS (fig. 52). Examine the plungers for excessive wear or scores. Check to see whether the oil pressure regulator plunger slips freely in its cylinder in the oil pan and the oil relief plunger slips freely in the sleeve. Check the springs for their over-all length, and see that they are free from rust or corrosion. Oil pressure regulator springs should support a 38 to 40 pound weight when 1.48 inches long. Oil relief valve springs should support a 4.40 to 4.70 pound weight when 1.62 inches long.

e. Repair.

(1) REPLACE DAMAGED STUDS. All studs which previous inspection showed to be damaged are to be replaced. See paragraph 12 **d** (1) *(a)* for removal of damaged or broken studs.

(2) INSTALL STUDS IN A NEW OIL PAN. If a new oil pan is to be used, all new studs are to be used throughout the oil pan. Use a standard stud driver of the size needed for a particular stud. See figure 53 for identification of the proper studs and their location, also for the proper protruding length for each stud after installation in the oil pan.

f. Modifications of Oil Pan.

(1) A new engine oil pan, 5700005 (FM-GAA6675B) was adopted in production starting with engine serial No. 7451. On the early production engines, serial numbers from 1 to 7450 inclusive, oil pan, E7187B (FM-GAA6675) was used. In order to use either oil pan, the following changes must be made:

(2) To use the new oil pan 5700005 (FM-GAA6675B) on engines with serial numbers 1 to 7450 inclusive, it is necessary to remove plug, A411717 (FM-GAA6783), from oil level indicator hole, and install metal tube, A296545 (FM-GAA6754), in oil level indicator hole.

(3) To use the old oil pan E7187B (FM-GAA6675), on engines with serial numbers above 7450, it is necessary to remove metal tube, A296545 (FM-GAA6754), from oil level indicator hole, and install plug, A411717 (FM-GAA6783), in oil level indicator holes.

(4) TABLE.

	OIL PAN E7187B (FM-GAA6675)	OIL PAN 5700005 (FM-GAA6675B)
Ford GAA tank Engine serial Nos. 1 to 7450	Use tube A296545	Remove plug A411717, use tube A296545
Ford GAA tank Engine serial Nos. Above 7450	Remove tube A296545, use plug A411717	Use plug A411717

g. Assembly.

(1) ASSEMBLE OIL PRESSURE REGULATOR IN OIL PAN (fig. 52). Place the oil pressure regulator plunger and heavy spring in the oil pressure regulator cylinder which is located at the end of the oil filter housing. Assemble the parts in the order shown, screw the nut with copper gasket in the threaded hole at the top of the cylinder, and tighten securely.

(2) ASSEMBLE OIL RELIEF VALVE (fig. 52). Place the oil relief valve sleeve, plunger, and light spring in the cylinder provided at the top of the oil filter housing. Assemble the parts in the order shown. Screw the nut with copper gasket in the top of the opening and tighten securely against the sleeve. NOTE: *The oil pressure regulator spring can be distinguished from the relief valve spring as it is made of much finer wire.*

(3) INSTALL OIL SCREEN ASSEMBLY (fig. 52). Place the oil screen in the cover on the tube assembly, and fasten it to the cover with four screws. Place a new gasket over the studs at the flange of the oil tube. Attach the assembly over the studs in the bottom of the oil pan, and secure it to the pan with six boot-type nuts.

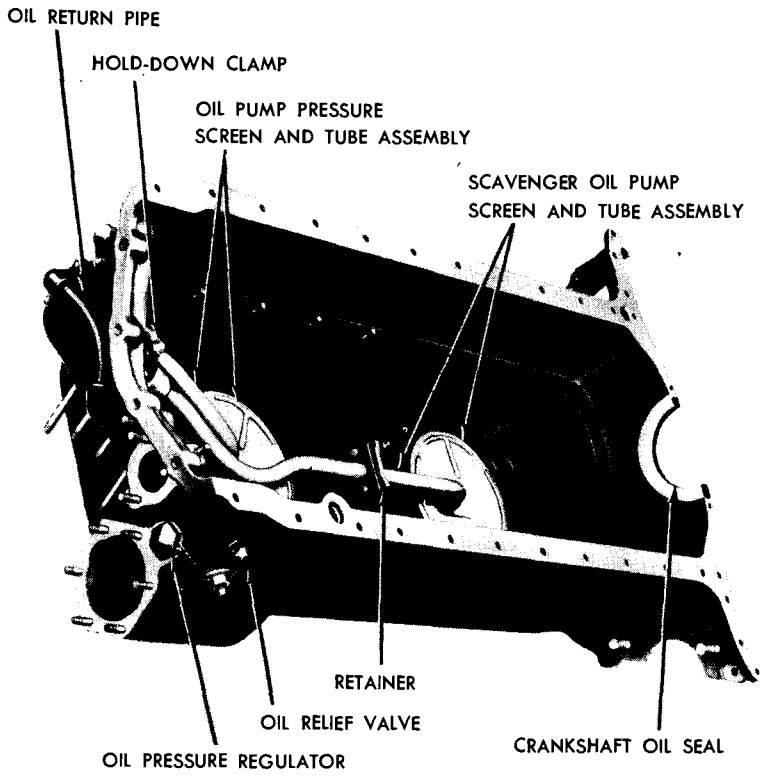
(4) INSTALL CRANKSHAFT OIL SEAL (fig. 51). Install a new crankshaft oil seal in the groove provided in the front end of the oil pan. Press the seal firmly in the groove with the ends protruding above the machined surface of the pan equally on each side. NOTE: *A seal must be soaked for 2 hours in warm engine oil before installation in the oil pan.*

(5) INSTALL FRONT AND REAR OIL BAFFLES IN PAN (fig. 52). Place the two oil baffles and new gaskets in position in the oil pan. Install the nuts that secure the two baffles to the pan.

(6) INSTALL MISCELLANEOUS PARTS. Install all oil passage plugs with copper gaskets, cover plates, and gaskets which were previously removed for cleaning purposes.

18. OIL PAN ASSEMBLY (USED ON LATE GAA AND ALL GAN AND GAF ENGINES).

a. General Description. The engine oil pan is an aluminum casting and has a dual oil compartment. The rear compartment has



RA PD 329633

Figure 54— Engine Oil Pan Assembly (Used on All Late Type Engines)

a baffle over it to retain the oil. The assembly includes two oil screens secured to the bottom of the oil pan. The oil screen, located in the rear compartment, leads to the pressure side of the oil pump. The oil screen, located at the forward end of the pan, leads to the oil scavenger side of the pump. The oil pressure regulator and the oil relief valve are accessible from the outside of the oil pan. The oil relief valve is located at the upper plug on the right-hand side of the oil pan at the rear, and the oil pressure regulator is located on the rear end of the pan. A disk-type oil filter, hydraulically operated by means of the engine oil pressure, is located on the rear end of the oil pan. **NOTE:** *If working on the early type oil pan, refer to paragraph 17.*

b. Differences Among Oil Pans. The oil pans on the various engines are not interchangeable, due to the location of the oil drain

plugs and engine supports, etc. The oil pans for the various engines can be identified as follows: The oil pan for the late type GAA engines has the oil pan drain plug located at the rear of the pan (magneto end); the oil drain plug on the GAN engines is located at the center of the oil pan; and the oil pan for the GAF engines has engine mounts cast integral with the pan.

c. Disassembly.

(1) REMOVE OIL BAFFLE FROM OIL PAN. Remove the nine nuts that secure the oil baffle to the pan, and remove the baffle from the pan.

(2) REMOVE OIL SCREENS FROM OIL PAN (fig. 54). Remove the three nuts that secure the scavenger screen and tube assembly in the front compartment of the oil pan. Remove the two cap screws and nuts from the retainer that secure the tube to the center portion in the oil pan. Remove the nut and hold-down clamp that secure both tubes at the oil pump. Remove the scavenger screen and tube assembly from the pan. Remove the three nuts that secure the pressure oil pump screen and tube assembly in the rear compartment, and remove the assembly from the pan.

(3) REMOVE OIL PRESSURE REGULATOR (fig. 54). Remove the plug from the pressure regulator located on the rear end of the pan. Remove the spring, plunger, and sleeve from the recess in the oil pan.

(4) REMOVE OIL RELIEF VALVE (fig. 54). Remove the plug from the oil relief valve located at the upper plug on the right-hand side of the pan at the rear. Remove the spring, plunger, and sleeve from the recess in the oil pan.

d. Cleaning. Remove all dirt and sludge by brushing and scraping. Immerse the oil pan in dry-cleaning solvent and remove all remaining dirt. CAUTION: *Do not use a caustic soda bath for cleaning as it will be injurious to the aluminum.* Blow out all oil passages and dry the entire oil pan with compressed air.

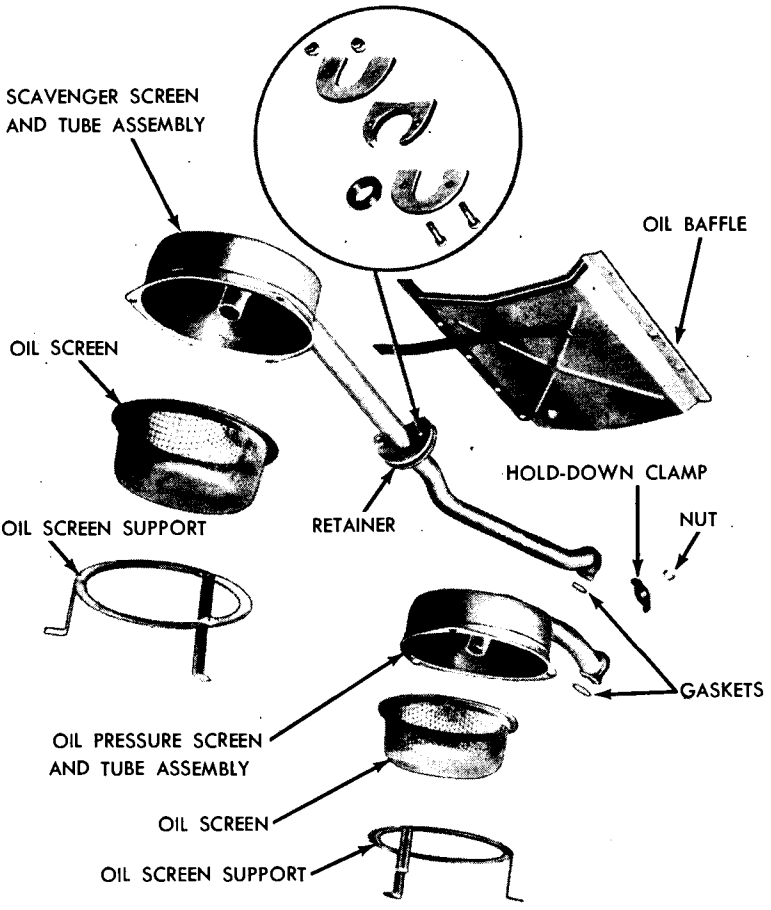
e. Inspection.

(1) OIL PASSAGES AND CASTING CRACKS. Examine the oil pan for casting cracks. Check all oil passages to see that they are open and clean.

(2) OIL SCREENS (fig. 55). Check all parts of the oil screen assembly. Examine the screen and tube assemblies to make sure they are clean. Check for broken welds and for improperly soldered joints on the tube assembly.

(3) STUDS. Bent studs or studs with damaged threads must be replaced. Removal of broken studs is covered in paragraph 12 **d** (1).

(4) OIL PRESSURE REGULATOR AND OIL RELIEF VALVE PARTS (fig. 55). Examine the plungers for excessive wear or scores. Check to see whether the oil pressure regulator plunger slips freely in the



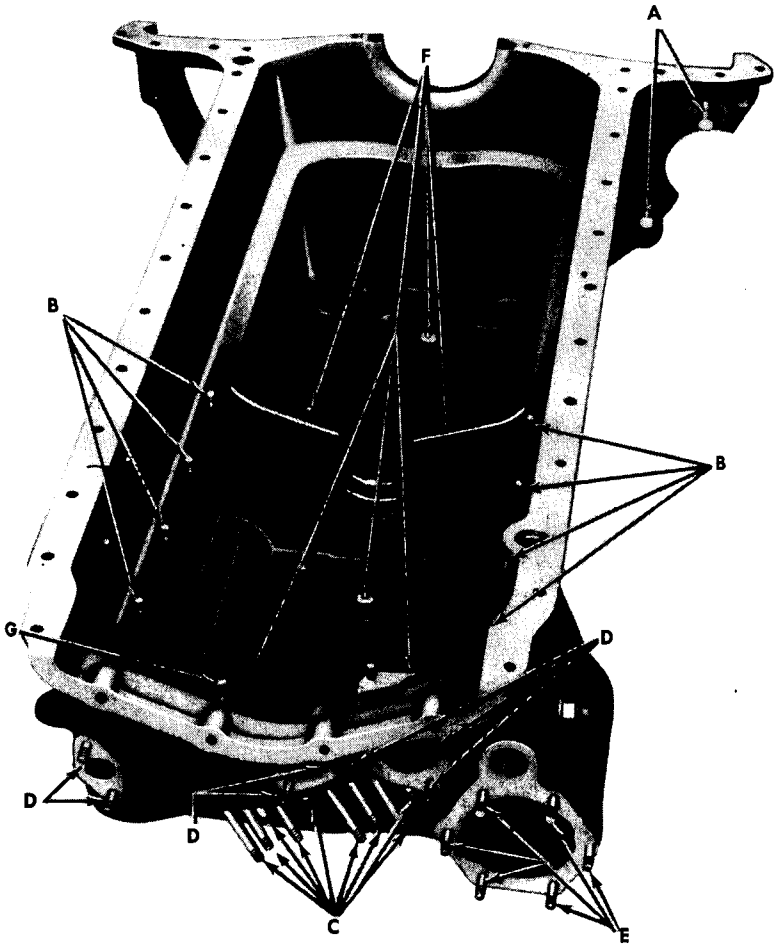
RA PD 329646

Figure 55 — Oil Pressure Regulator, Oil Relief Valve, Oil Screen, and Oil Baffle, Disassembled (Used on All Late Type GAA, GAN, and GAF Engines)

sleeve, and the sleeve slips freely into its recess in the oil pan. Check the springs for their over-all length and see that they are free from rust or corrosion. Oil pressure regulator springs should support a 38 to 40 pound weight when 1.48 inches long. Oil relief valve spring should support a 4.40 to 3.70 pound weight when 1.62 inches long.

f. Repair.

(1) REPLACE DAMAGED STUDS. All studs which previous inspection showed to be damaged are to be replaced. See paragraph 12 **d** (1) (a) for removal of damaged or broken studs.



STUD	A	B	C	D	E	F	G
TOTAL LENGTH	2 1/2"	1 3/16"	3 5/16"	1 5/16"	1 1/2"	1 5/16"	3 5/16"
PROTRUDING LENGTH	1 5/16"	9/16"	2 25/32"	13/16"	29/32"	1/2"	2 1/2"
DIAMETER	5/8"	5/16"	5/16"	5/16"	5/16"	1/4"	3/8"
NUMBER USED	2	9	8	7	6	6	1

RA PD 329630

Figure 56 — Identification of Oil Pan Studs (Used on All Late Type GAA, GAN, and GAF Engines)

(2) INSTALL STUDS IN NEW OIL PAN. When a new oil pan is to be used remove serviceable studs from old oil pan and install in new oil pan as required. Check all oil pan studs, and replace all broken or damaged studs. Use a standard stud driver of the size needed for a particular stud. See figure 56 for identification of the proper studs and their location, and also for the proper protruding length for each stud after installation in the oil pan.

g. Assembly.

(1) ASSEMBLE OIL PRESSURE REGULATOR IN OIL PAN (fig. 55). Place the oil pressure regulator sleeve, plunger, and heavy spring in the oil pressure regulator cylinder which is located on the rear end of the oil pan. Install the plug with copper gasket and tighten securely.

(2) ASSEMBLE OIL RELIEF VALVE IN OIL PAN (fig. 55). Place the oil relief valve sleeve, plunger, and light spring in the recess which is located at the upper plug on the right-hand side of the oil pan. Install the plug with copper gasket and tighten securely. Lock the oil pressure plug, oil relief plug, and core pocket plug together with lock wire.

(3) INSTALL OIL SCREENS (fig. 55). Place new gaskets in the two openings leading to the oil pump. Place the scavenger oil screen and tube assembly in the front oil compartment, and secure the assembly to the pan with three nuts. Install the retainer and rubber seal that secure the scavenger tube to the center partition in the pan. Place the oil pressure screen and tube assembly in the rear oil compartment, and secure the assembly to the pan with three nuts. Install the hold-down clamp and nut that secure the two tubes to the pan.

(4) INSTALL CRANKSHAFT OIL SEAL. Install a new crankshaft oil seal in the groove provided in the front end of the oil pan (fig. 54). Press the seal firmly in the groove with the ends protruding above the machined surface of the pan equally on each side. NOTE: *A seal must be soaked for 2 hours in warm engine oil before installation in the oil pan.*

19. OIL PUMP (USED ON EARLY TYPE GAA ENGINES).

a. Description. The oil pump is a gear-type (fig. 57) mounted on the rear of the oil pan. It is driven by the lower camshaft worm gear shaft by means of a splined quill connecting the pump shaft with left-hand worm gear shaft. If working on the late type oil pump, refer to paragraph 20.

b. Disassembly (fig. 57). Remove the flathead screw from the cover, and remove the cover from the housing. The gears and shaft can now be removed from the housing.

c. Cleaning (fig. 57). Clean all parts thoroughly in dry-cleaning solvent. Discard all old gaskets regardless of their condition.

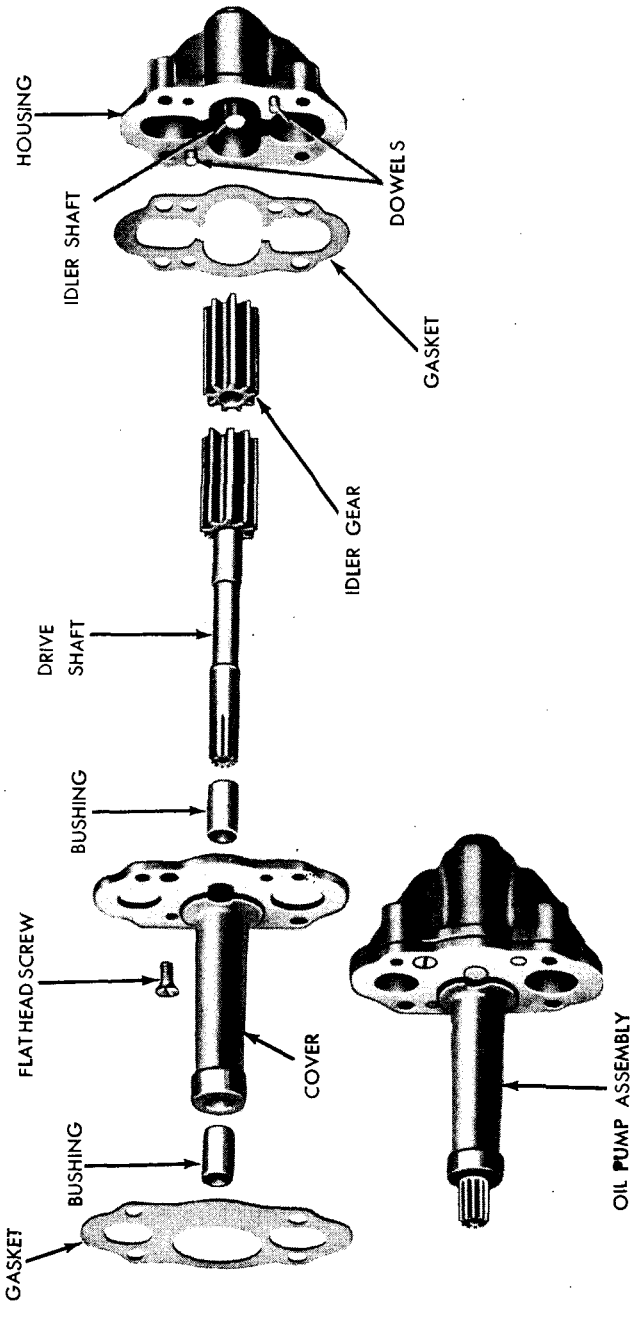


Figure 57 — Engine Oil Pump, Disassembled (Used on Early Type GAA Engines)

d. Inspection (fig. 57). Replace any gears that are excessively worn or have chipped or missing teeth. Check the inside diameter of the idler gear. The manufacturer's dimensions for this gear are 0.5625 inch to 0.5630 inch. If the inside diameter of the idler gear is worn to more than 0.5650 inch, it must be replaced. Check the inside diameter of each bushing in the oil pump cover. The manufacturers dimensions for these bushings are 0.5625 inch to 0.5630 inch. If they are worn to more than 0.5650 inch, replace the bushings (subpar. e (1) below). Replace the drive shaft if it is bent or has excessively worn splines. Check the diameter of the drive shaft. The manufacturer's dimensions for this shaft are 0.5610 inch to 0.5615 inch. If the shaft is worn to less than 0.5590 inch, replace the shaft. Check the diameter of the idler shaft. The manufacturer's dimensions for this shaft are 0.4345 inch to 0.4350 inch. If this shaft is worn to less than 0.4325 inch, replace the shaft (subpar. e (2) below).

e. Repair.

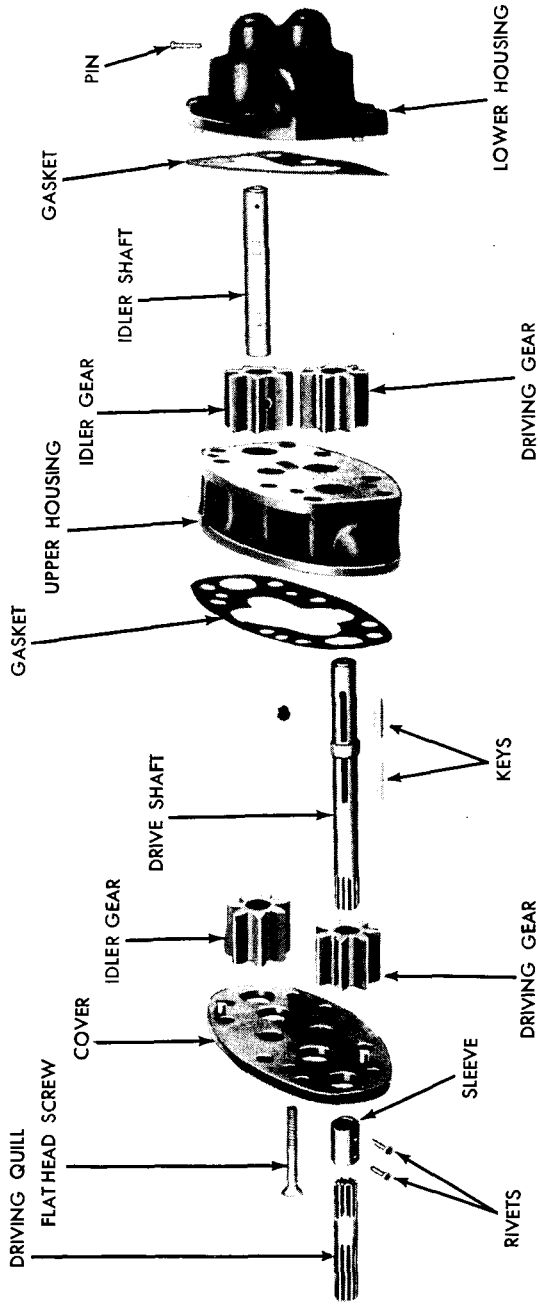
(1) OIL PUMP COVER BUSHING REPLACEMENT. Place the oil pump end cover (fig. 57) in a vise. Using a suitable driver, tap the bushings out of the cover. To install new bushings, place a bushing in position at one end of the cover. Tap the bushing in the housing, using a fiber block and a hammer. Turn the cover over and repeat the above operation to install the other bushing. Line-ream these bushings from 0.5625 inch to 0.5630 inch.

(2) IDLER SHAFT REPLACEMENT. Place the oil pump housing (fig. 57) in a vise. Using a long-nosed punch, drive out the pin that secures the idler shaft to the housing. Remove the shaft from the housing. Line up the dowel pin hole in the shaft with the hole in the housing, and place the new idler shaft in the oil pump housing. Install the dowel pin and stake it to prevent the pin from loosening.

f. Assembly (fig. 57). Place the idler gear on the idler shaft in the housing. Place a new gasket in position on the housing. Insert the drive shaft in the cover. Place the drive shaft and cover assembly on the housing. Install the flathead screw that secures the cover to the housing.

20. OIL PUMP (USED ON ALL LATE-TYPE ENGINES).

a. Description. The oil pump (fig. 58), mounted on the oil pan at the magneto end, is driven from the lower camshaft worm gear shaft by means of a driving quill. A dual pump is used on all late type engines and has two outlets and two inlets. One section of the pump pumps the oil from the front compartment (flywheel end) of the oil pan into the compartment at the rear of the pan. The other section of the pump draws the oil from the rear compartment and circulates the oil through the engine under pressure. If working on the early type pump, refer to paragraph 19.



RA PD 329634

Figure 58 — Engine Oil Pump, Disassembled (Used on All Late Type GAA, GAN, and GAF Engines)

b. Disassembly (fig. 58). Remove the two rivets from the sleeve that secures the driving quill to the pump drive shaft, and remove the driving quill and sleeve from the shaft. Remove the flathead screw that secures the cover to the housing. Tap the cover lightly with a brass hammer to disengage the two dowels from the dowel holes in the center housing and remove the cover and gasket. Remove the drive shaft, drive gear, and idler gear from the center housing. Tap the end housing off the center housing with a brass hammer. Remove the drive gear and idler gear from the end housing. Drive out the dowel pin that secures the idler shaft to the housing and remove the idler shaft.

c. Cleaning. Clean all parts thoroughly in dry-cleaning solvent. Discard all old gaskets regardless of their condition.

d. Inspection (fig. 58). Replace the oil pump housings if they are cracked or damaged in any way. Replace any gears that are excessively worn or have chipped or missing teeth. Check the inside diameter of the two idler gears. The manufacturer's dimensions are 0.5605 inch to 0.5610 inch. If the inside diameter of the gears is more than 0.5630 inch, replace the gears. Check the inside diameter of the bushing in the oil pump cover. The manufacturer's dimensions for this bushing are 0.5605 inch to 0.5610 inch. If the bushing is worn to more than 0.5630 inch, replace the bushing (subpar. e below). Replace the drive shaft if it is bent or has excessively worn splines. Check the diameter of the drive shaft. The manufacturer's dimensions are 0.5600 inch to 0.5605 inch at the upper end and 0.5620 inch to 0.5625 inch at the lower end of the shaft. If the shaft is less than 0.5580 inch at the upper end or less than 0.5600 inch at the lower end, replace the shaft. Check the diameter of the idler shaft. The manufacturer's dimensions for this idler shaft are 0.5620 inch to 0.5625 inch. If the shaft is less than 0.5600 inch, replace the shaft.

e. Oil Pump End Cover Bushing Replacement. Place the oil pump end cover (fig. 58) in a vise equipped with brass jaws. Drive the bushing out of the cover, using a suitable driver. Place a new bushing in position on the cover. Using a fiber block and a hammer, drive the bushing into the cover. Line-ream the bushing to 0.5605 inch to 0.5610 inch, being sure the bushing is exactly square with the face of the cover.

f. Assembly (fig. 59). Line up the pin hole in the lower housing and place the idler shaft in the housing. Drive the pin through the shaft and stake the pin to prevent it from loosening. Place an idler gear on the idler shaft. Place a driving gear in the lower housing. Place a key in the lower end of the drive shaft. Place this shaft and key in position in the drive gear in the lower housing. Place the gasket and the upper housing in position on the lower hous-

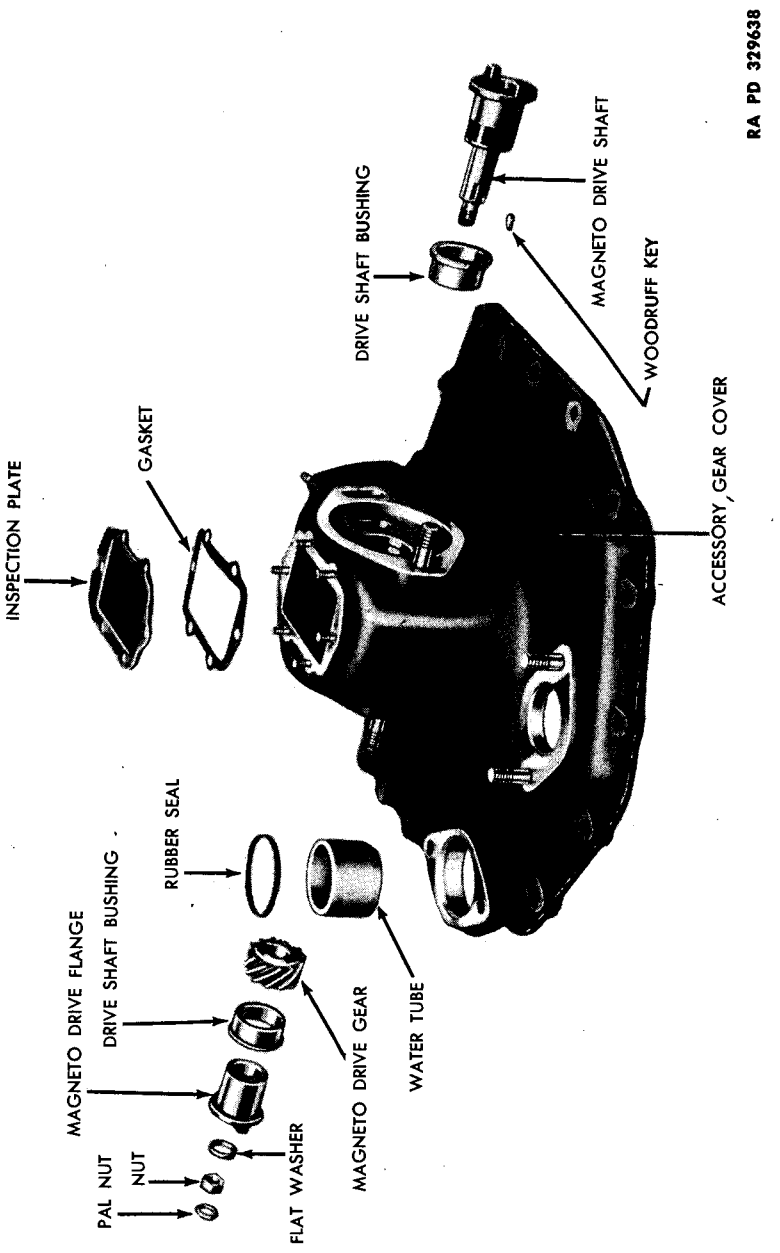
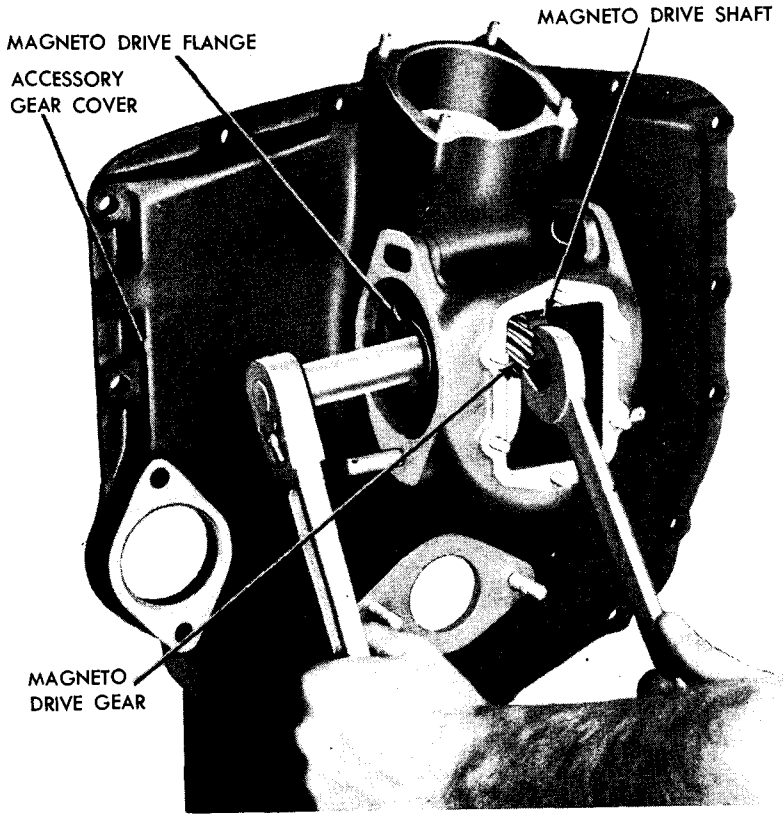


Figure 59 — Accessory Gear Cover, Disassembled



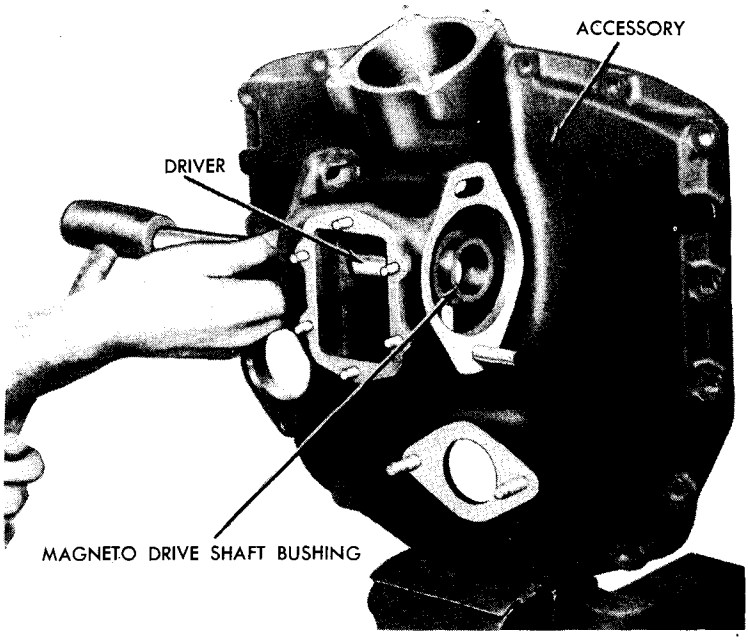
RA PD 329639

Figure 60 — Removing Magneto Drive Flange From Accessory Gear Cover

ng. Place the idler gear in the upper housing. Place the key in the upper groove in the drive shaft. Place the drive gear on the drive shaft. Place the gasket and the cover in position on the upper housing, and install the flathead screw that secures the cover to the housing. Place the splined sleeve on the driving quill, and install the two rivets securing the sleeve to the driving quill. Place the sleeve and quill assembly on the pump gear drive shaft, and install the rivets securing the sleeve to the drive shaft.

21. ACCESSORY GEAR COVER AND MAGNETO DRIVE SHAFT AND GEARS.

a. Description. The accessory gear cover carries the magneto drive shaft and magneto driven gear (fig. 59). This gear meshes



RA PD 329640

Figure 61 — Driving Magneto Drive Shaft Bushing Out of Accessory Gear Cover

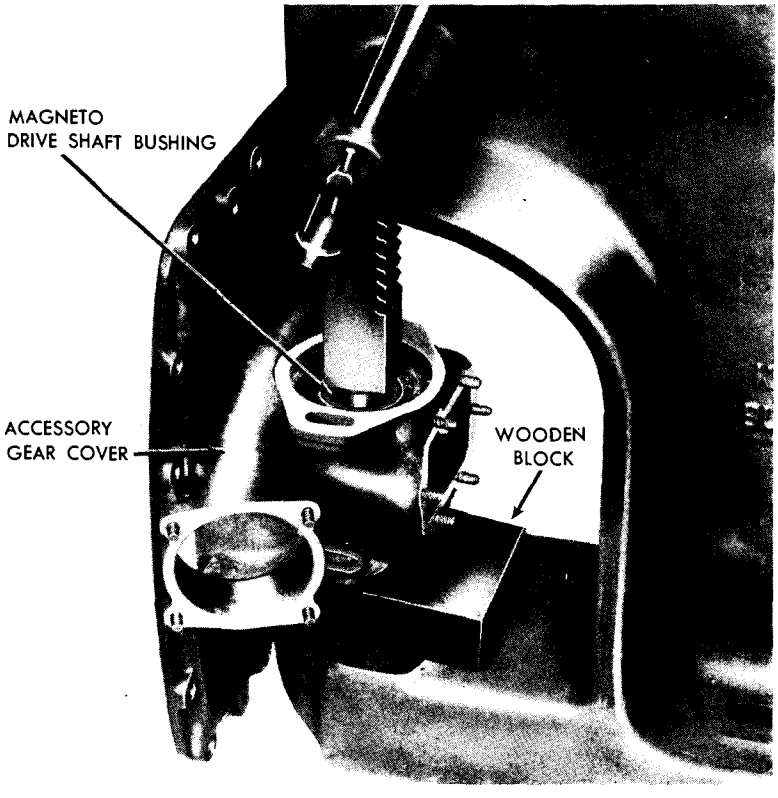
with the magneto drive gear when the cover is installed on the engine. The oil breather assembly is also attached to the upper part of the cover.

b. Disassembly (fig. 59). Place the accessory gear cover in a vise equipped with brass jaws. Remove the six nuts that secure the inspection plate to the cover and remove the inspection plate and gasket. Holding the magneto drive shaft stationary (fig. 60), remove the nut and pal nut that secure the left-hand magneto drive flange to the shaft. Remove the drive flange from the shaft. Remove the Woodruff key from the shaft, and pull the shaft out of the magneto driven gear and cover.

c. Cleaning. Clean all parts thoroughly in dry-cleaning solvent. Discard old gaskets regardless of their condition.

d. Inspection.

(1) ACCESSORY GEAR COVER (fig. 59). Replace the accessory gear cover if it is cracked. Replace all broken or damaged studs



RA PD 329641

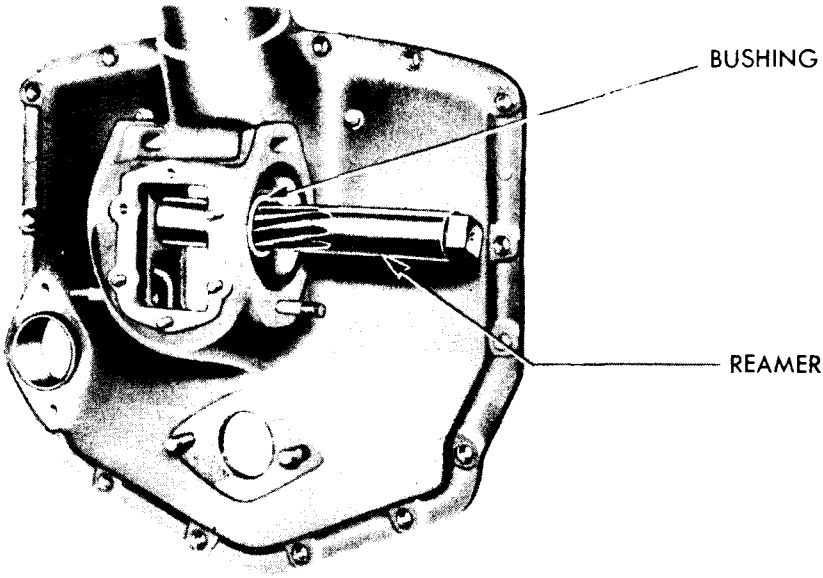
Figure 62 — Pressing Magneto Drive Shaft Bushings in Accessory Gear Cover

(par. 12 **d** (1)). Replace the water inlet tube if it is damaged (subpar. **e** (3) below).

(2) MAGNETO DRIVEN GEAR (fig. 59). Inspect the gear for excessive wear or burned spots. Discard the gear if it is excessively worn or damaged.

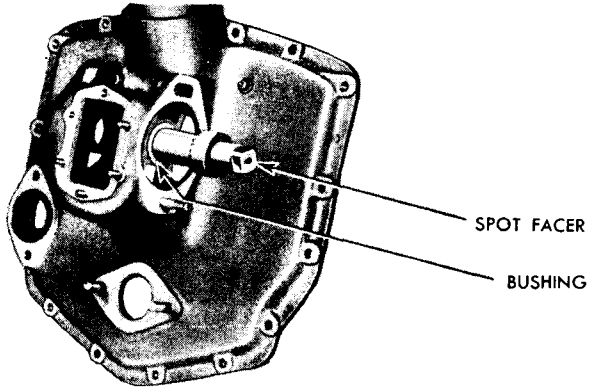
(3) MAGNETO DRIVE SHAFT BUSHINGS (fig. 59). Check the inside diameter of the drive shaft bushings in the cover. The manufacturer's dimensions for the bushings are 1.2515 inches to 1.2525 inches. Bushings that are worn and measure more than 1.2550 inches must be replaced (subpar. **e** (1) below).

(4) MAGNETO DRIVE SHAFTS (fig. 59). Check the bearing surface and driving lugs on the magneto driving flanges. The manu-



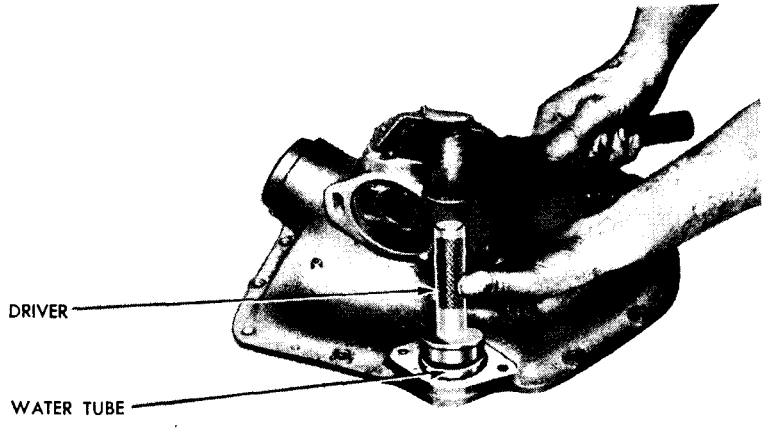
RA PD 27871

Figure 63 — Reaming Magneto Drive Shaft Bushing, Using Reamer (41-R-2312)



RA PD 27870

Figure 64 — Spot Facing Ends of Magneto Drive Shaft Bushings, Usina Tool (41-T-3361-60)



RA PD 28180

Figure 65 — Driving Water Tube in Accessory Gear Cover, Using Ferrule Driver (41-D-2980-155)

facturer's dimensions for the diameter of the drive shafts are 1.2490 inches to 1.2495 inches. Drive shafts that are worn and measure less than 1.2520 inches must be discarded.

e. Repair.

(1) MAGNETO DRIVE SHAFT BUSHING REPLACEMENT. Place the accessory gear cover in a vise equipped with brass jaws. Drive the two bushings out of the cover, using a suitable driver (fig. 61). Press new bushings into the cover as shown in figure 62. Line-ream the bushings, using reamer (41-R-2312) (fig. 63).

(2) SPOT-FACE MAGNETO DRIVE SHAFT BUSHINGS. Assemble the magneto drive shaft, gear, and magneto drive flange in the cover in the order shown in figure 59. Tighten the nut at the end of the shaft. Check the end play with a feeler gage blade between the bushing flange and the magneto drive flange. The correct end play is 0.006 inch to 0.008 inch. When new bushings are installed, if necessary, face off the ends of the bushings in order to establish the correct end play for the magneto drive shaft. Use the spot-facer tool (41-T-3361-60), as shown in figure 64 for facing off the end of the bushings. Remove just enough material to establish the correct end play for the shaft. It will be necessary to install the shaft and check the end play with the feeler gage several times in order to obtain the correct clearance.

(3) WATER PUMP INLET TUBE REPLACEMENT. The water pump inlet tube is a press fit in the accessory gear cover. To remove the tube, use the 2-inch ferrule driver (41-D-2980-155) and drive the tube out of the cover (fig. 65). Insert a new water inlet tube in the

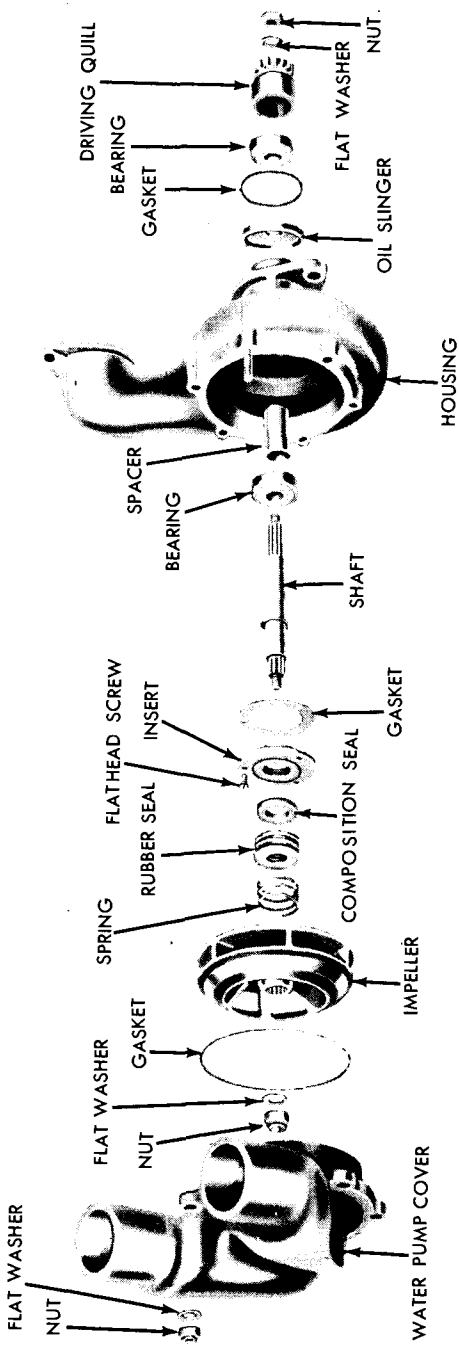


Figure 66 — Water Pump, Disassembled

cover, using the 2-inch ferrule driver (41-D-2980-155), and drive the water tube in the cover.

f. Assembly (fig. 59). Place the accessory gear cover in a vise equipped with brass jaws. Insert the magneto drive shaft in position on the right-hand side of the cover. Install the magneto drive gear on the shaft, being sure the serrated side of the gear is facing toward the left side of the cover. Install the Woodruff key on the shaft. Install the magneto drive flange on the drive shaft, being sure the serrations are properly meshed. Install the flat washer and nut that secure the flange to the shaft. Do not tighten the nut on the shaft at this time as it will be necessary to loosen it again when setting the ignition timing as described in paragraph 31.

22. WATER PUMP.

a. Description. The centrifugal-type pump (fig. 66) is driven at crankshaft speed by a splined quill from the main driving hub of the accessory gear assembly. The pump shaft rotates in two ball bearings, lubricated by the oil splash from the accessory gear assembly through a drilled hole in the pump housing. The water seal consists of a spring-loaded rubber spool and a composition disk which seats against the machined surface of an insert.

b. Disassembly.

(1) REMOVE WATER PUMP COVER FROM HOUSING (fig. 66). Remove the six nuts from the housing cover and remove the cover from the housing.

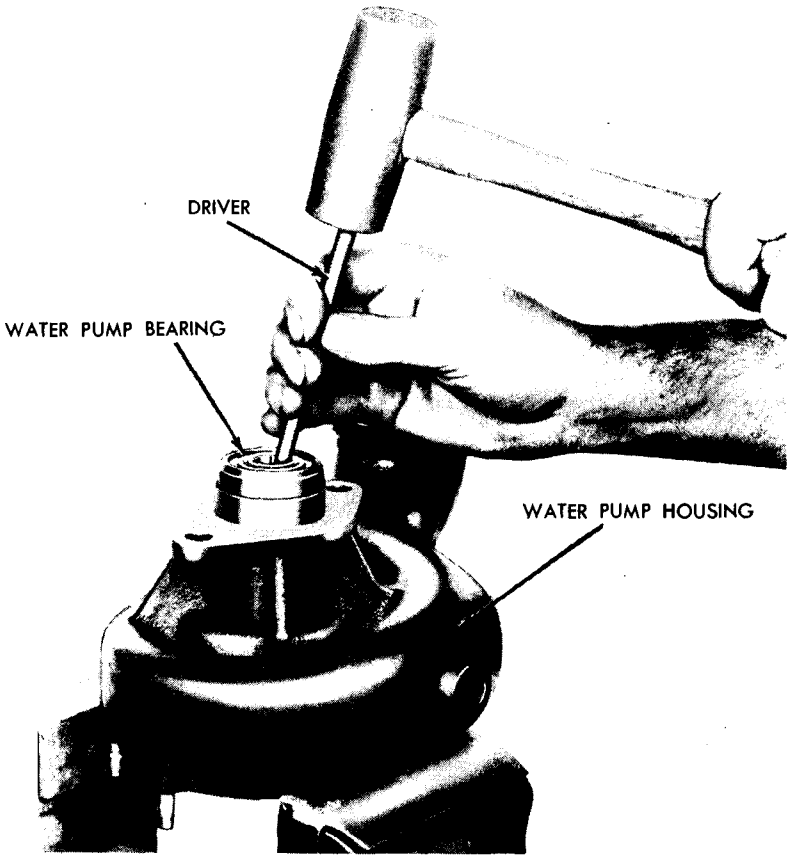
(2) REMOVE DRIVING QUILL FROM SHAFT (fig. 66). Remove the nut which secures the driving quill on the pump shaft, and pull the quill off the shaft.

(3) REMOVE IMPELLER FROM PUMP SHAFT (fig. 66). Remove the nut which secures the impeller on the pump shaft, and pull the impeller off the shaft. Remove the seals and spring from the shaft.

(4) REMOVE PUMP SHAFT FROM HOUSING (fig. 66). Remove the three screws from the insert, and lift the insert from the housing. Tap on the end of the shaft from which the driving quill has been removed using a brass drift and a hammer, and remove the shaft.

(5) REMOVE BALL BEARINGS FROM HOUSING. With a brass drift that contacts the outer race of the bearing, drive evenly around the outer race of the bearing until the bearing is removed from the recess in the housing (fig. 67).

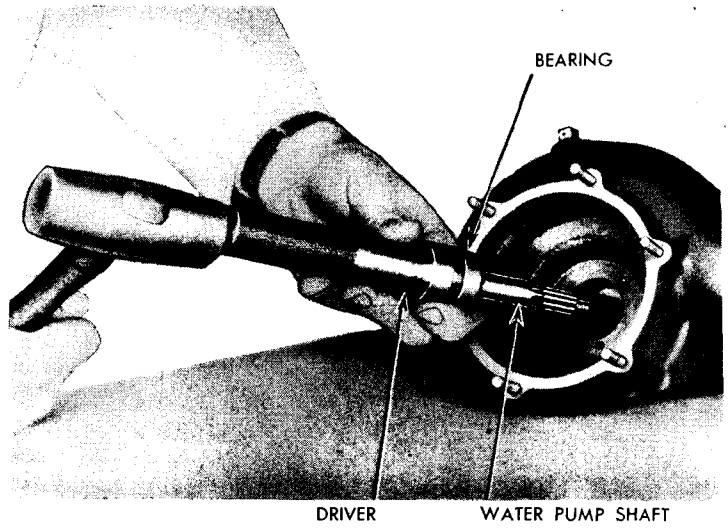
c. Cleaning. Clean all parts thoroughly in dry-cleaning solvent. Discard old gaskets regardless of their condition. To clean bearings thoroughly, rotate them while immersed in dry-cleaning solvent until all trace of lubricant has been removed. Oil the bearings immediately after cleaning to prevent rusting of the highly polished surfaces.



RA PD 329657

Figure 67 — Removing Ball Bearings From Water Pump Housing

d. Inspection (fig. 66). Check the water pump housing, cover, and impeller for cracks or other damage. Bearings that are rusted or have excessively loose races must be replaced. Water seals showing wear or damage must be replaced. The face of the insert at the point where the composition seal contacts it must be free from excessive wear or scratches. Inspect the rubber in the driving quill. If the bonding to the metal has loosened or shows damage of any kind, the quill must be replaced. Replace the shaft if it has worn splines. Check the diameter of the shaft. The manufacturer's dimensions are 0.5893 inch to 0.5898 inch. If the shaft is worn to less than 0.5880 inch, replace the shaft.



RA PD 350558

Figure 68 — Driving Water Pump Ball Bearing and Shaft Into Water Pump Housing

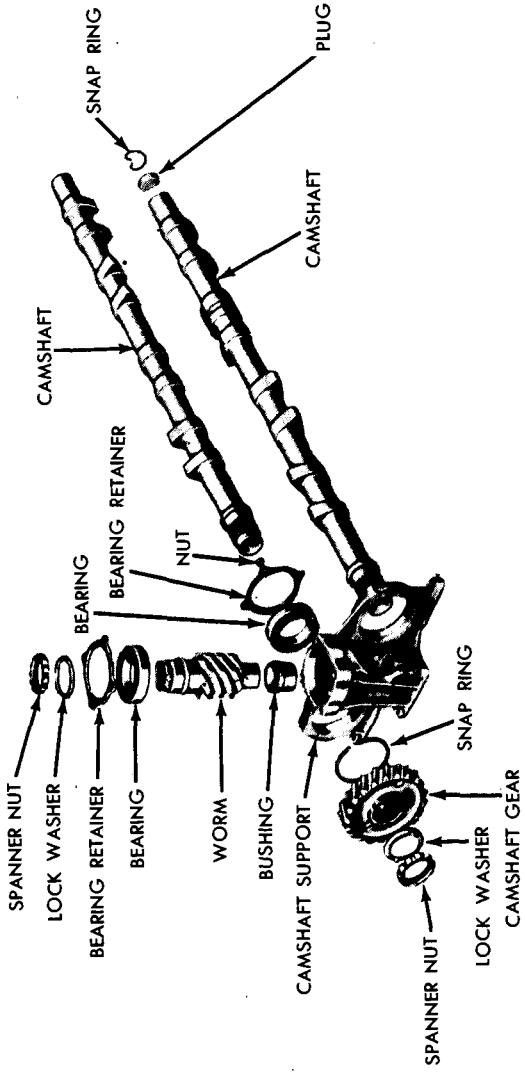
e. Assembly.

(1) INSTALL PUMP SHAFT AND INNER BEARING HOUSING (fig. 66). Place one of the ball bearings on the long end of the pump shaft with the sealed side of the bearing facing the shoulder on the shaft. Insert the shaft and bearing in the recess on the inside of the housing; using a suitable driver and hammer, drive the shaft and bearing into the housing (fig. 68). Place a new gasket and the insert over the shaft and secure it to the housing with three screws. Stake each of the screw heads to prevent them from loosening.

(2) INSTALL RUBBER SEALS AND SPRING (fig. 66). Place the spring over the rubber seal so the spring will be between the flanges on the ends of the seal. Slip the composition seal over the shaft and against the insert and follow up with the rubber seal and spring assembly.

(3) INSTALL IMPELLER ON PUMP SHAFT (fig. 66). Place the impeller on the spline of the pump shaft and secure it to the shaft with nut and flat washer. NOTE: *The open side of the impeller faces outward.*

(4) INSTALL BALL BEARING AND SPACER IN FORWARD END OF HOUSING (fig. 66). Slip the spacer over the end of the pump shaft and follow up with the ball bearing. Tap the bearing in the recess in the forward end of the housing, using a brass drift and a hammer. NOTE: *The sealed side of the ball bearing faces outward.*



RA PD 329645

Figure 69 — Camshafts and Gears, Disassembled

(5) INSTALL DRIVING QUILL ON PUMP SHAFT (fig. 66). Press the driving quill on the spline of the pump shaft, and secure it to the shaft with a flat washer and a self-locking nut. The shaft can be held from turning while tightening the nut by holding the nut on the opposite end of the shaft.

(6) INSTALL PUMP COVER ON HOUSING (fig. 66). Place the cover and a new gasket on the housing, and secure the cover to the housing with six nuts.

23. CAMSHAFTS AND GEARS.

a. Description (fig. 69). Four camshafts are used. One intake and one exhaust is used on each bank of cylinders. The shafts for the left bank of cylinders differ from the shafts for the right side. Each of the four camshafts can be identified by a marking etched on each shaft at a point between the gear and the first cam indicating whether the shaft is left-hand or right-hand, and whether it is an intake or an exhaust shaft. The camshafts are hollow to lessen the weight of the shafts, and also to provide an oil passage for lubrication of the camshaft bearing and cams.

b. Dissassembly.

(1) REMOVE GEARS FROM CAMSHAFTS (fig. 69). Release the lock washer from the spanner nut at each gear. Remove the spanner nut which secures each of the bronze gears to the camshafts. Use special turning wrench (41-W-2964-300) to hold the gears from turning while removing the spanner nuts (fig. 70). Remove the four nuts securing the bearing retainer to the top of the support (fig. 69). Insert the special turning wrench (41-W-2964-300) in the spline of the worm gear, and turn the worm gear and bearing out of the support. Use holding tool (41-W-3247-150) to prevent the camshaft from turning while removing worm gear (fig. 70). Pull the bronze camshaft gear from each camshaft, using puller (41-P-2909-58) (fig. 71).

(2) REMOVE CAMSHAFTS FROM SUPPORTS (fig. 69). Remove the four nuts from the ball bearing retainers at each camshaft, and remove each camshaft and bearing from the camshaft support.

(3) REMOVE OIL PLUG FROM CAMSHAFTS (fig. 69). Remove the snap ring retainer from the front end of the camshafts. Install a $\frac{5}{16}$-inch, 24-thread cap screw in the threaded hole in the oil plug at the end of the shaft. Use the cap screw as a puller, and pull the oil plug from each camshaft.

c. Cleaning. Clean all parts thoroughly, using a dry-cleaning solvent. Be sure the sludge and dirt are entirely removed from the oil passages in the camshaft, and the oilholes at each cam are clean.

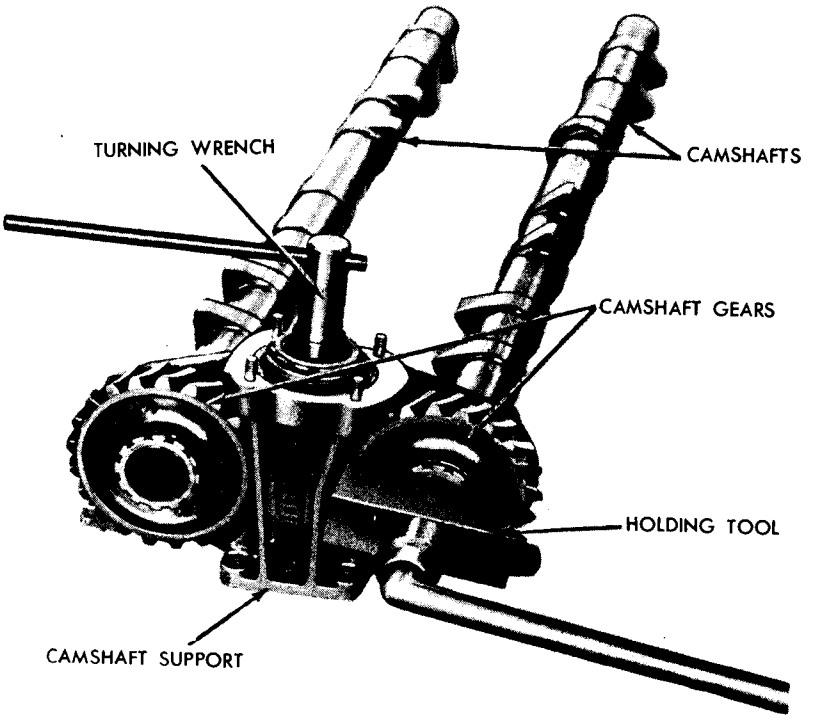


Figure 70 — Turning Worm Drive Gear and Bearing From Camshaft Support, Using Turn Wrench (41-W-2964-300) and Holding Tool (41-W-3247-150)

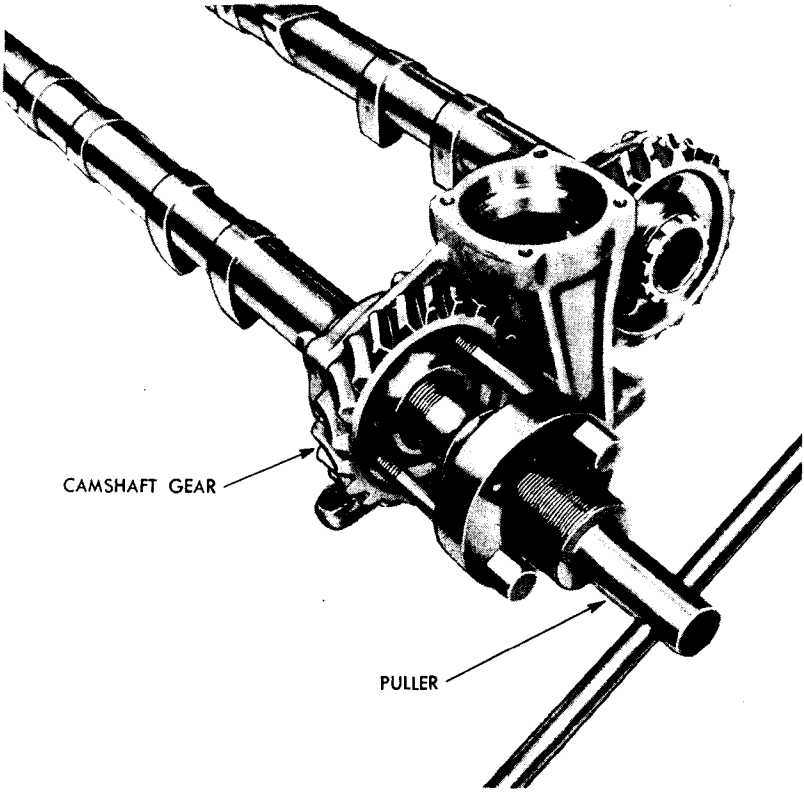
d. Inspection.

(1) CAMSHAFT (fig. 69). Inspect the cams on each camshaft for scores or damage. Check the diameter of the camshaft journals. The manufacturer's dimensions are 1.4730 inches to 1.4735 inches. If the journals are worn 0.003 inch, replace the camshaft.

(2) BALL BEARINGS (fig. 69). Check the four camshaft ball bearings and the two drive worm ball bearings for damage of any kind. Discard any bearings which are unfit for further use.

(3) BUSHING IN CAMSHAFT SUPPORT (fig. 60). Check the inside diameter of the bushing in the camshaft support. The manufacturer's dimensions are 1.253 inches to 1.254 inches.

(4) GEARS (fig. 69). Replace the bronze camshaft gears if they are excessively worn or have chipped or missing teeth. Pitted tooth flanks do not necessarily indicate that a replacement is necessary. Check the worm gear for worn or damaged teeth; also check the



RA PD 28169

Figure 71 — Pulling Gear From Camshaft, Using Puller (41-P-2909-58)

diameter of the bearing surface at the lower end of the worm gear. The manufacturer's dimensions are 1.2495 inches to 1.2500 inches. If the gear is worn to less than 1.2480 inches, replace the worm gear.

e. Camshaft Support Bushing Replacement. To remove the bushing from the camshaft support, use a suitable driver to press the bushing out of the supports. To install a new bushing, place the bushing in position on the support and using a suitable driver, press the bushing into the support until the shoulder of the bushing is seated firmly in the recess. Bushings are manufactured to the correct size and do not require reaming.

f. Assembly.

(1) ASSEMBLE CAMSHAFT SUPPORTS (fig. 69). Install the snap ring bearing retainer in the groove provided in the camshaft support.

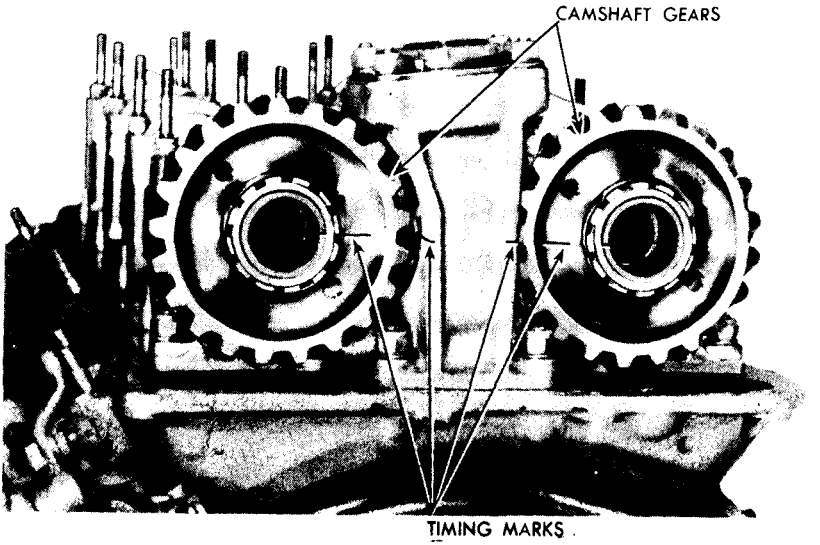


Figure 72 — Camshaft Gear Timing Marks

(2) INSTALL BALL BEARING ON EACH CAMSHAFT (fig. 69). Press a ball bearing on each of the camshafts until it is firmly seated against the shoulder on the shaft.

(3) INSTALL OIL PLUG IN CAMSHAFTS (fig. 69). Press an oil plug into the front end of each of the camshafts, and install a snap ring retainer in the groove to secure the plug in the camshaft.

(4) INSTALL CAMSHAFTS IN RIGHT AND LEFT SUPPORTS (fig. 69). NOTE: *The camshafts are right- and left-hand and can be identified by the markings etched on each camshaft. The intake and exhaust camshafts for the left-hand bank are marked "IN LH" AND "EX LH." The intake and exhaust camshafts for the right-hand bank are marked "IN RH" and "EX RH."* Insert the camshaft and ball bearing in the camshaft support. Place the bearing retainer plate on the support with the flat side of the retainer against the bearing. This is the side without rounded corners. Install the four boot-type nuts securing the retainer to the support. The same procedure applies to each of the camshafts.

(5) INSTALL BRONZE GEARS ON CAMSHAFTS (fig. 69). Heat the bronze gear to approximately 212° F. Use any means for heating except a direct flame. A blank spline is provided on the camshaft and also in the bronze gear to keep the timing marks on the gear in proper relation with the cams. Line up the blank splines and drive the gear on the camshaft, using a suitable hollow driver which will

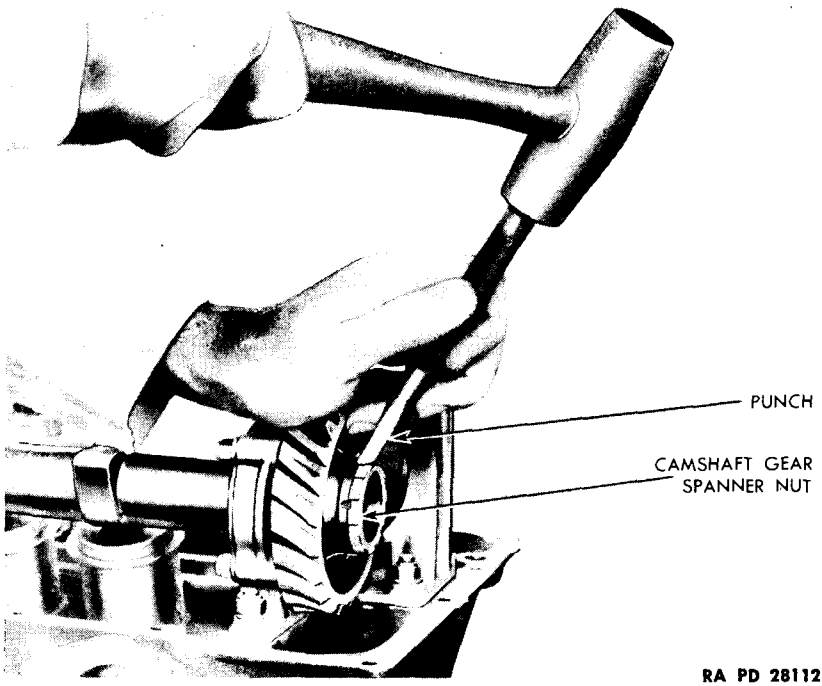


Figure 73 — Indenting Lock Washer in Notches on Spanner Nuts, Using Round-nose Punch (41-P-3640)

seat firmly against the hub of the gear. Use a block of hard wood for backing up the front end of the camshaft when driving the gear on the spline of the shaft. The same procedure applies to installing the gears on each of the four shafts.

(6) INSTALL BEARING ON WORM GEAR (fig. 69). Install the bearing on each of the worm gears and secure the bearing on the gear with a spanner nut and a new lock washer. This nut can best be tightened after the worm gear is assembled into the camshaft support.

(7) INSTALL WORM GEAR IN CAMSHAFT SUPPORT AND LINE UP TIMING MARKS (fig. 69). Set the timing marks on the bronze gears so they will line up with the marks on the camshaft support as shown in figure 72. Insert the worm gear in the camshaft support by turning the worm clockwise. This procedure permits the worm to mesh with the teeth on both of the bronze gears without moving them, thus keeping the timing marks lined up. Use the special wrench (41-W-2964-300) and camshaft holding tool (41-W-3247-150) as shown in figure 70 to turn the worm gear into the support. Place

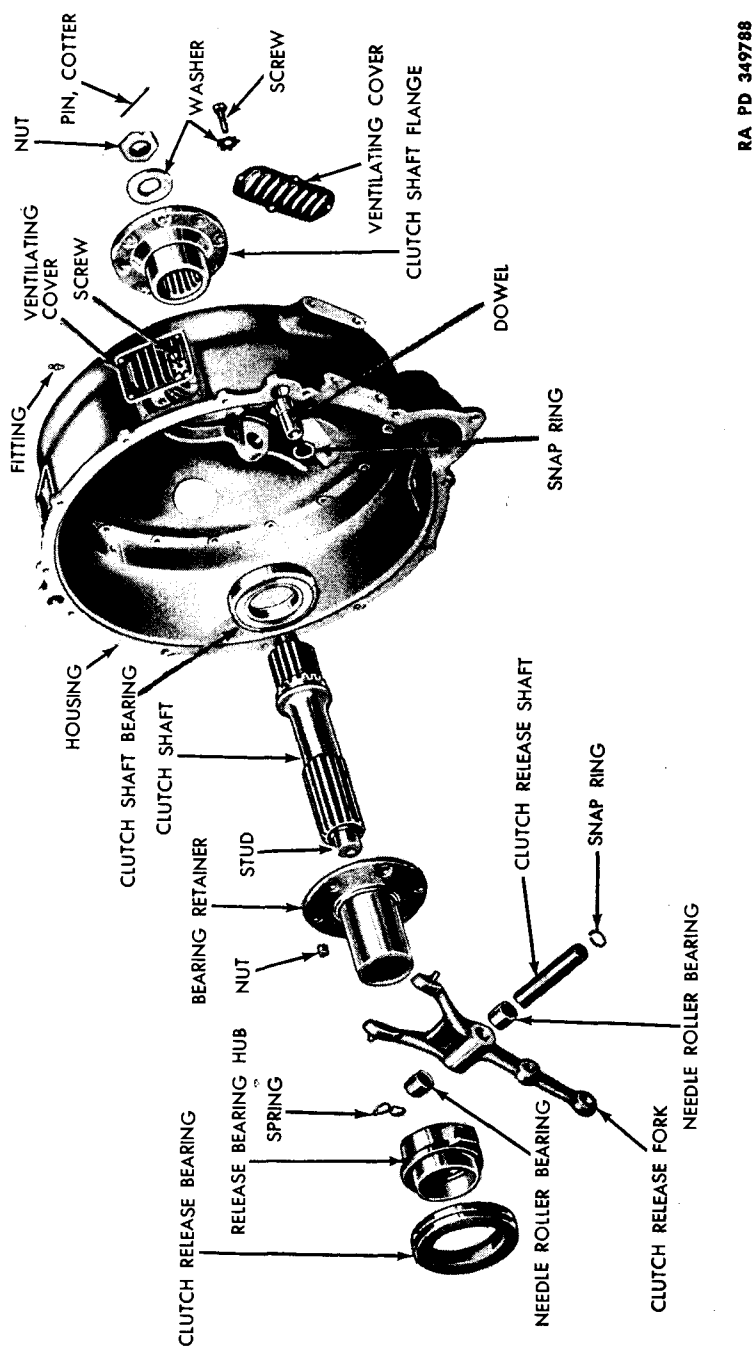


Figure 74 — Clutch Housing, Disassembled (Used on GAA Engines)

the bearing retainer on the top of the worm gear bearing with the flat side of the retainer against the bearing. This is the side without rounded corners. Secure the retainer to the camshaft support with four boot-type nuts.

(8) TIGHTEN SPANNER NUTS SECURING GEARS ON CAMSHAFTS. Install the spanner nut and lock washer and tighten the nut securely, using a spanner wrench. The shafts can be held from turning while tightening the nuts by inserting the turning wrench (41-W-2964-300) in the top of the worm drive gear (fig. 70). Indent the lock washer in the notches of the spanner nuts at three places after they are securely tightened. Use punch (41-P-3640) for indenting the lock washer as shown in figure 73.

24. CLUTCH ASSEMBLY (USED ON GAA ENGINES).

a. Description. The clutch is of the double-plate automotive type composed of three major units; the pressure plate assembly, the center drive plate, and the two driven plates or disks (fig. 79). The two driven plates have friction facings riveted on each side. The clutch release fork and the release levers in the pressure plate assembly are mounted on needle roller bearings. The clutch driven plates (disks) are supplied for service with the friction facings riveted to the disks.

b. Dissassembly.

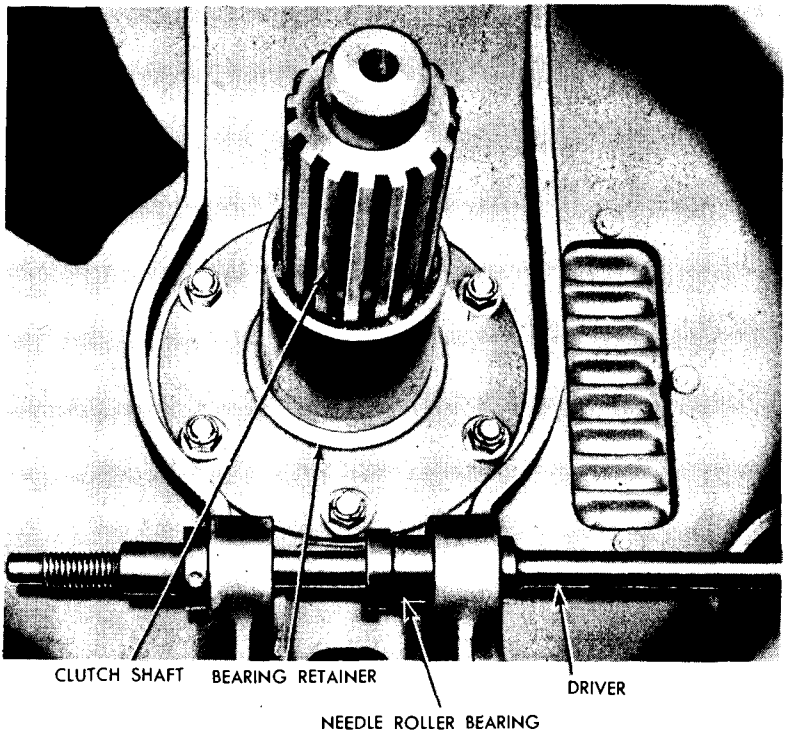
(1) DISASSEMBLE CLUTCH HOUSING.

(a) Remove Clutch Release Bearing and Hub (fig. 74). Unhook the two springs from the clutch release fork and slip the hub and bearing off the clutch shaft.

(b) Remove Clutch Shaft and Bearing From Housing (fig. 74). Take off the six nuts which secure the retainer and lift the retainer from the clutch housing. Remove the clutch shaft from the housing by driving on the end of the shaft from which the clutch flange has been removed, using a heavy rawhide hammer. The ball bearing can now be driven from the clutch housing.

(c) Remove Clutch Release Fork (fig. 74). Remove the snap ring retainers at each end of the clutch release shaft, and remove the release shaft and the clutch release fork from the housing.

(d) Remove Clutch Release Shaft Needle Roller Bearings From Housing. NOTE: *Replacement of the clutch release shaft needle roller bearings will not be necessary at each overhaul period since the operation is intermittent and wear ordinarily will be negligible.* Attach the driver (41-D-2869) as shown in figure 75, and press each of the needle roller bearings from the clutch housing.

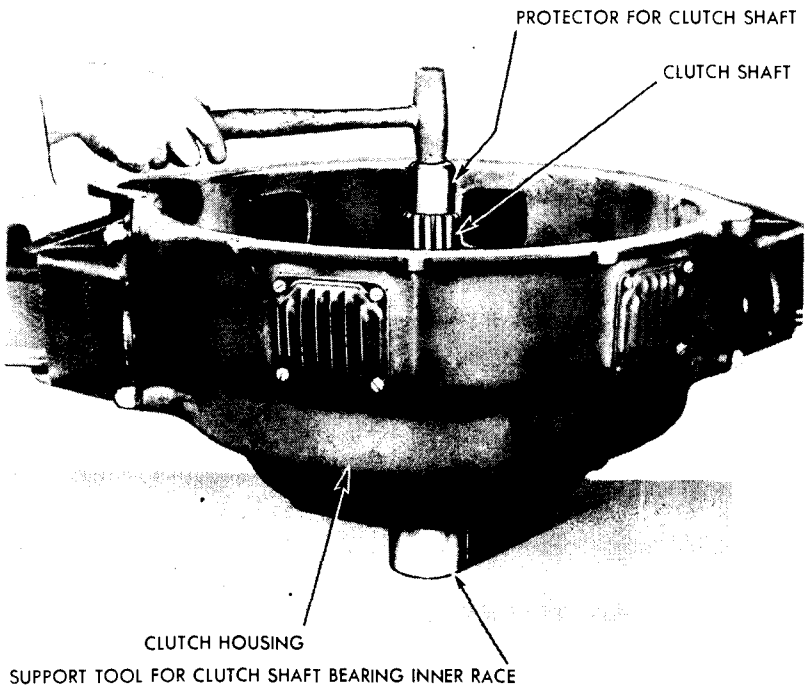


RA PD 349786

Figure 75 — Removing Clutch Release Shaft Needle Roller Bearings From the Clutch Housing, Using Replacer (41-R-2869)

(e) Remove Ventilating Covers From Clutch Housing (fig. 74). Remove the four screws from each of the ventilating covers on the housing and remove the covers.

(2) DISASSEMBLE PRESSURE PLATE (fig. 79). Lay the pressure plate assembly face down on an arbor press. Place three 1-inch wooden blocks evenly spaced under the face of the pressure plate. Lay a flat bar across the top of the pressure plate housing, clearing all cap screws, etc., and compress the pressure plate springs. Remove the ⅜-inch, 16-thread cap screws, which were installed prior to removal of the assembly for the engine. Remove the six thrust plates and clutch release lever adjusting nuts. Mark relation of pressure plate housing to pressure plate, and remove the pressure plate housing, clutch springs, and insulating washers. Remove the cotter pin



RA PD 28171

Figure 76 -- Driving Clutch Shaft in Bearing

and clevis pin which secure each release lever (fig. 80) to the pressure plate, and remove the release lever and needle roller bearings.

c. Cleaning. Clean all parts except the friction facings on the driven plate (disk) in dry-cleaning solvent. Clean the facings on the driven plates with a wire brush. Clean all ball bearings and needle roller bearings thoroughly.

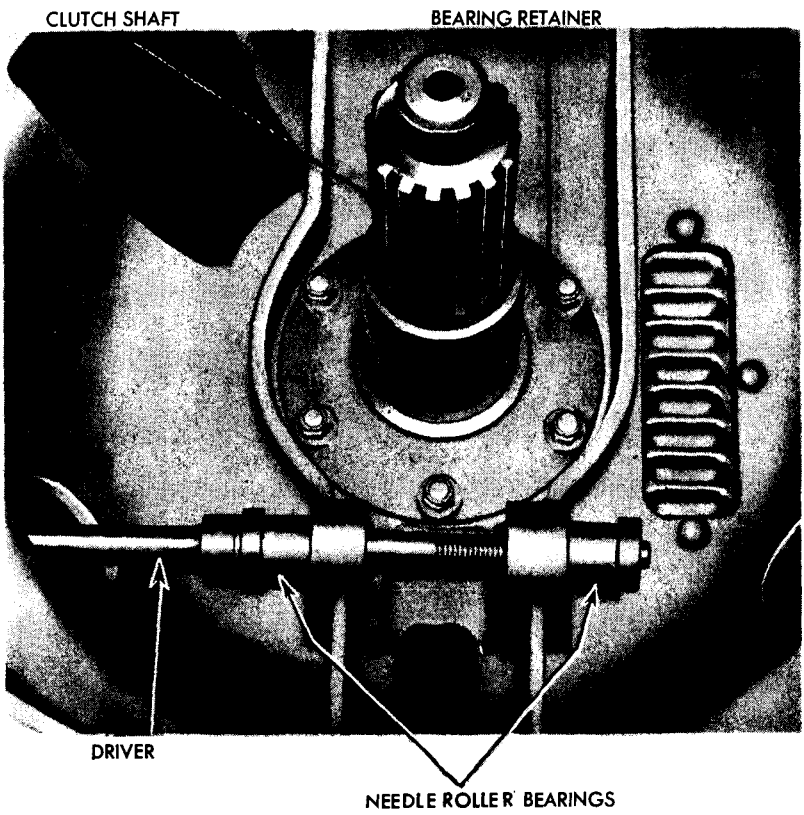
d. Inspection.

(1) CLUTCH HOUSING ASSEMBLY INSPECTION.

(a) Clutch Housing (fig. 74). Inspect the clutch housing for cracks or damage of any kind. If the condition is found unfit for further use it must be discarded.

(b) Clutch Shaft (fig. 74). Inspect the clutch shaft for wear at the splines. The clutch disk must be a sliding fit on the clutch shaft splines. The clutch shaft flange must be a light press fit on the spline at the end of the shaft.

(c) All Ball and Needle Roller Bearings (fig. 74). The inspection of a ball bearing is best performed after the bearing is washed,



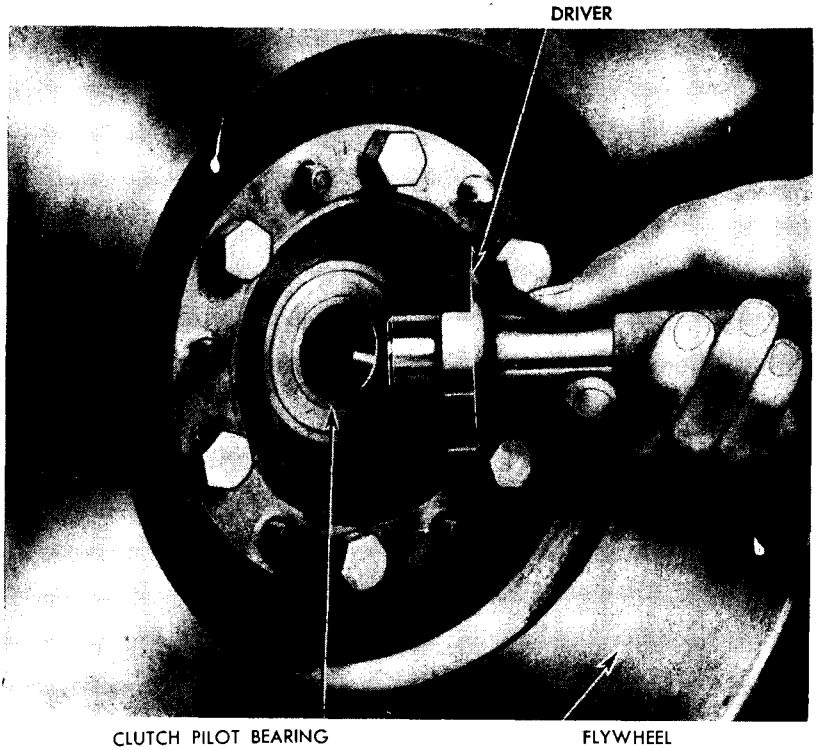
RA PD 349787

Figure 77 — Installing Clutch Release Shaft Needle Roller Bearings in Clutch Housing, Using Replacer (41-R-2869)

dried, and dipped in light oil. The condition of a ball bearing is best determined by the surface condition of the balls and races and the looseness in its races. Check for pits caused by corrosion. Check for discoloration of the balls, races, or retainers or for evidence of overheating. Bearings that have been overheated must be discarded. Spinning a bearing while holding it in the hands is not an accurate check of its running qualities, although this test will indicate presence of dirt or foreign matter in the bearing. Bearings in this condition are to be rewashed, lubricated, and rechecked.

(2) PRESSURE PLATE ASSEMBLY INSPECTION (fig. 79).

(a) Clutch Driven Plate (Disk) (fig. 79). Inspect the friction facings on the driven plates for wear. Plates with the facing worn



RA PD 350559

Figure 78 — Driving Clutch Pilot Bearing in Crankshaft

to within $\frac{1}{32}$ inch of the rivet heads must be replaced. Plates with friction facings that have deep scores or have become oil-soaked must also be replaced. NOTE: *Replacement of the friction facings on the plates is not permitted as they are cemented, riveted, then slotted in place by the manufacturer.*

(b) Drive Plate (fig. 79). Check the three retracting springs and pins on the drive plate and replace if broken or damaged. Check the width of the drive slots on the center drive plate. The manufacturer's dimensions are 0.743 inch to 0.745 inch. If the slots are worn and measure more than 0.760 inch, the drive plate must be replaced. If the friction surfaces on the plate are scored or contain heat checks or are worn unevenly, the plate must be resurfaced (subpar. e (1) below). The manufacturer's dimension for the thickness of a new drive plate is 1.092 inch to 1.094 inch. If it is anticipated that the thickness will be less than 1.031 inch to obtain a smooth, flat surface, it must be discarded.

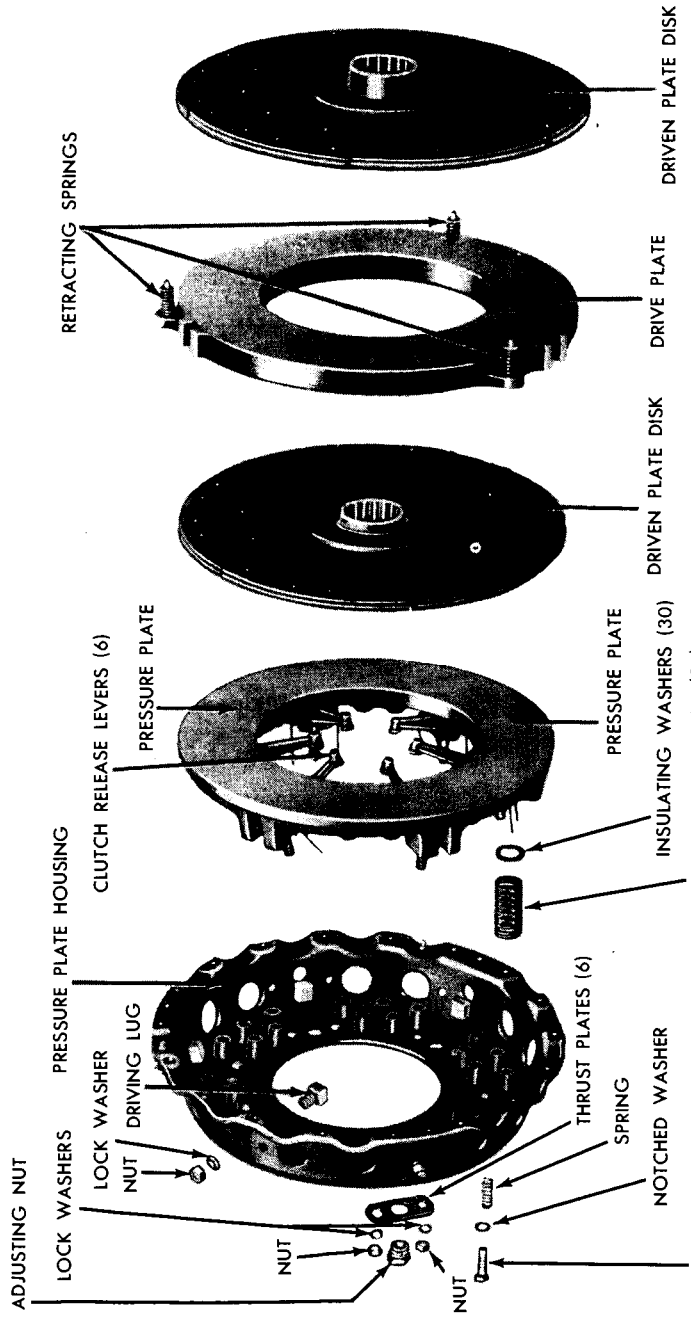
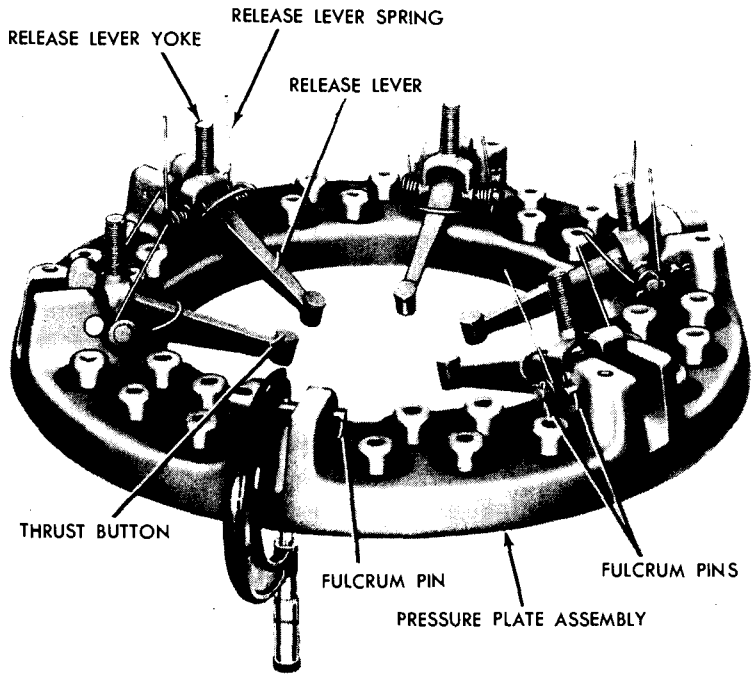


Figure 79 — Clutch Pressure Plate Assembly, Disassembled



RA PD 329653

Figure 80 — Checking Thickness of Pressure Plate

(c) Pressure Plate (fig. 79). If the friction surface on the pressure plate is scored, contains heat checks, or is worn unevenly, the plate must be resurfaced (subpar. e (2) below). The manufacturer's dimension for the thickness of a new pressure plate measuring from the friction surface to the top of the fulcrum pin, as shown in figure 80, is 1.895 to 1.900 inches. If it is anticipated that the thickness will be less than 1.835 inches to obtain a smooth, flat surface, it must be discarded.

(d) Release Levers (fig. 80). Check release lever needle roller bearings and fulcrum pins for scores, pits or rust. Replace if required. Also check the diameter of the bearing surface of the fulcrum pins. The manufacturer's dimension is 0.3275 inch to 0.3285 inch. Pins that are worn and measure less than 0.323 inch, must be replaced. Replace release levers that are bent. Replace the thrust buttons in the release levers if they are worn to larger than 0.500 inch wear pattern on the radius of the button (subpar. e (3) below). Replace any release lever springs that are broken.

(e) Pressure Plate Springs (fig. 79). Check the spring load of

each spring. The manufacturer's specifications for the spring load is 144 to 150 pounds at 1.950-inch spring length. Springs with a load less than 137 pounds must be tagged, indicating the amount of load to determine the amount of shims to be added during assembly procedure. Springs that have a spring load of less than 125 pounds must be discarded.

(f) Pressure Plate Housing (fig. 79). Check the driving lugs in the pressure plate housing for width. The manufacturer's dimension is 0.7525 to 0.7535 inch. Lugs that are worn and measure less than 0.7480 inch must be discarded.

e. Repair.

(1) REFACE CLUTCH DRIVE PLATE. If the center drive plate (fig. 79) requires refacing and the surface does not clean up to a smooth, flat surface when a minimum thickness of 1.031 inch is reached, the plate must be discarded.

(2) REFACE CLUTCH PRESSURE PLATE. If the pressure plate requires refacing and surface does not clean up to a smooth, flat surface when a minimum thickness of 1.900 inches is reached, measuring from the face of the pressure plate to the top of the clevis pin (fig. 80), the plate must be discarded.

(3) REPAIR RELEASE LEVERS. If the release lever thrust buttons (fig. 80) are worn and require replacement, use a hammer and a suitable punch and drive the worn buttons from the fingers. Press new buttons in the fingers until they are firmly seated. The width of the levers have been reduced on late production clutches to eliminate friction between the pressure plate lugs and the levers. Levers with thickness of more than 0.753 inch must be reground to from 0.748 inch to 0.753 inch.

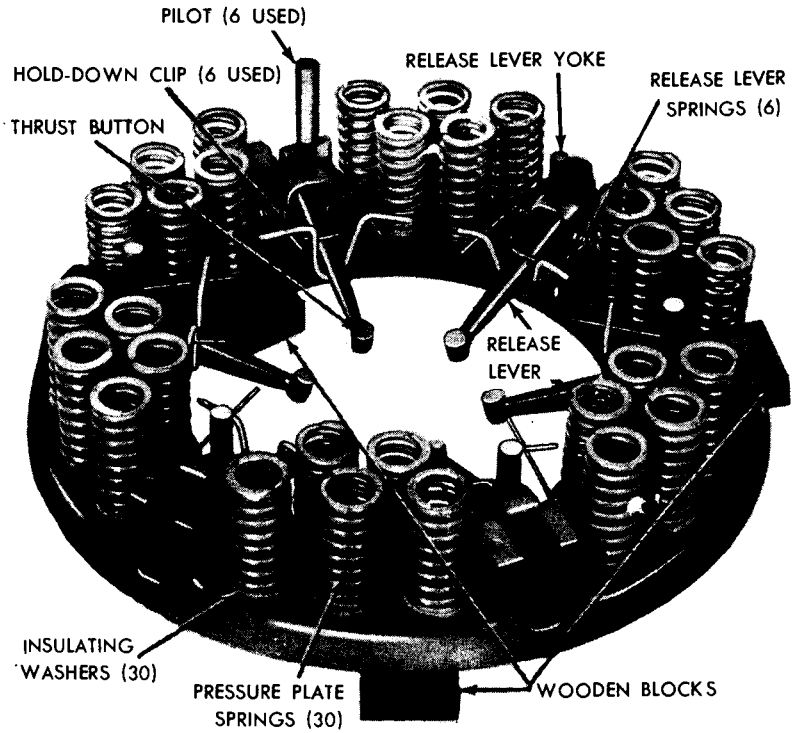
f. Assembly.

(1) ASSEMBLE CLUTCH HOUSING.

(a) Install Clutch Shaft Bearing in Housing (fig. 74). With a suitable driver, tap the clutch shaft bearing in the recess in the housing.

(b) Install Clutch Shaft and Clutch Shaft Bearing Retainer in Housing. Turn the clutch housing upside down. Insert the clutch shaft in the bearing. Place a suitable protector on the end of the clutch shaft as shown in figure 76, and drive the shaft through the bearing until it is firmly seated. Place the bearing retainer over the clutch shaft bearing and secure it to the housing with six boot-type nuts (fig. 74).

(c) Install Clutch Release Shaft Needle Roller Bearings in Housing. If the clutch release shaft needle roller bearings were removed during the disassembling of the clutch housing, they should be re-



RA PD 329652

Figure 81 — Pressure Plate Showing Hold-down Clips and Pilot on Clutch Release Levers

placed with new bearings. Attach the driver (41-D-2869) as shown in figure 77 and press the bearing in the housing.

(d) Install Clutch Release Shaft (fig. 74). Place the clutch release fork in the housing and insert the clutch release shaft through the needle roller bearings and fork. Install the snap ring retainer at each end of the shaft.

(e) Install Clutch Release Bearing and Hub in Housing (fig. 74). Press the clutch release bearing on the hub. Slip the hub and bearing assembly over the bearing retainer and hook the two springs to the clutch release fork and the hub of the release bearing.

(f) Install Ventilating Covers on Clutch Housing (fig. 74). Install each of the ventilating covers on the housing, and secure them to the housing with fillister-head screws and lock washers.

(g) Install Clutch Pilot Bearing in Front End of Crankshaft. Lubricate the clutch pilot bearing, using ball and roller bearing grease.

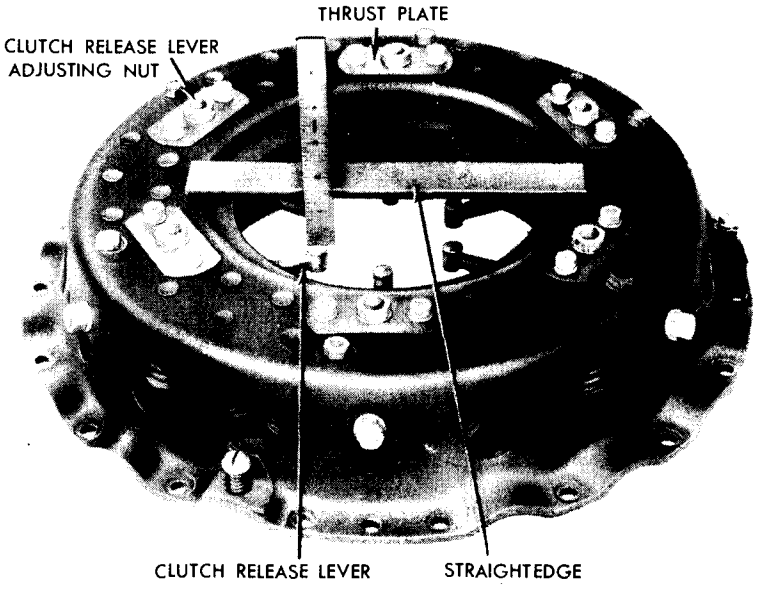


Figure 82 — Adjusting Clutch Release Levers

With the closed side of the bearing facing outward, tap the bearing in the recess in the crankshaft using a suitable driver as shown in figure 78.

(2) ASSEMBLE CLUTCH PRESSURE PLATE UNIT.

(a) Assemble Pressure Plate Housing (fig. 79). If the driving lugs have been removed from the housing, place the six driving lugs in position in the housing. Install the lock washers and nuts on the lugs. Do not tighten the nuts at this time. Use a pressure plate from which the release levers have been removed as a gage. Place the pressure plate in position over the lugs, then tighten the nuts securely. Slide the pressure plate up and down to make sure the lugs are not binding in the pressure plate slots. Place a notched washer and spring on each of the three adjusting screws, and install the screws in the pressure plate.

(b) Assemble Release Lever on Pressure Plate (fig. 80). To assemble the needle roller bearings in the release lever, use a dummy pin $\frac{5}{16}$ inch in diameter and $\frac{5}{8}$ inch long. Place the dummy pin in the release lever hole, and assemble the needle roller bearings around the dummy pin. Place the release lever yoke and spring in position on the lever. Install a flat washer on the fulcrum pin, and insert the

fulcrum pin through the yoke and lever. The dummy pin is pushed out when the regular pin is inserted. Install a flat washer and cotter pin on the pin. Install the needle roller bearings in the hole at the end of the lever, using the dummy pin as described above. Place the release lever in position on the pressure plate, and install the fulcrum pin which secures the lever to the plate. Install the cotter pin. Lubricate pressure plate slots sparingly.

(c) *Assemble Pressure Plate in Pressure Plate Housing* (fig. 81).

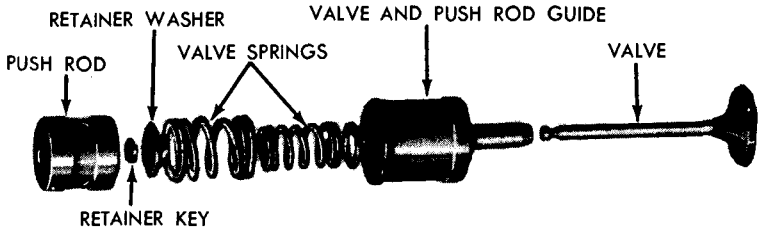
1. *Install spring on pressure plate* (fig. 81). Place the pressure plate face down on three ½-inch blocks. If old clutch springs are being used, note the spring load of each spring. For springs that have a load of less than 137 pounds, a 0.031-inch shim washer must be added for each 6 pounds under 137 pounds. If shims are required, they must be placed under insulator washer for that particular spring. If either the center drive plate or pressure plate has been refaced, use a 0.031-inch shim washer for each 0.031-inch total reduction in thickness of the center drive plate and pressure plate. These shims are used in addition to the shim which may have been used for correcting spring load. Place the specified amount of shims and insulators in position on the pressure plate.

2. *Install pressure plate housing on pressure plate* (fig. 81). Place a suitable pilot on the threaded end of each yoke. Fasten the release lever tension spring down with suitable spring clips. Place the housing over the pilots, making sure the matching marks on the pressure plate and housing are lined up. Slowly lower the housing until it is seated on the clutch springs. Place the assembly under an arbor press with the pressure plate, face down, resting on three ½-inch blocks. Lay a flat bar across the top of the housing, clearing all cap screws, etc. Compress the housing slowly until the housing mounting flange joint touches the table. Install six ⅜-inch, 16-thread cap screws, 1½ inches long in the six holes provided in the housing and tighten until the heads are just seated; then release the arbor press. Do not remove the six ⅜-inch bolts from the housing until the assembly has been installed on the flywheel.

3. *Adjust release levers (preliminary adjustment)* (fig. 82). Install the six release lever adjusting nuts and thrust plates. Place a straightedge across the top of the pressure plate housing, clearing all cap screws, etc. Adjust release lever to approximately 1.375 inches, measuring from the bottom of the straightedge to the top of the release lever buttons (fig. 82). A final adjustment must be made after the presure plate assembly is assembled on the flywheel.

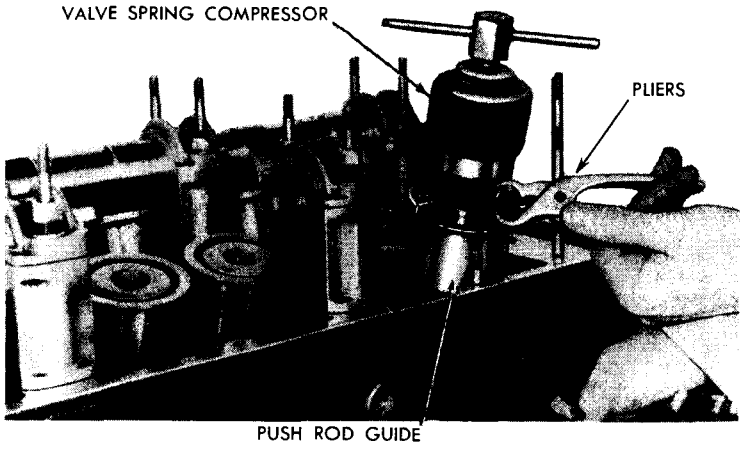
25. CYLINDER HEADS AND VALVES.

a. Description. Cylinder head assemblies are aluminum with steel alloy insert seats for both intake and exhaust valves. The push



RA PD 329644

Figure 83 — Valve Assembly, Disassembled



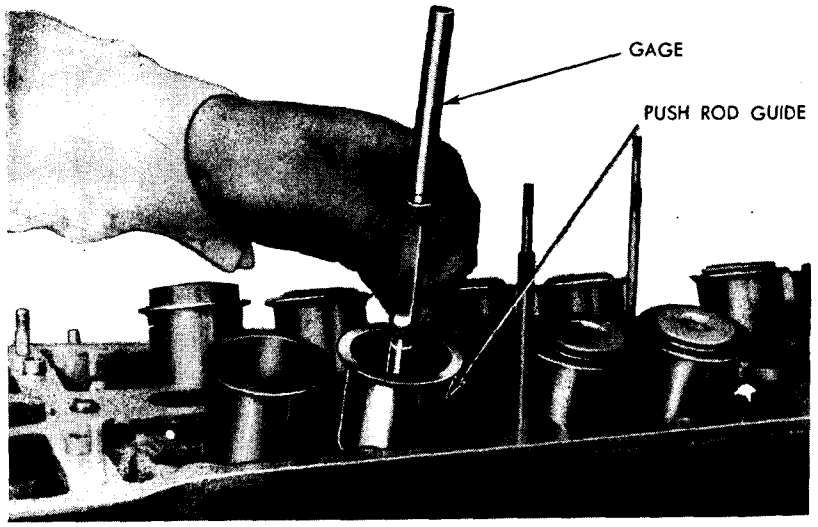
RA PD 28042

Figure 84 — Compressing Valve Spring, Using Compressor (41-C-2559-40)

rod guides are pressed in place, and the camshafts are mounted in bearings on the top of the heads and operate directly on the push rods. The gap or clearance between the push rods and cams is governed by the length of the valve stem. A clearance of 0.026 inch to 0.030 inch on the intake valves and 0.028 inch to 0.032 inch on the exhaust valves is established during manufacture or overhaul. Since this clearance is established cold and is greater than the maximum normal expansion of the parts, no further attention is normally required between overhaul periods.

b. Disassembly.

(1) REMOVE EXHAUST MANIFOLDS. Remove the lock wire and the nuts securing the manifold to the cylinder head, and remove the manifold from the head. The same procedure applies to each manifold.



RA PD 28135

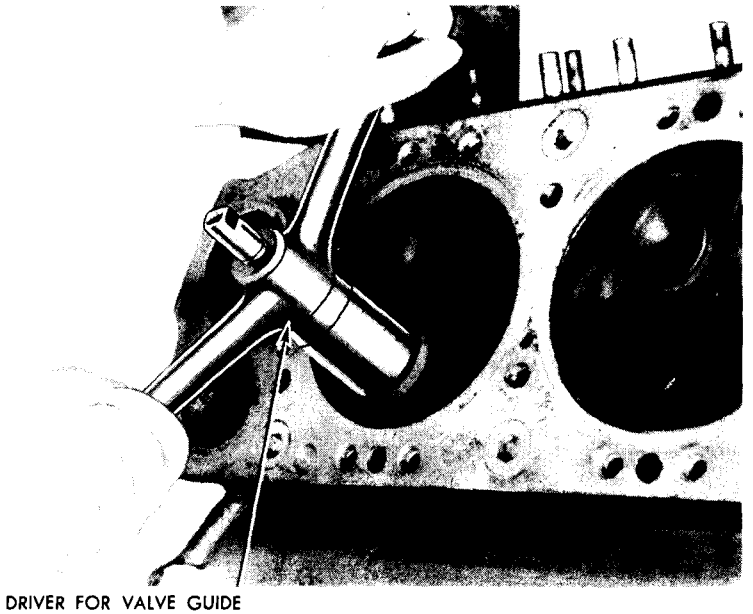
Figure 85 — GO and No-go Gage (41-G-500-100) for Checking Valve Guides

(2) REMOVE VALVES. NOTE: *A tray should be provided for holding the push rods as they must be kept in order so they may be assembled in their original position in the engine.* Lift the push rod from the valve guide. Attach the valve spring compressor (41-C-2559-40) to the rim of the push rod guide as shown in figure 84; compress the valve spring, and remove the key from the retainer washer. Remove the valve from the head. Remove the springs, retainer, and seat from the guide. Repeat this procedure for the other valves.

c. Cleaning. Remove all dirt and carbon from the cylinder head by brushing and scraping. Flush out all water jackets with a high-pressure hose. Immerse the cylinder head in dry-cleaning solvent and remove all remaining dirt. CAUTION: *Do not use a caustic soda bath for aluminum heads.* Thoroughly clean all oil passages in the cylinder head, using a rifle brush wherever possible and dry-cleaning solvent under pressure. Blow out all oil passages with compressed air, making sure all oil passages are open. Dry the entire head with compressed air.

d. Inspection.

(1) VALVE GUIDES AND PUSH RODS (fig. 83). Check the valve stem guides and push rod guides for wear. Use go and no-go gage



RA PD 28173

Figure 86 — Replacing Valve Guide, Using Replacer (41-R-2390-500)

(41-G-500-100) for checking the valve stem guide (fig. 85). Check the inside diameter of the push rod guide. The manufacturer's dimensions for the inside diameter of the push rod guide is 1.920 inches to 1.921 inches. Push rod guides that are worn and measure more than 1.923 inches, or valve stem guides that are found to be worn when checked with the gage must be replaced (par. e (1) below). Check the diameter of the push rods. The manufacturer's dimensions are 1.9170 inches to 1.9172 inches. Push rods that are worn and measure less than 1.9155 inches must be replaced.

(2) VALVES (fig. 83). Valves that are burned, pitted or warped must be replaced. Check the diameter of the intake and exhaust valve stems. The manufacturer's dimensions for the intake valve stems are 0.4345 inch to 0.4350 inch; and for the exhaust valve stem, the manufacturer's dimensions are 0.4340 inch to 0.4345 inch. Intake valves that have a worn stem and measure less than 0.4310 inch must be replaced. Exhaust valves that have a worn stem and measure less than 0.320 inch must be replaced. Reface all valves (subpar. e (7) *(b)* below).

(3) BROKEN OR DAMAGED STUDS. Studs with damaged threads or bent studs must be replaced. Removal of broken studs is covered in subparagraph e (5) *(b)* below.

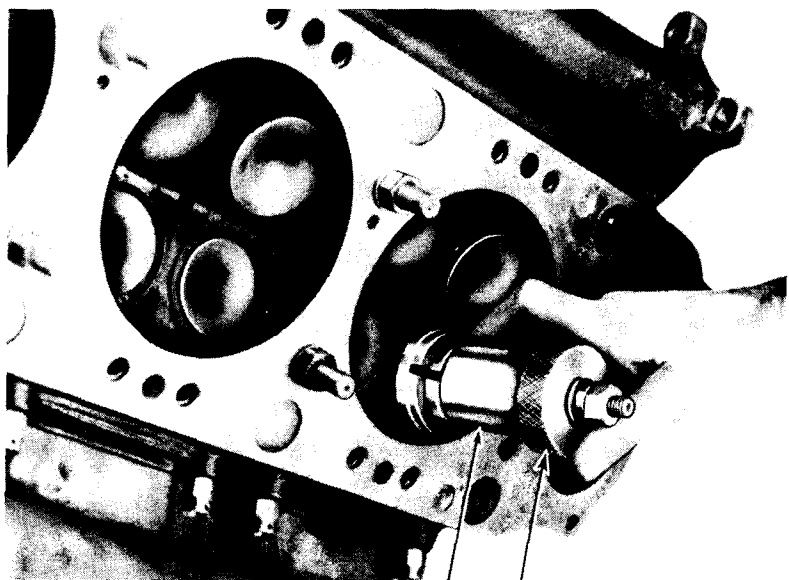


Figure 87 — Removing Valve Seat Inserts, Using Remover (41-R-2371-400)

(4) CYLINDER HEAD GASKET SURFACE. Inspect the gasket surface of the cylinder head. Heads that are corroded, or have burned spots on the gasket surface which will cause leakage of water, oil, or compression must be replaced. Heads that are warped in excess of 0.010 inch must be replaced.

(5) CYLINDER HEADS. Test cylinder heads for water leaks under pressure of 80 pounds per square inch.

(6) CAMSHAFT BEARINGS (fig. 14). Bearings found scored or damaged beyond further use must be replaced. Check the inside diameter of each bearing. The manufacturer's dimensions for the camshaft bearings are 1.476 inches to 1.477 inches. Bearings that are worn more than 0.002 inch must be discarded.

(7) SPARK PLUG INSERTS (fig. 91). Examine the condition of the threads in the spark plug inserts. Check to determine if the spark plug inserts are tight in the cylinder head. Replace or repair spark plug inserts if required (subpar. e (4) through (6) below).

(8) CORE PLUGS. Examine the heads for loose core plugs and mark any plugs which are loose or show signs of leaks. Replace or repair any core plugs as required (subpar. e (6) below).

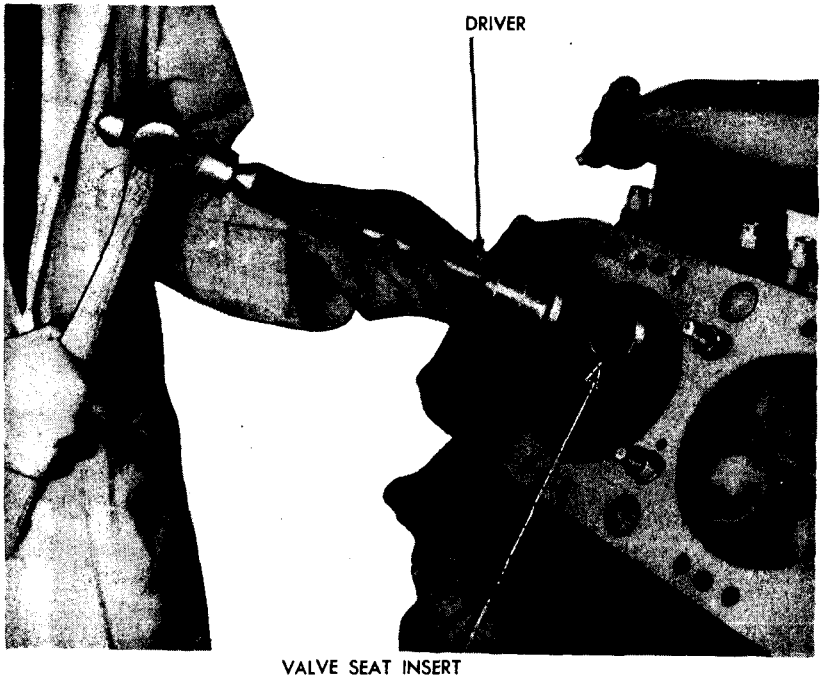
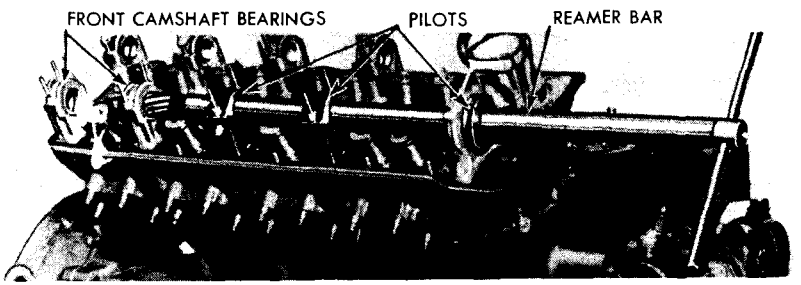


Figure 88 — Driving Valve Seat Insert, Using Driver (41-D-2980-155)

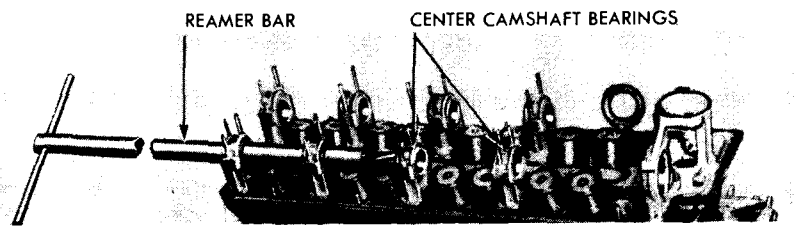
(9) VALVE SPRINGS (fig. 83). Check valve springs for cracks and rust spots. All springs having cracks or rust spots must be replaced. Check valve spring tension. The manufacturer's specifications are as follows: The tension for the larger springs for both intake and exhaust is 25 to 27 pounds at 2.08 inches length (valve closed) and 100 to 105 pounds at 1.58 inches length (valve open). The spring tension for the small springs for both the intake and exhaust is 11 to 13 pounds at 2.00 inches spring length (valve closed) and 70 to 75 pounds at 1.50 inches spring length (valve open). Large springs which test less than 22 pounds at 2.08 inches long and 95 pounds at 1.58 inches long are weak and must be discarded. Small springs which test less than 9 pounds at 2.00 inches long and 65 pounds at 1.50 inches long are weak and must be discarded.

(10) VALVE INSERTS (EXHAUST AND INTAKE). All valve inserts must be refaced (subpar. e (7) below). Valve inserts that are badly burned, pitted, cracked, or loose must be replaced (subpar. e (2) below).

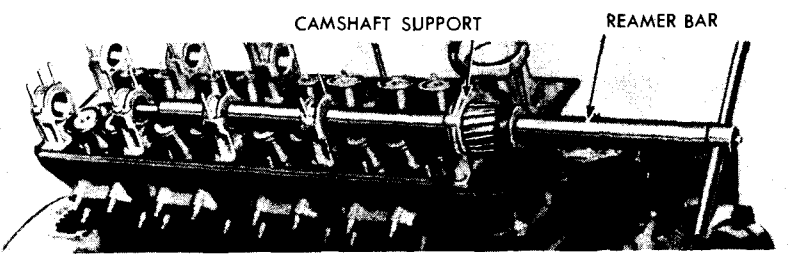
(11) EXHAUST MANIFOLDS. Check each exhaust manifold for burned spots, cracks, or damaged studs.



First Step—Reaming Two Front Camshaft Bearings



Second Step—Reaming Two Center Camshaft Bearings



Third Step - Reaming Camshaft Support RA PD 28137

Figure 89 — Reaming Camshaft Bearings, Using Reamer (41-F-2994-19)

e. Repair.

(1) VALVE GUIDE REPLACEMENT. Any valve guide which previous inspection has shown unfit for further use is to be replaced. With a suitable drift, drive the guide out of the cylinder head. To install valve guides, attach the valve guide replacer (41-R-2390-500) as shown in figure 86, and pull the new guide into the cylinder head until it is firmly seated. NOTE: *Valve guides are machined to size at the factory and do not require reaming after installation in the cylinder head.*

(2) VALVE INSERT REPLACEMENT (INTAKE OR EXHAUST).

(a) Removal. Any valve seat which previous inspection has shown unfit for further use must be replaced. Remove the valve

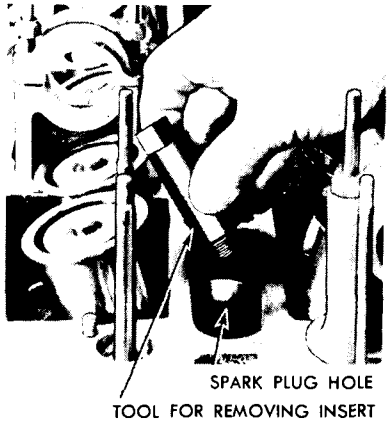


Figure 90 — Removing Spark Plug Insert, Using Remover (41-R-2371-350)

Figure 91 — Installing Spark Plug Insert in Cylinder Head, Using Replacer (41-W-3255-500)

guide from cylinder head (step (1) above). Attach the valve seat insert remover (41-R-2371-400) as shown in figure 87. To attach the remover, squeeze the pulling jaws together by means of the knurled nut (fig. 87). Push the pulling jaws through the valve seat insert, then turn the knurled nut counterclockwise several turns to release the jaws. Then tighten the hexagonal nut on the end of the puller just tightly enough to expand the jaws firmly behind the insert. Place a brass drift through the valve guide hole and drive on the end of the tool.

(b) Installation. Clean up the seat recess and outside diameter of the new valve seat. Heat the cylinder head to approximately 212° F. Any method for heating the head will be satisfactory except the use of a direct flame. Pack the new insert in dry ice for at least 15 minutes. Using a 2-inch ferrule driver (41-D-2980-155), drive the new seat firmly in the seat recess (fig. 88). After installation, the valve inserts must be refaced (step (7) below).

(3) CAMSHAFT BEARING REPLACEMENT.

(a) General. Bearings which previous inspection has found worn or damaged beyond further use are to be replaced. The four camshaft bearings for each camshaft are supplied for service 0.020 inch undersize, and must be line-reamed to 1.476 inches to 1.477 inches after installation on the head. The rear camshaft support which carries the ball bearings are also supplied for service 0.020 inch undersize, and require reaming along with the other bearings. The camshaft bearings are stamped with a number, and the cylinder head

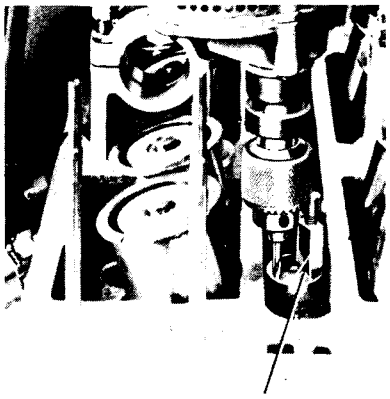


Figure 92 — Drilling Spark Plug Insert Dowel, Using Fixture (41-T-2990)

Figure 93 — Refacing Spark Plug Insert in Cylinder Head, Using Refacing Tool (40-C-1840)

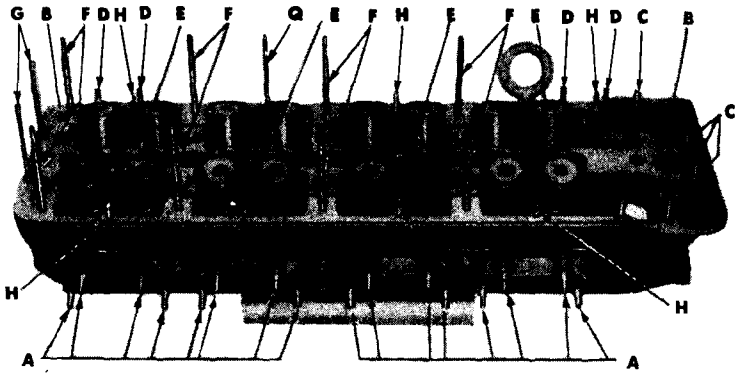
is stamped with a corresponding number. All old bearings must, therefore, be installed in the correct position, and new bearings must be stamped with correct number after installation.

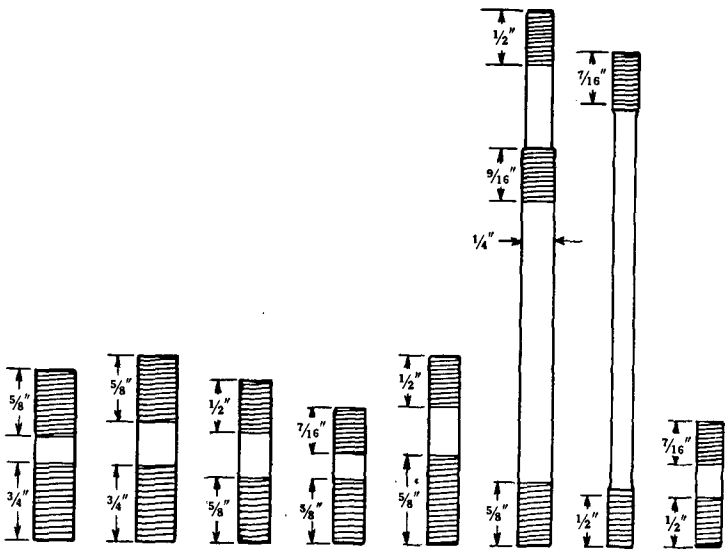
(b) Reaming New Camshaft Bearings.

1. General. When reaming the camshaft bearings, the cylinder head must be installed on the cylinder block and tightened down evenly, using a torque wrench and tightening each stud to 60 foot-pounds. The following procedure is written for one camshaft and should be followed for each of the four camshafts where new bearings are used. The reaming of the bearings requires three operations or steps as shown in figure 89.

2. Ream two front bearings. NOTE: *The bearings at the extreme front differ from the others in that they contain an oilhole and a dowel pin hole.* Install the two camshaft bearings in position at the front end of the cylinder head as shown in figure 89, first step. Install the pilots on the next two bearing positions as shown. Attach the rear support to the cylinder head and put the pilot bushing in the recess on the support as shown. Place the bearing caps on the two front bearings and the hold-down nuts on the two pilot bearings. Tighten the bearing cap nut and the nuts on the rear support. Use a torque wrench and tighten the bearing nuts to 16 foot-pounds pull. Insert the reamer (41-F-2994-19) through the pilot as shown in figure 89, first step, and ream the two front bearings.

3. Ream next two bearings. Remove the two pilot bearings and replace them with two new bearings. Insert the reamer through the

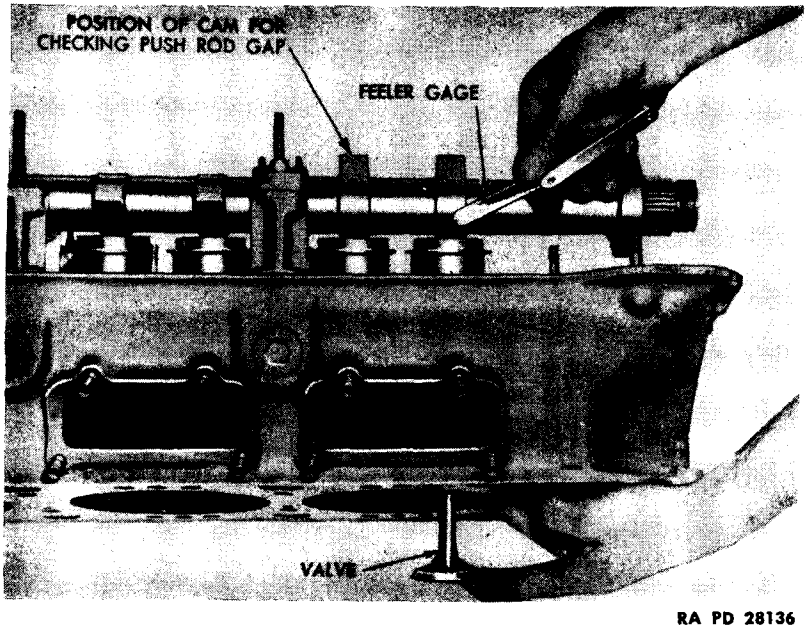




STUD	A	B	C	D	E	F	G	H
TOTAL LENGTH	1 5/8"	1 13/16"	1 9/16"	1 5/16"	1 13/16"	5 5/32"	4 3/4"	1 1/4"
PROTRUDING LENGTH	27/32"	1 1/8"	1"	13/16"	1 7/32"	4 17/32"	4 9/32"	13/16"
DIAMETER	3/8	3/8"	5/16"	5/16"	5/16"	5/16"	1/4"	1/4"
NUMBER USED (BOTH HEADS)	32	4	8	10	8	16	5	19

RA PD 329674

Figure 94 — Identification of Cylinder Head Studs



RA PD 28136

Figure 95 — Establishing Correct Clearance Between Push Rods and Cams

two front bearings which have just been reamed, and ream the next two bearings as shown in figure 89, second step.

4. Ream rear support. Remove the cutter from the end of the reamer bar. Attach the large cutter on the bar and ream the rear support as shown in figure 89, third step.

5. Final procedure. After reaming the bearings, the cylinder head must be removed from the engine and thoroughly cleaned of chips. NOTE: *Camshaft bearings must always be used on the cylinder head on which they were line-reamed.*

(4) SPARK PLUG INSERT REPLACEMENT.

(a) General. If previous inspection has shown any of the spark plug inserts loose in the cylinder head or the threads damaged, they are to be replaced.

(b) Remove Spark Plug Insert (fig. 90). Center-punch the dowel and drill approximately $\frac{3}{16}$ inch into the dowel using a $\frac{3}{32}$-inch drill. This is necessary in order to remove the spark plug insert. Screw the spark plug insert remover (41-R-2371-350) into the insert and continue turning the remover clockwise to remove the insert. (The

outside diameter of the spark plug insert and cylinder head have left-hand threads.)

(c) Install New Spark Plug Insert (fig. 91). Pack the new spark plug insert in dry ice for at least 15 minutes. With the special wrench (41-W-3255-500), screw the new insert into the cylinder block. The threads on the insert and cylinder block are left-hand; therefore, turn the driver counterclockwise when screwing the insert into the head.

(d) Dowel Spark Plug Insert (fig. 92). Set the fixture (41-T-2990) in the spark plug hole of the insert to be drilled, being careful not to drill new dowel hole so it will cut into the former dowel hole. Tighten the screw at the top of the fixture. Drill ½ inch deep through the insert and into the cylinder head with a No. 31 drill. Insert a dowel pin in the hole and drive it in until it is flush with the top face of the spark plug insert.

(e) Reface Spark Plug Insert (fig. 93). This operation is required only when a new insert is installed. Install the cutter (40-C-1840) in a suitable drill chuck and cut the driving lugs from the top of the insert, leaving a smooth surface on the flange of the insert.

(5) STUD REPLACEMENT.

(a) Remove Damaged Studs. To remove a damaged stud, use stud setter and extractor (41-S-2390).

(b) Remove Broken Studs. Indent the end of the broken stud exactly in the center with a center punch. Drill approximately two-thirds into the broken stud, using a small drill; then follow up with a larger drill. The size of the drill depends on the size of the stud to be removed. However, the drill selected must leave a wall thicker than the depth of the threads. Select an extractor of the proper size from the set (41-E-562). Insert it into the drilled hole and screw out the remaining part of the broken stud.

(c) Install Studs. A number of sizes and lengths of studs are used in the cylinder heads. See figure 94 when selecting new studs for the cylinder head. With a standard stud driver, drive all studs until the correct protruding length is obtained. See figure 94 for the type of stud and also the specified protruding length. If the stud is too tight or too loose in the stud hole, select another stud.

(6) CYLINDER HEAD CORE PLUG REPLACEMENT. Unscrew the plugs to be replaced with a ⅝-inch socket-head set screw wrench. Clean the recess thoroughly. Install a new gasket on the plug. Use joint and thread compound on the threads and gasket before installation. Screw the new plug in place tightly.

(7) RESEATING AND REFACING VALVES.

(a) Reseat Valve Seats. Valve seat inserts can be reseated either by grinding the seats, using a conventional valve seat grinder or a valve seat cutter having an angle of 45 degrees. The manufacturer's dimensions for the width of the finished seat is 0.09375 inch. The width of the seat will be increased by the reseating. If the width of the seat exceeds 0.125 inch, use a 30-degree cutter to reduce width to 0.09375 inch.

(b) Reface Valves. Grind the valves at a 45.5- to 46-degree angle (91 to 92 deg. included angle). The width of a seat will be increased by grinding. If the width of the valve seat exceeds 0.156 inch before it cleans up, the valve must be replaced.

(8) ESTABLISHING CORRECT GAP BETWEEN PUSH RODS AND CAMS. After the valves have been refaced and the valve seats have been reseated, the gap between the push rods and the heel of the cams will have been reduced. Install all push rods in their guides. Install the lower halves of the camshaft bearings. Set the camshafts in place, and secure with at least two bearing caps. Turn the camshaft so the heel of the cam is next to the push rod of the particular valve being worked on. Select the valve which is to be installed in the particular valve port, and push it up firmly against the valve seat. This will force the push rod up, and the clearance or gap between the push rod and the heel of the cam can be checked as shown in figure 95. The correct gap is from 0.026 inch to 0.030 inch on the intake valve and 0.028 inch to 0.032 inch on the exhaust valves. If the gap is less than the limits specified, grind sufficient material from the end of the valve stem to establish the correct gap. If the gap is more than the specified limits, either select a new longer valve, or seat the old valve more deeply by removing material from either the seating surface of the valve head or the valve seat insert, preferably from the valve head. Repeat the above procedure for all valves, marking each valve for later identification. Remove camshafts.

f. Assembly.

(1) INSTALL EXHAUST MANIFOLD ON CYLINDER HEADS. NOTE: *Due to better accessibility for tightening the exhaust manifold nuts, it is advisable to install the manifolds on the cylinder heads before the heads are installed on the engine.* Install new exhaust manifold gaskets. Place the manifold over the studs and new gaskets. Secure the manifold to the cylinder head with 16 special manifold nuts. Lock the nuts with wire. The same procedure applies to installing each manifold.

(2) INSTALL VALVES. Place a valve spring seat in the bottom of the push rod guide. Install the inner and outer valve spring in the guide. Place the retainer washer on top of the springs. Attach the

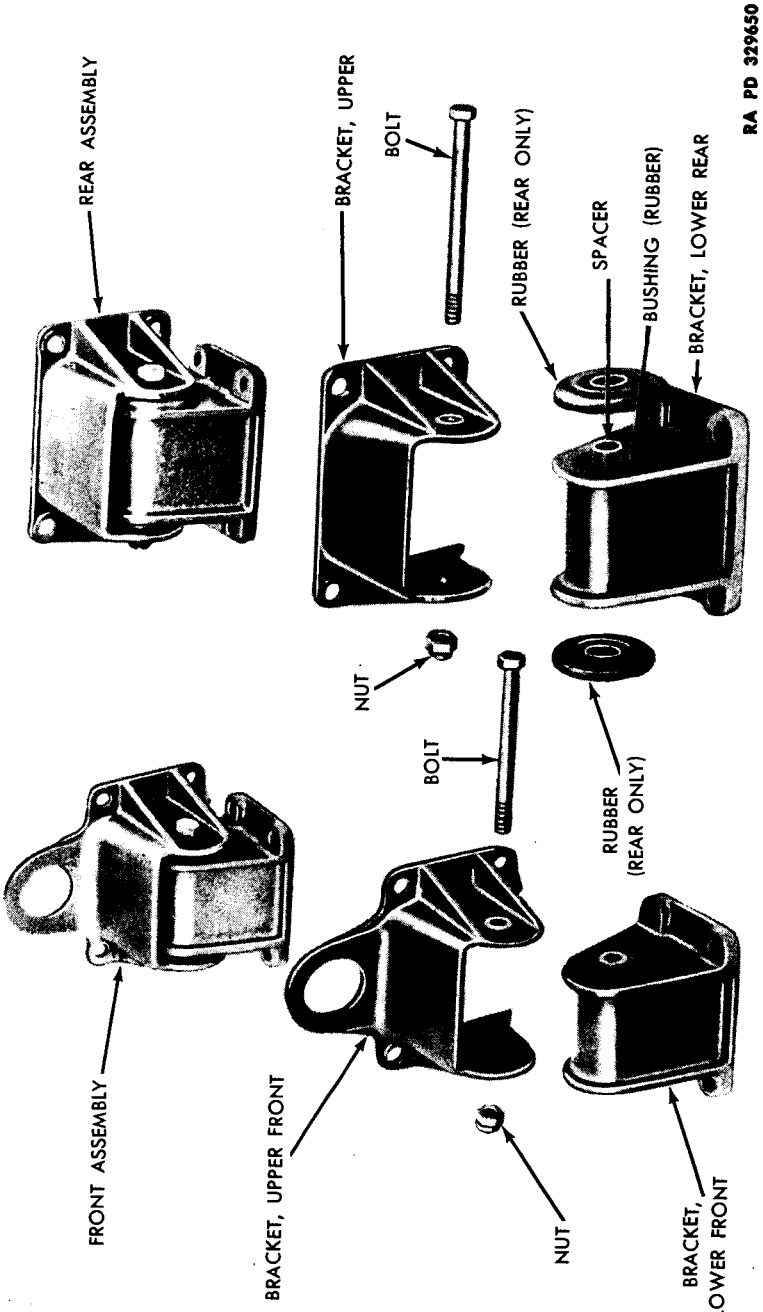


Figure 96 — Engine Supports, Disassembled (Used on GAA and GAN Engines)

valve spring compressor (41-C-2559-40) as shown in figure 84, and compress the springs. Insert the valve which was previously prepared for the particular port being worked on, and install the two keys in the groove provided on the end of the valve stem. Release the valve spring compressor, making sure the keys are firmly locked in the groove. The same procedure applies for installing each valve in the cylinder head.

(3) INSTALL OIL TUBES IN CYLINDER HEAD. Any oil tubes which are damaged must be removed from the cylinder heads and replaced with new tubes. Special drivers (41-D-2980-150) are available for driving the various size tubes in the cylinder heads. Tubes must be driven in the recess in the head until they are firmly seated, and they must also be square with the face of the head.

26. CARBURETOR ADAPTER HOUSING.

a. Description. The carburetor adapter housings (figs. 2 and 3) are located between each carburetor and the intake manifold. The adapter housings provide a means of preheating the fuel mixture. Heater pipes are connected between the ends of the exhaust manifolds and the adapter housings which permit the exhaust gases to pass through the outer section of the housing, thus heating the fuel mixture.

b. Cleaning. The exhaust passage in the adapter housing must be cleaned of any accumulation of carbon.

c. Inspection. Check the adapter housing for cracks or other damage. If any parts of the housing are damaged or worn in such a manner that it will affect the operation of the engine, the entire unit must be replaced as separate parts are not supplied for service.

27. ENGINE MOUNTS.

a. Description (fig. 96). The GAA engine has four rubber insulated engine mounts. The two front mounts are located on the clutch housing and are interchangeable. The two rear mounts are interchangeable in respect to right and left. The GAF engine has two mounts at the rear which are the same as the rear mounts on the GAA engine. The front engine mounts are cast integral with the oil pan. The GAN engine has two rear mounts of the solid bracket type. These brackets are not interchangeable in respect to the right and left. The front of the engine is supported by mounts on the propulsion generator.

b. Disassembly (fig. 96). After removing the screw, the upper bracket can be separated from the lower bracket. The spacer and the rubber bushing are integral with the lower bracket, and are

serviced as an assembly. The same procedure applies for the disassembling of each of the engine mounts as used on the GAA and the GAF engines.

c. **Inspection** (fig. 96). Examine each of the brackets for cracks. Check the condition of the rubber bushing and spacer in the lower bracket. If the rubber is damaged or loose in the bracket, the lower bracket assembly must be replaced. Replace rubber spacers if they are damaged. If the screws are worn excessively, they must also be replaced.

d. **Assembly** (fig. 96). Place the upper half of the bracket over the lower half. Insert the screw through the bracket, and secure the screw in the assembly with a safety nut. The same procedure applies for assembling the rear engine mounts. Rubber spacers are used at each end of the lower bracket.

Section V

ASSEMBLY OF STRIPPED ENGINE

28. GENERAL.

a. **Handling of Parts.** All engine parts and components have been inspected and replacements have been made where needed, as outlined in paragraphs 12 through 27. It is important that each part or subassembly be re-examined before it is installed in the engine. Take positive precaution to assure all parts are clean. Parts which have been coated with a rust-preventive compound must be washed and all traces of this material removed. Place a supply of clean lint-free wiping cloths where they can be conveniently reached. Hands doing this work cannot be kept clean, but they must be kept free from grit, sand, or any foreign material that could damage a bearing or any other close-fitting part of the engine.

b. **Types of Nuts and Washers Used.** Elastic-type nuts are used on all external parts of the engine, except the exhaust manifold flanges where special nuts are used. Boot-aircraft-type nuts are used on the interior of the engine, with the exception of main bearing and connecting rod nuts. Castellated nuts are used on connecting rods on all models and on the main bearings on the early type GAA engine. On all late type GAA engines, and all GAN and GAF engines, use a plain nut on the main bearings secured by lock plates. Plain nuts with pal nuts are used to hold the accessory gear assembly to the cylinder block. Flat washers are used under nuts on all aluminum surfaces.

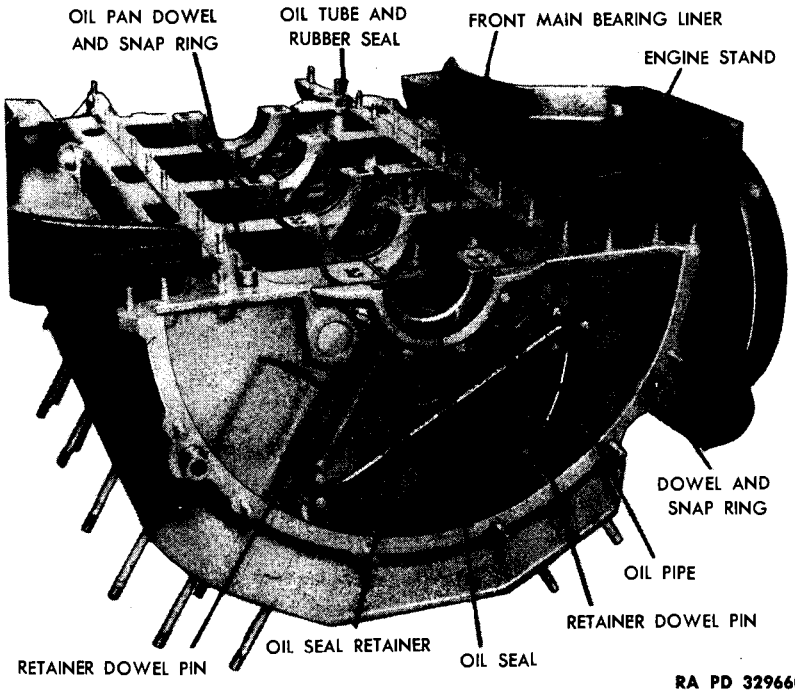


Figure 97 — Cylinder Block From Front — Bottom View

29. ASSEMBLY OF STRIPPED ENGINE.

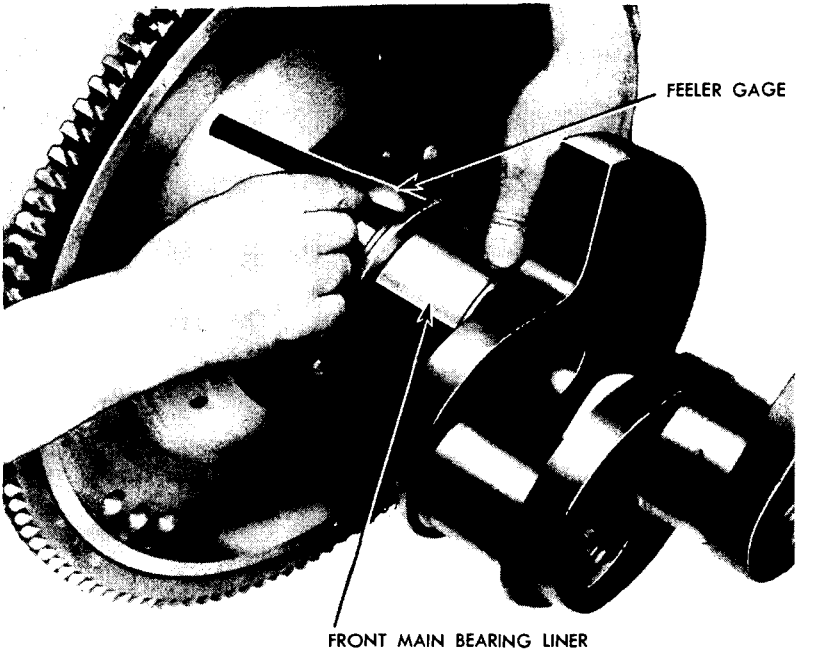
a. Cylinder Block Assembly.

(1) PLACE CYLINDER BLOCK ON ENGINE STAND. Place the cylinder block on the engine stand (41-S-4942-14) as shown in figure 97.

(2) INSTALL CYLINDER BLOCK "V" COVER. Place a new gasket and the cylinder block "V" cover in position on the cylinder block. Install the star washer and 12 cap screws which secure the cover to the block.

(3) INSTALL OIL PIPE ASSEMBLIES. Install the oil pipe assemblies to the front (fig. 97) and rear (fig. 104) of the cylinder block. Use new gaskets at the pipe flanges and secure the oil pipes with boot-type nuts.

(4) INSTALL CRANKSHAFT OIL SEAL AND RETAINER. Insert the two oil seal retainer dowel pins in the cylinder block (fig. 97). Use a new gasket and secure the oil seal retainer to the cylinder block with six cap screws and washers, and lock with wire. The crankshaft oil seal must be soaked approximately two hours in engine oil before



RA PD 28148

Figure 98 — Checking End Clearance of Front Main Bearing Liners

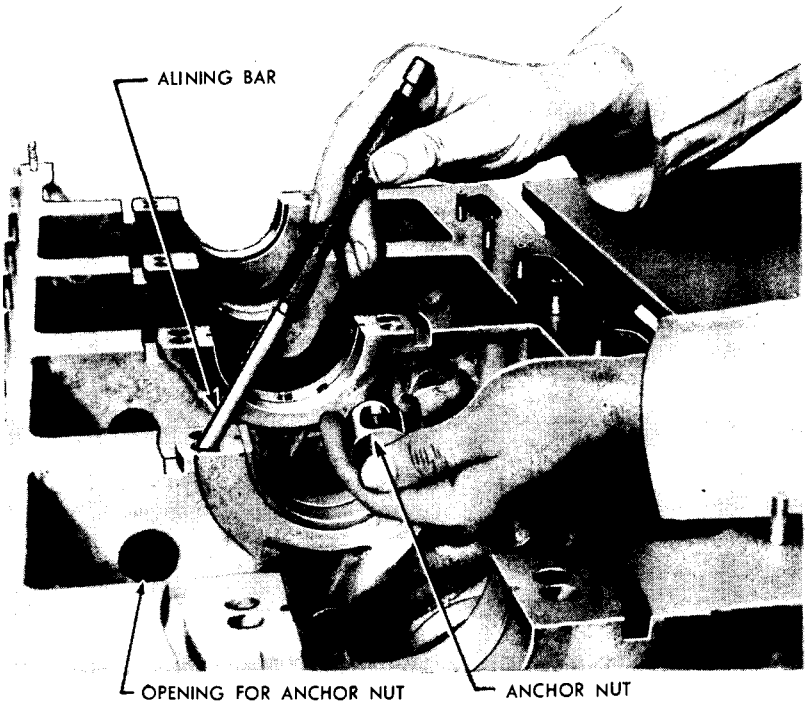
installation. Press the seal firmly in the retainer. The ends of the seal must extend above the machined surface of the retainer an equal height on each side as shown in figure 97.

b. Crankshaft Installation.

(1) INSTALL MAIN BEARING DOWEL PINS IN CYLINDER BLOCK. Insert the main bearing dowel pins in the block, using a brass drift; then drive each dowel pin until it is firmly seated in the hole provided.

(2) CHECK FRONT MAIN BEARING LINERS FOR END CLEARANCE. With the crankshaft still on the bench, place the upper and lower half of the front main bearing liner in position on the crankshaft with the wide flange toward the flywheel, and check the end clearance with a feeler gage as shown in figure 98. The correct clearance is 0.010 inch to 0.013 inch. Select liners of the proper length to obtain this clearance. The upper half can be identified from the lower half as the lower half has three drain holes in the oil return groove.

(3) INSTALL MAIN BEARING LINERS IN CYLINDER BLOCK. Insert the front main bearing liner (upper half) with the wide flange toward



RA PD 350562

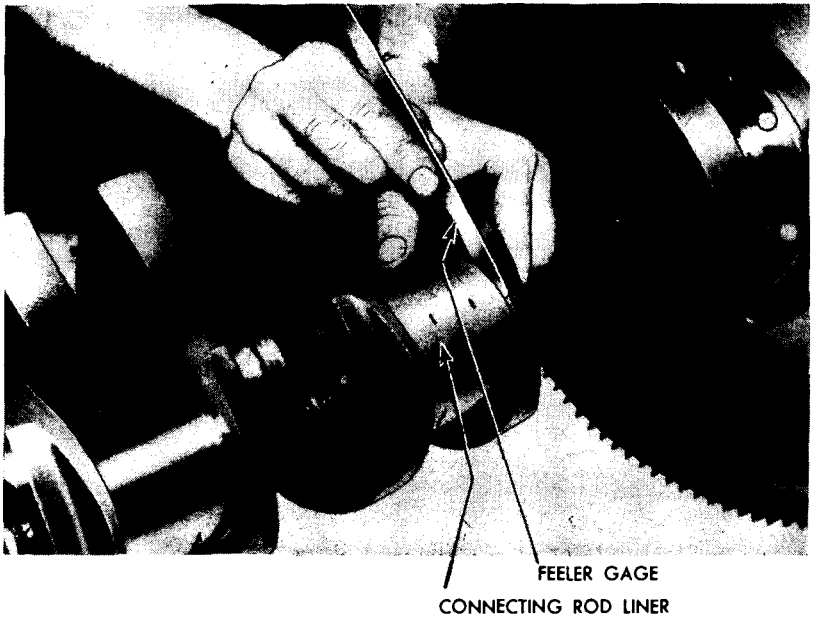
Figure 99 — Installing Main Bearing Anchor Nuts on Early-type GAA Engines

the front (toward the flywheel). Install the upper halves of the other main bearings in position in the cylinder block (fig. 97). The upper half of the bearing liners can be identified as they contain an oil groove on the bearing surface, whereas the lower half does not.

(4) INSTALL MAIN BEARING ANCHOR NUTS IN CYLINDER BLOCK (EARLY TYPE GAA ENGINES ONLY). If working on the early type GAA engine, install the three anchor nuts in the cylinder block at each of the five main bearings, and line up the bearing stud holes, using a suitable alining tool (fig. 99). These anchor nuts are not used on the late type engines.

(5) INSTALL CRANKSHAFT. Make sure the bearings are clean and free from lint. Squirt oil on the bearing surfaces before installing the crankshaft. Being careful not to damage the flanges on the front bearing liner, set the crankshaft in the bearings (fig. 21).

(6) INSTALL MAIN BEARING CAPS (EARLY TYPE GAA ENGINES ONLY). Bearing caps are numbered 1-2-3-4-5; No. 1 is the rear

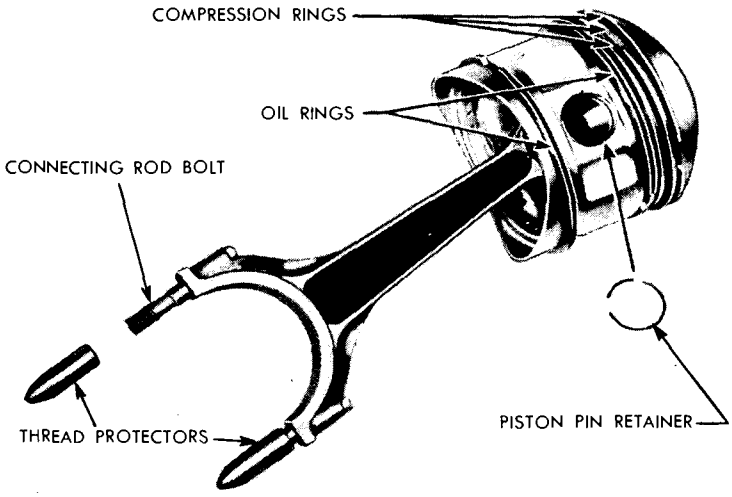


RA PD 28147

Figure 100 — Checking End Clearance of Connecting Rod Bearing Liners

bearing cap. The caps are also stamped with the cylinder block number and are not interchangeable with another block. Insert the bearing liners in the main bearing caps and install the caps in their respective positions. Set the bearing caps squarely in position, and screw the bearing studs into the anchor nuts until they bottom. Then back off the studs approximately one turn or until the lock wire hole is about parallel to the center of the crankshaft. If a stud fails to screw freely into the anchor nut, select another nut. Install a flat washer and a castellated nut on each of the studs. With a wrench on the square of the stud to prevent its turning, use a box wrench and tighten the nuts evenly on each stud. Do not permit the stud to turn while tightening the nuts. Use a torque wrench and tighten the nuts alternately and gradually to 49 to 51 foot-pounds. Line up the lock wire hole with the nut. It may be necessary to turn the stud slightly to line up the holes. Lock all nuts with wire.

(7) INSTALL MAIN BEARING CAPS ON LATE TYPE GAA ENGINES AND ALL GAN AND GAF ENGINES (fig. 20). Bearing caps are numbered 1-2-3-4-5; No. 1 is the rear bearing cap. The bearing caps are also stamped with the cylinder block number, and are not interchangeable with another block. Be sure the dowel pins are installed



RA PD 28146

Figure 101 — Piston and Connecting Rod Assembly

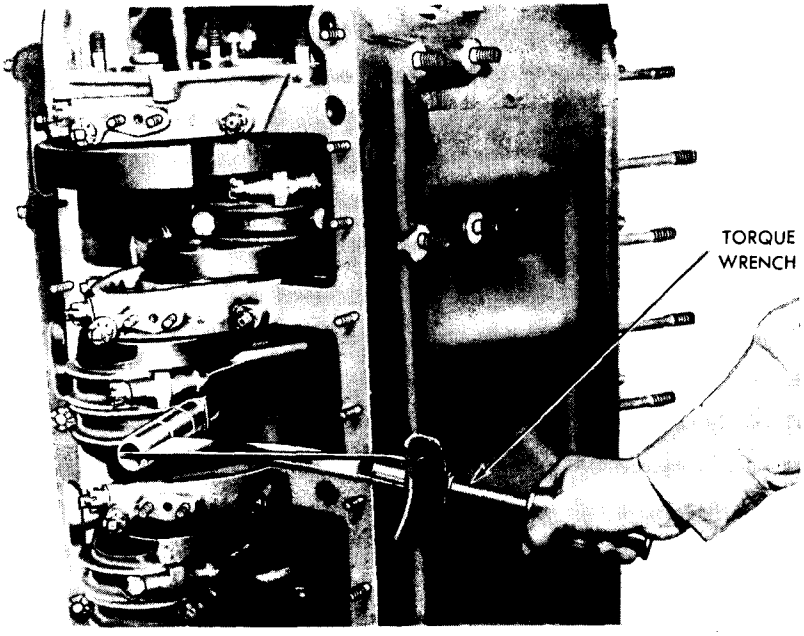
in the main bearing cap; then insert the bearing liners in the main bearing caps, and install the caps in their respective positions. Place the main bearing cap plate in position on the bearing caps, and install the two nuts that secure the caps to the block. Use a torque wrench, and tighten the nuts alternately and gradually to 99 to 101 foot-pounds. Line up the nuts with the main bearing cap lock plates. It may be necessary to turn the nuts slightly tighter in order to line them up. Install the cap screw that secures the lock plate to the main bearing cap, and lock the cap screw with lock wire.

(8) RECHECK CRANKSHAFT FOR END PLAY. After the front main bearing cap has been tightened, check the crankshaft end play. Insert a feeler gage between the bearing flange and the flange on the crankshaft. Clearance (end play) must be from 0.010 inch to 0.013 inch.

c. Connecting Rod and Piston Installation.

(1) SELECT CONNECTING ROD BEARING LINERS. Clean dirt and lint from bearing liners. When the same bearing liners are being used, they must be installed in their original positions. When new liners are used, they must be selected for correct end play. Place each bearing half on the crankpin for which it is intended and using a feeler gage, check the clearance (fig. 100). Side clearance must be from 0.003 inch to 0.006 inch.

(2) INSTALL PISTONS. Pistons and rods are numbered as follows: L1, L2, L3, L4, and R1, R2, R3, R4. No. 1 cylinders are the

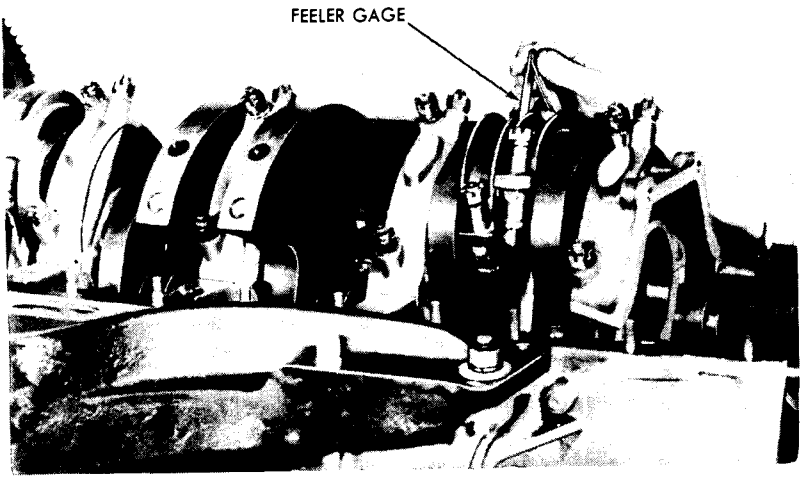


RA PD 28145

Figure 102 — Tightening Connecting Rod Nuts

rear cylinders of the engine (magneto end). One side of each connecting rod and connecting rod cap has a thrust surface of silver fused to it. The opposite side has a steel thrust surface. When installing the pistons, turn them so that the two rods on each crankpin have their silver sides away from each other and the two steel surfaces are together. Pistons at this stage of assembly will have already been fitted to their respective cylinders as outlined in paragraph 14. Clean the connecting rod and piston, and arrange the piston rings so they will overlap at the gaps. Clamp a piston ring compressor over the rings. Tape the connecting rod bolts or use a suitable protector (fig. 101) to prevent damaging the connecting rod bearings. Oil the piston and insert it into its proper cylinder.

(3) INSTALL CONNECTING ROD CAPS. Apply oil to the bearing liners previously selected for the crankpin, and place the two halves on the crankpin. Pull the connecting rod against the liner. Install the connecting rod caps with the identifying marks of the rod and cap together. Install and tighten the connecting rod nuts to 64 to 66 foot-pounds tension with a torque wrench (fig. 102). Lock the nuts with cotter pins. The same procedure applies for the installation of each connecting rod.



RA PD 28178

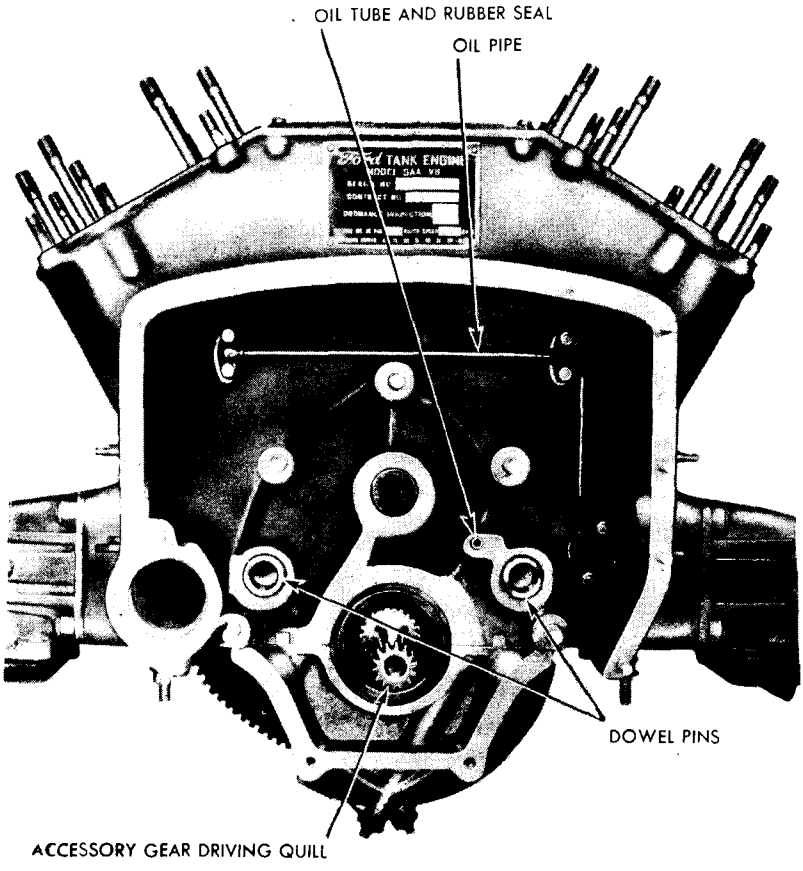
Figure 103 — Checking Connecting Rods for Side Play

(4) CHECK CONNECTING RODS FOR SIDE PLAY. After the connecting rods are secured to the crankpin, separate the rods and insert any size feeler gage blade which takes up all of the side play between the rods, as shown in figure 103. Normal side play of the rods when all parts are new is 0.003 inch to 0.006 inch. If old bearings are used, the clearance must not exceed 0.012 inch.

d. Accessory Gear Assembly and Accessory Drive Shaft Installation.

(1) INSTALL ACCESSORY GEAR ASSEMBLY. Install the snap ring in place in the splined end of the crankshaft if it was removed in disassembly. Place the accessory gear driving quill (fig. 104) in this spline. Install the oil tube which supplies oil to the accessory gear assembly in the cylinder block (fig. 104), using the ¼-inch ferrule driver (41-D-2980-165). Place a rubber oil seal on this tube. Place the accessory gear assembly (fig. 105) in position on the studs and dowels, and secure it in place with five flat washers, plain nuts, and pal nuts. Install the two flat washers and the cap screws at the bottom of the gear housing and lock with wire.

(2) INSTALL ACCESSORY DRIVE SHAFT (GAA AND GAN ENGINES ONLY) (fig. 105). If working on the GAF engine, refer to step (3) below. Place a new gasket on the engine studs. Insert the splined end of the drive shaft through the opening at each side of the cylinder block and into the bevel gear of the accessory gear assembly, and at the same time enter the bearing in the opening in the side of the block. Secure the bearing retainer to the block with four elastic-type



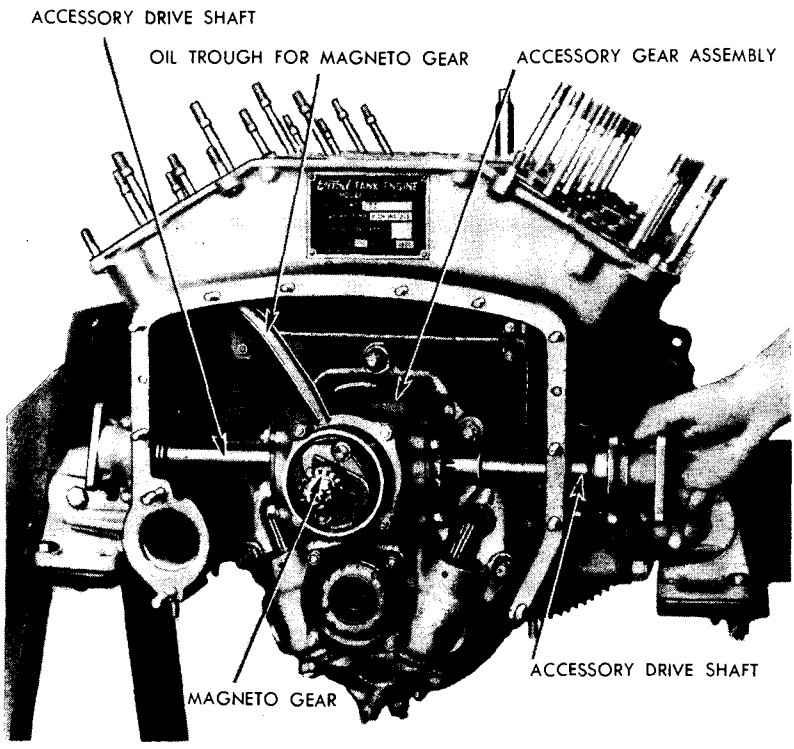
RA PD 28179

Figure 104 — Cylinder Block — Rear View

nuts and flat washers. The two drive shafts are interchangeable, and the above instructions apply to both right and left sides of the engine.

(3) INSTALL ANGLE DRIVES (GAF ENGINES ONLY) (fig. 5). Place a new gasket on the engine studs. Raise the angle drive into position. Rotate the drive flange to aline the splines on the drive shaft with bevel gears of the accessory gear assembly, and slide the assembly into position on the studs. Install and tighten the four elastic-type nuts that secure the angle drive to the block. The above instructions apply to both right and left sides of the engine.

e. Install Camshaft Drive Shaft (Lower). Install each of the camshaft drive shafts through the bushing at the top of the cylinder



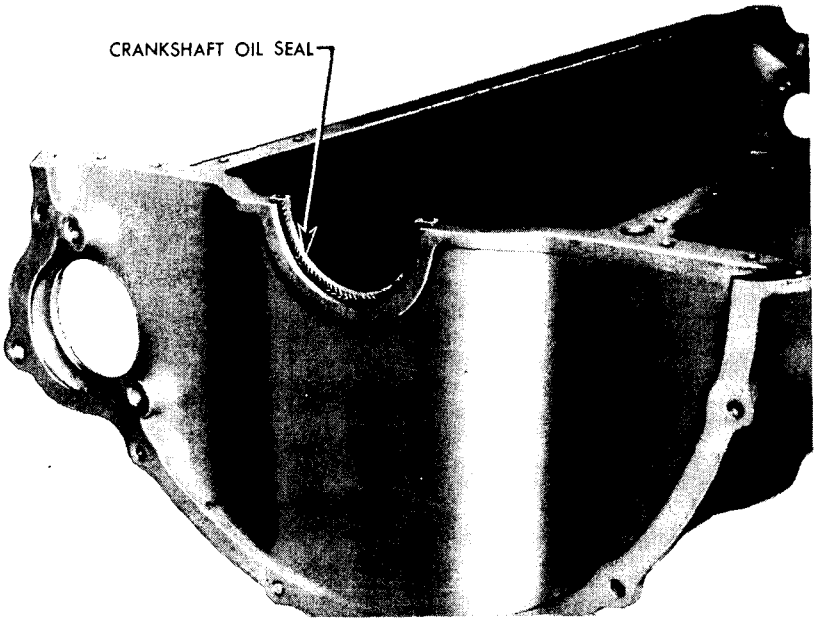
RA PD 28144

Figure 105 — Accessory Gear Assembly and Accessory Drive Shafts

block and on the lower end of the shafts on the spline of the worm gear shaft. NOTE: *On early production engines these shafts are secured in place with a washer and snap ring at the top of each shaft.* The shafts on present production engines are secured in place with a horseshoe-type lock at the bottom end of the camshaft drive shafts (fig. 19). The horseshoe-type lock permits the removal of the shafts without the necessity of removing the cylinder heads.

f. Oil Pan Installation. NOTE: *If working on a GAF engine, it is very important that the oil pan be installed on the cylinder block from which it was removed.*

(1) INSTALL CRANKSHAFT OIL SEAL. The crankshaft oil seal must be soaked in hot engine oil for approximately two hours before installation. Press the seal firmly into the groove in the oil pan. The ends of the seal must extend above the machined surface of the oil pan at an equal height on each side as shown in figure 106.



RA PD 28143

Figure 106 — Crankshaft Oil Seal

(2) INSTALL OIL TUBE IN BOTTOM OF CYLINDER BLOCK (fig. 97). Install the oil pan to cylinder block oil tube in the right rear bottom face of the cylinder block, using driver (41-D-2983-150). Drive the tube until it is firmly seated in the counterbore.

(3) INSTALL DOWEL PIN IN BOTTOM OF CYLINDER BLOCK. Install the dowel pin in the left front bottom face of the cylinder block. Install a snap ring in the groove provided in the dowel pin, and drive it into the cylinder block until the snap ring is seated in the chamfer of the dowel pin hole (fig. 97).

(4) INSTALL OIL PAN. Install the rubber seal over the oil tube on the cylinder block (fig. 97). Place new oil pan gaskets in position on the cylinder block. If the oil pan is being installed on the GAF engine, the adjacent surfaces on the rear of the engine block and the oil pan *must be flush* to avoid oil leakage. Use a straightedge to make sure the surfaces are flush. Most oil pans for the GAF engines have a little play between the stud slip holes so the pan may be positioned correctly. Install the oil pan, and secure it to the cylinder block with elastic-type stop nuts with flat washers.

(5) INSTALL OIL PUMP (fig. 12). Use a new gasket and place the pump over the studs. The engine may have to be cranked slowly

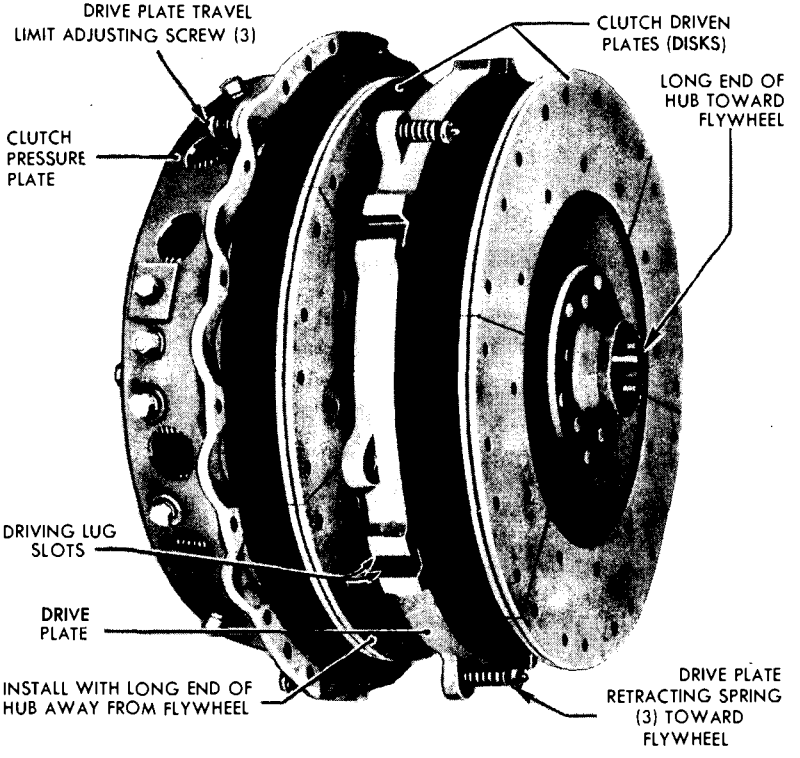


Figure 107 — Clutch Disks and Pressure Plates

so the spline on the pump shaft will line up with the splines in the accessory gear worm gear shaft. Do not drive on the pump, the pump should slip in place easily. Secure the pump to the oil pan with elastic-type nuts.

g. Install Accessory Gear Cover (fig. 12). Place a rubber seal over the water inlet tube. Use a new gasket and install the cover. Secure the cover in place with ten elastic-type nuts and flat washers. Install the flat washers and the four cap screws across the bottom of the cover and lock with wire.

h. Install Water Pump (fig. 12). Use a new rubber seal on the water tube and a new gasket on the water pump mounting flange. Place the pump mounting flange over the studs. The engine may have to be cranked slowly so the splined quill on the pump shaft will line up with the spline in the accessory gear hub. Secure the pump to the engine with four elastic-type nuts.

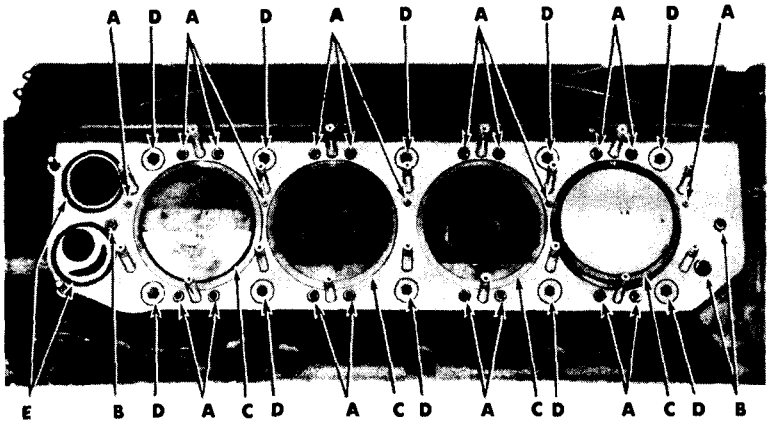


Figure 108 — Top of Cylinder Block

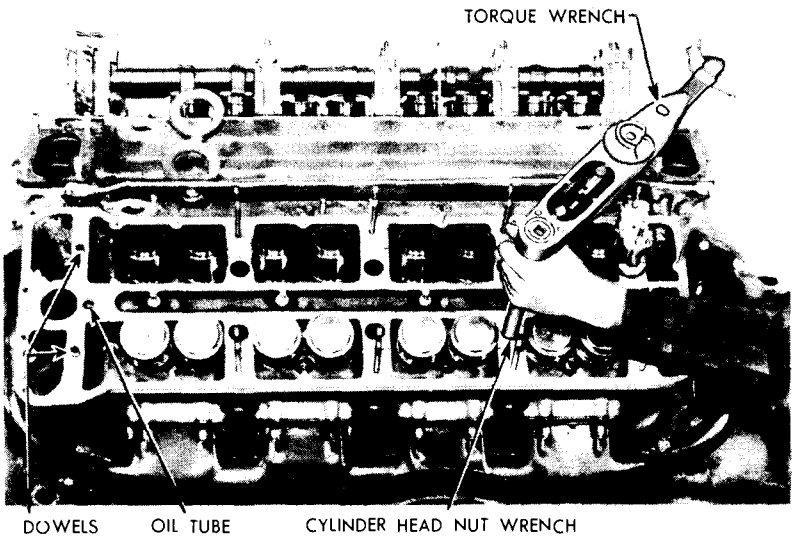
i. Install Clutch (GAA Engines Only).

(1) CLEAN FLYWHEEL FRICTION SURFACE. Any deposits should be sanded down and the surface cleaned with dry-cleaning solvent.

(2) CLUTCH PILOT BEARING. Be sure the clutch pilot bearing (fig. 78) is in place in the front end of the crankshaft and lubricated.

(3) INSTALL CLUTCH DISK. Place one driven plate (disk) against the flywheel with the long end of the hub toward the flywheel (fig. 107). Enter the clutch disk alining tool (41-T-3083-75) (fig. 18) through the pilot bearing. Insert the center drive plate with the retractor springs toward the flywheel, and make sure the driving lug slots fit freely on the driving lugs in the flywheel (fig. 107). Slip the second driven plate (disk) on the pilot with the long end of the hub away from the flywheel (fig. 107). This centers both driven numbers with the clutch shaft pilot bearing while the pressure plate is being assembled.

(4) INSTALL PRESSURE PLATE (fig. 18). Before installation, make sure the three center plate travel limit adjusting screws are backed off sufficiently (fig. 107). Install the clutch pressure plate assembly so the dowel holes line up, and secure it to the flywheel with 16 cap screws. Wire the screws to prevent loosening. Start the wire at the cap screw nearest the clutch adjusting screw and lock the two cap screws together. Proceed with the next two until all have been wired.



RA PD 28182

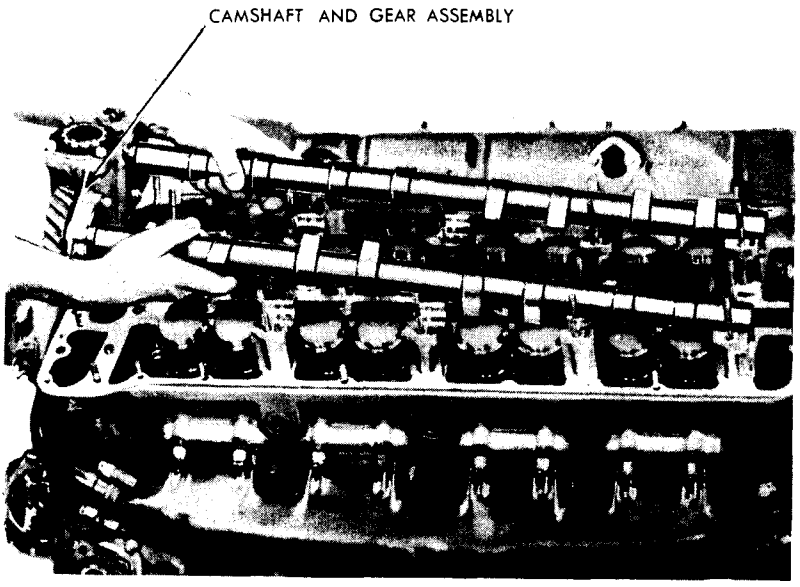
Figure 109 — Tightening Cylinder Head Nuts

(5) ADJUST CENTER PLATE TRAVEL LIMIT ADJUSTING SCREW (fig. 107). With a screwdriver, turn the three center plate travel limit adjusting screws in (clockwise) until they bottom lightly, then turn back four notches.

(6) ADJUST CLUTCH RELEASE LEVERS. Remove the six 3/8-inch bolts which were used to hold the pressure plate retracted. Remove the clutch alining tool (fig. 18). Place a straightedge across the top of the pressure plate housing, clearing all cap screws, etc. Figure 82 illustrates the proper method for checking this clearance. Adjust the release lever to approximately 1.375 inches, measuring from the release lever buttons to the straightedge.

(7) INSTALL CLUTCH HOUSING DOWELS. If the cylinder block or the clutch housing has been replaced, it will be necessary to install the dowel pins at this stage of the assembly. Install a snap ring in the groove of a dowel pin and insert it into the dowel hole on the right side of the cylinder block (fig. 18). Install the clutch housing, leaving the nuts slightly loose. Line up the dowel hole on the left side of the housing, then tighten the nuts. Use a 1-inch straight reamer and ream the left-hand dowel pin hole. Drive the dowel in and tighten all nuts, securing the clutch housing to the engine.

(8) INSTALL CLUTCH FLANGE (fig. 17). Slip the clutch flange



RA PD 329649

Figure 110 — Installing Camshaft and Gear Assemblies

over the spline on the end of the clutch shaft, and secure the flange on the shaft with a flat washer and castellated nut. Lock the nut with a cotter pin.

(9) INSTALL ENGINE OIL BAYONET GAGE HOUSING. Apply a light coat of oil on the end of the bayonet gage housing which is to be inserted into the cylinder block. Carefully insert the bayonet gage housing into the opening at the left side of the block, being careful not to damage the rubber seal in the block. Install the two elastic-type nuts securing the flange on the bayonet gage housing to the cylinder block.

j. Cylinder Head Installation.

(1) INSTALL WATER AND OIL TUBES ON TOP OF CYLINDER BLOCK (fig. 108). If any of the water or oil tubes have been removed, they must be replaced with new tubes. Use the driver-set (41-D-2980-150), selecting a driver of the proper size for the particular tube to be installed. The tubes are to be kept square with the surface of the block and driven into the counterbore of the cylinder block until they are firmly seated.

(2) INSTALL CYLINDER HEAD GASKETS. Place a new compression seal on top of each cylinder sleeve; then install the cylinder head gasket in place on the cylinder block (fig. 108). NOTE: *Early*

production engines use an individual rubber seal at each water and oil tube instead of a conventional-type cylinder head gasket. When cylinder heads are removed for any reason, the conventional cylinder head gasket should be installed and all the rubber seals on the water and oil tubes are to be omitted. The two large rubber seals at the extreme rear end (magneto end) of the cylinder block (fig. 108) on early engines are to be used with this late type gasket.

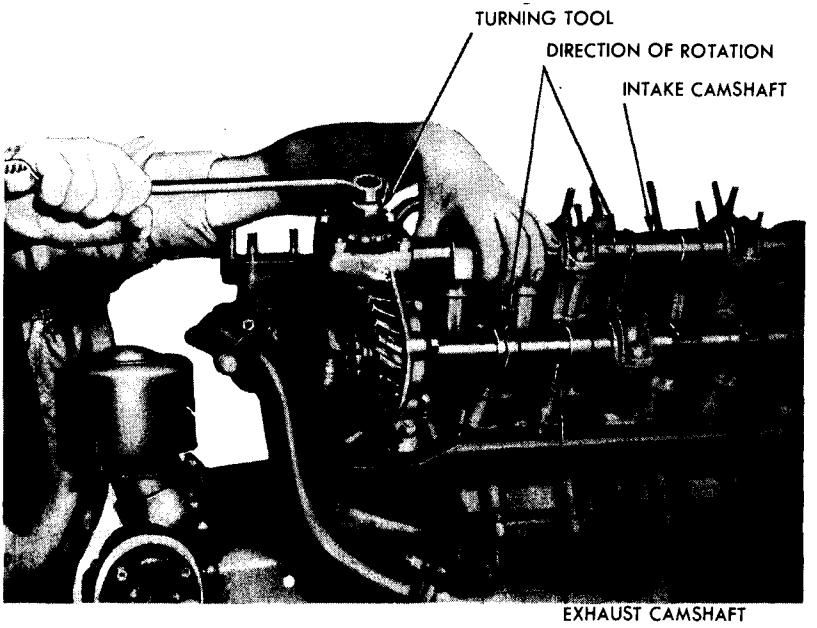
(3) INSTALL CYLINDER HEADS. With a man at each end of the cylinder head, place the head over the studs and lower it evenly on the cylinder block. Care must be used when putting the head over the studs so as not to mar or damage the bottom face of the head.

(4) TIGHTEN CYLINDER HEADS. Place a washer and nut on each cylinder head stud. Eight long nuts are used on the two center rows of studs which are located under the camshaft bearings, and 10 short nuts are used on the outer rows of studs. The center row of nuts over which the camshaft bearings set are longer than the balance of the nuts so as to accommodate the studs for the camshaft bearings. On all early production GAA engines, do not install these long nuts without first removing the camshaft bearing studs from the nuts. Starting with engine No. 9783, these cylinder head nuts are swedged on the threads of the camshaft bearing studs, and are not to be removed from the studs. Use cylinder head nut wrench (41-W-866-200) to tighten the long nuts, and use wrench (41-W-866-250) for tightening the short nuts. These wrenches are to be used in connection with torque wrench (41-W-3630). Tighten each nut gradually and alternately to 60 foot-pounds tension, starting with a centrally located nut and working alternately each way (fig. 109). Install the five elastic-type nuts and flat washers at the front and rear ends of the head.

k. Install Camshafts and Gear Assemblies.

(1) INSTALL CAMSHAFT BEARING OIL TUBES AND DOWEL PINS. If the oil tubes or dowel pins for the camshaft bearings have been removed for any reason, new tubes and dowel pins must be installed. Select the proper size driver from the set (41-D-2980-150), and insert the oil tube for each of the front camshaft bearings and the oil tube for each of the camshaft supports into the cylinder head (fig. 109). Install a new dowel pin for each of the front camshaft bearings and the two hollow dowel pins for each of the camshaft supports (fig. 109).

(2) INSTALL CAMSHAFT BEARINGS. At this stage of the assembly, the camshaft bearings have been inspected and new bearings, if any, have been line-reamed and are ready for installation. The camshaft bearings and bearing caps are numbered from 1 to 8 for both the right and left cylinder heads. A corresponding number is stamped



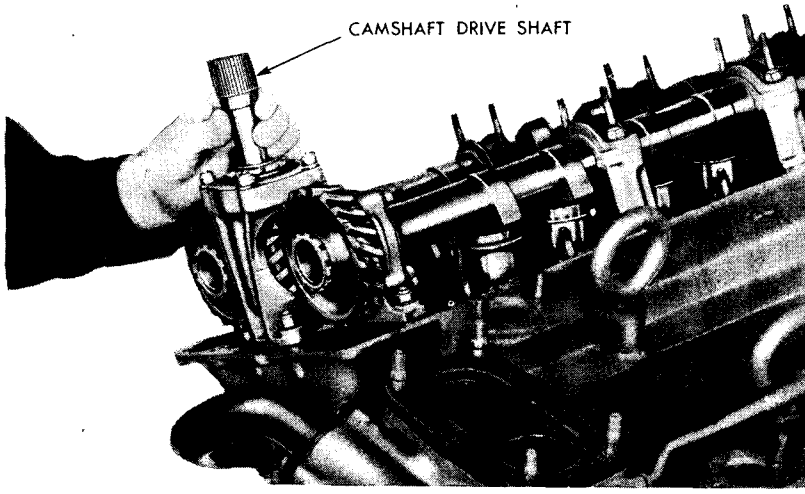
RA PD 329675

Figure 111 — Setting Camshaft Timing, Using Turning Wrench (41-W-2964-300)

on the heads at each bearing. Install a rubber oil seal on the oil tube for the camshaft support. NOTE: *The oil tube for the front camshaft bearings does not require a rubber seal.* Place the bearings over the studs in their respective positions, making sure the corresponding numbers are facing each other; also make certain they set firmly on the cylinder heads.

(3) INSTALL PUSH RODS. The push rods were individually selected for fit in the guides, and were fitted for the proper valve clearance during the inspection and repair of the cylinder head; therefore, they must be put in the guides for which they were intended.

(4) INSTALL CAMSHAFTS AND GEAR ASSEMBLIES. NOTE: *The camshaft and gear assemblies consist of the intake and exhaust camshafts, the camshaft gears, and the rear support.* The assemblies are right- and left-hand and can be identified by the markings etched on the camshafts. Coat the camshaft bearings with oil. Place each assembly in the camshaft bearings and the rear support over the studs (fig. 110). The two nuts and flat washers on each side of the camshaft support must be put in position on the studs before tightening any nuts on the bearing caps. Coat each bearing cap with oil and place each camshaft bearing cap on the bearing carrying a corresponding number. Be sure the corresponding numbers are adjacent



RA PD 28141

Figure 112 — Inserting Camshaft Drive Shaft (Upper)

to each other. Put a flat washer and boot-type nut on each stud and tighten all nuts evenly so as not to spring the camshafts as a result of the valve spring pressure. Use a torque wrench and tighten the nuts to 16 foot-pounds.

l. Camshaft Timing.

(1) TIMING MARKS. The location of the inspection opening for the flywheel timing marks differs on the GAA, GAN, and GAF engines. On the GAA engine a pointer is provided in the clutch housing at the top left-hand side. The inspection opening and pointer for the GAN engine is located on the left-hand side of the oil pan. The inspection opening for the pointer for the GAF engine is located in the torque converter housing at the top right-hand side. In order to time the GAF engine when the housing is removed, position the timing mark on the flywheel 6⅜ inches from the far side of the dowel pin on the right-hand side of the cylinder block, using a combination square as shown in figure 115.

(2) TIMING RIGHT-HAND CAMSHAFTS. NOTE: *At this stage of assembly, the intake and exhaust camshafts should have been properly timed in relation to each other as outlined in paragraph 23 f (7). However, the timing should be rechecked.* Set the flywheel mark "INTAKE OPEN R.H." at the pointer in the clutch housing opening. The inspection opening for the timing marks on the GAN engine is located on the left-hand side of the oil pan. Insert the camshaft

turning wrench (41-W-2964-300) in the top of the worm gear and turn the camshafts in the direction of rotation (the arrows in figure 111 show the direction of rotation) until No. 1 intake valve is just starting to open. The direction of rotation of the right- and left-hand intake camshafts is the same as the direction of rotation of the crankshaft. The valve opening point can be determined by placing the thumb and forefinger on No. 1 intake valve push rods, and rotating it while turning the camshaft slowly (fig. 111). The moment the push rod begins to turn hard, the valve has just started to open. With the flywheel still setting at the mark "INTAKE OPEN R.H.," insert the upper camshaft drive shaft (fig. 112). When inserting the upper camshaft drive shaft, do not force it or drive it as it may be necessary to try it in several positions until the splines on each end of the shaft line up; at this time it will drop in place freely.

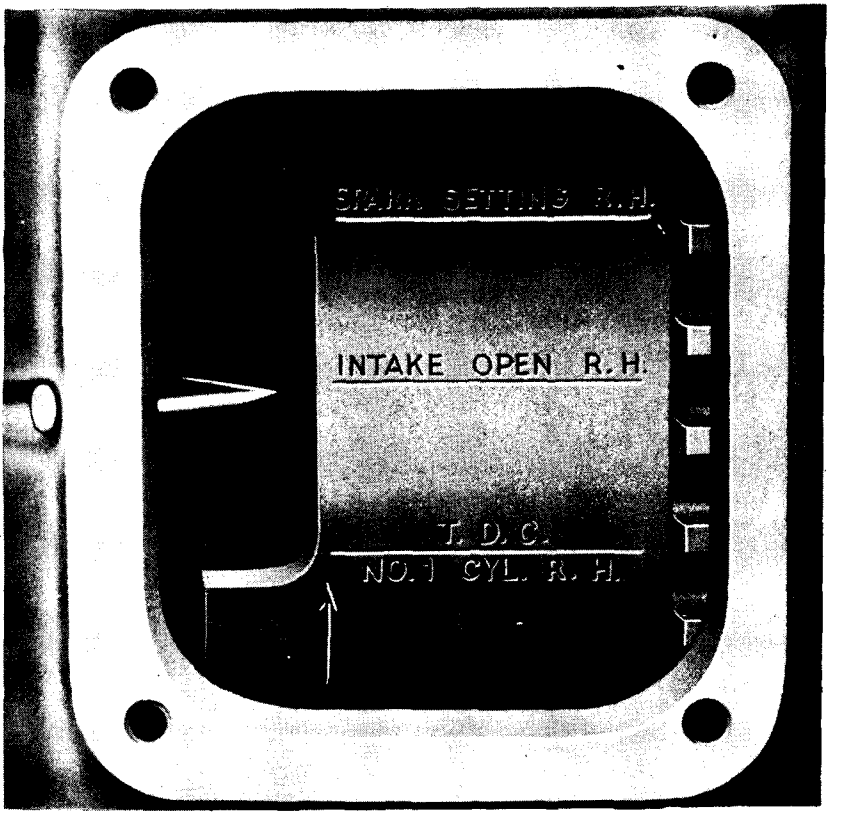
(3) RECHECK TIMING. Turn the flywheel backward approximately 30 degrees, then turn it in the direction of rotation until the timing mark "INTAKE OPEN R.H." again appears at the pointer. No. 1 intake valve should have just begun to open. If not, repeat the procedure outlined in step (1) above more carefully.

(4) TIMING LEFT-HAND CAMSHAFTS. Turn the flywheel 300 degrees (five-sixths of a turn) in the direction of rotation until the mark "INTAKE OPEN L.H." on the flywheel appears at the pointer. From this point, the procedure for timing the left-hand camshafts is the same as described for the right-hand camshafts. The opening of the No. 1 left-hand intake valve is used when establishing the timing of the camshafts on the left-hand side.

(5) INSTALL SNAP RING. Install a snap ring in the top of each camshaft worm gear to hold the upper camshaft drive shaft in place.

m. Install Carburetor Adapter Housings (fig. 12). The rear housing of the GAA engine differs from the front in that it has two holes in the throttle plate lever. The GAN and GAF adapter housings do not have a throttle plate assembly, and are interchangeable for use at either the front or rear of the engine. Install the carburetor adapter housings on each end of the cylinder heads, using new gaskets. Attach the primer fittings and tubes to the cylinder head, and place the tube support bracket over the adapter housing studs. Secure each housing to the cylinder heads with boot-type nuts and flat washers. Use the off-set box wrench (41-W-639-850) for tightening the nuts which are located behind the heater flanges.

n. Carburetor Heater Pipe Installation (fig. 12). Four pipes are connected between the carburetor adapter housings and the exhaust manifolds. These pipes vary in length and shape; therefore, they must be tried in place when selected for installation. Use a new gasket and attach the lower end of the carburetor heater pipe to the



RA PD 28039

Figure 113 — Flywheel Timing Marks for Camshaft Timing on GAA Engine

exhaust manifold, using three steel collar nuts. Lock the nuts with wire. Use a new gasket and attach the upper end to the carburetor adapter housing with cap screws and lock the cap screws with wire. Repeat the above procedure for the other three carburetor heater pipes.

o. **Install Camshaft Housings** (fig. 12). Use new inner and outer gaskets on the top of both cylinder heads. Place the housing over the studs and install the elastic-type nuts on the four centrally located studs. Use copper washers under all nuts on the top of the housings and steel flat washers under the remainder of the nuts. The spark plugs and the spark plug wires are to be installed at the time the accessories are assembled on the engine. Therefore, the spark plug covers must not be secured to the housings at this time. CAUTION: *Corks should be inserted in the spark plug holes to prevent dirt or other foreign material from falling into the cylinders.*

Section VI

INSTALLATION OF ACCESSORIES

30. GENERAL.

a. Because of the difference in the procedures for installing the accessories on the GAA, GAN, and GAF engines, a separate paragraph will be provided for each engine. Select accessories which have been rebuilt and put in serviceable condition for installation on the engine. Remove dust, dirt, or foreign matter which may have accumulated on the accessories since they were repaired or rebuilt.

31. INSTALLATION OF ACCESSORIES ON GAA ENGINE.

a. Magneto Installation and Ignition Timing.

(1) IDENTIFICATION OF RIGHT- AND LEFT-HAND MAGNETOS. Magnetos can be identified from right- or left-hand by the model number on the name plate which appears on the top of the magnetos. All magnetos which have odd numbers are left-hand and all magnetos with even numbers are right-hand. The number of the cylinders and the firing order are shown in figure 114.

(2) INSTALL MAGNETOS AND TIME ENGINE.

(a) Flywheel Timing Mark Data. The flywheel marks on current production engines are 10 degrees before dead center mark and are stamped "SPARK SETTING R.H." for setting the timing on the right-hand cylinders, and "SPARK SETTING L.H." for the left-hand cylinder (fig. 113). Early production engine timing marks are only 5 degrees before the dead center mark and are stamped "SPARK RETARD R.H." for setting the timing on the right-hand cylinders, and "SPARK RETARD L.H." for the left-hand cylinders. When setting the spark-timing on early production engines, the timing should be set 5 degrees in advance of the "SPARK RETARD" mark for both the right- and left-hand cylinders. Keeping in mind the direction of rotation, measure 7/8 inch ahead of these marks (equivalent to 5 deg.) and scribe a line on the flywheel. Set the flywheel with the scribed line at the pointer when timing engines with the early type flywheel markings.

(b) Set Engine Flywheel Mark at Pointer. Turn the crankshaft in the direction of rotation until the No. 1 piston on the right-hand side is on its compression stroke (use a compression gage in No. 1 cylinder spark plug hole to determine the compression stroke) and the "SPARK SETTING R.H." mark (or the scribed line, step *(a)* above) on the flywheel is at the pointer (fig. 113). In order to locate the position of the timing mark pointer on the GAF engine, use a

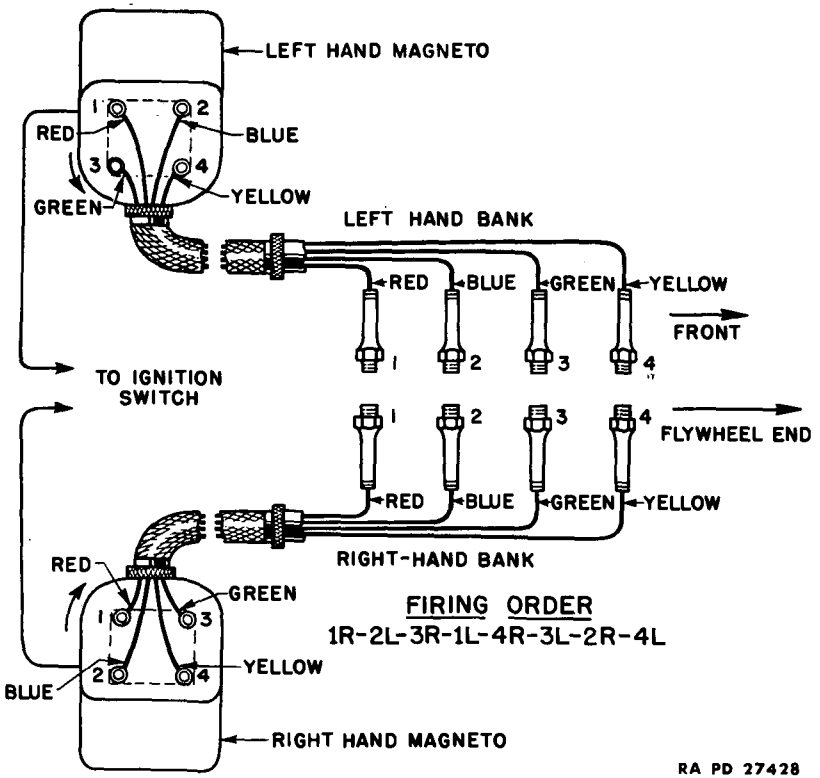


Figure 114 — Cylinder Numbering and Firing Order

combination square, and measure 6⅜ inches from the dowel on the right-hand side of the cylinder block (fig. 115). Scribe a line on the cylinder block and use this mark as a pointer.

(c) Install Magneto Drive Flange on Magnetos. Install a Woodruff key in the magneto shaft and place the magneto drive flange on the shaft. Secure the flange on the shaft with a flat washer and a boot-type nut. Use holder (41-H-2350) to hold the magneto shaft from turning while tightening this nut (fig. 120). NOTE: *If, for any reason, it is necessary to remove the drive flange from the magneto, use magneto drive flange puller (41-P-2941-750) (fig. 121).*

(d) Install Right-hand Magneto and Set Timing. Remove the distributor plate circular cover and the breaker cover (fig. 122) from each magneto. Install the right-hand magneto, using a new gasket and securing it to the engine with two flat washers and castellated nuts. Do not tighten the nuts securely at this time. Shift the magneto so the mounting studs are approximately midway in the slot

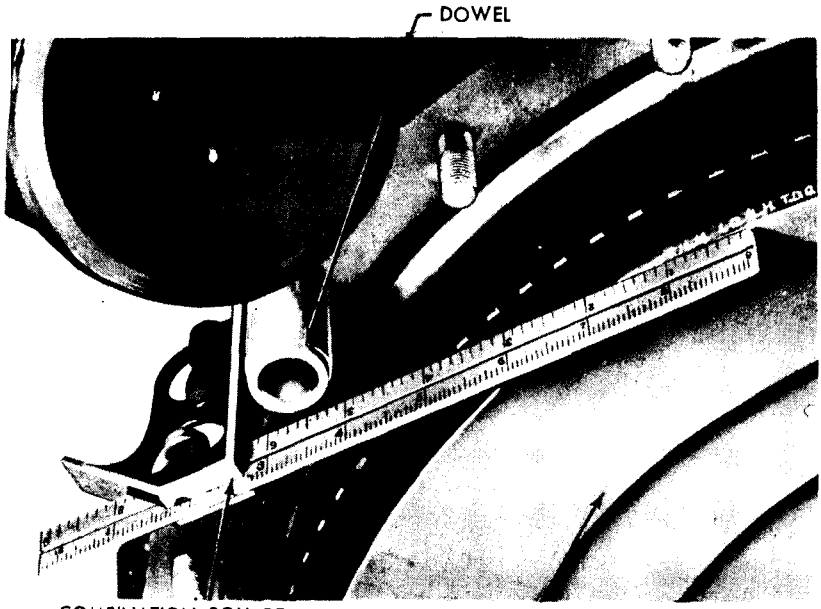


Figure 115 — Locating Timing Marks on GAF Engine

on the magneto mounting flange. Use a timing light fixture and attach one lead to the breaker arm and the other lead to a ground. Turn the magneto by means of the driving flange on the left end of the shaft in the direction of rotation (clockwise) until the arrow in the rotor window (fig. 116) is opposite the terminal to which No. 1 red wire is to be attached (figs. 114 and 116). The light in the timing fixture will go on the instant the breaker points have separated. Tighten the nut securing the left-hand driving flange while the magneto is setting in this position. This will lock the driven gear to the shaft.

(e) Recheck Timing. Turn the flywheel backward approximately one-quarter of a revolution; then turn it in the direction of rotation until the timing light goes on. Note whether the timing mark or scribed line on the flywheel is opposite the pointer. The reason for turning the flywheel backward before bringing it up to the timing mark is to compensate for backlash in the magneto drive mechanism. If a minor correction is necessary, tilt the top of the magneto forward or backward, whichever is required. Tilting the magneto toward the front of the engine advances the spark, and tilting the magneto toward the rear of the engine retards the spark. If a major correction is to be made, it will be necessary to loosen the nut securing the left-

hand driving flange in the accessory gear cover to move the flange and shaft forward or backward. Tighten the nut and recheck the timing. NOTE: *One serration on the flange and driven gear is equal to 5 degrees at the flywheel.*

(f) Install Left-hand Magneto and Set Timing. Turn the flywheel in the direction of rotation 300 degrees (five-sixths of a turn) until "SPARK SETTING L.H." mark or scribed line appears opposite the pointer. Turn the magneto by means of its driving flange until the arrow in the rotor window (fig. 116) is opposite the terminal to which No. 1 red wire (figs. 114 and 116) is to be attached. Install the magneto, using a new gasket, and hold it in place with two castelated nuts and washers. Do not tighten the nuts securely at this time. Shift the magneto so the mounting studs are approximately midway in the slot of the magneto mounting flange. Use the timing light fixture and attach one lead to the breaker arm and the other lead to a ground. Turn the flywheel backward approximately one-quarter of a revolution, then turn it in the direction of rotation until the timing light goes on, and note whether the timing mark or scribed line on the flywheel is opposite the pointer. The reason for turning the flywheel backward before bringing it up to the timing mark is to compensate for the backlash in the magneto drive mechanism. Any correction in the timing of the left-hand magneto can be made by tilting the magneto forward or backward.

(g) Lock Magnetos in Place. After both magnetos have been properly set in the mounting slots and the correct timing established, tighten the mounting nuts and lock with wire.

b. Spark Plug Installation. Examine each spark plug to make sure the spark gap on the three prong early type is set between 0.011 inch and 0.014 inch and that the two prong late type is set between 0.014 and 0.017 inch (fig. 11). Use new spark plugs and copper gaskets, and insert the plugs in the spark plug holes. Tighten the spark plugs moderately with the special plug wrench (41-W-3336-300) (fig. 13).

c. Spark Plug Wire and Conduit Installation.

(1) INSTALL CONDUIT ASSEMBLIES ON ENGINE. NOTE: *The spark plug wires and conduits when made up in assemblies are right- and left-hand.* The assembly with the longer rigid section is for the left-hand side of the engine. Insert the four spark plug wires through the hole in the top of the camshaft housing and secure the conduit mounting flanges to the housing with elastic-type nuts. This same procedure applies for both of the assemblies.

(2) ATTACH SPARK PLUG WIRES TO MAGNETO DISTRIBUTOR PLATES AND SPARK PLUGS. Attach the spark plug wires to the magneto distributor plates and to the spark plugs in the arrangement shown in figure 114. Use socket spark plug wrench (41-W-3336-300)

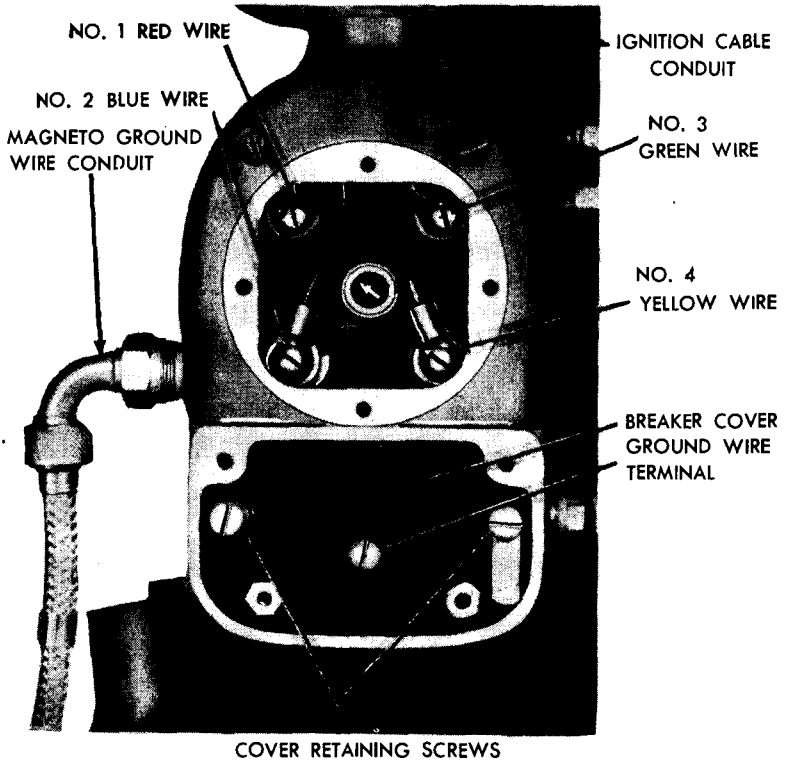


Figure 116 — Magneto — End View

for tightening the spark plug wire terminals on the spark plug (fig. 12). Tighten the knurled nut on each end of the flexible conduit securely.

(3) INSTALL SPARK PLUG COVER (fig. 2). Use a new gasket on the spark plug cover. Position the cover on the camshaft housing with the louver opening facing outward. Install the 10 copper washers (use steel washers if copper washers are not available) and elastic-type nuts which secure the cover to the housing.

d. Fuel Pump Installation (fig. 2). Use a new gasket and place the fuel pump over the studs on the left-hand camshaft housing. Install the two flat washers and elastic-type nuts that secure the pump to the housing.

e. Primer Fuel Tube Installation. Attach the primer tube on the bracket located on the carburetor adapter housing at the magneto end of the engine. Connect the fuel tube to each nozzle tube.

f. Carburetor Installation (fig. 1).

(1) INSTALL CARBURETORS ON ENGINE (fig. 2). Attach a carburetor to each of the carburetor adapter housings, using a new gasket on each side of the insulating spacer block. Secure the carburetors to the adapter housing with four flat washers and elastic-type nuts. NOTE: *The two carburetors used on the engine are identical and can be installed on either the front or the rear of the engine.*

(2) INSTALL FUEL FEED LINES TO CARBURETORS (fig. 1). Attach a fuel feed line between each of the carburetors and the fuel pump, and tighten the fittings securely.

(3) INSTALL CARBURETOR AIR INTAKE MANIFOLD (fig. 1). Use new gaskets and attach the carburetor air intake manifold to the top of the carburetors. Secure the manifold to each carburetor with elastic-type nuts.

(4) INSTALL THROTTLE RODS ON ENGINE (fig. 117). Install the center bracket on the studs at the top center of the right-hand cylinder head and secure it to the cylinder head with two elastic-type nuts. Both throttle rods which attach to the throttle shaft arm of the carburetors must be adjusted to 16⅝ inches long (measure from the center of the ball to the center of the pin hole at the other end of the rod). Attach the ball joint stud to the carburetor arm and lock the ball stud with a lock nut. Attach the other end of the rod to the arm at the center bracket with a clevis pin. Secure the clevis pins with cotter pins. Hook the return spring as shown in figure 117.

g. Throttle Governor Installation (fig. 1). Use a new gasket on the mounting flange of the governor and place the governor over the studs at the rear end of the right camshaft housing. It may be necessary to turn the governor shaft slightly in order to line up the splines on the shaft with the splines in the camshaft. Secure the governor to the housing with six flat washers and elastic-type nuts. Adjust the connecting link between the governor arm and the throttle arm on the carburetor adapter so the throttle valves are open and the shaft arm is against the stop. Attach the link to the throttle shaft arm and the governor arm, and lock the ball joints with cotter pins. Adjust the length of the engine speed governor throttle rod (fig. 117) so the throttle arms in both the front and rear adapters are against the stops. After the proper length is attained, connect the rods to the arms with clevis pins and secure with cotter pins.

h. Tachometer Drive Assembly Installation. Place a snap ring on the large spline of the tachometer driving quill. Slip the quill on the end of the tachometer shaft. Use a new gasket and install the assembly over the studs at the rear end of the left-hand camshaft housing. It may be necessary to turn the tachometer shaft slightly

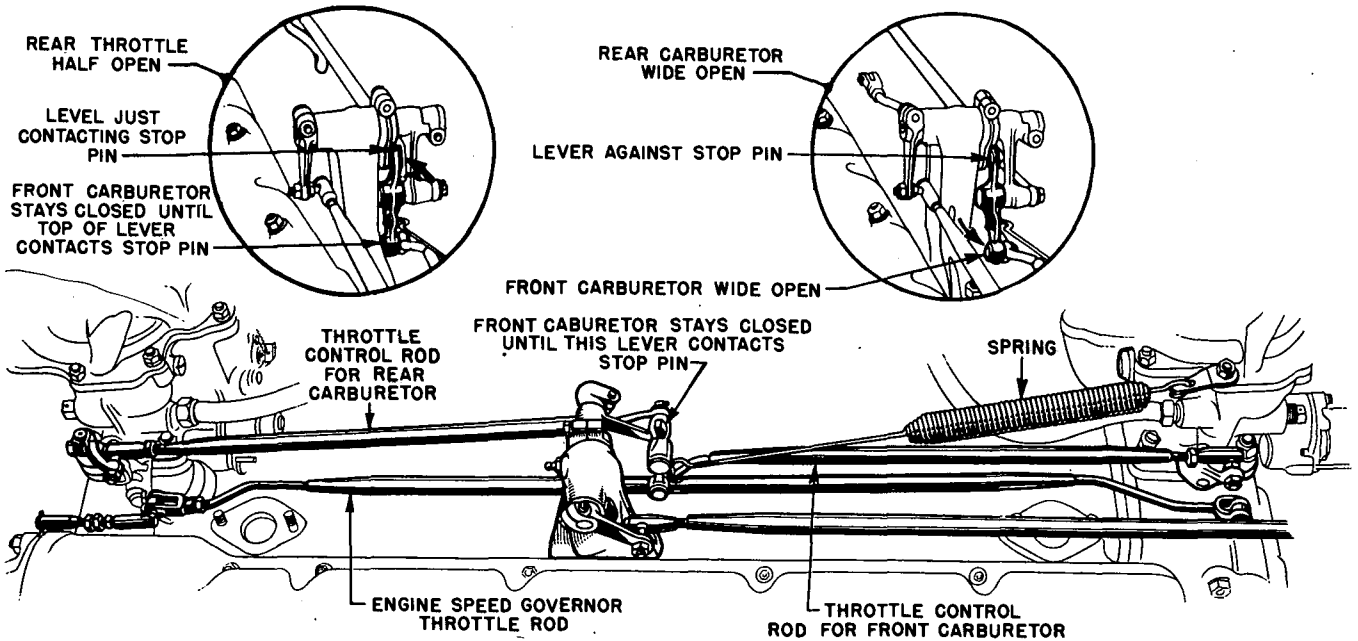


Figure 117 — Carburetor Throttle Linkage on GAA Engine

so the splines on the quill will engage with the splines in the end of the camshaft. Secure the tachometer drive assembly to the housing with four elastic-type nuts.

i. Oil Filter Installation (fig. 1). Use a new oil filter gasket and set it in place so that the oilhole in the gasket lines up with the drilled oilhole in the oil pan. Insert the oil filter in the opening provided in the oil pan. Be sure the two pilot rods at the end of the filter are properly entered in the holes in the partition at the inner end of the chamber. Secure the filter to the oil pan with six flat washers and elastic-type nuts.

j. Starter Motor Installation (fig. 1). Insert the drive end of the starter through the opening in the oil pan. Secure the starter to the pan with self-locking nuts and flat washers on the two mounting studs, and one bolt with a flat washer and self-locking nut.

k. Water Manifold Installation (fig. 1). NOTE: *The manifolds are right- and left-hand. However, it is possible to install them on the wrong side of the engine.* For proper installation, the manifolds should tilt toward the camshaft housing and the outlet opening toward the rear (magneto end). Use new gaskets and secure the manifolds to the cylinder heads with elastic-type nuts.

32. INSTALLATION OF ACCESSORIES ON GAN ENGINE.

a. Magneto Installation and Ignition Timing. To install magnetos and time ignition on the GAN engines, refer to paragraph 31.

b. Spark Plug Installation. Examine each spark plug to make sure the spark gap is set between 0.011 inch to 0.014 inch. Use new spark plugs and copper gaskets, and insert the plugs in the spark plug holes. Tighten the spark plug moderately with the special spark plug wrench (41-W-3336-300) (fig. 12).

c. Spark Plug Wire and Conduit Installation.

(1) INSTALL CONDUIT ASSEMBLIES ON ENGINE. NOTE: *The spark plug wires and conduits when made up in assemblies are right- and left-hand.* The assembly with the longer rigid section is for the right-hand side of the engine. Insert the four spark plug wires through the hole in the top of the camshaft housing and secure the conduit mounting flanges to the housing with four elastic-type nuts. This same procedure applies for both of the assemblies.

(2) ATTACH SPARK PLUG WIRES TO MAGNETO DISTRIBUTOR PLATES AND SPARK PLUGS. Attach the spark plug wires to the magneto distributor plates and to the spark plugs in the arrangement shown in figure 114. Use special spark plug wrench (41-W-3336-300) for tightening the spark plug wire terminals on the spark plugs (fig. 13). Tighten the knurled nut on each end of the flexible conduit securely.

(3) INSTALL SPARK PLUG COVER (fig. 4). Use a new gasket on the spark plug cover. Position the cover on the camshaft housing with the louver opening facing outward. Install the 10 copper washers (use steel washers if copper washers are not available) and elastic-type nuts which secure the cover to the housing.

d. Fuel Pump Installation (fig. 4). Use a new gasket and attach the fuel pump over the studs on the left-hand camshaft housing. Install the two flat washers and elastic-type nuts that secure the pump to the housing.

e. Primer Fuel Tube Installation. Attach the primer fuel tube on the bracket located on the carburetor adapter housing at the magneto end of the engine. Connect the fuel tube to each nozzle tube.

f. Carburetor Installation (fig. 4). Insert the four long and the four short bolts in position in the carburetor adapter housing. Use new gaskets on each side of the insulating spacer block and place them over the bolts. The front and rear carburetors differ due to the location of the throttle arm, and they must be attached to the adapter with the throttle arm facing toward the right-hand side of the engine. Position the carburetor on the adapter, and tighten the bolt securing the carburetor to the adapter. Lock the bolts with lock wire. Connect and tighten the fuel lines leading from the carburetor to the fuel pump.

g. Air Intake Manifold Installation (fig. 4). Slide the four air intake hoses on the air intake manifold, being sure that two hose clamps are on each hose. Use a new gasket, and place the manifold in position on the four studs on the engine with the openings on the manifold facing toward the magneto end of the engine. Install the four elastic-type nuts which secure the manifold to the engine. Slide each air intake hose on the carburetor intake openings and tighten the hose clamps.

h. Electro-hydraulic Governor Installation (fig. 4). Lower the governor vertically in position on the engine, and install the two mounting bolts and support brace that secure the governor to the engine. Connect the two throttle rods leading from the governor to each carburetor throttle arm, and install the clevis pin and cotter pin. Place the throttle spring bracket in position on the carburetor adapter at the flywheel end of the engine, and install the cap screws which secure the bracket to the adapter. Install the throttle return spring. Attach the oil lines to the governor inlet and to the fitting at the top of the accessory housing.

i. Water Manifold Installation. Place new gaskets over the studs at each of the water outlet openings at the top of each cylinder

head. Place the manifold over the studs on the right-hand cylinder head with the manifold tilting away from the center of the engine and the openings toward the magneto end of the engine. Slide each hose on the manifold, being sure the two hose clamps are on each hose. Secure the manifold to the head with copper washers and elastic-type nuts. Place the two water outlet pipes in position on the left-hand cylinder head. Secure the two outlet pipes to the head with copper washers and elastic-type nuts. Connect the hose connections at each water pipe and tighten the hose clamps.

j. Throttle Governor and Overspeed Switch Assembly Installation (fig. 3). Place a new gasket and the governor assembly in position on the right-hand camshaft housing. It may be necessary to turn the governor shaft slightly in order to line up the splines on the shaft with the splines on the camshaft. Install the six flat washers and elastic-type nuts which secure the assembly to the camshaft housing.

k. Sending Unit Conduit Installation (figs. 3 and 4). Place the sending unit conduit in position on the top of the right-hand camshaft housing. Install the two pronged connections leading to the electro governor. Connect the conduits leading to the degassers at each carburetor. Connect the conduit leading to the overspeed switch. Install the clamps that secure the conduit to the camshaft housing, water manifold, carburetor adapter housing, and to the accessory gear cover.

l. Revolution Counter Installation (fig. 3). Place a snap ring on the large spline of the tachometer driving quill. Insert the revolution counter drive quill in the exhaust camshaft through the opening in the left-hand camshaft housing. Place a new gasket on the studs. Place the revolution counter over the three studs and on the drive quill, being sure the revolution counter is facing upward. Install the elastic-type nuts that secure the counter to the camshaft housing.

m. Oil Filter Installation (fig. 3). Place a new gasket over the studs so that the oilhole in the gasket lines up with the oilhole in the oil pan. Insert the oil filter in the opening provided in the oil pan. Be sure the two pilot rods at the end of the filter are properly entered in the holes in the partition at the inner end of the chamber. Install the six flat washers and elastic-type nuts that secure the filter to the pan.

n. Starter Assembly Installation (fig. 3). Insert the drive end of the starter through the opening in the oil pan. Secure the starter to the pan with flat washers and self-locking nuts on the two mounting studs, and one bolt with a flat washer and self-locking nut.

33. INSTALLATION OF ACCESSORIES ON GAF ENGINES.

a. Magneto Installation and Ignition Timing. To install magnetos and time the ignition on the GAF engines, refer to paragraph 31.

b. Spark Plug Installation. Examine each spark plug to make sure the spark gap is set between 0.011 inch to 0.014 inch. Use new spark plugs and copper gaskets, and insert the plugs in the spark plug holes. Tighten the plugs moderately with the special spark plug wrench (41-W-3336-300) (fig. 12).

c. Spark Plug Wire and Conduit Installation.

(1) INSTALL CONDUIT ASSEMBLIES ON ENGINE. NOTE: *The spark plug wires and conduits, when made up in assemblies, are right- and left-hand.* The conduit with the longer rigid section is for the left-hand side of the engine. Insert the four spark plug wires through the hole in top of the camshaft housing and secure the conduit mounting flanges to the housing with four elastic-type nuts. This same procedure applies for both of the assemblies.

(2) ATTACH SPARK PLUG WIRES TO MAGNETO DISTRIBUTOR PLATES AND SPARK PLUGS. Attach the spark plug wires to the magneto distributor plates and to the spark plugs as shown in figure 116. Use special spark plug wrench (41-W-3336-300) for tightening the spark plug wire terminals on the spark plugs (fig. 13). Tighten the knurled nut on each end of the flexible conduit securely.

(3) SPARK PLUG COVER INSTALLATION (fig. 6). Use a new gasket on the spark plug cover. Position the cover on the camshaft housing with the louver opening facing outward. Install the copper washers and elastic-type nuts which secure the cover to the housing.

d. Fuel Pump Installation (fig. 6). Use a new gasket and attach the fuel pump over the studs on the left-hand camshaft housing. Install the two flat washers and elastic-type nuts that secure the pump to the housing.

e. Revolution Counter Installation (fig. 5). Install the snap ring on the large spline of the revolution counter driving quill. Insert the revolution counter drive quill in the left-hand exhaust camshaft through the opening in the left-hand camshaft housing. Place a new gasket on the studs. Place the revolution counter on the drive quill with the revolution counter facing downward. Install the three elastic-type nuts that secure the counter to the camshaft housing.

f. Tachometer Drive Installation (fig. 5). Install the snap ring on the large spline of the tachometer driving quill. Insert the tachometer drive quill in position in the left-hand intake camshaft through the opening in the left-hand camshaft housing. Place a new gasket on the studs, and install the tachometer drive. Install the four elastic-type nuts that secure the tachometer drive to the camshaft housing.

g. Governor Installation (fig. 5). Place a new gasket on the governor attaching studs at the right-hand camshaft housing. Rotate the governor shaft to aline the splines and install the governor on the housing with the oil connections on the governor facing downward. Install the six elastic-type nuts that secure the governor to the camshaft housing.

h. Primer Fuel Tube Installation (fig. 12). Attach the primer tube on the bracket located on the carburetor adapter housing at the magneto end of the engine. Connect the fuel tube to each nozzle tube.

i. Air Intake Manifold Installation (fig. 6). Slide the four air intake hoses on the manifold, being sure the hose clamps are also on the hoses. Use a new gasket, and place the manifold in position on the four studs on the engine. Install the four elastic-type nuts that secure the manifold to the engine.

j. Carburetor Installation (fig. 6). Insert the four long and the four short bolts in position on the carburetor adapter housing. Use a new gasket on each side of the spacer block, and place them over the bolts. The front and rear carburetors differ due to the location on the throttle arm, and they must be attached to the adapter with the throttle arm facing toward the right-hand side of the engine. Position the carburetor on the adapter housing. Tighten the eight bolts which secure the carburetor to the adapter, and lock the bolts with lock wire. Connect and tighten the fuel lines from the carburetor to the fuel pump.

k. Governor Booster Installation (fig. 5). Place a new gasket and the governor booster on the cylinder block at the magneto end of the engine. Install the four elastic-type nuts that secure the booster to the block. Connect the oil supply tube to the governor and cylinder block. Connect the oil tube leading from the governor to the booster.

l. Water Manifold Installation (fig. 6). Place a new gasket on the studs at each outlet. Place the manifold on the engine with the

manifold tilting away from the center of the engine, and with the outlets facing toward the flywheel end of the engine. Install the elastic-type nuts that secure the manifold to the engine.

m. Throttle Control Rod Installation (fig. 6). Place the throttle control rods in position on the engine. Install the throttle control rod assembly on the stud at the air intake manifold, and secure with a flat washer and an elastic-type nut.

n. Starter Assembly Installation. Insert the drive end of the starter to the opening in the oil pan. Secure the starter to the oil pan with safety nuts and flat washers on the two mounting studs and one bolt with a flat washer and safety nut.

Section VII

RUN-IN TEST

34. PURPOSE.

a. The purpose of this section is to prescribe a run-in schedule for Models GAA, GAN, and GAF overhauled or rebuilt engines prior to being placed in service. The purpose of an engine run-in after rebuilding is to assist in breaking in new parts installed, such as bearings and piston rings; to detect faulty assembly and oil leaks; and to determine whether the engine may be expected to operate satisfactorily when installed in a vehicle. This run is not to be confused with manufacturer's power performance curves.

35. GENERAL.

a. Length of Run. The length of run required to properly break in an engine varies with different types of engines and is dependent upon a number of variable factors, including piston and bearing clearances, type of piston rings and bearings used, and upon the duty to which the engine is to be subjected in the vehicle. In general, a longer run results in a quieter running engine, lowers oil consumption by properly seating piston rings and bearings, and reduces the hazard of engine failure upon being subjected to full throttle operation. Combat vehicle engines require a longer run-in than transport vehicle engines because they are subjected to heavier duty and are often called upon to deliver full output at wide open throttle immediately after installation in the vehicle.

b. Load. During the break-in run, the engine must be coupled to a suitable load. This load may be a water brake, an electric dynamometer, or other load which will permit the engine to be operated under varying loads and speeds.

c. Cooling. Liquid-cooled engines may be cooled by conventional radiator and fan installed in the vehicle, by means of a heat exchanger, or by circulating water from an outside source. Some means must be provided for regulating the water inlet temperature when using a heat exchanger or circulating water, as it is not desirable to allow cold water to enter the cylinder block directly from the water main. A blast of air from a blower, directed over the engine block and crankcase, will help maintain engine and oil temperatures at safe values.

d. Instruments. The following instruments are necessary for performing a complete engine run-in test:

Tachometer
Fuel pressure gage
Oil pressure gage
Oil temperature gage
Coolant temperature gage
Barometer
Wet and dry bulb thermometer (psychrometer)

e. Exhaust System. The exhaust system should be constructed to reduce back pressure to a minimum, since the slightest back pressure has a considerable effect upon the power output of the engine. Exhaust piping should be as short as possible and free from restrictions caused by reduction of piping diameter, sharp bends, or angles.

f. Air Induction System. The air induction system must be equipped with the same type air cleaners used with the engine when installed in the vehicle. Air intake should be located in such a manner that only fresh, cool air will be inducted into the engine.

g. Accessories. Test engine with all power consuming accessories completely installed in the vehicle, except where installation of certain accessories is obviously impractical. Power consuming accessories are such items as water and fuel pump and air cleaner, etc. When engines are run with other than specified accessories, allowance must be made when computing maximum horsepower during full throttle run. Since power consumed by most accessories is relatively small, corrections are required only at full throttle stages in the run-in schedule.

h. Timing. All valve and magneto timing shall be in accordance with pertinent operators' technical manuals.

i. Oil Consumption. Engine oil consumption is determined by measuring the amount of oil required to fill the crankcase to the "FULL" mark on the dip stick at the conclusion of the test period. Maximum permissible oil consumption is listed under run-in schedules in paragraph 37 below. Excessive oil consumption may indicate seri-

ous trouble, such as loose bearings, leaky internal oil lines, scored piston, or it may be due only to piston rings not being fully "worn in" or seated. Before rejecting an engine due to high oil consumption, it is advisable to run the engine for a longer period. If high oil consumption is due to piston rings not being fully seated, a longer run will usually cause oil consumption to be reduced while most other conditions will cause it to increase.

j. **Correction for Atmospheric Conditions.** Engine output varies due to differences in barometric pressure, carburetor air temperature, humidity, and altitude. In order to evaluate the performance of an engine and compare it with the performance of other similar engines, it is necessary to correct the observed engine output to standard sea level conditions of 29.92 inches of mercury barometric pressure, 60° F carburetor air temperature, and zero humidity. The dynamometer schedule prescribed is so set up that no correction for atmospheric conditions is required except for the full throttle run. During this run, it is necessary to correct the engine output to standard conditions so that a determination can be made as to whether the engine meets minimum power requirements. A simplified set of correction charts and a sample calculation are listed in paragraph 38.

k. **Data.** Pertinent data including time, speed, load, oil pressure and temperature, coolant temperatures, etc., will be recorded during the test run on log sheets as shown in figure 119. Log sheets may be printed, mimeographed, or otherwise reproduced locally. If any quantity of engines of a particular model are to be tested, it is recommended that fixed items such as period, speed, and load (except full throttle) be incorporated in the printed form. Log sheets will be retained at the overhaul facility.

l. **Definitions.**

(1) OBSERVED BRAKE HORSEPOWER. By observed brake horsepower is meant the actual net horsepower at the output shaft of the engine as computed from the dynamometer scale reading and speed.

(2) CORRECTED BRAKE HORSEPOWER. By corrected brake horsepower is meant the actual net or observed horsepower corrected to standard conditions (subpar. k above).

(3) FULL THROTTLE. By full throttle is meant wide open throttle with sufficient load on the dynamometer to maintain the speed at the specified value.

36. PROCEDURE.

a. **Oil.** Run engines using engine oil (SAE 50).

b. **Fuel.** Run all gasoline engines on fuel conforming to U. S. Army Specification 2-103B, or latest revision thereof.

c. Installation. Install engine on test stand making all fuel, oil, water, and electrical connections. Couple engine to dynamometer, making sure that no misalinement exists between engine output shaft and dynamometer shaft.

d. Preliminary Preparation.

(1) Check all items vital to safe engine operation such as fuel and oil lines, oil level, coolant, magneto ground connections, throttle control, mounting bolts, air cleaner, etc.

(2) Increase tension on the governor spring to hold the butterfly in wide open position at all speeds.

e. Test Run.

(1) Start engine and set throttle to obtain an engine speed of approximately 1,000 revloutions per minute. CAUTION: *If oil pressure gage does not indicate oil pressure within 30 seconds, shut down the engine and determine the cause.*

(2) Enter starting data on log sheet.

(3) Follow through the test schedule for the engine being tested as prescribed in paragraph 37. Conversion factors for converting brake horsepower to dynamometer loads are listed in paragraph 38.

(4) As the test progresses, check carefully for oil leaks, unusual noises, misfiring, or other unusual operating conditions.

(5) Check magnetos. When engine is sufficiently warm, set hand throttle to 600 revolutions per minute. Run the engine on each magneto and compare tachometer reading with the reading when both magnetos were used. If engine speed drops below 450 revolutions per minute on either magneto, the cause should be investigated.

(6) Check oil pressure during each period of the run. Low oil pressure or a sudden drop in oil pressure should be investigated and corrected before continuing test.

(7) Check oil temperature during each period. Oil temperature must not exceed 250° F in the oil gallery.

(8) Check coolant temperatures. Try to maintain coolant temperature at or near the normal operating range.

(9) Check oil consumption where specified during run-in schedule.

(10) Pay particular attention to all instrument readings during full throttle run.

f. Adjustments. At conclusion of run, adjust governor to control top speed at 2,800 revolutions per minute at no load (see operators' manual). Set idle speed at 500 revolutions per minute and the idle fuel adjustments as prescribed in the operator's manual. Make final adjustments as required. Correct any unsatisfactory condition or malfunctioning noted during test.

g. Penalty Run. Any engine which requires major adjustment, correction for malfunctioning, or replacement of major components must be completely retested before being released. Where only minor correction is made, such as correcting valve clearance or replacement of a spark plug, engine must be run long enough to determine whether it is operating satisfactorily.

h. Minimum Power Requirements. Compute observed brake horsepower for full throttle run and correct to standard conditions, using tables in paragraph 38. Reject any engines which do not develop minimum horsepower specified under run-in schedule. In this connection, it must be noted that some engines are rated with and some without accessories. Allowance must be made for any difference in accessories on the rebuilt engine being tested and that upon which the manufacturer's rating is based.

i. Inspection After Testing. For purpose of quality control, engines will be disassembled periodically for inspection. Such inspections will be frequent enough to assure disclosure of all imperfections or defects. Where some unsatisfactory condition is encountered, additional engines shall be disassembled and inspected. Corrective action shall be taken to prevent recurrence of any unsatisfactory condition revealed by inspection. Upon assembly, engines shall be given a dynamometer run of sufficient duration to assure satisfactory performance.

j. Preparation for Shipment. All engines which satisfactorily pass the run-in test shall be prepared for shipment in accordance with Ordnance Department, U. S. Army tentative specifications AXS 836, latest revision.

37. RUN-IN SCHEDULES.

a. The following 4½-hour test schedule is based on engine complete with air cleaners, water pump, fuel pump, etc., but less fan drive.

PRELIMINARY RUN

Period	Time (Minutes)	RPM	BHP Approx.
1	10	1,000	20
2	30	1,000	50
3	30	1,500	105
4	30	1,800	144
5	30	2,100	210
6	30	2,400	288
		Check oil level	
7	10	2,100 Wide open throttle	
8	10	2,400 Wide open throttle	
9	10	2,600 Wide open throttle	
10	10	2,800 Wide open throttle	

Shut down engine for inspection, remove valve covers, and check valve clearance. Tighten cylinder head nuts to 60 foot-pounds of torque, correct any leaks or deficiencies noted, and fill crankcase to full mark on dip stick.

FINAL RUN-IN

Period	Time (Minutes)	RPM	BHP Approx.
11	15	1,100	50
12	15	2,100	100
13	10	2,100 Wide open throttle	
14	10	2,400 Wide open throttle	
15	10	2,600 Wide open throttle	
16	10	2,800 Wide open throttle	

Total time: 4 hours, 30 minutes.

Minimum acceptable output for rebuilt engine with air cleaners and fuel pump, but less fans and generators, is 475 horsepower with wide open throttle at 2,600 revolutions per minute corrected to standard conditions.

b. Data.

Use SAE 50 engine oil.

Oil pressure: Minimum 60 lb/sq in. at 2,600 rpm.

Oil temperature: Maximum 250° F in oil gallery.

Maximum oil consumption during final run: (periods 11 through 16) 12 lb or 1½ gal.

38. TABLES.

a. General. Tables contained in this paragraph are designed to simplify and reduce to a minimum the mathematical calculations required for computing dynamometer loads, horsepower, and making correction for atmospheric conditions.

b. Use of Tables.

(1) CONVERSION OF BRAKE HORSEPOWER TO DYNAMOMETER SCALE READINGS.

(a) Table I contains conversion factors for determining dynamometer scale readings from brake horsepower valves listed in the run-in schedules in paragraph 37. Conversion factors are for dynamometers in common usage having dynamometer constants "K" as listed. Some dynamometers have different constants from those listed in Table I or different means of determining load; in such cases, manufacturer's instructions furnished with dynamometer are applicable.

(b) To find scale load for any brake horsepower, select conversion factor from Table I in column headed by appropriate dynamometer constant opposite specified speed and multiply specified

brake horsepower by conversion factor. Example: Assuming it is required to find the dynamometer scale reading for a load of 150 horsepower at 1,800 revolutions per minute, use a dynamometer having a constant "K" = 750.

From Table I conversion factor = 0.417. Scale load = 0.417 × 150 = 62.5 pounds.

(c) For dynamometers having constants other than those listed in Table I, the following formula is applicable:

$$W = \frac{K \times BHP}{N}$$

Where: W = Scale reading
K = Dynamometer constant
BHP = Brake horsepower
N = Speed, rpm

(2) CONVERSION OF DYNAMOMETER SCALE READINGS TO BRAKE HORSEPOWER.

(a) Table II contains conversion factors for determining brake horsepower from dynamometer scale readings. Conversion factors are for dynamometers in common usage having dynamometer constants "K" as listed. Some dynamometers have different constants from those listed in Table II or different means of determining load; in such cases, manufacturer's instructions furnished with dynamometer are applicable.

(b) To find brake horsepower: Select conversion factor from Table II in column headed by appropriate dynamometer constant opposite observed speed and multiply scale reading by this factor. Example: Assume an engine is running on a dynamometer having a constant "K" = 3,000 with a scale reading of 90 pounds at 2,600 revolutions per minute.

From Table II conversion factor = 0.867.

BHP = 0.867 × 90 = 78.03 HP.

(c) For dynamometers having constants other than those listed in Table II, the following formula is applicable:

$$BHP = \frac{WN}{K}$$

Where: W = Scale load, lb
N = Dynamometer speed, rpm
K = Dynamometer constant

(3) CORRECTION FOR ATMOSPHERIC CONDITIONS.

(a) Correction of brake horsepower developed during the full throttle run to standard conditions is accomplished by use of Tables III, IV, and figure 118 as described in example below:

(b) Assume the following conditions:

Observed BHP during full throttle (maximum) run — 412
Barometer reading — 29.10 inches of mercury
Carburetor air temperature — 95° F
Dry bulb temperature — 87° F
Wet bulb temperature — 82° F

(c) Correct Barometer Reading for Temperature.

1. Refer to Table III. Select the barometer correction in the column headed by the figure closest to the observed barometer reading (in this case the column headed "30") and opposite the observed mercury column temperature. (Most barometers are equipped with a built-in thermometer for determining temperature of the mercury column; if not, temperature of the mercury column may be assumed to be the same as room temperature, dry bulb temperature.) In this case the correction is — 0.15. NOTE: *It is not necessary to make this correction if an aneroid barometer is used.*

2. Apply correction to observed barometer reading:

Barometer corrected for temperature = 29.10 – 0.15 = 28.95 inches of mercury. NOTE: *It is permissible to interpolate between barometer and temperature values in Table III but this is not necessary for routine testing as the correction is very small. In fact, correction of barometer for temperature may be omitted entirely with little effect upon final results.*

(d) Correct Barometer Reading for Humidity:

1. Select dry bulb temperature at bottom of chart (fig. 118) corresponding to observed dry bulb temperature (87° F in example) and follow the vertical line upward from this point to the point of intersection with a diagonal line corresponding to the observed wet bulb temperature (82° F in example). Follow the horizontal line from the point of intersection to the right-hand side of the chart and read the vapor pressure. In this case the vapor pressure is 1.06 inches of mercury.

2. Apply correction to barometer reading:

Barometer corrected for temperature and humidity = 28.95 – 1.06 = 27.89. NOTE: *The chart in figure 118 is based on a barometer pressure of 30 inches of mercury but is applicable to other normal barometric pressures with sufficient accuracy for this purpose.*

(e) Correct Observed Horsepower to Standard Conditions:

1. Refer to Table IV and select power correction factor from column headed by the figure nearest corrected barometer reading and opposite observed carburetor air temperature in the left-hand column. In this case, for a corrected barometer reading of 27.89 inches of mercury and a carburetor air temperature of 95° F, the power correction factor is 1.108.

2. Apply power correction factor:

Corrected BHP = 1.108 × 412 = 456.5 HP.

(4) CORRECTION FORMULA FOR ATMOSPHERIC CONDITIONS. Should unusual conditions prohibit the use of the tables, the following table may be used:

$$\text{Corrected BHP} = \text{Observed BHP} \times \frac{29.92}{\text{B-E}} \sqrt{\frac{\text{T} + 460}{520}}$$

Where: B = Obs. barometer reading corrected for temperature (Table III)

E = Vapor pressure from chart in figure 118.

T = Carburetor air temperature.

TABLE I

Conversion of BHP to Dynamometer Scale Readings

SPEED RPM	CONVERSION FACTOR *K = 750	*K = 1,000	*K = 3,000	*K = 5,000
800	0.938	1.250	3.750	6.250
900	0.834	1.111	3.333	5.560
1,000	0.750	1.000	3.00	5.00
1,100	0.682	0.910	2.73	4.54
1,200	0.625	0.835	2.50	4.17
1,300	0.577	0.770	2.31	3.84
1,400	0.535	0.715	2.14	3.67
1,500	0.500	0.667	2.00	3.33
1,600	0.468	0.625	1.87	3.12
1,700	0.442	0.588	1.76	2.94
1,800	0.417	0.556	1.67	2.78
1,900	0.395	0.526	1.58	2.63
2,000	0.375	0.500	1.50	2.50
2,100	0.357	0.476	1.43	2.38
2,200	0.341	0.455	1.36	2.27
2,300	0.326	0.435	1.30	2.17
2,400	0.312	0.417	1.25	2.08
2,500	0.300	0.400	1.20	2.00
2,600	0.288	0.385	1.15	1.92
2,700	0.278	0.370	1.11	1.85
2,800	0.268	0.357	1.07	1.79
2,900	0.259	0.345	1.03	1.72
3,000	0.250	0.333	1.00	1.67
3,100	0.242	0.323	0.97	1.61
3,200	0.234	0.313	0.94	1.56
3,300	0.227	0.303	0.91	1.51
3,400	0.221	0.294	0.883	1.47
3,500	0.214	0.286	0.858	1.43
3,600	0.208	0.278	0.833	1.39
3,700	0.203	0.270	0.812	1.35
3,800	0.197	0.263	0.790	1.31
3,900	0.192	0.256	0.769	1.28
4,000	0.187	0.250	0.750	1.25

*K = Dynamometer constant.

TABLE II

Conversion of Dynamometer Scale Readings to BHP

SPEED RPM	CONVERSION FACTOR *K = 750	*K = 1,000	*K = 3,000	*K = 5,000
800	1.067	0.80	0.267	0.16
900	1.20	0.90	0.300	0.18
1,000	1.25	1.00	0.333	0.20
1,100	1.47	1.10	0.367	0.21
1,200	1.60	1.20	0.400	0.24
1,300	1.73	1.30	0.433	0.26
1,400	1.87	1.40	0.467	0.28
1,500	2.00	1.50	0.500	0.30
1,600	2.14	1.60	0.533	0.32
1,700	2.27	1.70	0.567	0.34
1,800	2.40	1.80	0.600	0.36
1,900	2.54	1.90	0.633	0.38
2,000	2.67	2.00	0.667	0.40
2,100	2.80	2.10	0.700	0.42
2,200	2.94	2.20	0.733	0.44
2,300	3.07	2.30	0.767	0.46
2,400	3.20	2.40	0.800	0.48
2,500	3.33	2.50	0.833	0.50
2,600	3.47	2.60	0.867	0.52
2,700	3.60	2.70	0.900	0.54
2,800	3.74	2.80	0.933	0.56
2,900	3.86	2.90	0.967	0.58
3,000	4.00	3.00	1.00	0.60
3,100	4.13	3.10	1.03	0.62
3,200	4.27	3.20	1.07	0.64
3,300	4.40	3.30	1.10	0.66
3,400	4.53	3.40	1.13	0.68
3,500	4.67	3.50	1.17	0.70
3,600	4.80	3.60	1.20	0.72
3,700	4.93	3.70	1.23	0.74
3,800	5.07	3.80	1.27	0.76
3,900	5.20	3.90	1.30	0.78
4,000	5.33	4.00	1.33	0.80

*K = Dynamometer constant.

TABLE III

Temperature Corrections for Barometer Mercury Column

Temperature of Column in Deg. F	OBSERVED READING OF BAROMETER IN INCHES OF MERCURY 26	28	30	32
		ADD		
0	0.07	0.07	0.08	0.08
10	0.04	0.05	0.05	0.05
20	0.02	0.02	0.02	0.02
30	0.00	0.00	0.00	0.00
		SUBTRACT		
35	0.01	0.02	0.02	0.02
40	0.03	0.03	0.03	0.03
45	0.04	0.04	0.04	0.05
50	0.05	0.05	0.06	0.06
55	0.06	0.07	0.07	0.08
60	0.07	0.08	0.08	0.09
65	0.09	0.09	0.10	0.10
70	0.10	0.10	0.11	0.12
75	0.11	0.12	0.13	0.13
80	0.12	0.13	0.14	0.15
85	0.13	0.14	0.15	0.16
90	0.14	0.15	0.17	0.18
95	0.16	0.17	0.18	0.19
100	0.17	0.18	0.19	0.20

TABLE IV

Power Correction Factors

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY 26.10	26.20	26.30	26.40	26.50	26.60	26.70	26.80	26.90	27.00
40	1.123	1.117	1.114	1.110	1.106	1.103	1.098	1.094	1.089	1.084
1	.124	.119	.115	.111	.107	.104	.099	.095	.090	.085
2	.125	.120	.116	.112	.108	.105	.100	.096	.091	.086
3	.126	.121	.117	.113	.109	.106	.101	.097	.092	.087
4	.127	.122	.118	.114	.110	.107	.102	.098	.093	.089
45	1.128	1.123	1.120	1.115	1.111	1.108	1.103	1.099	1.094	1.090
6	.129	.124	.121	.116	.113	.109	.105	.100	.096	.091
7	.130	.125	.122	.118	.114	.110	.106	.101	.097	.092
8	.131	.126	.123	.119	.116	.111	.107	.102	.098	.093
9	.132	.127	.124	.120	.117	.112	.108	.103	.099	.094
50	1.134	1.128	1.125	1.121	1.118	1.113	1.109	1.105	1.100	1.095
1	.136	.130	.126	.122	.119	.115	.110	.106	.101	.097
2	.137	.131	.127	.123	.120	.116	.111	.107	.102	.098
3	.138	.133	.129	.124	.121	.117	.112	.108	.103	.099
4	.139	.134	.130	.125	.122	.118	.113	.109	.104	.100
55	1.140	1.135	1.131	1.127	1.123	1.119	1.115	1.110	1.105	1.101
6	.141	.136	.132	.128	.124	.120	.116	.111	.107	.103
7	.142	.138	.133	.129	.125	.121	.117	.112	.108	.104

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	26.10	26.20	26.30	26.40	26.50	26.60	26.70	26.80	26.90	27.00
8	.143	.139	.134	.130	.126	.122	.118	.113	.109	.105
9	.144	.140	.135	.131	.127	.123	.119	.114	.110	.106
60	1.146	1.141	1.137	1.133	1.128	1.124	1.120	1.116	1.111	1.107
1	.147	.142	.138	.134	.129	.125	.121	.117	.112	.108
2	.148	.143	.139	.135	.130	.126	.122	.118	.113	.109
3	.149	.145	.140	.136	.131	.127	.123	.119	.114	.110
4	.150	.146	.141	.137	.132	.128	.124	.120	.115	.111
65	1.151	1.147	1.142	1.138	1.133	1.129	1.125	1.121	1.116	1.112
6	.152	.148	.143	.139	.134	.130	.126	.122	.117	.113
7	.153	.149	.144	.140	.135	.131	.127	.123	.118	.114
8	.154	.150	.145	.141	.136	.132	.128	.124	.119	.115
9	.155	.151	.146	.142	.137	.133	.129	.125	.120	.116
70	1.156	1.152	1.147	1.143	1.138	1.134	1.130	1.126	1.121	1.117
1	.157	.153	.148	.144	.139	.136	.131	.127	.122	.118
2	.158	.154	.149	.145	.140	.137	.132	.128	.123	.119
3	.159	.155	.150	.146	.141	.138	.133	.129	.124	.120
4	.160	.156	.151	.147	.142	.139	.134	.130	.125	.121
75	1.161	1.158	1.153	1.149	1.143	1.140	1.135	1.131	1.126	1.123
6	.162	.159	.154	.150	.144	.141	.136	.132	.127	.124
7	.163	.160	.155	.151	.145	.142	.137	.133	.128	.125
8	.164	.161	.156	.152	.146	.143	.138	.134	.129	.126
9	.165	.162	.157	.153	.148	.144	.139	.135	.130	.127
80	1.166	1.163	1.158	1.154	1.149	1.145	1.140	1.136	1.131	1.128
1	.167	.164	.159	.155	.150	.146	.141	.137	.132	.129
2	.168	.165	.160	.156	.151	.147	.142	.138	.133	.130
3	.169	.166	.161	.157	.152	.148	.143	.139	.134	.131
4	.170	.167	.162	.158	.153	.149	.144	.140	.135	.132
85	1.171	1.168	1.163	1.159	1.154	1.150	1.146	1.141	1.136	1.133
6	.172	.169	.164	.160	.155	.151	.147	.142	.137	.134
7	.173	.170	.165	.161	.156	.152	.148	.143	.138	.135
8	.174	.171	.166	.162	.157	.153	.149	.144	.139	.136
9	.175	.172	.167	.163	.158	.154	.150	.145	.140	.137
90	1.176	1.173	1.168	1.164	1.159	1.155	1.151	1.146	1.141	1.138
1	.177	.174	.169	.165	.160	.156	.152	.147	.142	.139
2	.178	.175	.170	.166	.161	.157	.153	.148	.143	.140
3	.180	.176	.171	.167	.162	.158	.154	.149	.144	.141
4	.181	.177	.172	.168	.163	.159	.155	.150	.145	.142
95	1.182	1.179	1.173	1.170	1.164	1.160	1.156	1.151	1.146	1.143
6	.183	.180	.174	.171	.165	.161	.157	.152	.147	.144
7	.185	.181	.176	.172	.166	.162	.158	.153	.148	.145
8	.186	.182	.177	.173	.167	.163	.159	.154	.149	.146
9	.187	.183	.178	.174	.168	.164	.160	.155	.150	.147
100	1.188	1.184	1.179	1.175	1.169	1.165	1.161	1.157	1.151	1.149
1	.189	.185	.180	.176	.170	.166	.162	.158	.152	.150
2	.190	.186	.181	.177	.171	.167	.163	.159	.153	.151
3	.191	.187	.182	.178	.172	.168	.164	.160	.154	.152
4	.192	.188	.183	.179	.173	.169	.165	.161	.155	.153

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	26.10	26.20	26.30	26.40	26.50	26.60	26.70	26.80	26.90	27.00
105	1.193	1.190	1.184	1.180	1.175	1.170	1.166	1.162	1.156	1.154
6	.194	.191	.185	.181	.176	.171	.167	.163	.157	.155
7	.195	.192	.186	.182	.177	.172	.168	.164	.158	.156
8	.196	.193	.187	.183	.178	.173	.169	.165	.159	.157
9	.197	.194	.188	.184	.179	.174	.170	.166	.160	.158
110	1.198	1.195	1.189	1.185	1.180	1.175	1.171	1.167	1.161	1.159
1	.199	.196	.190	.186	.181	.176	.172	.168	.162	.160
2	.200	.197	.191	.187	.182	.177	.173	.169	.163	.161
3	.201	.198	.192	.188	.183	.178	.174	.170	.164	.162
4	.202	.199	.193	.189	.184	.180	.175	.171	.165	.163
115	1.203	1.200	1.194	1.190	1.185	1.181	1.176	1.172	1.166	1.164
6	.204	.201	.195	.191	.186	.182	.177	.173	.167	.165
7	.205	.202	.196	.192	.187	.183	.178	.174	.168	.166
8	.206	.203	.197	.193	.188	.184	.179	.175	.169	.167
9	.207	.204	.198	.194	.189	.185	.180	.176	.170	.168
120	1.208	1.205	1.199	1.195	1.190	1.186	1.181	1.177	1.171	1.169
1	.209	.206	.200	.196	.191	.187	.182	.178	.172	.170
2	.210	.207	.201	.197	.192	.188	.183	.179	.173	.171
3	.211	.208	.202	.198	.193	.189	.184	.180	.174	.172
4	.212	.209	.203	.199	.194	.190	.185	.181	.175	.173
125	1.213	1.210	1.204	1.200	1.195	1.191	1.186	1.182	1.176	1.174

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	27.10	27.20	27.30	27.40	27.50	27.60	27.70	27.80	27.90	28.00
40	1.081	1.078	1.073	1.068	1.064	1.061	1.057	1.055	1.051	1.048
1	.082	.079	.074	.069	.065	.062	.058	.056	.052	.049
2	.083	.080	.075	.070	.066	.063	.059	.057	.053	.050
3	.084	.081	.076	.071	.067	.064	.060	.058	.054	.051
4	.086	.082	.077	.072	.068	.065	.061	.059	.055	.052
45	1.087	1.083	1.079	1.073	1.069	1.066	1.062	1.060	1.056	1.053
6	.088	.084	.080	.074	.070	.067	.063	.061	.057	.054
7	.089	.085	.081	.075	.071	.068	.064	.062	.058	.055
8	.090	.086	.082	.076	.072	.069	.065	.063	.060	.056
9	.091	.087	.083	.077	.073	.070	.066	.064	.061	.057
50	1.092	1.089	1.084	1.079	1.075	1.071	1.068	1.065	1.062	1.058
1	.093	.090	.085	.080	.076	.072	.069	.066	.063	.059
2	.094	.091	.086	.081	.077	.073	.070	.067	.064	.060
3	.095	.092	.087	.082	.078	.074	.071	.068	.065	.061
4	.096	.093	.088	.083	.080	.075	.072	.069	.066	.062
55	1.097	1.094	1.090	1.085	1.081	1.077	1.073	1.071	1.067	1.063
6	.098	.095	.091	.086	.082	.078	.074	.072	.068	.064
7	.100	.097	.092	.087	.083	.079	.075	.073	.069	.065
8	.101	.098	.093	.088	.085	.080	.076	.074	.070	.066
9	.102	.099	.094	.090	.086	.082	.078	.075	.071	.067
60	1.103	1.100	1.095	1.091	1.087	1.083	1.079	1.076	1.072	1.068
1	.104	.101	.096	.092	.088	.084	.080	.077	.073	.069
2	.105	.102	.097	.093	.089	.085	.081	.078	.074	.070

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	27.10	27.20	27.30	27.40	27.50	27.60	27.70	27.80	27.90	28.00
3	.106	.103	.098	.094	.090	.086	.082	.079	.075	.071
4	.107	.104	.099	.095	.091	.087	.083	.080	.076	.072
65	1.108	1.105	1.100	1.096	1.092	1.088	1.084	1.081	1.077	1.073
6	.109	.106	.101	.097	.093	.089	.085	.082	.078	.074
7	.110	.107	.102	.098	.094	.090	.086	.083	.079	.075
8	.111	.108	.103	.099	.095	.091	.087	.084	.080	.076
9	.112	.109	.104	.100	.096	.092	.088	.085	.081	.077
70	1.113	1.110	1.105	1.101	1.097	1.093	1.089	1.086	1.082	1.078
1	.114	.111	.106	.102	.098	.094	.090	.087	.083	.079
2	.115	.112	.107	.103	.099	.095	.091	.088	.084	.080
3	.116	.113	.108	.104	.100	.096	.092	.089	.085	.081
4	.117	.114	.109	.105	.101	.097	.093	.090	.086	.082
75	1.119	1.115	1.111	1.106	1.102	1.098	1.094	1.091	1.087	1.083
6	.120	.116	.112	.107	.103	.099	.095	.092	.088	.084
7	.121	.117	.113	.108	.104	.100	.096	.093	.089	.085
8	.122	.118	.114	.109	.105	.101	.097	.094	.091	.086
9	.123	.119	.115	.110	.106	.102	.098	.095	.092	.087
80	1.124	1.120	1.116	1.111	1.107	1.103	1.099	1.096	1.093	1.088
1	.125	.121	.117	.112	.108	.104	.100	.097	.094	.089
2	.126	.122	.118	.113	.109	.105	.101	.098	.095	.091
3	.127	.123	.119	.114	.110	.106	.102	.099	.096	.092
4	.128	.124	.120	.115	.111	.107	.103	.100	.097	.093
85	1.129	1.125	1.121	1.116	1.112	1.108	1.104	1.101	1.098	1.094
6	.130	.126	.122	.117	.113	.109	.105	.103	.099	.095
7	.131	.127	.123	.118	.114	.110	.106	.104	.100	.096
8	.132	.128	.124	.119	.115	.111	.107	.105	.101	.097
9	.133	.129	.125	.120	.116	.112	.108	.106	.102	.098
90	1.134	1.130	1.126	1.121	1.117	1.113	1.109	1.107	1.103	1.099
1	.135	.131	.127	.122	.118	.114	.110	.108	.104	.100
2	.136	.132	.128	.123	.119	.115	.111	.109	.105	.101
3	.137	.133	.129	.124	.120	.116	.112	.110	.106	.102
4	.138	.134	.130	.125	.121	.117	.113	.111	.107	.103
95	1.139	1.135	1.131	1.126	1.122	1.118	1.114	1.112	1.108	1.104
6	.140	.136	.132	.127	.123	.119	.115	.113	.109	.105
7	.141	.137	.133	.128	.124	.120	.116	.114	.110	.106
8	.142	.138	.134	.129	.125	.121	.117	.115	.111	.107
9	.143	.139	.135	.130	.126	.122	.118	.116	.112	.108
100	1.144	1.140	1.136	1.131	1.127	1.123	1.119	1.117	1.113	1.109
1	.145	.141	.137	.132	.128	.124	.120	.118	.114	.110
2	.146	.142	.138	.133	.129	.125	.121	.119	.115	.111
3	.147	.143	.139	.134	.130	.126	.122	.120	.116	.112
4	.148	.144	.140	.135	.131	.127	.123	.121	.117	.113
105	1.149	1.145	1.141	1.136	1.132	1.128	1.124	1.122	1.118	1.114
6	.150	.146	.142	.137	.133	.129	.125	.123	.119	.115
7	.151	.147	.143	.138	.134	.130	.126	.124	.120	.116
8	.152	.148	.144	.139	.135	.131	.127	.125	.121	.117
9	.153	.149	.145	.140	.136	.132	.128	.126	.122	.118

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	27.10	27.20	27.30	27.40	27.50	27.60	27.70	27.80	27.90	28.00
110	1.154	1.150	1.146	1.141	1.137	1.133	1.129	1.127	1.123	1.119
1	.155	.151	.147	.142	.138	.134	.130	.128	.124	.120
2	.156	.152	.148	.143	.139	.135	.131	.129	.124	.120
3	.157	.153	.149	.144	.140	.136	.132	.129	.125	.121
4	.158	.154	.150	.145	.141	.137	.133	.130	.126	.122
115	1.159	1.155	1.151	1.146	1.142	1.138	1.134	1.131	1.127	1.123
6	.160	.156	.152	.147	.143	.139	.135	.132	.128	.124
7	.161	.157	.153	.148	.144	.140	.136	.133	.129	.125
8	.162	.158	.154	.149	.145	.141	.137	.134	.130	.126
9	.163	.159	.155	.150	.146	.142	.138	.135	.131	.127
120	1.164	1.160	1.156	1.151	1.147	1.143	1.139	1.136	1.132	1.128
1	.165	.161	.157	.152	.148	.144	.140	.137	.133	.129
2	.166	.162	.158	.153	.149	.145	.141	.138	.134	.130
3	.167	.163	.159	.154	.150	.146	.142	.139	.135	.131
4	.168	.164	.160	.155	.151	.147	.143	.140	.136	.132
125	1.169	1.165	1.161	1.156	1.152	1.148	1.144	1.141	1.137	1.133

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	28.10	28.20	28.30	28.40	28.50	28.60	28.70	28.80	28.90	29.00
40	1.044	1.040	1.037	1.033	1.029	1.026	1.022	1.019	1.015	1.011
1	.045	.041	.038	.034	.030	.027	.023	.020	.016	.012
2	.046	.042	.039	.035	.031	.028	.024	.021	.017	.013
3	.047	.043	.040	.036	.032	.029	.025	.022	.018	.014
4	.048	.044	.041	.037	.033	.030	.026	.023	.019	.015
45	1.049	1.045	1.042	1.038	1.034	1.031	1.027	1.024	1.020	1.016
6	.050	.046	.043	.039	.035	.032	.028	.025	.021	.017
7	.051	.047	.044	.040	.036	.033	.029	.026	.022	.018
8	.052	.048	.045	.041	.037	.034	.030	.027	.023	.019
9	.053	.049	.046	.042	.038	.035	.031	.028	.024	.020
50	1.054	1.050	1.047	1.043	1.039	1.036	1.032	1.029	1.025	1.021
1	.055	.051	.048	.044	.040	.037	.033	.030	.026	.022
2	.056	.052	.049	.045	.041	.038	.034	.031	.027	.023
3	.057	.053	.050	.046	.042	.039	.035	.032	.028	.024
4	.058	.054	.051	.047	.043	.040	.036	.033	.029	.025
55	1.059	1.055	1.052	1.048	1.044	1.041	1.037	1.034	1.030	1.026
6	.060	.056	.053	.049	.045	.042	.038	.035	.031	.027
7	.061	.057	.054	.050	.046	.043	.039	.036	.032	.028
8	.062	.058	.055	.051	.047	.044	.040	.037	.033	.029
9	.063	.059	.056	.052	.048	.045	.041	.038	.034	.030
60	1.064	1.060	1.057	1.053	1.049	1.046	1.042	1.039	1.035	1.031
1	.065	.061	.058	.054	.050	.047	.043	.040	.036	.032
2	.066	.062	.059	.055	.051	.048	.044	.041	.037	.033
3	.067	.063	.060	.056	.052	.049	.045	.042	.038	.034

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	28.10	28.20	28.30	28.40	28.50	28.60	28.70	28.80	28.90	29.00
4	.068	.064	.061	.057	.053	.050	.046	.043	.039	.035
65	1.069	1.065	1.062	1.058	1.054	1.051	1.047	1.044	1.040	1.036
6	.070	.066	.063	.059	.055	.052	.048	.045	.041	.037
7	.071	.067	.064	.060	.056	.053	.049	.046	.042	.038
8	.072	.068	.065	.061	.057	.054	.050	.047	.043	.039
9	.073	.069	.066	.062	.058	.055	.051	.048	.044	.040
70	1.074	1.070	1.067	1.063	1.059	1.056	1.052	1.049	1.045	1.041
1	.075	.071	.068	.064	.060	.057	.053	.049	.046	.042
2	.076	.072	.069	.065	.061	.058	.054	.050	.047	.043
3	.077	.073	.070	.066	.062	.059	.055	.051	.048	.044
4	.078	.074	.071	.067	.063	.060	.056	.052	.049	.045
75	1.079	1.075	1.072	1.068	1.064	1.061	1.057	1.053	1.050	1.046
6	.080	.076	.073	.069	.065	.062	.058	.054	.051	.047
7	.081	.077	.074	.070	.066	.063	.059	.055	.052	.048
8	.082	.078	.075	.071	.067	.064	.060	.056	.053	.049
9	.083	.079	.076	.072	.068	.065	.061	.057	.054	.050
80	1.084	1.080	1.077	1.073	1.069	1.066	1.062	1.058	1.055	1.051
1	.085	.081	.078	.074	.070	.067	.063	.059	.056	.052
2	.086	.082	.079	.075	.071	.068	.064	.060	.057	.053
3	.087	.083	.080	.076	.072	.069	.065	.061	.057	.054
4	.088	.084	.081	.077	.073	.069	.066	.062	.058	.055
85	1.089	1.085	1.082	1.078	1.074	1.070	1.067	1.063	1.059	1.056
6	.091	.086	.083	.079	.075	.071	.068	.064	.060	.057
7	.092	.087	.084	.080	.076	.072	.069	.065	.061	.058
8	.093	.088	.085	.081	.077	.073	.070	.066	.062	.059
9	.094	.089	.086	.082	.078	.074	.071	.067	.063	.060
90	1.095	1.090	1.087	1.083	1.079	1.075	1.072	1.068	1.064	1.061
1	.096	.091	.088	.084	.080	.076	.073	.069	.065	.062
2	.097	.092	.089	.085	.081	.077	.074	.070	.066	.062
3	.098	.093	.090	.086	.082	078	.075	.071	.067	.063
4	.099	.094	.091	.087	.083	.079	.076	.072	.068	.064
95	1.100	1.095	1.092	1.088	1.084	1.080	1.077	1.073	1.069	1.065
6	.101	.096	.093	.089	.085	.081	.078	.074	.070	.066
7	.102	.097	.094	.090	.086	.082	.079	.075	.071	.067
8	.103	.098	.095	.091	.087	.083	.080	.076	.072	.068
9	.104	.099	.096	.092	.088	.084	.081	.076	.073	.069
100	1.105	1.100	1.097	1.093	1.089	1.085	1.082	1.077	1.074	1.070
1	.106	.101	.098	.094	.090	.086	.083	.078	.075	.071
2	.107	.102	.099	.095	.091	.087	.084	.079	.076	.072
3	.108	.103	.100	.096	.092	.088	.085	.080	.077	.073
4	.109	.104	.101	.097	.093	.089	.086	.081	.078	.074
105	1.110	1.105	1.102	1.098	1.093	1.090	1.087	1.082	1.078	1.075
6	.111	.106	.103	.099	.094	.091	.088	.083	.079	.076
7	.112	.107	.104	.100	.095	.092	.089	.084	.080	.077

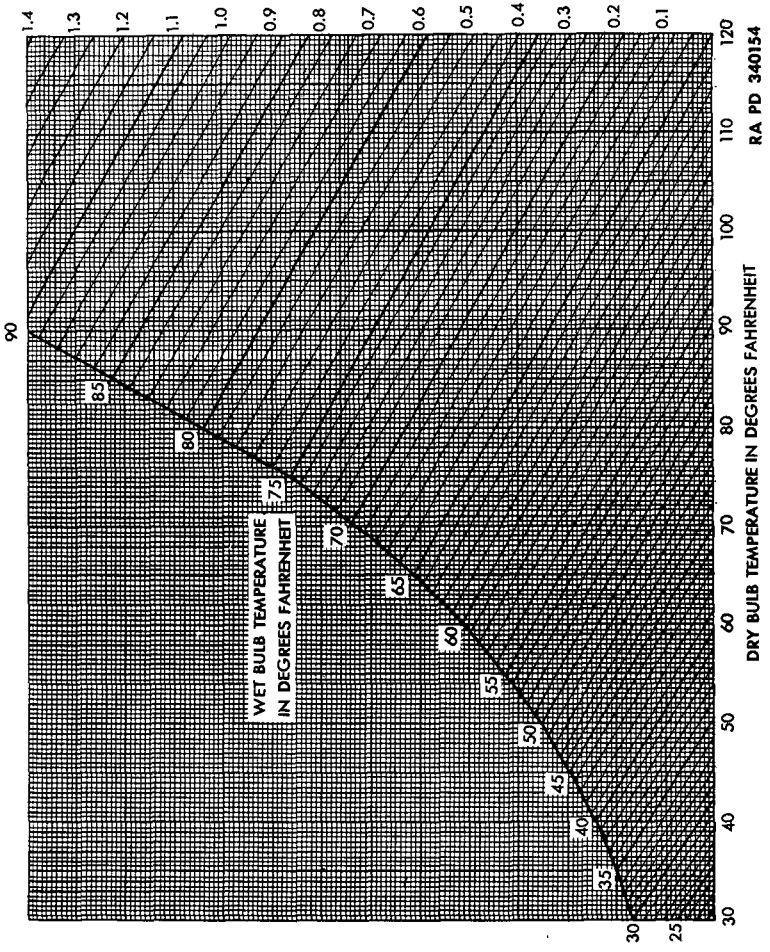


Figure 118 — Vapor Pressure Chart for Barometer, 30 Inches of Mercury

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	28.10	28.20	28.30	28.40	28.50	28.60	28.70	28.80	28.90	29.00
8	.113	.108	.105	.101	.096	.093	.090	.085	.081	.078
9	.114	.109	.106	.102	.097	.094	.091	.086	.082	.078
110	1.115	1.110	1.107	1.103	1.098	1.095	1.092	1.087	1.083	1.079
1	.116	.111	.108	.104	.099	.096	.093	.088	.084	.080
2	.116	.112	.109	.105	.100	.097	.094	.089	.085	.081
3	.117	.113	.110	.106	.101	.098	.094	.090	.086	.082
4	.118	.114	.111	.107	.102	.099	.095	.091	.087	.083
115	1.119	1.115	1.112	1.108	1.103	1.100	1.096	1.092	1.088	1.084
6	.120	.116	.113	.109	.104	.101	.097	.093	.089	.085
7	.121	.117	.114	.110	.105	.102	.098	.094	.090	.086
8	.122	.118	.114	.111	.106	.103	.099	.095	.091	.087
9	.123	.119	.115	.112	.107	.104	.100	.096	.092	.088
120	1.124	1.120	1.116	1.112	1.108	1.105	1.101	1.097	1.093	1.089
1	.125	.121	.117	.113	.109	.106	.102	.098	.094	.090
2	.126	.122	.118	.114	.110	.107	.103	.099	.095	.091
3	.127	.123	.119	.115	.111	.108	.104	.100	.096	.092
4	.128	.124	.120	.116	.112	.109	.105	.101	.097	.093
125	1.129	1.125	1.121	1.117	1.113	1.110	1.106	1.102	1.098	1.094

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	29.10	29.20	29.30	29.40	29.50	29.60	29.70	29.80	29.90	30.00
40	1.007	1.004	1.001	0.997	0.994	0.991	0.988	0.983	0.980	0.976
1	.008	.005	.002	.998	.995	.992	.989	.984	.981	.977
2	.009	.006	.003	.999	.996	.993	.990	.985	.982	.978
3	.010	.007	.004	1.000	.997	.994	.991	.986	.983	.979
4	.011	.008	.005	.001	.998	.995	.992	.987	.984	.980
45	1.012	1.009	1.006	1.002	0.999	0.996	0.993	0.988	0.985	0.981
6	.013	.010	.007	.003	1.000	.997	.994	.989	.986	.982
7	.014	.011	.008	.004	.001	.998	.995	.990	.987	.983
8	.015	.012	.009	.005	.002	.999	.996	.991	.988	.984
9	.016	.013	.010	.006	.003	1.000	.997	.992	.989	.985
50	1.017	1.014	1.011	1.007	1.004	1.001	0.998	0.993	0.990	0.986
1	.018	.015	.012	.008	.005	.002	.999	.994	.991	.987
2	.019	.016	.013	.009	.006	.003	1.000	.995	.992	.988
3	.020	.017	.014	.010	.007	.004	.001	.996	.993	.989
4	.021	.018	.015	.011	.008	.005	.002	.997	.994	.990
55	1.022	1.019	1.016	1.012	1.009	1.006	1.003	0.998	0.995	0.991
6	.023	.020	.017	.013	.009	.007	.004	.999	.996	.992
7	.024	.021	.018	.014	.010	.008	.005	1.000	.997	.993
8	.025	.022	.019	.015	.011	.009	.006	.001	.998	.994
9	.026	.023	.020	.016	.012	.010	.007	.002	.999	.995
60	1.027	1.024	1.021	1.017	1.013	1.011	1.007	1.003	1.000	0.997
1	.028	.025	.022	.018	.014	.012	.008	.004	1.000	.998

REBUILT ENGINE TEST LOG

STATION _____ DATE _____

ENGINE MAKE AND MODEL _____ SERIAL NO. _____

OBS. BAROMETER _____ " HG _____ DRY BULB TEMP. _____ F *CARB. AIR TEMP. _____ °F

CORR. BAROMETER _____ " HG _____ WET BULB TEMP. _____ °F CORRECTION FACTOR _____

PERIOD	TIME	RPM		DYN. LOAD	BPH		OIL PRESS.	FUEL PRESS.	OIL TEMP.		WATER TEMP.		CYL. HEAD TEMP.			REMARKS
		ENGINE	DYN.		OBS.	CORR.			IN	OUT	IN	OUT	No. ___	No. ___	No. ___	

OIL CONSUMPTION DURING PERIOD(S) _____ WAS _____ LB

*MEASURED DURING MAXIMUM POWER RUN

_____
TEST OFFICER

RA PD 340155

Figure 119 — Rebuilt Engine Test Log

Run-in Test

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	29.10	29.20	29.30	29.40	29.50	29.60	29.70	29.80	29.90	30.00
2	.029	.026	.023	.019	.015	.013	.009	.005	.001	.999
3	.030	.027	.024	.020	.016	.014	.010	.006	.002	1.000
4	.031	.028	.025	.021	.017	.015	.011	.007	.003	.001
65	1.032	1.029	1.026	1.022	1.018	1.016	1.012	1.008	1.004	1.002
6	.033	.030	.027	.023	.019	.017	.013	.009	.005	.003
7	.034	.031	.028	.024	.020	.018	.014	.010	.006	.004
8	.035	.032	.029	.025	.021	.019	.015	.011	.007	.005
9	.036	.033	.030	.026	.022	.020	.016	.012	.008	.006
70	1.037	1.034	1.031	1.027	1.023	1.021	1.016	1.012	1.009	1.006
1	.038	.035	.032	.028	.024	.021	.017	.013	.010	.007
2	.039	.036	.033	.029	.025	.022	.018	.014	.011	.008
3	.040	.037	.034	.030	.026	.023	.019	.015	.012	.009
4	.041	.038	.035	.031	.027	.024	.020	.016	.013	.010
75	1.042	1.039	1.036	1.032	1.028	1.025	1.021	1.017	1.014	1.011
6	.043	.040	.037	.033	.029	.026	.022	.018	.015	.012
7	.044	.041	.038	.034	.030	.027	.023	.019	.016	.013
8	.045	.042	.039	.035	.031	.028	.024	.020	.017	.014
9	.046	.043	.039	.036	.032	.029	.025	.021	.018	.015
80	1.047	1.044	1.040	1.037	1.033	1.030	1.026	1.021	1.019	1.016
1	.048	.045	.041	.038	.034	.031	.027	.022	.020	.017
2	.049	.046	.042	.039	.035	.032	.028	.023	.020	.018
3	.050	.047	.043	.040	.036	.033	.029	.024	.021	.019
4	.051	.048	.044	.041	.037	.034	.030	.025	.022	.020
85	1.052	1.049	1.045	1.042	1.038	1.035	1.031	1.026	1.023	1.020
6	.053	.050	.046	.043	.039	.036	.032	.027	.024	.021
7	.054	.051	.047	.044	.040	.037	.033	.028	.025	.022
8	.055	.052	.048	.045	.041	.038	.034	.029	.025	.023
9	.056	.052	.049	.045	.042	.038	.034	.030	.026	.024
90	1.057	1.053	1.050	1.046	1.043	1.039	1.035	1.030	1.027	1.025
1	.058	.054	.051	.047	.044	.040	.036	.031	.028	.026
2	.059	.055	.052	.048	.045	.041	.037	.032	.029	.027
3	.060	.056	.053	.049	.046	.042	.038	.033	.030	.028
4	.061	.057	.054	.050	.047	.043	.039	.034	.031	.029
95	1.062	1.058	1.055	1.051	1.048	1.044	1.040	1.035	1.032	1.030
6	.063	.059	.055	.052	.048	.045	.041	.036	.033	.031
7	.064	.060	.056	.053	.049	.046	.042	.037	.034	.032
8	.065	.061	.057	.054	.050	.047	.043	.038	.035	.033
9	.065	.062	.058	.055	.051	.048	.044	.039	.036	.034
100	1.066	1.063	1.059	1.056	1.052	1.049	1.045	1.040	1.037	1.034
1	.067	.064	.060	.057	.053	.050	.046	.041	.038	.035
2	.068	.065	.061	.058	.054	.051	.047	.042	.039	.036
3	.069	.066	.062	.058	.055	.051	.048	.043	.040	.037
4	.070	.067	.063	.059	.056	.052	.049	.044	.040	.038

TABLE IV (Cont'd)

Carb. Air Temp. Degrees F.	CORRECTED BAROMETER READING IN INCHES OF MERCURY									
	29.10	29.20	29.30	29.40	29.50	29.60	29.70	29.80	29.90	30.00
105	1.071	1.067	1.064	1.060	1.057	1.053	1.049	1.045	1.041	1.039
6	.072	.068	.065	.061	.058	.054	.050	.046	.042	.040
7	.073	.069	.066	.062	.059	.055	.051	.047	.043	.041
8	.074	.070	.067	.063	.060	.056	.052	.048	.044	.042
9	.075	.071	.068	.064	.060	.057	.053	.049	.045	.043
110	1.076	1.072	1.069	1.065	1.061	1.058	1.054	1.049	1.046	1.043
1	.077	.073	.069	.066	.062	.059	.055	.050	.047	.044
2	.078	.074	.070	.067	.063	.060	.056	.051	.048	.045
3	.079	.075	.071	.068	.064	.061	.057	.052	.049	.046
4	.080	.076	.072	.069	.065	.061	.058	.053	.050	.047
115	1.081	1.077	1.073	1.070	1.066	1.062	1.058	1.054	1.050	1.048
6	.082	.078	.074	.071	.067	.063	.059	.055	.051	.049
7	.083	.079	.075	.071	.068	.064	.060	.056	.052	.050
8	.084	.080	.076	.072	.069	.065	.061	.057	.053	.051
9	.085	.080	.077	.073	.070	.066	.062	.058	.054	.052
120	1.086	1.081	1.078	1.074	1.071	1.067	1.063	1.058	1.055	1.052
1	.087	.082	.079	.075	.071	.068	.064	.059	.056	.053
2	.088	.083	.080	.076	.072	.069	.065	.060	.057	.054
3	.089	.084	.080	.077	.073	.070	.066	.061	.058	.055
4	.090	.085	.081	.078	.074	.071	.067	.062	.059	.056
125	1.091	1.086	1.082	1.079	1.075	1.072	1.068	1.063	1.060	1.057

Section VIII

SERVICEABILITY STANDARDS

39. INTRODUCTION.

a. The table of fits, limits, tolerances and maximum wear limits in paragraph 40 gives the original minimum, maximum and desired size of the new parts when manufactured, as well as wear limits which indicate that point to which a part may be worn before replacement in order to obtain maximum service with minimum replacement. Accordingly, all parts will be approved for service which have not been worn beyond the dimensions indicated in column (5), "Additional Allowable Wear or Clearances." The figures in column (5) are the additional limits above or below the manufacturer's new minimum or maximum size (columns (2) and (3), par. 40). For example, paragraph 40 e (1), camshaft journals, the manufacturer's minimum is 1.4730 inches; the additional allowable wear is 0.003 inch, making the minimum usable size 1.470 inches. In paragraph 40 f (1), camshaft bearing, the manufacturer's maximum is 1.477 inches and the additional allowable wear is 0.002 inch, making the maximum allowable size 1.479 inches. NOTE: *In base shops, after an engine and accessories have been completely disassembled, the dimensions in column (6) "Additional Allowable Wear or Clearances at Overhaul" will be used instead of those in column (5).*

40. FITS, TOLERANCES, AND WEAR LIMITS.

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
a. Cylinders.					
(1) Bore	5.401	5.4015	5.402	0.012	0.006
(2) Taper	—	—	—	0.012	0.012
(3) Press fit of sleeve in block	0.003	0.004	0.005	—	—
(4) Relation of liner face to block face	0.013	0.014	0.015	—	—
NOTE: *0.020-inch oversize pistons are available. Test blocks with hot water (110° F), backed with 75 pounds air pressure.*					
b. Main Bearing Bores, Caps, and Bearings.					
(1) Bore	3.772	—	3.773	—	—
(2) Inside diameter of main bearings when installed to proper torque tightness	3.377	—	3.3805	—	—
(3) Clearance of main bearing to crankshaft	0.004	4.0045	0.005	0.0035	0.0015
(4) End play of crankshaft in bearings when installed	0.010	—	0.013	0.005	0.005
(5) Thickness of lead coating in bearing liner	0.001	—	0.0015	—	—
NOTE: *Torque tightness of bolts—50 ft-lb minimum on laced bearings; 80 to 100 ft-lb on vertical studs.*					

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
c. Crankshaft.					
(1) Main bearing journals.					
(a) Diameter	3.3755	—	3.3760	0.002	0.001
(b) Allowable out-of-round	—	—	0.001	—	0.001
(c) Allowable run-out of nearest to center main journal when supported at each end	—	—	0.001	—	—
(d) Fillet radius	0.185	—	0.190	—	—
NOTE: *0.020-inch undersize is authorized.*					
(2) Connecting rod journals.					
(a) Diameter	3.2505	—	3.2510	0.002	0.0015
(b) Allowable out-of-round	—	—	0.001	0.002	0.001
(c) Fillet radius	0.140	—	0.150	—	—
NOTE: *0.020-inch undersize is authorized.*					
(3) Run-out of flywheel face when mounted on crankshaft	—	—	0.005	0.006	—
NOTE: *Balance crankshaft and pulley to 0.3 inch-ounce; statically, 0.2 inch-ounce.*					
d. Timing Gears.					
(1) Total backlash of camshaft gear	0.006	—	0.008	—	—

e. Camshaft.					
(1) Diameter of journals.					
(a) No. 1 journal	1.4730	—	1.4735	0.003	0.001
(b) No. 2 journal	1.4730	—	1.4735	0.003	0.001
(c) No. 3 journal	1.4730	—	1.4735	0.003	0.001
(d) No. 4 journal	1.4730	—	1.4735	0.003	0.001
(2) Allowable run-out of journal nearest center when end journals are supported	—	—	0.005	0.004	0.004
(3) Permissable wear of lobes from heel to toe	—	—	—	0.010	0.010
NOTE: *Straighten camshaft if run-out is more than 0.007 inch (except cast steel camshaft).*					
f. Camshaft Bearings.					
(1) Diameter.					
(a) No. 1 bearing	1.476	—	1.477	0.002	0.001
(b) No. 2 bearing	1.476	—	1.477	0.002	0.001
(c) No. 3 bearing	1.476	—	1.477	0.002	0.001
(d) No. 4 bearing	1.476	—	1.477	0.002	0.001
(2) Clearance between camshaft journal and bushing	0.0025	—	0.004	0.003	0.001
(3) Replacement bushing nominal diameter	1.456	—	1.457	—	—
(4) Line-ream replacement bushings to	1.476	—	1.477	—	—

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
g. Valve Seats (Inserts).					
(1) Exhaust valve seats.					
(a) OD of replacement valve seat inserts	2.296	—	2.299	—	—
(b) Width of valve seat	0.09375	—	0.125	—	—
(c) Angle of seat	—	45 deg	—	—	—
(d) Angle of relief (for narrowing width of seat)	—	30 deg	—	—	—
(2) Intake valve seats.					
(a) OD of replacement valve seat inserts	2.498	—	2.499	—	—
(b) Width of valve seat	0.09375	—	0.125	—	—
(c) Angle of seat	—	45 deg	—	—	—
(d) Angle of relief	—	30 deg	—	—	—
h. Valve Guides.					
(1) Exhaust.					
(a) Bore	0.437	—	0.438	0.002	0.001
(b) Interference, OD of valve guide bushing to ID of bore	0.001	—	0.0015	—	—

(2) Intake.					
(a) Bore	0.437	—	0.438	0.002	0.001
(b) Interference, OD of valve guide bushing to ID of bore	0.001	—	0.0015	—	—

NOTE: *0.020-inch oversize valve guides are available.*

i. Valves.					
(1) INTAKE.					
(a) Angle of seat	45.5 deg	46 deg	—	—	—
(b) Stem diameter	0.4345	—	0.4350	0.003	0.001
(c) Stem to guide clearance	0.002	—	0.0035	0.003	0.001

NOTE: *If after refacing valve, thickness from top of head to edge of refaced outer circle is less than 0.060 inch, replace valve. Never reface below stellite facing.*

(2) EXHAUST.					
(a) Angle of seat	45.5 deg	46 deg	—	—	—
(b) Stem diameter	0.4340	—	0.4345	0.0035	0.001
(c) Stem to guide clearance	0.0025	—	0.004	0.004	0.004

NOTE: *If after refacing valve, thickness from top of head to edge of refaced outer circle is less than 0.065 inch, replace valve. Never reface below stellite facing.*

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
j. Valve Springs.					
(1) EXHAUST.					
(a) Large spring	—	—	—	—	—
1. Scale reading at 2.08 inches	—	25 to 27 lb	—	—	—
2. Scale reading at 1.58 inches	—	100 to 105 lb	—	—	—
(b) Small spring					
1. Scale reading at 2.00 inches	—	11 to 13 lb	—	—	—
2. Scale reading at 1.50 inches	—	70 to 75 lb	—	—	—
(2) INTAKE.					
(a) Large spring					
1. Scale reading at 2.08 inches	—	25 to 27 lb	—	—	—
2. Scale reading at 1.58 inches	—	100 to 105 lb	—	—	—
(b) Small spring					
1. Scale reading at 2.00 inches	—	11 to 13 lb	—	—	—
2. Scale reading at 1.50 inches	—	70 to 75 lb	—	—	—

NOTE: *Reject any spring that does not come within 10 percent of scale reading for a given height.*

k. Connecting Rod.						
(1) Torque tightness of connecting rod bolts	64 ft-lb	65 ft-lb	66 ft-lb	—	—	
(2) Stretch on connecting rod bolts	0.006	0.009	0.012	—	—	
(3) ID of large (crankshaft) end	3.751	—	3.7515	0.0015	0.0015	
(4) ID of liner when installed in large (crankshaft) end	3.2533	—	3.2561	—	—	
(5) Clearance of connecting rod bearing to crankshaft, including clearance between rod and liner	0.0048	—	0.0066	0.005	0.001	
(6) Side clearance of connecting rod bearing to crankshaft	0.003	—	0.006	0.012	0.004	
(7) Maximum out-of-round (horizontal)	—	—	—	0.001	0.001	
(8) Diameter of small (piston) end (with proper bolt torque)	1.5195	—	1.5200	—	—	
(9) ID of bushing (small end) (with proper bolt torque)	1.375	—	1.3753	—	—	
(10) Interference, OD of bushing to ID of rod	0.005	—	0.007	—	—	
(11) Fit of piston pin to connecting rod bushing	0.001	—	0.0016	0.0025	0.0025	
(12) Allowable twist of connecting rod (measured in 3 inches)	—	—	0.004	0.003	0.003	
(13) Total weight of rod	2173 grams	—	2356 grams	—	—	

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
(14) Thickness of connecting rod bearing (standard)	0.2467	—	0.2471	—	—
(15) Thickness of connecting rod bearing (0.020 inch oversize)	0.2467	—	0.2471	—	—
NOTE: *Balance rods within 4 grams when in sets of eight.*					
l. Pistons.					
(1) Nominal diameter of available pistons					
(a) Standard	5.384	—	5.386	—	—
(b) 0.020 inch oversize	5.404	—	5.406	—	—
(2) Allowable wear from nominal diameter of skirt	—	—	—	0.005	0.005
(3) Degree of cam used for regrinding	—	0.00548	—	—	—
(4) Width of ring groove					
(a) Groove No. 1 (top)	0.095	—	0.096	0.003	0.003
(b) Groove No. 2	0.095	—	0.096	0.003	0.003
(c) Groove No. 3	0.095	—	0.096	0.003	0.003
(d) Groove No. 4	0.1875	—	0.1875	0.003	0.003

(e) Groove No. 5	0.1875	—	0.1875	0.003	0.003
(5) Piston pin diameter	1.3737	—	1.3740	0.001	0.0007
(6) Piston pin bore diameter in piston	1.3739	—	1.3747	—	—
(7) Fit between piston pin and piston	0.0001T	—	0.0015L	0.001	0.001

NOTE: *Pistons are selective fit in bore—4 to 8 pounds pull with ½ in. wide feeler gage. Use three feeler blades 0.004 in. thick, or two blades 0.006 in. thick.*

m. Rings.					
(1) Gap clearance (when fitted in cylinder)	0.002	0.025	0.0027	—	—
(2) Clearance of ring in piston groove					
(a) Groove No. 1	0.002	—	0.004	—	—
(b) Groove No. 2	0.002	—	0.004	—	—
(c) Groove No. 3	0.002	—	0.004	—	—
(d) Groove No. 4	0.0015	—	0.0035	—	—
(e) Groove No. 5	0.0015	—	0.0035	—	—
n. Valve Lifter or Push Rod.					
(1) OD of valve push rod at top and bottom	1.9170	—	1.9172	0.001	0.001
(2) Clearance between push rod and guide	0.0028	—	0.0040	0.002	0.002

NOTE: *Face must be square with OD within 0.002 inch.*

o. Cylinder Head Face.					
(1) Maximum allowable warpage per foot of length	—	—	—	—	0.005

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
p. Block Face.					
(1) Maximum allowable warpage per foot of length	—	—	—	—	0.005
q. Oil Pump, Gear Type (GAA-6600).					
(1) Allowable wear on end plates before regrinding or replacement	0.190	—	0.210	0.004	0.004
(2) End play between gear and end cover with 0.0095 inch gasket and cover bolted tight	0.003	—	0.006	0.004	0.004
(3) Minimum thickness of plate after regrinding	0.175	—	—	—	—
(4) Bushing inside diameter:					
(a) Lower	0.552	—	0.553	0.002	0.002
(b) Upper	0.5625	—	0.5630	0.002	0.002
(5) Drive shaft diameter	0.5610	—	0.5615	0.002	0.002
(6) Fixed shaft diameter	0.4345	—	0.4350	0.002	0.002
(7) Clearance between gear and housing	0.002	—	0.0045	0.004	0.004
(8) Backlash	0.008	—	0.010	0.006	0.006
(9) Clearance between bushings and shaft	0.001	—	0.002	0.004	0.004

r. Oil Pump, Gear Type (GAN-6600).

(1) Depth of bore (lower pump)	1.249	—	1.2505	—	—
(2) Dept of bore (upper pump)	1.249	—	1.2505	—	—
(3) End play between gear and housing with 0.0095 gasket and pump bolted tight:					
(a) Upper	0.003	—	0.0055	0.006	0.006
(b) Lower	0.003	—	0.0055	0.006	0.006
(4) Thickness of pump body between end surfaces	0.297	—	0.299	0.006	0.006
(5) Bushing inside diameter:					
(a) Upper ID (installed)	0.5605	—	0.5610	0.002	0.002
(b) Lower ID (installed)	0.5620	—	0.5625	0.002	0.002
(6) Drive shaft diameter (upper)	0.5585	—	0.5595	0.002	0.002
(7) Driven shaft diameter (lower)	0.5600	—	0.5605	0.002	0.002
(8) Diametrical clearance between gear and housing	0.007	—	0.011	0.004	0.004
(9) Fixed shaft diameter	0.5620	—	0.5625	0.002	0.002
(10) Clearance between bushings and shafts:					
(a) Upper	0.001	—	0.0025	0.004	0.004
(b) Lower	0.0015	—	0.0025	0.004	0.004

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear or Clearances (inches)	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
s. Relief Valves.					
(1) Scale reading at 1.48 inches (when practicable)	—	38 to 40 lb	—	—	—
(2) Free length of spring	—	2.2	—	—	—
(3) Angle of beveled-type set (when used)	—	45 deg	—	—	—
(4) Clearance of valve in body	0.010	—	0.020	—	—
t. Flywheel and Ring Gear (GAA Only).					
(1) Permissible amount that can be removed from clutch face of flywheel	—	—	—	0.099	0.099
(2) Interference of ID of ring gear to OD of flywheel	0.016	—	0.026	—	—
(3) Wobble of flywheel machined surface for clutch plate contact mounted in crankcase	—	—	—	0.006	0.006
(4) Housing face run-out (at engine assembly) Indicator mounted on flywheel (GAF engine only)	—	—	0.002	—	—
NOTE: *Balance flywheel within 0.5 inch-ounce.*					

u. Clutch (Long Model 217).

(1) Thickness of lined clutch plates	0.445	0.457	0.469	0.200	0.100
(2) Thickness of pressure plate measured from face of machined surface to top of fulcrum pin	1.895	—	1.900	0.062	0.062
(3) Permissible amount that may be removed from pressure plate	—	—	—	0.062	0.062
(4) Maximum thickness of each shim to compensate for refacing (locate shims beneath springs)	—	—	—	0.062	0.062
(5) Spring scale reading at 1.950 inch	—	144 to 150 lb	—	—	—
(6) Balance of clutch components					
(a) Intermediate plate	—	½ in.-oz	—	—	—
(b) Spring housing and pressure plate	—	1 in.-oz	—	—	—
(7) Free travel of throw-out levers for full release	0.750	0.900	—	—	—
(8) Permissible amount that can be worn from fingers	—	—	—	0.062	0.062
(9) Initial setting of fingers measured from pressure plate housing to top of thrust button on fingers	—	1.375	—	—	—
(10) Thickness of intermediate plate	1.092	1.094	1.096	0.031	0.031

(1) Point of Measurement	(2) Manufacturers' Fits, Limits, Tolerances and/or Dimensions Min (inches)	(3) Desired (inches)	(4) Max (inches)	(5) Additional Allowable Wear (inches) or Clearances	(6) Additional Allowable Wear or Clearances at Overhaul (inches)
v. Water Pumps.					
(1) Diameter of shaft bearing surface at flange	0.5898	—	0.5903	—	—
(2) Clearance between impeller and body	0.010	—	0.017	—	—
(3) Packing spring:					
(a) Free length	—	0.480	—	—	—
(b) Scale reading at 0.350 inch	—	9.5 to 10.5 lb	—	—	—
(4) Diameter of shaft bearing surface at spline end	0.5893	—	0.5898	—	—
(5) Diameter of shaft at packing surface	0.6262	—	0.6267	—	—
w. Accessory Gear Assembly.					
(1) Backlash of gears	0.006	—	0.008	0.006	0.006
x. Camshaft Drive.					
(1) Diameter of bushing for cam worm drive in bracket (upper)	1.253	—	1.254	—	—
(2) Diameter of worm journal	1.2495	—	1.250	—	—
(3) Clearance of worm in bushing	0.003	—	0.0045	—	—

y. Magneto (American Bosch).

(1)	Point gap	0.014	0.016	0.018	—	—
(2)	E-gap	2 mm	2.5 mm	3 mm	—	—
(3)	Rotating magnet end play	0.001	0.000	0.001	—	—
(4)	Distributor gear backlash	0.001	0.001	0.002	—	—
(5)	Distributor gear shaft diameter	0.6235	0.6245	0.6245	—	—
(6)	Distributor gear shaft bushing diameter	0.625	0.625	0.627	—	—
(7)	Breaker spring tension	17 oz	19 oz	20 oz	—	—

CHAPTER 3 — MAGNETOS

41. DESCRIPTION AND DATA.

a. Description. Two 4-cylinder magnetos (fig. 122) are used on each engine, one firing the cylinders in the right bank and the other firing the cylinders in the left bank. The magnetos are left-hand and right-hand and can be identified by the model number on number plate at the top of the magnetos. All model numbers which have odd numbers are left-hand and model numbers which have even numbers are right-hand. These magnetos use the induction principle of current generation; the coil windings being stationary and the magnets rotating between laminated pole shoes. The numbering of the cylinders and firing order are illustrated in figure 114. The wires leading from both the the right- and left-hand magnetos are identified by the colors marked on the wires as follows: No. 1, red; No. 2, blue; No. 3, green; and No. 4, yellow.

b. Data.

Direction of rotation:

Right-hand magneto	Clockwise
Left-hand magneto	Counterclockwise
Breaker point gap	0.014 to 0.016 in.
Make	American Bosch

Models:

Left-hand	Right-hand
MJF4A-307	MJF4A-308
MJF4A-309	MJF4B-310
MJF4B-311	MJF4B-312
MJF4B-313	MJF4B-314
MJF4B-315	MJF4B-316

42. PRELIMINARY INSTRUCTIONS.

a. Various models have been used and are listed in the paragraph above. When repairing magnetos, it is important that some of the earlier models be brought up to date. Magnetos which have been previously repaired and have had the necessary changes made to bring them up to date can be identified by the letter "X" stamped after the serial number on the name plate.

43. REMOVAL.

a. To remove the magnetos from the engine, refer to paragraph 7 e. If the engine is in the vehicle, refer to pertinent operator's manual.

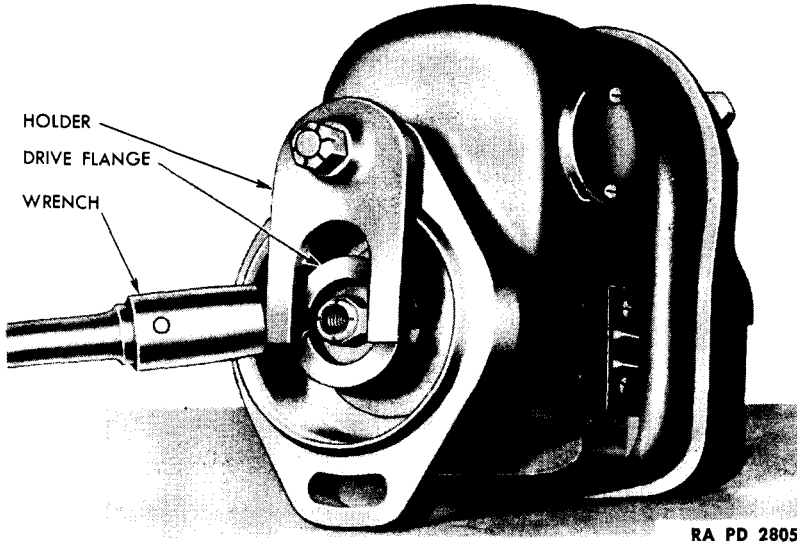


Figure 120 – Magneto Drive Flange Holding Tool (41-H-3350)

44. CLEANING AND INSPECTION (EXTERNAL).

a. Cleaning. Clean each magneto externally, using dry-cleaning solvent.

b. Inspection. Magnetos should be completely rebuilt at each engine overhaul period, or after every 600 hours (approximate) of service. Magnetos known to have less than 600 hours of service are to be inspected externally for damage of any kind. If found in good condition, the breaker points should then be inspected for the condition of the points and spacing. Adjust or replace the points if necessary (par. 48 a). Place the magneto on a test stand, and test its performance as outlined in paragraph 50. If the performance is found satisfactory from this test, the magneto may be considered satisfactory for further use. If the test does not show satisfactory performance, the magneto must be completely disassembled and rebuilt.

45. DISASSEMBLY.

a. Remove Magneto Drive Flange. Attach the holder (41-H-3350) to the magneto drive flange, and remove the nut securing the flange to the rotor shaft (fig. 120). Remove the holding tool. Attach the drive flange puller to the flange and pull the flange from the shaft (fig. 121). After the drive flange has been removed, place the magneto on the holding fixture (41-F-2993-600).

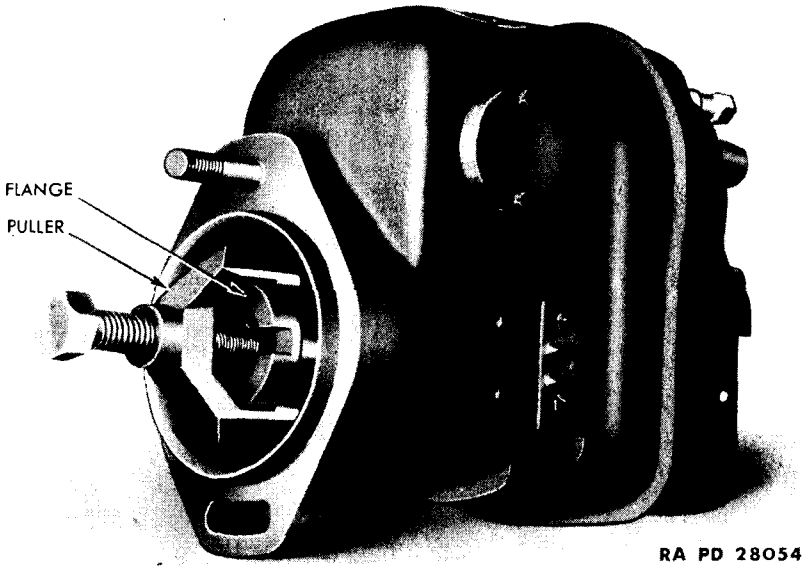


Figure 121 — Pulling Magneto Drive Flange, Using Puller (41-P-2941-750)

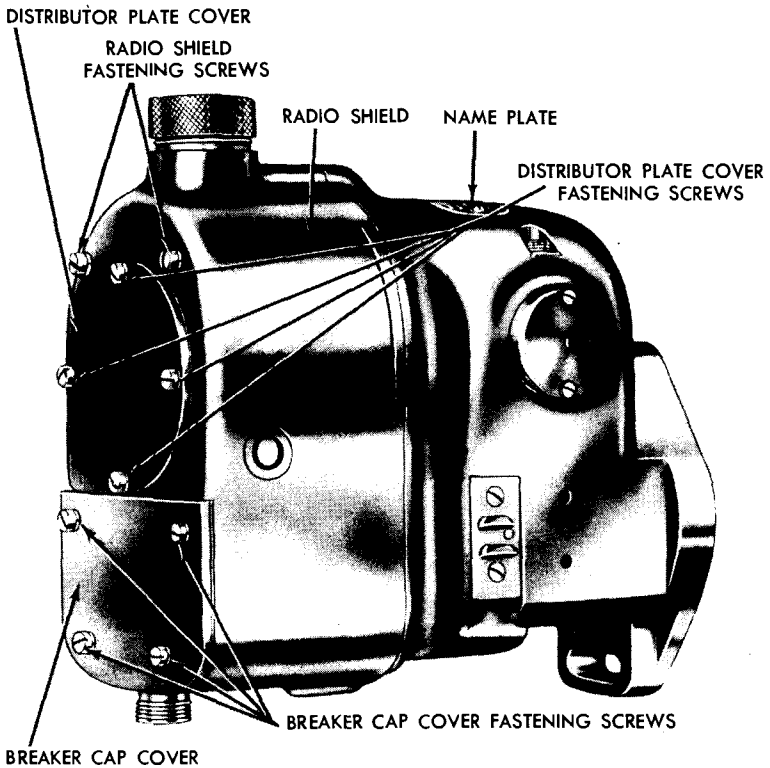
b. Remove Inspection Plates (fig. 122). Remove the four screws from the distributor plate cover and remove the cover and copper gasket. Remove the four screws from the breaker cap cover and remove the cover and copper gasket.

c. Remove Radio Shield (fig. 122). Remove the two screws at the upper end of the radio shield and remove the shield.

d. Remove Distributor Plate Assembly (fig. 123). Remove the two long and the two short studs at the lower and upper ends of the distributor plate assembly. Remove the two screws at the center of the plate and remove the plate assembly and gasket from the magneto housing.

e. Remove Breaker Cam (fig. 124). Remove the screw securing the breaker cam to the magnet rotor shaft and remove the cam from the shaft. It may be necessary to pry the cam off the rotor shaft.

f. Remove Breaker Assembly (fig. 124). Remove the stop plate stud, spring, and the three washers from the distributor gear bracket. Remove the stop plate fastening screw. Remove the screw securing the breaker plate to the distributor gear bracket at the right-hand side. Pivot the breaker plate assembly counterclockwise, and remove



RA PD 329692

Figure 122 — Magneto — Rear Left View

the other breaker plate fastening screw. Lift the breaker plate assembly off the distributor gear bracket. NOTE: *Do not unsolder the coil cable connection at the breaker plate assembly at this time.*

g. Remove Condenser (fig. 125). Remove the screw securing the coil cable to the terminal block. Remove the screw securing the condenser to the distributor gear bracket and lift out the condenser.

h. Remove Distributor Gear and Rotor Assembly (fig. 125). Lift out the distributor gear and rotor assembly, and at the same time slide the timing collar off the magnet rotor shaft. Be sure to keep them both even when removing so they will not bind.

i. Remove Drive Gear (fig. 126). Remove the drive gear using puller (41-P-2918). Remove the Woodruff key from the magnet rotor shaft.

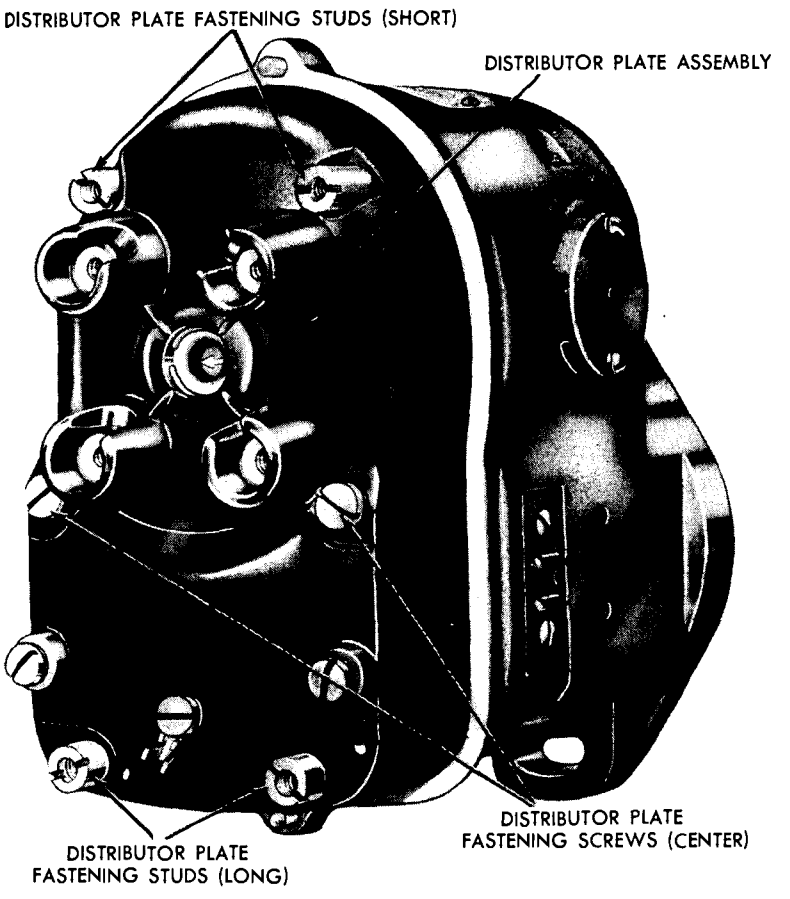
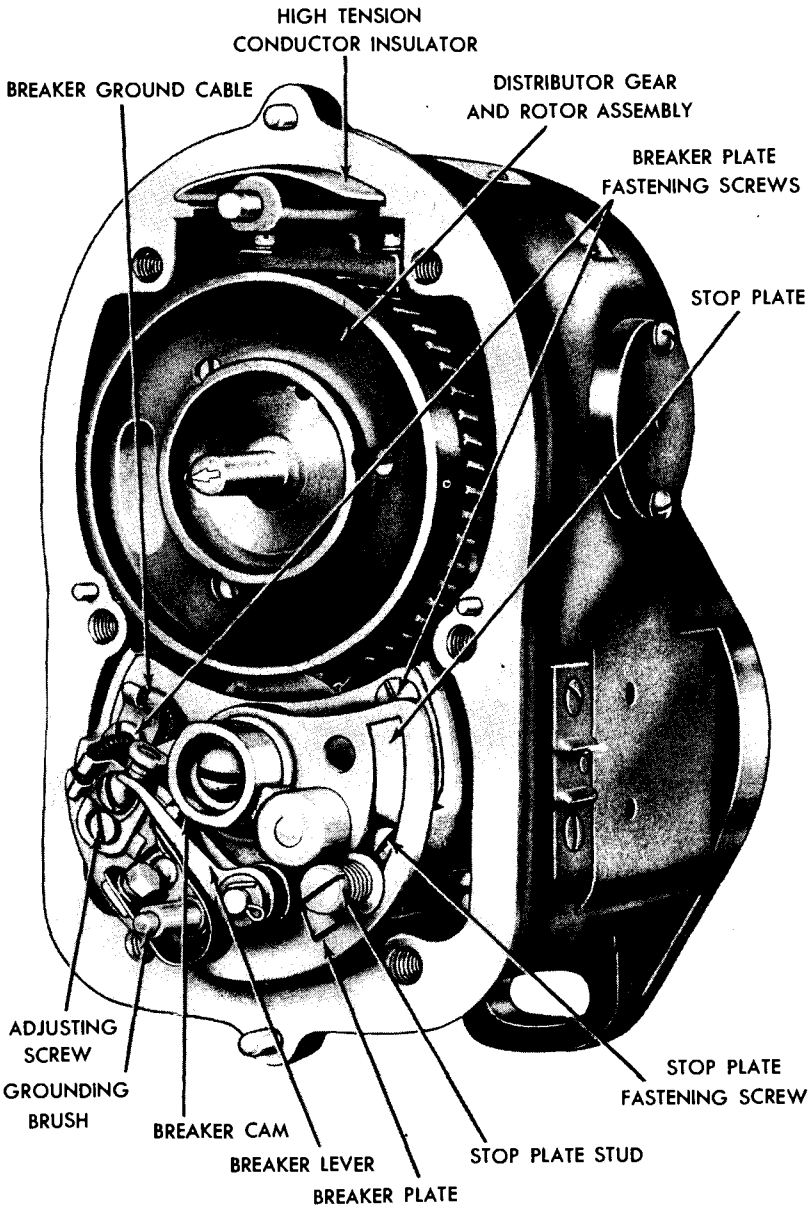


Figure 123 — View of Magneto With Radio Shield Removed

j. Remove Distributor Gear Bracket Assembly (fig. 127). Remove the screw securing the terminal block to the distributor gear bracket and remove the block. Remove the four screws securing the bracket to the magneto housing and remove the bracket. Remove the two screws securing the high tension conductor to the gear bracket and remove the conductor.

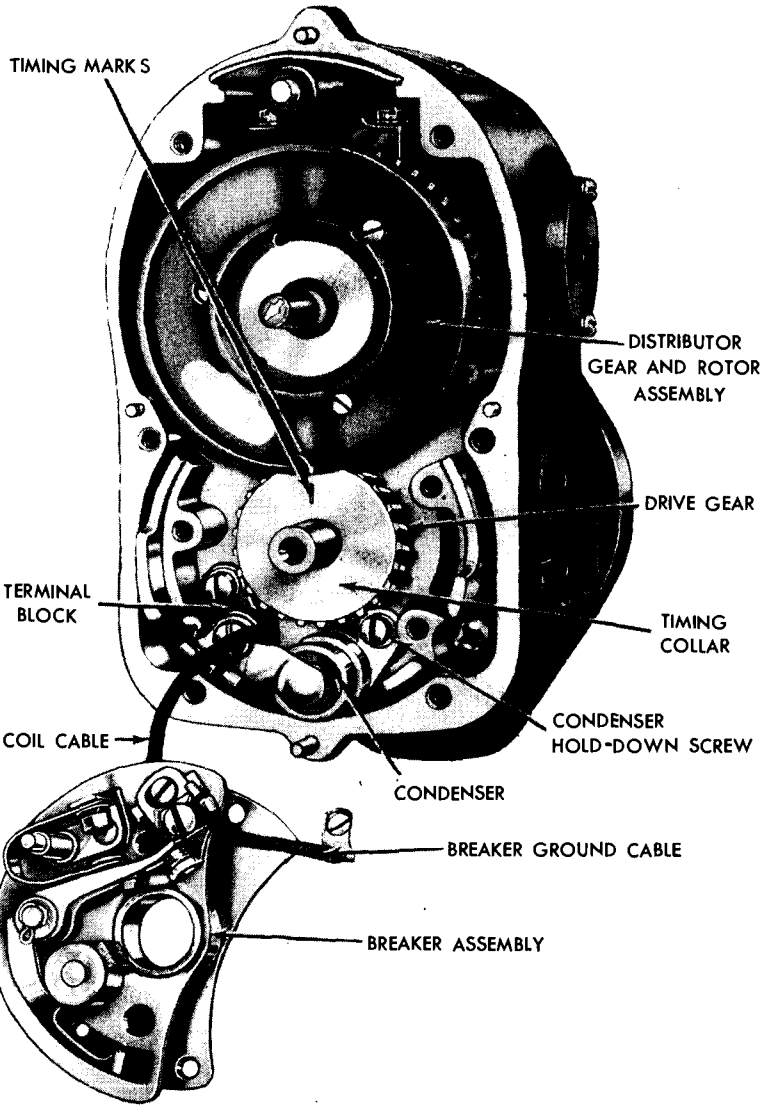
k. Remove Magnet Rotor (fig. 128). Remove Woodruff key from the drive end of the magnet rotor shaft. Remove the magnet rotor assembly from the housing by pushing on the drive end of the rotor.

l. Remove Coil Assembly (fig. 128). Loosen the two set screws at the top of the magneto housing which secure the coil in the



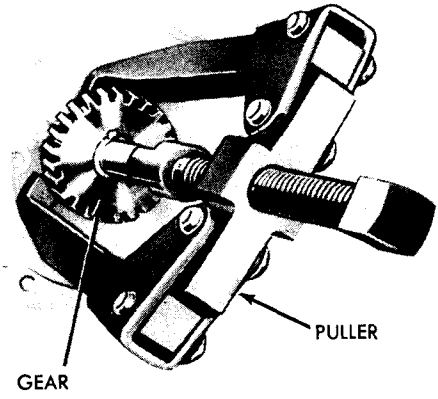
RA PD 329680

Figure 124 — View of Magneto Without Radio Shield and Distribution Plate



RA PD 329681

Figure 125 — View of Magneto Without Radio Shield, Distributor Plate, and Breaker Assembly



RA PD 349795

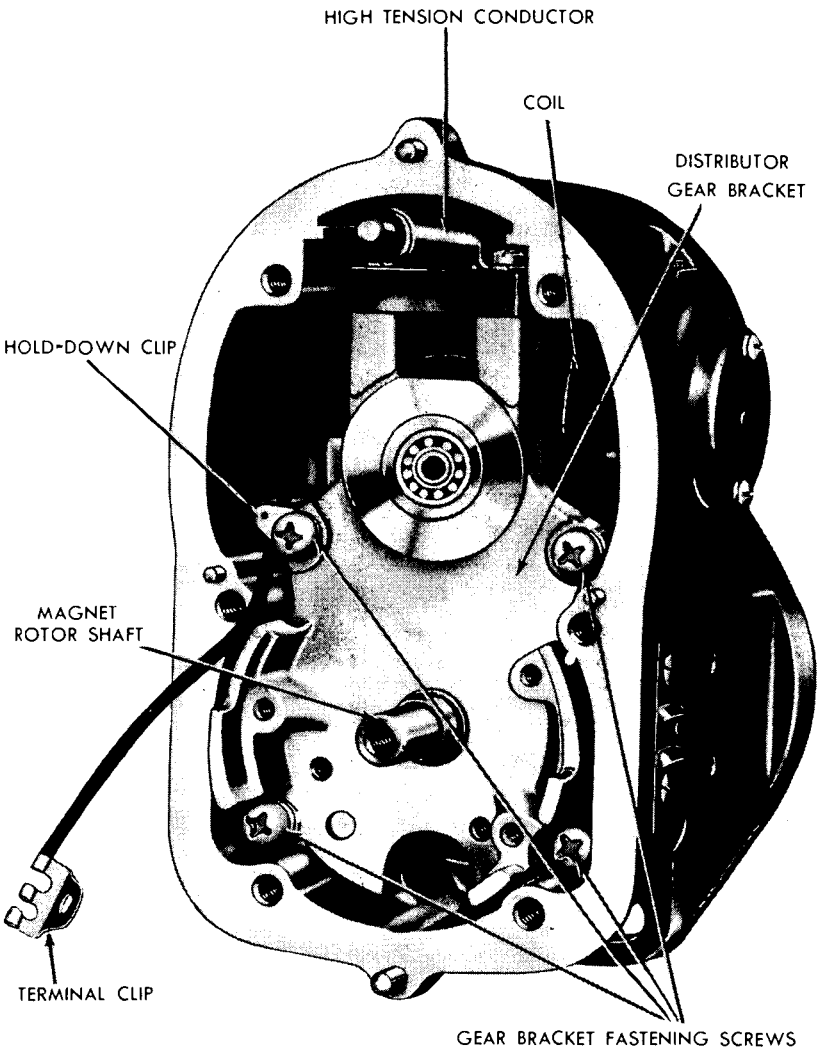
Figure 126 – Removing Distributor Drive Gear, Using Puller (41-P-2918)

magneto housing and remove the coil from the housing. NOTE: *The coil will still be fastened to the breaker assembly by the coil cable and should not be unsoldered at this time.*

m. Remove Ventilator Cover (fig. 129). Remove the two screws securing the two circular ventilator covers to the housing, and remove the gasket, wire screen, silk screen, and wire screen. Remove the two screws securing the two rectangular ventilator covers to the housing and remove the cover and felt filter.

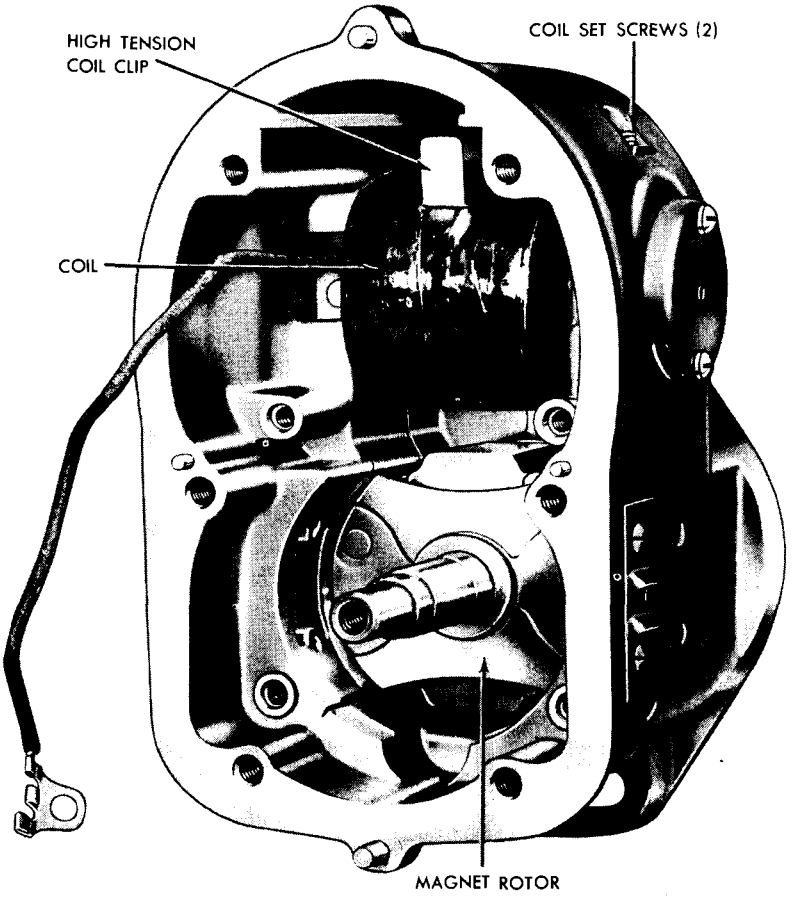
46. CLEANING.

a. Wash all metal parts in dry-cleaning solvent and make sure the parts are free from chips or other foreign materials. All insulated parts such as distributor plate, distributor gear and rotor assembly, high tension conductor, coil, and terminal block must be cleaned with a cloth dampened with dry-cleaning solvent. If the distributor plate or distributor gear and rotor assembly have a carbonized track, they



RA PD 329682

Figure 127 — View of Magneto Without Radio Shield, Distributor Plate, Breaker, and Distributor Gear



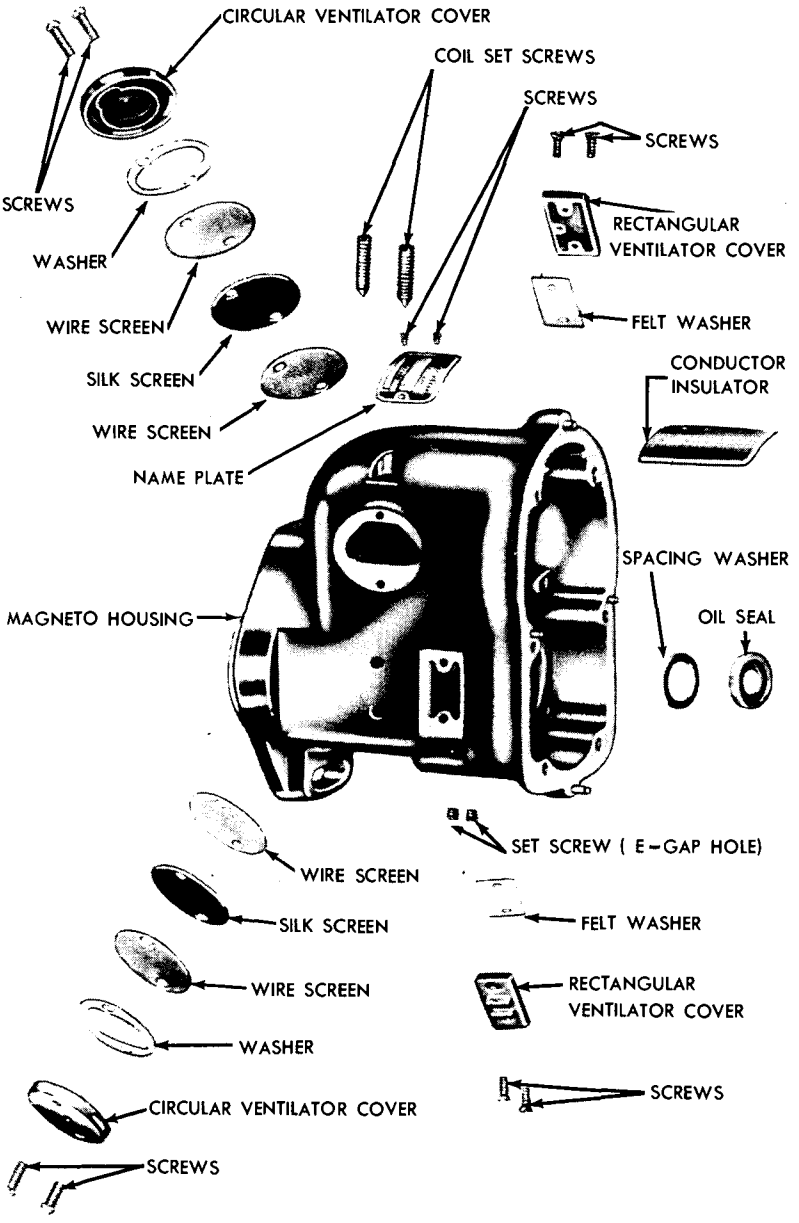
RA PD 329683

Figure 128 — View of Magneto Without Radio Shield, Distributor Plate, Breaker Assembly, Distributor Gear, and Distributor Gear Bracket

must be discarded. Discard all old oil seals and felt washers regardless of their condition.

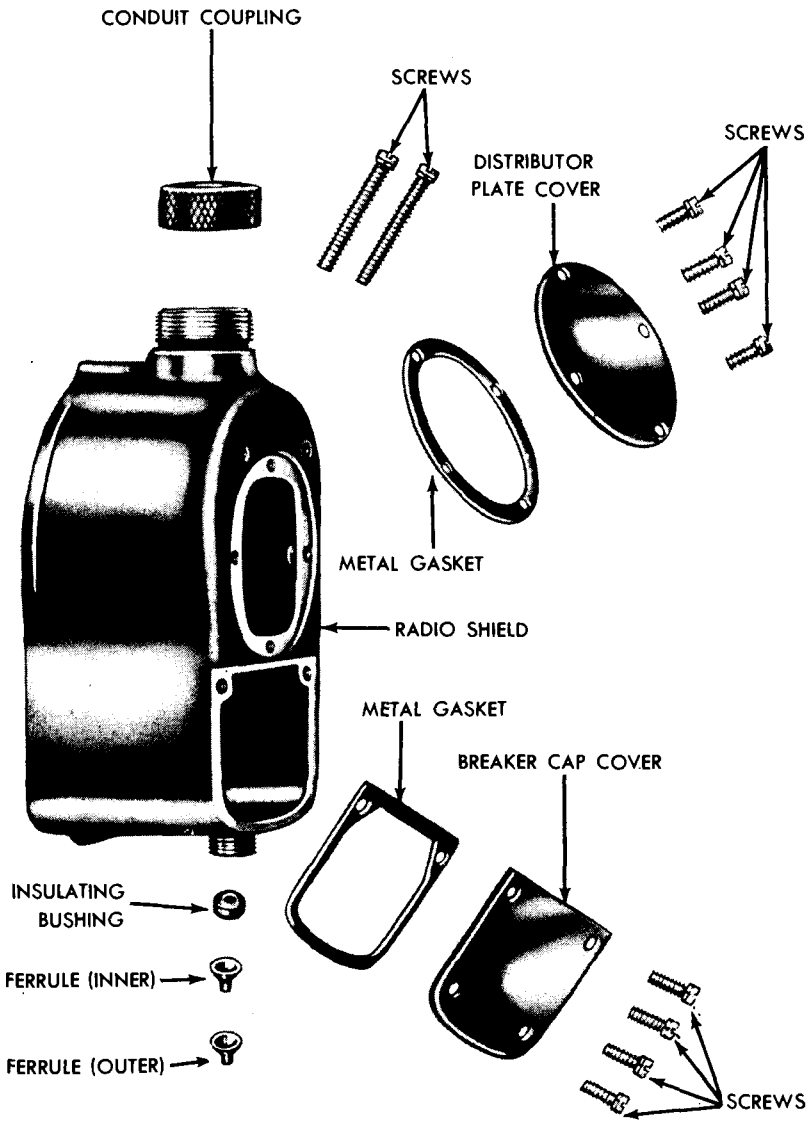
47. INSPECTION.

a. Inspect Radio Shield (fig. 130). Discard the radio shield if it is cracked, has damaged threads, or if it is bent or sprung out of shape. If a replacement of the radio shield is required on the MJF4A-307 or 308 models, it must be replaced with the latest type



RA PD 329684

Figure 129 — Magneto Housing, Disassembled



RA PD 329685

Figure 130 — Radio Shield, Disassembled

shield as the early type shields are no longer supplied for service. Discard any gaskets or covers that are damaged.

b. Inspect Distributor Plate (fig. 131). Examine the distributor plate for cracks or damaged threads. Check the condition of the brushes. If the diameter of the brushes are worn to the extent that a shoulder is visible, or have broken brush springs, or if the brushes are worn and measure less than $^{11}/_{32}$ inch in length, they must be discarded. Check the distributor plate for current leakage and discard if leaks are found.

c. Inspect Breaker Assembly (fig. 132). Inspect the breaker plate assembly and discard the assembly if any of the component parts are damaged. Check the contact points for pitting or wear. If point removal is necessary, always replace both the breaker lever and the contact bracket (subpar. a above). Points which are slightly pitted or worn can be dressed on a suitable oil-free stone, being sure that a flat square surface is obtained.

d. Inspect Condenser (fig. 133). Use an approved tester device and check the condenser for short circuit, leakage, open circuit, or damage. Discard the condenser if any of these conditions are found.

e. Inspect Distributor Gear and Rotor Assembly and Drive Gear (fig. 133). NOTE: *Magneto Model Nos. MJF4A-307 and 308, and also Model Nos. MJF4B-309, 310, 311, and 312 which do not have the letter "X" stamped after the serial number on the name plate must have the distributor gear and rotor assembly replaced with the latest type distributor gear and rotor assembly. See preliminary instructions (par. 42) regarding the various conversion kits.* If the magneto is already equipped with the latest type gear and rotor assembly, check the distributor gear and rotor assembly for cracks causing current leakage. Check both the distributor gear and the drive gear for burs, missing teeth, excessive wear, or other defects. Discard the distributor gear and rotor assembly or the drive gear if found in any of these conditions.

f. Inspect Distributor Gear Bracket Assembly (fig. 133). Magneto Model Nos. MJF4A-307 and MJF4A-308, and also Model Nos. MJF4B-309, 310, 311, and 312 which do not have the letter "X" stamped after the serial number on the name plate must have the distributor gear bracket replaced with the latest type bracket. See preliminary instructions (par. 42) regarding the various magneto conversion kits. If the magneto is already equipped with the latest type bracket, inspect all tapped holes and examine for cracks or damage of any kind. Check the ball bearing outer race ring at the lower end of the bracket for scores or excessive wear and replace if necessary (par. 48 **b** (1)). Check the ball bearing at the upper end of the bracket for excessively loose races or binding when turned by hand and replace if necessary (par. 48 **b** (2)). The upper ball

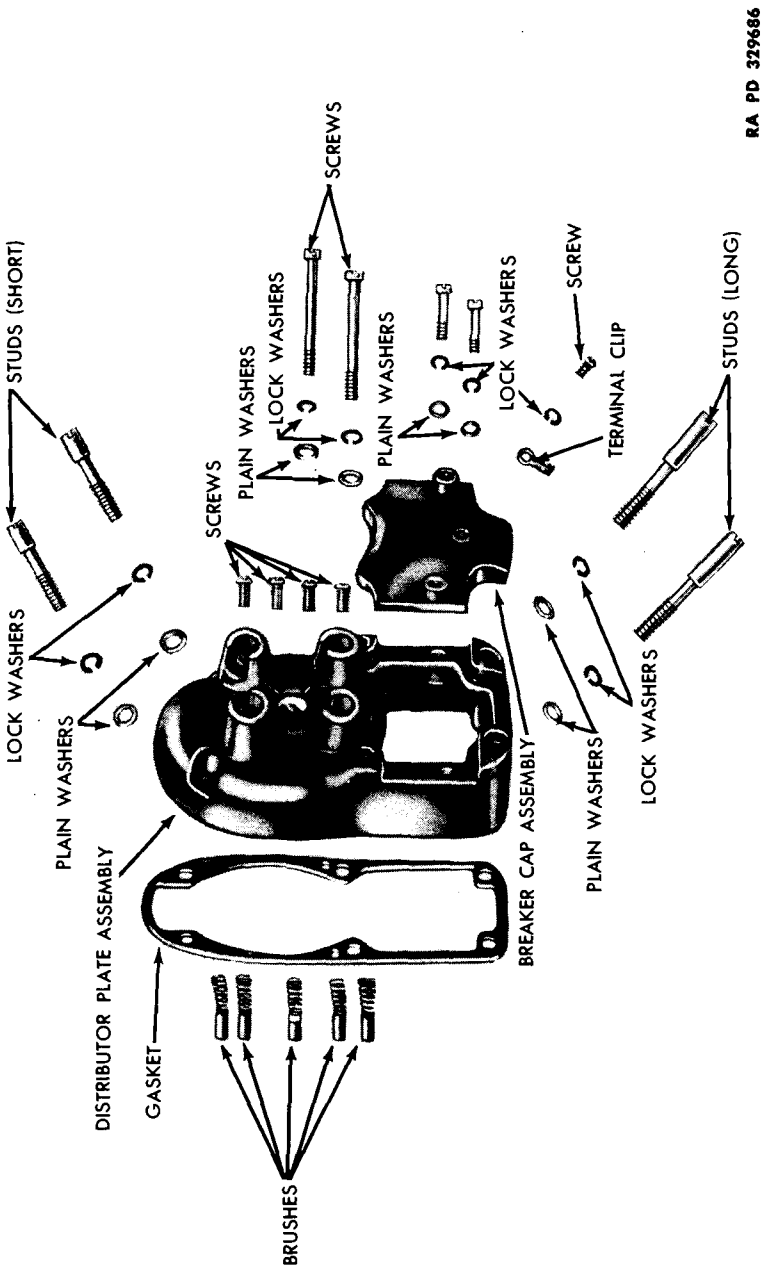


Figure 131 — Distributor Plate, Disassembled

bearing and the lower bearing outer race are insulated from the bracket. Test if either of these parts are grounded to the bracket, using a test lamp. Contact one lead of the test lamp against the bearing surface and the other lead against the bracket. If the lamp lights, it indicates the insulation is faulty and must be replaced.

g. **Inspect High Tension Conductor** (fig. 133). If a new distributor gear bracket is required as described in subparagraph **f** above, the early type high tension conductor must be discarded as this part is included in the conversion kit which is provided for the particular model magneto being repaired. If the magneto is already equipped with the latest type high tension conductor, check the plunger spring and see that the brass plungers are free. Check the conductor for current leakage. Replace the conductor if it has faulty insulation.

h. **Inspect Magnet Rotor** (fig. 134). The magnet rotor is usually stable in its magnetization and does not require remagnetization during routine inspection or in complete disassembly. Remagnetization should not be attempted unless the primary current reading is below 2.0 amperes tested on test stand at 800 revolutions per minute. Magnet rotor is best tested after assembly (par. 50). Check the ball bearings at both ends of the magnet rotor. Bearings that are discolored, rough, or excessively worn must be replaced (par. 48 **c**).

i. **Inspect Coil Assembly** (fig. 134). Examine the coil for loose core and loose primary cable connection, and check all soldered connections. Using an approved test stand, provided with three electrode needle-pointed test gaps, and a six-lobe cam, test the coil as follows: With a 2-volt input and cam speed of 150 to 175 revolutions per minute, the spark should jump 0.351-inch gap; with a 6-volt input and the cam speed at 1,000 revolutions per minute, the spark should jump a 0.390-inch gap. Coil is suitable for further use if found satisfactory in the above test. If the coil is faulty, the coil which is soldered to the breaker assembly must be unsoldered and the coil must be discarded.

j. **Inspect Magneto Housing** (fig. 129). Circular wire screens must be discarded if the screens are plugged or damaged. Replace the circular silk screen and rectangular felt filter regardless of their condition. The rectangular ventilator cover must be discarded if the screen on the cover is badly plugged or damaged. Discard the magneto housing if it is cracked or has damaged threaded holes. Replace the oil seal in the housing regardless of its condition (par. 48 **d**). Check the bearing outer race for rough spots or discoloration and replace if necessary (par. 48 **e**).

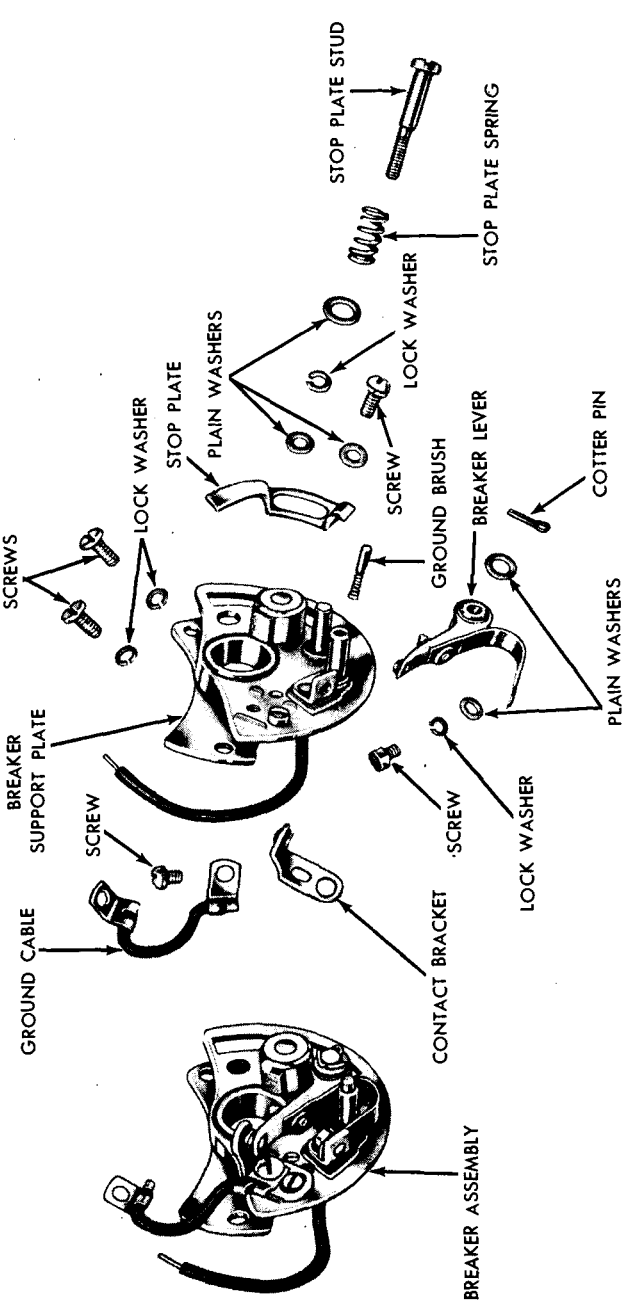


Figure 132 — Breaker Assembly, Disassembled

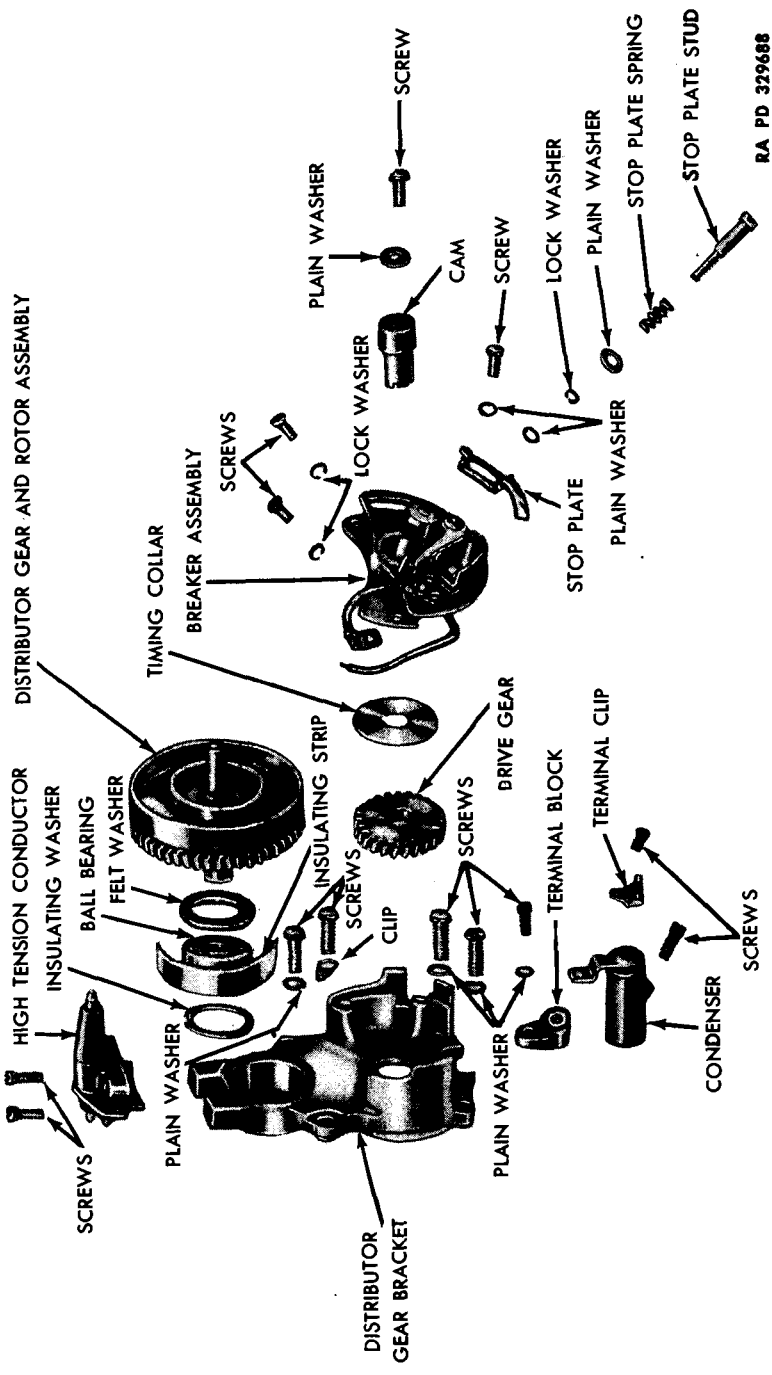
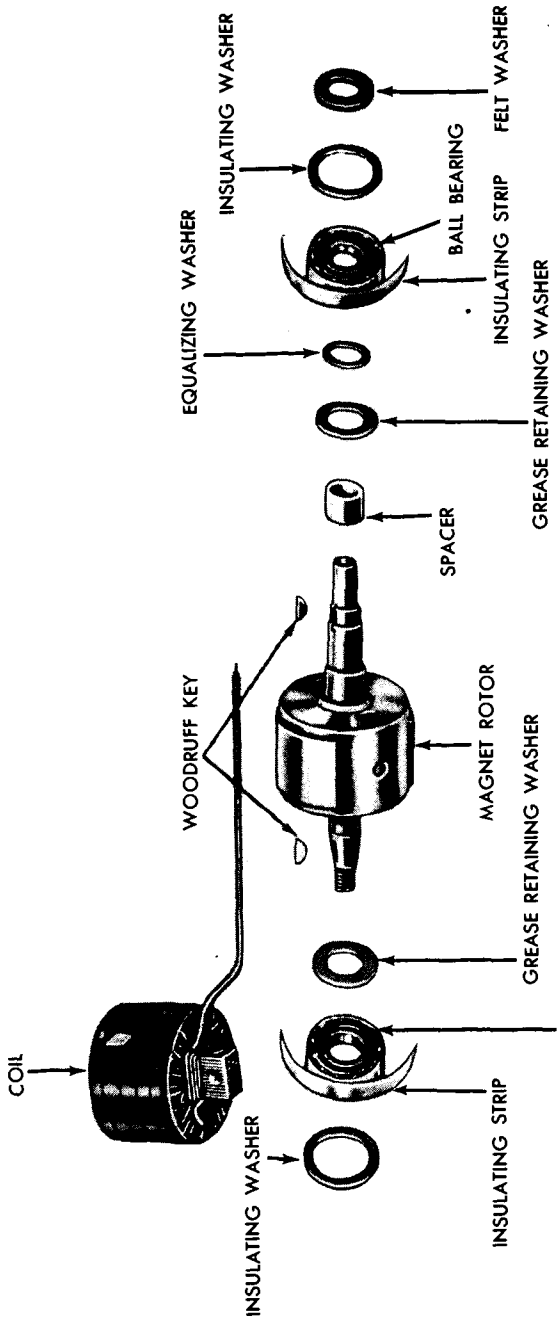


Figure 133 — Distributor Gear Bracket, Disassembled



RA PD 329689

Figure 134 — Magnet Rotor and Coil, Disassembled

48. REPAIR.

a. Breaker Contact Point Replacement.

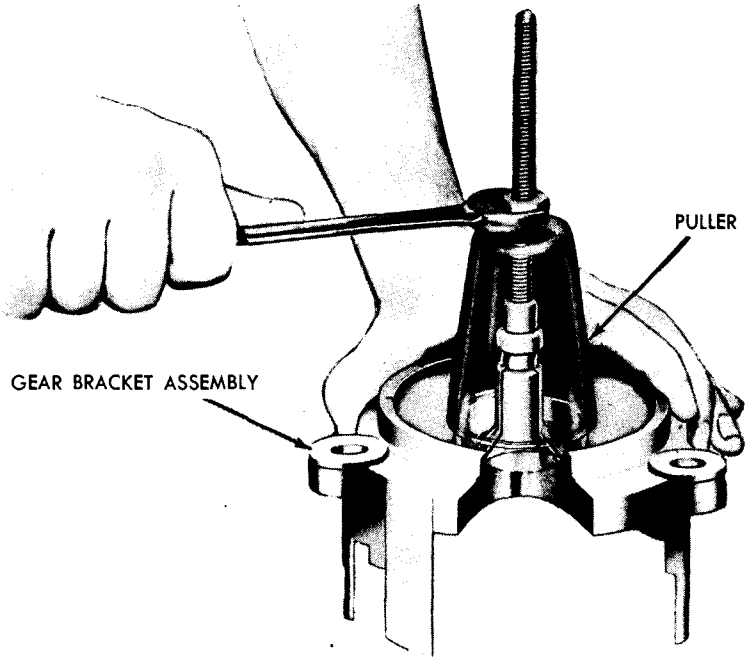
(1) REMOVAL (fig. 132). Remove the cotter pin and plain washer securing the breaker lever to the pivot post. Remove the cap screw securing the breaker lever tension spring, and lift the breaker lever off the pivot post. Remove the screw securing the ground cable and contact bracket to the breaker plate, and remove the contact bracket and ground cable.

(2) INSTALLATION (fig. 132). Place the contact bracket and ground cable in position on the breaker plate, and install the lock washer and screw securing the contact bracket and ground cable to the plate. Place the breaker lever in position on the pivot post. Install the flat washer and cotter pin. Install the lock washer and cap screw securing the breaker lever tension spring. Point setting must be made after the breaker assembly is installed on the magneto (par. 49 l).

b. Distributor Gear Bracket Repair.

(1) BALL BEARING OUTER RACE RING REPLACEMENT. Set the distributor gear bracket on a work bench. Place the puller (41-P-2905-19) over the ball bearing race ring at the lower end of the bracket (fig. 135), and remove the outer race ring from the bracket. To install a new outer race ring, set the distributor gear bracket on an arbor press. Be sure the gear bracket is supported by a block so as not to damage the bracket when pressing the outer race ring in place. Place a new ball bearing insulation washer into the ball bearing outer race ring recess. Place a new magnet rotor ball bearing insulation strip around the ball bearing recess, lapping it together in the special groove in the bearing recess. Place the outer race ring in the ball bearing recess. Press the bearing outer race in place, using tool (41-R-2386-705) (fig. 136).

(2) DISTRIBUTOR GEAR BRACKET BALL BEARING REPLACEMENT. Place the distributor gear bracket on a work bench. Set the puller (41-P-2897-350) over the ball bearing (fig. 137). Turn the wing nut on the puller until the spring collet has spread sufficiently to grip the ball bearing firmly from the underside, and remove the bearing. To install a new bearing, set the distributor gear bracket on an arbor press. Be sure the gear bracket is placed on a block so as not to damage the bracket when pressing the ball bearing in place. Place a new ball bearing insulation washer into the ball bearing recess. Place a new insulation strip around the bearing recess, lapping it together in the special groove in the bearing recess. Pack the ball bearing with special high temperature grease and place the bearing in position on the bearing recess. Press the ball bearing in place, using tool (41-R-2386-705). Check the ball bearing after installation to make sure that it is properly insulated as outlined in paragraph 47 f.



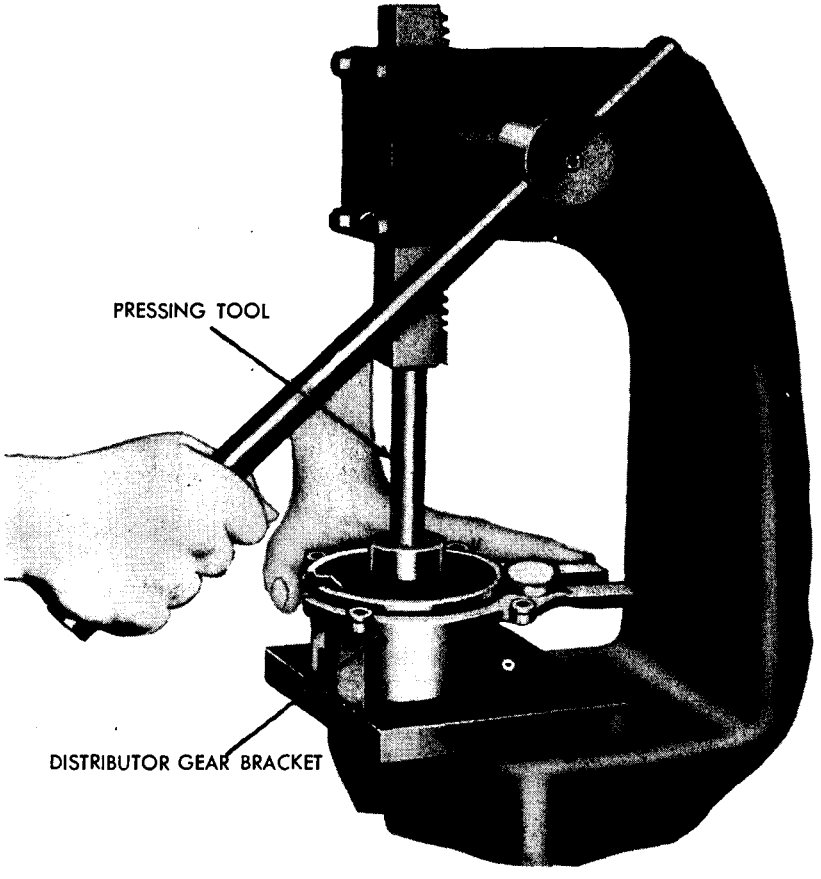
RA PD 28223

Figure 135 — Removing Ball Bearing Outer Race Ring, Using Puller (41-P-2905-19)

c. Magnet Rotor Bearing Replacement.

(1) REMOVAL. Set the magnet rotor in a vise having brass jaws. Remove the bearing cage with balls from the bearing inner race ring. Install the puller (41-P-2905-20) on the bearing race and remove the inner bearing race ring off the magnet rotor shaft (fig. 138). Use the same procedure for removing the inner bearing race ring from the other end of the shaft.

(2) INSTALLATION. Set the magnet rotor in a vertical position through the hole in the arbor press plate with the threaded end of the shaft down. Place the spacer, grease retaining washer, and equalizing washer over the shaft in the order shown in figure 134. **NOTE:** *If the magnet rotor was originally equipped with a fan, place the fan over the shaft instead of the spacer.* Place a new ball bearing inner race ring on the shaft of the magnet rotor. Set the open end of the pressing tool (41-T-3261-225) over the ball bearing inner race ring and press the race in place on the shaft (fig. 139). To install the ball bearing inner race ring on the opposite end of the shaft, place the grease retaining washer on the shaft and use the same procedure for pressing on the bearing race.



RA PD 329698

Figure 136 — Pressing Ball Bearing Outer Race in Bracket, Using Replacer (41-R-2386-705) (Also Used for Pressing Outer Race in Housing)

d. Magneto Housing Oil Seal Replacement.

(1) REMOVAL. Remove the ball bearing outer race ring from the magneto housing (subpar. e (1) below). Place the magneto housing on a bench with the open end facing down. Place a screwdriver behind the seal and tap lightly with a hammer.

(2) INSTALLATION. Set magneto housing in an arbor press with the open end facing upward and supported on the flange end by a block placed in the circular recess in the housing to prevent damage to the magneto housing. Place the oil seal over the small end of the pressing tool, being sure that the chamfered side of the oil seal

rests against the shoulder of the pressing tool, and press the oil seal into place in the housing. Install the ball bearing outer race ring in the magneto housing (subpar. e (2) below).

e. Magnet Rotor Shaft Ball Bearing Outer Race Ring Replacement.

(1) REMOVAL. Set the magneto housing on a work bench. Using puller (41-P-2905-19), remove the ball bearing outer race ring from the housing.

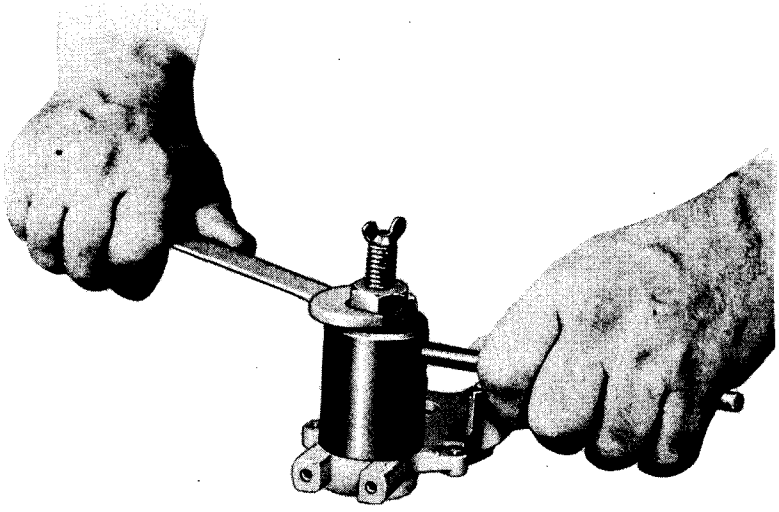
(2) INSTALLATION. Set the magneto housing on an arbor press with the open end facing upward and supported on the flange end by a block placed in the circular recess in the housing to prevent damage to the housing. Place the ball bearing insulation washer into the ball bearing outer race ring recess. Place the magneto rotor ball bearing insulation strip around the edge of the recess, lapping it together in the special groove provided in the bearing recess. Place the outer race ring in the recess. Set the large end of the pressing tool (41-R-2386-705) over the outer race and press it into place.

49. ASSEMBLY.

a. Install Ventilator Covers (fig. 129). Place the felt filter and rectangular ventilation cover in position on each side of the magneto housing, being sure the slots on the cover are facing downward. Install the two screws securing each cover to the housing. Place a circular wire screen, a silk screen, and a wire screen on the circular opening at each side of the magneto housing and aline the hole on the screens with the holes in the housing. Place the circular washer and ventilating cover in position on the screens, being sure the slots in the cover are toward the bottom of the magneto. Install the two lock washers and screws securing each cover to the housing.

b. Install Conductor Insulator (fig. 129). Push the conductor insulator into the slots in the top of the magneto housing, being sure that the straightedge of the insulator fits into the slots first, leaving the curved edge of the insulator projecting over the edge of the housing.

c. Install Coil Assembly (fig. 128). NOTE: *If the coil wire has been separated from the breaker plate, it will be necessary to resolder the coil wire to the clip.* Place the coil assembly into the housing so that the countersunk holes in the core of the coil are toward the top of the housing and the coil cable is on the left-hand side of the magneto. Secure the coil in place with two set screws at the top of the housing. After the coil is secured in place, check the distance between the high tension coil clip and the top of the magneto housing. This distance must be from 0.490 inch to 0.500 inch. If the distance is less than 0.490 inch, the coil must be removed and the clip filed until the correct distance is obtained.



RA PD 329694

Figure 137 — Removing Ball Bearing From Distributor Gear Bracket, Using Puller (41-P-2897-350)

d. Install Magnet Rotor Assembly (fig. 128). Install the bearing cages on the inner race ring at each end of the rotor shaft. **NOTE:** *Do not pack the bearings with grease until the end play has been checked (subpar. f below).* Insert the magnet rotor assembly into the housing with the threaded end of the shaft first, until it bottoms. Place new felt washers on the rotor shaft. Place the Woodruff key in the slot on the drive end of the rotor shaft.

e. Install Distributor Gear Bracket (fig. 127). Place the high tension conductor on the upper edge of the distributor gear bracket, being sure that the long end of the conductor is facing toward the front of the bracket. Install the two lock washers and screws securing the conductor to the bracket. Mount the magneto on the holding fixture (41-F-2993-600) so that the Woodruff key in the magnet rotor shaft fits into the slot in the collar of the holding fixture. Place the gear bracket in the housing. Install the four lock washers and screws securing the bracket to the housing. Be sure the hold-down clip for retaining the coil cable is on the left-hand upper screw. Place the terminal block on the gear bracket so that the round boss on the terminal block fits into the recess that is provided for it. Install the plain washer and screw securing the block to the gear bracket.

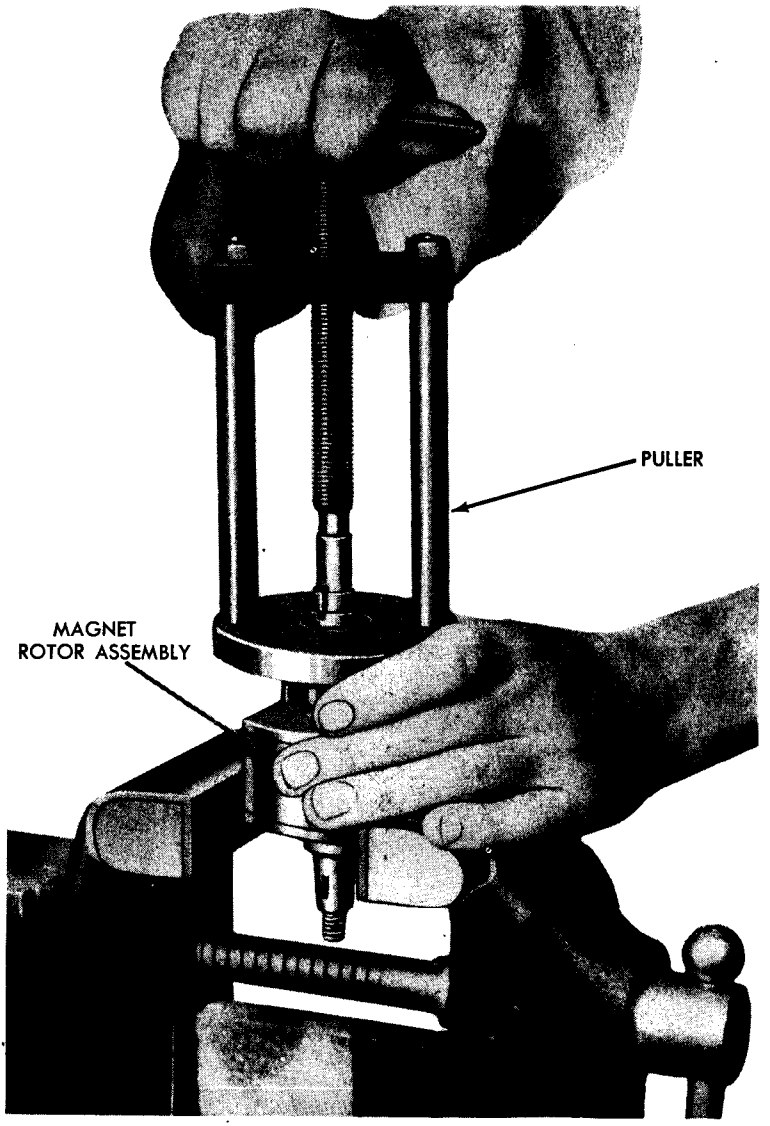
f. Check Magnet Rotor Shaft End Play. After the distributor gear bracket is secured in place, check the end play of the magnet

rotor. The end play must be 0.000 to 0.001-inch preload. The magnet rotor must turn freely when turned by hand. If there is end play, the bearing must be removed from the magnet rotor shaft at the gear end (par. 48 c). Select an equalizing washer of the proper thickness to make the correct end play. Place the equalizing washer on the shaft and install the bearing on the shaft. Install the magnet rotor and distributor gear bracket in the housing and again check the end play. After the correct end play is obtained, remove the magnet rotor and pack the bearing with special high temperature grease.

g. **Install Drive Gear** (fig. 125). Place the Woodruff key for the drive gear in the slot in the magnet rotor shaft. If working on a left-hand magneto, use the drive gear with the letter "A" stamped on the gear. If working on the right-hand magneto, use the drive gear with the letter "C" stamped on the gear. Line up the keyway and slide the drive gear over the magnet rotor shaft with the letter stamped on the gear facing upward. Place the pressing tool (41-T-3261-225) over the end of the magnet rotor shaft and flush against the top of the drive gear, and press the drive gear into place on the shaft with an arbor press. Be sure the shoulder on the shaft does not stick up beyond the gear. NOTE: *It is not necessary to remove the magneto from the holding fixture when pressing the drive gear on the magnet rotor shaft.*

h. **Install Distributor Gear and Rotor Assembly** (fig. 125). Apply approximately ¼ ounce of special high temperature grease to the surface of the distributor gear teeth. Place the distributor gear and rotor assembly into the housing, at the same time putting the timing collar over the end of the magnet rotor shaft. When the distributor gear and rotor assembly meshes with the magnet rotor gear, the timing slot on the timing collar must be in direct alinement with the timing mark on the edge of the distributor rotor. This is accomplished by slipping the timing collar into the groove of the distributor gear and rotor assembly, and sliding both the gear and the timing collar in their respective positions at the same time. Recheck to make sure the slot in the timing collar is over the Woodruff key, and the timing slot lines up with the timing mark on the distributor rotor.

i. **Install Condenser** (fig. 125). Place the condenser in the recess of the distributor gear bracket, being sure that the condenser lead is over the coil cable. Secure the clip on the coil cable and the condenser lead to the terminal block with a screw and lock washer. Secure the condenser ground bracket to the gear bracket with a screw and lock washer. Tuck the coil cable running from the condenser clip and coil into the space between the housing and the gear bracket, being sure the coil cable does not rub against the drive gear.



RA PD 28224

Figure 138 — Removing Ball Bearing Inner Race, Using Puller (41-P-2905-20)

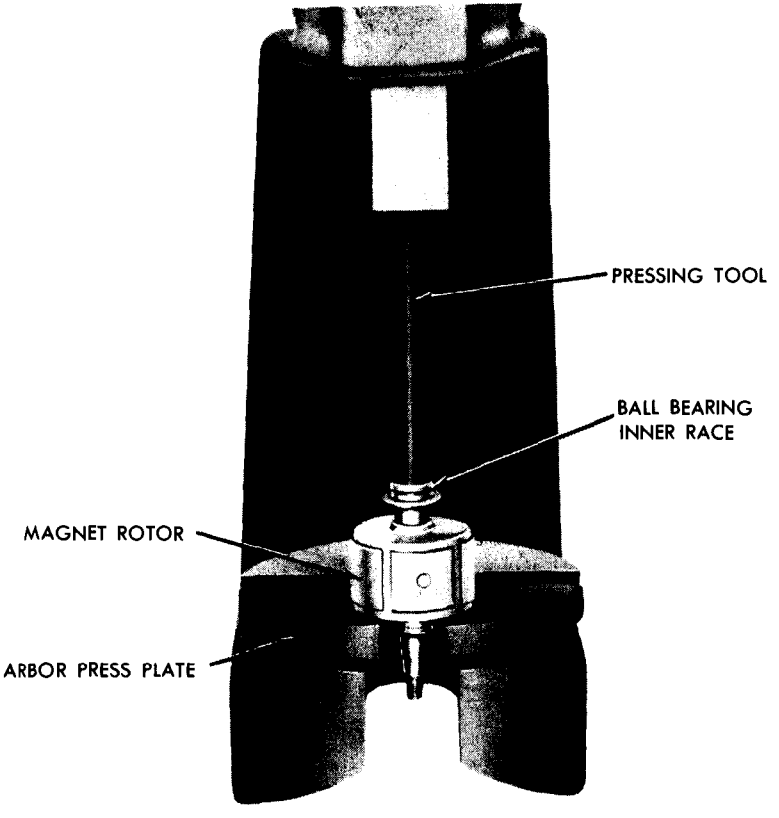
j. Install Breaker Assembly (fig. 124). Push the grounding brush with its spring into the hollow stud. Slide the stop plate into its slot in the breaker assembly (fig. 132). Place the breaker assembly into place on the distributor gear bracket, and secure the breaker plate to the gear bracket with two screws. Make sure the breaker ground cable is secured by the left screw directly under the contact bracket. Secure the stop plate to the breaker plate with a screw, lock washer, and plain washer. Install the stop plate stud assembly into the stop plate so that the spring and plain washer are above the breaker plate. The lock washer and plain washer must be below the breaker plate and resting on the stop plate.

k. Install Cam (fig. 124). Slide the cam over the end of the magnet rotor shaft and into the keyway provided for it. Note that the "A" ("C" if working on the right-hand magneto) on the cam corresponds with the marking on the distributor gear and rotor assembly. Be sure the slot on the cam fits over the Woodruff key on the magnet rotor shaft. Secure the cam in place with a screw, lock washer, and flat washer.

l. Adjustment of the Contact Points (fig. 140). Breaker contacts are adjusted to an opening of from 0.014 inch to 0.016 inch when the breaker lever fiber rubbing block rests on the high point of the cam. Adjust the contact bracket by means of the eccentric adjusting screw (fig. 124) until the correct gap is obtained. Lock the contact bracket with the lock screw. Contact points must be free from oil and grease and in proper alinement so that the surfaces of both contacts meet squarely. When the breaker points have been set to the correct gap, set the position of the breaker plate to the correct relationship with the edge of the pole shoe in the magneto housing as outlined in subparagraph **m** below.

m. Set Breaker Plate Position.

(1) EXPLANATION. From the standpoint of maximum efficiency, it is important that the primary circuit in the coil or winding is interrupted by the breaker points at the most favorable position of the rotor in relation to pole shoe for maximum disturbance or change of flux. This relationship is established when, with the magnet rotor leaving the pole shoe, the gap between the edge of the magnet rotor and the edge of the pole shoe is from 0.079 inch to 0.118 inch at the instant the breaker points start to open. This gap originally was referred to as the "EDGE" gap, which designation has been abbreviated to E-gap by most magneto technicians. The E-gap adjustment is established by setting the position of the breaker plate so that the points just begin to open after mechanically fixing the relationship of the magnet rotor with the pole shoe as outlined below.



RA PD 329695

Figure 139 — Ball Bearing Inner Race Pressing Tool (41-T-3261-225) (Also Used for Pressing Distributor Plate Drive Gear on Shaft)

(2) E-(EDGE) GAP ADJUSTMENT.

(a) Right-hand Magneto. NOTE: *The direction of rotation of the right-hand magneto is clockwise. It is important that the direction of rotation be kept in mind when setting the E-gap.* The E-gap is determined as the magnet rotor leaves the pole shoe; never when the magnet rotor approaches it (fig. 140).

1. Set magnet rotor position. Remove the mounting stud from the magneto housing and place the magneto on the holding fixture. Remove the small plug screw from the bottom of the housing at the left-hand side. Select a 2.5-mm rod from the E-gap gage set (41-G-198-300) and insert the gage in the hole from which the plug was removed, as shown in figure 140. Turn the magneto clockwise until the timing marks on the distributor rotor gear and the drive gear

are alined. At this position, the magneto pole shoe is about to leave the magnet rotor. Apply a slight pressure on the gage and continue to turn the magneto clockwise until the gage leaves the curved surface of the magnet rotor, and drops in the notch as shown in figure 140.

2. *Set breaker plate.* When the location of the magnet rotor has been established, adjust the breaker plate so the contact points will just begin to open. This is very important. To adjust the breaker plate, loosen the stop plate stud, the stop plate fastening screw, and turn the breaker plate in its slot until the contact points just begin to open; then lock the breaker plate in this position by tightening the screw and stud. Install the plug in the bottom of the magneto.

(b) Left-hand Magneto. The procedure for setting the E-gap and breaker plate for the left-hand magneto is the same as for the right-hand magneto, except the gage is inserted in the hole at the bottom right-hand side of the magneto as shown in figure 140. NOTE: *The direction of rotation of the left-hand magneto is counterclockwise and must be turned counterclockwise when inserting the gage in the notch.*

n. Install Distributor Plate Assembly (fig. 123). NOTE: *All early type magnetos (MJF4A-307 and 308) which have had the radio shield replaced with the late type radio shield must use a special steel plate (PL-5232) between the distributor plate and housing. The two lower studs which secure the lower end of the distributor plate must also be changed and a longer stud (SD-52153) must be used. Do not use any studs from the late type magneto as the studs have a different thread.* Place the distributor plate gasket on the edge of the housing. Aline the holes in the gasket with the locating dowel pins on the edge of the housing. If a steel plate is being used between the radio shield and housing, place a gasket on each side of the plate and place this assembly on the housing. Push the four outside plate brushes with their springs into their holders with the brushes projecting from the brush holders. Push the center brush with its spring into the center brush holder. The center brush can be identified as it is copper plated on the end toward the spring. Place the distributor plate in position on the housing and secure into place with four studs (long studs at the bottom), lock washers and flat washers, and the two screws, lock washers and flat washers. Fasten the breaker cap and gasket to the distributor plate assembly with the two screws, lock washers and plain washers.

o. Install Radio Shield Assembly (fig. 122). Place the radio shield in position on the magneto housing. Secure the radio shield to the distributor plate with two screws and lock washers. Place the copper gasket and the breaker cap cover on the radio shield and secure the cover with four screws and lock washers. Place the copper gasket and the distributor plate cover on radio shield and secure with four screws and lock washers.

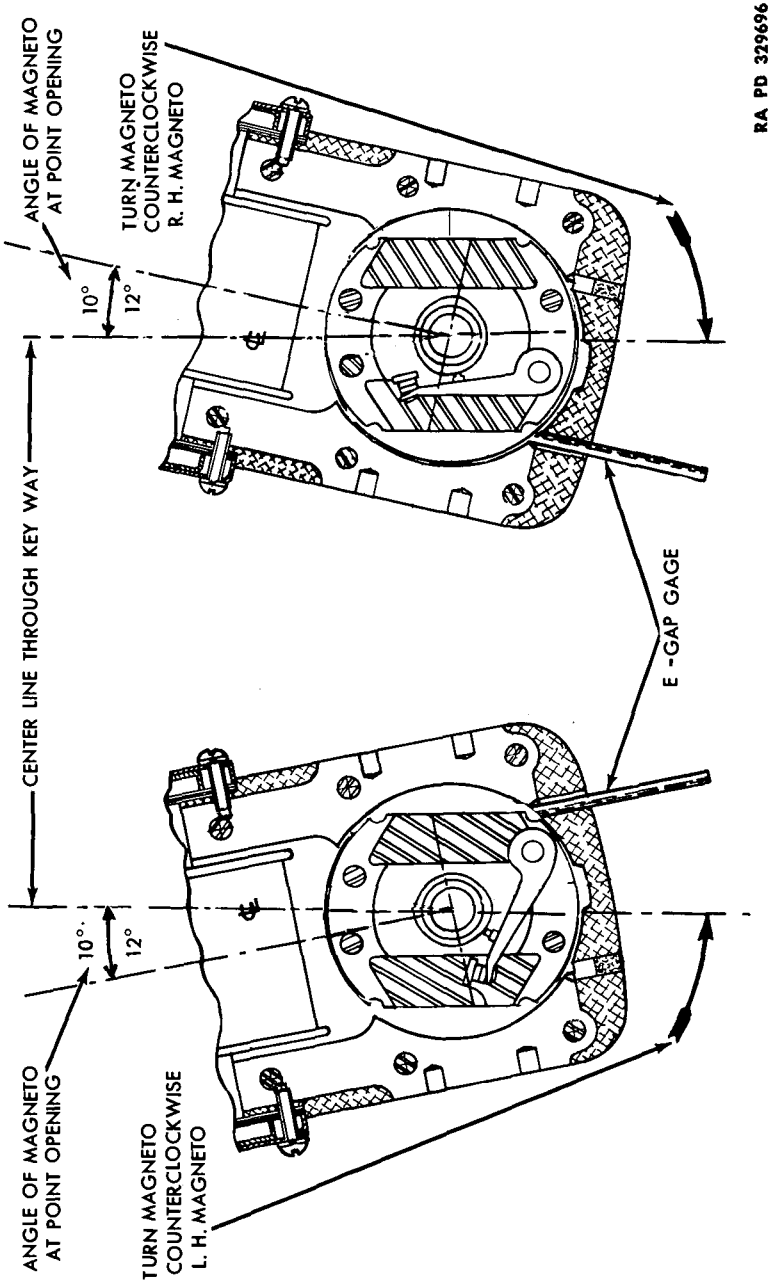


Figure 140 — Setting E-gap as Viewed From the Breaker End, Mounted on Holding Fixture (41-F-2993-660)

p. Install Magneto Drive Flange (fig. 120). Place the drive flange in position on the drive end of the magnet rotor shaft. Secure the flange to the shaft with a boot-type nut. Use holder (41-H-3550) for holding the shaft from turning while tightening the nut (fig. 120).

50. TEST.

a. General. Use any standard approved test stand, provided with pointed (three electrodes) test gaps. If the following test procedure indicates unsatisfactory performance, the magneto must be disassembled, and the various units inspected and repaired or replaced as required.

b. Test Spark. Place the magneto on test stand, and run the magneto at each of the following speeds with the spark gap openings set as indicated for each speed:

Speed	Spark Gap
60 rpm	0.179 inch
150 rpm	0.295 inch
400 rpm	0.335 inch
1,200 rpm	0.354 inch
2,000 rpm	0.354 inch
3,000 rpm	0.335 inch

During the run, 100 percent firing is required at all gaps. Only slight intermittent arcing of the contact points is allowable.

c. Check Ground Brush. Check the ground brush circuit by grounding the low tension while the magneto is running. If the ground brush circuit is functioning correctly, the magneto will cease sparking when grounded.

d. Test Primary Current. Magnetos are usually stable in their magnetization, and ordinarily do not require remagnetization during routine inspection or complete disassembly. Remagnetization should not to be attempted unless the primary current reading is below 2.0 amperes (tested on a test stand at 800 rpm). If remagnetization is required, use magnetizing stand (17-C-8805).

51. INSTALLATION OF ENGINE AND TIMING.

a. Install the magnetos on the engine and set the timing as outlined in paragraph 31, or the pertinent operators' manual.

CHAPTER 4 — SPECIAL TOOLS

52. SPECIAL TOOLS.

a. General. This list is for information only and is not to be used as a basis for requisitioning.

b. Special Tools for GAA, GAN, and GAF Engines.

Nomenclature	Federal Stock No.	Mfg. No.
ADAPTER, stand, engine overhaul	41-A-26-785	KRW-T-61
ADAPTER (set), puller, cylinder sleeve, universal (use with 41-P-2907-117)	41-A-18-72	
ADAPTER, puller, main bearing, stud and quill shaft (upper and lower)	41-A-18-226	
ADAPTER, stand, engine	41-A-26-700	MTM-M23-31
COMPRESSOR, valve spring	41-C-2559-40	KRW-T-15
CUTTER, cylinder head spark plug insert face, with holder, No. 2 Morse taper shank (formerly 41-C-2835)	40-C-1848	KRW-T-82
DRIVER, set of 6, oil and water line ferrules, consisting of drivers to drive (formerly 41-D-2983-150)	41-D-2980-150	KRW-T-42
3/16-in ID of ferrule	41-D-2980-160	KRW-T-42-A
1/4-in. ID of ferrule	41-D-2980-165	KRW-T-42-C
3/8-in. ID of ferrule	41-D-2980-170	KRW-T-42-D
5/8-in. ID of ferrule	41-D-2980-175	KRW-T-42-E
3/4-in. ID of ferrule	41-D-2980-180	KRW-T-42-F
2-in. ID of ferrule	41-D-2980-155	KRW-T-42-H
DRIVER, seal, right angle drive output flange (use w/41-H-1397)	41-D-2983-75	MTM-M23-2
FIXTURE, grinding, cylinder sleeve ends	40-F-13-563	
FIXTURE, assembly, accessory drive case	41-F-2987-300	KRW-T-16
FIXTURE, crankshaft and flywheel assembling	41-F-2989-210	HL-2
FIXTURE, drill spark plug insert dowel	41-F-2990	KRW-T-32
FIXTURE reaming camshaft bearing	41-F-2994-19	KRW-T-86
GAGE, micrometer depth (graduated in 1000ths), with case, range 0- to 3-in., base 2 1/2-in.	41-G-141	B&S-607
GAGE, valve guide, go and no-go	41-G-500-100	KRW-T-62
HANDLE, 3/4 in., for removers and replacers	41-H-1397	TEC-4-223
INDICATOR, top dead center and timer	41-I-115	KRW-T-77
INSTALLER, connecting rod and bearing auxiliary generator	41-I-144-100	MTM-M23-23
LIGHT, timing, Bosch magneto, complete w/battery and neon bulbs	41-L-1439	TSE-5230
PULLER, crankpin bearing	41-P-2906-285	HL-3
PULLER, crankshaft assembly	41-P-2906-290	HL-1

Special Tools

Nomenclature	Federal Stock No.	Mfg. No.
PULLER, cylinder sleeve, universal (removing and replacing)	41-P-2907-117	
PULLER, dowel, engine flywheel to crankshaft (slide hammer type)	41-P-2907-122	KM-J-4365
PULLER, dowel flywheel to crankshaft	41-P-2907-190	KRW-T-4
PULLER, camshaft, gear	41-P-2909-58	KRW-T-26
PULLER, plate type, universal	41-P-2951-43	MTM-M23-26
REAMER, taper pin, flywheel, dowel	41-R-2307-500	KRW-T-53
REAMER, high speed, hand, magneto drive shaft bushing	41-R-2312	KRW-T-18
REMOVER, piston pin bushing (formerly 41-R-2384-44)	41-R-2369-550	KRW-T-37
REMOVER, flywheel (formerly 41-R-2381-73)	41-R-2370-650	HL-4
REMOVER, spark plug insert (formerly 41-R-2384-60)	41-R-2371-350	KRW-T-25
REMOVER, valve seat inserts (formerly 41-R-2384-87)	41-R-2371-400	KRW-T-54
REPLACER, worm bearing double row (formerly 41-R-2405-255)	41-R-2380-6	KRW-T-44
REPLACER, gear accessory, bevel driven (formerly 41-R-2393-500)	41-R-2389-400	KRW-T-30
REPLACER, valve guide (formerly 41-R-2397-700)	41-R-2390-500	KRW-T-12
SLING, engine, lifting	41-S-3013	HL-7
SLING, engine, transmission and controlled differential assembly lifting	41-S-3830-30	KM-J-3322
SLING, engine	41-S-3831	KRW-T-68
SLING, engine lifting	41-S-3831-700	MTM-M23-33
SLING, cable, 3/8-in. dia (remove and replace differential and transmission gears)	41-S-3832-24	MTM-M23-7
STAND, engine, overhaul	41-S-4942-14	ST-15035
TOOL, alining clutch disk	41-T-3083-75	KRW-T-3
TOOL, spotfacer, magneto drive bushing	41-T-3361-60	KRW-T-16
WRENCH, box, special offset, carburetor heat-box nuts	41-W-639-850	KRW-T-40
WRENCH, cylinder head nut, long	41-W-866-200	KRW-T-9
WRENCH, cylinder head nut, short	41-W-866-250	KRW-T-29
WRENCH, crankshaft, cam drive, worm bearing nut	41-W-871-28	KRW-T-81
WRENCH, socket, spline, turning camshaft	41-W-2964-300	KRW-T-80
WRENCH, spanner, camshaft	41-W-3247-150	KRW-T-1
WRENCH, spark plug insert	41-W-3255-500	KRW-T-39
WRENCH, socket, spark plug	41-W-3336-300	KRW-T-5
WRENCH, tubular, pronged, single end, OD 1 3/4-in., length 2 1/2-in., 4 prongs	41-W-3736-155	KM-J-4326

c. Special Tools for Bosch Magnetos.

Nomenclature	Federal Stock No.	Mfg. No.
ADAPTER, puller, rotor gear	41-A-18-225	TSE-522
BASE, locating, gear housing	41-B-346-300	TSE-5248-10
COMPASS, magnetic, small	18-C-1598	MCE-36438
DRIVER, bearing (ball)	41-D-2862	TSE-5248-8
DRIVER, gear, distributor	41-D-2966-200	TSE-5248-7
EXTRACTOR, wick distributor gear shaft	41-E-606	TSE-5254
FIXTURE, breaker, assembly	41-F-2987-475	TSE-5252
FIXTURE, holding magneto	41-F-2993-610	EXP-132
GAGE, cab, magneto (edge distance)	41-G-198-300	TSE-St-415
HOLDER, coupling	41-H-2269-200	TSE-5275
HOLDER, magneto drive flange	41-H-2350	KRW-T-31
INDICATOR, contact opening	41-I-60-10	TSE-5277
LIGHT, timing, Bosch, complete w/battery and neon bulbs	41-L-1439	TSE-5230
MAGNETIZING, stand (base shop)	17-C-8805	WEI-818
PILOT (pin), ball bearing (use with 41-P-346-300)	41-P-401-450	TSE-5248-11
PIN, setting, press plate, set of 3 (use with 41-P-1535-300)	41-P-758-25	TSE-5248-2
PLATE, base, arbor press	41-P-1535	TSE-5248-1A
PLATE, housing support	41-P-1543-300	TSE-5248-4
POST, housing support	41-P-2345	TSE-5248-3
PULLER, bearing (ball)	41-P-2897-350	TSE-5261
PULLER, bearing race, 12-, 15-, and 17-mm magneto (w/collete)	41-P-2905-19	
PULLER, bearing race (inner) magneto	41-P-2905-20	TSE-5265
PULLER, gear and coupling	41-P-2918	ST-425-1
PULLER, magneto drive flange	41-P-2941-750	KRW-T-43
PUNCH, center, point size 0.109-in. (7/64-in.), length 6-in.	41-P-3162	TSE-5262-2
PUNCH, drive pin, solid, point size 0.109-in. (7/64-in.), length 6-in.	41-P-3636	TSE-5262-1
REMOVER, distributor gear and governor assembly	41-R-2370-250	TSE-5225
REMOVER AND REPLACER, oil seal	41-R-2378-125	TSE-5248-5
REPLACER, bearing race (outer) length 7-in.	41-R-2386-705	TSE-5269
REPLACER, oil seal, magneto	41-R-2392-980	TSE-527
TOOL, inner ball race installing, 15-mm	41-T-3261-225	

APPENDIX

REFERENCES

53. PUBLICATIONS INDEXES.

a. The following publications indexes should be consulted frequently for latest changes to or revisions of the publications given in this list of references and for new publications relating to materiel covered in this manual:

Introduction to Ordnance Catalog (explains SNL system)	ASF Cat. ORD-1 IOC
Ordnance publications for supply index (index to SNL's)	ASF Cat. ORD-2 OPSI
Ordnance Major Items and Combinations and Pertinent Publications (alphabetical listing of Ordnance major items with available publications pertaining thereto, including TM's, OFSTB's, WDTB's, FSMWO's, MWO's and ASF catalogs)	SB 9-1
List of publications for training (lists MTP's, TR's, TC's, FM's, TM's, WDTB's, Firing Tables and Charts and Lubrication Orders)	FM 21-6
List of miscellaneous publications (lists MP's, MWO's, SB's, RR's, and War Department Pamphlets)	W.D. Pamphlet 12-6
List of training films, film strips and film bulletins (lists TF's, FS's, and FB's by serial number and subject)	FM 21-7
Military training aids (lists graphic training aids, models, devices, and displays)	FM 21-8

54. STANDARD NOMENCLATURE LISTS.

a. Maintenance.

Cleaning, preserving and lubricating materials: recoil fluids, special oils, and miscellaneous related items	SNL K-1
Lubricating equipment, accessories and related dispensers	SNL K-3
Soldering, brazing and welding material, gases and related items	SNL K-2

Tools, maintenance, for repair of automatic guns, automatic gun aircraft materiel, automatic and semiautomatic cannon and mortars—Individual items and parts ..... SNL A-35

Tool sets, for ordnance service command automotive shops ..... SNL N-30

Tool sets (common), specialists and organizational ..... SNL G-27 (Section 2)

Tool sets (special), automotive and semiautomotive ..... SNL G-27 (Section 1)

b. Vehicular.

Carriage, motor, 3-inch gun, M10A1 ..... SNL G-170
Carriage, motor, 90-mm gun, M36 (T71) ..... SNL G-210
Carriage, motor, 90-mm gun, M36B1 ..... SNL G-233
Carriage, motor 105-mm howitzer M7B1 ..... SNL G-199
Tank, heavy, T26E3 ..... SNL G-226
Tank, medium, M4A3 (25-mm gun, dry) ..... SNL G-104 Vol. 8
Tank, medium, M4A3 (76-mm gun, wet) ..... SNL G-204
Tank, medium, M4A3 (105-mm howitzer) ..... SNL G-104 Vol. 15
Tank, medium, T23 ..... SNL G-183

55. EXPLANATORY PUBLICATIONS.

a. Fundamental Principles.

Automotive electricity ..... TM 10-580
Basic maintenance manual ..... TM 37-250
Care and maintenance of ball and roller bearings ..... TM 37-265
Cooling systems—Vehicles and powered ground equipment ..... TM 9-2858
Driver's manual ..... TM 21-305
Driver selection and training ..... TM 21-300
Driver training, half-track and full-track vehicles ..... TM 21-301
Electrical fundamentals ..... TM 1-455
Fuels and carburetion ..... TM 10-550
Military motor vehicles ..... AR 850-15

Motor vehicle inspections and preventive maintenance service	TM 37-2810
Ordnance service in the field	FM 9-5
Precautions in handling gasoline	AR 850-20
Radio fundamentals	TM 11-455
Standard military motor vehicles	TM 9-2800
Storage batteries—Lead-acid type	TM 9-2857
The radio operator	TM 11-454

b. Maintenance and Repair.

Cleaning, preserving, lubricating and welding materials and similar items issued by the Ordnance Department	TM 9-850
Maintenance and care of pneumatic tires and rubber treads	TM 31-200
Ordnance Maintenance: Hull and turret, electrical system, track and suspension for 3-inch gun motor carriage M10 and M10A1	TM 9-1750L
Ordnance Maintenance: Hydraulic traversing mechanism for medium tank M4 and modifications (Oilgear)	TM 9-1731G
Ordnance Maintenance: Power train unit, one-piece differential case, for medium tanks M3, M4 and modifications and related gun motor carriages	TM 9-1750B
Ordnance Maintenance: Speedometers, tachometers, and recorders	TM 9-1829A
Ordnance Maintenance: Tracks, suspension, turret and hull for medium tank M4 and modifications	TM 9-1750K
Tank, medium, T23—Electric drive equipment	TM 9-1734A

c. Operation.

Carriage, motor, 105-mm howitzer M7B1	TM 9-749
Heavy tank, T26E3	TM 9-735
Medium tank, T23	TM 9-734
Tank, medium M4A3	TM 9-759
3-inch gun motor carriage M10A1	TM 9-731B
90-mm gun motor carriage T71 (M36)	TM 9-758
90-mm gun motor carriage M36B1	TM 9-748

d. Protection of Materiel.

Camouflage	FM 5-20
Chemical decontamination, materials and equipment	TM 3-220
Decontamination of armored force vehicles	FM 17-59
Defense against chemical attack	FM 21-40
Explosives and demolitions	FM 5-25

Storage and Equipment.

Ordnance company, depot	FM 9-25
Ordnance packing and shipping (posts, camps, and stations)	TM 9-2854
Ordnance storage and shipment chart, group G-Major items	SB 9-OSSC-G
Protection of ordnance materiel 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 850-18

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