TM 9-1768A

WAR DEPARTMENT TECHNICAL MANUAL

ORDNANCE MAINTENANCE

TRACTOR TRUCK M20, COMPONENT OF 45-TON TANK TRANSPORTER TRUCK-TRAILER M19, ENGINE, CLUTCH, FUEL SYSTEM, AND COOLING SYSTEM

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WAR DEPARTMENT • *22 JUNE 1945*

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Washington 25, D. C., 22 June 1945

TM 9-1768A, Ordnance Maintenance: Tractor Truck M20, Component of 45-ton Tank Transporter Truck-Trailer M19, Engine, Clutch, Fuel System, and Cooling System, is published for the information and guidance of all concerned.

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The Adjutant General.

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

CONTENTS

	Paragraphs	Pages
CHAPTER 1. INTRODUCTION	1– 2	1– 3
CHAPTER 2. DESCRIPTION	3– 6	4– 10
CHAPTER 3. TOOLS	7– 9	11– 19
SECTION I. Special tools	7– 8	11– 19
II. Improvised tools	9	19
CHAPTER 4. INSPECTION AND TROUBLE SHOOTING	10–25	20– 33
SECTION I. Inspection and trouble shooting before removal or operation	10–13	20– 27
II. Trouble shooting before removal and during operation	14–17	27– 30
III. Inspection and trouble shooting after removal and before operation	18–21	31– 32
IV. Trouble shooting after removal and during operation	22–25	32– 33
CHAPTER 5. ENGINE	26–51	34–133
SECTION I. Description and data	26–27	34– 36
II. Disassembly of engine into subassemblies	28–29	36– 51
III. Overhaul of engine subassemblies	30–47	51–115
IV. Assembly of engine from subassemblies	48–49	115–130
V. Dynamometer run-in test and adjustment	50–51	130–133
CHAPTER 6. CLUTCH	52–55	134–145
SECTION I. Description and data	52–53	134–135
II. Overhaul of clutch assembly	54–55	135–145

	Paragraphs	Pages
CHAPTER 7. FUEL SYSTEM	56– 86	146–226
SECTION I. Description	56	146–151
II. Description of fuel injector pump, governor, and fuel transfer pump assembly	57	151–157
III. Test and adjustments of fuel injector pump, governor, and fuel transfer pump assembly	58– 60	157–169
IV. Disassembly of fuel injector pump, governor, and fuel transfer pump assembly into subassemblies	61	169–170
V. Overhaul of fuel injector pump	62– 64	171–191
VI. Overhaul of governor	65– 68	191–203
VII. Overhaul of fuel transfer pump	69– 71	204–207
VIII. Assembly and test of fuel injector pump, governor, and fuel transfer pump assembly	72– 76	207–213
IX. Fuel nozzles	77– 81	214–222
X. Starter burner	82– 86	222–226
CHAPTER 8. COOLING SYSTEM	87–104	227–253
SECTION I. Description and operation	87– 88	227–229
II. Cleaning cooling system	89	229–232
III. Water pump	90– 93	232–244
IV. Radiator	94– 97	244–247
V. Water outlet manifold and thermostat	98–100	247–249
VI. Fan assembly	101–104	249–253
CHAPTER 9. SERVICEABILITY STANDARDS	105–108	254–262
APPENDIX		
REFERENCES	109–111	263-265
INDEX		266–271

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CHAPTER 1

INTRODUCTION

1. SCOPE.

a. These instructions are published for the information and guidance of personnel responsible for third and higher echelons of maintenance on the Hercules-Diesel Model DFXE engine, clutch, fuel system, and cooling system for the Tractor Truck M20 (component of the 45-ton Tank Transporter Truck-Trailer M19). They contain information on maintenance which is beyond the scope of tools, equipment, or supplies normally available to using organizations. This manual does not contain information which is intended primarily for the using arm, since such information is available to ordnance maintenance personnel in 100-series TM's or FM's.

b. This manual contains a description and procedure for trouble shooting, disassembly, inspection, repair, and assembly of the engine, clutch, fuel system, and cooling system for the Tractor Truck M20.

c. TM 9-768 contains operating and record echelon maintenance instructions on the 45-ton Tank Transporter Truck-Trailer M19.

d. TM 9-1768B contains a description and procedure for trouble shooting, disassembly, inspection, repair, and assembly of the power train, chassis, and auxiliary equipment for the Tractor Truck M20.

e. TM 9-1768C contains a description and procedure for trouble shooting, disassembly, inspection, repair, and assembly of the Trailer M9 (component of 45-ton Tank Transporter Truck-Trailer M19).

f. TM 9-1825A contains a description and procedure for disassembly, inspection, repair and assembly of the electrical equipment on the Tractor Truck M20.

g. TM 9-1827A contains a description and procedure for disassembly, inspection, repair, and assembly of the air brake systems for the Tractor Truck M20 and Trailer M9.

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 Order No. 160 prescribes lubrication maintenance for this vehicle. 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. 461, PREVENTIVE MAINTENANCE SERVICE AND TECHNICAL INSPECTION WORK SHEET FOR WHEELED AND HALF-TRACK VEHICLES. This form will be used for all monthly and semiannual maintenance services and all technical inspections performed on wheeled or half-track vehicles.

(3) W.D., A.G.O. FORM 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 the vehicle, will be used by all personnel completing a modification or major unit assembly (engine, transmission, transfer case, 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, 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
DESCRIPTION

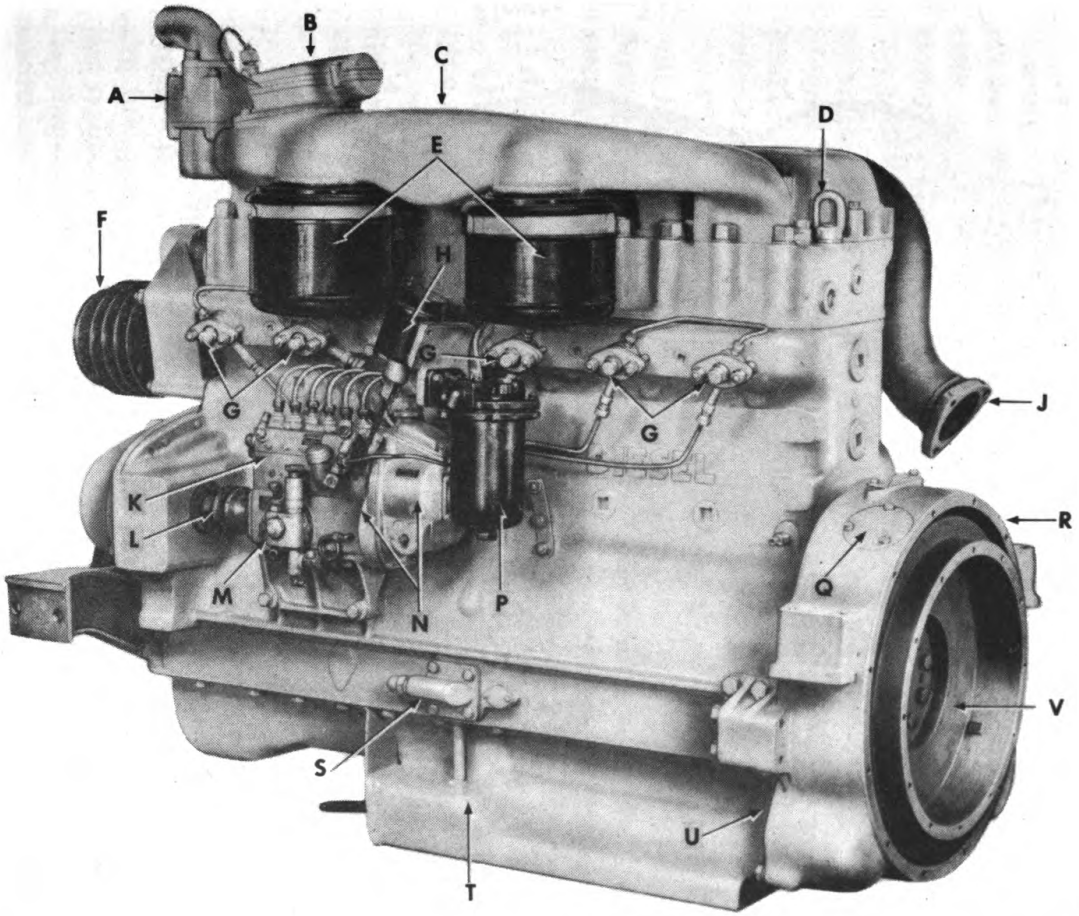
3. ENGINE.

a. Description (figs. 1 and 2). The Hercules-Diesel Model DFXE engine is of the 6-cylinder compression ignition type, with a piston displacement of 839 cubic inches. It develops a maximum torque of 685 foot-pounds at 1,150 revolutions per minute and 660 foot-pounds torque at 1,600 revolutions per minute. The developed brake horsepower at governed speed of 1,600 revolutions per minute is 201. Normal operating temperature is 160° to 180° F. The cylinder block and crankcase are cast integral. Valve mechanism is of the overhead type with the valves located in the two cylinder heads. The crankshaft is supported on seven main bearings. Cylinder bores contain replaceable liners.

4. FUEL SYSTEM (fig. 106).

a. General. The fuel injector assembly, which consists of fuel injector pump, variable speed governor, and fuel transfer pump, is mounted as a unit on the left side of the engine and driven by sprockets and chain from the camshaft. Each of the six elements of the injector pump are connected to one of the six nozzles which inject metered fuel into the cylinder combustion chambers. There are two fuel tanks, one on each side the vehicle, on the frame rail just below the cab. Both tanks are connected to the intake line of the fuel transfer pump, but gate valves are provided so that fuel is drawn from only one tank at a time.

b. Operation. Fuel drawn from the tank by the fuel transfer pump passes through a fuel strainer mounted to the rear of the injector assembly. The filtered fuel then passes through a line and into the gallery of the injector pump where the helical valves of the injector pump meter the fuel, in accordance with timing and calibration setting, to the fuel nozzles under a pressure above 2,000 pounds to the square inch. The spring-loaded nozzles close as soon as fuel pressure drops below 2,000 pounds per square inch; at each stroke a small amount of the fuel passes back through the leak-off manifold through the overflow valve and into the fuel tank through an overflow line. A stop control solenoid connected by lever to the fuel control rack operates to shut off the fuel supply to the injector pump, and stop the engine when the stop push button on the dash is pressed by the operator. A fuel suction line extends from the bottom of the fuel transfer pump (fig. 115) to the starter burner, which is mounted on the forward section of the air intake manifold. The starter burner creates a flame in the air intake manifold, from fuel ignited by a spark, to aid in cold weather starting.



A—THERMOSTAT
B—STARTER BURNER
C—INTAKE MANIFOLD
D—LIFTING EYE
E—AIR CLEANERS
F—FAN PULLEY
G—FUEL NOZZLES
H—STOP CONTROL SOLENOID
J—EXHAUST MANIFOLD FLANGE
K—FUEL INJECTOR PUMP
L—ADJUSTABLE COUPLING
M—FUEL TRANSFER PUMP
N—GOVERNOR
P—FUEL FILTER
Q—FLYWHEEL TIMING HOLE COVER
R—BELL HOUSING
S—OIL PRESSURE REGULATOR
T—OIL PAN
U—GEAR OPENING FOR EXTRA STARTER
V—FLYWHEEL

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Figure 1—Three-quarter Rear View of Engine

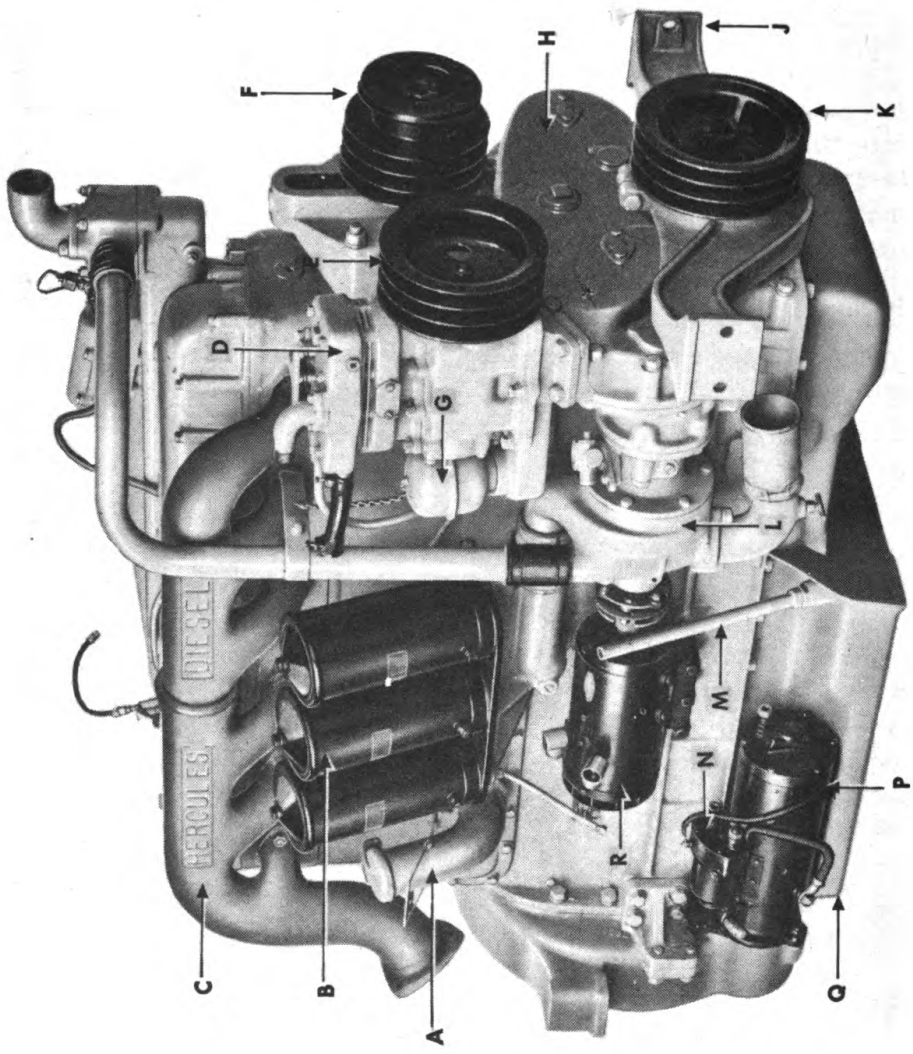


Figure 2—Three-quarter Front View of Engine

c. Fuel Injector Pump.

(1) DESCRIPTION. The fuel injector pump contains six lapped, plunger-type helical valves (fig. 111) which are actuated by a cam. Each valve has an outlet through a high-pressure line to its respective nozzle in accordance with the firing order of the engine. When correctly timed and calibrated this pump meters the fuel accurately and delivers it under pressure at a definite moment and during a fixed time, through the spray nozzles to the combustion chambers of the respective cylinders of the engine.

(2) OPERATION. Cams on the camshaft operate the six plungers inside their respective barrels by means of tappets. The helix on the adjustable plunger controls the amount of fuel driven under pressure to the nozzle (fig. 111). Relation of helix on each of the six plungers to their port holes in the fuel gallery of the pump is controlled by a toothed control rack rod, which meshes with a toothed segment on each plunger (fig. 112). This control rack rod is linked to the governor (H and J, fig. 121) so that when the governor moves this rod inward, the amount of fuel metered by each plunger is equally increased; when rod is pulled outward by the governor, the plungers turn so that the amount of fuel pumped to the nozzles is proportionately reduced.

(3) TIMING. The fuel injector pump is timed with the engine by means of marks on the pump coupling (fig. 133), proper spotting of engine flywheel (par. 101), and adjustment of pump tappets to proper port closing (fig. 115). For timing procedure on test stand, refer to paragraph 58 **b.**

(4) CALIBRATION. Calibration of the pump so that equal fuel will be delivered to each of the six nozzles is accomplished by adjustment of control sleeves (fig. 137). For accurate calibration, it is necessary to use test stand and tubes (par. 58 **c**).

d. Governor.

(1) DESCRIPTION. The governor is of the centrifugal flyweight-type and is gear-driven from the fuel injector pump camshaft. All the working parts of the governor, except the drive gear and disk spring clutch, are contained in the governor end cover which is mounted on the back of the injector pump housing (M, fig. 121). It is necessary to remove the governor end cover to test the fuel injector pump. The shallow part which contains the drive gear, spring disk assembly, and control rack pin is described as the governor housing (F, fig. 121). It is not necessary to remove this housing to test or repair the governor or fuel injector pump, even if necessary to remove the fuel pump camshaft. The governor operating lever, which is at the right-hand side between governor and crankcase, is connected to the throttle lever of the engine and is set to maintain a desired engine speed under a given load. The stop adjustment screws are inside the

stop flange (K, fig. 109); one of these screws limits the travel of operating lever shaft for minimum idling speed, and the other limits the travel of operating lever shaft for maximum speed throttle position.

(2) OPERATION. When the load increases, governor flyweights move inward, releasing tension on the spring and permitting the spring to push the control rack rod of fuel injector inward. This increases the quantity of fuel metered by the injector pump to the nozzles so as to maintain the same steady speed under the additional load. When the load decreases, the flyweights move the sliding sleeve assembly backward, thereby pulling the rack rod outward so that fuel metered to the nozzles is proportionately decreased, thus preventing the engine from speeding up under reduced load. The control rack stop screw (fig. 128) limits the travel of fuel injector pump rack rod inward so that its setting determines the maximum point to which the governor can increase the fuel metered to nozzles, and thus naturally determines the maximum speed at which the governor can set the engine. The bumper spring adjusting screw (H, fig. 109) adjusts tension of the governor spring. This screw is set at the factory and only requires adjustment when the spring tension is too weak to properly move the rack rod.

e. Fuel Transfer Pump.

(1) DESCRIPTION. This pump is mounted on the side of the fuel injector (Z, fig. 109). Working parts consist of inlet and outlet piston valves and a hand-operated priming pump mounted over the outlet valve. These valves are driven by one of the lobes on the injector pump camshaft, which contacts the tappet roller of the fuel transfer pump (B, fig. 121).

(2) OPERATION. The inlet valve draws fuel from the tank and this fuel is discharged by the outlet valve through a tube to the fuel strainer (J, fig. 110); from the strainer, the fuel is forced through a tube to the fuel gallery of the injector pump. Below the inlet line connection, a suction line to the starter burner is connected (G, fig. 110), which draws fuel for use in starter burner when the operator of vehicle uses the starter burner hand pump on the dash (par. 82).

f. Fuel Nozzles (fig. 161).

(1) DESCRIPTION. Each of the six fuel nozzles is composed of a nozzle holder assembly which forms a housing for an adjustable spring-loaded spindle, and which also serves to secure the nozzle proper (pintle valve and body) projected into the combustion chamber in the cylinder head. Spring pressure is adjustable by washers (fig. 155), to permit the pintle to lift from its seat when pressure reaches 2,000 pounds per square inch.

(2) OPERATION. The fuel charge from the injector pump enters the nozzle through a side connection to the pressure chamber directly

behind the valve seat and pintle. Hydraulic pressure moves the pintle valve from its seat against the force of spring pressure, and fuel is sprayed into the combustion chamber at the instant the cylinder reaches the top of the compression stroke. The pintle returns to its seat the instant hydraulic pressure drops below 2,000 pounds per square inch. The small amount of leak-off fuel passes back along the spindle shaft into the spring chamber, and back through the overflow valve through a connecting overflow line.

5. COOLING SYSTEM (fig. 163).

a. General. The engine is cooled by means of air-cooled water circulated through the water passages by means of a centrifugal impeller-type water pump mounted on the right-hand side of the cylinder block and gear-driven from the camshaft gear. Other units which comprise the cooling system are the fan, radiator, thermostat, water outlet manifold, and connecting lines. For instructions on cleaning cooling systems, refer to paragraph 89.

b. Operation. Water is drawn by the water pump from bottom tank of radiator, and passes through water jackets in the crankcase and also through the air compressor bypass. Water then passes through outlet manifold to top tank of radiator. Pressure is maintained in the system slightly above atmospheric pressure by a mechanism in the radiator cap (fig. 164). Temperature of water is regulated by a valve in the thermostat mounted on the forward section of water outlet manifold.

c. Water Pump (fig. 14). The water pump is of the packless, centrifugal impeller type. It is directly gear-driven by the camshaft gear and has spring-loaded water seals which require no attention. The front bearings are lubricated from the timing gear compartment; rear bearings require regular lubrication. The water pump shaft is connected by a flexible coupling to the generator shaft. The tachometer drive gear is installed on the water pump shaft.

d. Radiator (fig. 174). The radiator is of the tube and fin type and consists of the steel outer shell, which includes the top and bottom tanks with side supports, the core assembly, sheet-metal fan shroud, and the filler cap which contains a mechanism to maintain pressure in the cooling system slightly above atmospheric pressure.

e. Fan Assembly (fig. 177). The fan has eight blades and is driven by three V-belts from a pulley on the crankshaft. Adjustment of belt tension is made by means of an adjusting screw in the top of the fan bracket.

6. MODIFICATIONS.

a. Fuel Injector Pump.

(1) BODY. Model APE-6A-90 QK, which supersedes Model APE 6A-90 P on recent models, has a cast-iron body on both injector pump and governor, and some parts required for replacements are different in minor details. Model APE-6A-90 P has an aluminum body. When ordering replacement parts, it is necessary to give full designation of model number. Refer to SNL G-159. Servicing and adjustments on these two models are otherwise the same.

(2) OVERFLOW VALVE. Valve bearing (DT-BB-3873) is obsolete, and has been superseded by valve (DT-BB-13773). The assemblies are interchangeable, but the parts are not. The assembly part number of the new valve (BO-VA-7918-A) is stamped on end of screw.

(3) FUEL TRANSFER PUMP. Cast iron housing, from serial No. 9801799, supersedes aluminum pump (BO-AFP/K-16N-524). Assemblies and parts are interchangeable.

b. Governor Models.

(1) THREE MODELS. There are three models of American Bosch governors in use on this type engine as follows:

Model	Abbreviation
GVA-250/800-B-29	B-29
GVA-250/800-BK-29	BK-29
GVA-250/800-B-29-S	B-29-S

(2) MODELS B-29 AND B-29-S. Model B-29 can be altered to Model B-29-S by replacing the shut-off lever arrangement and set screw with the newly designed shut-off lever arrangement, which utilizes a larger serrated shaft and eliminates the set screw. Governors marked GVA-250/800-B-29-S have already been altered and need not be serviced. Elimination of the set screw is to avoid the possibility of its working loose and causing failure of governor to operate.

(3) MODEL BK-29. This type governor is essentially the same as the B-29-S, except that type BK-29 supersedes types B-29 and B-29-S.

(4) DIFFERENCE IN REPLACEMENT PARTS. Parts especially adapted to one of the three types of governors are so designated by the proper abbreviation (step (1) above) in the listing of parts in SNL G-159.

(5) HOUSING. Up to certain serial numbers, governor housings were made of aluminum, but later serial governors have cast-iron housings. The assemblies are interchangeable.

CHAPTER 3—TOOLS

Section I

SPECIAL TOOLS

7. PURPOSE.

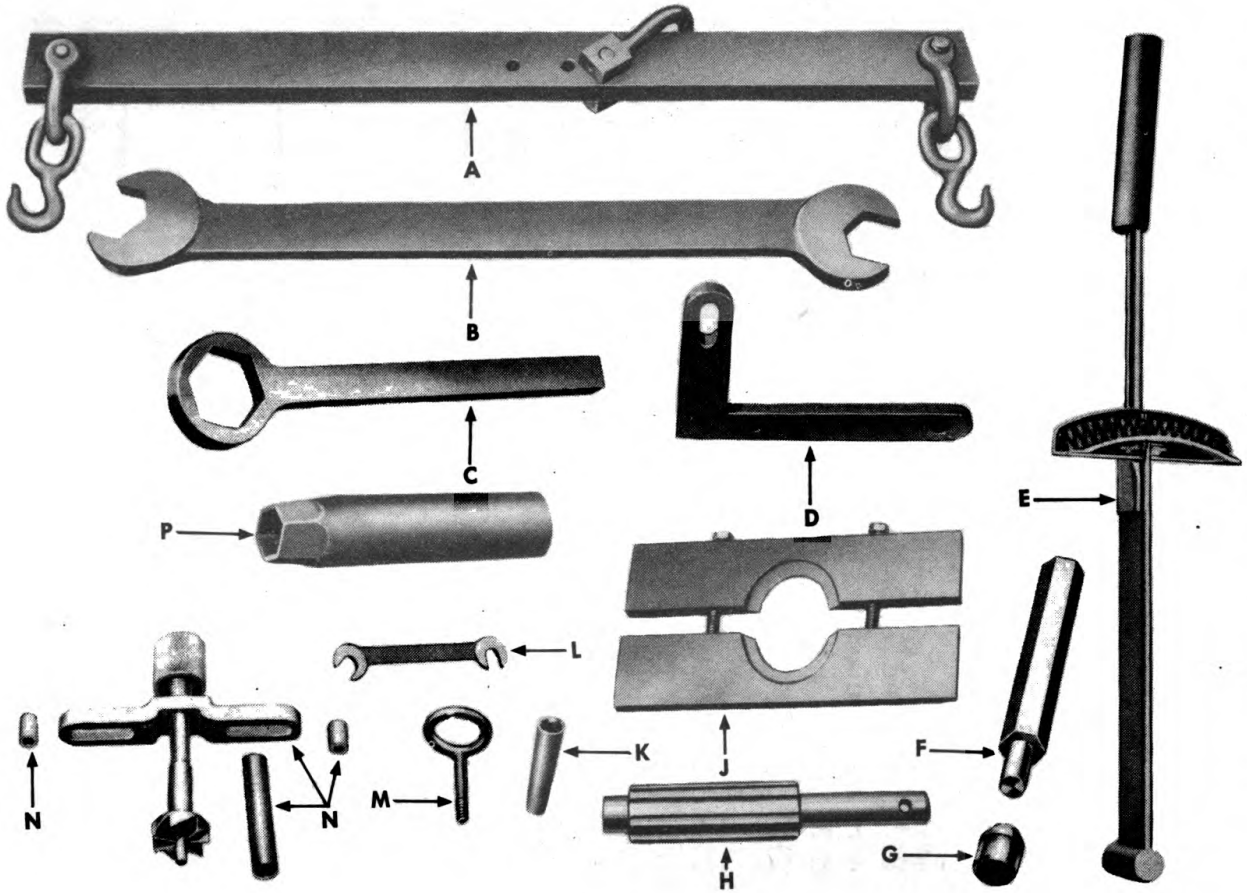
a. The following list of special tools contains only those special tools necessary to perform the operations described in this manual.

b. The following list of special tools is for information only. It is not to be used as a basis for requisition.

8. LISTS OF SPECIAL TOOLS.

a. Engine. The special tools listed in the table below are used on the engine and accessories exclusive of the fuel injector pump, governor, and fuel nozzles, special tools for which are listed in tables under subparagraphs **b**, **c**, and **d**. The tools in the table below are shown in figures 3, 4, 5, and 6, and the set-up for use of each tool is shown in the other figures designated.

Name	Federal Stock Number	Manufacturer's Number
ADAPTER, camshaft bearing, removing and replacing (figs. 3 and 28)	41-A-14-83	———
ADAPTER, sleeve (figs. 3 and 26)	41-A-18-90	———
ADAPTER, stand, engine overhaul (figs. 6 and 11)	41-A-26-730	———
BOLT, eye, lifting. For lifting cylinder heads (figs. 3 and 95)	41-B-1586-75	———
EYE, lifting, engine	41-E-626	TEC-8-108
HANDLE, replacer	41-H-1395-988	TEC-207
PILOT, shock absorber, assembling. (For installing oil seal in fuel pump shaft) (figs. 3 and 68)	41-P-405	J-4339
PLATE, engine lifting	41-P-1542-285	———
PULLER, cylinder sleeve, universal (removing and replacing) (figs. 4 and 26)	41-P-2907-117	———
REMOVER AND REPLACER, bearing, water pump shaft (figs. 3 and 166)	41-R-2374-435	———



A—SLING, ENGINE LIFTING
41-3831-400

B—WRENCH—41-W-1584

C—WRENCH—41-W-639-310

D—PLATE ENGINE LIFTING
41-P-1542-285

E—TORQUE-INDICATING
WRENCH—41-W-3634

F—HANDLE—41-H-1395-988

G—REMOVER AND REPLACER
41-R-2376-445

H—ALINER, CLUTCH PLATE—
41-A-134-480

J—REMOVER AND REPLACER
41-R-2374-435

K—PILOT—41-P-405

L—WRENCH—41-W-1469-100

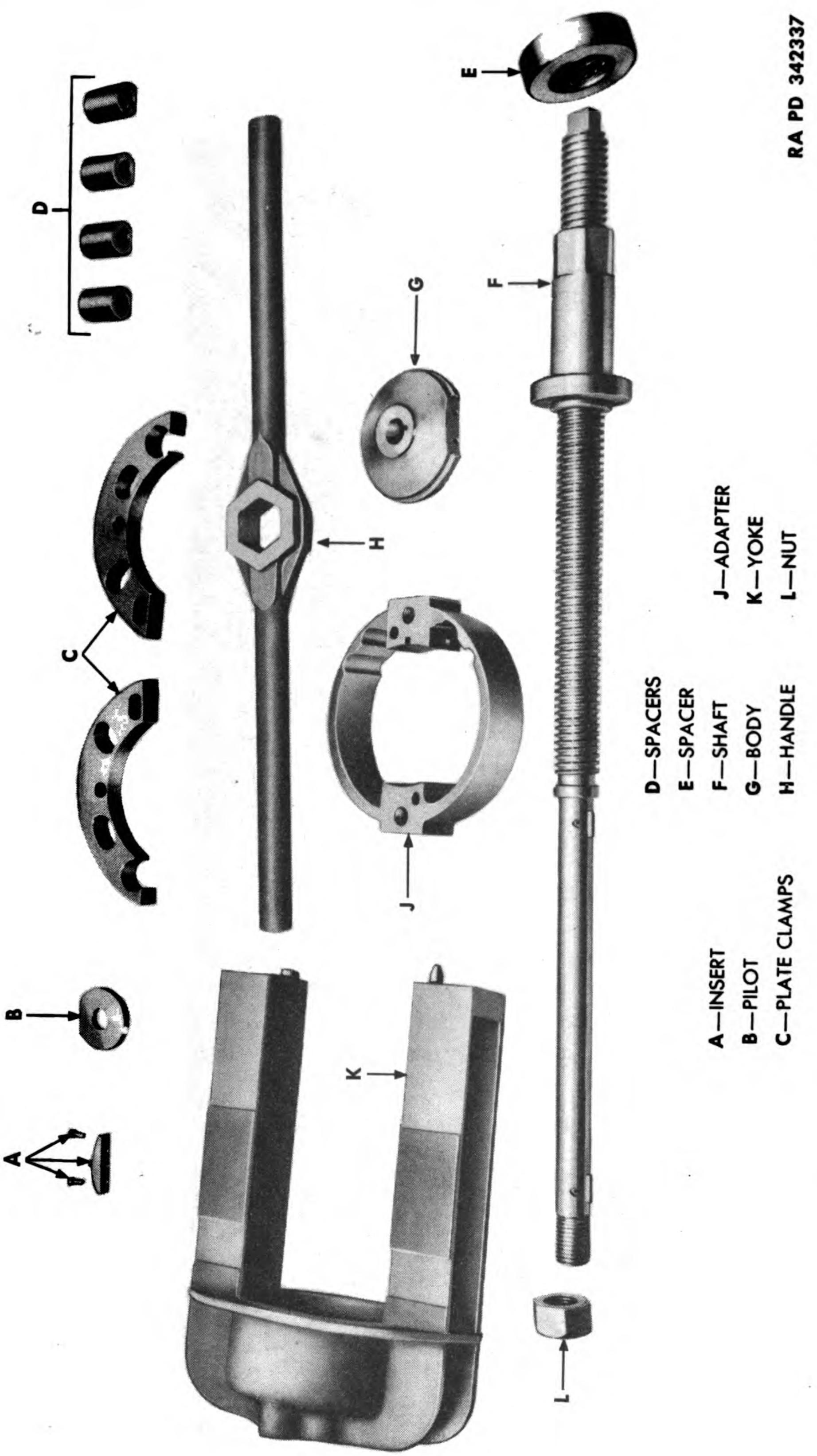
M—BOLT, EYE—41-B-1586-75

N—TOOL—41-T-3095-500
AND ADAPTERS

P—WRENCH—41-W-3059-150

RA PD 350594

Figure 3—Special Tools for Engine



A—INSERT
B—PILOT
C—PLATE CLAMPS
D—SPACERS
E—SPACER
F—SHAFT
G—BODY
H—HANDLE
J—ADAPTER
K—YOKE
L—NUT

Figure 4—Universal Puller (41-P-2907-117) and Adapters (41-A-18-73)

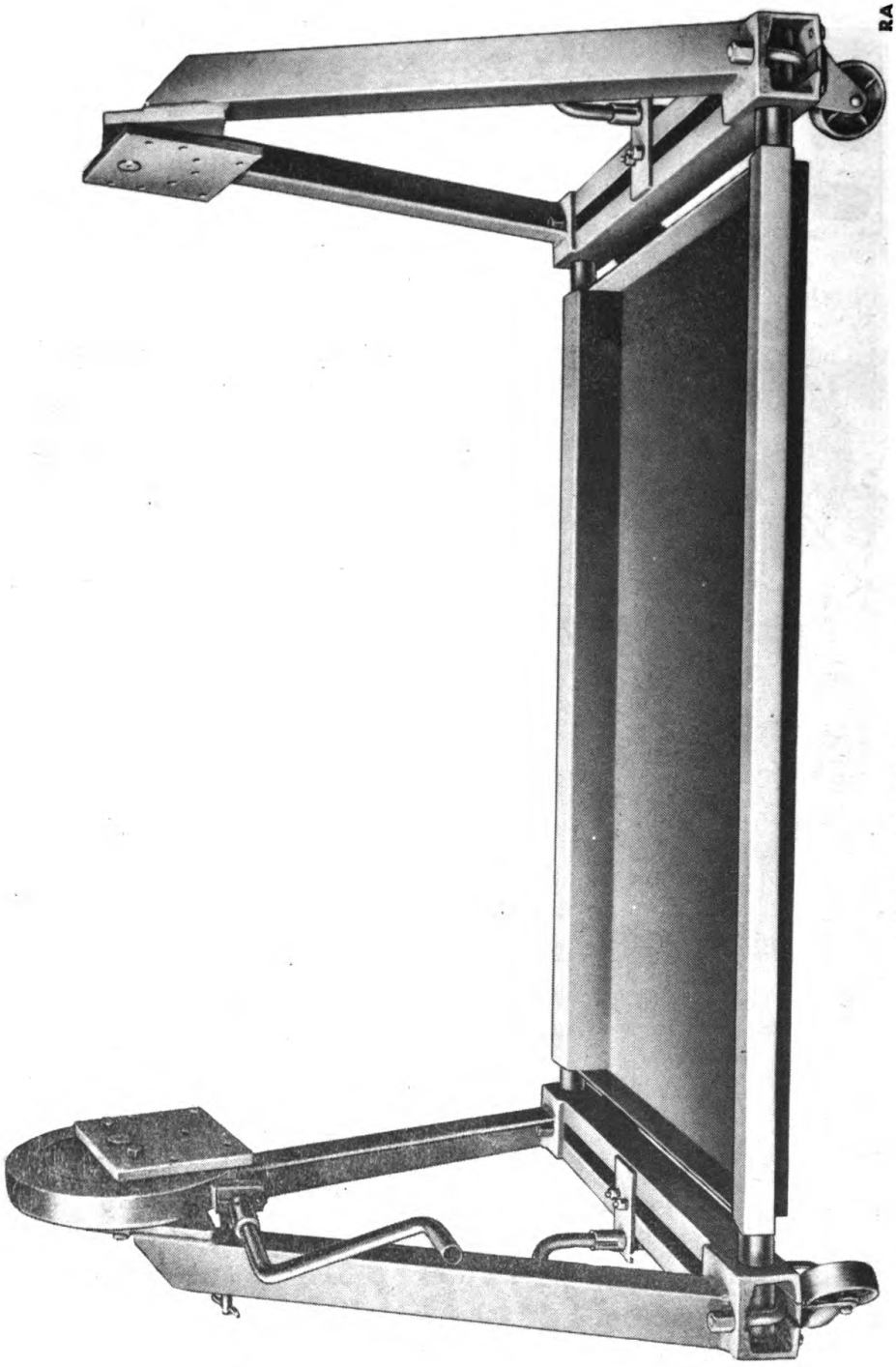


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Figure 5—Engine Stand (41-S-4942-14)

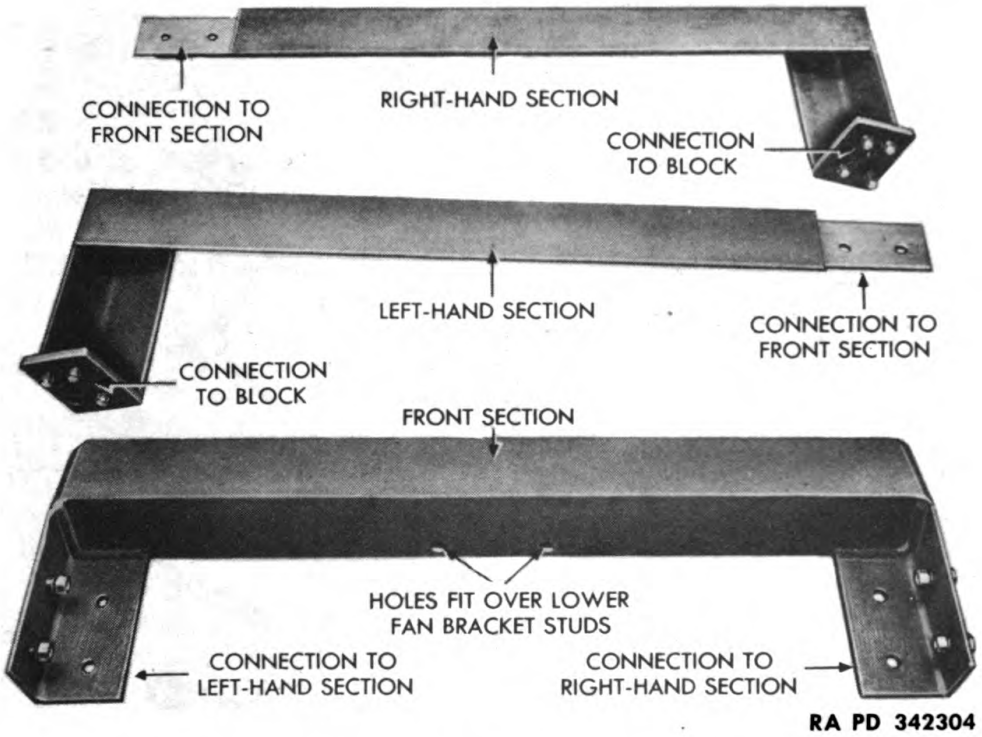


Figure 6—Engine Adapter Stand (41-A-26-730)

Name	Federal Stock Number	Manufacturer's Number
REMOVER AND REPLACER, bushing and oil seal, steering gear	41-R-2377-275	TEC-2-745
REMOVER AND REPLACER, bushing (front axle), steering knuckle (use with standard handle (41-H-1395-988) (figs. 3 and 67))	41-R-2376-445	TEC-8-509
SLING, engine lifting (figs. 3 and 9)	41-S-3831-400	———
STAND, engine, overhaul (figs. 5 and 9)	41-S-4942-14	STY-15035
TOOL, finishing, water pump impeller seat (figs. 3, 168 and 169)	41-T-3095-500	———
WRENCH, box, single end, hex, $2\frac{7}{32}$-in. (figs. 3 and 180)	41-W-639-310	———
WRENCH, engineer's double-head ($\frac{5}{8}$-in., 45- and 90-degree angles) (fig. 3)	41-W-1469-100	TEC-8-114

A—REAMER, CONTROL ROD BUSHINGS (11-MM)—41-R-490
B—FIXTURE, DELIVERY VALVE CHECKING (HERCULES)—17-F-5550
C—EXTRACTOR, DELIVERY VALVE—41-E-538
D—WRENCH, FUEL INJECTION PUMP—41-W-1494-850
E—BIT, SOCKET WRENCH—41-B-647-50
F—HOLDERS, SET, TAPPET (6 PER SET) (HERCULES)—41-H-2374
G—LIFTER, TAPPET—41-L-1396
H—WRENCH, TAPPET, 14-MM—41-W-3571
J—PULLER, PLUNGER—41-P-2951-45
K—PULLER, CAMSHAFT BEARING INNER RACE—41-P-2905-18
L—JAW, CAMSHAFT BEARING PULLER—41-J-312
M—PULLER, CAMSHAFT BEARING OUTER RACE—41-P-2905-12
N—WRENCH, BUSHING, CONTROL ROD—41-W-645-500
P—DRIVER, CAMSHAFT BEARING INNER RACE—41-D-2862-100
Q—RESEATER, INJECTOR SUPPLY PUMP—17-R-6072-150
R—PULLER, GEAR HUB—41-P-2924
S—WRENCH, SOCKET—41-W-2573-25
T—WRENCH, SPANNER, FACE—41-W-3247-716
U—WRENCH, TORQUE—41-W-3628-50
V—PULLER, BEARING, MAGNETO—41-P-2900-30
W—SCALE, SPRING—41-S-509
X—DRIVER, BEARING CAMSHAFT, OUTER RACE—41-D-2862-50
Y—PIN, ADJUSTING, CONTROL SLEEVE—17-P-853

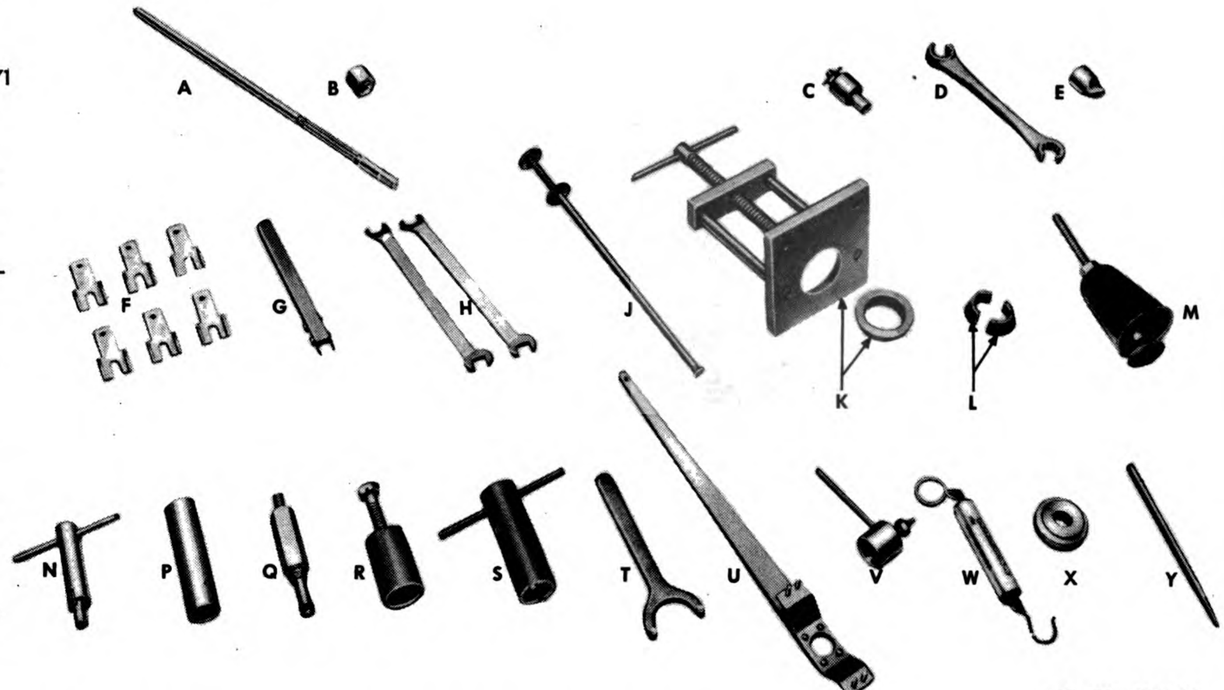


Figure 7—Special Tools for Fuel Injector Pump and Governor

Special Tools

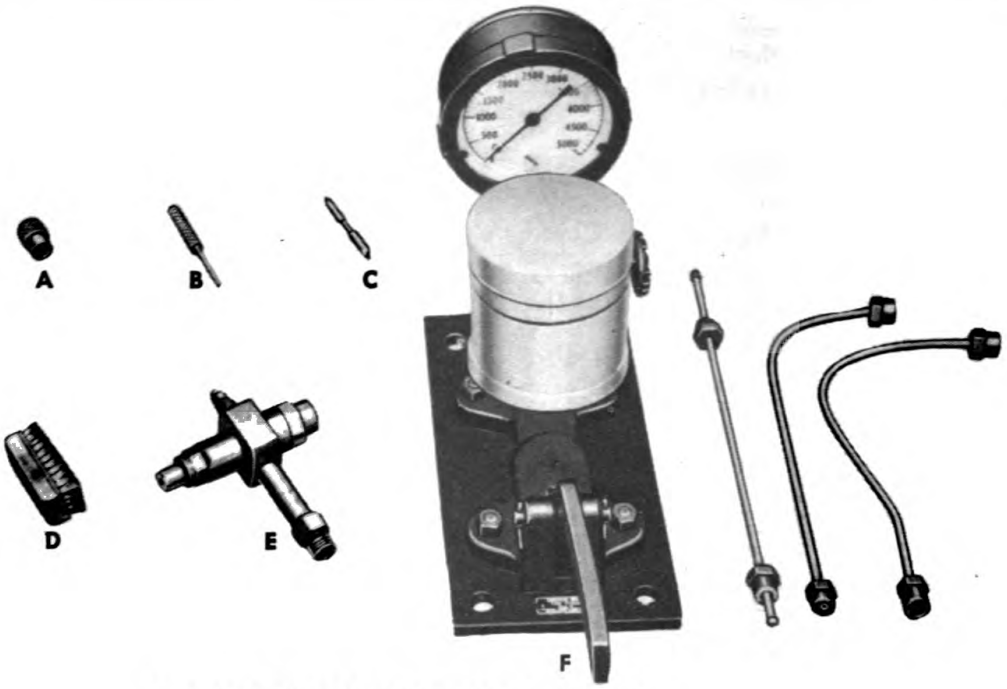
Name	Federal Stock Number	Manufacturer's Number
WRENCH, socket, single end, hex, $1\frac{17}{64}$-in. (figs. 3, 79 and 80)	41-W-3059-150	MAS-14-128
WRENCH, open-end, 15 deg angle, double head, $1\frac{1}{2}$-in. and $1\frac{5}{8}$-in. (figs. 3 and 21)	41-W-1584	TEC-8-113
WRENCH, torque-indicating, $\frac{3}{4}$-in. sq dr, capacity 0-300 ft-lb (figs. 3 and 87)	41-W-3634	STU-F-300-2500

b. Clutch.

ALINER, clutch plate, length 10-inch (figs. 3 and 101)	41-A-134-180	SEV-1-313

c. Fuel Injector Pump and Governor. The special tools listed in the table below are used for special maintenance and adjustments of the fuel injector pump and governor. All of these tools are illustrated in figure 7, and set-up for use of each tool is illustrated in the figures designated in description of each special tool.

Name	Federal Stock Number	Manufacturer's Number
BIT, socket wrench, drag link, $\frac{1}{2}$-in. sq dr, $\frac{5}{16}$-in. width, 0.117-in. thick, $1\frac{5}{8}$-in. long (fig. 122)	41-B-647-50	TSE-7674
DRIVER, bearing, camshaft, inner race (fig. 133)	41-D-2862-100	TSE-76113
DRIVER, bearing, camshaft, outer race (fig. 135)	41-D-2862-50	GMPG-45
EXTRACTOR, delivery valve (fig. 127)	41-E-538	TSE-7682
FIXTURE, checking, delivery valve (figs. 7 and 136)	17-F-5550	TSE-76115
HOLDERS, set, tappet (6 to set) (fig. 124)	41-H-2374	TSE-7692
JAW, puller, camshaft bearing (fig. 132)	41-J-312	TSE-7672
LIFTER, tappet (fig. 123)	41-L-1396	TSE-7688
PIN, adjusting, control sleeve (fig. 116)	17-P-853	TSE-7695
PULLER, camshaft bearing inner race (fig. 132)	41-P-2905-18	TSE-7669
PULLER, bearing, camshaft, outer race (fig. 134)	41-P-2905-12	TSE-7618
PULLER, gear, hub (fig. 145)	41-P-2924	TSE-7920
PULLER, bearing, magneto (fig. 138)	41-P-2900-30	TSE-7916



A—SLEEVE, NOZZLE CENTERING—17-S-7747
B—SCRAPER, PRESSURE CHAMBER—17-S-250-25
C—SCRAPER, NOZZLE BODY VALVE SEAT—17-S-250-65
D—BRUSH, BRASS WIRE, NOZZLE CLEANING—38-B-982
E—NOZZLE, FUEL INJECTOR, ASSEMBLY—G-120-03-11310
F—STAND, NOZZLE TEST AND TUBES—17-S-15550

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Figure 8—Special Tools for Fuel Nozzles

Name	Federal Stock Number	Manufacturer's Number
PULLER, plunger (fig. 124)	41-P-2951-45	TSE-7661
REAMER, control rod bushing (fig. 130)	41-R-490	TSE-7634
RESEATER, injector supply pump valve seat (fig. 149)	17-R-6072-150	TSE-7914
SCALE, spring (fig. 146)	41-S-509	TSE-7927
WRENCH, bushing, control rod (fig. 129)	41-W-645-500	TSE-76128
WRENCH, fuel injection pump (fig. 119)	41-W-1494-850	TSE-7688
WRENCH, socket (fig. 144)	41-W-2573-25	TSE-7919
WRENCH, spanner, face solid (pin type) (fig. 140)	41-W-3247-716	TSE-7917
WRENCH, tappet (fig. 115)	41-W-3571	TSE-7679
WRENCH, torque indicating (fig. 146)	41-W-3628-50	TSE-7928

d. Nozzles. The special tools listed in the table below are for maintenance and test of fuel nozzles. All of these tools are shown in figure 8. Set-up for use of each tool is shown in the designated illustrations.

Name	Federal Stock Number	Manufacturer's Number
STAND, nozzle test (including tubes) (fig. 136)	17-S-5550	TSE-7722B
TOOL SET, injector nozzles, Bosch (Diesel), consisting of:	41-T-3535-500	———
BRUSH, cleaning, brass wire (fig. 156)	38-B-982	MBM-M-17-T-112
SCRAPER, pressure chamber (fig. 159)	17-S-250-25	TSE-7735
SCRAPER, valve seat, nozzle body (fig. 158)	17-S-250-65	TSE-7747
SLEEVE, centering, nozzle (fig. 116)	17-S-7747	TSE-773

Section II
IMPROVISED TOOLS

9. PURPOSE AND USE.

a. Information furnished in this section is intended for Base Shops, Arsenals, and all other corresponding fifth echelon organizations performing major overhaul work on the Hercules-Diesel Model DFXE engine and accessories.

b. The chief value of tools listed and illustrated in this section is to organizations engaged in rebuilding a large number of identical components. These tools are not available for issue; the list is furnished for information only. The following list describes improvised tools and their use, with references to illustrations in which their use is shown:

Name	Figure Reference
BLOCKS, wooden (1 block, 6 inches wide, 17 inches long, and 2 inches thick; 2 blocks, 5 inches wide, 5 inches long, and 2 inches thick). For removing fulcrum rings, lever, and balls from clutch pressure plate.	99
LINES, plumb (consists of two strings and weights). For checking arrows on fuel pump drive sprockets; for vertical timing position.	93
NIPPLE, pipe (1¼-inch inside diameter, 3 inches long). For arbor press set-up when pressing fuel pump driven sprocket on shaft.	71
ROD, steel (½-inch diameter, 8 inches long). For removing nozzle sleeve from cylinder block.	32

CHAPTER 4—INSPECTION AND TROUBLE SHOOTING

Section I

INSPECTION AND TROUBLE SHOOTING BEFORE REMOVAL OR OPERATION

10. GENERAL.

a. Operation of a deadlined vehicle without a preliminary examination can cause further damage to the disabled component and possible injury to personnel. This section describes inspections to be made of the Hercules-Diesel Model DFXE engine and accessories. The inspections are to be made before attempting to operate the vehicle, and for the large part are visual. The object of these inspections is to determine the condition of, and when possible, what is wrong with the power plant. If these inspections do not disclose the fault and the vehicle is operable, proceed as described in section II.

b. Some of the inspections prescribed in this section may be difficult to make while the engine is installed in the vehicle. Such inspections can be postponed until the engine is removed from the vehicle, if defects which will require removal are found early in this inspection procedure. If only the engine is received by the Ordnance organization, the pertinent inspections outlined in this section will have to be made as well as the additional inspections outlined in section III of this chapter.

11. ENGINE.

a. Check for Seizure Due to Internal Damage. If following checks do not reveal defects which may be corrected without further disassembly, remove and overhaul engine (chapter 5).

(1) LOOK FOR EXTERNAL OBSTRUCTIONS. Inspect engine carefully to make sure there is no external damage or obstruction which might prevent engine from being turned over by hand crank.

(2) TURN ENGINE WITH HAND CRANK. Try to turn engine over with hand crank. If it cannot be turned by hand with transmission in neutral, crankcase oil of proper viscosity for prevailing temperatures, and no apparent outside damage or obstruction, internal damage or obstruction is indicated.

(3) INSPECT FUEL PUMP CHAIN. Remove inspection plug from gear cover to make sure chain is not broken. If chain is broken, repair after removal of engine (par. 15).

(4) INSPECT FOR BEARING SEIZURE. Remove oil pan and inspect for bearing seizure or broken connecting rod.

b. Inspect for Signs of Compression Loss. Inspect cylinder heads for any signs of oil leakage at cylinder head gaskets. If any signs of leakage are found, the cylinder head will have to be removed to correct the trouble. It is possible for a cylinder head to bind on one or more of the upper combustion chamber liners so that cylinder head cannot be tightened down on gasket. If this is the cause of leakage, remove cylinder head and file off upper combustion chamber liner enough to allow clearance.

c. Inspect Cooling System.

(1) INSPECT WATER PUMP. Examine water pump connections for any signs of leaks at body or sleeve. If there are leaks at shaft, this may indicate a worn cork washer or other internal damage. Refer to paragraph 92 **c**. Replace any leaking or damaged hose connections. Inspect tachometer drive grease cup for damage and for sufficient grease. Replace if damaged.

(2) INSPECT WATER MANIFOLD AND THERMOSTAT BY-PASS.

(a) Water Manifold. Inspect gasket points at block and at thermostat housing for signs of leaks. Inspect plugs. Replace defective gaskets or plugs. Inspect body of water manifold for any signs of cracks or rust holes. Replace manifold if cracked or damaged by excessive rust.

(b) Thermostat Housing and By-pass Tube. Inspect hose connection of by-pass tube to thermostat housing. Replace if defective. Inspect thermostat housing and elbow for any signs of leakage or cracks. Inspect stud nuts. Replace any defective part. Inspect small hose which connects by-pass tube to air compressor. Replace if leaky, cracked, or decaying.

(3) INSPECT RADIATOR. Examine radiator core for damage which may cause clogging or leaks. Examine water outlet hose connection and replace hose if leaky or decaying. Inspect radiator cap to see that relief mechanism is not damaged and that cap fits tightly in place. Replace cap if defective. Inspect overflow pipe for signs of bends or looseness at connection. Repair if loose or bent.

(4) INSPECT FAN ASSEMBLY. Examine fan, fan pulley, bracket, and belts for any signs of damage. Inspect adjusting screw and bracket nuts. Repair or replace any damaged part (par. 103).

d. Inspect Electrical System.

(1) BATTERIES. Check batteries for proper connections. Look for excessive acid corrosion. Test each battery cell with hydrometer to make sure batteries are correctly charged and cells are not dead. Clean, charge, or replace battery as its condition may require.

(2) STARTER AND SOLENOID. Examine starter to see that connections are intact. Inspect brushes and test brush spring tension. Examine solenoid switch connections. See if solenoid is stuck. If

solenoid is stuck, make a note to check flywheel ring gear for damaged teeth when engine is removed from vehicle. Refer to TM 9-1825A for servicing details.

(3) GENERATOR. Inspect connecting lines for damage or looseness. Tighten loose lines and replace damaged, broken, or poorly insulated lines. Remove cover and see if brushes are present, in good condition, and properly adjusted; adjust or replace as needed. Examine flexible coupling to see that all bolts, nuts, and cups are correctly installed and in good condition; replace any damaged parts of coupling. See that generator mounting bracket is securely fastened to block and not cracked; replace bracket if defective. Refer to TM 9-1825A for servicing details.

(4) STARTER BURNER. Inspect electrical and fuel lines and connections. Replace if damaged or worn. Inspect cover, gasket connection, and body for signs of damage or leaks. Replace any damaged part.

e. Inspect Intake Manifold. Examine body of manifold for any signs of cracks or other damage. Replace if cracks are large and weld, if small. Inspect gasket connections at cylinder block, at air cleaner connections, and at starter burner connection for any signs of leaks or defective gaskets. Examine attaching cap screws and lock washers for presence and good condition. Replace gaskets or damaged cap screws.

f. Inspect Air Cleaners. Inspect air cleaners for cleanliness of elements, secure attachment, and good condition. Clean dirty elements, or replace if damaged. Examine top and skirt. Replace if damaged beyond ordinary repair. Examine bowls for any dents or any signs of holes which may result in oil leaks. Replace entire unit if damage is serious.

g. Inspect Exhaust Manifold. Inspect gasket connections for any indication of smoke leak or portions of gaskets blown out. Examine stud nuts for presence, tightness, and good condition. Replace damaged gaskets, nuts, or studs. Inspect telescoped joint for signs of looseness or exhaust leaks, and each section for signs of cracks. Replace section that is cracked too severely for welding (par. 39 **b**). Inspect cap screws and lock washers at connection of exhaust manifold to front tail pipe. Tighten if loose; replace if damaged.

h. Inspect Gear Cover. Some parts of gear cover are difficult to inspect while engine is in vehicle; therefore, if the engine is to be removed these inspections can be postponed until engine is mounted in the stand.

(1) CONNECTIONS. Inspect for cracks in body and for damage at air compressor bracket mounting. If gear cover is cracked, it must be welded or replaced. Examine mounting bolts for presence, tightness, and good condition. Tighten or replace.

(2) THRUST PLATES AND SHIMS. Inspect thrust plate flanges and attaching cap screws and lock washers for signs of damage. Remove the two holding cap screws and examine surface of each thrust plug. If right-hand thrust plug (facing front of engine) is worn or damaged, it may indicate incorrect shim adjustment and improper end play of fuel pump driven sprocket. The same condition would be indicated if left-hand thrust plug is worn or damaged, indicating incorrect end play of camshaft (par. 41 c (2) *(a)*).

(3) INSPECTION PLUG AND FUEL PUMP DRIVE CHAIN. Remove and inspect the inspection plug. Replace plug if threads are damaged. While plug is removed, check tension of fuel pump drive chain, and adjust if necessary (par. 49 l).

(4) ADJUSTING SCREW ASSEMBLY. Inspect adjusting screw clamp and attaching cap screw and lock washer. Replace if damaged. If there is an oil leak at clamp, it indicates a defective cork seal which must be replaced. Inspect threads of adjusting screw; replace screw if threads are stripped or flattened, or if screw eye is worn or damaged. Replace adjusting screw castle nut and cotter pin if broken or damaged.

i. Inspect Drive Pulley and Crank Grab. Inspect drive pulley and crank grab for any signs of damage. Replace broken crank grab. If there is an oil leak at drive pulley, it indicates a defective oil seal which must be replaced at disassembly.

j. Inspect Front Engine Support. Inspect support for any signs of cracks or damage. Cracked support must be replaced. Inspect clamp bolt, nut, and lock washer for good condition. Replace if damaged. Test tightness of clamp shim with screwdriver to see that clamp is drawn up tight. Tension of clamp must be correctly adjusted with shims. Inspect front support spacers for cracks; cracked spacers must be replaced (fig. 73). See that mounting bolts, castle nuts, and cotter pins are present, secure, and in good condition; replace any of these parts that are damaged.

k. Inspect Air Compressor. Inspect all mounting connections for signs of leaks. Inspect air, water, and lubricating oil connections for leaks. Inspect cylinder head, body, and sump casting for signs of damage or cracks. Refer to TM 9-1827A for servicing details.

l. Inspect Breather Cap and Pipes. See that breather cap chain is present and correctly attached. Examine cap for fit on pipe or any signs of excessive damage; replace if unserviceable. Inspect breather pipe for dents or damage at top; repair or replace if dented or damaged.

m. Inspect Oil Pan Assembly. See that oil pan is securely installed. Inspect for evidence of oil leaks at cylinder block or at strainer gasket. If leaks are indicated, gaskets must be replaced. Remove

drain plug and washer; inspect plug for stripped threads or other damage, and washer for good condition; replace if defective. Examine bayonet gage tube to see that it is securely installed and not bent; inspect for stripped threads; replace if seriously damaged. Inspect bayonet gage; replace if unserviceable.

n. Inspect Oil Filter Assembly. Remove covers from the three oil filters and examine element for any signs of damage or clogging; clean if clogged, and replace if damaged. Inspect gasket, spring, cover, washer, and clamp bolt of each filter; replace any of these parts if damaged or defective. Remove drain plug from bottom of each filter body and the plug in bottom of bracket; replace any of these plugs that are damaged; replace entire filter if plug threads in body are damaged so as to cause leaks. Examine bracket and integral water pipe for cracks; replace bracket, if seriously damaged or if cracked. Examine bracket mounting nuts and lock washers for presence, tightness, and good condition; replace if broken or damaged. Examine slotted water plug at end of pipe for presence and tightness; replace if damaged.

o. Inspect Oil Pressure Regulator. Remove cap nut and examine inside threads of cap nut and threads of adjusting screw and lock nut; replace if damaged. Examine body and flange for cracks; replace body if cracked or if threads are badly damaged. If attaching cap screws and lock washers are securely installed and there are signs of oil leaks at flange, it indicates a defective flange gasket; replace gasket. If adjusting screw turns in very easily, it indicates a broken or weak spring; replace spring (fig. 81).

p. Inspect Viscometer Instrument. Examine body of instrument for cracks or damage; replace the nut if body is cracked or damaged. Examine oil lines and connections; replace lines if leaking. Remove and examine cleaning plug, and examine threads and internal threads in body; replace the unit if plug or internal threads are seriously damaged. Remove screen plug and screw, and examine for damage; if either are damaged, replace the unit. Look for leaks at flange connection, and if any are found, replace gasket.

12. FUEL INJECTOR, TRANSFER PUMP, GOVERNOR, AND FUEL LINES.

a. Inspect Fuel Injector Pump Coupling.

(1) TIMING MARKS. Inspect rear hub to see that timing mark is lined up with mark on pump flange as shown in figure 133. Also check "0" marks on flange disk and adjustable front hub flange to see that these marks are lined up. If these marks are not lined up, bear this in mind during trouble shooting procedure outlined in paragraph 16, so that incorrect timing can be corrected.

(2) INSPECT FLANGES. Inspect flanges of coupling and the connecting cap screws and lock washers. Also inspect flange disk for any signs of damage. Replace adjustable flange or disk if either of these parts are damaged seriously.

b. Inspect Fuel Lines. Inspect all connecting fuel lines to injector pump, transfer pump, and overflow valve, to see that they are properly and securely connected (fig. 110). Examine the loom-covered line from transfer pump to starter burner to make sure it is correctly installed and not damaged. Inspect the loom-covered pressure line from injector pump gallery to pressure gage to make sure it is connected properly and not damaged. Examine all connections shown in figure 128 for leaks. See that high-pressure flexible lines from the six delivery valve elements to nozzles are properly and securely connected, and that none of these lines are dented or otherwise damaged. Look for any signs of leaks at connections of lines. Replace any defective or leaking lines or fittings.

c. Inspect Fuel Tanks and Lines. Trace the line from fuel inlet connection on fuel transfer pump, to see that connections are correctly made at transfer pump and at both fuel tanks. Check tanks for leaks, caps for clogged condition, and straps for breaks or looseness. Leaking tanks, defective straps, or damaged caps must be replaced. See that gate valve is turned on at tank in use, and that gate valve at tank not in use is turned off. Inspect both valves for signs of leaks or damage; replace if defective.

d. Inspect Fuel Transfer Pump and Hand Primer. Inspect the hexagon spring retaining screw in center of pump for signs of leaks at gasket. Examine valve retaining screw, and hand primer connection for leaks. If leaks are evident, replace gaskets. Examine hand primer for signs of damage. Operate hand primer to see if it is stuck. If hand primer is damaged, replace the entire primer unit; if stuck, it must be cleaned and tested again. If fuel transfer pump is suspected of malfunction, disconnect discharge line, operate hand primer and note whether or not oil flows from discharge line opening; if no oil flows after working hand primer two minutes, the fuel transfer pump must be removed and tested (par. 60).

e. Inspect Fuel Strainer. Examine connecting fixture for line from fuel transfer pump and fixture for line to injector gallery. Inspect strainer head, vent valve, and filler plug for leaks or damage. If there is evidence of leaking at head, head gasket must be replaced. Examine drain plug at bottom of unit for any signs of damage or leaking. Replace plug if damaged; install new gasket if leaking.

f. Inspect Oil Filler Cover and Oil Level Cock. Remove oil filler cover and inspect cover for any signs of damage. Replace if

damaged. Open oil level cock and if oil does not drain, inspect for clogged condition. If oil level cock is damaged or defective, replace it.

g. Inspect Stop Control Solenoid. Inspect stop control solenoid linkage to see that it is properly connected to governor fuel shut-off lever. Examine mounting bracket and cap screws for any signs of damage or looseness. Inspect solenoid wire connections. See that fuel shut-off lever is securely installed and properly connected to its spring. Replace any broken or defective part.

h. Inspect Governor End Cover (fig. 109).

(1) BREATHER CAP. Remove and inspect breather cap. If damaged, it must be replaced.

(2) INSPECTION CAP. Examine inspection cap at gasket for leaks, and lock wires on nuts for any signs of tampering. If there is any reason to suspect malfunction of governor, inspection cap can be removed for examination of internal parts. If this inspection reveals internal damage, governor must be overhauled at disassembly.

(3) END CAP. Inspect governor end cap at gasket for any signs of leaks. If leaky gasket is indicated, replace it. Inspect attaching cap screws and lock washers for presence and secure installation, and see that lock wires are not broken. Replace damaged or broken wires, or damaged cap screws.

(4) STOP FLANGE AND DUST COVER. See that stop flange side cover plate is securely installed and not damaged. Examine dust cover to make sure attaching screw is securely installed. Dust cover can be removed and speed-adjusting screws examined if poor speed regulation has been reported. Replace any damaged part. **NOTE:** *Refer to paragraph 73 for adjustment of governor on engine. Governor spring can be removed and replaced with new spring without removing governor.*

13. FUEL NOZZLES.

a. Inspect High-pressure Lines. Examine high-pressure lines and their connections at nozzles for any signs of dents, kinks, or leaks. Replace any defective lines or connecting fixtures. See that high-pressure lines are correctly installed to nozzles and injection pump elements in accordance with firing order of engine, 1-5-3-6-2-4. Inspect each nozzle at the block and at high-pressure and by-pass connections for any signs of fuel leaks. Nozzle leaks may be caused by a damaged or defective nozzle sleeve (fig. 32). Refer to paragraph 78 for method of testing nozzles, and test any nozzle suspected of malfunction.

b. Inspect Nozzle Overflow Lines. Examine connecting unions of overflow lines for signs of leaks. Examine overflow lines from nozzles to overflow valve, and at brazed nozzle outlet connections for any signs of leaks or damage. Defective line must be repaired or replaced.

c. Inspect Nozzle Flange and Cap Nut. Examine attaching flange and holding nut on each nozzle to see that nozzle is securely installed to block. Test each cap nut with a wrench to see that it is not loose, as a loose nut may cause loss of pressure.

Section II

TROUBLE SHOOTING BEFORE REMOVAL AND DURING OPERATION

14. GENERAL.

a. If inspections in section I do not reveal causes of failure, and the engine is operable, trouble shoot it. The trouble shooting operations described in this section are beyond the normal scope of second echelon organizations. They are used to determine if the fault can be remedied without removing the engine from the vehicle and also, when subsequent removal is necessary, to indicate when repair can be made without complete disassembly of the component. Check the trouble shooting section in TM 9-768 to be sure the trouble is not a defect normally corrected by using organizations.

b. In checking the possible causes of trouble, it will save time and needless disassembly if the most accessible suspected defects are investigated first to see if they are causing the trouble. If correction of the most accessible defects stops the trouble, needless disassembly will be avoided. Remedies suggested in the subparagraphs of this section are listed in the order of their difficulty; check and try the remedies in the order given unless the cause of trouble is clearly evident.

15. ENGINE.

a. Unusual Noises. If inspection has shown that the engine is operable, start the engine and allow it to operate 4 or 5 minutes. Listen for knocks or other unusual noises. NOTE: *When the engine is operating normally it makes considerable noise, but the trained ear can detect noises which indicate trouble.*

(1) NOISES WHILE ENGINE IS IDLING.

(a) Noise at Front of Engine. Stop engine immediately, remove inspection plug from gear cover, and inspect to see if fuel pump drive chain is visible and properly adjusted. If chain is visible and adjusted, it will be necessary during overhaul to inspect sprockets for wear; replace sprockets if worn. If chain is not visible in inspection hole, the noise is caused by a broken chain which will have to be repaired or replaced at overhaul.

(b) Squeaking Noise in Generator. Check lubrication and look for worn bearings. Correct the trouble as outlined in TM 9-1825A.

(2) NOISES WHILE ENGINE IS UNDER LOAD.

(a) Metallic Knock. Make a note to look for worn pistons, worn or damaged cylinder liners, or worn or sticking piston pins, when engine is removed from vehicle for overhaul.

(b) Regular Heavy Knock. Remove oil pan and look for worn bearings.

b. Engine Overheats.

(1) CHECK COOLING SYSTEM. Disconnect water inlet to air compressor and start engine to determine circulation. If there is no circulation, remove water pump and repair (pars. 91, 92, and 93). If water begins to circulate but pressure drops off, blocking of cooling system is indicated. Clean and flush the cooling system (par. 89).

(2) CHECK LUBRICATION SYSTEM. Remove oil pan and examine oil lines and connections at oil pump and cylinder block for breakage or damage. Replace pipe assembly if damaged beyond repair.

16. FUEL INJECTOR, TRANSFER PUMP, AND GOVERNOR.

a. Engine Missing Badly or One Cylinder Cuts Out. If filters and fuel lines are in good condition, this fault may be due to one of the following conditions in fuel system:

(1) FUEL TRANSFER PUMP VALVES STUCK OR SPRING BROKEN. Clean sticking valves or replace spring (par. 69). Test (par. 60).

(2) STICKING FUEL PUMP DELIVERY VALVE OR SPRING BROKEN. Remove valve holder and inspect and test as instructed in paragraph 63 b (7). Clean valve or replace spring.

b. Governor Action Rough and Fuel Injector Sleeves Oscillate. This indicates that spring disk on governor drive gear is too tight. Governor end cover will have to be removed (par. 61 a), and tension on spring disk adjusted by removing spacers (par. 67 b (1) *(b)*).

c. Slow Surge of Fuel Injector Sleeves. This indicates that spring disk on governor drive gear is too loose. Check spring tension (fig. 146) after governor end cover is removed, and add spacers to secure correct tension (par. 67 b (1) *(b)*).

d. Engine Speeds Up Under No Load. This indicates malfunction of governor. If governor cannot be adjusted on engine (par. 73), remove governor end cover and disassemble sufficiently to locate and correct the trouble (pars. 65 and 66).

e. Engine Does Not Develop Full Power.

(1) FUEL SUPPLY RESTRICTED.

(a) Dirt in Fuel Transfer Pump. Remove pump, clean valves and springs; resurface valve seats if necessary (par. 70 c). Replace defective parts. Test on test stand (par. 60).

(b) Defective Valve in Fuel Transfer Pump. Replace valve.

(c) Broken or Weak Valve Spring in Fuel Transfer Pump. Replace spring.

(2) IMPROPER TIMING OF FUEL INJECTOR PUMP. See paragraph 58 b.

(3) IMPROPER CALIBRATION OF FUEL INJECTOR PUMP. See paragraph 58 c.

f. Excessive Fuel Consumption.

(1) IMPROPER INJECTOR PUMP TIMING. See paragraph 58 b.

(2) IMPROPER INJECTOR PUMP CALIBRATION. See paragraph 58 c.

g. Fuel Pressure Too Low. If there are no leaks or clogged fuel lines or filters, this trouble may be due to one of the following causes:

(1) OVERFLOW VALVE STUCK OPEN. Disconnect and remove overflow valve. Clean valve while holding it open. If cleaning does not correct trouble, disassemble and repair, or replace (par. 63 b (13)).

(2) WEAK INJECTOR PUMP DELIVERY VALVE SPRINGS. Remove delivery valve and replace spring (par. 62 p).

h. Engine Stalls Under Normal Load. If this trouble is not found to be due to compression loss or improper fuel, check the following:

(1) IMPROPER INJECTOR PUMP TIMING. Time injector pump (par. 58 b).

(2) DEFECTIVE FUEL TRANSFER PUMP. Inspect for sticking valve. Clean or replace valves. If sticking valves are not the cause of trouble, test pump (par. 60).

(3) MALFUNCTION OF GOVERNOR FULCRUM YOKE ASSEMBLY. Remove governor end cover and disassemble sufficiently to locate trouble (par. 65).

i. Engine Stops Suddenly.

(1) FUEL INJECTOR DRIVE COUPLING OUT OF TIME. Time drive coupling (pars. 74 or 75).

(2) BROKEN FUEL PUMP DRIVE CHAIN. Remove gear cover and repair or replace chain.

(3) FUEL TRANSFER PUMP NOT WORKING. Look for sticking valve. Clean or replace (par. 70 c). Test pump (par. 60).

j. Increased Smoke at Exhaust.

(1) FUEL PUMP DRIVE CHAIN LOOSE. Adjust (par. 49 m).

(2) DIRTY NOZZLES. Clean nozzles (par. 80) and test (par. 78).

(3) FUEL INJECTOR DELIVERY VALVE STUCK. Repair or replace (pars. 62 o and 63 b (7)).

(4) FUEL INJECTOR DELIVERY VALVE SPRING BROKEN. Replace spring (subpar. g (2) above).

(5) EARLY OR LATE INJECTION TIMING. Time injector pump with engine (par. 74).

k. Fuel Knocking in Engine.

(1) DEFECTIVE NOZZLES. Test nozzles (par. 78), and replace if necessary.

(2) STUCK FUEL DELIVERY VALVE IN INJECTOR PUMP. Clean or replace spring (par. 62 b).

(3) BROKEN INJECTOR DELIVERY VALVE SPRING. Replace (par. 62 o).

17. FUEL NOZZLES.

a. White Smoke at Exhaust. If there is white smoke at exhaust when engine is warming up and when operating under load, this indicates one or more of the following nozzle defects:

(1) FUEL NOZZLE LEAKING. Replace.

(2) LOW FUEL NOZZLE OPENING PRESSURE.

(a) Defective Nozzle Spring. Test nozzle and adjust or replace spring (par. 78).

(b) Incorrect Thickness of Adjusting Washers (fig. 155). Make test (par. 78) and install washers of correct thickness.

(c) Damaged Nozzle Sleeve. Replace sleeve (par. 31 c (11)).

(d) Identify Defective Nozzle. Locate the cylinder where there is loss of compression, if possible; otherwise, remove all six nozzles and test each for low pressure (par. 78). NOTE: *Do not attempt to adjust nozzle pressure without using the proper testing fixture, such as shown in figure 154.*

Section III

INSPECTION AND TROUBLE SHOOTING AFTER REMOVAL AND BEFORE OPERATION

18. GENERAL.

a. After the component has been removed from the vehicle, further inspection is necessary to verify the diagnosis made when the component was in the vehicle, to uncover further defects, or to determine faults if only the component is received by the Ordnance establishment. This inspection is especially important when only the component is received, because it is often the only means of determining the trouble without completely disassembling the component.

19. FLYWHEEL.

a. Clutch Face. Inspect clutch face of flywheel for any signs of pitting or friction heat checks. Check clutch face squareness with dial gage, as shown in figure 92 (par. 49 f (5)).

b. Clutch Pilot Bearing. Turn bearing to see if it is too loose in the bore. Remove the bearing with standard puller and examine it for cracked, pitted, or scored balls or races. If bearing is too loose or balls and races are defective, replace the bearing.

c. Pilot Bearing Bore. Check for pilot bearing bore run-out as shown in figure 88 (par. 49 f (4)).

d. Ring Gear. Remove the flywheel as shown in figure 15, using bolts against the two dowels; inspect ring gear for broken or worn teeth. If teeth are badly damaged, ring gear will have to be replaced. **NOTE:** *Damaged ring gear teeth indicate malfunction of starter solenoid switch and similar damage of starter gear. This trouble will also have to be corrected (TM 9-1825A).*

e. Pilot Surface. See that flywheel pilot surface is polished smooth to prevent damage to oil seal in bell housing. Polish with crocus cloth.

20. BELL HOUSING.

a. Casting. Inspect casting for cracks or damage at bolt holes, timing hole, or face. Inspect mounting brackets at sides of casting for any signs of damage caused by stress. Replace bell housing if cracked. Check attaching cap screws and lock washers; replace damaged parts.

b. Face Run-out. Remove flywheel and check bell housing for face run-out as shown in figure 90. Set gage to avoid button entering cap screw holes. If run-out is more than 0.006 inch, housing will have to be refaced on a machine lathe.

c. Bore Run-out. Check for housing bore run-out as shown in figure 91. If run-out exceeds 0.010 inch, shift bell housing until reading is 0.010 inch or less.

d. Bell Housing Seal. Inspect seal for any signs of damage or oil leaks. If seal is excessively dented or if oil leaks are found, bell housing will have to be removed and a new seal installed. Drive out old seal, using a piece of wood and hammer. Drive from outside toward inside of housing. Install new seal as shown in figure 54. Keep bore of seal concentric with crankshaft.

21. ENGINE.

a. Turn the crankshaft by hand to check for internal breakage which would prevent engine from operating.

b. Examine cylinder head covers, crankcase, and oil pan for damage or cracks which permit oil or water leaks.

c. Examine all accessories for secure mounting, and for damage which would affect engine operation.

d. Remove and test fuel injector pump (par. 58 **b**), fuel transfer pump (par. 60), and fuel nozzles (par. 78).

Section IV

TROUBLE SHOOTING AFTER REMOVAL AND DURING OPERATION

22. GENERAL.

a. Trouble shooting a disabled component after it has been removed from the vehicle consists of subjecting it to tests on a dynamometer and testing fuel injector pump on test stand. This section discusses those symptoms which can be diagnosed by using the testing equipment and interprets the results in terms of probable causes.

23. ENGINE.

a. Dynamometer Test. Mount engine on dynamometer stand and make the test as outlined in paragraph 51. Check for symptoms of trouble during the test and apply the remedy indicated by diagnosis.

b. Unusual Noises. Refer to paragraph 15 **a**.

c. Smoke at Breather Pipe.

(1) Check oil level to make sure oil pan is not overfilled.

(2) PLUGGED OPENINGS IN OIL CONTROL RINGS. Clean rings; replace if damaged or worn. Check gap which should be 0.018 to 0.022 inch.

(3) WORN CYLINDER BORE LINERS. Check for wear, scoring, and out-of-round. Standard bore is 5.6245 to 5.6250 inches; out-of-round limit allowable is 0.012 inch; wear limit at complete overhaul is 0.006 inch. Do not attempt to hone cylinder liners; replace as described in paragraph 31 **c** (8).

d. Low Power Output.

(1) If engine is missing, test nozzles (par. 78); check timing of fuel injector pump with the engine (par. 74); and check governor adjustments (par. 73). If engine performance is erratic after governor adjustment, test fuel injector pump for timing and calibration (par. 58).

(2) Look for oil leaks at cylinder head gaskets. Such leaks can be caused by defective gaskets, loose cylinder head nuts, or by the cylinder head binding on combustion chamber liners. NOTE: *It is sometimes necessary to use a file on the top of upper combustion chamber liner to permit cylinder head to seat tightly on gasket.*

(3) Check intake and exhaust valves for leakage, and if leaks are present, grind valves and reface seats.

e. Engine Overheats. See paragraph 15 **b**.

f. Excessive Oil Consumption. Check for overheating (par. 15 **b**). If leaks are present at gear cover, replace the gasket. Remove cylinder head covers and inspect for broken expansion plugs in rocker arms. Replace rocker arm if necessary (par. 37 **c**).

g. Engine Stops Suddenly. Test fuel system (subpar. **d** (1) above). If engine stops because of seizure, overhaul engine (ch. 5).

h. Engine Missing Badly. Test fuel system (subpar. **d** (1) above). Measure clearance between valves and rocker arms; replace rocker arm bushings if clearance exceeds 0.004 inch (par. 37).

i. Increased Smoke at Exhaust. Check oil level. Test fuel system (subpar. **d** (1) above).

24. FUEL INJECTOR, TRANSFER PUMP, AND GOVERNOR.

a. Refer to paragraph 23 above for diagnosis of engine trouble and suggested remedies. Mount fuel injector pump on test stand, as outlined in paragraph 58 **b**, and test for correct timing and calibration. Test fuel transfer pump as instructed in paragraph 60. Adjust governor as instructed in paragraph 65.

25. FUEL NOZZLES.

a. If trouble diagnosis (par. 23) indicates defective nozzle, locate the nozzle and test and adjust (par. 78).

CHAPTER 5—ENGINE

Section I

DESCRIPTION AND DATA

26. DESCRIPTION AND OPERATION.

a. General (figs. 1 and 2). The Hercules Model DFXE engine is a 4-cycle Diesel-type, having a piston displacement of 839 cubic inches. The cylinder block and crankcase are cast integral for maximum rigidity. The valve mechanism is of the conventional overhead type with the valves located in the cylinder head. The crankshaft is supported on seven main bearings which have a nominal diameter of 4½ inches. The engine develops a maximum torque of 685 foot-pounds at 1,150 revolutions per minute and 660 foot-pounds torque at 1,600 revolutions per minute. The developed horsepower at governed engine speed of 1,600 revolutions per minute is 201. Normal operating temperature is 160°F to 180°F.

b. Cylinder Block and Crankcase. The cylinder block and crankcase are cast in one piece in order to permit more efficient cooling by extending the water jacket down lower around the cylinders. The water jacket slopes inward toward the bottom. The crankshaft is supported on seven main bearings.

c. Cylinder Head. The cylinder head for each three cylinders is made in one casting. The valve seats and valve guides are a part of this casting, but the valve guide bushings are removable. Heads are held to cylinder block by large studs, and the order of tightening stud nuts must be from the center of head toward the ends and sides as shown in figure 96.

d. Main Bearings. Main bearings are of the removable shell type. Replacement shells are not machined after installation in the case, which makes replacement a simple job.

e. Connecting Rod Bearings. The nominal diameter of connecting rod journal is 3 5/16 inches. Connecting rod bearings are precision shell type. Shims are not used between connecting rod and cap. Shells are held in place and rotation prevented by an ear on the shell at the split line. Connecting rods are drilled for oil passage from crank bearing to piston pin.

f. Pistons. Pistons are aluminum alloy with four compression rings and two oil rings. The metal of the piston forms a suitable bearing, and no bushings are required for the wrist pins which have a working fit in the piston. Pin hole is diamond-bored.

g. Camshaft. The camshaft is located on the right of block and supported by eight bearings. Bearings have a diameter of 2⅜ inches.

The camshaft is gear-driven from crankshaft gear. Camshaft and crankshaft gears are punch-marked for proper timing (fig. 17). The drive sprocket for fuel pump driving chain is keyed to the front end of the camshaft.

h. Valves. The exhaust and intake valves are located in the cylinder head, and are operated by conventional-type tappets with hollow, push rods which extend from the tappets to the rocker arms. Removing top cover dome makes valves and rocker arms accessible; removing inspection plates on right side of block makes tappets accessible.

i. Water Pump Drive. Water pump drive is on right side of engine. Pump is gear-driven from camshaft gear. Water pump assembly can be removed without disturbing the gear case cover.

j. Fuel Pump Drive. Fuel pump is driven by a chain and sprockets; one sprocket being attached to the camshaft and the other sprocket to the fuel pump drive shaft. A sleeve is attached to the cylinder block, and can be removed toward the front of engine after gear cover has been removed and chain has been taken off sprocket. Oil seals are provided at the rear of this shaft to prevent oil leakage.

k. Oil Pump. The gear-type oil pump is mounted on front main bearing cap and driven by a gear off the crankshaft gear. Two of the pump gears are used for the scavenging side of oil pump, and the other two gears are used on the pressure side of oil pump.

l. Engine Oil System. For description and details on servicing oil lines, oil filters, and viscometer instrument, refer to TM 9-768.

m. Injection Equipment (fig. 106). The fuel injection equipment consists of an injector pump equipped with a fuel transfer pump mounted on the side of the lower part of injector pump case; a fuel governor mounted on the end of the injector pump; an overflow check valve to maintain constant pressure in the fuel manifold; six fuel lines; six nozzles; and a leak-off manifold.

27. DATA.

Make	Hercules
Model	DFXE
Type	Diesel, compression ignition
Horsepower, SAE	76.8
Bore	5⅝ in.
Stroke	6 in.
Number of cylinders	6
Piston displacement	893 cu in.
Governed speed	1,600 rpm
Brake horsepower	201 at 1,600 rpm

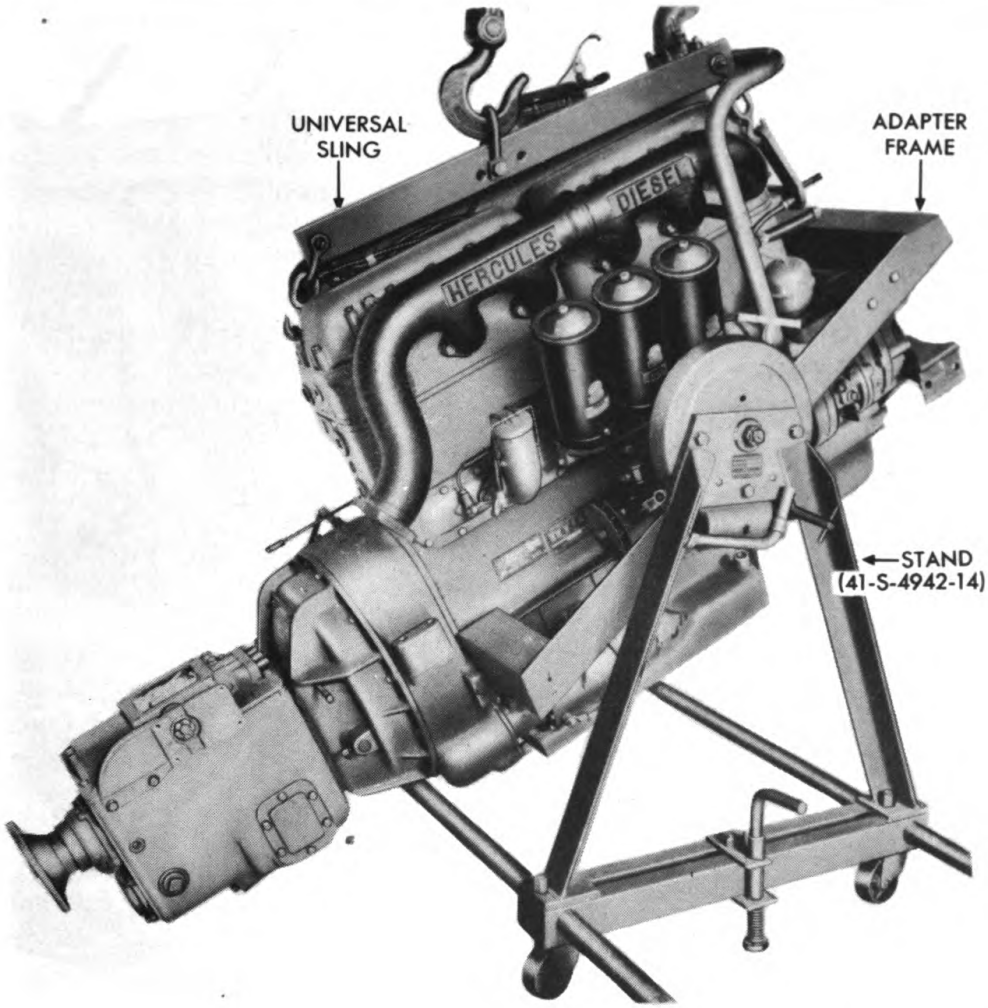
Maximum torque	685 ft-lb at 1,150 rpm
Crankcase capacity	26 qt
Cooling capacity	61 qt
Valve timing:	
Intake valve opens	5 degrees before top dead center
Intake valve closes	50 degrees after lower dead center
Exhaust valve opens	45 degrees before lower dead center
Exhaust valve closes	10 degrees after top dead center
Injector pump timing:	
In relation to engine	No. 1 pump plunger closes port 29 degrees before top dead center of crankshaft, as marked on flywheel
Firing order	1-5-3-6-2-4
Mounting	Four point
Number of crankshaft main bearings	7
Type	Alloy
Main bearing journal diameter	4½ in.
Number of connecting rod bearings	6
Connecting rod journal diameter	3 5/16 in.
Type	Alloy
Crankshaft thrust taken by	Rear main
Center-to-center length of connecting rods	12 in.
Upper connecting rod bearings	Bushing type
Lower connecting rod bearings	Shell type
Pistons	Aluminum alloy
Piston rings	Cast iron
Size, compression rings	⅛ in.
Number used	24
Size, oil rings	¼ in.
Number used	12
Number of camshaft bearings	8
Camshaft thrust taken	At front
Torque wrench pull on cylinder head stud nuts	300 ft-lb

Section II

DISASSEMBLY OF ENGINE INTO SUBASSEMBLIES

28. PRELIMINARY INSTRUCTIONS.

a. Clean. Use a putty knife or scraper to remove accumulations of heavy dirt and grease. Use a steam jet or an air blast of dry-cleaning solvent to clean all external dirt and grease from outside surfaces of engine and accessories. Clean cooling system as instructed in paragraph 89.



RA PD 350597

Figure 9—Engine and Transmission Mounted on Stand

b. Remove Fan and Fan Bracket. In order to attach the adapter frame to the two lower fan bracket studs as shown in figure 9, it is necessary to remove the air compressor, breather pipe, torque arm supports, fan assembly, and fan bracket. Refer to TM 9-768 for detailed procedure for removing the fan assembly. Special wrench (41-W-639-310) is provided for removing the fan belt adjusting bolt (fig. 180).

c. Remove Air Compressor and Breather Pipe Assembly. While engine is suspended on sling, remove air compressor and pulley to make room for front section of adapter frame. Remove compressor assembly by taking out six bolts and lock washers and lifting compressor off the bracket. Take out two bolts inside air compressor sump and two bolts on outer flange. Lift off air compressor sump and breather pipe assembly as a unit.

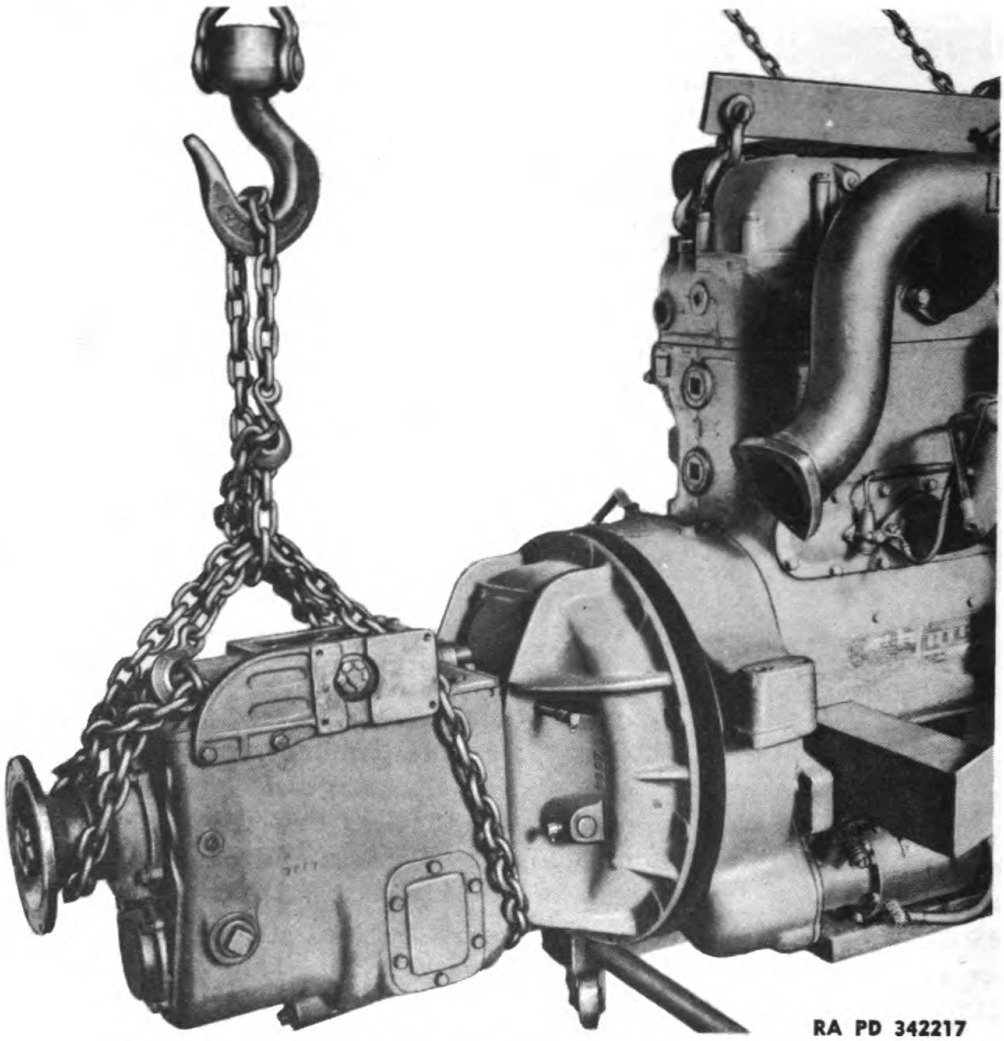


Figure 10—Removing Transmission From Engine

d. Remove Right and Left Torque Arm Supports. Remove torque arm supports so that the two side sections of adapter frame can be attached at these points. Remove supports by taking out the cap screws and lock washers which fasten supports to the block and to bell housing. Remove gaskets.

e. Attach Adapter Frame (fig. 11).

(1) ATTACH SIDE SECTIONS. Attach each side section of adapter frame at points from which torque arm supports were removed. Install four cap screws and plain washers to hold each section to block, but do not tighten cap screws on either side.

(2) ATTACH FRONT SECTION.

(a) Slide front section of adapter frame onto the two lower fan bracket studs.

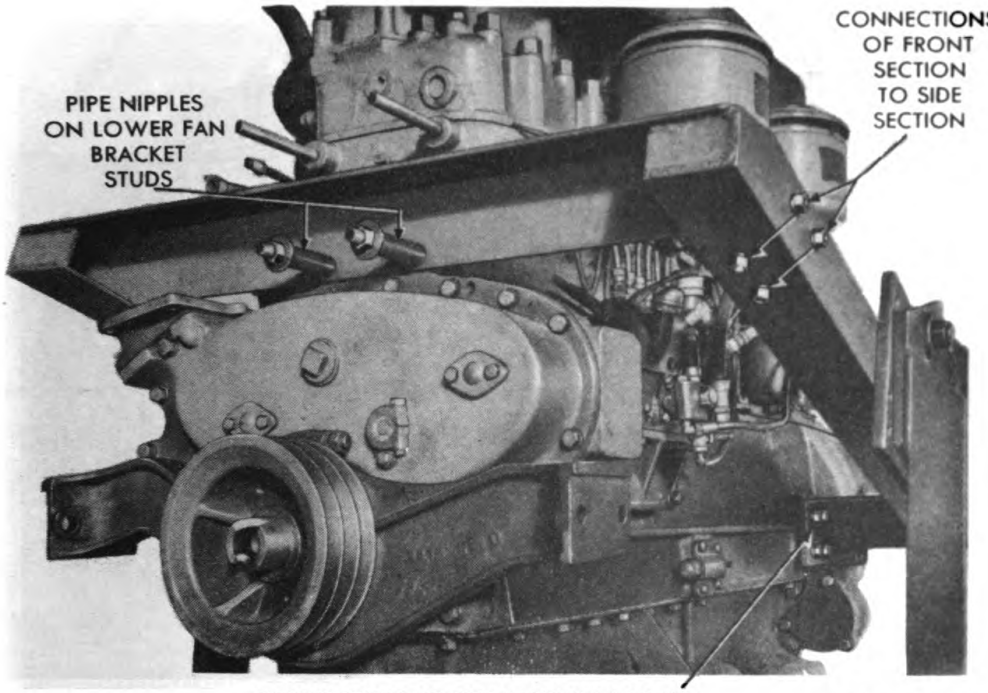


Figure 11—Adapter Frame Connections

(b) See that sides of front section fit over the offset ends of side sections, and install the four holding cap screws and washers on each to fasten front section to each of the side sections.

(3) Tighten the holding cap screws securely at rear and at sides.

f. Install Engine in Stand (fig. 9).

(1) LOWER ENGINE INTO STAND. Hoist engine and swing it into position over the stand. Lower slowly and carefully until bolt holes in sides of adapter frame are lined up with the two bolt holes just below lock holes in the stand hinge plate on each side.

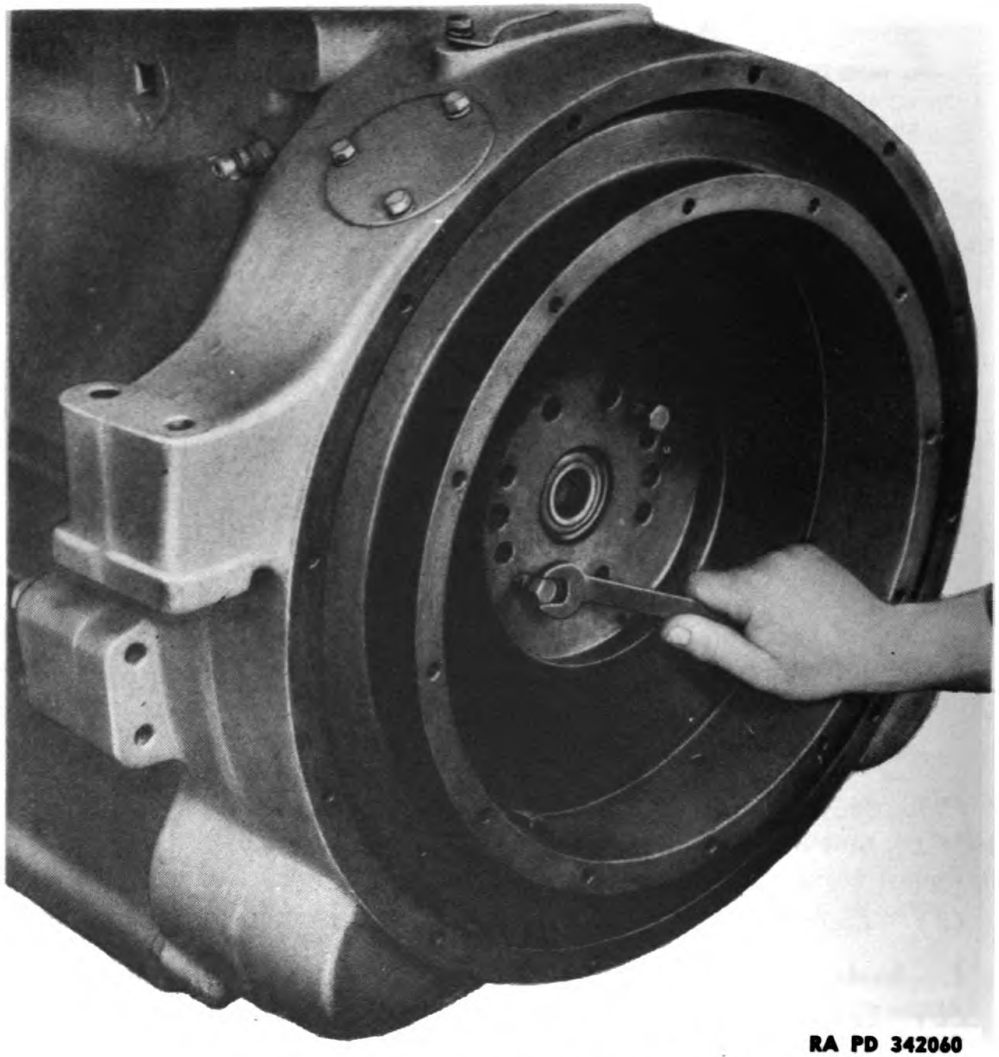
(2) FASTEN FRAME TO STAND. Install two cap screws on each side to hold frame to the stand hinge plates, and tighten cap screws securely.

(3) FASTEN FRONT OF ADAPTER FRAME.

(a) Remove the two nuts and plain washers that hold universal sling adapter plate to upper fan bracket studs. Remove the two 3½-inch pipe nipples from upper studs.

(b) Install pipe nipples, washers, and nuts on lower studs. Tighten nuts securely so that pipe nipples are tight against front section of adapter frame (fig. 10).

(c) Remove universal sling after taking hook out of rear lifting eye bolt.



RA PD 342060

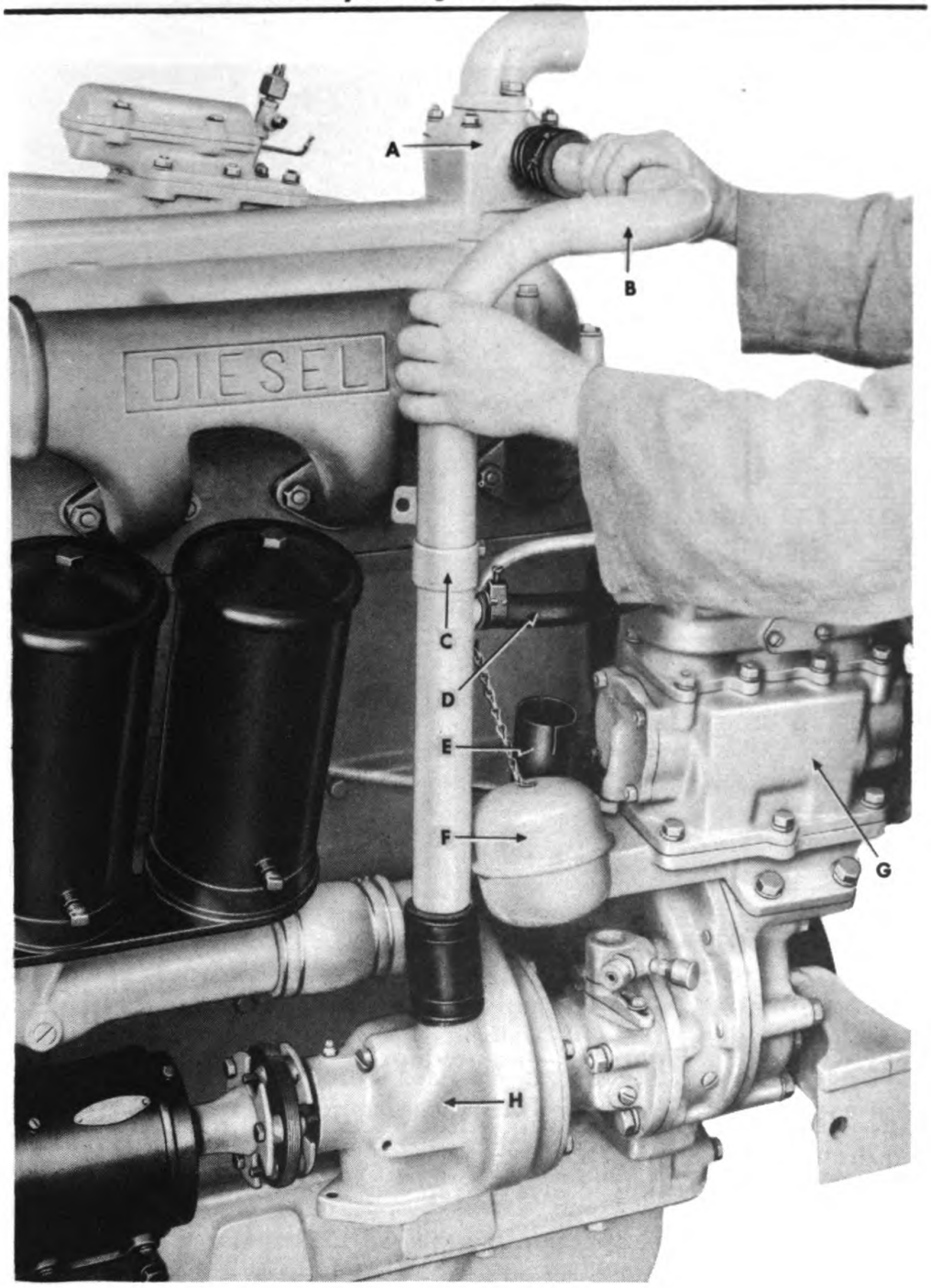
Figure 12—Removing Flywheel

g. Remove Transmission. Attach hoist to transmission housing and draw taut. Remove the 12 cap screws and lock washers and slide transmission out; swing it away from engine and lower to floor or bench.

h. Remove Accessories. Refer to TM 9-768 and remove air cleaners, stop control solenoid, fuel strainer, fuel injector pump and governor, supply and return fuel lines, fuel nozzles, oil filters, water pump, generator, and starter.

29. DISASSEMBLY.

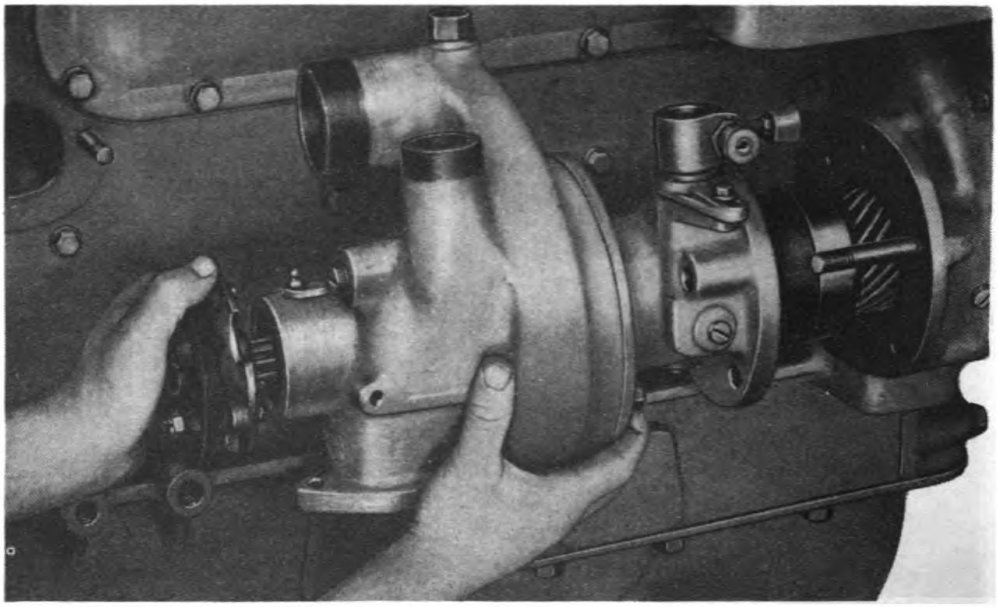
a. Remove Clutch. Take out 12 bolts and lock washers from outer rim of clutch ring and remove clutch assembly as a unit.



A—THERMOSTAT HOUSING
B—THERMOSTAT BY-PASS TUBE
C—CLAMP
D—AIR COMPRESSOR BY-PASS HOSE
E—BREATHER
F—BREATHER CAP
G—AIR COMPRESSOR
H—WATER PUMP

RA PD 342066

Figure 13—Removing Thermostat By-pass Tube



RA PD 342063

Figure 14—Removing Water Pump

b. Remove Flywheel. Take out eight cap screws. Use two 5/8-inch bolts to seat against the two dowels, drawing down each bolt a little at a time to pull flywheel from shaft (fig. 12).

c. Remove Bell Housing. Remove five nuts and lock washers inside and three cap screws outside; remove bell housing.

d. Remove Water Pump and By-pass Tube.

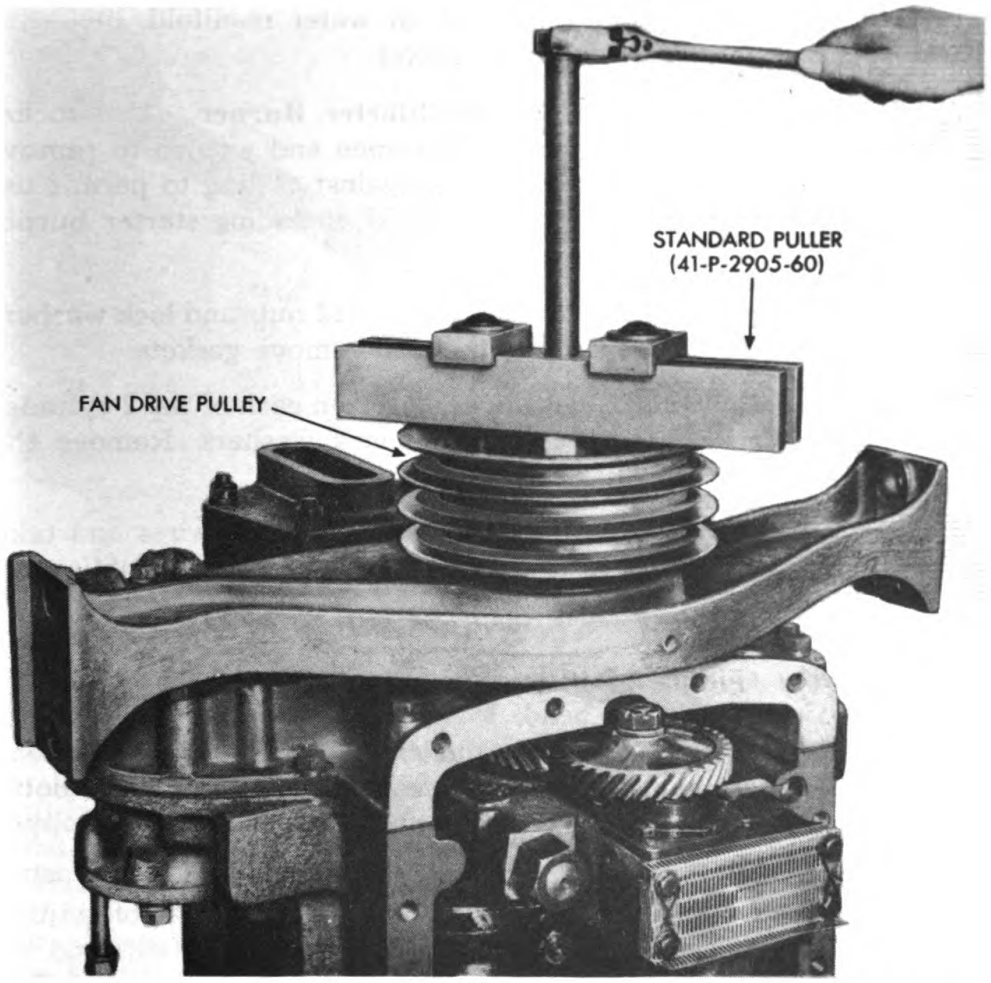
(1) REMOVE WATER INLET PIPE. Remove two nuts and lock washers from flange and remove water inlet pipe from bottom of water pump.

(2) REMOVE THERMOSTAT BY-PASS TUBE (fig. 13). Disconnect hose coupling at water pump and hose coupling on by-pass tube at water manifold. Disconnect hose which connects by-pass tube to air compressor case by loosening screw in hose strap. Take out the exhaust manifold nut which fastens by-pass tube clamp to manifold flange. The breather cap chain is attached to this clamp, so breather cap can be lifted off at the same time that by-pass tube, clamp, and water hose are removed as a unit.

(3) REMOVE OIL LINE. Remove the oil line which extends from top of water pump to air compressor head.

(4) REMOVE WATER PUMP (fig. 14).

(a) Lift up tachometer drive after taking out nut in slotted flange; pull tachometer drive upward about 1 inch to make room for wrench on cap screw behind water pump and remove this cap screw.



RA PD 342074

Figure 15—Pulling Drive Pulley, Using Standard Puller (41-P-2905-60)

(b) Remove the remaining three cap screws and the stud nut.

(c) Slide water pump assembly back, disengaging gear from camshaft gear (fig. 11) and lift assembly off the engine.

e. Remove Crank Grab. Turn crank grab counterclockwise to unscrew it from end of crankshaft, using a suitable wrench or drift. Remove the large plain washer.

f. Remove Drive Pulley (fig. 15). Remove drive pulley from end of crankshaft, using puller (41-P-2905-60) and two ½-inch cap screws, 6 inches long with plain washers. Remove hub assembly and plain key.

g. Remove Front Engine Support. Loosen pinch bolt in center of support, and pry support from flange of gear cover.

h. Remove Water Manifold and Thermostat. Take out four cap screws and lock washers and lift off water manifold, including thermostat assembly. Remove fiber gasket.

i. Remove Intake Manifold and Starter Burner. Use socket wrench to remove eight long bolts. Use open end wrench to remove the four short bolts which are too snug against casting to permit use of socket wrench. Lift off intake manifold, including starter burner assembly.

j. Remove Exhaust Manifold. Remove 12 nuts and lock washers and take off exhaust manifold from studs; remove gaskets.

k. Remove Cylinder Head Covers. From each of the 2 cylinder head covers, remove 13 cap screws and lock washers. Remove the 2 cylinder head covers and asbestos gaskets.

l. Remove Rocker Arm Assemblies. Cut lock wires and take out six bolts from each of the two assemblies; lift out assemblies.

m. Remove Valve Push Rods. Withdraw the 12 push rods.

n. Remove Cylinder Heads. Remove the 20 nuts and washers from studs of each cylinder head. Install lifting eye bolt (41-B-1586-75) in center stud hole, and lift cylinder head off studs, using hoist (fig. 95). Be careful not to damage studs or surface of head or block. Remove the other head in the same manner and take off both copper gaskets.

o. Remove Gear Cover. Remove cap screw and take off adjusting screw support bracket and cork washer. Remove 16 bolts and lift off gear cover and gasket, being careful not to damage the oil seal.

p. Remove Fuel Pump Drive Chain (fig. 16). The master link in chain is easily identified by the gun metal chain lock. Pry off lock with screwdriver, remove two pins from master link, and take chain off sprockets. To prevent loss of lock and pins, put them back into chain until ready for assembly. Length of chain with lock pin removed is 39 inches, and the chain contains 78 links.

q. Remove Chain Idler Sprocket (fig. 17). Take out three cap screws and lock washers, and remove chain idler sprocket.

r. Remove Fuel Pump Driven Sprocket and Flange Coupling. Remove three cap screws and lock washers, and lift out sprocket with shaft, flange coupling, and shaft sleeve assembly.

s. Remove Fuel Pump Drive Sprocket (fig. 18). Use standard puller (41-P-2905-60) to remove this sprocket. This is a two-man job; one man to hold wrench on screw while the other man turns the nut, as shown in figure 18. Use a nut or steel plate of proper size between

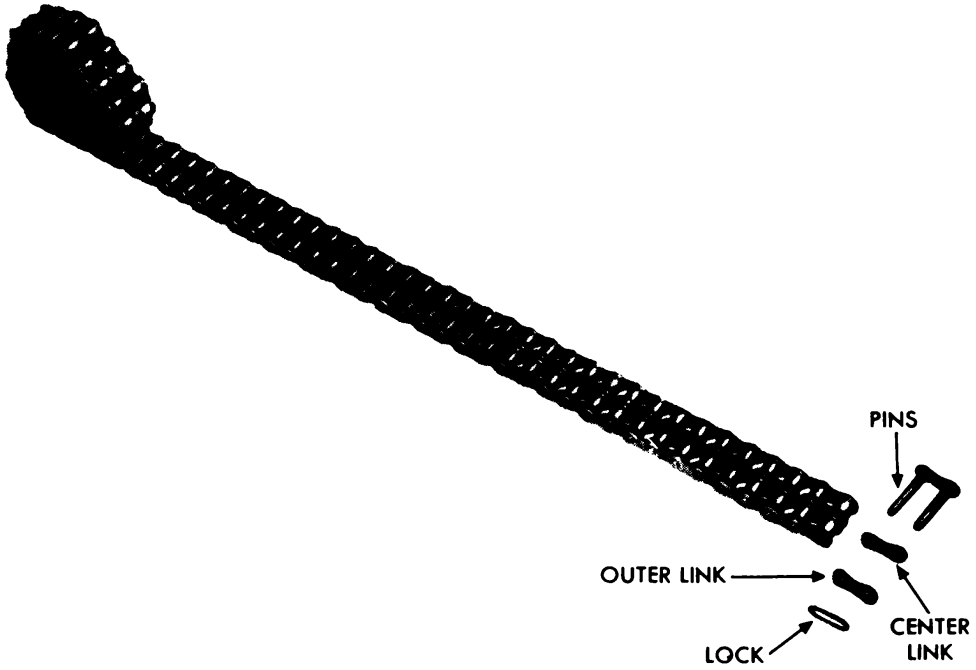


Figure 16—Fuel Pump Drive Chain With Master Link Disassembled

puller and end of shaft to avoid damaging contact face of shaft which must be kept smooth so it will fit against the brass thrust plug in gear cover. Remove drive sprocket and Woodruff key.

t. Remove Oil Pan. At the bottom of oil pan, take out 20 bolts and 8 large flathead screws. At bell housing end, take out five bolts. Lift off oil pan and remove gasket.

u. Remove Oil Pipe Assembly (fig. 19).

(1) Cut and remove lock wires and take out two cap screws from flanges of oil scavenger pipe, oil supply pipe, and oil delivery pipe at oil pump body.

(2) Remove lock wire and cap screws which hold metal strap which extends over the three pipes.

(3) Remove two cap screws which hold oil delivery pipe flange to case.

(4) Remove two cap screws which hold metal strap to oil scavenger pipe. All of these pipes are brazed to the metal straps, and the pipe assembly is lifted out as a unit.

v. Remove Oil Pump and Front Main Bearing Cap.

(1) REMOVE OIL PUMP DRIVE GEAR (fig. 20). Use standard puller (41-P-2911) as shown in figure 20, and remove oil pump drive gear. Remove key.

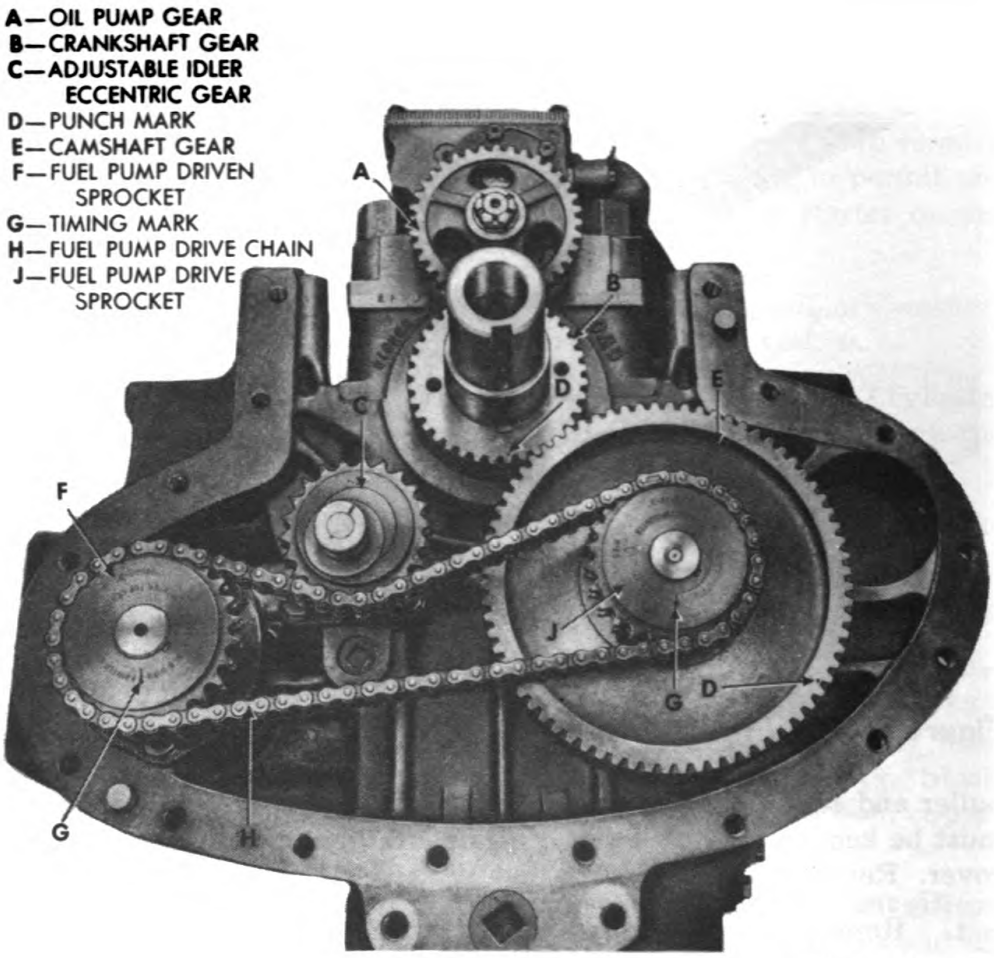
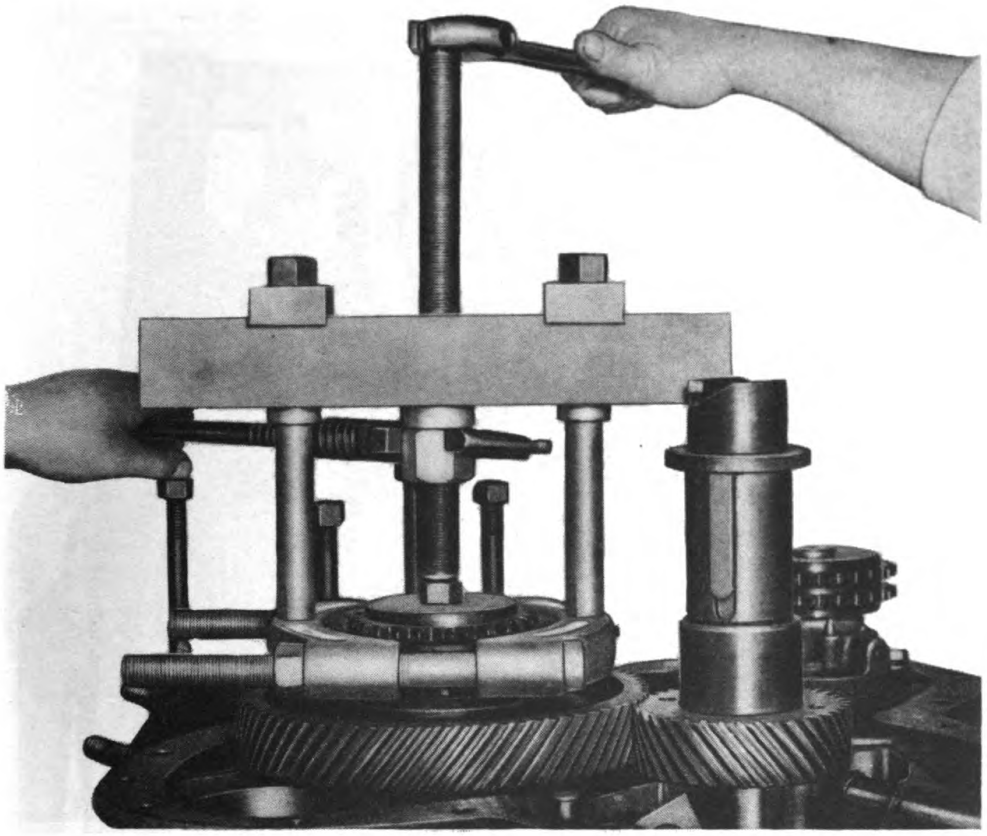


Figure 17—Gears, Sprockets, and Chain

(2) REMOVE OIL PUMP. Straighten bent washers and use special open-end wrench (41-W-1584) to remove the two front main bearing cap nuts (fig. 21). Remove oil pump and front main bearing cap as a unit, including lower main bearing shell. Oil pump is held to bearing cap by two dowel pins. To separate pump from bearing cap, pry the cap loose.

w. Remove Oil Pressure Regulator. Remove four cap screws and lock washers from flange, and remove oil pressure regulator and gasket.

x. Remove Pistons and Connecting Rods. Take out cotter pins and castle nuts, and remove bearing caps and lower halves of bearing shells. To remove pistons and connecting rods out of top of cylinder, two men will be required; one man to push against connecting rod with a wooden stick while the other man pulls assembly out through top



RA PD 342112

Figure 18—Pulling Fuel Pump Drive Sprocket, Using Standard Puller (41-P-2905-60)

of cylinder. If carbon has collected at top of cylinder bore, clean it off before removing the assembly to avoid too much force in pushing piston out of cylinder. NOTE: *Keep connecting rod bearing shells in the same positions from which they were removed so that they will be assembled in the same positions, unless new bearing shells are to be used.*

y. Remove Camshaft and Gear. Turn camshaft so that all tappets are up, hold them in that position and pull out the camshaft with the gear attached.

z. Remove Crankshaft and Main Bearings.

(1) REMOVE BEARING CAPS. Flatten the bent retainer washers, and remove main bearing stud nuts. See that crankcase is turned horizontally to prevent crankshaft from tipping when bearing caps are removed. Remove lower halves of main bearing shells. The bearing caps are numbered for correct assembly, and each shell must be kept with the same cap from which it was removed, as the position of shells

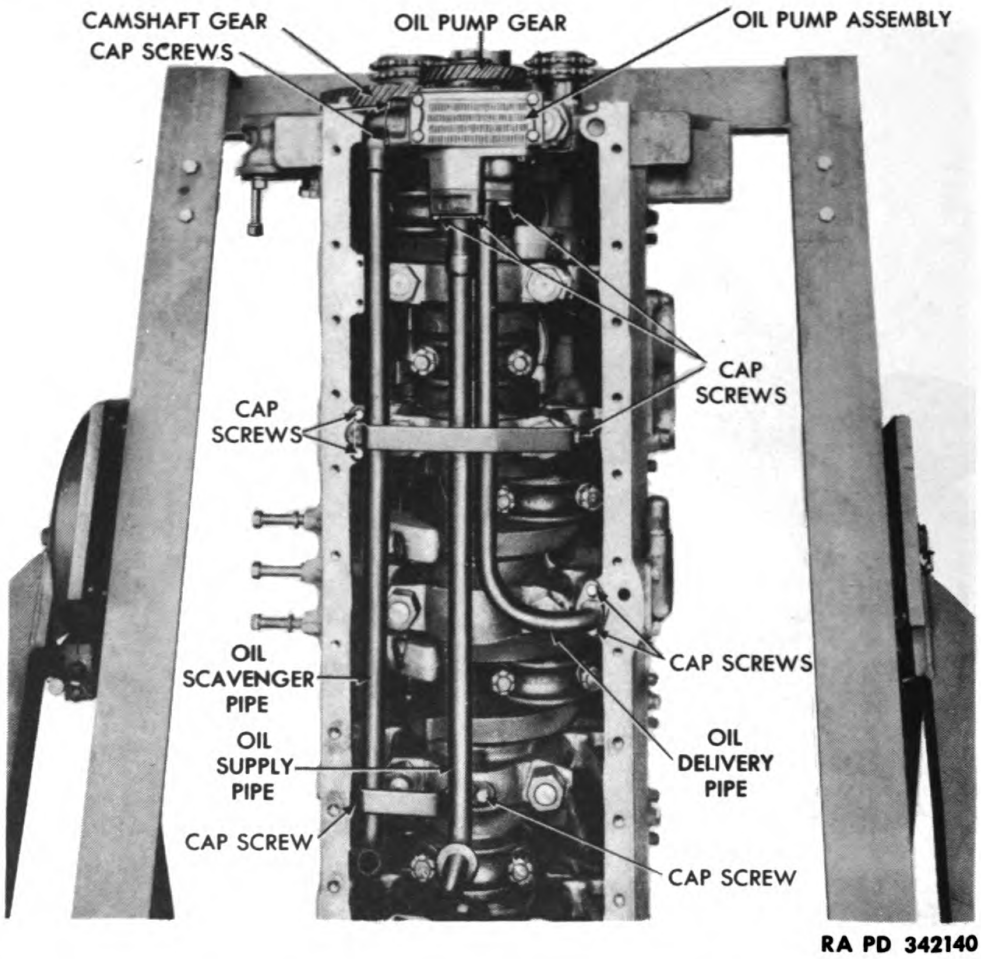


Figure 19—Oil Pipe Assembly Installed

must not be changed after engine has been in operation. Identify shells that are separated from their caps by scribing numbers on edges of shells, but do not stamp or punch.

(2) LIFT OUT CRANKSHAFT. Using a rope sling looped around the second and fifth connecting rod journals, lift out crankshaft with hoist. NOTE: *To prevent bearing journals from being damaged, use two men; one at each end of crankshaft to guide it until it is lifted clear.*

(3) REMOVE THRUST FLANGES. The two brass thrust flanges, one on each side of the rear main bearing, are made in halves; bottom halves can be taken out with the crankshaft. Remove these halves and tag them "bottom outer," "bottom inner," "top outer," and "top inner," so the mating halves will be assembled together correctly and inner and outer flanges will be installed in the positions from which they were removed.

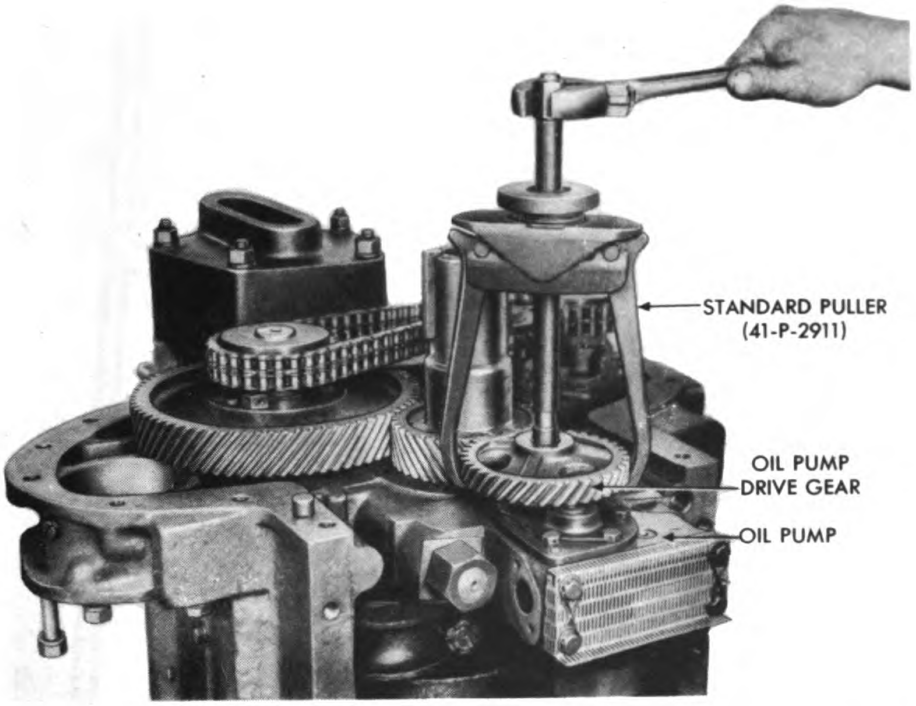


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Figure 20—Pulling Oil Pump Drive Gear, Using Standard Puller (41-P-2911)

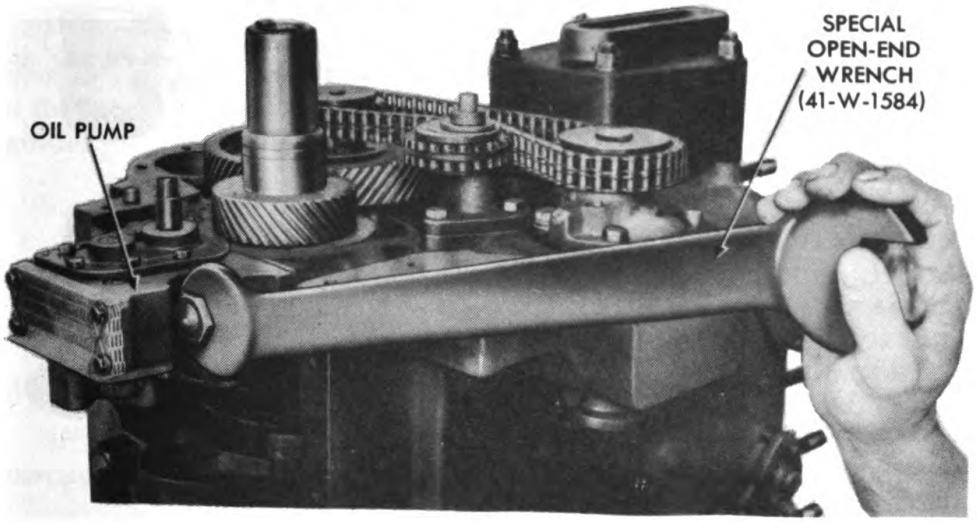

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Figure 21—Removing Nuts From Front Main Bearing Cap, Using Special Wrench (41-W-1584)

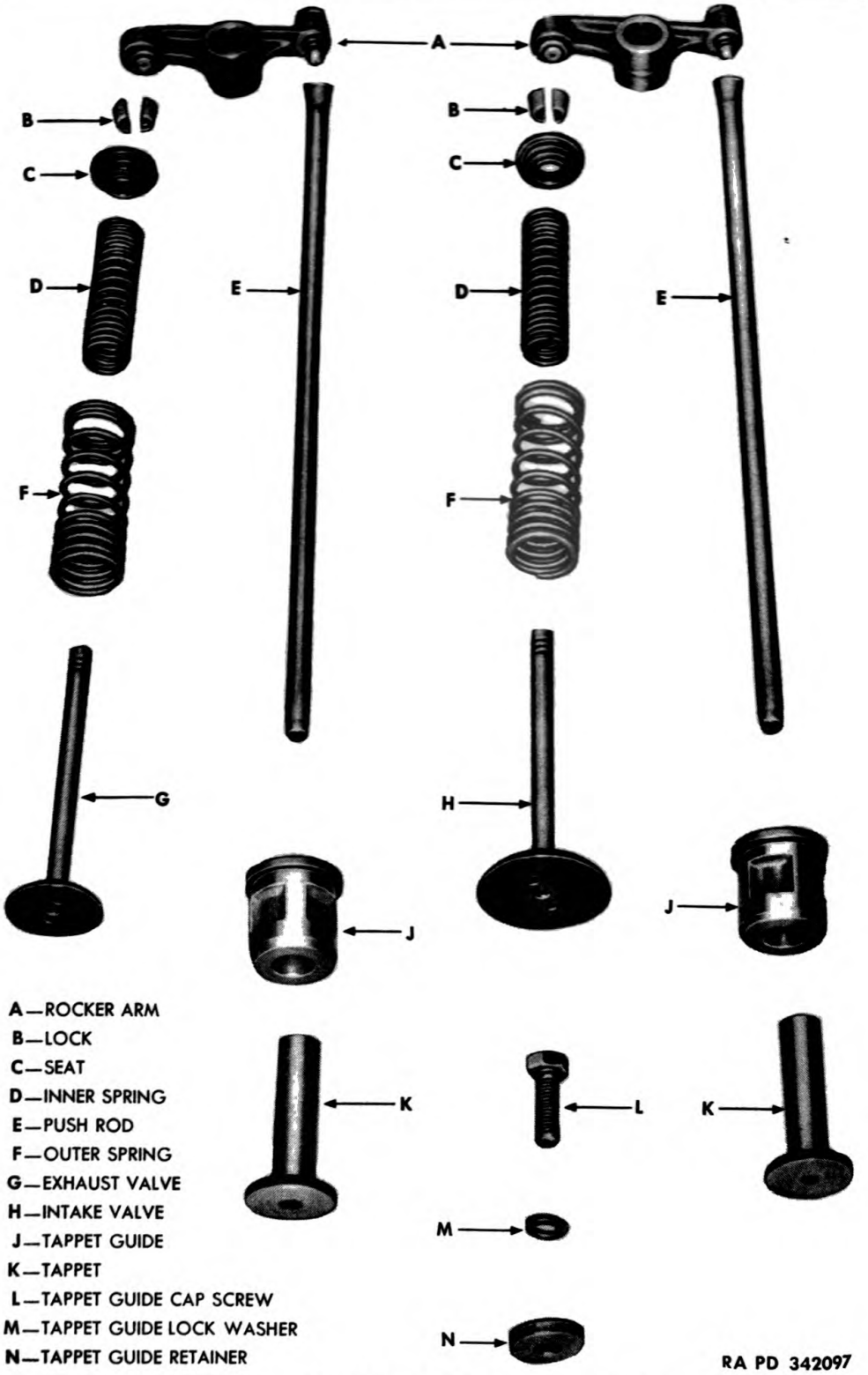
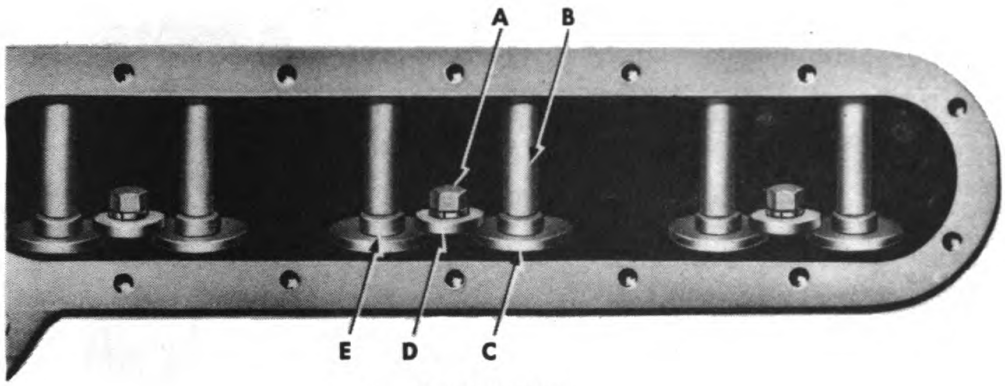


Figure 22—Valves, Push Rods, Tappets and Tappet Guides, Disassembled



A—GUIDE SCREW
B—PUSH ROD
C—VALVE TAPPET GUIDE
D—GUIDE WASHER
E—TAPPET

RA PD 321471

Figure 23—Tappets, Inspection Cover Removed

(4) REMOVE MAIN BEARING UPPER SHELLS. Remove upper shells by turning them in the direction which will disengage the nib on the edge from the notch in crankcase. Mark shells for identification in the same manner that lower shells were marked (step (1) above).

aa. Remove Tappets (fig. 22).

(1) REMOVE VALVE LIFTERS. Withdraw the 12 valve lifters from their bores in upper part of crankcase.

(2) REMOVE TAPPETS AND GUIDES (fig. 23). Remove tappets. Remove cap screws and retaining washers, and tap guides loose with a drift at the bottom, then lift out. Each retainer washer secures two guides.

Section III

OVERHAUL OF ENGINE SUBASSEMBLIES

30. GENERAL.

a. This section contains instructions on the cleaning, disassembly, inspection, repair and assembly of the engine subassemblies.

31. CYLINDER BLOCK CASTING.

a. Cleaning.

(1) GENERAL. Clean cylinder block thoroughly before inspection. Removal of such parts as cylinder liners, camshaft bearings, and nozzle

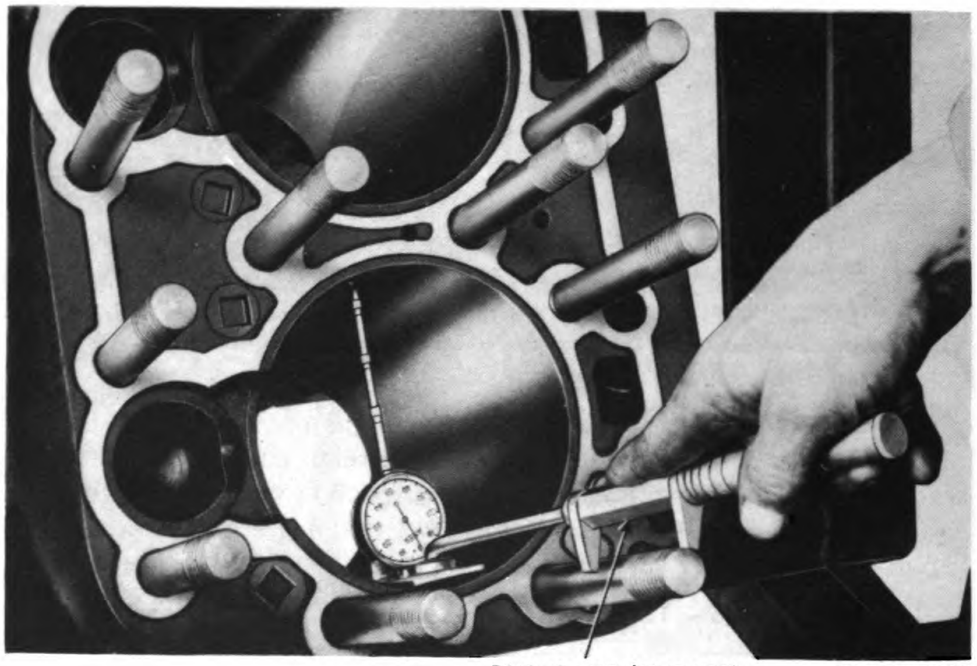


Figure 24—Checking Cylinder Bore Liner for Out-of-round, Using Dial Gage (41-G-122)

sleeves, will depend on inspection after cleaning to determine if replacement of any of these parts is necessary. Scrape all connecting surfaces to remove particles of gaskets or gasket cement.

(2) PRESSURE-FLUSHING. If pressure-cleaning equipment does not contain vapor-cleaning compound, clean the entire cylinder block with dry-cleaning solvent before pressure-flushing. Force the hot water into block through water outlet manifold openings. Remove oil plugs at front and rear and flush out oil passages. This flushing pressure will produce a high-velocity turbulence which will carry off large particles of sediment, and any grit or abrasive substance which would damage bearings. NOTE: *At the same time flushing equipment is being used to flush out cylinder block, time can be saved by using it to clean other large units, such as the crankshaft, bell housing, and cylinder head covers.* After cleaning, dry all parts thoroughly with compressed air.

(3) EXCESSIVE CORROSION. Maintenance personnel must report excessive corrosion to proper authority, as operators are cautioned against the habitual or careless use of hard or dirty water. Moreover, excessive corrosion may indicate a leaky system and maintenance personnel must take this condition as a warning, to make sure that the cooling system does not admit too great a percentage of oxygen as this will cause rapid corrosion under heat in normal engine operation.

b. Disassembly.

(1) REMOVE CYLINDER DRAIN VALVE. Remove drain valve by unscrewing from block.

(2) REMOVE OIL PLUGS. Remove front and rear oil plugs to allow for pressure-flushing.

(3) REMOVE STUDS. Remove studs, using a stud wrench.

(4) REMOVE COMBUSTION CHAMBER LINERS. Lift out upper liners. Remove lower liners by prying out with a screwdriver; if a lower liner is stuck by carbon, tap it to loosen.

c. Inspection and Repair.

(1) CASTING. Inspect block for any signs of cracks, broken parts of casting, broken studs, or damaged gaskets. Cracks on outside of water jacket or small cracks in heat zone, such as combustion chamber, can be repaired as outlined in step (7) below; but if cracks are serious, replace the cylinder block. Check face of block for warpage, using straightedge and feeler. If warpage exceeds 0.010 inch, surface grind not more than 0.004 inch from original surface to correct warpage.

(2) MEASURE CYLINDER BORES. After carefully inspecting cylinder bores to see that surfaces of liners are free from scoring, use a dial gage as shown in figure 24, to check bore of each cylinder by making the following measurements:

(a) Rotate the gage in the bore at the top until maximum reading is obtained.

(b) Without changing position of gage in relation to the bore, measure bottom of bore.

(c) Measure top of bore at right angles to measurement *(a)* above.

(d) Without changing position of gage in relation to the bore, measure the bottom of the bore. NOTE: *This measurement will be at right angles to measurement in step (b) above.*

(e) By comparing the above measurements, the amount of taper or out-of-round of the liner may be determined. Comparing *(a)* with *(b)* will determine the taper at the greatest diameter. Comparing *(c)* with *(d)* will determine the taper at the smallest diameter. Maximum taper allowable at either diameter is 0.012 inch. If engine is being overhauled, taper allowable is 0.006 inch. Comparing *(a)* with *(c)* will determine the amount of out-of-round at the top of the bore. Comparing *(b)* with *(d)* will determine the amount of out-of-round at the bottom of the bore. Maximum out-of-round allowable at any part of bore is 0.006 inch. If either taper or out-of-round of liner is excessive, repair or replace liner. Original bore diameter of liner is 5.6245 to 5.6250 inches. Pistons are available in 0.020, 0.040 and 0.060 inch oversize (SNL G-159).

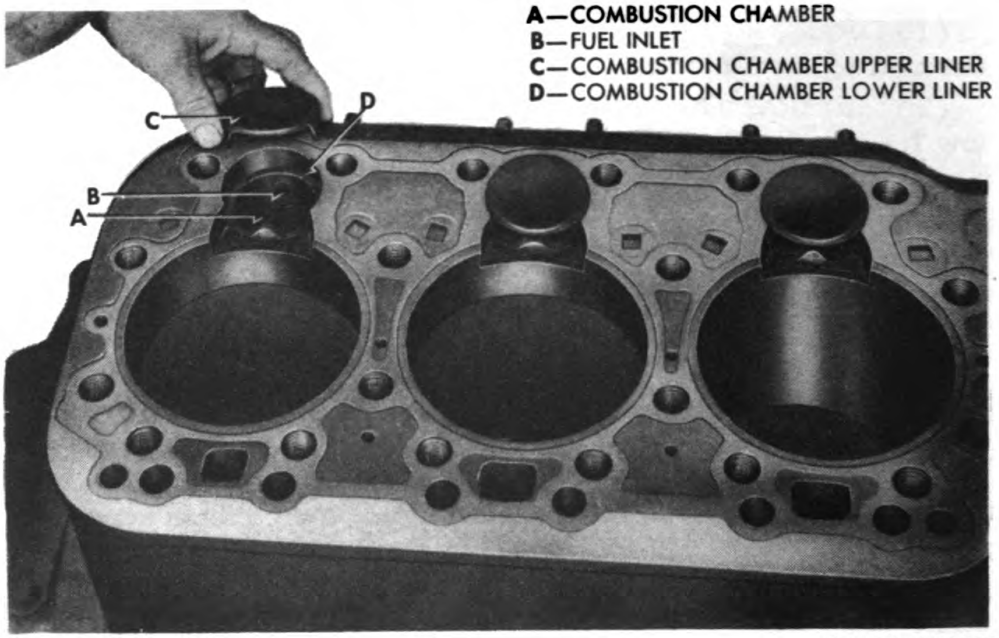


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Figure 25—Combustion Chamber Liners

(3) CAMSHAFT BEARINGS. Inspect camshaft bearings for any signs of scoring, pitting, or other damage. If a bearing is found to be damaged, inspect camshaft journal to determine if a defect in journal is the cause of damage. With inside micrometer, measure inside diameter of each bearing. Inside diameter of new bearing is 2.347 to 2.375 inches. Clearance between bearing and camshaft journal is 0.003 to 0.0035 inch. Wear at complete overhaul should not exceed 0.003 inch. Interference of outside diameter of bushing to inside diameter of case is 0.0025 to 0.0045 inch. Permissible wear of lobes from heel to toe is 0.050 inch. If end bearings show more wear than intermediate bearings, it is an indication that camshaft is out of alinement (step (10) *(b)* below). Replace worn bearings as outlined in step (9) below. Make sure that oilholes in camshaft bearings line up with holes in case, and that the bolts on outside of block are securely installed. If any bearing is improperly installed, correct this condition.

(4) COMBUSTION CHAMBER LINERS. Remove upper liners by lifting them out of block (fig. 25). Lower liner fits into recess in block and may be pried up and lifted out. Tap it if stuck by carbon. Inspect both upper and lower liners for cracks or for signs of damage at contact surfaces. Damaged liners must be replaced with new parts. Carefully inspect tops of upper liners for signs of wear from cylinder head binding against it. If evidence of such binding is found in an otherwise good liner, file off a portion from top of upper liner to remedy this

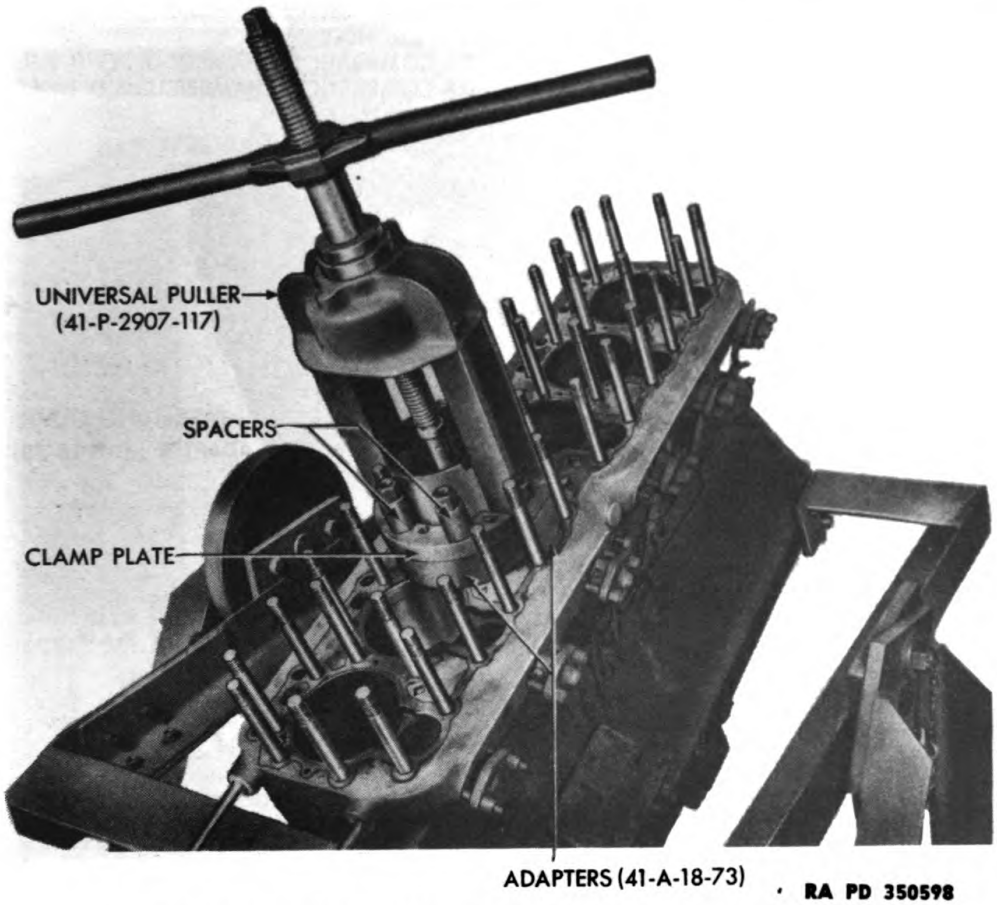

Figure 26—Pulling Cylinder Bore Liner, Using Puller (41-P-2907-117) and Adapters (41-A-18-73)

condition. CAUTION: *Care must be used when installing cylinder head after new liners have been used, as a liner which binds on cylinder head will prevent cylinder head being drawn down tight on the gasket.*

(5) NOZZLE SLEEVES. Fit of nozzle into nozzle sleeves is a tight press fit. Inspect outside and inside openings for any evidence of damage. Inspect inside for carbon formation, and make sure sleeves are clean and free from damage. Replace any defective sleeve as outlined in step (11) below. See that flanges, which may be observed through outside openings, are smooth and free from burs or pitting which might prevent a tight fit of nozzle. If flange shows evidence of damage, replace the nozzle sleeve.

(6) STUDS. Inspect cylinder head studs for bend, and examine threads for signs of damage. If studs are bent so that straightening would be difficult or threads are stripped or nicked, replace damaged studs.

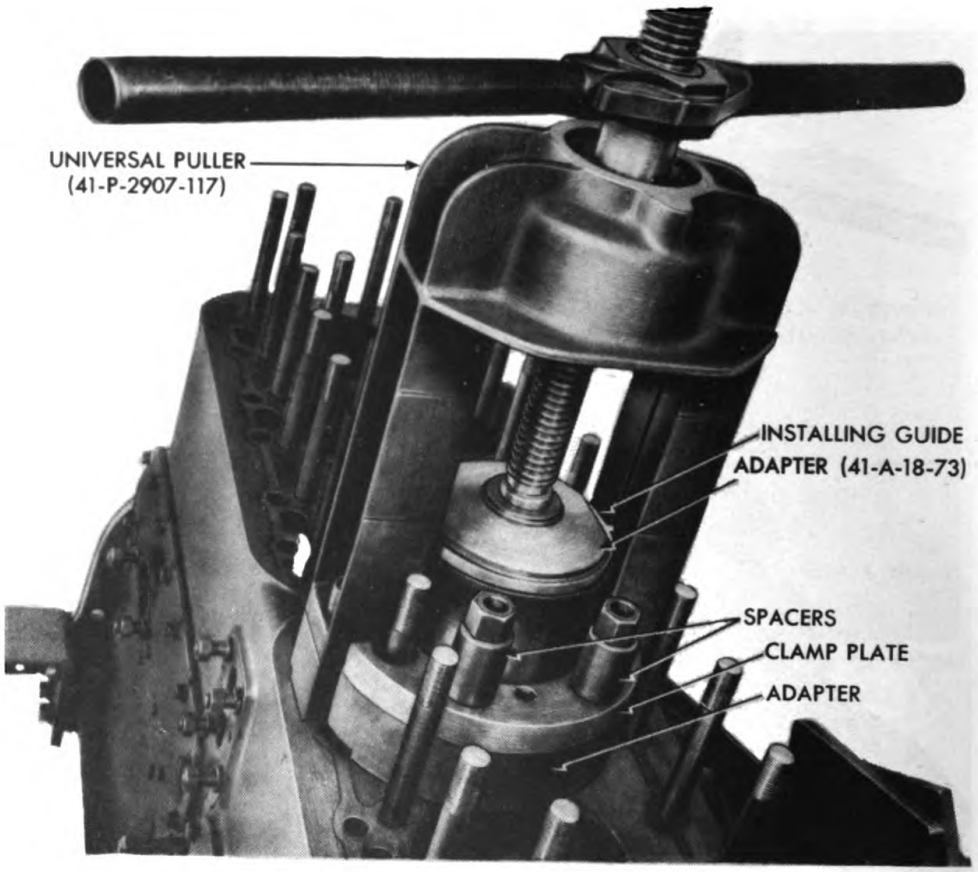

Figure 27—Installing Cylinder Bore Liner, Using Puller (41-P-2907-117) and Adapters (41-A-18-73)

(7) CRACKS IN BLOCK. Location, extent, and nature of a crack determines whether or not a repair can be made. Cracks on outside of water jacket can be repaired by brazing after block is preheated evenly. Small cracks in the heat zone, such as the combustion chamber, are repaired by "stitching" with threaded plugs. If cracks cannot be repaired so that trouble-free operation of the engine is certain, replace the cylinder block.

(8) REPLACING CYLINDER BORE LINERS.

(a) Clearances. If cylinder bore liners cannot be repaired by refinishing to allow 0.0085 to 0.0095 inch clearance for oversize pistons, replace liners. Oversize pistons are available in 0.020, 0.040, and 0.060 inch oversize (SNL G-159). NOTE: *Oversizing is desirable only for restoring bore accuracy and must be in accordance with running clearance between piston and cylinder wall of 0.0085 and 0.0095 inch and ring gap not more than 0.018 and 0.022 inch.* When new liners are installed, corresponding standard size pistons must be installed

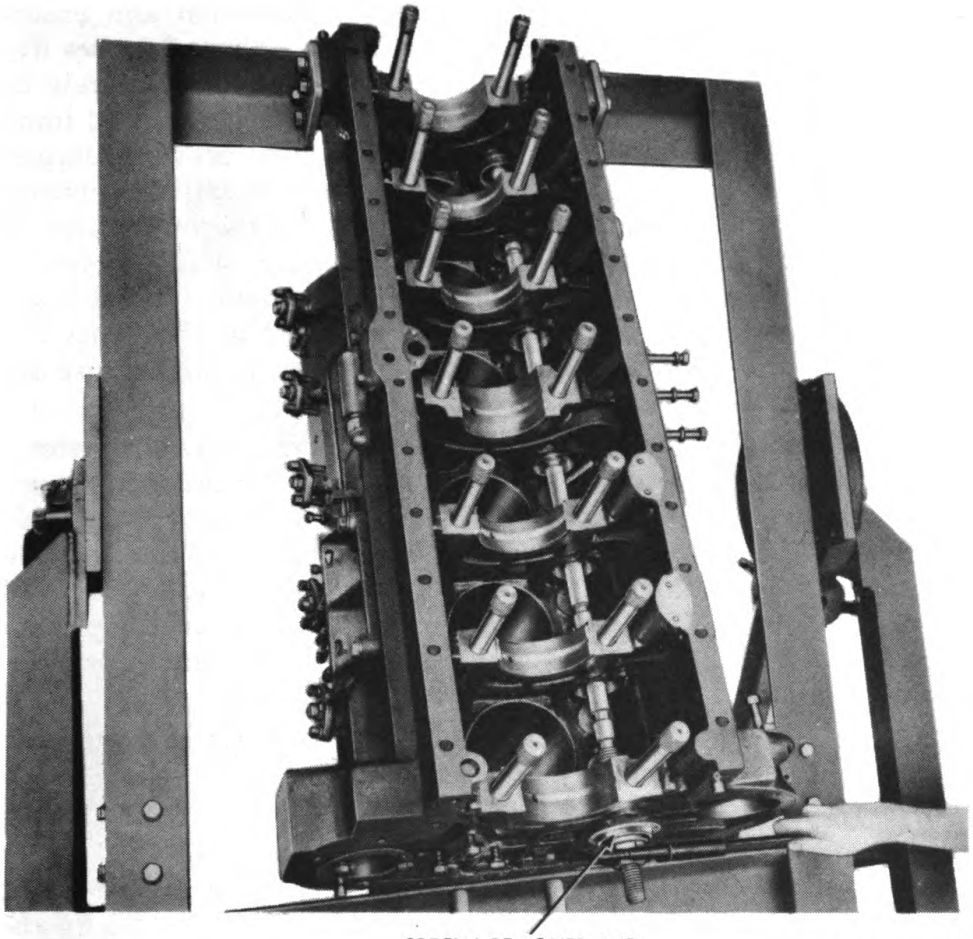

Figure 28—Removing Camshaft Bearings, Using Special Remover and Replacer (41-P-2373-650) and Adapter (41-A-14-83)

(par. 33 **d** (3)). The press fit of liners in cylinder block is held within close limits. Interference is 0.003 to 0.005 inch. Do not attempt to remove liners except as instructed in step *(b)* below.

(b) Removal. Use puller (41-P-2907-117) with adapters, as shown in figure 26. See that top surface of liner is protected against damage. Liner is more easily removed when two men keep screw handle moving steadily.

(c) Installation (fig. 27). Before installing new liner, clean block bore thoroughly and see that it is absolutely smooth and free from burs, rust, or corrosion. Liners must be clean and smooth. Should it be necessary to use crocus cloth to smooth the block bore, first fill lower end of bore with wadding, then clean and draw wadding upward

out of bore. Coat both block bore and outside of liner with a thin mixture of white lead and oil. This eases installation and ensures against seizure. As liner nears "bottoming" (when about 2 inches from assembled position), blow the projecting portion of liner entirely dry of lubricant with compressed air, or wipe dry, using a pointed implement in rag to wipe under the shoulder. This will prevent lubricant being trapped in bore, which may prevent liner from being pressed into position. After new liner is installed, make a thorough check for bore accuracy with a dial-type gage. Out-of-round will be local and probably slight enough to be corrected by light honing. Avoid honing beyond required degree. Finally, make a record of the exact bore diameter for use in selective placement of pistons. Make sure that face of liner is flush with face of block.

(9) CAMSHAFT BEARING REPLACEMENT (fig. 28). Diameter of new camshaft bearing journals is 2.371 to 2.372 inches. Diameter of bearings after reaming must be 2.374 to 2.375 inches. If camshaft bearings are damaged or worn so that clearance is in excess of 0.003 inch, replace them. Special remover and replacer (41-R-2373-650) and ring adapter (41-A-14-83) are used for both removal and installation of camshaft bearings. Use these special tools for removal as follows:

(a) From outside of cylinder block, take out doweled bolts which hold bearings in position.

(b) Install special remover and replacer (41-R-2373-650) with ring adapter (41-A-14-83) as shown in figure 28. This tool set includes semifinished ring adapters which can be finished to required size if proper size ring adapter is damaged or misplaced. To do this, put semifinished adapter on lathe and turn it down to required diameter of 2.367 inches. Diameter of shoulder should be 2⅝ inches in order to match outside diameter of camshaft bearing.

(c) Install new end and intermediate bearings by pressing into place, making sure that oilholes in bearings line up with holes in block. If oilholes are correctly lined up, the holes for doweled bolts will also be lined up with bolt holes in block.

(d) The two center bearings are pressed in, one from one end of case and one from the opposite end. This means that if both are being replaced, the remover and replacer will have to be set up for each bearing installation. Be careful not to press center bearings in too far; if bearing is allowed to protrude not more than 1/64 inch, installation will be satisfactory.

(10) LINE-REAMING NEW CAMSHAFT BEARINGS.

(a) Install Line-boring Machine. Install line-boring machine (41-B-20) as shown in figure 29. Follow instructions in the instruction book furnished with this machine for correct installation, adjustment, and operation. Correct diameter is 2.374 to 2.375 inches.

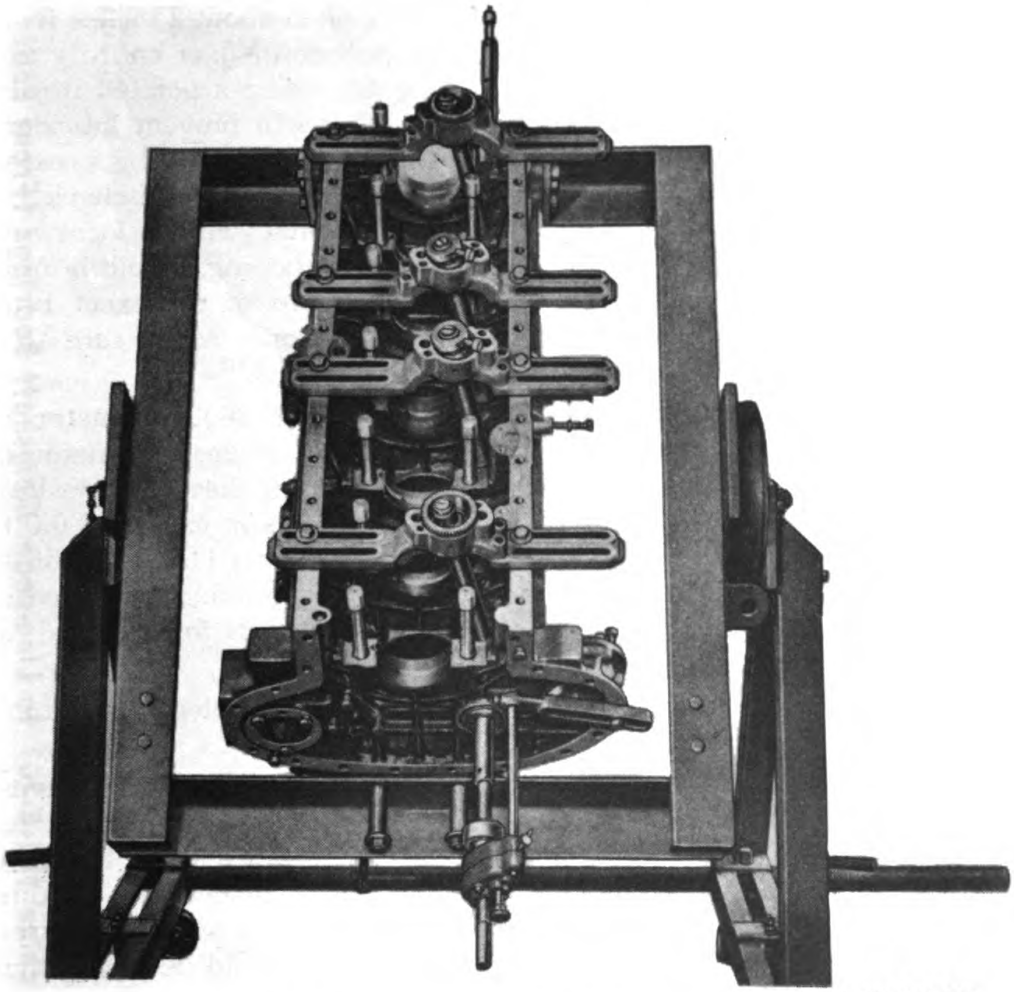

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Figure 29—Line-boring machine (41-B-20) Installed for Line-reaming Camshaft Bearings (Rear End)

(b) Inspect Camshaft. Before using line-boring machine, inspect camshaft carefully for alinement as shown in figure 31. Maximum allowable run-out at intermediate bearings is 0.005 inch, but run-out should be corrected to less than 0.002 inch. Also use micrometer to check each camshaft journal for out-of-roundness. Diameter of new camshaft bearing journals is 2.371 to 2.372 inches. It is impossible to secure good line-boring results if a defective camshaft is used. Wear limit of camshaft journals is 0.005 inch. Permissible wear of lobes from heel to toe is 0.050 inch.

(c) Setting Tool Bit. Figure 30 shows the use of drill motor and the tool bit installed. This bit is set by the tool-setting micrometer furnished with the line-boring machine.

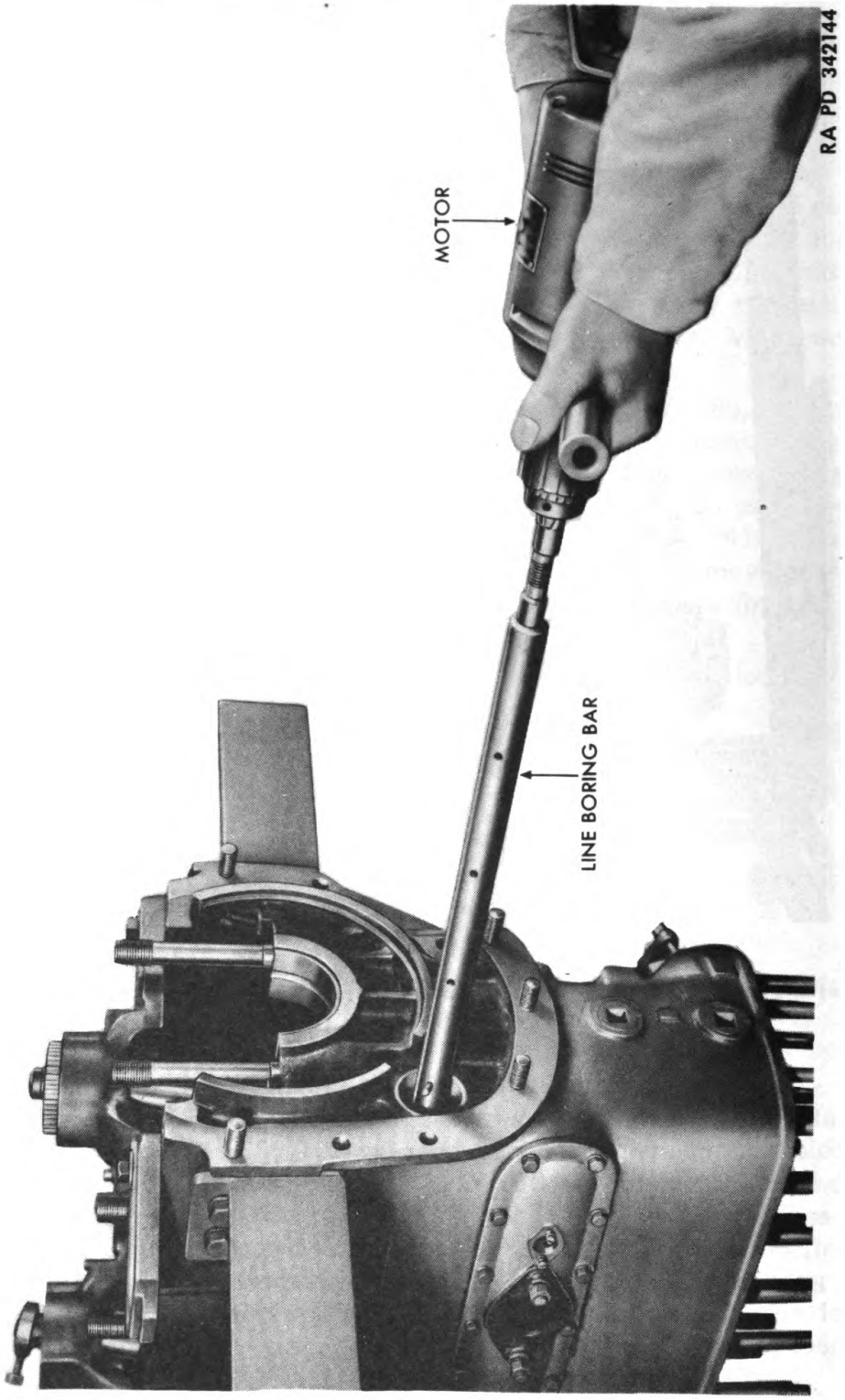

Figure 30—Using Line-boring Machine (41-B-20) to Line-ream Camshaft Bearings (Front End)

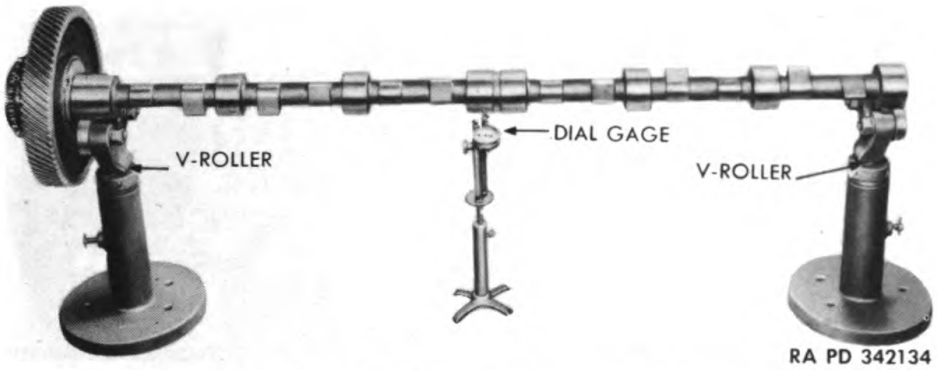

Figure 31—Checking Camshaft Alinement

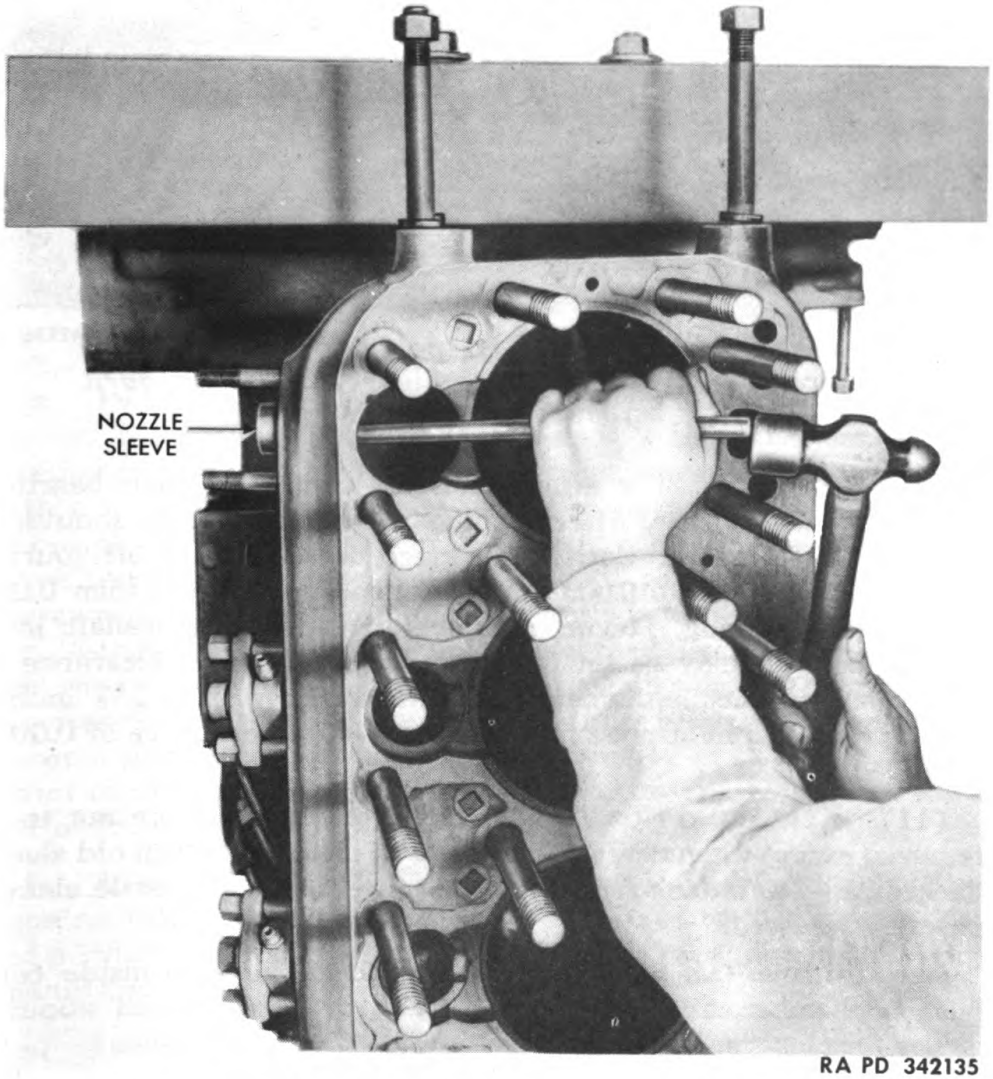

Figure 32—Removing Nozzle Sleeve, Using Steel Bar ½ inch in Diameter

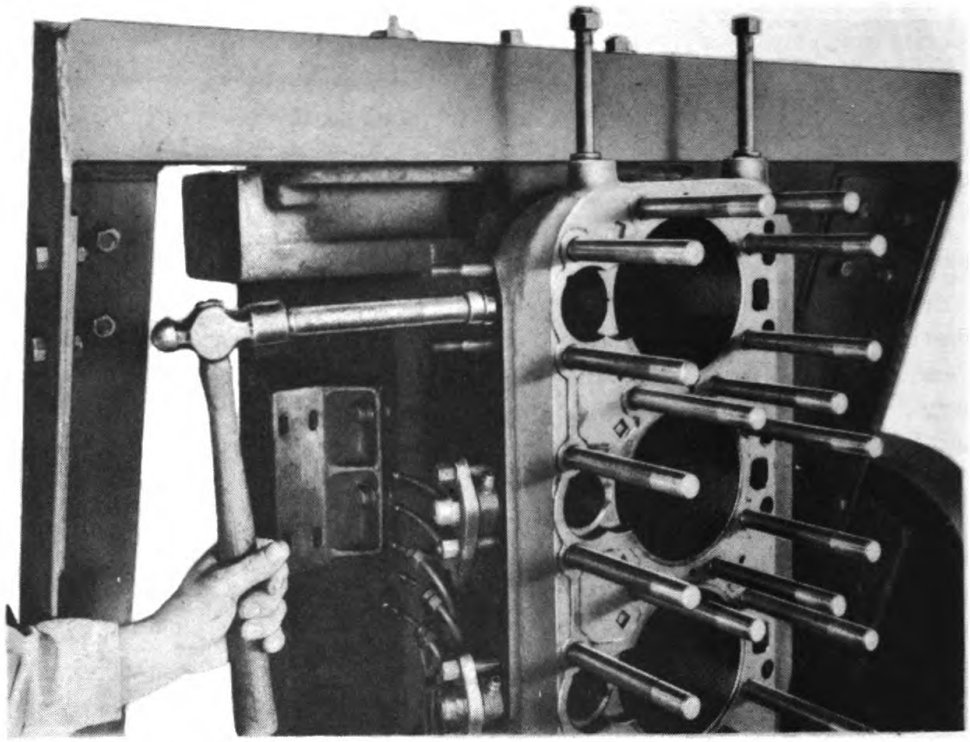

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Figure 33—Installing Nozzle Sleeve, Using Standard Driver (41-D-2869)

(d) Dimensions. The inside diameter of new camshaft bearings is 2.371 to 2.372 inches. After reaming, the inside diameter should be 2.374 to 2.375 inches. Correct clearance between camshaft journal and bearing is 0.003 to 0.0035 inch. If clearance is more than 0.003 inch, replace bearing. Having micrometer reading of camshaft journal, the tool bit may be set for line-reaming to proper clearance at each bearing. Outside diameters of camshaft bearings is 2⅝ inches, which provides a tight press-fit in the case, with interference of 0.0025 to 0.0045 inch.

(11) REPLACING NOZZLE SLEEVES. Nozzle sleeves are not to be removed except when new sleeves are to be installed. When old sleeve flanges have been damaged enough to cause leaks, the nozzle sleeves must be replaced.

(a) Remove Old Sleeve. Drive out old sleeve from inside combustion chamber, using steel bar ½ inch in diameter and about 8 inches long, as shown in figure 32.

(b) Install New Sleeve. Install new sleeve from outside the block. Drive new sleeve in snug, using standard driver (41-D-2869) as shown in figure 33.

d. Assembly of Cylinder Block.

(1) PRECAUTIONS. If any of the preceding repair operations were performed, such as line-reaming camshaft bearings, make sure all bits of metal or foreign matter are cleaned from block before starting assembly. Blow out all lines again with compressed air, and if considered necessary, repeat pressure-flushing procedure as outlined in subparagraph **a** (2) above.

(2) INSTALL CYLINDER DRAIN VALVE. Install drain valve by screwing it into place in block and tightening.

(3) INSTALL OIL PLUGS. Install front and rear oil plugs which were removed for pressure-flushing. CAUTION: *Make certain that rear oil plug is tightened up flush with face of block; if it is not up flush when fully tightened, file it off flush to prevent it from interfering with proper installation of the bell housing.*

(4) INSTALL STUDS. If studs were removed for straightening or replacement, install studs with stud wrench.

(5) INSTALL COMBUSTION CHAMBER LINERS. Before installing lower and upper liners, make sure combustion chamber is free of carbon. Tap lower liner in place and seat upper liner on the lower liner. See that upper liners are properly seated to avoid cylinder heads binding against them.

32. CRANKSHAFT AND BEARINGS.

a. Disassembly. Disassembly of the crankshaft consists of removing the crankshaft gear. This gear is a tight press-fit, and no attempt must be made to remove it except when it is to be replaced with a new gear. Replacement can be made with the crankshaft in or out of the engine; if it is in the engine, it will be necessary to remove the gear cover, the fuel pump drive chain and sprocket, and the camshaft gear. Turn crankshaft until keyway is up, then bore two ¼-inch holes in gear, one hole above the other, and both holes in line with keyway. Then break off the gear by driving a cold chisel in across the holes and keyway. NOTE: *It has been proved impractical to use a puller and two bolts in holes provided in this gear. Any attempt to use a puller may result in damage to crank grab threads in end of crankshaft.*

b. Cleaning. Thoroughly clean all journal surfaces, using dry-cleaning solvent, and clean out all oil passages with compressed air and a rifle brush. Clean all main bearings and caps thoroughly in dry-cleaning solvent.

c. Inspection and Repair.

(1) INSPECTION.

(a) Crankshaft Gear. Examine gear for chipped, broken, or worn teeth. Replace gear if teeth are defective.

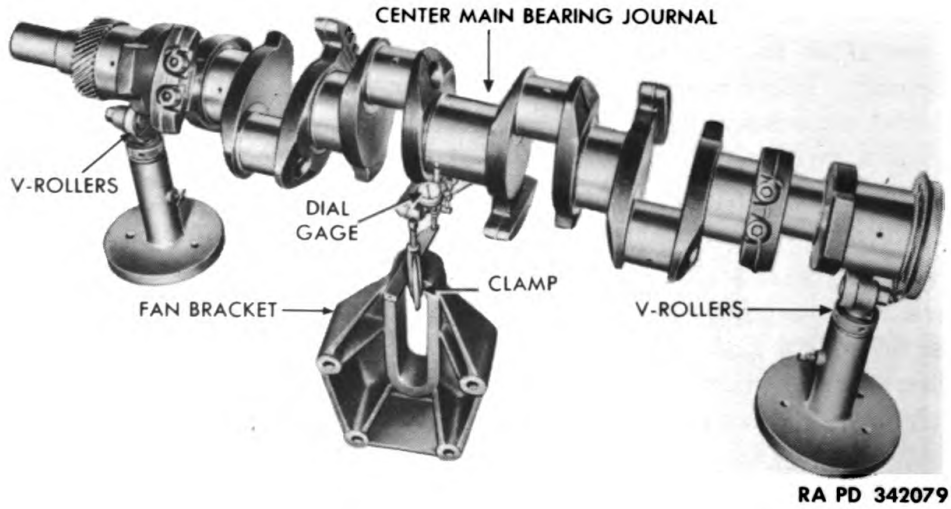


Figure 34—Method of Checking Crankshaft for Run-out

(b) Crankshaft Run-out (fig. 34). Turn shaft, supported at each end on V-rollers, and use a dial-type indicator on center main bearing to detect bend. Maximum run-out at intermediate bearings is 0.002 inch. Mark shaft to indicate direction and degree of run-out. Correct the alinement with a bending press so that run-out is not more than 0.002 inch, using the indicator for checking during the straightening operation.

(c) Journal Surfaces. Examine each journal surface for scratches, pits, or scores. Slight roughness can usually be removed or smoothed with a hone. If badly pitted or scored, regrind journal to permit use of available undersize bearing shells. Authorized undersize shells of crankshaft and main and connecting rod journals are 0.020, 0.040 and 0.060 inch.

(d) Journal Wear. Manufacturer's dimensions of crankshaft journals are: main bearing journals, 4.499 to 4.500 inches; connecting rod bearing journals, 3.309 to 3.310 inches. Measure main bearing journals and connecting rod journals with a micrometer for wear, taper, or out-of-round. Use a micrometer which has been checked with gage for accuracy. Make at least two checks of each journal, one at right angles to the other, and in each instance, move the micrometer along entire length of the journal. If main or connecting rod journal out-of-round exceeds 0.0015 inch at base shop overhaul, regrind to permit use of crankshaft with available undersize main bearing shells, which are 0.020, 0.040, and 0.060 inch (SNL G-159). If inspection is for replacement only, 0.003 inch out-of-round is permissible. NOTE: *When regrinding crankshaft, it is of the utmost*

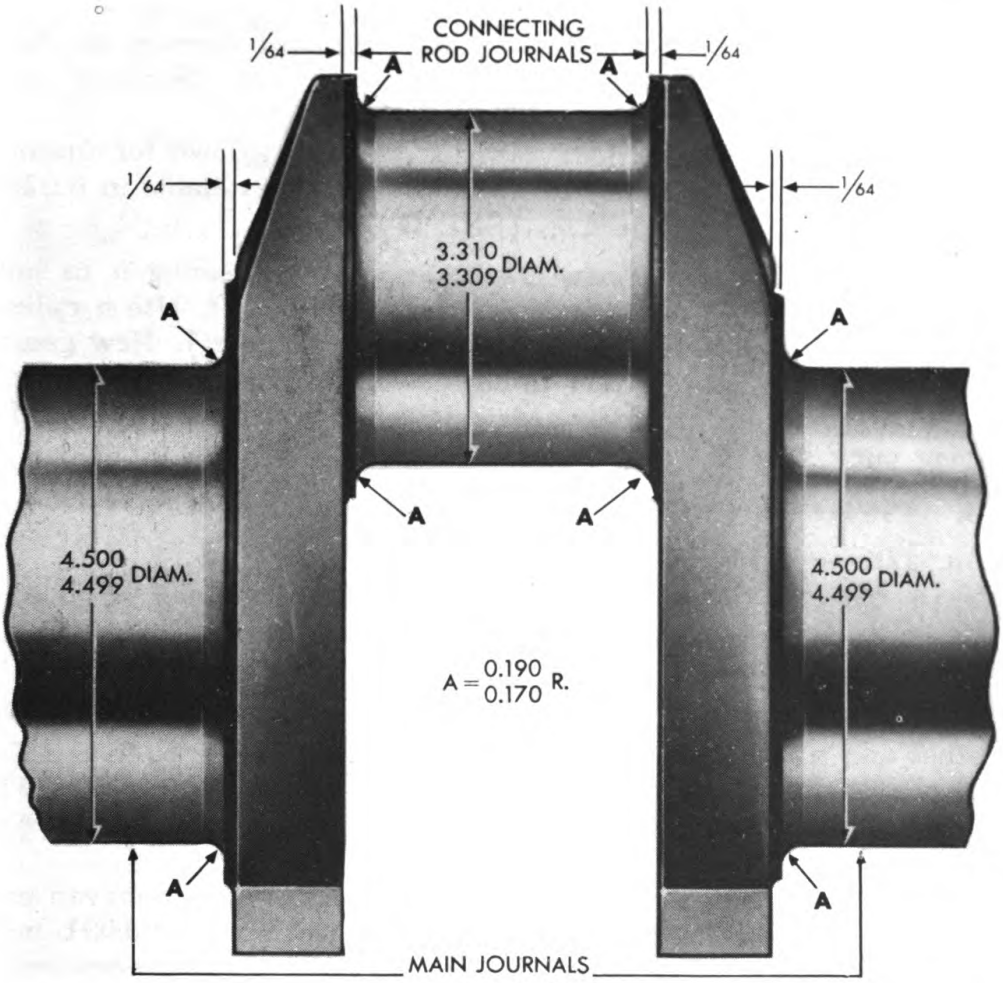


Figure 35—Radius Chart for Crankshaft Journals

importance to maintain the fillets with radius of 0.170 to 0.190 inch, as shown in figure 35 at points marked "A."

(e) Oil Wick. Inspect oil wick in rear flange of crankshaft to see that it is clean and properly installed in the sleeve. If this wick is damaged or dirty, replace it with a new wick soaked in crankcase oil.

(f) Main Bearings and Caps. Inspect shells for damage or scoring. Replace any defective or worn bearings. Wear limit of bore at complete overhaul is 0.0015 inch. If any main bearing is found scored or scratched, it is a signal to carefully inspect the crankshaft journal for similar damage from the same possible cause. Check warpage of machined parting surfaces with straightedge and feeler; warpage must not exceed 0.0035 inch. Be sure bearing shells are kept with the caps from which they were removed, and the upper halves of main bearing

shells are installed on the same journals from which they were removed. The thickness of copper bead coating in bearing shells is $\frac{1}{32}$ inch. Inspect caps for any signs of cracks, chips, or damage, at stud holes. Examine threads of studs and attaching nuts. Replace any damaged parts.

(2) REPAIR. If crankshaft journals are turned down for undersize bearings, use new undersize shells. These are available in 0.020, 0.040 and 0.060 inch undersizes (SNL G-159).

d. Assembly. Install new crankshaft gear by heating it in hot oil (250° to 280° F) and driving it on shaft while hot. Use a cylindrical drift or a piece of pipe (3 inches inside diameter). New gears are punch-marked for correct timing. Be sure Woodruff key is installed on shaft, and that new gear is installed with punch mark side facing out.

33. PISTON AND CONNECTING ROD ASSEMBLIES.

a. Disassembly.

(1) PISTON RINGS (fig. 36). Remove four compression rings and two oil control rings from each piston. Keep rings in order so that they can be installed in same position from which they were removed.

(2) PISTON PINS. Pinch ends of piston pin retainer rings together and remove rings. Use a suitable drift and drive piston pins out of pistons and remove connecting rods. Tag piston pins or keep them in order so they can be installed in the same pistons from which they were removed.

(3) PISTON PIN BUSHINGS. These bushings are not removed except for replacement with new bushings, when worn beyond 0.001-inch fit. Use arbor press to press out old bushings and press in the new ones (fig. 37). Inside diameter of new bushings is 2.0005 to 2.001 inches.

b. Cleaning.

(1) PISTONS. Remove carbon from piston ring grooves and tops of pistons. Wash all parts in dry-cleaning solvent.

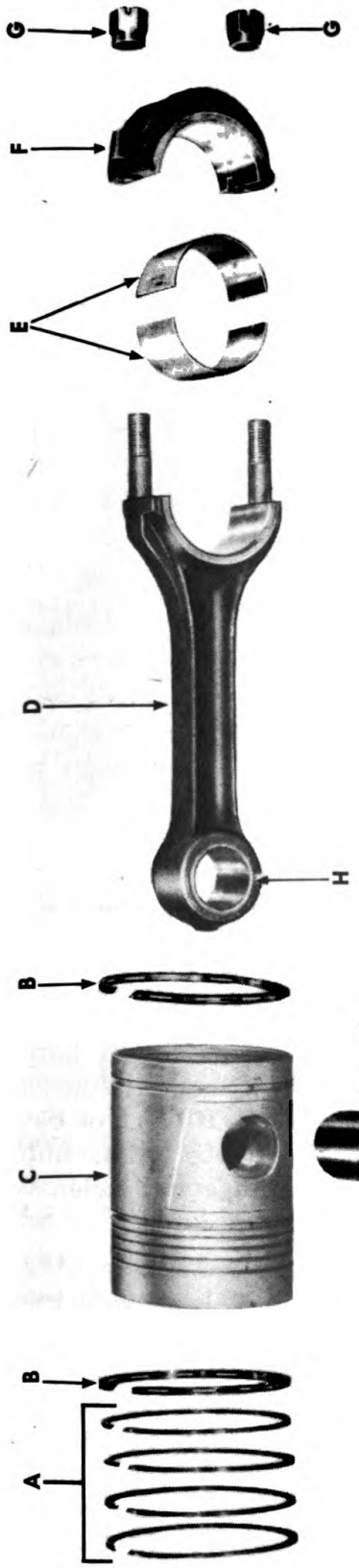
(2) CONNECTING RODS. Blow out oil passages in connecting rods with compressed air. Make sure bearing shells are free from dirt or particles of metal. Clean parts thoroughly in dry-cleaning solvent.

c. Inspection.

(1) CONNECTING ROD BEARINGS.

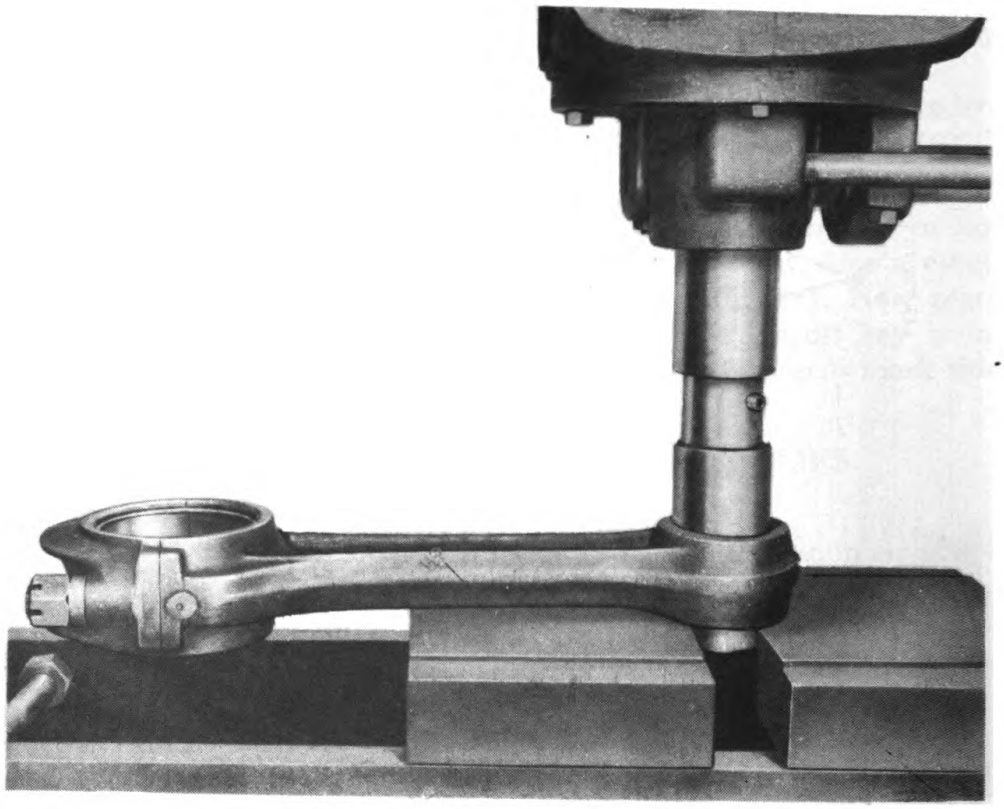
(a) The nominal diameter of the connecting rod journal is 3.309 to 3.310 inches.

(b) Normal clearance of journal and connecting rod bearing shells is 0.0035 to 0.0045 inch. Side clearance is 0.005 to 0.012 inch. If wear of journal has increased running clearance to more than 0.008 inch, regrind the crankshaft and use undersize bearing shells. Authorized undersizes are 0.020, 0.040 and 0.060 inch (SNL G-159).



A—COMPRESSION RINGS
B—OIL CONTROL RINGS
C—PISTON
D—CONNECTING ROD
E—CONNECTING ROD BEARING
F—CONNECTING ROD CAP
G—CONNECTING ROD CAP NUT
H—CONNECTING ROD BUSHING
J—PISTON PIN
K—PISTON PIN RETAINER

Figure 36—Piston and Connecting Rod, Disassembled



RA PD 342119

Figure 37—Arbor Press Set-up for Removing Piston Pin Bushing

(c) Examine bearings for pitted, worn, or scored surfaces.

(2) CONNECTING RODS.

(a) Examine bearing shell bore for wear. Lower bore diameter with standard size bearings is 3.313 to 3.3135 inches. Upper bore diameter with bushing is 2.0010 to 2.0005 inches. If worn or badly scored, or bores are worn more than 0.002 inch, replace rod assembly. Check machined surfaces for warp, using straightedge and feeler. Warp must not exceed 0.002 inch.

(b) Inspect for bend and twist, using aliner (41-A-135) (fig. 46). Maximum allowable twist is 0.002 inch. Slight bends or twists can be corrected but if rod is badly bent or cracked, replace it.

(3) PISTONS (fig. 38).

(a) Check pistons for cracks, scores, worn ring grooves, and other defects. Diameter of new piston pin hole ream is 2.0000 to 1.9994 inches.

(b) With a micrometer measure the diameter at edge of skirt, taking measurement at a right angle to the piston pin axis (fig. 38).

RA PD 342128

Figure 38—Measuring Diameter of Piston Skirt

If piston is worn in excess of 0.010 inch, replace it. The original diameter at top of skirt is 5.614 to 5.613 inches; at bottom of skirt, 5.615 to 5.616 inches. Diameters at ring lands should measure as follows: top land, 5.586 to 5.584 inches; second and third land, 5.605 to 5.603 inches; fourth and fifth land, 5.607 to 5.605 inches.

(c) The minimum clearance in cylinder bore should be 0.0085 inch, and the maximum 0.0095 inch. These clearances are obtained by measuring the piston diameter at the skirt or near the bottom of the piston with outside micrometer, and measuring the bore diameter with dial gage or inside micrometers. If feeler gage is used, this should be a gage 0.009 inch thick. The gage should be ½ inch wide, and it should be possible to pull out the gage with 4 or 5 pounds pull (fig. 40).

(d) New pistons with pin assembly, are available in standard or 0.020, 0.040, and 0.060 inch oversize (SNL G-159).

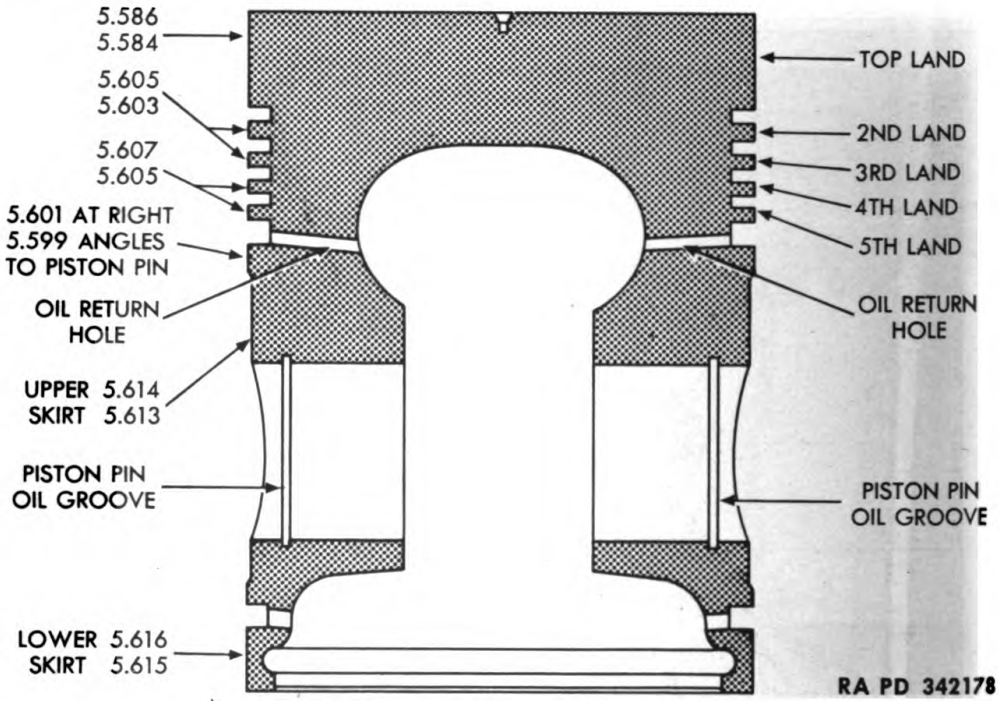


Figure 39—Sectional View of Piston

(4) PISTON PINS.

(a) Diameter of new piston pins is 2.0000 to 1.9998 inches. Clearance in piston must not exceed 0.001 inch at 70°F (fig. 43). When piston is replaced, piston pin should also be replaced since the piston pin hole is reamed for a standard pin.

(b) At 70°F, the piston pin should have a clearance of 0.0015 inch to 0.002 inch in the bushing in the top of the connecting rod. If clearance at 70°F exceeds 0.004 inch, replace pin and bushing. Check clearance as shown in figure 42. Piston pins 0.005 inch oversize are available (SNL G-159).

(c) If replacement requires grinding connecting rod bushing, use grinder (40-G-103) as shown in figure 41, and hone after grinding. Clearance of pin in connecting rod must not be over 0.004 inch at 70°F. Check this clearance as shown in figure 42.

(5) PISTON RINGS.

(a) Replace piston rings at general overhaul.

(b) See that new rings have a gap between 0.018 inch and 0.022 inch. Check gap with feelers (fig. 44). Rings must have from 0.0015 to 0.003 inch groove clearance; wear limit is 0.005 inch clearance. Check groove clearance with feeler gage (fig. 45).

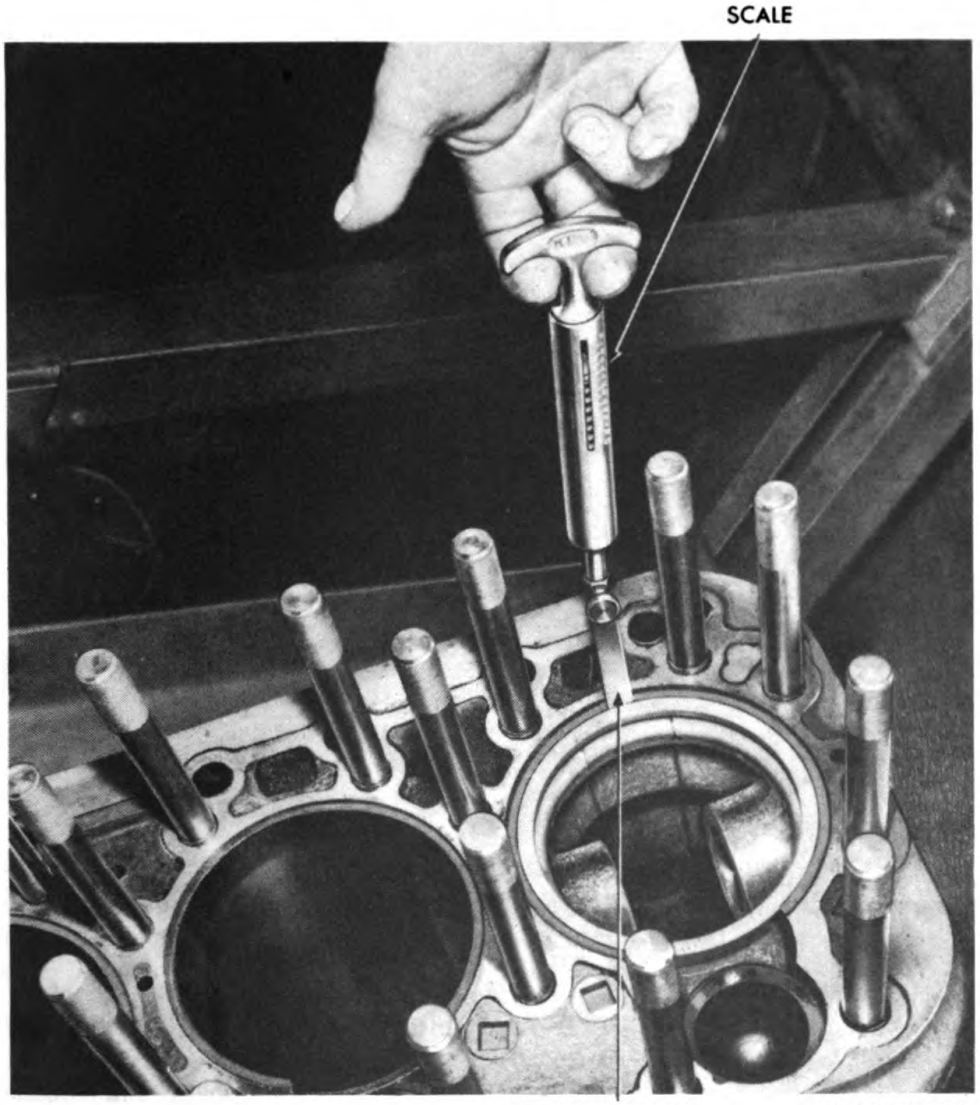


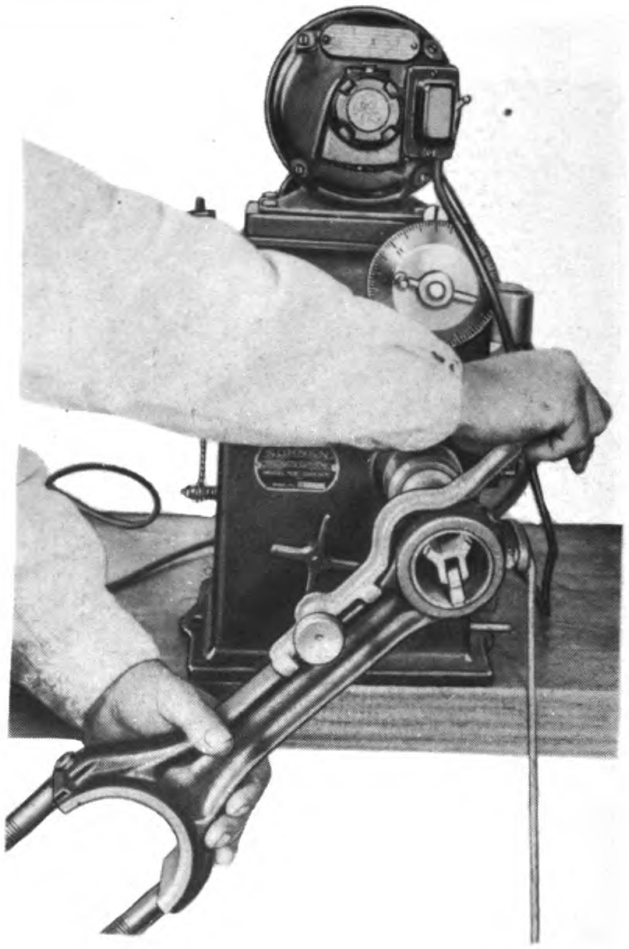
Figure 40—Measuring Piston Clearance, Using Feeler Gage and Scale (41-S-498)

d. Repair and Assembly.

(1) FITTING GAPS OF NEW RINGS.

(a) Place each new piston ring in the cylinder, sliding it down about one inch with a piston so that ring will be square with cylinder bore.

(b) Measure gap between the ring ends with a feeler gage (fig. 44). If gap is less than 0.018 to 0.022 inch, remove the ring and file the ends with piston ring filer until correct gap is obtained.



RA PD 342108

Figure 41—Grinding Connecting Rod Bushing, Using Grinder (40-G-103) and Hone

(c) Install each ring on the proper piston as soon as correct gap for that cylinder is obtained, using a ring installer.

(2) FITTING NEW RINGS ON PISTON.

(a) Roll the ring around the piston in its proper groove, to make sure there is no raised metal which would prevent the ring from rolling freely.

(b) Measure clearance between ring and groove (fig. 45) with a feeler gage. Clearance at top groove should be 0.003 to 0.0045 inch, and must not exceed 0.0075 inch. Clearance at groove of all other rings should be 0.0015 to 0.003 inch, and must not exceed 0.005 inch. Widths of ring grooves on new piston are as follows: No. 1 (top groove), 0.127 to 0.128 inch (wear limit 0.003 inch); Nos. 2, 3, and 4 grooves, 0.1255 to 0.1265 inch (wear limit 0.002 inch); Nos. 5, and 6 grooves, 0.2505 to 0.2515 inch (wear limit 0.002 inch).

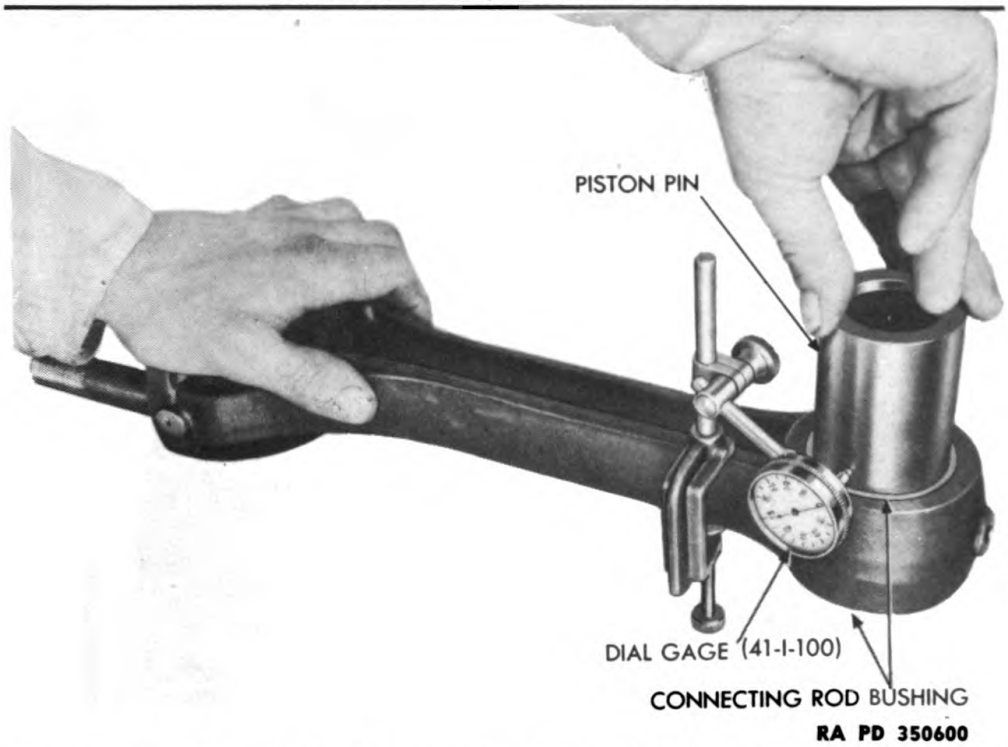
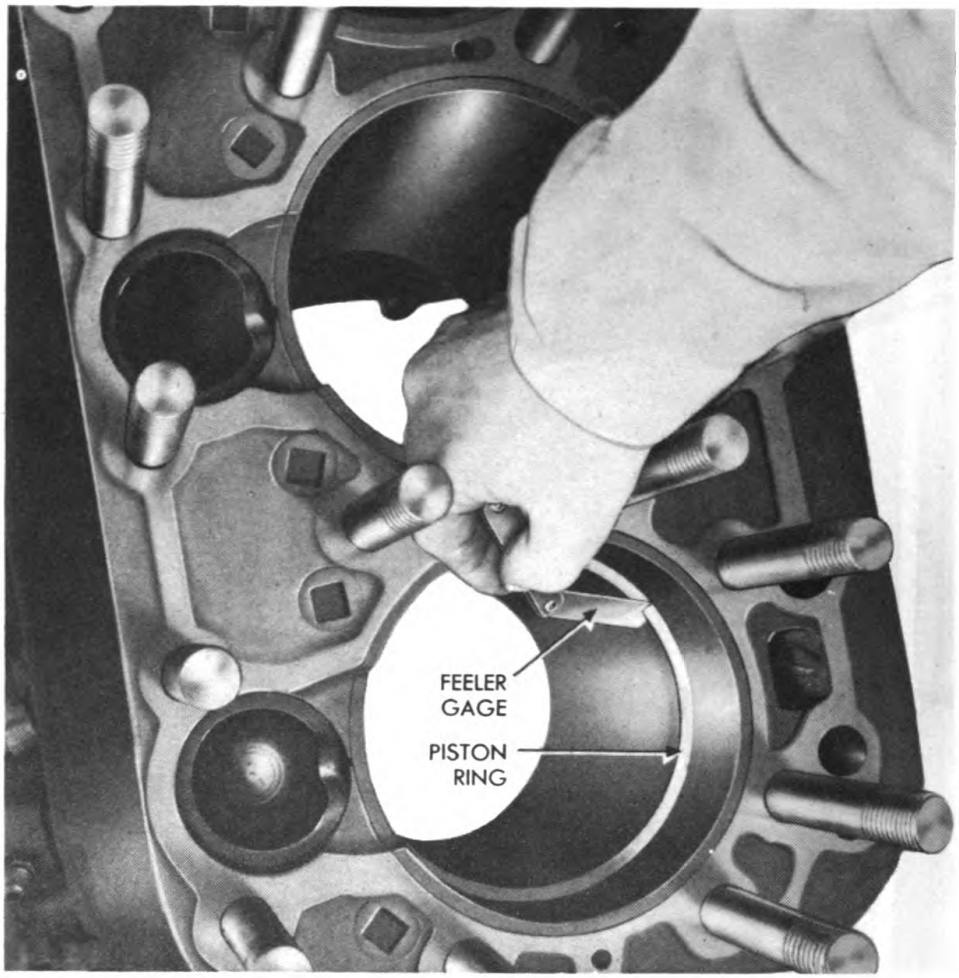


Figure 42—Checking Clearance of Piston Pin in Connecting Rod

Figure 43—Checking Clearance of Piston Pin in Piston



RA PD 342127

Figure 44—Checking Piston Ring Gap

(3) FITTING NEW PISTON.

(a) If a new piston must be used, new parts must be numbered with the same cylinder number as parts removed. Diameter of standard size piston is 5.615 to 5.616 inches. Available oversizes are 0.020, 0.040, and 0.060 inch (SNL G-159).

(b) If new piston and pin assembly is needed, the piston and cylinder wall are thoroughly clean and dry. Insert piston upside down in cylinder. Measure clearance at skirt with feeler gage, taking measurement at right angles to piston pin on the thrust side. Clearance between piston and cylinder wall should be 0.0085 to 0.0095 inch (subparagraph c (3) above).

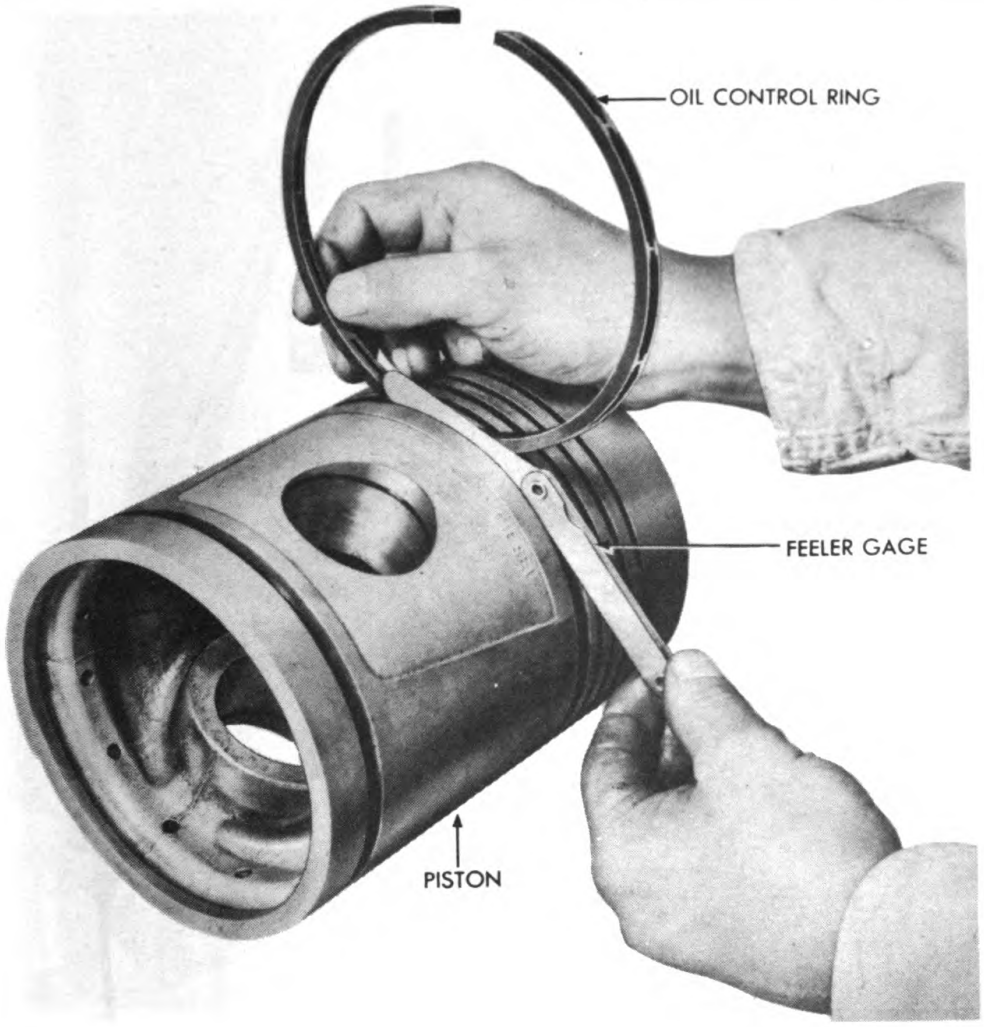


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Figure 45—Checking Piston Ring to Groove Clearance

(4) CONNECTING RODS.

(a) Correct slightly bent or twisted connecting rods to within 0.0025 inch accuracy, using connecting rod aliner (41-A-135) and press (41-P-2730) (figs. 46, 47, and 48).

(b) Check connecting rod and piston alinement as shown in figure 49.

(5) FITTING CONNECTING ROD BEARINGS.

(a) Correct running clearance is 0.0035 to 0.0045 inch; side clearance is 0.005 to 0.012 inch. Running clearance must not exceed 0.0015 inch. Should wear of journal increase this clearance beyond 0.0045 inch, regrind crankshaft journals and use undersize bearing shells,

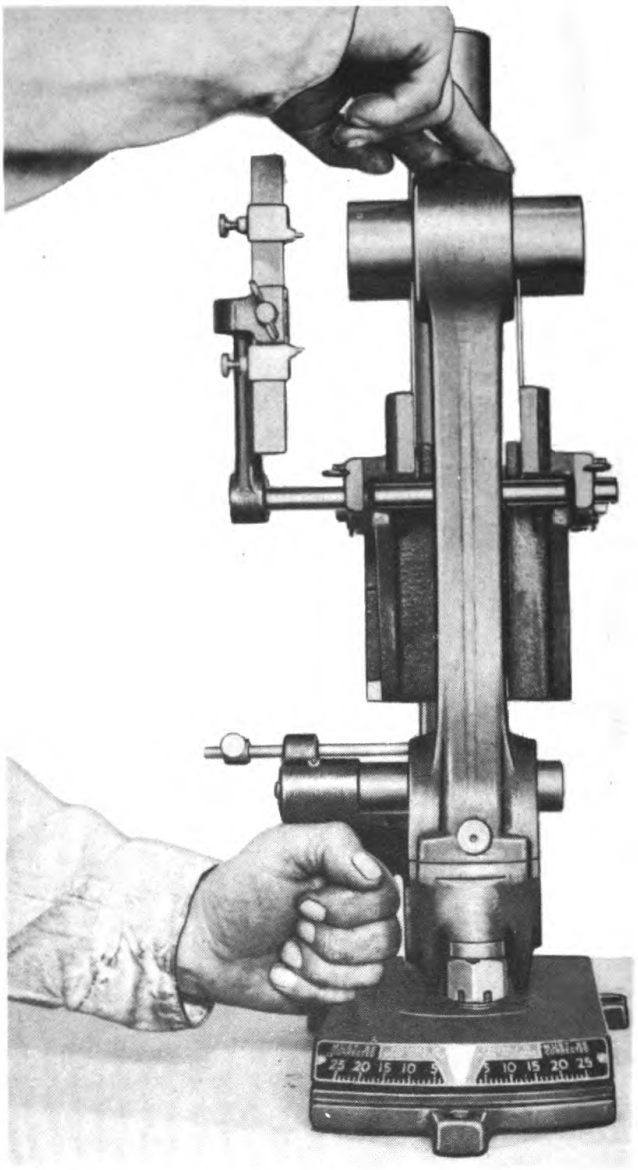

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Figure 46—Checking Connecting Rod for Bend or Twist, Using Aliner (41-A-135)

which are available in 0.020, 0.040, and 0.060 inch undersizes. Manufacturer's diameter of connecting rod journals on new crankshaft is 3.309 to 3.310 inches. Out-of-round limit of connecting rod journals is 0.002 inch. Clean bearing shells and connecting rod bores. Match shells to their proper rods.

(b) Due to the absence of shims, adjustment of connecting rod clearance is made by replacement of bearing shells.

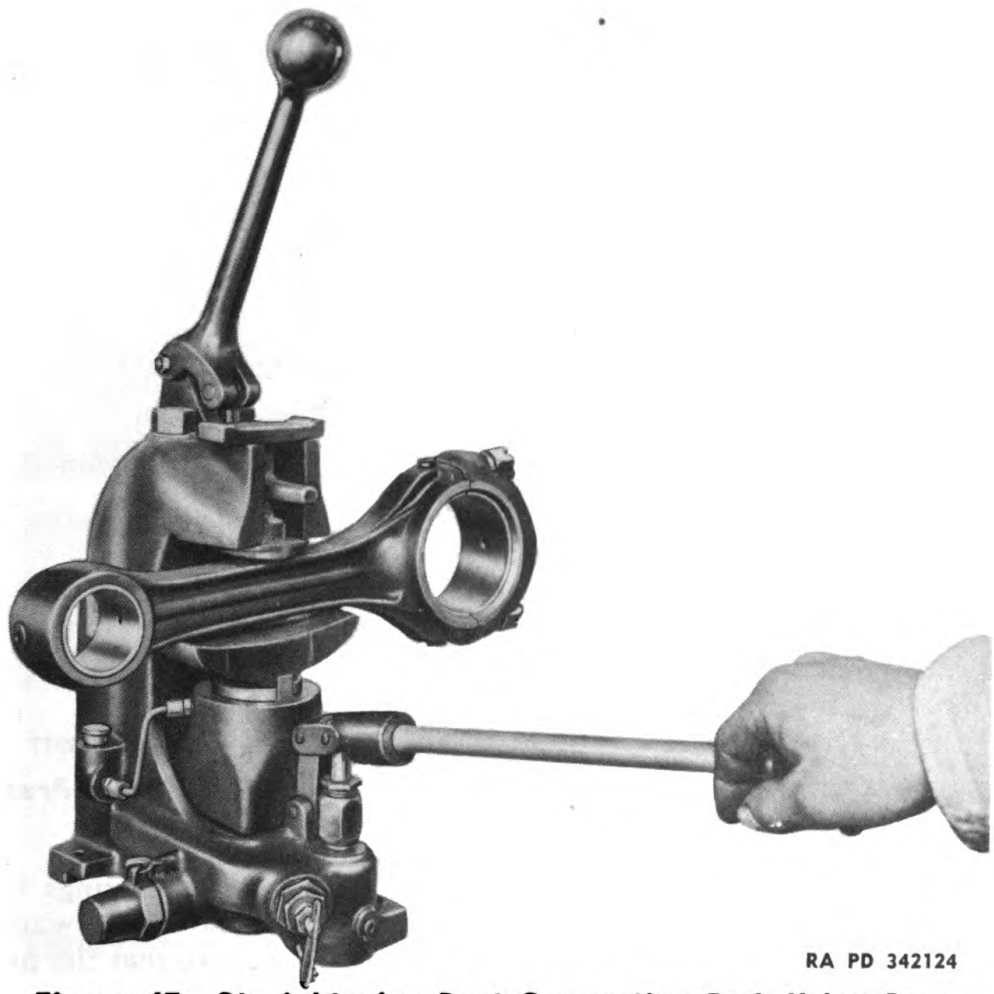

Figure 47—Straightening Bent Connecting Rod, Using Press (41-P-2730)

(c) Clearance is measured by using a piece of brass shim stock (½ inch wide and slightly shorter than length of bearing) (fig. 50). Place shim stock parallel to crankshaft, between either upper or lower bearing half and the connecting rod journal. The connecting rod bearing must be in proper position in rod and shell, with the bearing nibs resting squarely in their proper notches in rod and shell. Bearing must be free when tested with 0.0055-inch shim, and drag when tested with 0.007-inch shim. If a 0.0085-inch shim does not lock, it indicates that a bearing of incorrect size is being used. Connecting rod bearings are furnished only in 0.020, 0.040, and 0.060 inch undersizes in addition to the standard size. If undersize bearings are to be used, grind connecting rod journals to a diameter which will afford the proper

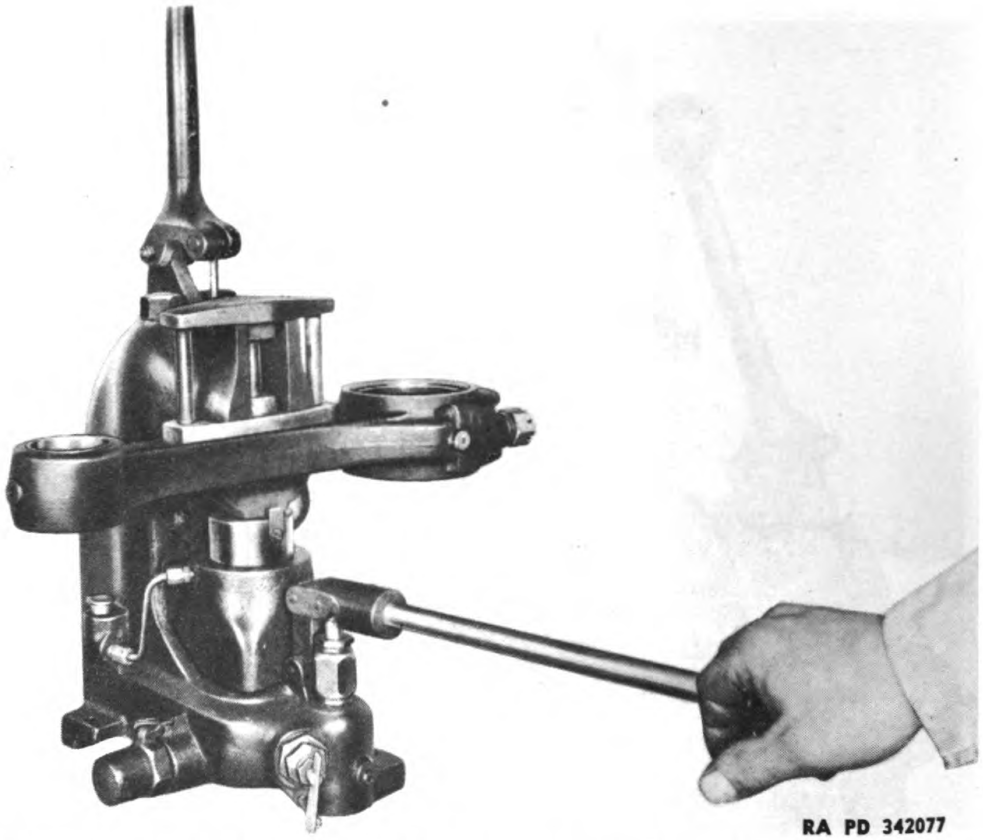

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Figure 48—Straightening Twisted Connecting Rod Using Press (41-P-2730)

clearance of 0.0035 to 0.0045 inch. After checking rod bearings for clearance, make sure they remain assembled in the same rods in which they were fitted for journals; and, when installed, be sure that the piston and rod assembly is installed in the cylinder to which the piston was fitted, and on the crankshaft journal to which the bearing was fitted.

(6) CHECK CONNECTING ROD SIDE CLEARANCE. Check side clearance of each connecting rod with feeler gage as shown in figure 51. Side clearance between connecting rod bearing and crankshaft should be 0.005 to 0.012 inch. If clearance exceeds 0.012 inch, install new bearing.

34. FLYWHEEL AND BELL HOUSING.

a. Flywheel Assembly (fig. 52).

(1) DISASSEMBLY. Pull pilot bearing out of flywheel, using puller (41-P-2957).

(2) CLEANING. Clean flywheel and clutch pilot bearing thoroughly with dry-cleaning solvent, and dry with compressed air.

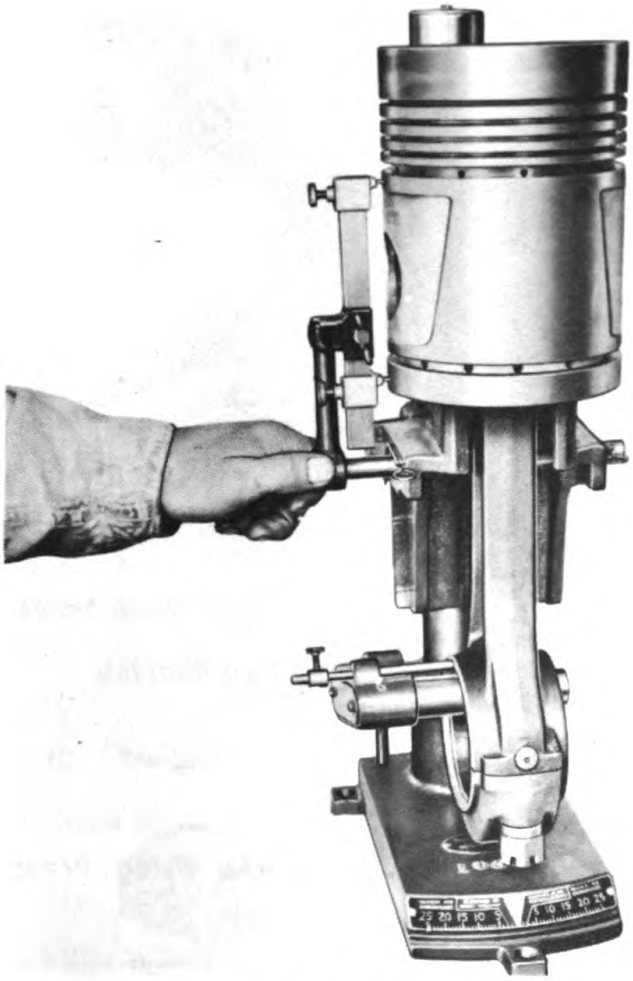

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Figure 49—Checking Connecting Rod Alinement, Using Aliner (41-A-135)

(3) INSPECTION AND REPAIR.

(a) Clutch Pilot Bearing (fig. 53). This is a "loose ball" type bearing with 0.002 to 0.004 inch total radial clearance between balls and races. Examine bearing for cracked, pitted, or scored balls or races. If any of these conditions exist, or if looseness of bearing is excessive, replace the bearing.

(b) Flywheel (fig. 52). The nominal depth from surface of machined flange for bell housing to face of clutch surface is 2.9325 to 2.9425 inches. Inspect ring gear for damaged or worn teeth or for loose fit on flywheel. If any of these conditions are found, gear must be replaced. CAUTION: *Malfunction of cranking motor solenoid switch will result in damage to ring gear teeth. If inspection shows damaged or worn gear teeth, cranking motor solenoid switch must be*

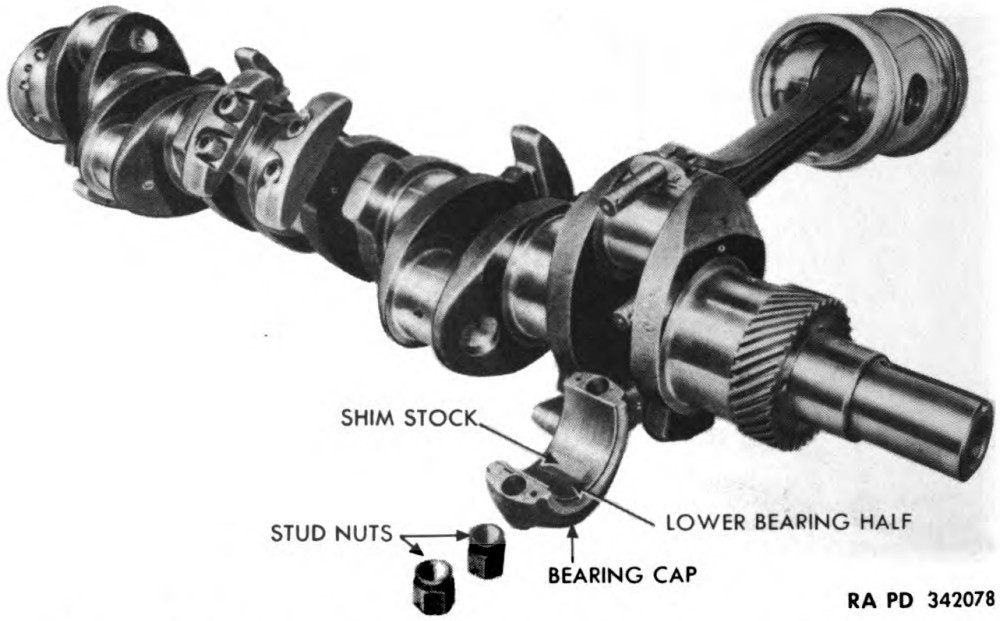


Figure 50—Method of Checking Connecting Rod Bearing Clearance, Using Shim Stock

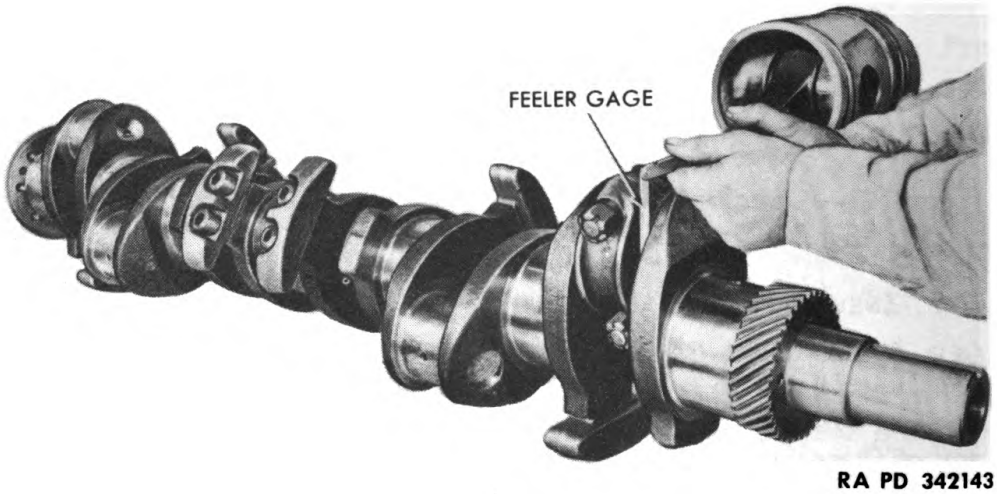


Figure 51—Checking Connecting Rod Side Clearance

inspected and repaired as continued malfunction would soon damage the new ring gear. If necessary to replace ring gear, heat with a torch to expand it, and drive it off flywheel while hot. Heat new gear with a torch to 440°F and tap into position so that it is seated firmly against flywheel shoulder. Interference of inside diameter of ring gear to

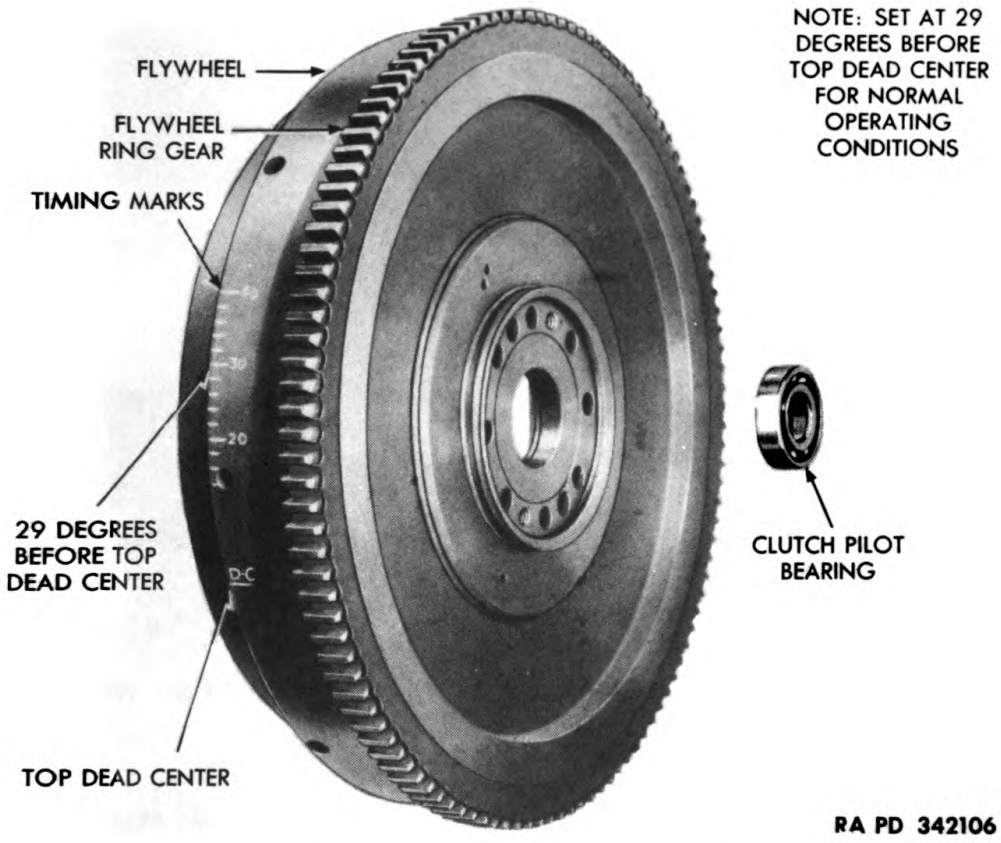


Figure 52—Flywheel and Clutch Pilot Bearing

outside diameter of flywheel is 0.020 to 0.025 inch. Examine clutch friction face of flywheel for score marks, heat checks, or roughness. If such defects cannot be eliminated by refacing, replace the flywheel. Flywheel can be refaced in a lathe by taking a light cut, and polishing with crocus cloth. Replace flywheel if refinishing cut would go deeper than 0.045 inch.

(4) ASSEMBLY. Repack clutch pilot bearing with grease, and with shielded side toward clutch press bearing into position in flywheel.

b. Bell Housing. Drive seal from outside toward inside of housing, using a piece of wood and hammer. Be careful not to damage bore of housing. Install new seal by driving into position as shown in figure 54.

(1) CLEANING. Scrape off all faces. Clean housing with dry-cleaning solvent. The oil seal consists of leather or synthetic rubber supported in a steel housing. Proper sealing depends on the flywheel pilot surface being polished so that seal will not wear rapidly. Be sure all nicks or rough spots are smoothed off flywheel pilot surface. If necessary, polish with crocus cloth.

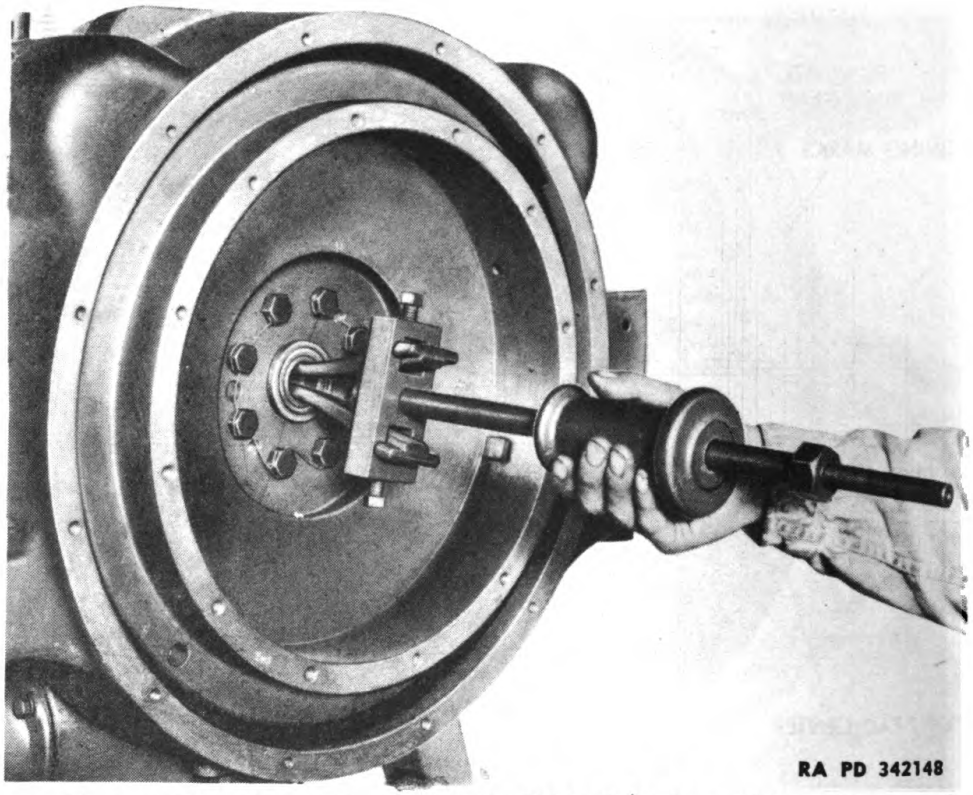


Figure 53—Removing Clutch Pilot Bearing, Using Puller (41-P-2957)

(2) INSPECTION. Inspect face for burs, scratches, or any signs of roughness or damage. Examine entire casting for cracks. Replace cracked bell housing. Replace oil seal, as shown in figure 54, if it is unserviceable.

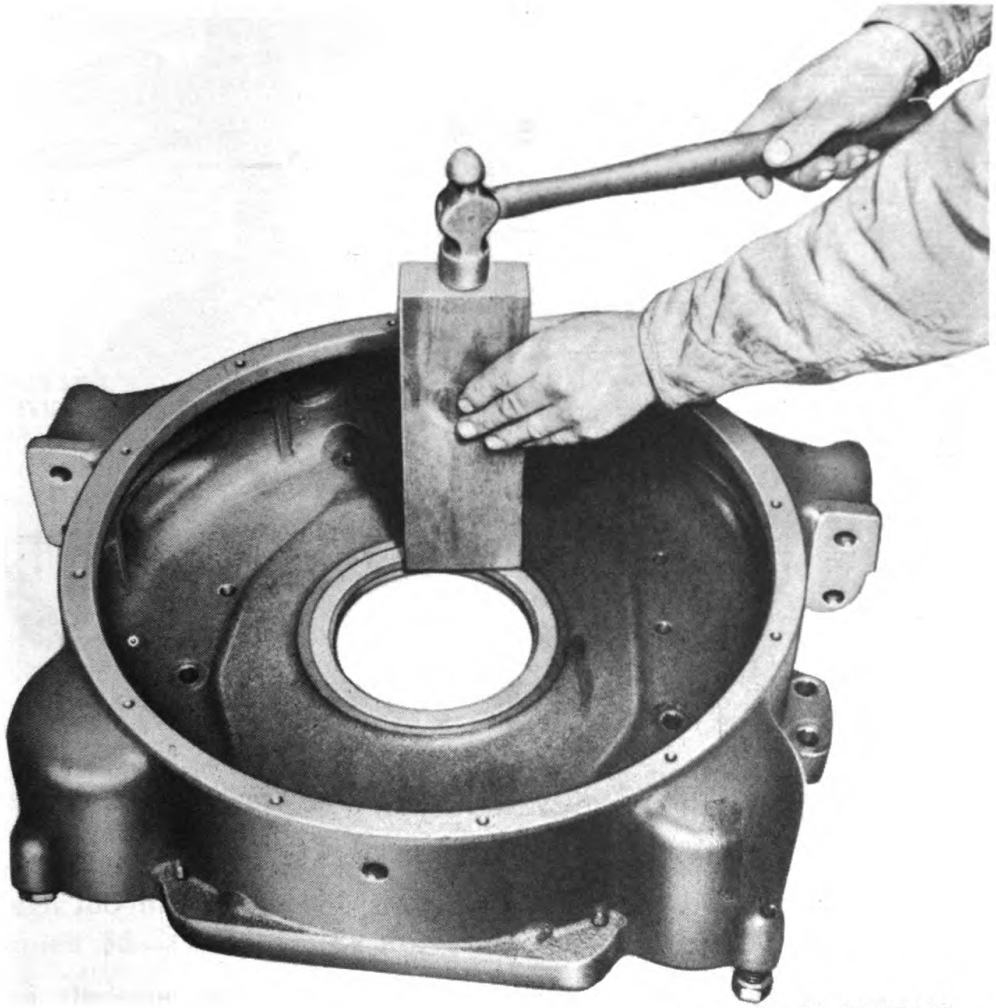
35. CAMSHAFT.

a. Disassembly (fig. 55). It is not necessary to remove gear from camshaft unless inspection shows that a new gear is needed. To remove gear, fasten camshaft in vise with copper jaws, cut lock wire, remove three cap screws, and use two ½-inch bolts, tightening them evenly against flange of shaft. Remove gear and Woodruff key.

b. Cleaning. Clean with dry-cleaning solvent, and dry with compressed air.

c. Inspection and Repair.

(1) GEAR (fig. 55). Examine camshaft gear for worn, chipped, or broken teeth. Replace if defective.



RA PD 342133

Figure 54—Installing New Oil Seal in Bell Housing

(2) CAMSHAFT.

(a) Cam Lobes. Examine cam lobes for indication of wear or scratches. Permissible wear of lobes from heel to toe is 0.050 inch. Slight scratches can be cleaned up with a hone, but if cams show excessive wear the shaft must be replaced. NOTE: *All valve tappets must be replaced whenever a new camshaft is installed.*

(b) Journals. Measure each journal with a micrometer, making two checks at each, one at right angle to the other. In each instance, move micrometer across entire surface of journal. Camshaft bearing clearance is 0.003 to 0.0035 inch. End thrust is 0.005 to 0.008 inch. New camshaft journal diameter is 2.371 to 2.372 inches. If journals are worn so that diameter is less than 2.366 inches, replace camshaft and tappets. Place camshaft on V-blocks and check run-out. If

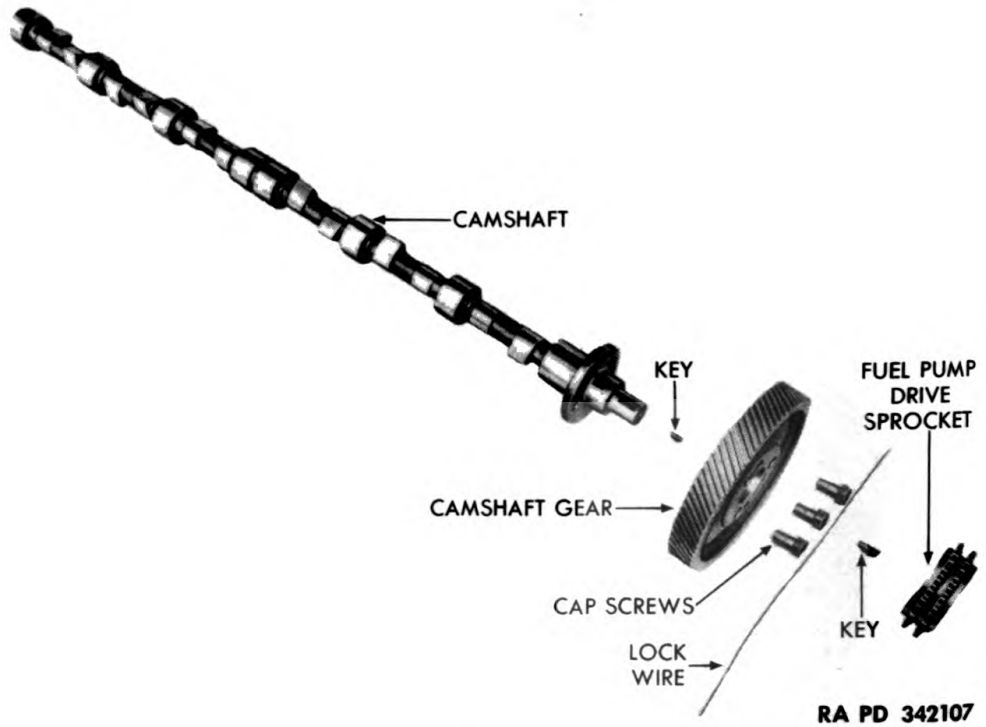


Figure 55—Camshaft, Gear, and Sprocket

run-out exceeds 0.004 inch, mark shaft to indicate degree of run-out and correct the bend with a bending press; then check run-out again to make sure it does not exceed 0.004 inch.

(3) THRUST BEARINGS. The end movement of camshaft and fuel pump drive are adjusted by means of shims placed between the gear cover and the thrust plate (fig. 74). Removal of shims permits the plates to be reassembled to take up end play; care must be exercised not to take out too many shims, as this would throw a heavy thrust load on thrust plug. Correct end thrust is 0.005 to 0.008 inch. Check the condition of thrust bearing surfaces; if damaged or worn too far for adjustment with shims, replace the thrust plates in gear cover (par. 41).

36. CYLINDER HEADS.

a Disassembly.

(1) REMOVE VALVES (fig. 56). Compress valve spring with compressor (41-L-1408). Note use of small hammer in figure 56. This may be necessary as there is a tendency of valve spring washer to stick tightly in the tapered lock; therefore, after exerting slight tension with compressor, tap the washer lightly with a small hammer. This

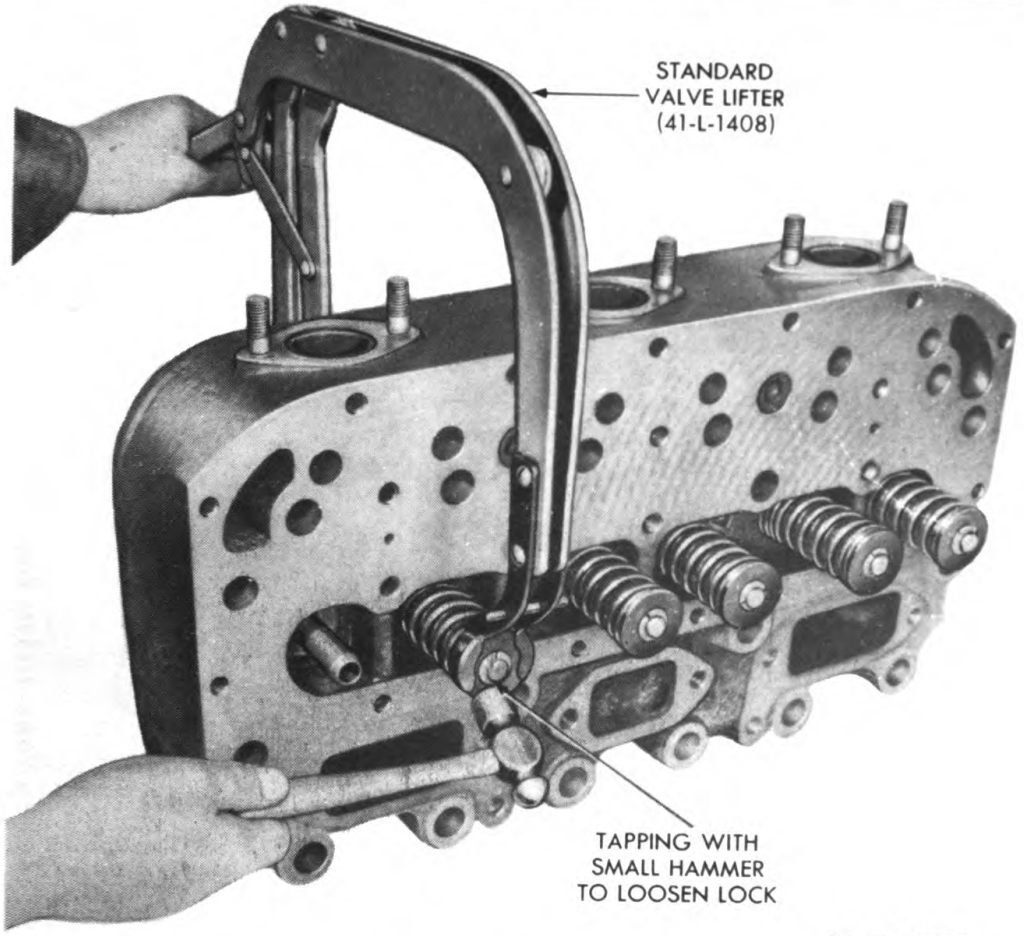


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Figure 56—Compressing Valve Springs, Using Lifter (41-L-1408)

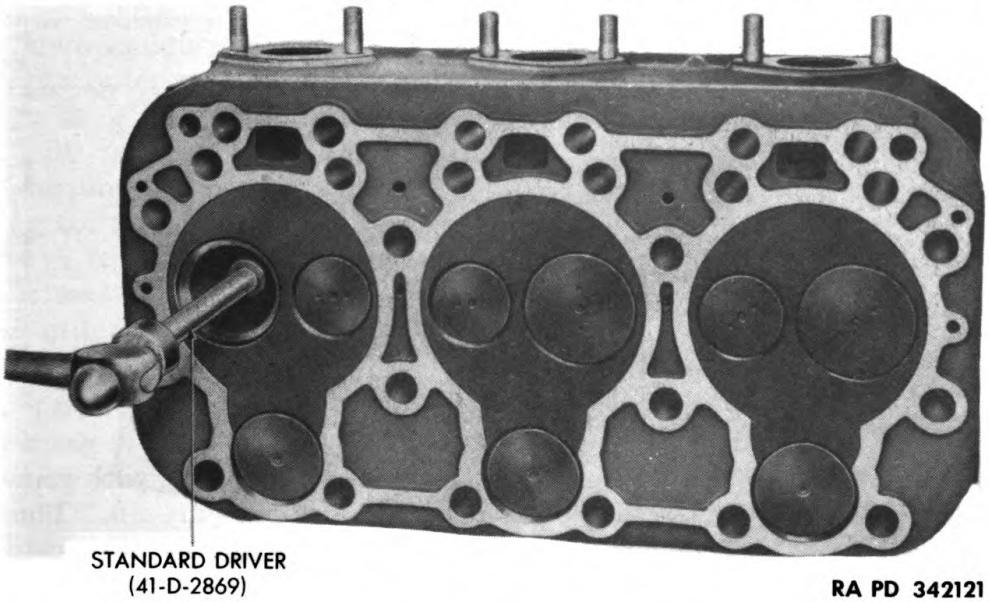

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Figure 57—Removing Valve Guide, Using Driver Set (41-D-2869)

Figure 58—Checking Tension of Valve Springs, Using Tester (41-T-1600)

will release the lock and prevent the possibility of putting too much strain on the valve spring compressor. CAUTION: *As valves are removed, put them in a rack in correct order so they will be assembled in the same guides from which they were removed.* Remove spring seat, valve lock, and inner and outer springs. Remove valves.

(2) REMOVE VALVE GUIDES. Guides are not removed unless inspection indicates need for replacement. Use driver (41-D-2869) as shown in figure 57.

b. Cleaning. Clean all parts with dry-cleaning solvent and dry with compressed air. Use wire brush and scraper to remove external carbon deposits. Clean carbon from valve guides with a reamer. Make sure all particles of old gasket and cement are removed from cylinder head.

c. Inspection.

(1) WARPAGE. Check face of cylinder heads for warp, using straightedge and feeler. If warpage is more than 0.010 inch, correct warpage by surface grinding but do not grind more than 0.004 inch. Also inspect for channeling; permissible channeling before refacing is 0.003 inch. Inspect tapped holes for damage or wear.

(2) INSPECT GASKETS AND STUDS. Inspect copper gaskets for manifold connections. Replace if worn or broken. Examine manifold studs to see that threads are in good condition.

(3) INSPECT VALVE ASSEMBLY.

(a) Valve Springs. Examine inner and outer springs for any signs of weakness or damage, and replace any defective springs. Check tension of inner and outer springs, using tester (41-T-1600) as shown in figure 58. At $3\frac{15}{32}$ inches high (minimum working height), large outer springs should test 51 to 59 pounds in tester. Scale reading at $2\frac{31}{32}$ inches high (maximum working height) should be 89 to 99 pounds. Small inner springs should test at $3\frac{5}{32}$ inches high (minimum working height), 29½ to 35½ pounds. The scale reading for the small intake valve springs at $2\frac{21}{32}$ inches high should be 54½ to 60½ pounds. Free length of inner valve springs should be 4 inches ± 0.005 inch; length with valve open, $2\frac{21}{32}$ inches. Free length of outer springs is 4½ inches ± $\frac{1}{16}$ inch; length with valve open, $2\frac{31}{32}$ inch.

(b) Valves and Stems. Inspect valves and stems for signs of pitting or damage. If valve stem is bent, replace the valve. Examine valve for pits. Valve stem diameter on new valves is 0.4980 to 0.4970 inch.

(c) Valve Seats. Look for pits in valve seats, and make sure that valves seat evenly. Grind seats to 45-degree angle if pitted (subpar. **d** below).

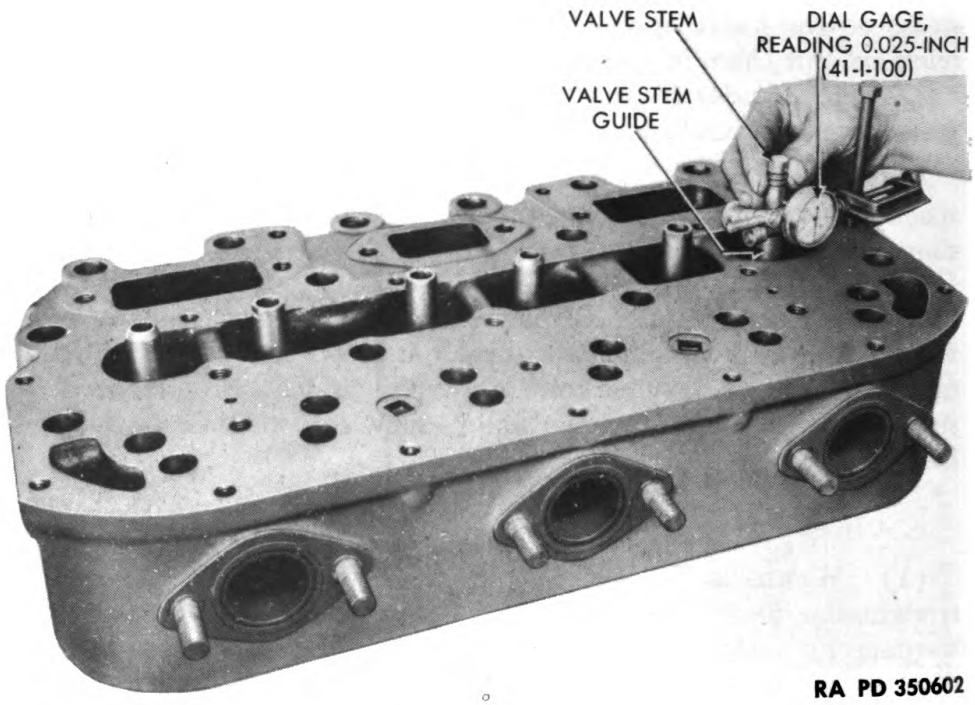


Figure 59—Checking Clearance of Valve Stem in Guide (Sideways)

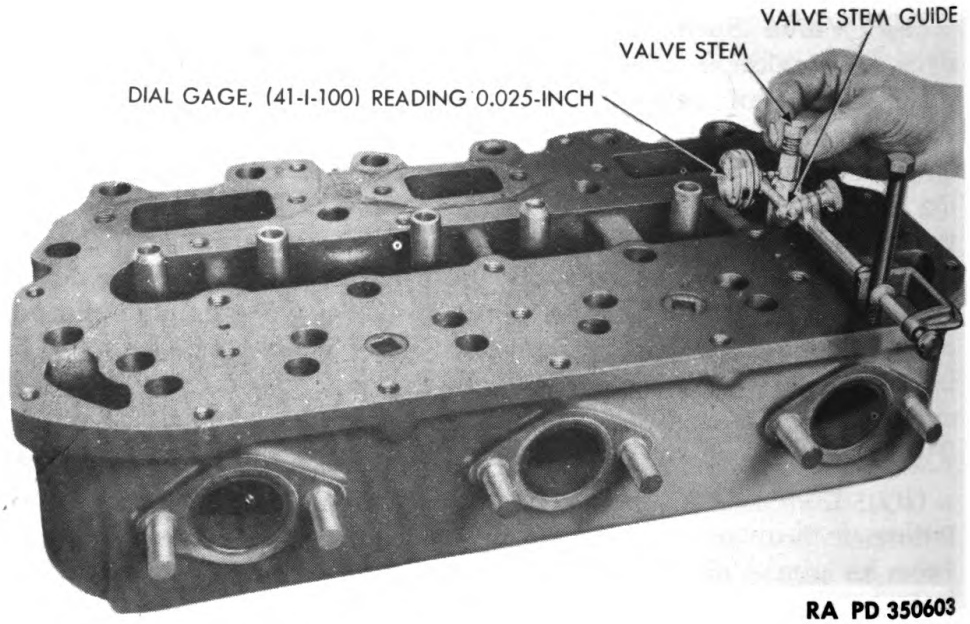


Figure 60—Checking Clearance of Valve Stem in Guide (Endways)

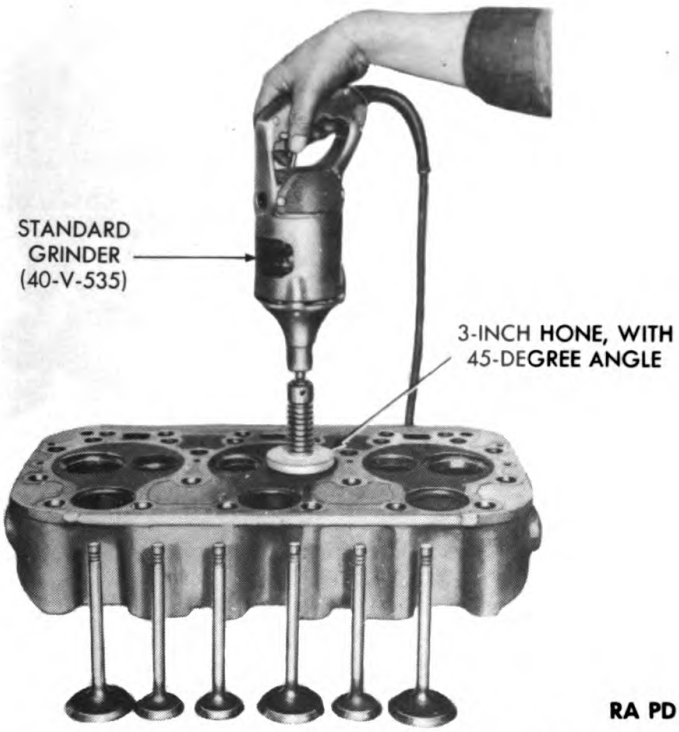


Figure 61—Grinding Intake Valve Seat, Using Grinder (40-V-535) and 3-inch Hone (45-degree Angle)

(d) Refaced Valve. On a refaced valve, if thickness from top of head to edge of refaced outer circle is less than 0.025 inch, replace the valve with a new one.

(e) Spring Seats and Locks. Examine spring seats for wear and valve locks for signs of damage. Replace any defective parts.

(f) Clearances. Clearance between valve stems and valve guides (when new) is 0.0025 to 0.003 inch. Limit of permissible clearance is 0.004 inch for intake valves, 0.005 inch for exhaust valves. Check this clearance with dial gage as shown in figures 59 and 60, moving gage to check both ways. If clearance exceeds the limit, replace valves and guides.

(g) Valve Guides. Dimensions of valve guide bores is 0.499 to 0.500 inch. Maximum allowable wear on exhaust valve tappet guides is 0.005 inch, and on intake valve tappet guides is 0.003 inch. Interference to bore is 0.001 to 0.0025 inch. After new guides are installed, finish to secure proper clearances (step *(f)* above).

(4) INSPECT TAPPETS AND PUSH RODS.

(a) Tappet Assembly. Examine adjusting screws, valve tappets, tappet guides, and washers for any signs of damage or excessive

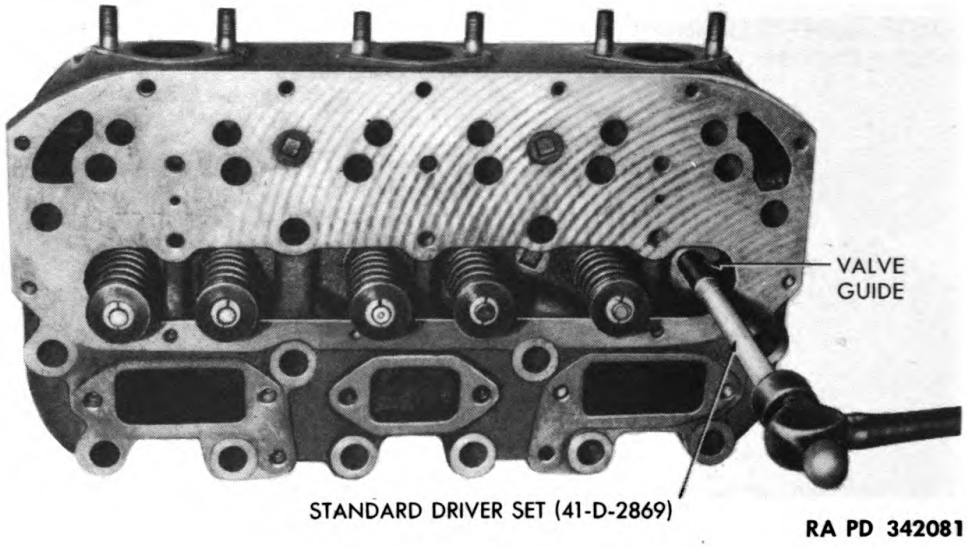


Figure 62—Installing Valve Guide, Using Driver Set (41-D-2869)

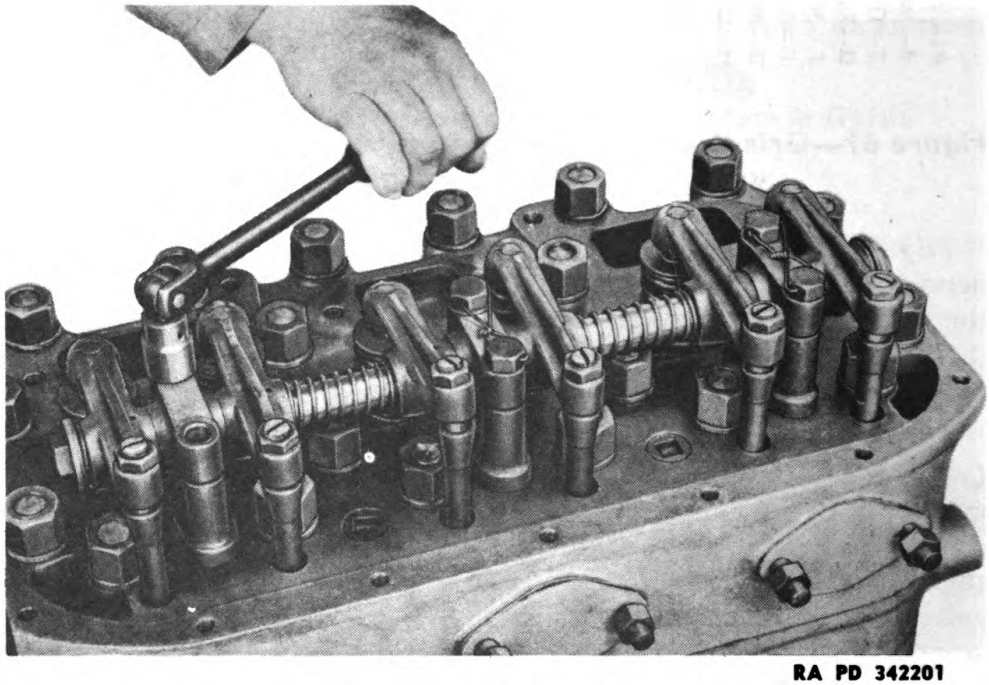


Figure 63—Removing Rocker Arm Assembly

wear. Replace any damaged parts. Diameter of new valve tappet is 0.8735 to 0.874 inch. Clearance in bushing is 0.0005 to 0.002 inch. Replace tappets if worn more than 0.004 inch. Clearance of outside diameter of bushing to inside diameter of bore is 0.0005 to 0.0025 inch. Dimension of tappet guide is 0.8745 to 0.8755, and wear limit

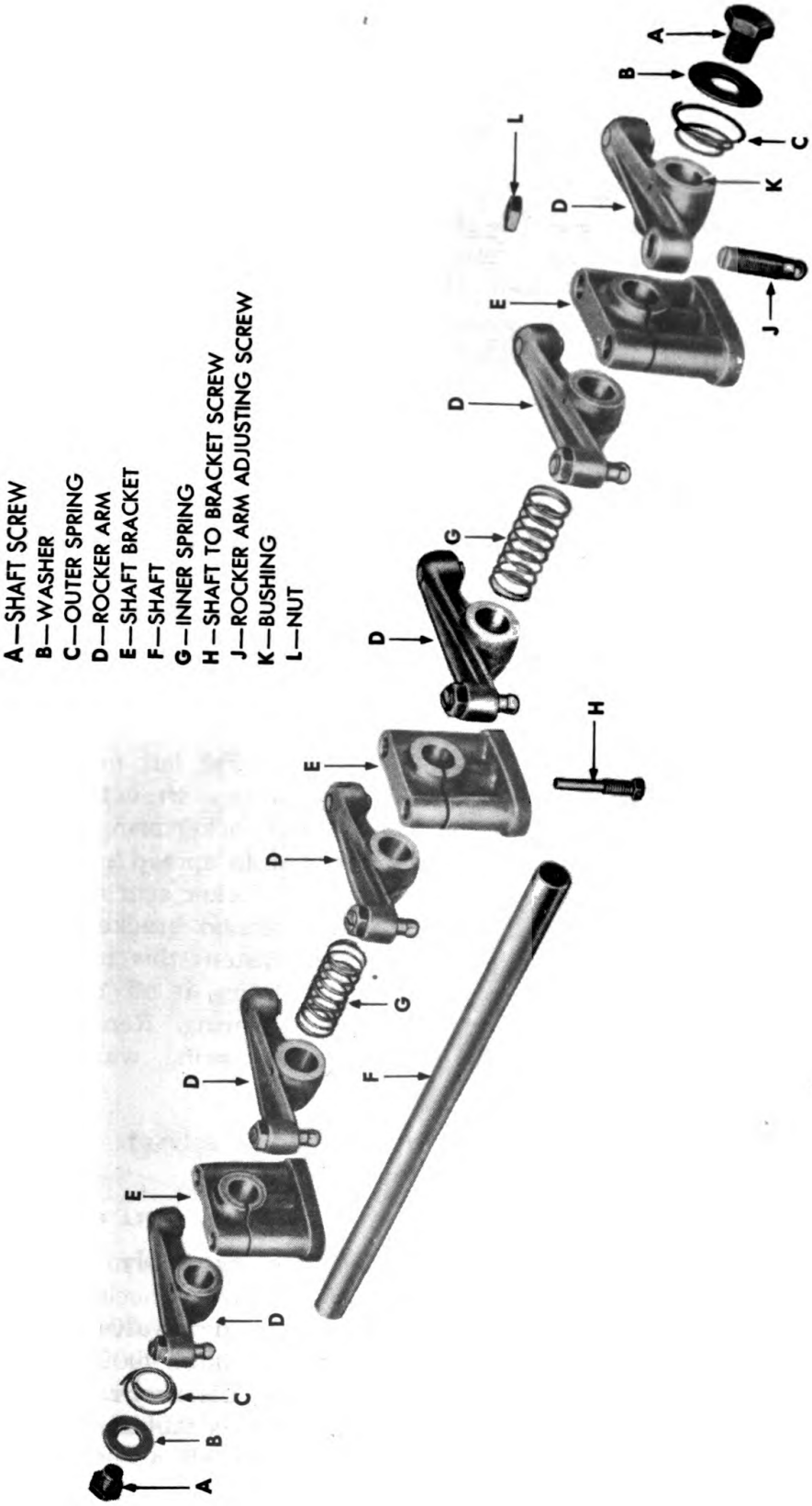


Figure 64—Rocker Arm Assembly, Disassembled

before replacement at general overhaul is 0.002 inch; maximum surface removable from tappet is 0.005 inch.

(b) Push Rods. Inspect push rods to see if they are bent or badly worn at the cupped end. Replace rods that are bent or worn.

d. Repair.

(1) GRINDING VALVE SEATS. If inspection shows deep pits in valve seats, reseat them using valve reseater (40-V-535) and a 3-inch hone with 45-degree angle (fig. 61). NOTE: *Because of the large diameter and surface of valve seats, a good reseating job is not practicable with a reamer-type tool.* Remove all shoulders and pits from seat, but do not grind any deeper than necessary to do this. Seat angle is 45 degrees. Angle of relief is 60 degrees. Width of valve seats is $^{13}/_{64}$ inch.

e. Assembly.

(1) VALVE GUIDES. If valve guides were removed use driver set (41-D-2869) as shown in figure 62, to install them.

(2) VALVES. Install valves in the guides from which they were removed. Insert valve, inner and outer springs, and spring seat. Compress valve as shown in figure 56. Install the two halves of valve lock, and release lifter slowly.

37. VALVE ROCKER ARM ASSEMBLY.

a. Disassembly (figs. 63 and 64). Starting at left end of assembly, remove shaft screws from shaft by using a wrench at each end of assembly. Remove outer spring and first rocker arm. Remove first bracket by inserting a screwdriver in slot to spread enough so that it will slide off the shaft. Remove second rocker arm and inner spring. Remove third rocker arm. Remove second bracket by unscrewing and removing bracket screw which fastens this bracket to shaft, inserting screwdriver to spread, and sliding it off the shaft. Remove fourth rocker arm and second inner spring. Remove fifth rocker arm and third bracket. Remove outer spring, washer, and washer screw.

b. Cleaning. Wash all parts in dry-cleaning solvent. Blow out oil passages in rocker arms with compressed air.

c. Inspection and Repair.

(1) SHAFTS, BUSHINGS, AND BALLS. New rocker arm shaft diameter is 0.855 to 0.856. Wear limit is 0.0125 inch. Check for wear with micrometers. Clearance to rocker arms should be 0.001 to 0.015 inch; wear limit is 0.017 inch. Rocker arm bore is 0.9990 to 1.0005 inch. Examine shafts, rocker arm bushings, and balls on rocker arm adjusting screws for damage or wear. Diameter of rocker arm bushing is 0.8575 to 0.8585 inch. Maximum wear limit is 0.003 inch.

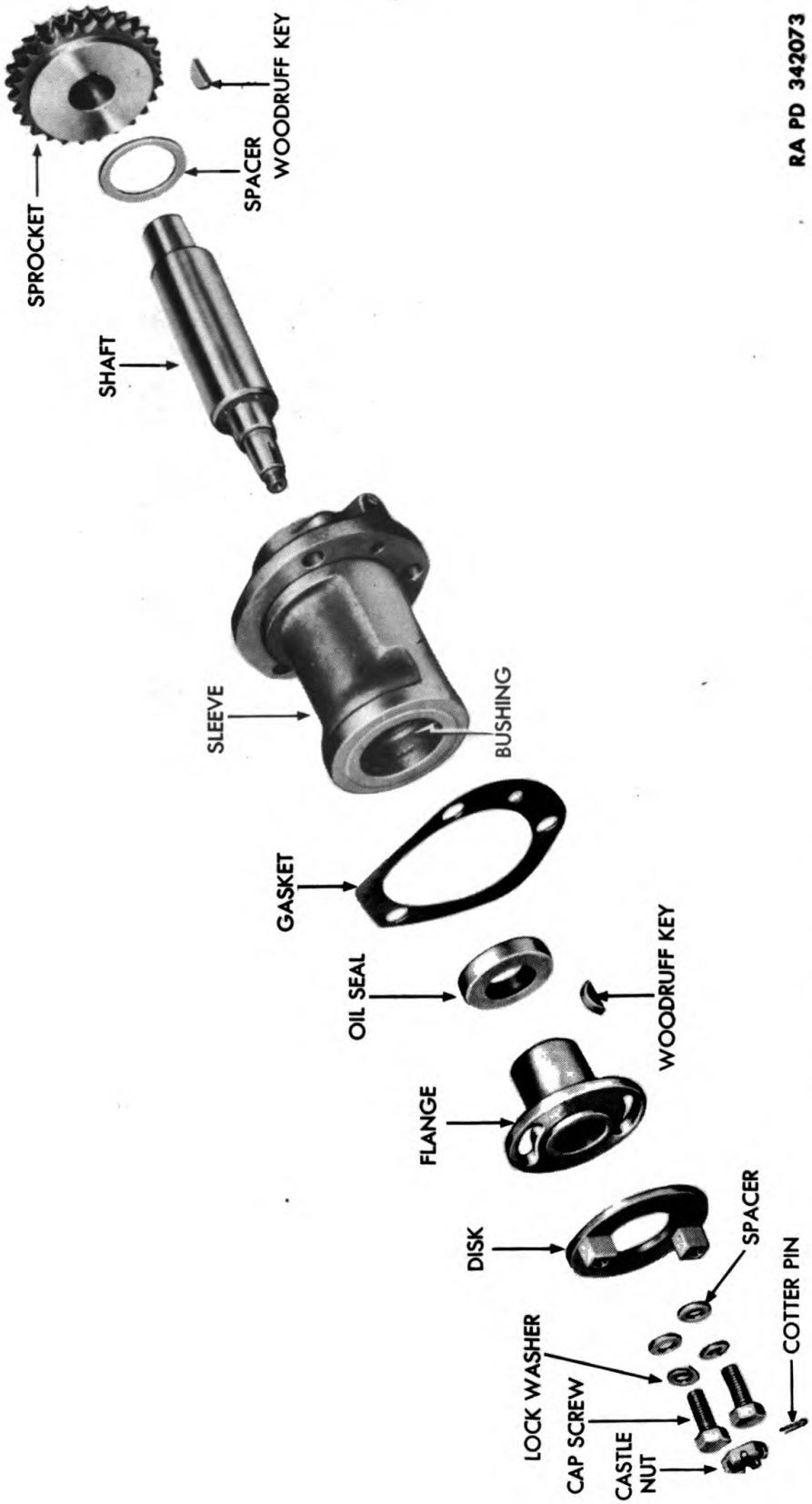


Figure 65—Fuel Injector Pump Drive, Disassembled

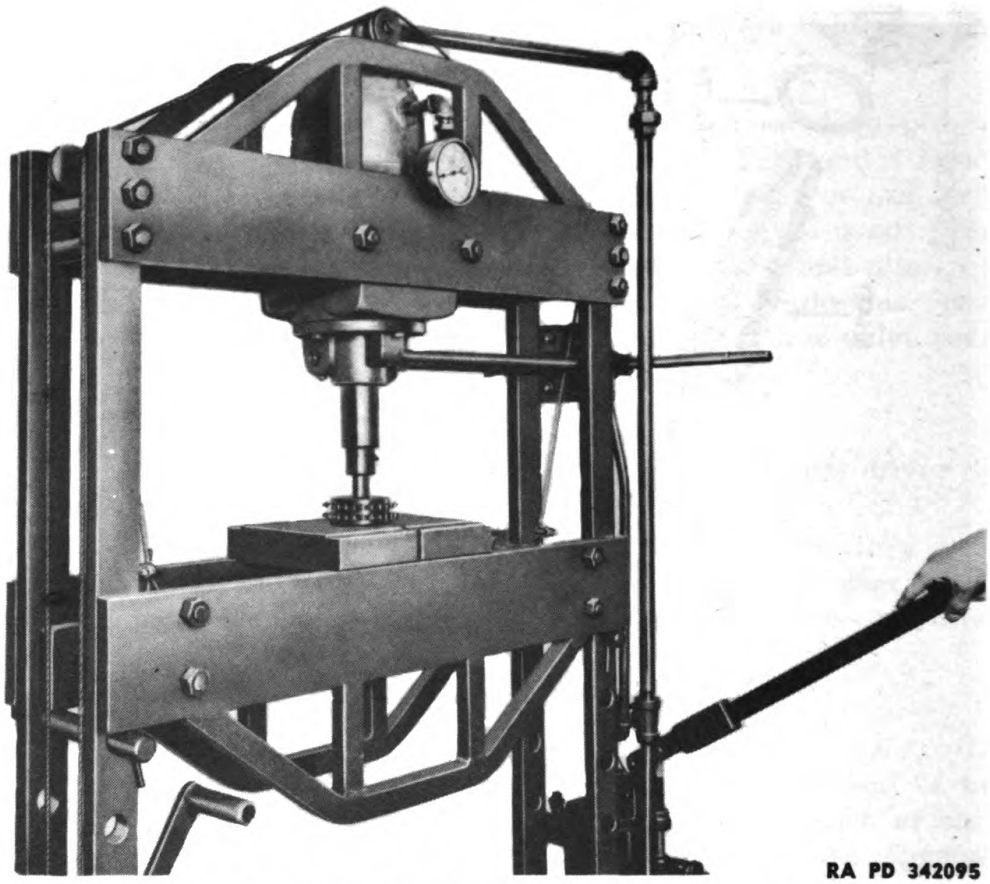


Figure 66—Pressing Fuel Pump Driven Sprocket From Shaft

(2) EXPANSION PLUGS. Make sure that rocker arm expansion plugs, which are anchored into the ends of rocker arms opposite the ends on which adjusting screws are installed, are securely in place. Considerable trouble will result from excessive oil leak if one of these plugs becomes loose during operation of the vehicle. If a loose plug is found anchor it securely in place by peening edge of hole with a small chisel, or replace the rocker arm. Check expansion plug on each rocker arm to make certain all of them are securely anchored in place.

d. Assembly (fig. 64.) If bushings are worn beyond 0.003 inch, press in new bushings and ream to 0.8575 to 0.8585 inch. Press center bracket on shaft, and install bracket screw so that screw engages shaft. Install the balance of rocker arms, springs, and brackets on shaft, using cylinder heads as templates to secure proper alinement; then press brackets into positions on shaft. Install rocker arm at each end of shaft; place outer springs on ends of shaft with shaft washers

and screws, and tighten screws. Assemble the other rocker arm assembly in the same manner.

38. FUEL INJECTOR PUMP DRIVE.

a. Disassembly.

(1) REMOVE COUPLING FLANGE (fig. 65). Remove castle nut from shaft Remove cap screws and take off disk. Coupling flange can be tapped off shaft unless it is "frozen" on the tapered shaft, in which case use a puller to remove it. Be sure to remove Woodruff key before withdrawing shaft from sleeve, as there is danger of the key scratching bearing surface of bushings (fig. 66). Remove oil seal from sleeve. It is not necessary to remove bushings from sleeve unless inspection shows need of new bushings. Use special tools, as outlined in subparagraph d to remove bushings (fig. 67).

(2) PRESS OFF SPROCKET. Mount shaft and sprocket in arbor press as shown in figure 66, and press sprocket off shaft; remove Woodruff key.

b. Cleaning. Clean all parts with dry-cleaning solvent. Blow out oilholes in shaft and sprocket with compressed air.

c. Inspection and Repair.

(1) SHAFT. Inspect shaft threads and shoulders for damage or wear; replace if damaged. Drive shaft end clearance must be 0.002 to 0.004 inch. Bearing clearance must be 0.0025 to 0.003 inch. Wear limit is when play of shaft causes a 2-degree variation from prescribed timing of injection.

(2) SLEEVE. Examine sleeve closely for cracks, and examine bushings in sleeve for score marks or other signs of wear. Replace sleeve if cracked. Replace bushings if worn or damaged.

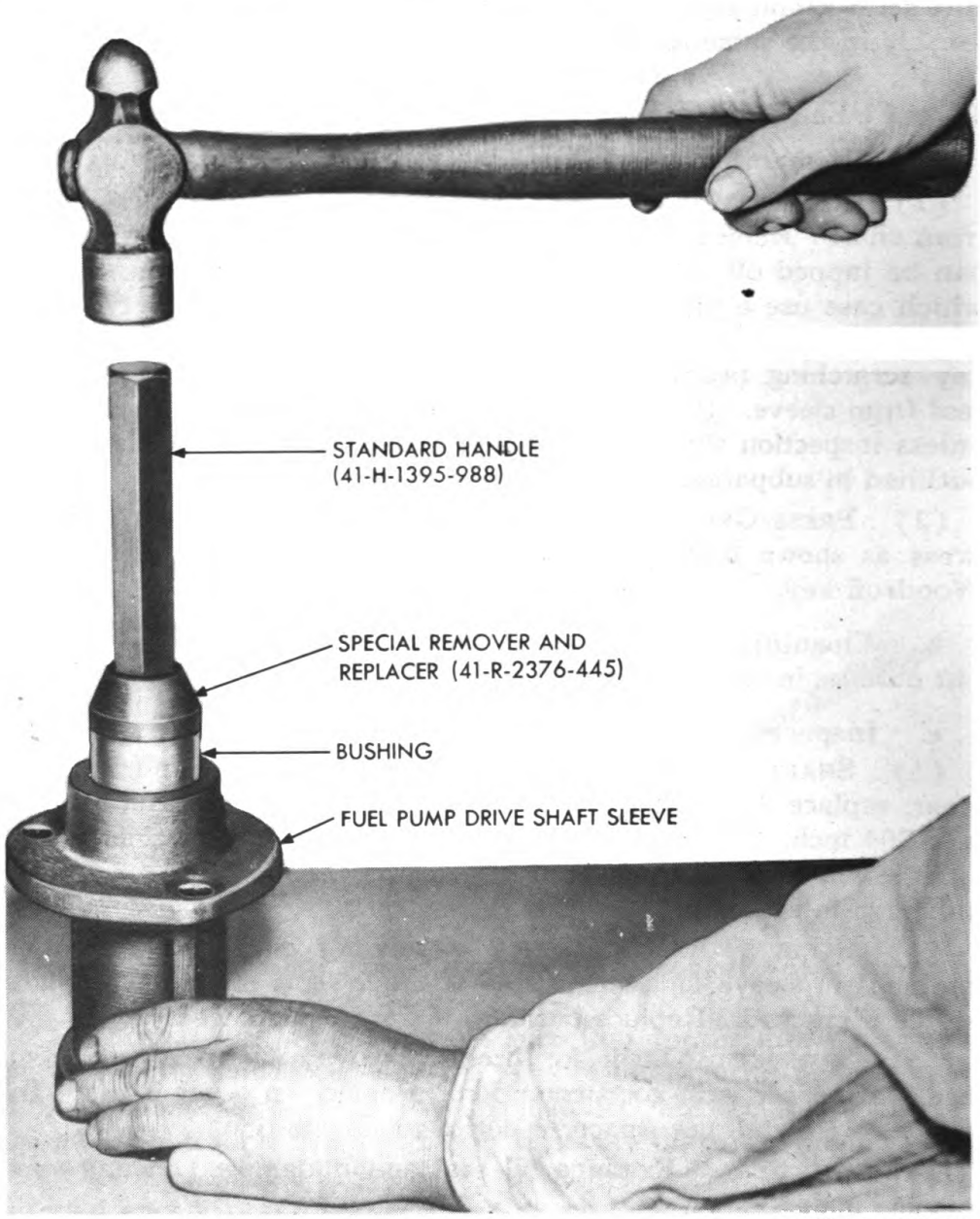
(3) SPROCKET. Look for broken or worn teeth on sprocket. See that spacer is in good condition. Replace sprocket if teeth are damaged. Install new spacer if not in good condition.

(4) OIL SEAL. Examine oil seal and if damaged in any way, replace it.

(5) FLANGE AND DISK. Examine flange for any signs of damage caused by slipping. Replace it if it cannot be smoothed properly with file. See that lugs on disk are not damaged, and that threads of connecting bolts are not stripped. Replace any unserviceable part.

d. Assembly.

(1) INSTALL BUSHINGS IN SLEEVE. If old bushings were removed, tap new bushings in, using special remover and replacer (41-R-2376-445) with standard handle (41-H-1395-988) as shown in figure 67. Use special pilot (41-P-405) to insert shaft in sleeve, as shown in figure 68. This pilot prevents damaging the oil seal.



RA PD 350604

Figure 67—Installing Bushing in Fuel Pump Drive Shaft Sleeve, Using Remover and Replacer (41-R-2376-445) and Handle (41-H-1395-988)

(2) PRESS SPROCKET ON SHAFT. Figure 69 shows the correct set-up for pressing fuel pump driven sprocket on shaft. Use a piece of pipe, 1¼-inch inside diameter, 3 inches long; rest this pipe on shoulder of shaft and press shaft on sprocket. Be sure that shaft is positioned so that Woodruff key will enter keyway in sprocket.

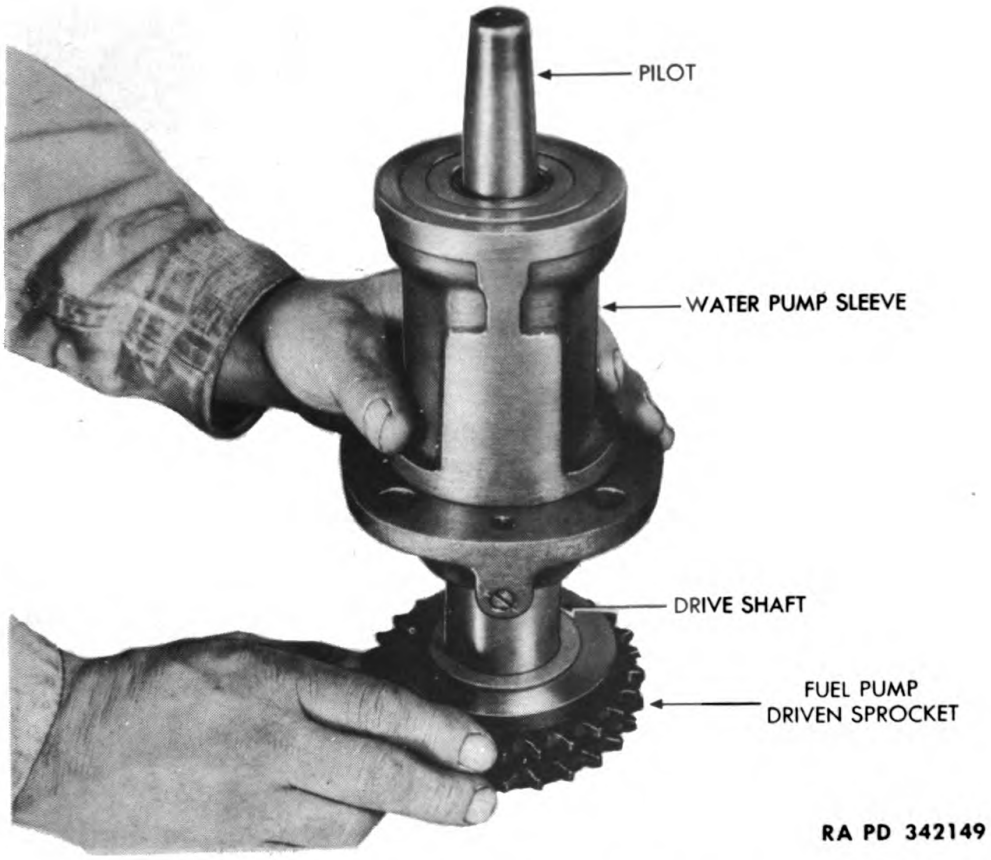


Figure 68—Inserting Fuel Pump Drive Shaft in Sleeve, Using Special Pilot (41-P-405)

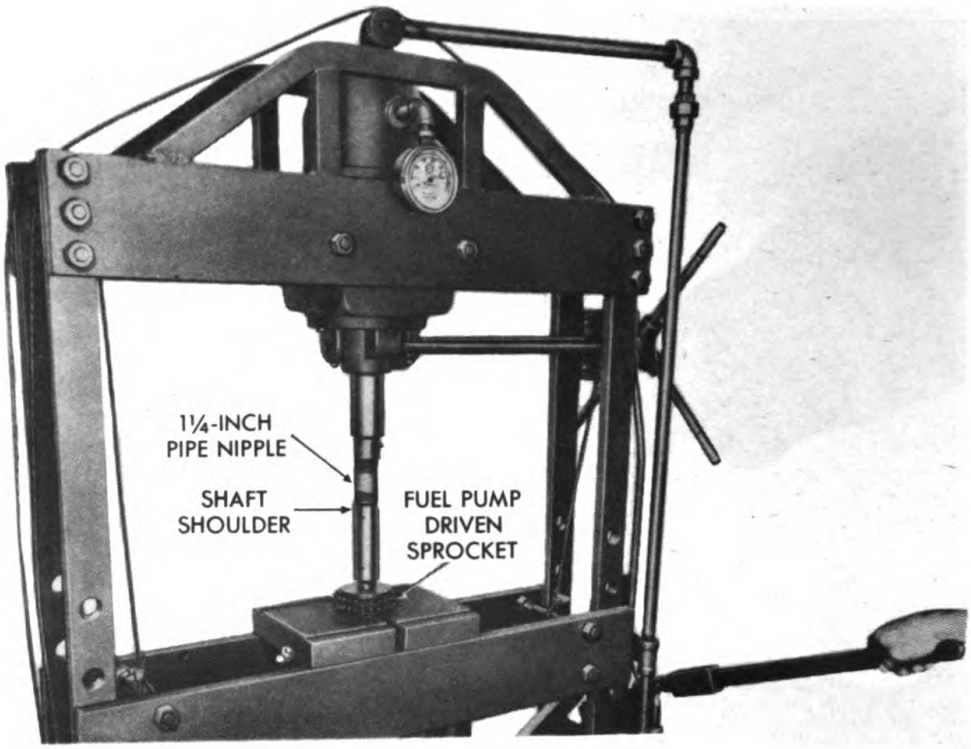
(3) INSTALL FLANGE COUPLING. Flange coupling cannot be installed until balance of assembly is installed on the engine. The flange is a loose press-fit, and is held from turning on shaft by a Woodruff key.

39. INTAKE AND EXHAUST MANIFOLDS.

a. Intake Manifold (fig. 70).

(1) CLEANING. Wash thoroughly in dry-cleaning solvent and dry parts with air hose, or wipe dry with rags. Scrape all particles of gaskets and adhesive material from machined surfaces.

(2) INSPECTION AND REPAIR. Check finished surfaces of flanges for warp, using a straightedge and feeler gage. Replace if warped more than $\frac{1}{32}$ inch. Examine all sections of manifold for cracks or



RA PD 342075

Figure 69—Pressing Fuel Pump Driven Sprocket on Shaft

broken flanges. Examine starter burner attaching studs to see that threads are not stripped. See that air cleaner adapter screws are in place and in good condition. Replace any defective part which cannot be repaired by ordinary means.

b. Exhaust Manifold (fig. 71).

(1) DISASSEMBLY. It is not necessary to separate the two sections except when one section is to be replaced. The two sections telescope together, and if tight are loosened by tapping with a hammer.

(2) CLEANING. Remove carbon deposits from interior of manifold, and scrape finished flanges clean.

(3) INSPECTION AND REPAIR. Check finished surfaces with straightedge and feeler gage to determine if warped. If cracked, broken, or warped more than $\frac{1}{32}$ inch, replace the defective section. Examine for cracks or breaks at stud holes in flanges. If cracked, broken, or warped in excess of $\frac{1}{32}$ inch, replace defective section.

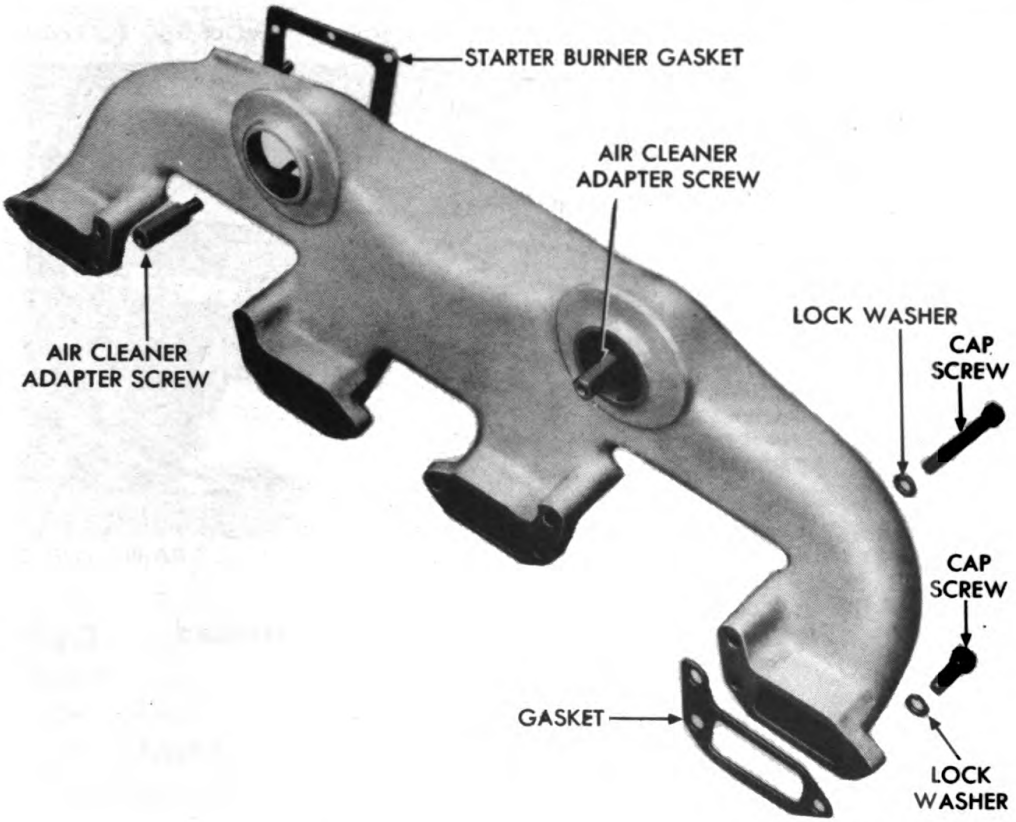


Figure 70—Intake Manifold, Disassembled

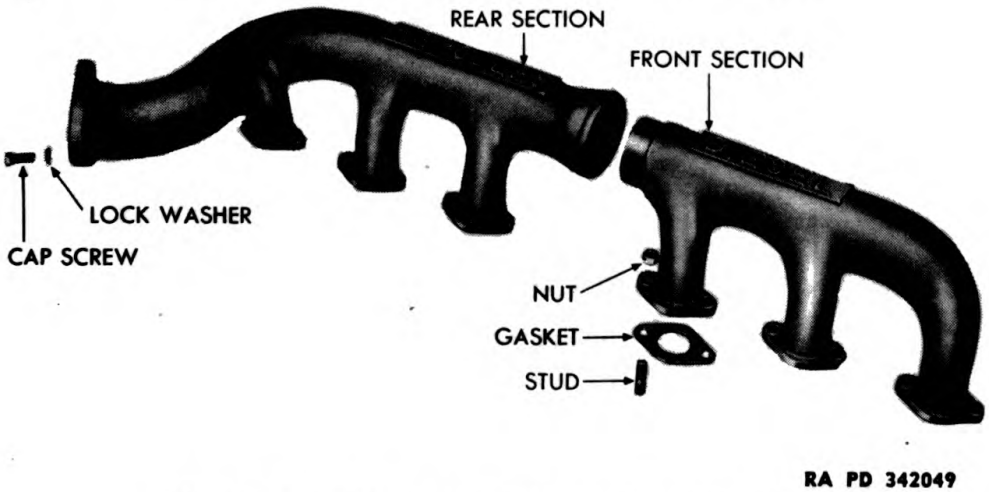


Figure 71—Exhaust Manifold, Disassembled

(4) ASSEMBLY. Only when installing a new section will there be an assembly operation, which consists of fitting the two sections together.

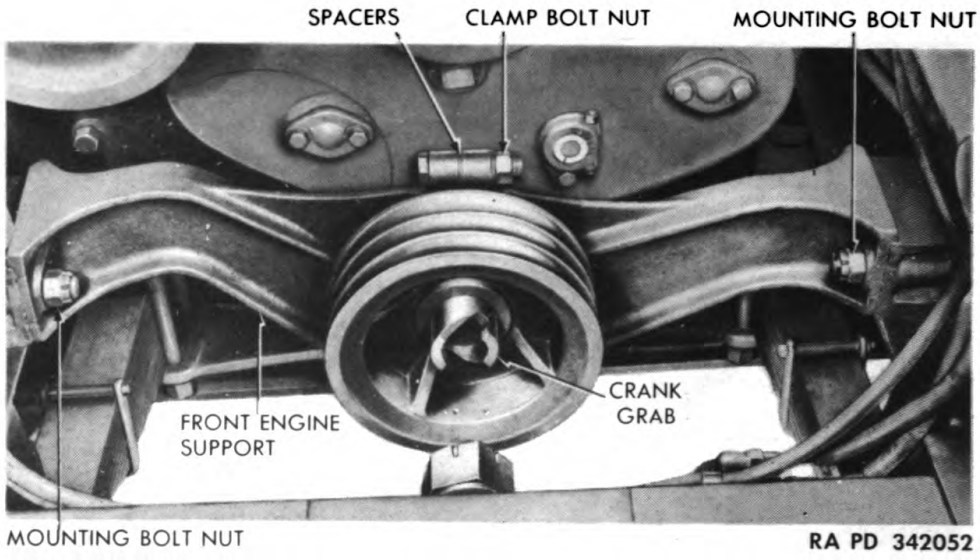


Figure 72—Front Engine Support, Installed

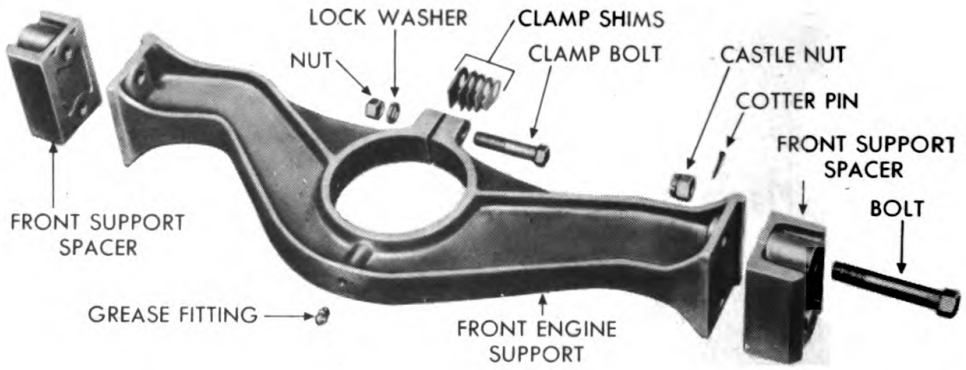


Figure 73—Front Engine Support, Disassembled

40. FRONT AND REAR ENGINE SUPPORTS.

a. Engine Front Support (figs. 72 and 73).

(1) DISASSEMBLY. Remove clamp bolt nut and lock washer, take out clamp bolt, and remove shims. Unscrew and remove grease fitting. Spacers, with attaching bolts and nuts, were removed when front support was removed from chassis.

(2) CLEANING. Scrape off all caked grease and dirt, and wash all parts in dry-cleaning solvent. Blow out lubricating hole with compressed air.

(3) INSPECTION AND REPAIR. Examine support and spacers for cracks, breaks, chips, or any other signs of damage or weakness.

Replace support or spacers if cracked, broken, or if there is any reason to suspect weakness. Inspect to see that there are two thick shims and three thin shims. Examine threads of clamp bolt and mounting bolts. See that clamp bolt nut and lock washer are not damaged. Make sure that mounting bolt nuts and cotter pins are present and in good condition. Replace any part not found to be in good condition, especially the support bracket in case there is any reason to suspect weakness.

(4) ASSEMBLY. Install grease fitting. Install shims with the three thin ones in center and a thick shim on each side. Install clamp bolt, lock washer, and nut. Front support spacers, with holding bolts and nuts, are installed when engine is installed in vehicle.

b. Engine Rear Support Brackets.

(1) CLEANING. Clean off all accumulated dirt and scrape brackets clean of rust, then wash in dry-cleaning solvent.

(2) INSPECTION AND REPAIR. Examine brackets for cracks or breaks, and inspect attaching bolts and lock washers for good condition. Replace brackets if cracked or broken; use new bolts and lock washers if old ones are damaged in any way NOTE: *Before installing engine, make sure the two engine rear support brackets are firmly in place on frame side rails.*

41. CRANKCASE GEAR COVER.

a. Disassembly (fig. 74).

(1) REMOVE INSPECTION PLUG. Remove inspection plug and gasket by unscrewing plug from cover.

(2) REMOVE THRUST PLATE. Remove two cap screws and lock washers from each of the two thrust plates, and remove shims from thrust plugs.

(3) REMOVE CRANKSHAFT SEAL. Do not remove crankshaft seal unless inspection shows the need of replacing it with a new seal. Drive seal out, using drift and hammer.

(4) REMOVE ADJUSTING SCREW AND CLAMP.

(a) Take out cotter pin and remove adjusting screw nut.

(b) Remove adjusting screw.

(c) Remove cap screw and lock washer from flange of clamp, and take off clamp and cork seal. NOTE: *The adjusting screw fits into threaded groove of split bushing on eccentric bushing shaft. Split bushing, eccentric bushing, and chain idler sprocket are shown in figure 76 to show how adjusting screw turns the eccentric bushing to adjust chain.*

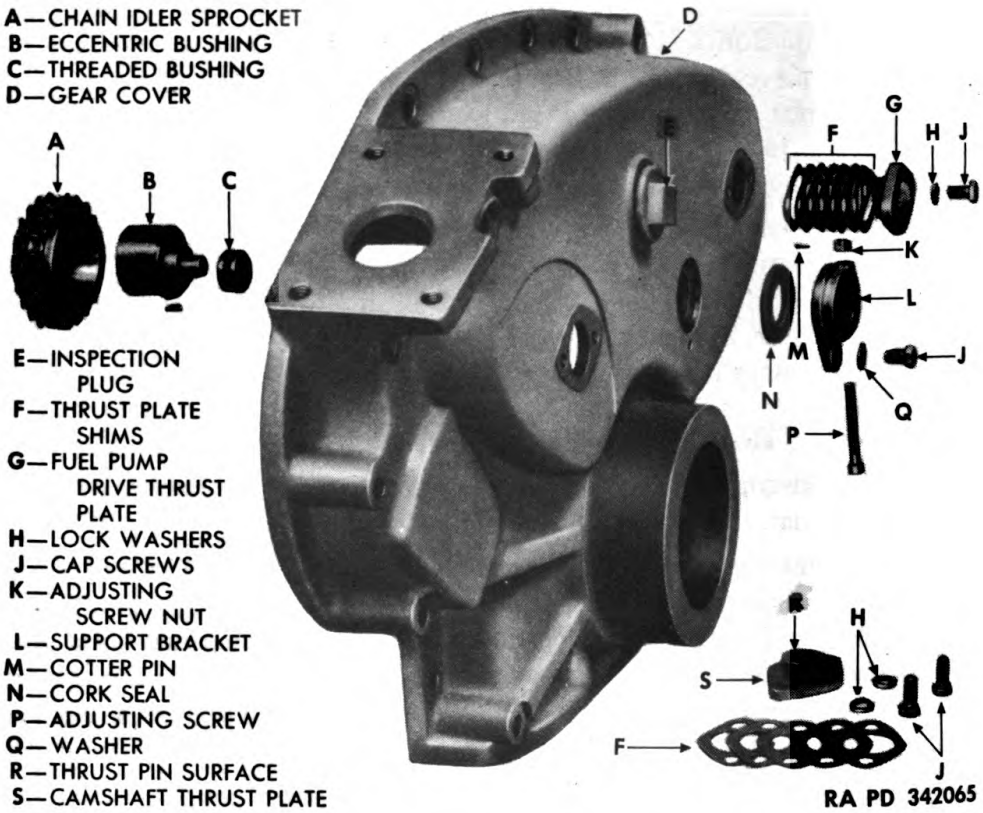


Figure 74—Gear Cover and Chain Idler, Disassembled

b. Cleaning.

(1) COVER. Scrape gasket surface clean. Gear cover may be cleaned with pressure-flushing equipment at the same time cylinder block and other large castings are cleaned, or clean with dry-cleaning solvent.

(2) PARTS. Wash all parts, including shims and thrust plates, in dry-cleaning solvent.

c. Inspection and Repair.

(1) INSPECTION.

(a) Cover. Examine entire surface of cover for cracks. Inspect all openings for signs of damage or wear. If cracked or damaged beyond ordinary means of repair, replace the cover.

(b) Thrust Plates. See that surfaces of thrust plates are flat and smooth. If damaged so they have to be ground down too much for shim adjustment, a new thrust plate must be installed. Examine attaching cap screws for stripped or worn threads, and replace if damaged.

(c) Adjusting Clamp. Examine thrust clamp opening to see that it is not battered or damaged; if battered or damaged, split bushing will not have proper free clearance. Examine threads on adjusting screw and nut, and attaching cap screw; if stripped or worn, replace these parts.

(d) Shims. See that shims are not oil-soaked or damaged. Replace all damaged shims.

(2) REPAIR.

(a) Thrust Plates. Grind heads of thrust plates smooth if inspection has revealed roughness. If grinding creates clearance which cannot be corrected by shims, replace thrust plate (par. 49 **m**).

(b) Crankshaft Seal. If crankshaft seal is dented, damaged, or unserviceable, replace it.

(c) Parts. - Discard old cork seal and all old gaskets and replace them with new parts. Replace adjusting screw if threads are damaged or flattened. Replace any attaching cap screws, washers, nuts, or shims that show signs of wear or damage.

d. Assembly.

(1) INSTALL ADJUSTING SCREW AND CLAMP. Install new cork seal. Position clamp and fasten in place with cap screw and lock washer. Install adjusting screw, nut, and cotter pin, but do not bend cotter pin, as adjusting screw must be removed to fit into split bushing when cover is installed on engine.

(2) INSTALL CRANKSHAFT SEAL. If old crankshaft seal was removed, install new seal using brass drift and hammer to tap it in evenly.

(3) INSTALL THRUST PLATES. Install shims, using the same number and thickness of shims as removed if thrust plates were not ground down. If thrust plates were ground, install estimated number of shims required, and make a note to check thrust on shaft of the gear affected when gears and cover are installed (par. 49 **m**). Fasten thrust plates in place with cap screws and lock washers.

(4) INSTALL INSPECTION PLUG. Install gasket and inspection plug. It is not necessary to tighten plug in place, as it will have to be removed to test chain adjustment when cover is installed on engine.

42. OIL PAN AND STRAINER.

a. Disassembly. Remove six cap screws and lock washers, and lift out cap and strainer as a unit. Remove cork gasket. Remove oil pan drain plug and washer from strainer cap (fig. 75).

b. Cleaning. Clean oil pan and strainer with dry-cleaning solvent, flushing all dirt out of lower sump and bayonet gage tube opening. See that connecting surfaces are cleaned of all remnants of old gasket or gasket cement.

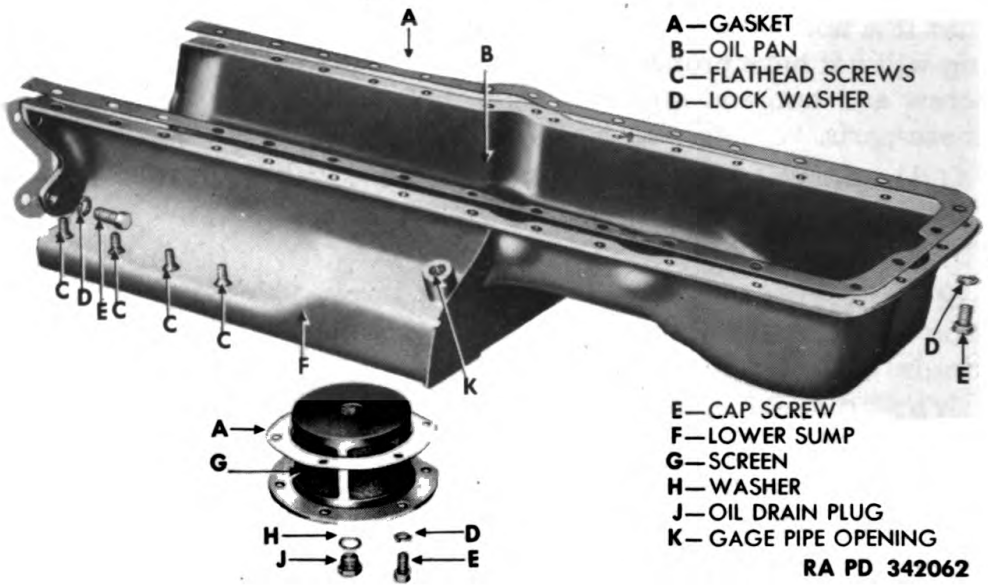


Figure 75—Oil Pan and Screen Disassembled

c. Inspection and Repair.

(1) OIL PAN. Inspect inside and outside of oil pan for signs of damage, such as dents or breaks at welded corners, which might result in leaks. Shine a light into lower sump from inside and examine bottom of sump to detect any small holes. Replace oil pan if damaged so that it cannot be repaired by welding.

(2) OIL STRAINER. Inspect screen in strainer for broken wires or other damage. Examine strainer cap and base for dents or rusting. Inspect drain plug hole and threads, Replace the unit if screen, cap, or base is badly damaged.

(3) BAYONET GAGE AND PIPE. Inspect bayonet gage for bends. Inspect pipe for defective threads. Replace if damaged.

d. Assembly. Install drain plug in strainer cap, using new gasket. Use new cork gasket and install strainer on oil pan with six cap screws and lock washers.

43. CRANKCASE BREATHER CAP.

a. Description. The crankcase breather cap is an integral unit containing screen and strainer element. It is attached to the thermostat by-pass tube strap by means of a chain and nut (fig. 13).

b. Cleaning. Wash inside and outside with dry-cleaning solvent. Apply compressed air from both ends to make sure that any substance stuck in screen or strainer element is blown out.

c. Inspection and Repair. Examine screen and strainer element around the sides to make sure there are no breaks or clogging substance in screen, and that strainer element is intact and not obstructed, nor working down onto screen. See that breather cap fits snugly over breather pipe. Examine attaching chain to see that it is not damaged so that it might break during operation of vehicle. If screen is broken, element is clogged so that it cannot be properly cleaned, or cap is damaged, replace the unit.

44. OIL FILLER.

a. Disassembly. The only disassembly possible is removing the filler cap which contains felt washer and clamp wire. Remove cotter pin from hinge bolt, and remove bolt and cover. Remove clamp wire by pulling out sideways.

b. Cleaning, Inspection, and Repair.

(1) CLEANING. Clean all parts in dry-cleaning solvent.

(2) INSPECTION AND REPAIR. Inspect casting for cracks or broken flange at bottom. Inspect cap and felt washer. Inspect clamp wire to see that it is not bent so it will fall out of holes in casting. Replace any worn or broken part.

c. Assembly. Install cover, if removed, and install hinge bolt and cotter pin. Install new clamp wire in holes in casting if old one was discarded.

45. OIL PUMP AND OIL LINES.

a. Oil Pump (fig. 76).

(1) DISASSEMBLY. Cut lock wires, remove four cap screws and lock washers, and remove screen. Take out two long and four short cap screws, and remove rear cover. This cover is held from shifting by two snug-fitting dowels. If cover is stuck on these dowels so that it cannot be pried off, do not attempt to drive it off by hammering on gear shaft; use standard slide hammer with 3-jaw puller (41-P-2957) on a cap screw. To remove front cover, cut lock wire, take out seven cap screws, and lift cover off dowels. Lift out idler gears. Remove pump gears by driving the shaft free from one gear.

(2) CLEANING. Wash all parts in dry-cleaning solvent and dry with air hose, blowing out oil passages in shafts and gears.

(3) INSPECTION AND REPAIR.

(a) Pump Housing, Gears, and Shafts. Inspect housing for cracks, score marks, and excessive wear. As there are no gaskets between covers and housing, the surfaces must be smooth and free from pitting. If damage or pitting on surfaces cannot be remedied by honing, replace housing. Radial clearance between gear teeth and housing

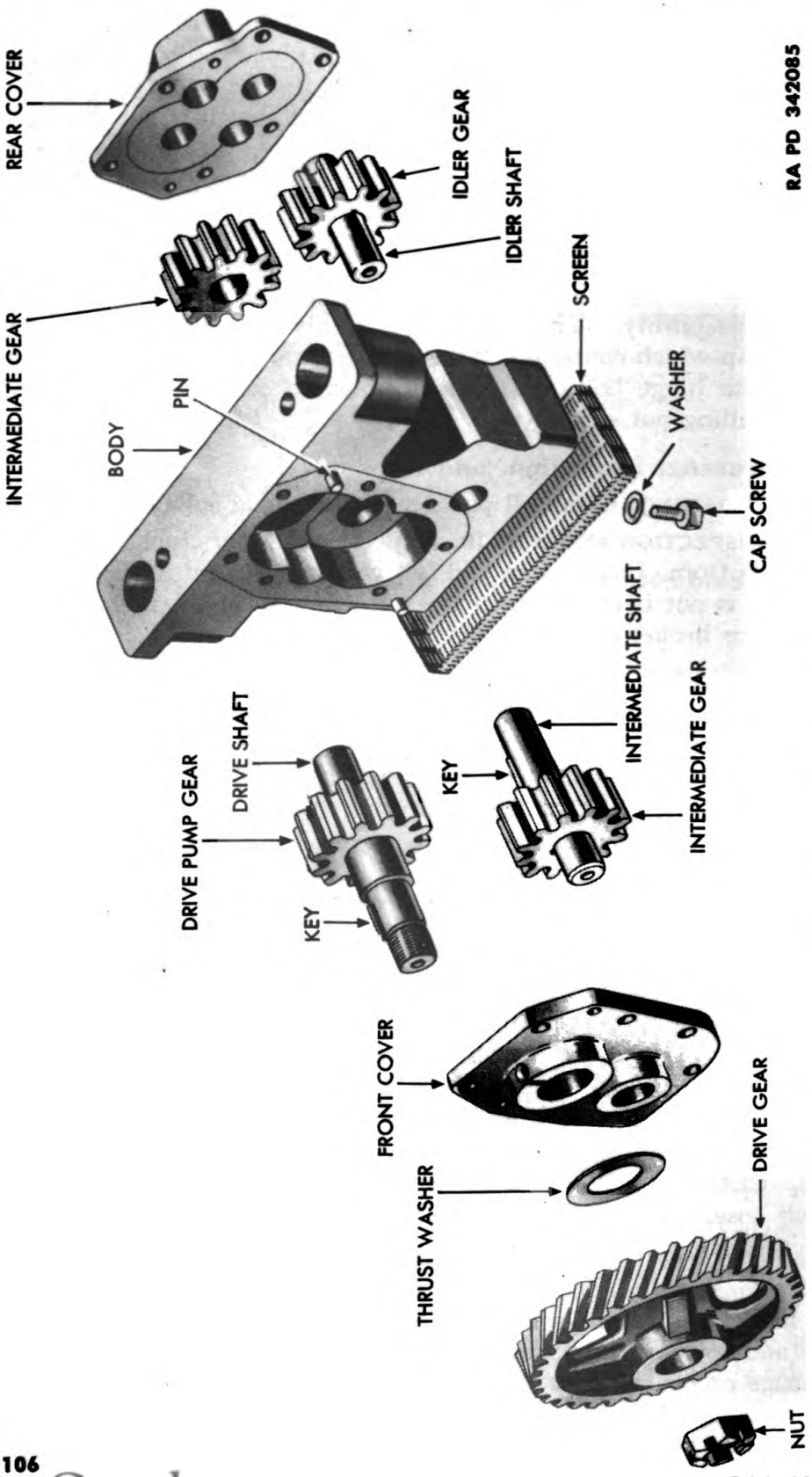


Figure 76—Oil Pump, Disassembled

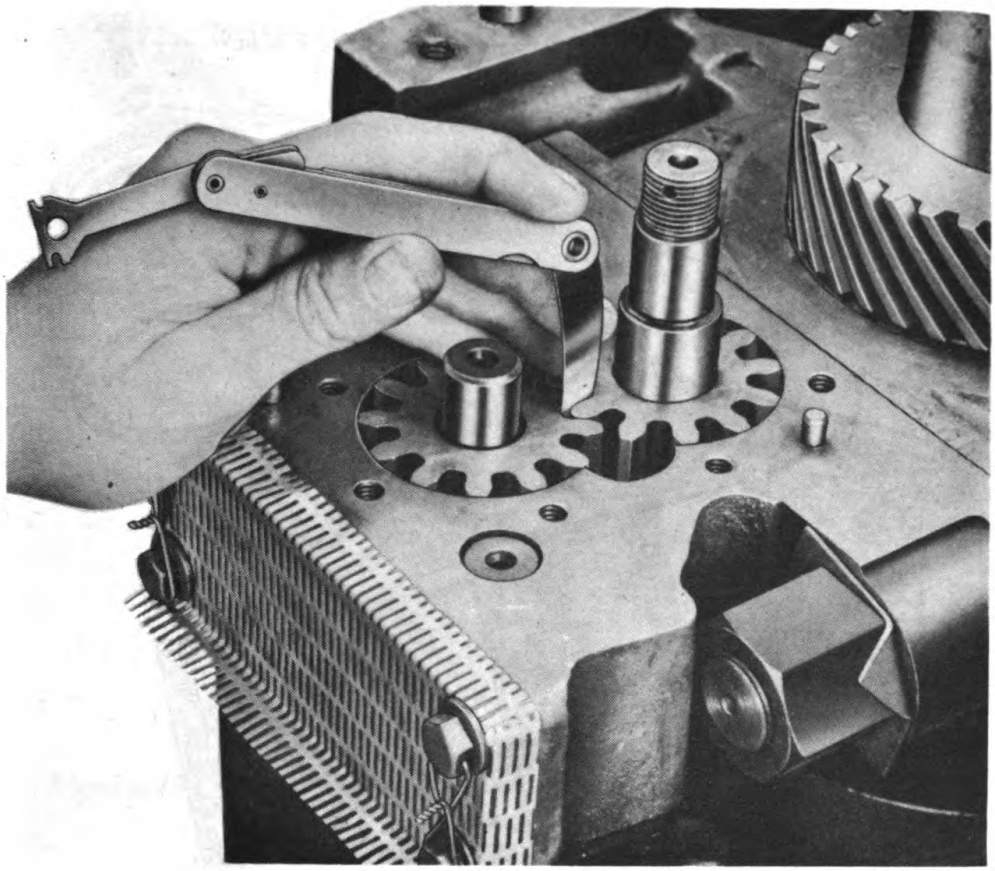


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Figure 77—Checking Oil Pump Gear Backlash

should not be more than 0.001 inch; if this clearance is 0.010 inch or more, replace the gear or housing (whichever shows wear). Check shaft bearing clearance, which should be 0.0015 to 0.002 inch; if clearance exceeds 0.002 inch, replace shaft. Shaft end thrust should be 0.003 to 0.001 inch. Backlash between pump gear and idler gear should be 0.006 and 0.010 inch; replace gears if backlash exceeds 0.005 inch (fig. 77).

(b) Diameters. Refer to paragraph 106 for diameters of new parts of oil pump.

(c) Oil Pump Covers. Check bore diameters (par. 106). Examine covers for cracks or wear, and for smoothness of contact surfaces. Examine dowels over which covers fit to see that dowels are not burred at the ends, and that covers fit over dowels snugly. Maximum allowable surface grind from end plate is 0.010 inch.

(d) Oil Pump Drive Gear. Inspect teeth for wear or breaks. If teeth are damaged or worn excessively, replace drive gear.

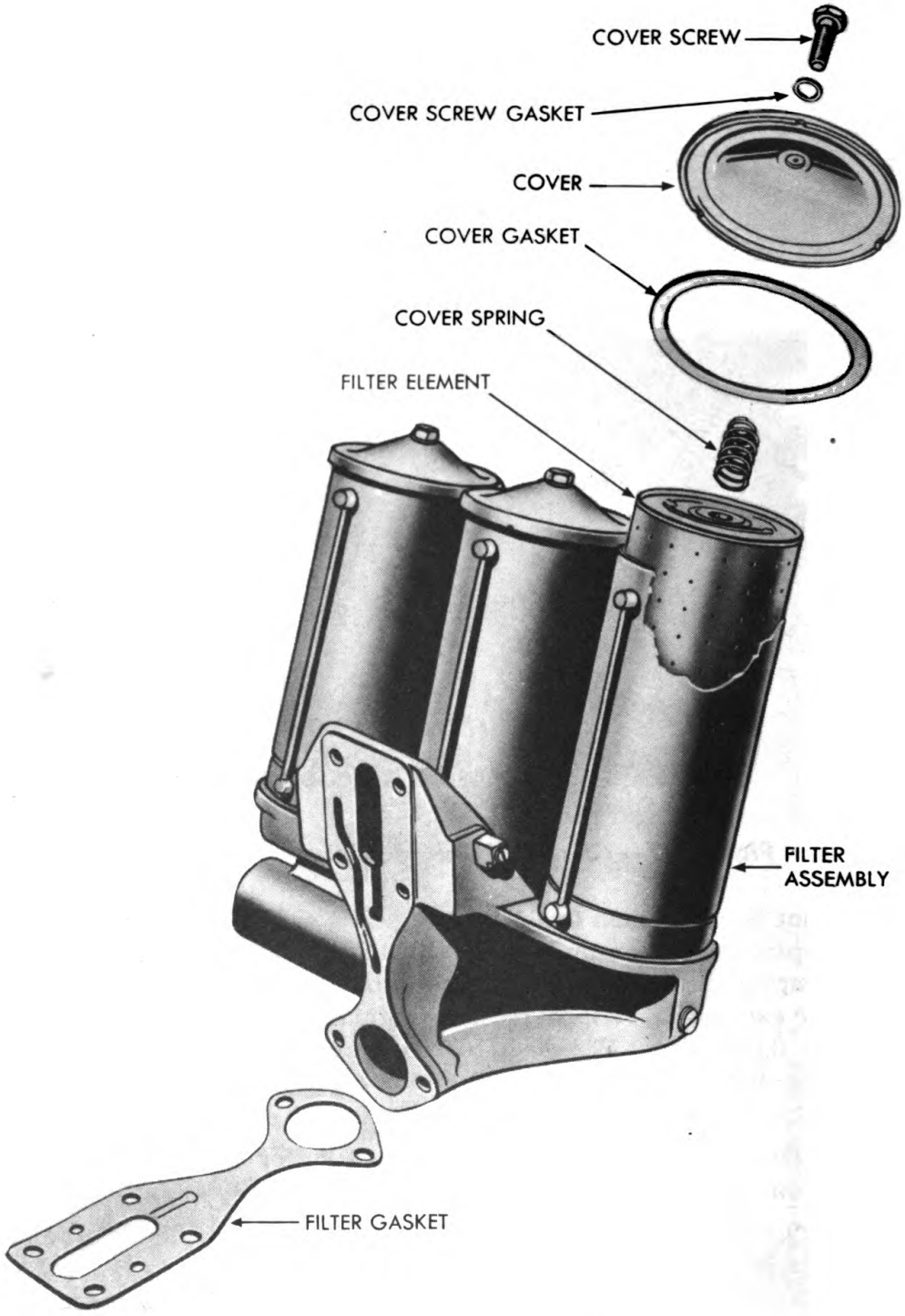


Figure 78—Oil Filters, Disassembled

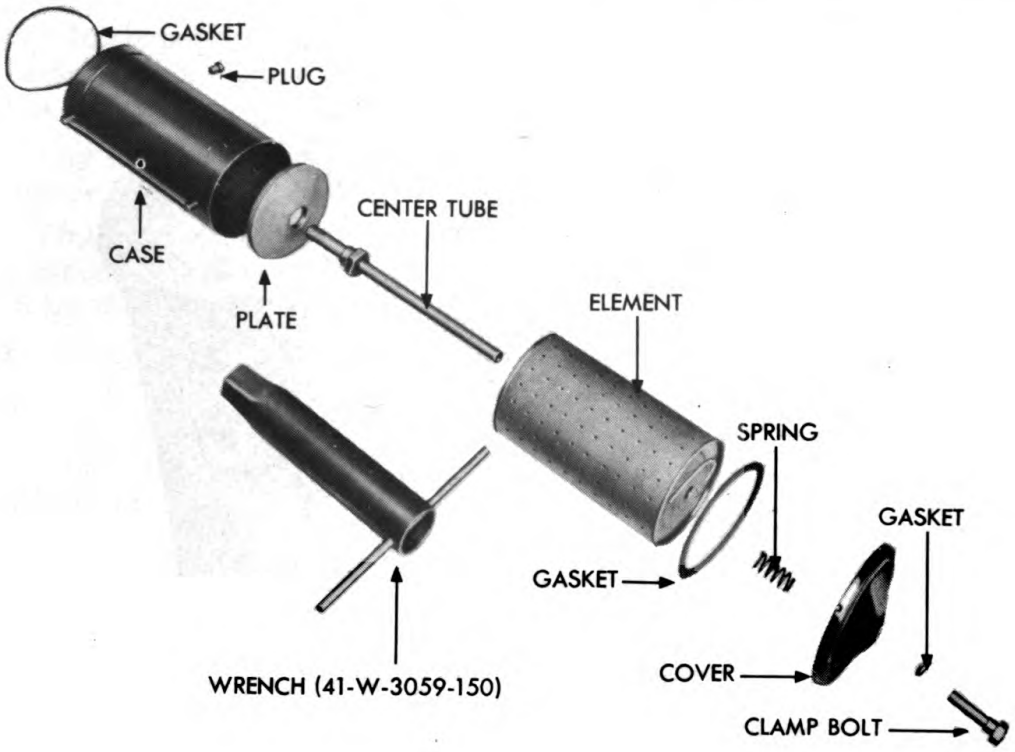


Figure 79—Oil Filter, Disassembled, Showing Special Wrench (41-W-3059-150) for Removing Center Tube

(4) ASSEMBLY.

(a) Clean Before Assembly. Clean each part before or during assembly, being careful to avoid foreign matter settling on parts from tools or bench. Coat all internal parts with crankcase oil to prime the pump, and to provide lubrication until circulation starts.

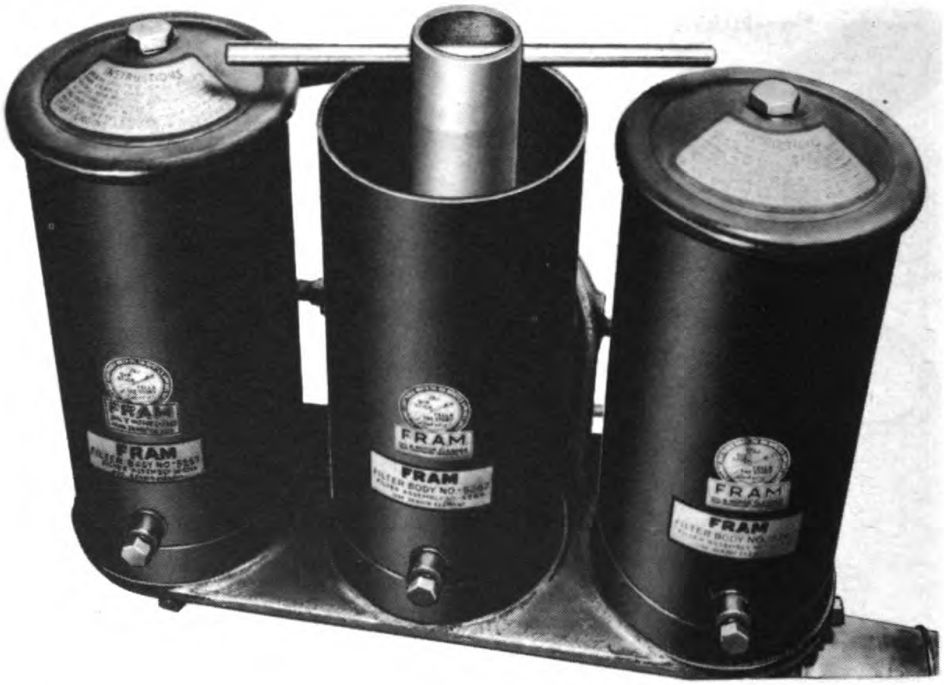
(b) Install Gears. Install idler gears. Place shaft, with lower gear attached, in running position in housing. Install key and upper gear on shaft. Check gears for free floating movement.

(c) Install Rear Cover. Fit rear cover over gear shafts and dowels; install seven cap screws, securing them with locking wire.

(d) Install Front Cover. Fit front cover over gear shafts and dowels; install seven cap screws, securing them with locking wire.

(e) Install Screen. Install screen so that the side which is bent down fits over the front of the housing, and the side which is bent up is located at the rear. Fasten in place with four cap screws and lock wire.

(f) Install Drive Gear. Install Woodruff key and press drive gear on shaft.



RA PD 342138

Figure 80—Set-up for Removing Center Tube From Oil Filter, Using Special Wrench (41-W-3059-150)

b. Oil Lines.

(1) CLEAN. The lines connected to oil pump are welded to straps so that the three lines are integral. Clean in dry-cleaning solvent, and blow out with compressed air.

(2) INSPECT AND REPAIR. Inspect lines for dents or any signs of damage which may result in leaks. See that straps are securely brazed in place, and that straps are not damaged at cap screw holes. Weld strap at any broken point. Replace assembly if unserviceable.

46. OIL FILTERS, OIL PRESSURE REGULATOR, AND VISCOMETER INSTRUMENT.

a. Oil Filters (fig. 78).

(1) DISASSEMBLY. Remove drain plug and drain out oil Remove clamp bolt, washer, cover, cover gasket, and spring. Remove filter element. To remove filter body from bracket, use wrench (41-W-3059-150) as shown in figures 79 and 80, to unscrew the center tube from inside of filter body; removing center tube detaches filter body from bracket. Remove plate from bottom. Remove mounting flange gasket.

(2) CLEANING. Scrape off remnants of mounting flange gasket. Wash all parts in dry-cleaning solvent. Blow out inlet and outlet passages with compressed air.

(3) INSPECTION AND REPAIR.

(a) Inspect clamp bolt threads, drain plug threads, and threads of center tube.

(b) Examine filter element for good condition; element must be replaced periodically at every oil change, so if element does not appear to be new, replace it.

(c) Inspect bottom plate, cover, spring, and center tube for any signs of damage.

(d) Replace all damaged parts.

(4) ASSEMBLY. Use new mounting flange gasket, position case on flange, and install bottom plate. Use wrench (41-W-3059-150), to install center tube (fig. 80). Install element, new cover gasket, spring, cover, copper washer, and clamp bolt. Make sure that both case and cover seat tightly on gaskets.

b. Oil Filter Bracket.

(1) DESCRIPTION. The bracket on which the three oil filters are mounted, is integral with the water inlet line which is connected by a rubber hose coupling to the water pump. This bracket is mounted on the case just above the generator, with gasket and six stud nuts. Oil leads in casting connect to oil delivery lines to oil pump and to crankcase. Pressure tubes extend into the oil delivery orifice in casting.

(2) DISASSEMBLY. It is not necessary to disassemble this bracket, except for cleaning out orifices and lines. Remove oil plug from front and one plug from each end. Remove water drain plug at front for inspection, if considered necessary.

(3) CLEANING. Clean all parts in dry-cleaning solvent. Blow out orifices and leads with compressed air.

(4) INSPECTION. Inspect casting for cracks, and make sure all oil leads in casting are open and not clogged with sludge deposits. Inspect oil plugs and water plug for good condition of threads. Replace plugs if threads are stripped or worn. Replace the entire casting if cracked.

c. Oil Pressure Regulator (fig. 81).

(1) DISASSEMBLY. Remove valve cap nut, loosen lock nut, and remove valve adjusting screw and spring; then remove valve piston.

(2) CLEANING AND INSPECTION. Clean the assembly with dry-cleaning solvent. Inspect the spring for damage or wear. Replace spring if broken or damaged. Inspect piston for end and side wear. If piston is scored, replace the unit. Scale reading (when practicable)

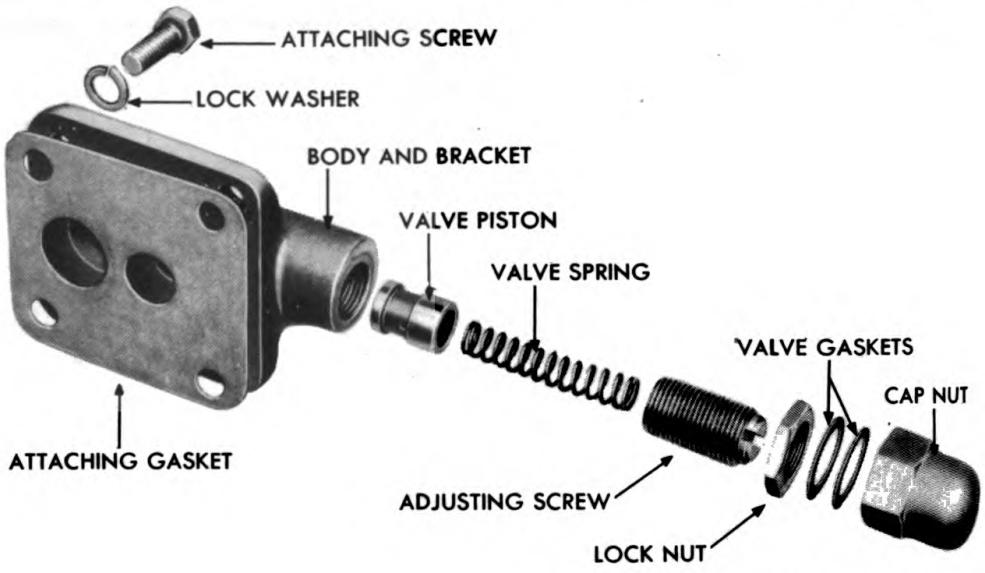


Figure 81—Oil Pressure Regulator, Disassembled

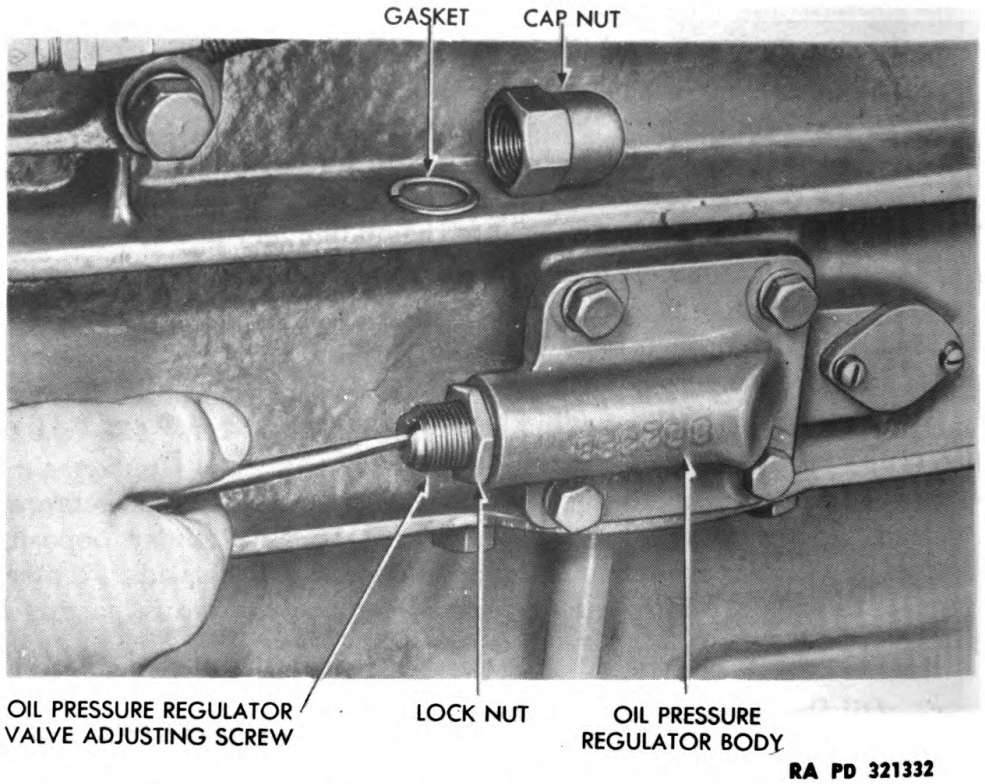


Figure 82—Adjusting Oil Pressure Regulator

is 12 pounds at 1⅞-inch height. Free length of spring is 2¼ inches. Valve should open at 40 pounds. Clearance of valve in body is 0.002 to 0.006 inch. Wear limit is 0.004 inch.

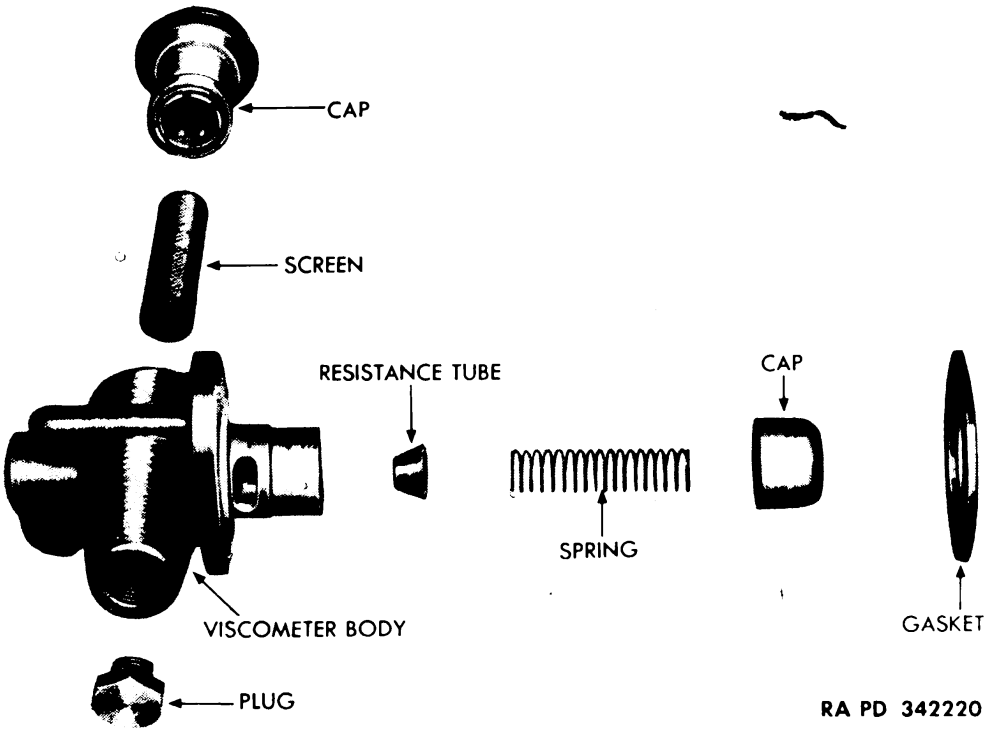


Figure 83—Viscometer Instrument, Disassembled

(3) ASSEMBLY. Install piston, spring, and adjusting screw with lock nut and two copper washers. Tighten lock nut, and install cap nut. After unit is mounted on engine, it can be adjusted by removing cap nut, loosening lock nut, turning adjusting screw, and checking oil pressure gage until proper adjustment has been made (fig. 82).

d. Viscometer Instrument.

(1) DISASSEMBLY. Remove screen plug and screen. Remove cleaning plug. Remove gasket, cap, spring, and resistance tube.

(2) CLEANING AND INSPECTION (fig. 83). Clean all parts with dry-cleaning solvent. Soak body of instrument in dry-cleaning solvent until all carbon is loosened; then use compressed air to blow out chambers and resistance tube. If compressed air is not available, use a pipe cleaner or wooden dowel which will go through the resistance tube easily. Work up and down through tube from unloading valve end until tube is clean. Wash again in dry-cleaning solvent, paying particular attention to resistance tube. Wash both the oil lines before reassembling. Inspect the instrument for signs of damage to spring or body.

(3) REPLACEMENT. Resistance tube, tee, nut, gasket, and attaching screws are replacable. If other parts of instrument are damaged, the entire instrument must be replaced.

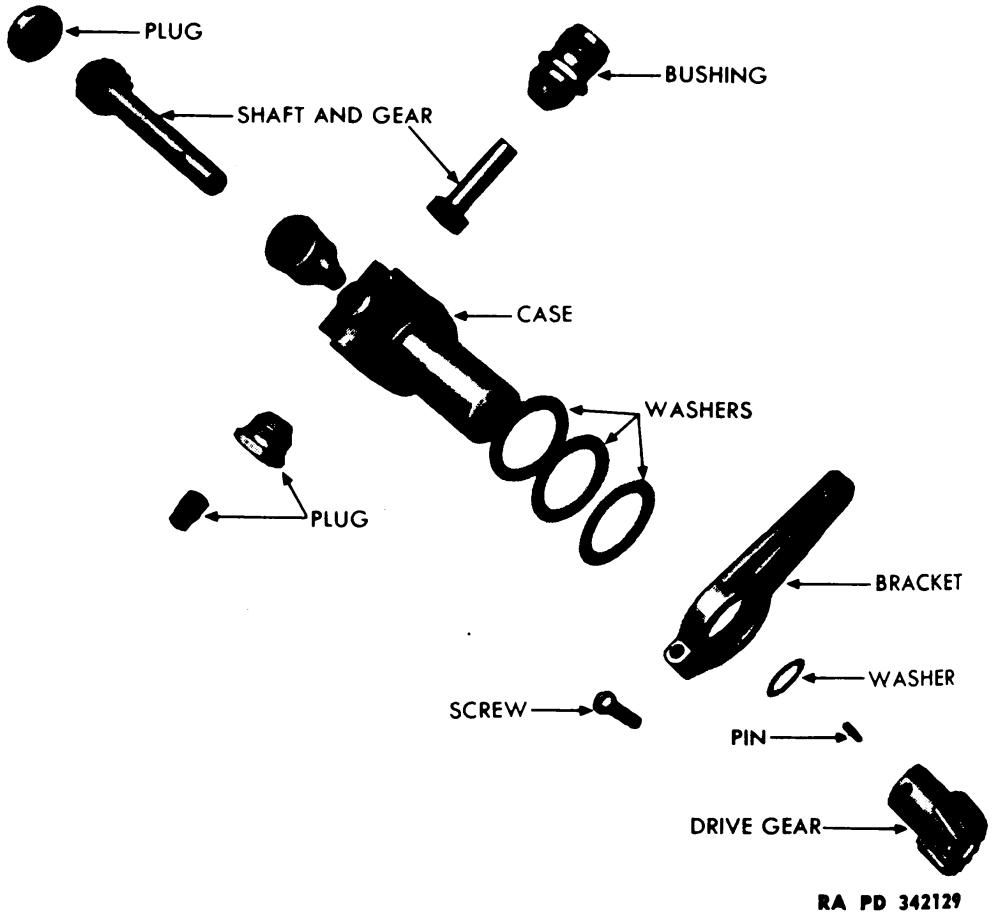


Figure 84—Tachometer Drive, Disassembled

(4) ASSEMBLY. Install resistance tube, spring, cap, and gasket (fig. 85). Install cleaning plug. Install screen and screen plug.

47. TACHOMETER DRIVE.

a. Disassembly (fig. 84). Do not disassemble unless inspection shows the necessity of cleaning or replacing drive gear (subpar. c below).

b. Cleaning and Inspection. Clean assembly thoroughly in dry-cleaning solvent, and dry with compressed air. Examine gear for chipped, broken, or worn teeth. Replace gear or shaft if found worn or defective. Examine shaft bores in bracket and case and if bores are worn, replace the unit.

c. Repair.

(1) REMOVE GEAR AND SHAFT. Loosen screw from bracket and remove bracket, two thin washers, and one thick washer. File off head of pin which attaches gear to shaft, drive out pin, and remove large gear from shaft. If parts other than drive gear are damaged, re-

place the entire unit. Drive gear may be replaced with a new gear. Complete assembly is available in 4:1 or 2:1 ratio; be sure correct part is used when making replacement.

(2) INSTALL GEAR AND SHAFT. See that small gears are properly meshed. Install gear on shaft and attach with new pin. Install thick washer and two thin washers in bracket. Install screw in bracket and tighten.

Section IV

ASSEMBLY OF ENGINE FROM SUBASSEMBLIES

48. GENERAL PRECAUTIONS.

a. During assembly of the engine, keep in mind the following general precautions in order to avoid trouble which may necessitate further work and loss of time:

(1) USE NEW GASKETS. Remove all traces of the old gasket, and install new gasket in each connection where a gasket is required. Do not take chances by installing the old gasket.

(2) FITTING PARTS. Check to be sure part is being installed in proper position and location. Do not force parts to fit. Use special tools where specified for correct alinement.

(3) FREE MOVEMENT OF PARTS. As moving parts are assembled, check often and carefully to make sure parts move freely. Be sure tappets are adjusted so that valve is not held open. If a valve is held open, the piston will strike it and bend the push rod. After assembly, turn engine over slowly by hand to make sure there is clearance between valve and piston.

(4) USE TORQUE-INDICATING WRENCHES. In tightening nuts to specified foot-pounds, use torque-indicating wrench.

(5) INSPECT AND LUBRICATE SUBASSEMBLIES. See that all subassemblies are clean before installing them. Do not install a subassembly unless it is new or rebuilt. Carefully inspect the unit before installing. Note carefully in each procedure of assembly the instructions on lubrication before installation, and see that these instructions are carried out. Refer to TM 9-768 for lubrication orders.

49. ASSEMBLY.

a. **Install Camshaft and Crankshaft.** Installation is facilitated by observing the following order:

(1) INSTALL UPPER HALVES OF MAIN BEARINGS. Place upper halves of main bearings in position, starting the side without rib into

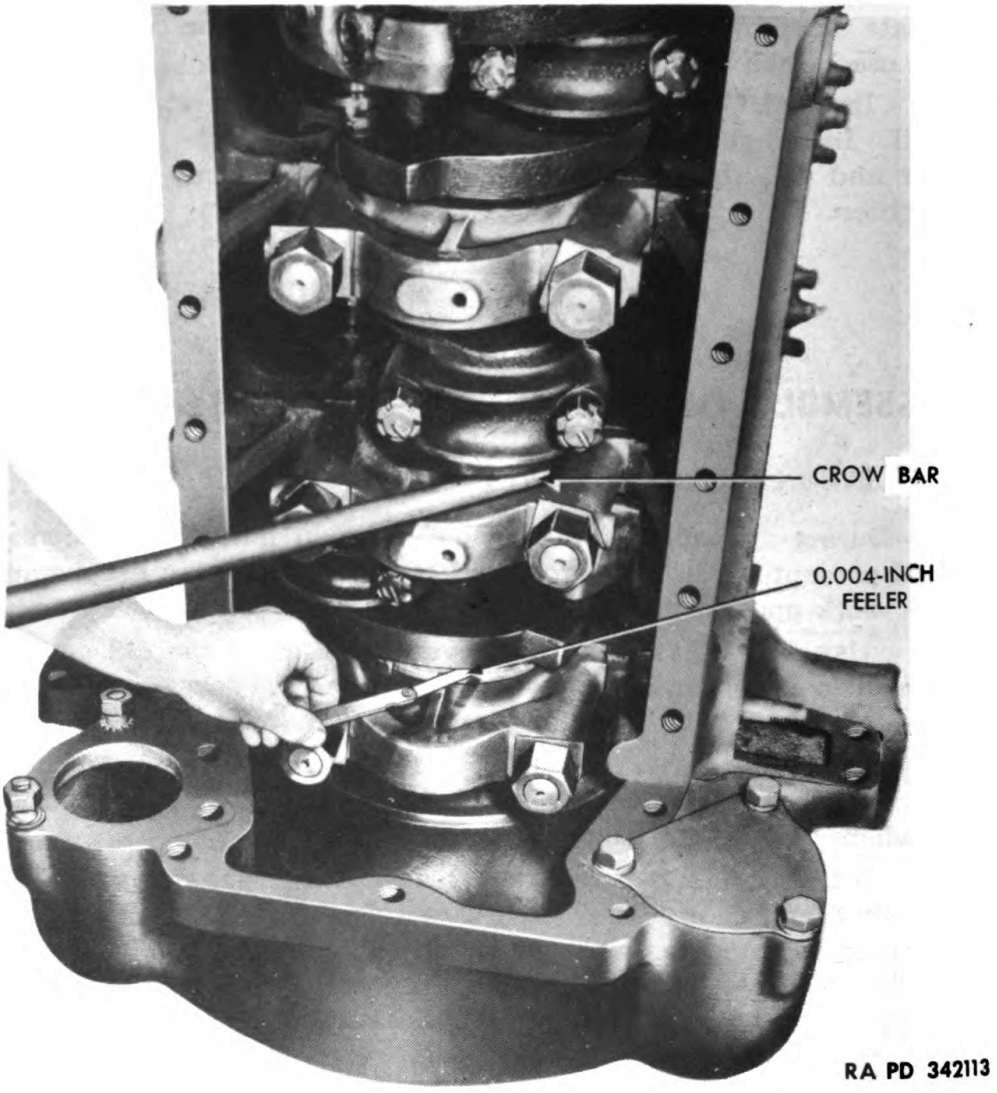
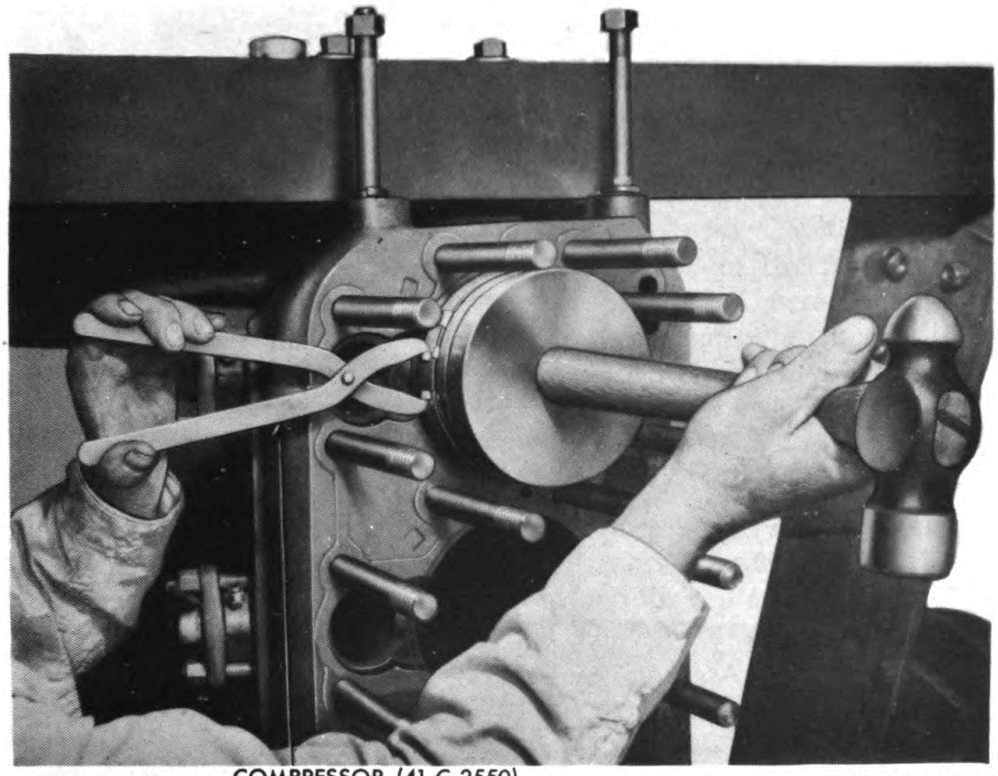


Figure 85—Checking Crankshaft End Play

support first; then rotate bearing into place so that rib of bearing locks in the slot. After upper halves are in place, pour a few drops of engine oil on bearing surfaces.

(2) INSTALL UPPER HALVES OF THRUST FLANGES. The two upper halves of thrust flanges, which were tagged "top inner" and "top outer" when removed, can be installed so they will remain in position by using a little heavy oil on contact face of each. The half which was tagged "top-inner" goes on the inner side of main bearing shell, and the one tagged "top outer" goes on the outward side of main bearing shell.



COMPRESSOR (41-C-2550)

RA PD 350606

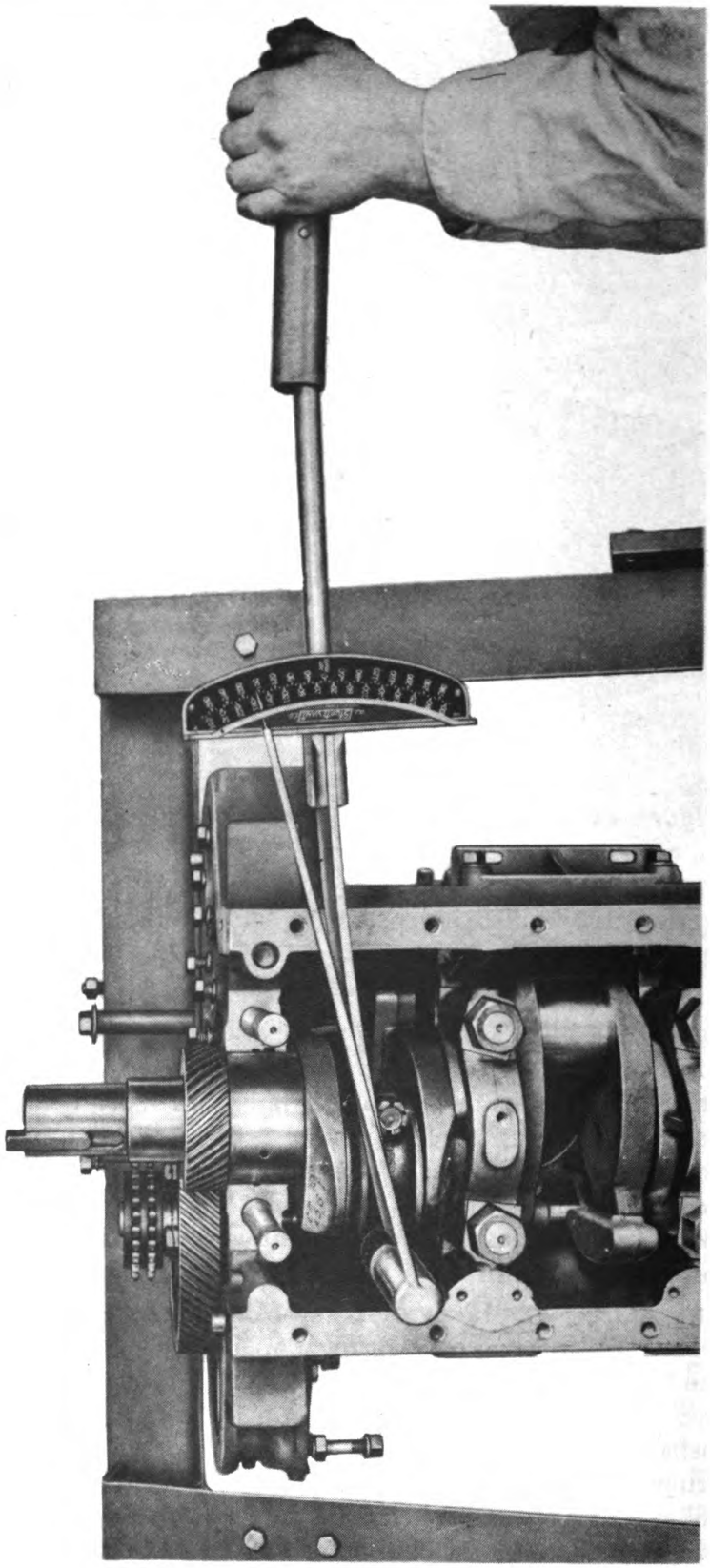
Figure 86—Installing Piston and Connecting Rod

(3) INSTALL TAPPET GUIDES AND TAPPETS. Install tappet guides, tapping them into place; then install retaining washers and fasten in place with cap screws. Insert tappets into tappet guides.

(4) INSTALL CAMSHAFT WITH GEAR AND SPROCKET. Install camshaft, with gear and fuel pump drive sprocket attached.

(5) INSTALL CRANKSHAFT. Using rope sling and hoist, carefully lower crankshaft into position on upper halves of main bearings. This is a 3-man job; one man to operate hoist, and one man at each end of shaft to guide it carefully as it is slowly lowered into position. This will avoid damaging crankshaft journals. Turn crankshaft until crank shaft gear will mesh with camshaft gear, and be sure that the punch marks (for valve timing) line up.

(6) INSTALL LOWER HALF OF REAR MAIN BEARING. Place lower half of rear main bearing in bearing cap in the same manner that upper main bearing half was installed (step (1) above). Then position lower halves of thrust flanges on lugs, and fit bearing cap over studs; install washers and nuts, and tighten. Check crankshaft journal to main bearing clearance by using shim stock in center main bearing, in the same manner connecting rod bearing clearance was determined (par. 33 d (5)) (fig. 50). Clearance should be 0.004 to 0.0055 inch.



RA PD 342145

Figure 87—Tightening Connecting Rod Bearing Nut, Using Torque-indicating Wrench (41-W-3634)

(7) CHECK CRANKSHAFT END PLAY AND FLYWHEEL FLANGE RUN-OUT. Install lower half of center main bearing and cap; then check crankshaft end play, using pry bar and feeler gage, as shown in figure 85. Correct end play is 0.004 to 0.005 inch. If end play is more than 0.009 inch, replace thrust flanges and check again for correct end play.

(8) INSTALL LOWER MAIN BEARINGS AND CAPS. Install the balance of lower main bearings and caps, except the front to which the oil pump is attached. Caps are numbered for correct installation. Install washers and nuts. Use torque-indicating wrench and tighten nuts to 260 foot-pounds. Bend washers up to hold nuts in place.

b. Install Pistons and Connecting Rods (figs. 86 and 87).

(1) PRECAUTIONS. Pistons, rods, and caps are die-stamped to indicate the cylinders in which they must be installed. Make sure that die-stamped numbers on rods, caps, and cylinders are on the camshaft side. Bearing shells are not stamped for top and bottom position but must be assembled in same positions from which they were removed, unless new shells are to be used (par. 32 **c**). Arrange piston rings on cylinders so that gaps are evenly spaced around pistons.

(2) NO. 1 PISTON. In case of complete overhaul when gear cover and oil pump have been removed, it is easier to install No. 1 piston and rod before installing oil pump, as oil pump protrudes over the No. 1 cylinder. However, if maintenance has not required removal of oil pump, it will still be possible to remove and replace No. 1 piston and rod.

(3) INSTALLATION. Clean cylinder bore thoroughly inside with a clean, dry, lint-free cloth. Apply engine oil on inside of bore, on inner surfaces of connecting rod bearing shells, and on the piston. Carefully insert connecting rod in cylinder, with side of connecting rod on which number is stamped facing toward camshaft. Turn crankshaft so that crankpin for piston being inserted is at a point farthest away from camshaft side. Two men are necessary; one man to tap pistons into bore while the other man guides connecting rod upper bearing into place. Use compressor (41-C-2550) and compress button ring. Push piston down until bottom ring is inside cylinder bore. Install compressor over upper half of piston, contract rings, and push piston down to a point where connecting rod can be attached (fig. 86). Check clearance between piston and cylinder wall; correct clearance is 0.0085 to 0.0095 inch (par. 33 **c** (3) *(c)*). Place connecting rod bearing cap with lower shell in position, over crankpin, and attach cap to connecting rod with two connecting rod nuts. Tighten nuts evenly with torque-indicating wrench to 260 foot-pounds (fig. 87).

c. Install Oil Pump and Front Main Bearing Cap. Connect pump assembly to front main bearing cap, by fitting the two dowel

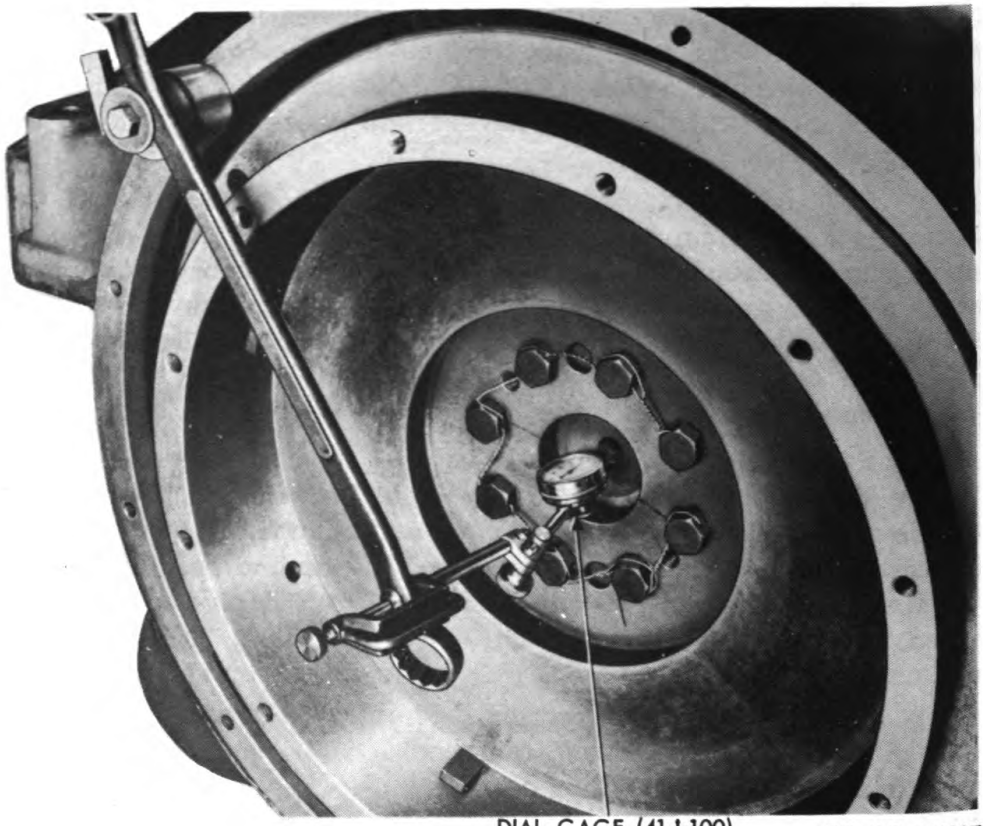
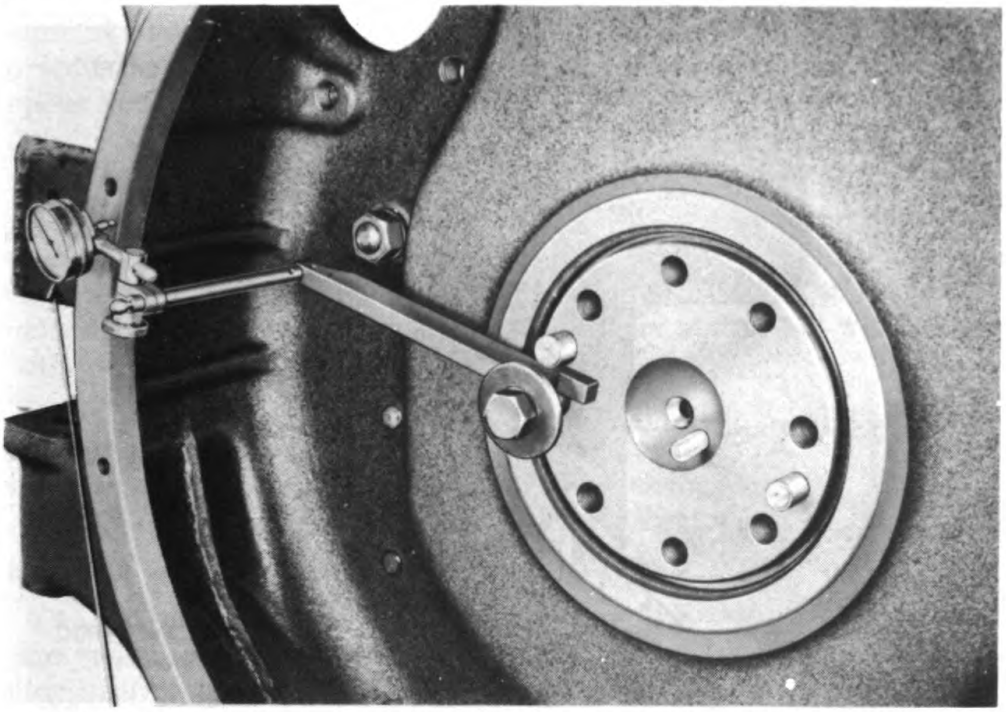


Figure 88—Indicating Pilot Bearing Bore Run-out

pins on pump into holes in cap. Place oil pump and bearing cap in position so that oil pump gear meshes in crankshaft gear. Install square washers, and the two main bearing nuts. Use special open-end wrench (41-W-1584) to tighten nuts (fig. 21). Bend up one corner of square washer to lock the nut in place. **NOTE:** *As it is impossible to use torque-indicating wrench to tighten these two nuts to exactly 260 foot-pounds, test the pull of special wrench on a center nut as follows: Tighten center nut with special wrench, observing the amount of strength exerted. Then determine torque by using torque-indicating wrench on the same nut. This will indicate about how much strength is needed on special wrench to secure, as nearly as possible, the correct torque of 260 foot-pounds on the front main bearing nuts.*

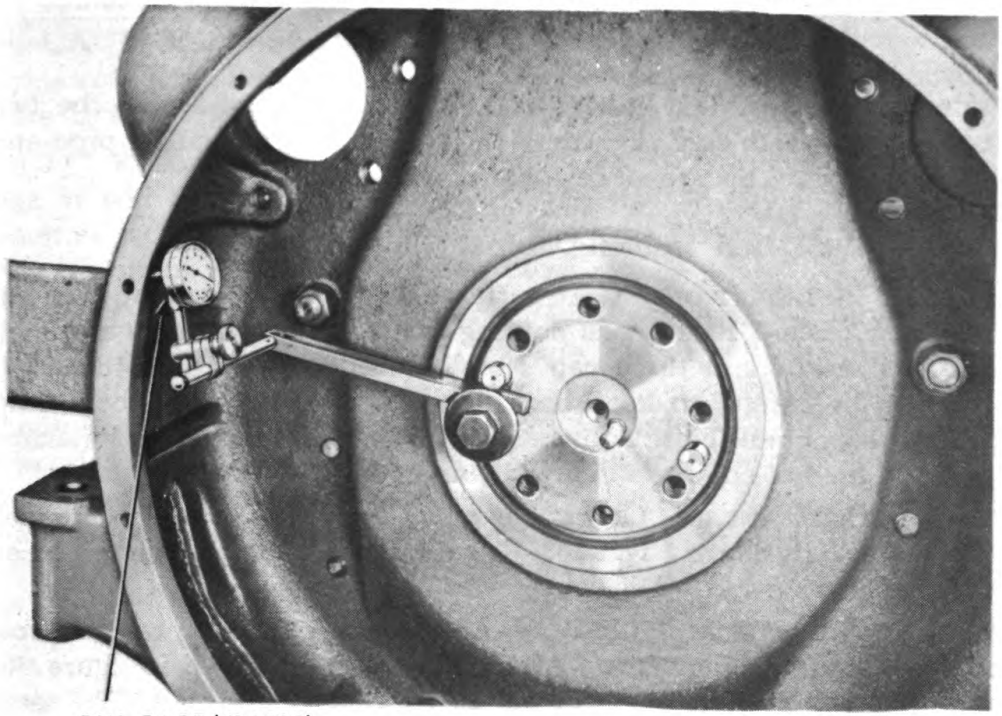
d. Install Oil Pipe Assembly. The oil supply pipe and scavenger pipe are held together by metal straps which are brazed to these pipes, and all three pipes are installed as a unit (fig. 16). Install two cap screws on each of the three pipe flanges which attach pipe assembly to oil pump. Install two cap screws which hold oil delivery pipe to case. Install the cap screws, which fasten strap to case on one



DIAL GAGE (41-I-100)

RA PD 350608

Figure 89—Checking Bell Housing Face Run-out



DIAL GAGE (41-I-100)

RA PD 350609

Figure 90—Checking Bell Housing Bore Run-out

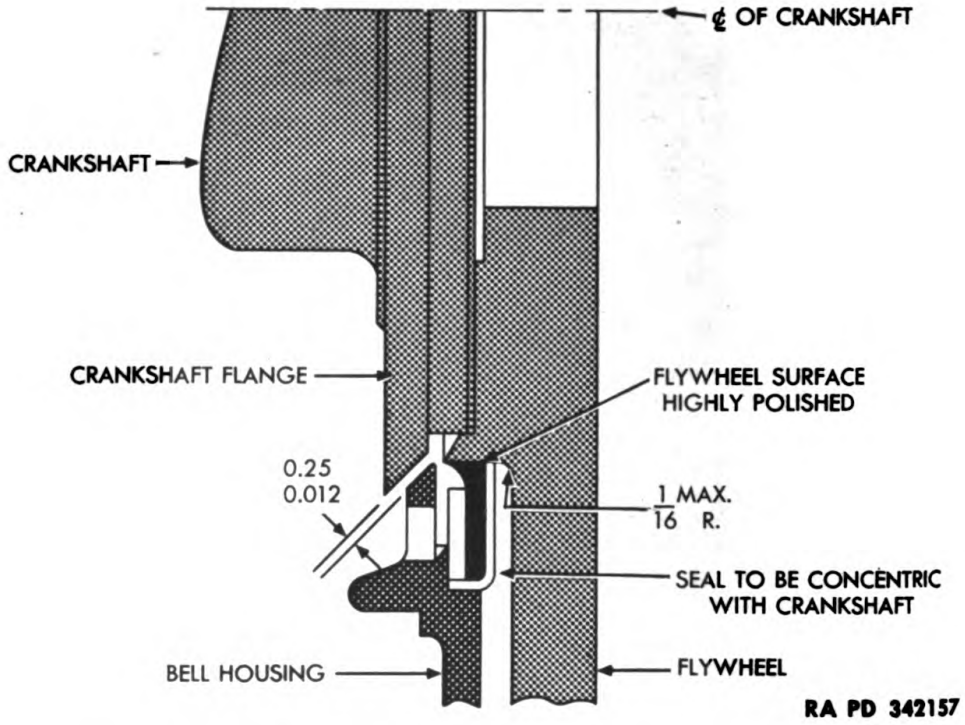


Figure 91—Sectional Diagram of Flywheel, Bell Housing, and Oil Seal

side and to third main bearing cap on the other side. Install the two cap screws, which hold the strap which passes over scavenger pipe and oil supply pipe. Secure all cap screws with lock wire.

e. Install Bell Housing.

(1) INSTALLATION. Coat surfaces with gasket cement, and install new gasket. Fasten bell housing in place with five nuts and lock washers inside, and three cap screws outside. When installing bell housing, be careful to keep bore of seal and clutch pilot bore concentric with crankshaft. To install bell housing correctly, an indicator must be used as shown in figures 89 and 90.

(2) CLEARANCES. Check clearance between housing chamber and crankshaft flange (fig. 91). This clearance must be maintained at 0.012 inch to avoid oil leaks.

(3) CHECK BORE RUN-OUT. Attach dial gage, adapter, and rod to flywheel attaching screw. Attach dial gage as shown in figure 90, and note bell housing bore run-out as crankshaft is turned. The total gage reading must not exceed 0.006 inch. If reading is greater than 0.006 inch, loosen attaching screws slightly, and with a wooden block placed at a point near oil pan side of bell housing and opposite the

point of highest reading, bump wooden block with a heavy hammer to shift bell housing; then tighten screws. Check run-out again, and repeat above procedure until reading is 0.006 inch or less.

f. Install Flywheel.

(1) CLEAN AND POLISH. Clean out bell housing thoroughly, and wipe off attaching flange of crankshaft. Clean flywheel attaching face. Make sure there are no nicks on flywheel pilot where seal rides. If nicks are found, smooth down with fine stone and polish with crocus cloth.

(2) POSITION FLYWHEEL. Make sure that No. 1 piston is at top dead center, and install flywheel on dowels so that "DC" mark on flywheel lines up with timing mark on bell housing.

(3) FASTEN IN PLACE. Install cap screws and tighten each a little at a time until all are uniformly tight. Install lock wire.

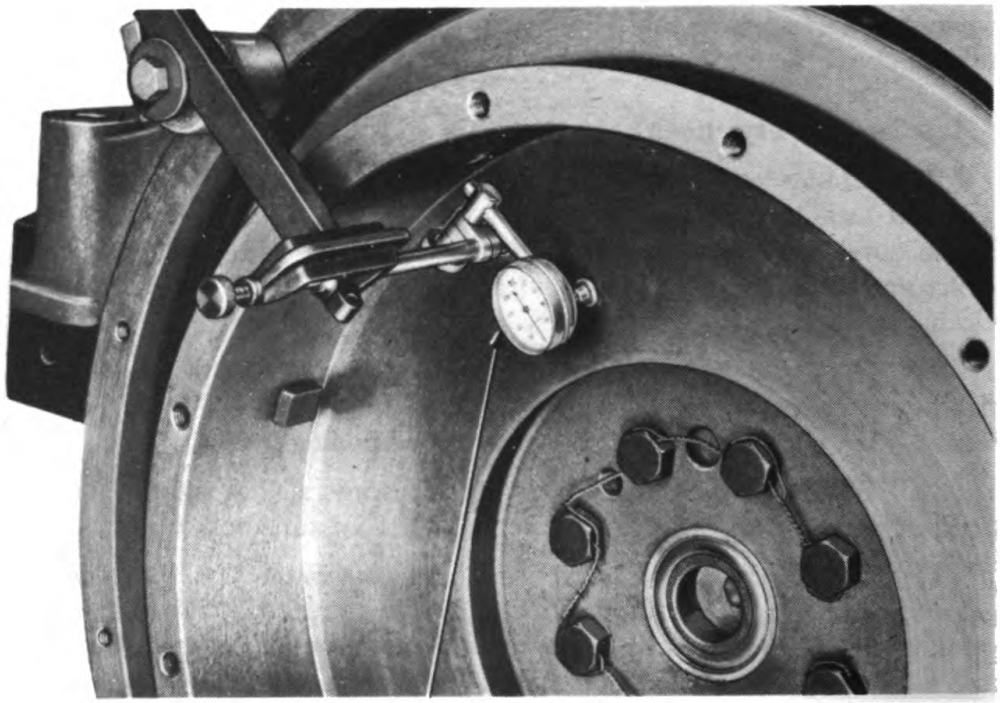
(4) CHECK CLUTCH PILOT BEARING BORE RUN-OUT. Attach dial gage to bell housing as shown in figure 88, and check flywheel clutch pilot bearing bore run-out as crankshaft is turned. The reading must not exceed 0.005 inch. Press flywheel toward front of engine while turning it, to avoid crankshaft end-float. Install new flywheel if reading is more than 0.005 inch.

(5) CHECK FACE RUN-OUT. Place dial gage as shown in figure 89. CAUTION: *Make sure dial gage button will not enter one of the cap screw holes when crankshaft is turned.* Face must not run out more than 0.004 inch.

(6) REBORE OR REFACE. If impossible to obtain correct readings, it will be necessary to rebore or reface the bell housing on a machine lathe. If proper alinement cannot be secured by machining or using shims, replace with a new housing.

(7) CHECK FLYWHEEL CLUTCH FACE SQUARENESS. Move indicator to rest on flywheel clutch face, as shown in figure 92. Turn crankshaft and observe needle of dial gage. Indicator must not read above 0.005 inch out-of-square. If reading is above 0.002 inch, place a wooden block against edge of flywheel where reading is highest and give wooden block a sharp blow with hammer. Usually this will seat flywheel and true up face. Check to see if indicator now reads 0.002 inch or less. Permissible amount that can be removed from clutch face of flywheel is 0.045 inch. Flywheel must be balanced within 0.3 inch-ounce.

g. Install Fuel Pump Sprocket, Sleeve, and Shaft. Place gasket on flange of sleeve. See that oil seal is in place. If shaft has not been inserted into sleeve, install spacer next to sprocket and insert shaft through sleeve. Refer to figure 17, and insert assembly in place.



DIAL GAGE (41-I-100)

RA PD 350610

Figure 92—Indicating Flywheel Clutch Face Squareness

h. Install Fuel Pump Flange Coupling (fig. 67). Install Woodruff key in shaft, and slide flange on shaft. Place disk in position and fasten it to flange temporarily with spacers, lock washers, and cap screws. Install castle nut and cotter pin temporarily on end of shaft. In timing fuel injector pump, it will be necessary to move disk on flange.

i. Install Chain Idler Sprocket. Insert eccentric bushing in sprocket hub, and install split bushing on shaft. See that chain adjusting screw on cover fits into split bushing.

j. Install Fuel Pump Drive Chain. Turn crankshaft so the arrows on hubs of sprockets are pointing straight upward when No. 1 cylinder is on top dead center (fig. 93). Place chain on sprockets so that arrows will remain in above described positions, passing chain under idler sprocket as shown in figure 17. Use plumb lines as shown in figure 93 to see that timing arrows on both sprockets are vertical.

k. Install Gear Cover (H, fig. 2). Install cover gasket and cover. Install 16 attaching bolts and lock washers, but do not draw bolts up tight until after chain is adjusted (step l, below). Install cork seal and adjusting screw support bracket, and fasten in place with cap screw and lock washer. Install adjusting screw, castle nut,

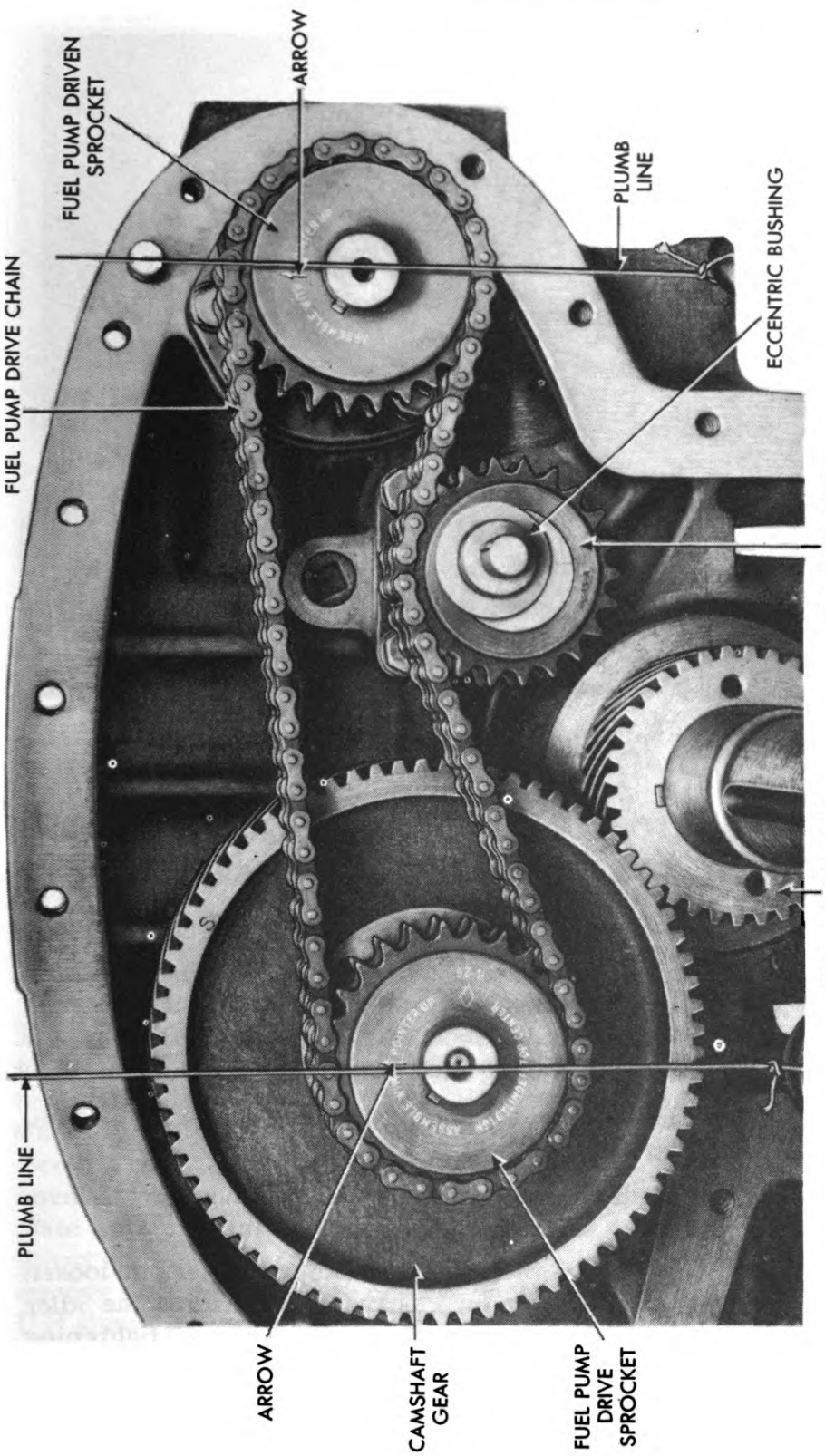
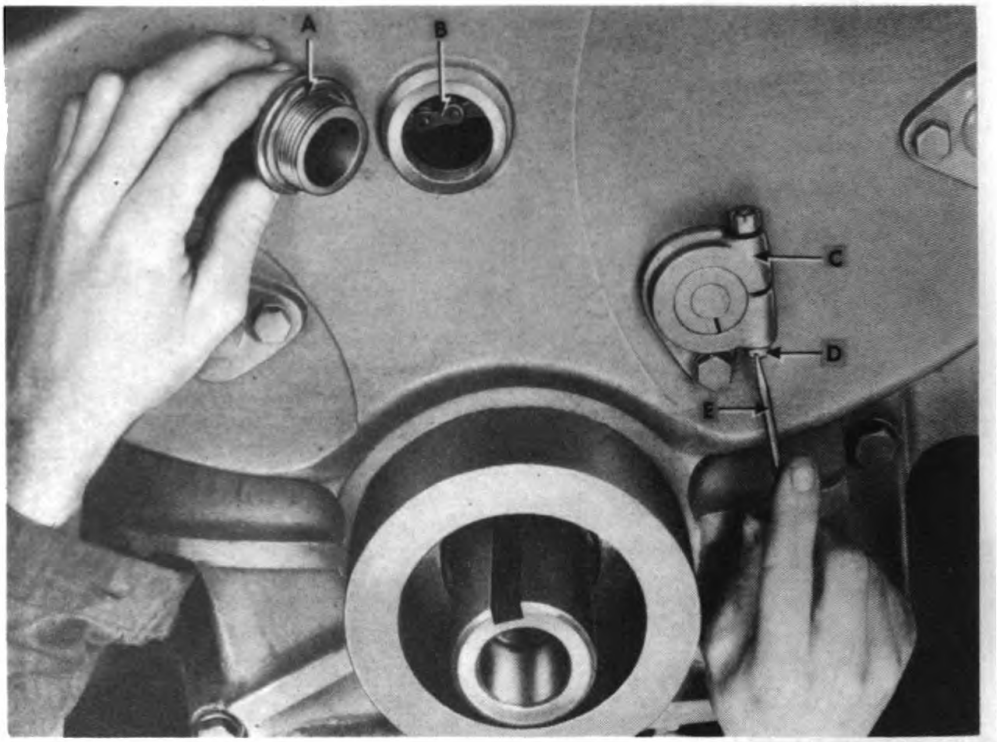


Figure 93—Setting Sprockets, Using Plumb Lines To Check Timing Arrows



A—INSPECTION PLUG
B—CHAIN
C—SUPPORT BRACKET
D—ADJUSTING SCREW
E—SCREWDRIVER

RA PD 342092

Figure 94—Adjusting Fuel Pump Drive Chain

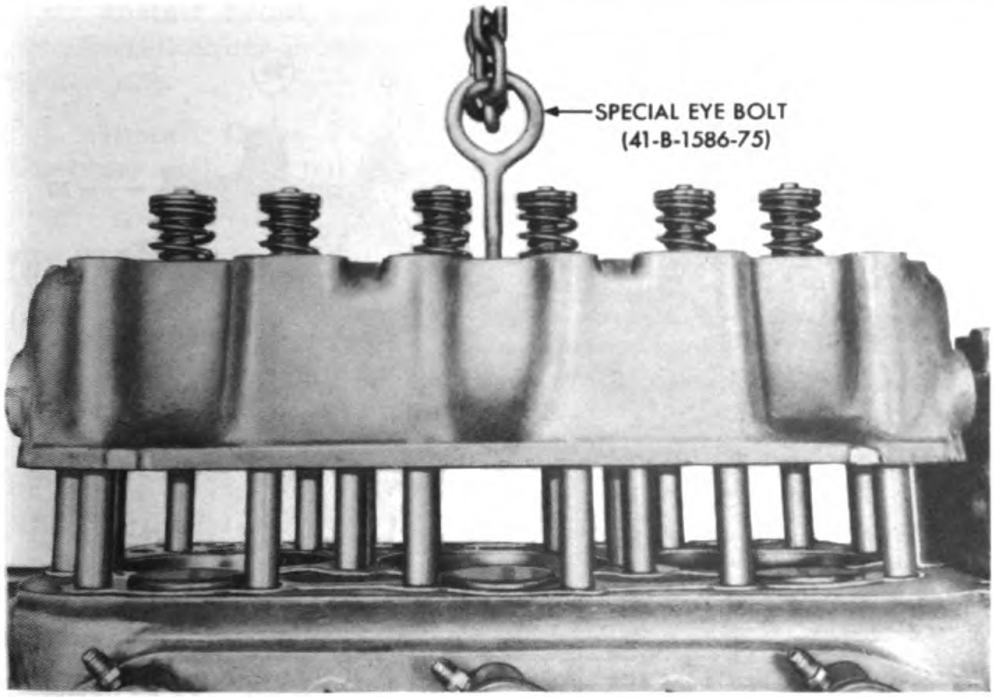
and cotter pin. See that adjusting screw fits properly into threaded groove in split bushing. Install thrust plate shim and thrust plates, and fasten in place with cork washers and cap screws. Make sure the oil seal in gear cover is installed concentric with crankshaft. Gear cover clearance around crankshaft must be 0.006 to 0.015 inch.

l. Adjust Fuel Pump Drive Chain. Refer to figure 94 and observe the following steps:

(1) Test chain with finger through inspection plug hole. Movement should be about ⅜ inch up and down.

(2) If movement is more than ⅜ inch, take out cotter pin, loosen castle nut, and turn adjusting screw clockwise. This turns the idler eccentric bushing, thus moving idler sprocket down and tightening chain.

(3) If chain is too tight, turn adjusting screw counterclockwise until castle nut rests against support bracket; then turn adjusting screw counterclockwise until chain is too loose. Repeat step (2)

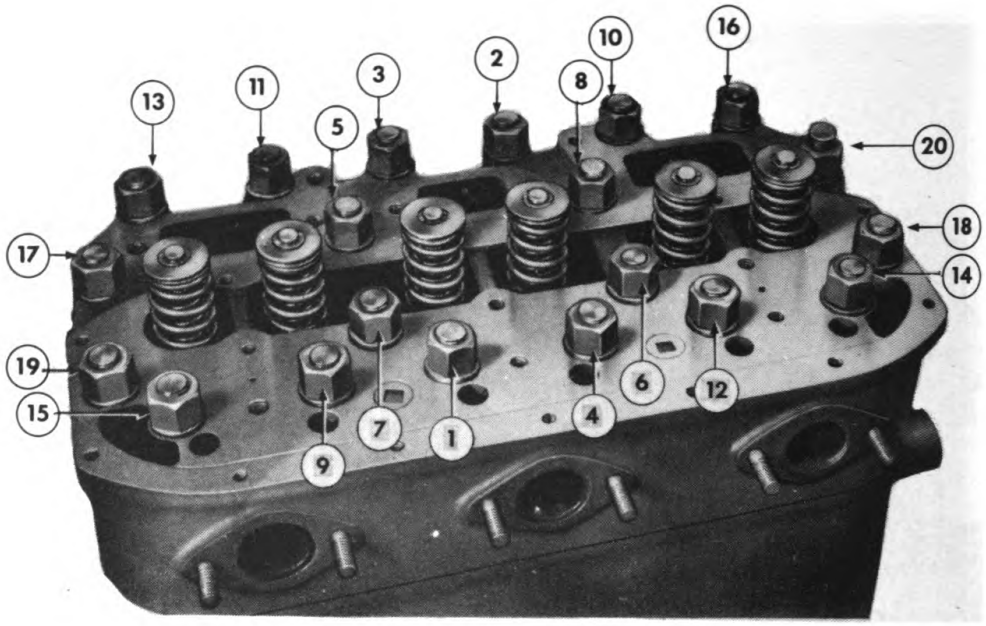


RA PD 350611

Figure 95—*Method of Removing and Installing Cylinder Heads, Using Special Eye Bolt (41-B-1586-75)*

above, and tighten chain to correct tension. NOTE: *It is not necessary to remove the cap screw which attaches support bracket to gear cover in order to make chain adjustment.* After chain adjustment is made, tighten castle nut and install cotter pin; then tighten the 16 bolts which hold gear cover to case.

m. Check Camshaft and Fuel Pump Drive End Play (fig. 76). The end thrust of both these shafts is adjusted by means of thrust plate shims placed on thrust plate. Removal of shims permits plate to be moved closer to shaft so that thrust surface of plate will take up end play. CAUTION: *Do not take out too many shims as this would throw a heavy thrust load on plates.* One way to make sure that thrust adjustment is correct is to put a thin layer of Prussian blue on plate thrust surface; then using estimated number of shims, install thrust plate, turn crankshaft over carefully one or two revolutions, remove thrust plate, and observe marks on thrust surface of plate. If it shows a definite pressure, the adjustment is too close. In securing right clearance, allowance must be made for expansion of various parts when they become hot. Camshaft end clearance, under operating temperatures, should be 0.005 to 0.008 inch and must never exceed 0.010 inch. Fuel pump drive shaft end clearance must not exceed 0.004 inch.



RA PD 342059

Figure 96—Tightening Sequence for Cylinder Head Nuts

n. Install Oil Pan Assembly. Coat flange surfaces with gasket cement, and install new gasket. Install 5 cap screws at bell housing end. Install 8 flathead screws and 20 cap screws at bottom of oil pan.

o. Install Cylinder Head Assemblies. Install lower and upper combustion chamber liners in cylinder block. Install the two copper gaskets. Left cylinder head with lifting eye (41-B-1586-75) in center hole, and position on studs (fig. 95). Install the 20 washers and nuts on studs of each cylinder head, and tighten with torque-indicating wrench to 300 foot-pounds. Tighten nuts in sequence shown in figure 96. Tighten gradually about 50 pounds at a time, which means going over the proper tightening sequence about six times. CAUTION: *Make sure cylinder block is not binding on upper combustion chamber liner. If it is binding, remove liner and clean; then file off top of upper liner enough to provide clearance.*

p. Install Push Rods. Insert the 12 push rods in holes.

q. Install Rocker Arms. Place each of the two rocker arm assemblies in position, and install the six bolts in each assembly. Tighten bolts and install lock wires.

r. Install Cylinder Head Covers. Install new asbestos gaskets, and install cylinder head covers, fastening each cover in place with 13 cap screws and lock washers.

s. Install Front Engine Support. Position front engine support; install shims in center clamp, install bolt, washer, and nut, and tighten nut.

t. Install Drive Pulley. Install plain key and drive pulley. Use brass drift and large hammer to drive the pulley on evenly.

u. Install Crank Grab. Install large plain washer. Use a suitable wrench to install crank grab by screwing it in clockwise. CAUTION: *Make sure that threads inside of crankshaft are not stripped. Do not force crank grab. If it does not screw into crankshaft with normal wrench torque, investigate to see if there are any stripped threads.*

v. Install Breather Pipe Assembly. Install breather pipe assembly, and fasten in place with two bolts.

w. Install Exhaust Manifold. Use new copper-covered asbestos gaskets and install exhaust manifold. Install and tighten all stud nuts except the one in front by which thermostat by-pass tube clamp is fastened.

x. Install Thermostat Housing and Elbow. Use a new gasket, and install thermostat housing on four studs; fasten in place with four nuts and lock washers. Install new gasket, and install elbow with two cap screws and lock washers. Be sure that thermostat is in place.

y. Install Intake Manifold. Install intake manifold, using new gaskets. Tighten in place with 12 bolts.

z. Install Starter Burner. Use new gasket, and install starter burner on intake manifold studs with four nuts and lock washers. Connect fuel line which extends from starter burner to intake line of fuel injector pump.

aa. Install Water Outlet Manifold. Use new fiber gasket and install water outlet manifold, including thermostat assembly. Tighten in place with four bolts and lock washers.

ab. Install Water Pump and By-pass Tube. For overhaul of water pump, refer to paragraph 95.

(1) Install gasket on water pump flange, and insert water pump gear so that it will mesh with camshaft gear.

(2) Install three bolts and the nut on one stud, but do not tighten.

(3) Lift up tachometer drive about one inch to make room for wrench, and install the fourth bolt which goes behind water pump. Install nut in slotted flange.

(4) Connect oil line which extends from top of water pump to air compressor head.

(5) Install thermostat by-pass tube, clamp, water hose, breather cap, and chain as a unit (fig. 13). Install the nut which fastens clamp to exhaust manifold flange. Connect the water hose to air compressor, and tighten clamp screw. Connect hose coupling on by-pass tube to thermostat housing at top, and to water pump at bottom.

ac. Install Accessories. Refer to TM 9-768 for detailed instructions covering installation of accessories. Refer to figure 110 for proper line connections to fuel injector pump. NOTE: *Fan bracket, fan assembly, torque arm supports, and air compressor cannot be installed until adapter frame is removed, but air compressor bracket, which includes the crankcase breather, can be installed.*

Section V

DYNAMOMETER RUN-IN TEST AND ADJUSTMENT

50. PRELIMINARY INSTRUCTIONS.

a. Cooling. Provision must be made for cooling the engine during test run. Means must be provided for regulating water inlet temperature; cold water, as it comes from water main, must not be allowed to enter the cylinder block. A blast of air, from a blower, directed over the engine block will help to maintain engine and oil temperatures at safe values.

b. 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).

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

d. Air Induction System. See that air intake is located to provide only fresh, cool air for intake. Do not use an air cleaner.

e. Fuel System. A fuel tank that has been thoroughly cleaned must be provided. Fuel must conform to U. S. Army Specification 2-102, or latest revision thereof.

f. Accessories. Test the engine without power-consuming engine accessories. By power-consuming accessories is meant such items as cooling fan, air compressor, muffler, generator, air cleaner, etc. The fuel injection pump with governor and the water pump are considered part of the engine.

g. Correction for Atmospheric Conditions. Engine power output varies due to differences in barometric pressure, 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 intake air temperature, and 0° humidity. The dynamometer schedule (par. 51) is so set up that no corrections for atmospheric conditions are required except for the full throttle run.

h. Data. Pertinent data, including time, speed, load, oil pressure, oil and coolant temperatures, etc., must be recorded during the test run on a log sheet. Log sheets may be printed, mimeographed, or otherwise produced locally; if any quantity of Hercules Model DFXE engines are to be tested, it is recommended that fixed items such as period, speed, and load (except full throttle) be included in the printed form. Log sheets will be retained at the overhaul facility.

i. Definitions.

(1) OBSERVED BRAKE HORSEPOWER. This means the actual net horsepower at the output shaft of engine, as computed from the dynamometer scale reading and speed.

(2) CORRECTED BRAKE HORSEPOWER. This means the actual net or observed horsepower corrected to standard conditions (subpar. g above).

(3) FULL THROTTLE. This means wide-open throttle with sufficient load on dynamometer to maintain the speed at the specified value.

51. DYNAMOMETER TEST RUN.

a. Preparations for Run. Mount engine on dynamometer stand; make sure that preliminary instructions (par. 50) have been observed; fill crankcase to 4/4 mark on bayonet gage with SAE 30 lubricating oil.

b. Start Engine.

(1) Start engine and set throttle to obtain an engine speed of approximately 600 revolutions per minute. CAUTION: *When engine*

is first started up, see that oil pressure is at least 30 pounds. If oil pressure gage does not indicate oil pressure within 30 seconds, shut down engine and determine the cause.

(2) Enter starting data on log sheet.

c. Test Run.

(1) Run engine at no load for 30 minutes at 600 revolutions per minute, and set tappets; intake at 0.010-inch clearance, and exhaust at 0.016-inch clearance.

(2) Run engine at 1,200 revolutions per minute for 2 hours with a load of 50 brake horsepower applied.

(3) Increase speed to 1,400 revolutions per minute, and increase load to about 80 brake horsepower. Set control rack rod stop screw on fuel injector pump (fig. 128) to consume one pound of fuel, or approximately 550 cubic centimeters, in 45 seconds. NOTE: *Turn stop screw clockwise to decrease fuel, and counterclockwise to increase fuel quantity. Always replace the cotter pin in control stop screw before taking a reading on gage. One-fourth turn of screw changes fuel quantity about 5 percent.* Run engine until temperature of lubricating oil is 170° F. Turn the adjusting screw on oil pressure regulator all the way in (fig. 84). There should not be less than 60 pounds or more than 100 pounds oil pressure at 1,600 revolutions per minute with no load. This will mean that the oil pressure is then set at a maximum of 45 pounds at 1,200 revolutions per minute and not less than 15 pounds at idle speed of 500 revolutions per minute.

(4) Again check tappets to see that valve clearances are correct; intake at 0.010-inch, exhaust at 0.016-inch.

(5) Run engine at 1,200 revolutions per minute, with approximately 100 brake horsepower load, for 3 hours; then step up speed to 1,400 revolutions per minute and run for one hour with 140 brake horsepower load.

(6) Make final check for horsepower. The engine must pull approximately 180 corrected horsepower at 1,400 revolutions per minute.

(7) Set governor for a maximum speed of 1,625 revolutions per minute, no load (par. 73 **b** (5)).

(8) With control rod lever in wide open position, apply sufficient load to pull the engine down to 1,500 revolutions per minute. Check engine for knocks, noisy gears, oil leaks, and other defects. If engine is satisfactory, adjust slow idle speed for 500 revolutions per minute, no load (par. 73 **b** (6)).

(9) Make final check of oil pressure. Oil pressure must be between 28 and 35 pounds per square inch at 600 revolutions per minute, and at least 50 pounds per square inch at 1,200 revolutions per minute when oil temperature is 170° F.

(10) Remove engine from dynamometer, remove engine oil pan, and inspect condition of cylinder bores, side clearance of connecting

rods, and end play of crankshaft. Make sure cotter pins are present in all main bearing studs, and connecting rod bolts. If this inspection reveals the above items are in good condition, install oil pan and the engine is ready for service. If inspection reveals any deficiency or the presence of an unusual amount of dirt or bearing material, disassemble engine and remedy cause.

d. Penalty Run. If major adjustments or replacements of major components have been necessary, the engine must be tested again before being released. Where only minor corrections are made, such as adjustment of valve tappets or replacement or testing of nozzles or fuel transfer pump, engine must be run long enough to determine that it is operating satisfactorily.

e. Preparation for Shipment. If only the engine was received by the Ordnance establishment, it must be prepared for shipment in accordance with Ordnance Department U. S. Army Tentative Specifications AXS 836, latest revision.

CHAPTER 6—CLUTCH

Section I

DESCRIPTION AND DATA

52. DESCRIPTION AND DATA.

a. Description (fig. 97). The clutch is a 2-plate, dry-disk type, all parts of which are locked to the flywheel and rotate with it; the driven disks are disconnected when the clutch is released. Driving pressure is provided by a heavy spiral spring located in the pressure plate.

b. Operation. When clutch pedal is depressed, the release sleeve is moved toward the flywheel, acting on the hinged levers in a manner opposite to the spring pressure on them. This relieves pressure against pressure plate and the retractor springs prevent pressure plate from contacting the driven disks, thus releasing the clutch. As pedal is released, the spring again transmits pressure through the levers (this pressure being multiplied by the action of the 20 ball-mounted levers) so that driven disks are pressed between the pressure plate, intermediate drive plate, and flywheel, thus engaging the clutch. The hinged levers are provided with raised edges which, because of their fan-like action, force cooling air through the clutch spring and into the clutch.

53. DATA.

Type	2-plate, dry-disk
Make	W.C. Lipe
Model	MTC-207
Facings:	
Area (total for two plates)	460 sq in.
Outside diameter	14½ in.
Inside diameter	8 in.
Thickness	5/32 in.
Spring:	
Type	Spiral
Number used	1
Clutch throw-out bearing:	
Type	Ball with retainer
Make	BCA
Model	CWY-88

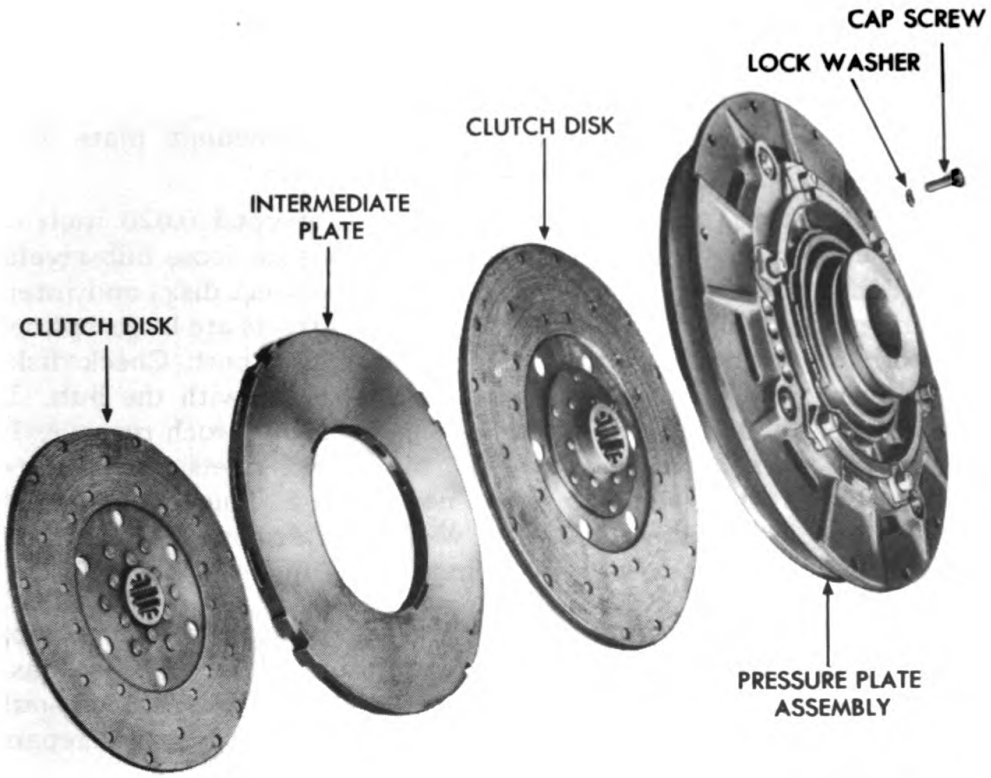


Figure 97—Clutch Plates and Disks

Clutch pilot bearing:

Type	Ball
Make	New Departure
Model	7506

Adjustment:

Length of sleeve travel	9/16 in.
Dimension "A" (fig. 105) from face of flywheel ring to face of release sleeve, with clutch engaged	1⅛ in. + 1/16 in. — 0 in.

Section II

OVERHAUL OF CLUTCH ASSEMBLY

54. DRIVEN DISK ASSEMBLY.

a. Disassembly (fig. 98). When clutch assembly is removed, the disk on flywheel side, intermediate plate, and disk on pressure plate side are free from any attachment to one another. The only

further disassembly is the removal of rivets from the disks if facings are worn down so that replacement of facings is necessary. Facings are removed by punching out the rivets.

b. Cleaning, Inspection, and Repair.

(1) CLEAN. Clean both disks and the intermediate plate with dry-cleaning solvent, and dry with compressed air.

(2) INSPECT AND REPAIR. If plates are warped 0.020 inch or more, they must be replaced. Inspect both disks for loose hub rivets; inspect the splines carefully for signs of wear; inspect disks and intermediate plate closely for any signs of cracks. If rivets are loose, splines are worn, or cracks are found, replace the damaged part. Check disks and intermediate plate for flatness and squareness with the hub. If run-out exceeds 0.015 inch, replace the part showing such run-out. If facings are worn down to the rivets, punch out rivets and replace facings. Use riveting stand to install new facings. Thickness of lined clutch plates is 0.450 to 0.442 inch; wear limit at complete overhaul is 0.284 inch. Thickness of new facings is $\frac{5}{32}$ inch.

c. Assembly. The only assembly of the disks is replacement of worn facings. When the two disks and intermediate plate are assembled to the pressure plate assembly, check disks for run-out to make sure distortion of disks has not taken place during repair operations.

55. PRESSURE PLATE ASSEMBLY.

a. Disassembly (fig. 99).

(1) REMOVE PRESSURE PLATE (fig. 99).

(a) Place the clutch assembly in an arbor press with the pressure plate down. Place two substantial blocks, about 5 inches long, in position as shown in figure 99. Arrange a strong bar or wooden block over these blocks, compress the assembly, and lock the press in position. CAUTION: *Only slight pressure is necessary. Do not compress enough to threaten breakage of large wooden block.*

(b) Remove the four retractor spring pins, retaining washers, and the springs.

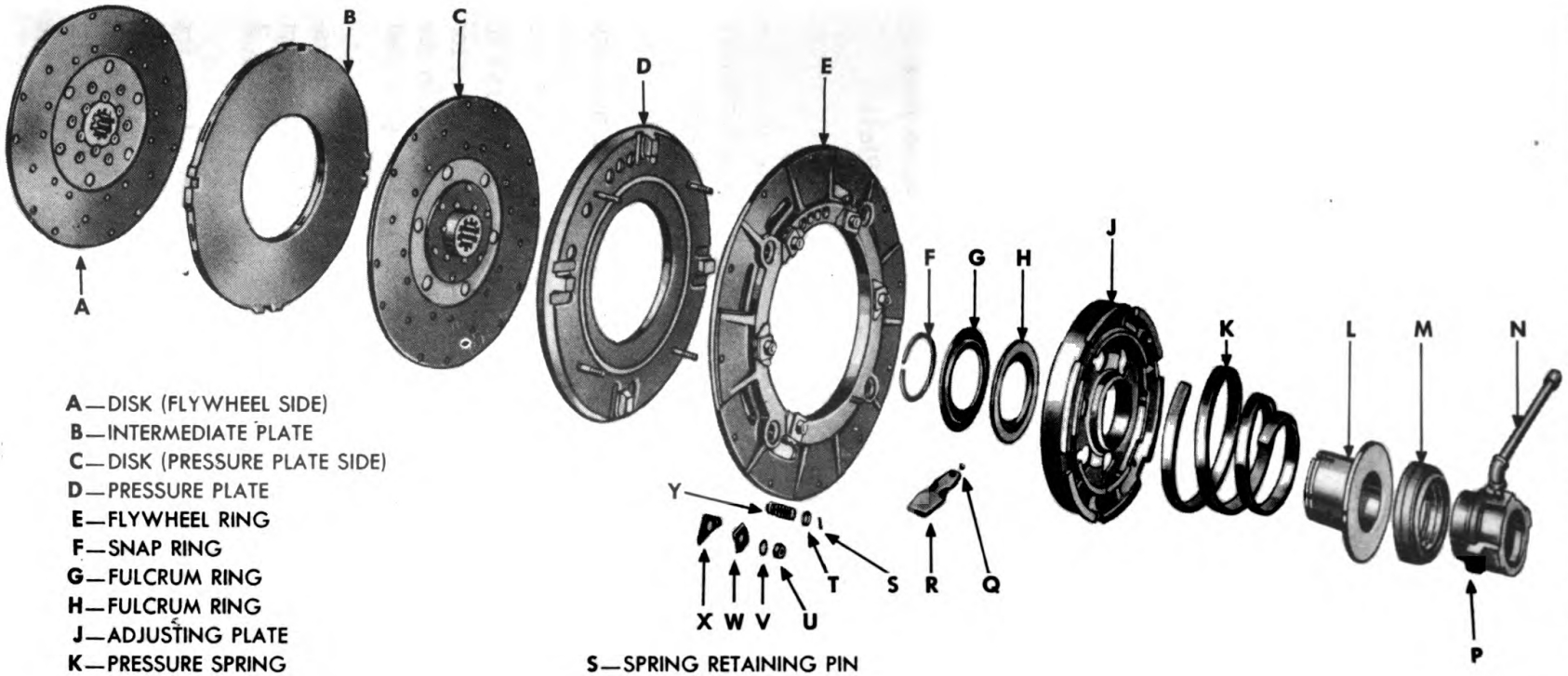
(c) Raise the spindle slowly to release the clutch in the arbor press.

(d) Turn the assembly over and remove the pressure plate.

(2) REMOVE SNAP RING, FULCRUM RINGS, LEVERS, AND BALLS (fig. 98).

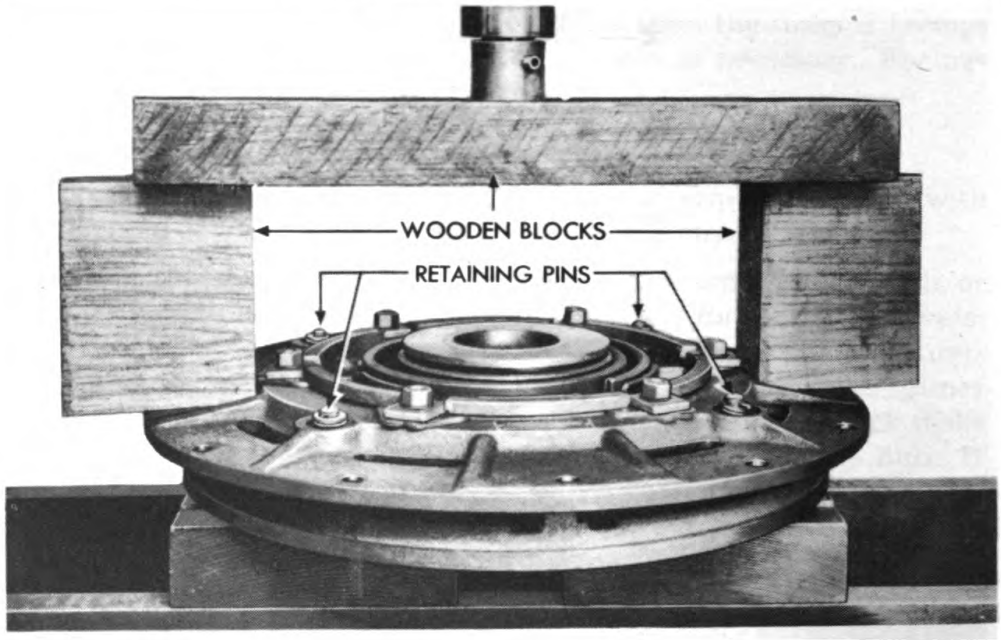
(a) Place the assembly on the press so that it rests on the clutch sleeve. Place wooden blocks in position as shown in figure 100.

(b) Remove the snap ring, using a snap ring spreader.



A—DISK (FLYWHEEL SIDE)
B—INTERMEDIATE PLATE
C—DISK (PRESSURE PLATE SIDE)
D—PRESSURE PLATE
E—FLYWHEEL RING
F—SNAP RING
G—FULCRUM RING
H—FULCRUM RING
J—ADJUSTING PLATE
K—PRESSURE SPRING
L—RELEASE SLEEVE
M—RELEASE BEARING
N—OIL PIPE
P—RELEASE BEARING CARRIER
Q—PRESSURE LEVER LOCKING BALL
R—PRESSURE LEVER
S—SPRING RETAINING PIN
T—SPRING WASHER
U—FLYWHEEL RING NUT
V—LOCK WASHER
W—FLYWHEEL RING ADJUSTING STRAP
X—FLYWHEEL RING ADJUSTING SHIM
Y—PRESSURE PLATE RETRACTING SPRING

Figure 98—Clutch, Disassembled



RA PD 342182

Figure 99—Set-up for Removing Clutch Pressure Plate

(c) Remove the fulcrum rings, levers, and balls.

(d) Slowly release the assembly in the arbor press until the spring, sleeve, and remaining parts can be removed. Do not remove the adjusting plate, or disturb the shim setting unless necessary.

b. Cleaning, Inspection, and Repair.

(1) CLEAN. Clean all parts with dry-cleaning solvent, and dry with compressed air.

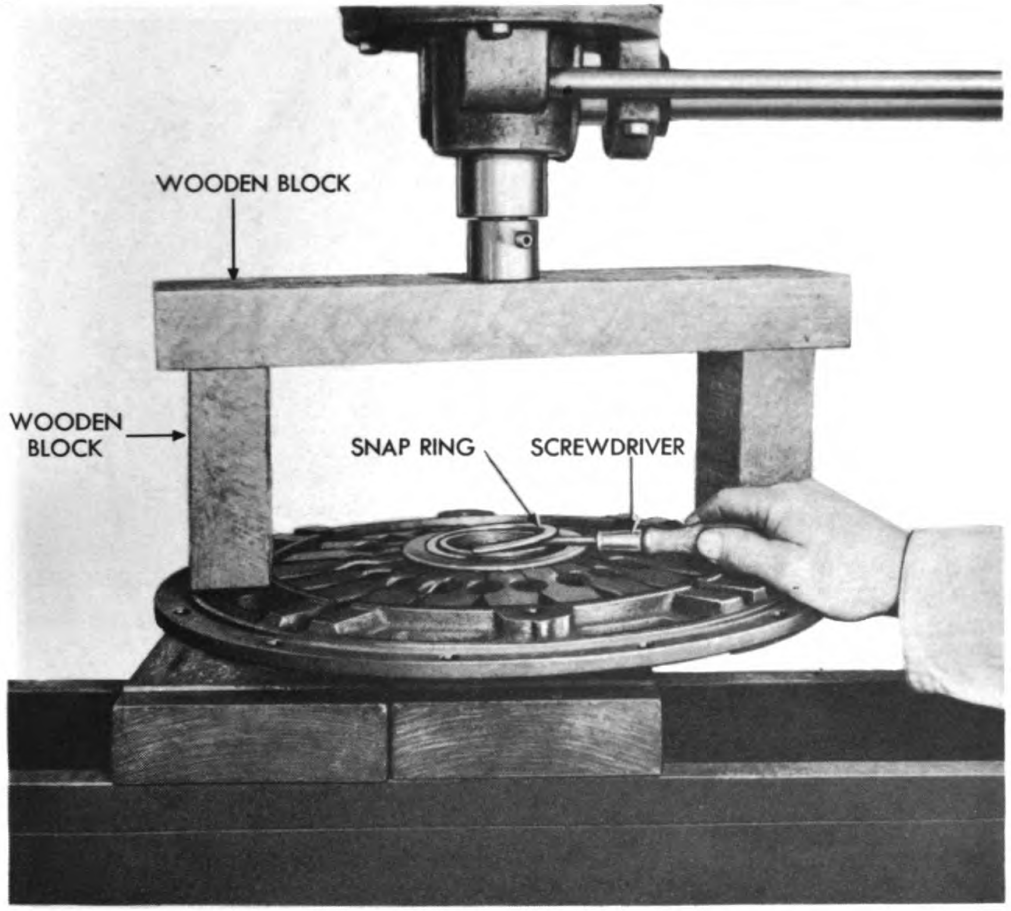
(2) INSPECT AND REPAIR.

(a) Pressure Plate. Thickness of a new pressure plate is 1.154 to 1.156 inch; wear limit at complete overhaul is 0.015 inch. Inspect for distortion and heat checks. Check clearance of the driving lugs in the flywheel ring. A looseness of 0.005 to 0.006 inch should be provided between the lugs and their slots in flywheel ring.

(b) Clutch Cover. Inspect for distortion and cracks. Check retractor spring washers for wear, and if broken, replace them. Inspect fulcrum ring balls, retracting springs, washers, and pins; replace if any of these parts show signs of damage or looseness.

(c) Release Sleeve. Inspect release sleeve contact face for galling; also inspect release bearing, bearing carrier, and bearing carrier oil pipe. Replace if defective.

(d) Springs. The clutch pressure spring scale reading should be 460 pounds at $2\frac{13}{16}$ inches minimum, and 480 pounds at $2\frac{13}{16}$



RA PD 342166

Figure 100—Removing Snap Ring

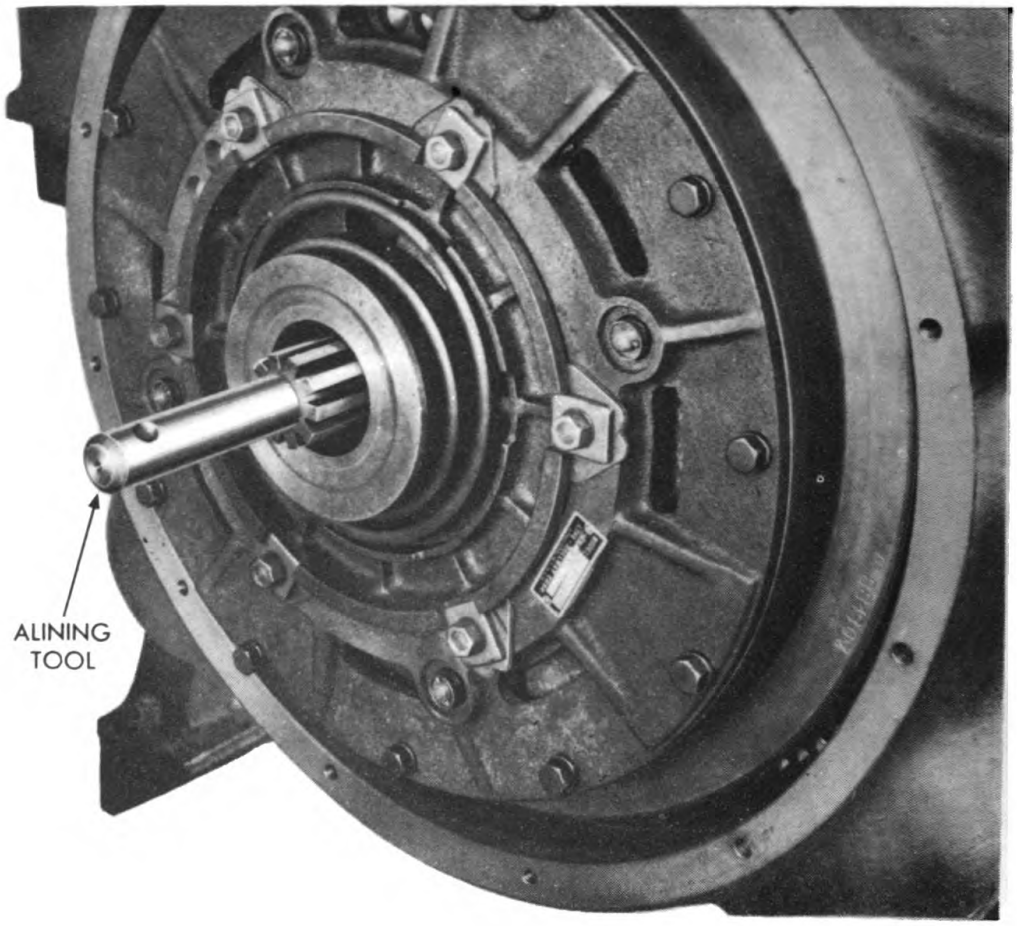
inches maximum. Replace spring if weak or damaged. Inspect all retractor springs and retainers for damage or breaks, and replace if defective. Maximum permissible wear of pressure levers is 0.110 inch.

c. Assembly and Adjustment.

(1) ASSEMBLY.

(a) Place the clutch release sleeve on the table of drill or arbor press, with flange down. NOTE: *If a coned pilot tool is available, it may be used to act as a guide in assembling the sleeve in adjusting plate.*

(b) With the large coil of pressure spring against the left of small boss (stop) in adjusting plate, place the flywheel ring, adjusting plate, and spring over the release sleeve. Make sure that all burs in bore of adjusting plate or on release sleeve have been smoothed out, as sleeve must be a free fit in adjusting plate. If contact face of release sleeve is galled, discard it and use a new sleeve.



RA PD 342167

Figure 101—Clutch Installed, Showing Alining Tool (41-A-134-840)

(c) Arrange two blocks and a bar on the assembly, and compress carefully; then lock the press and remove the coned pilot tool.

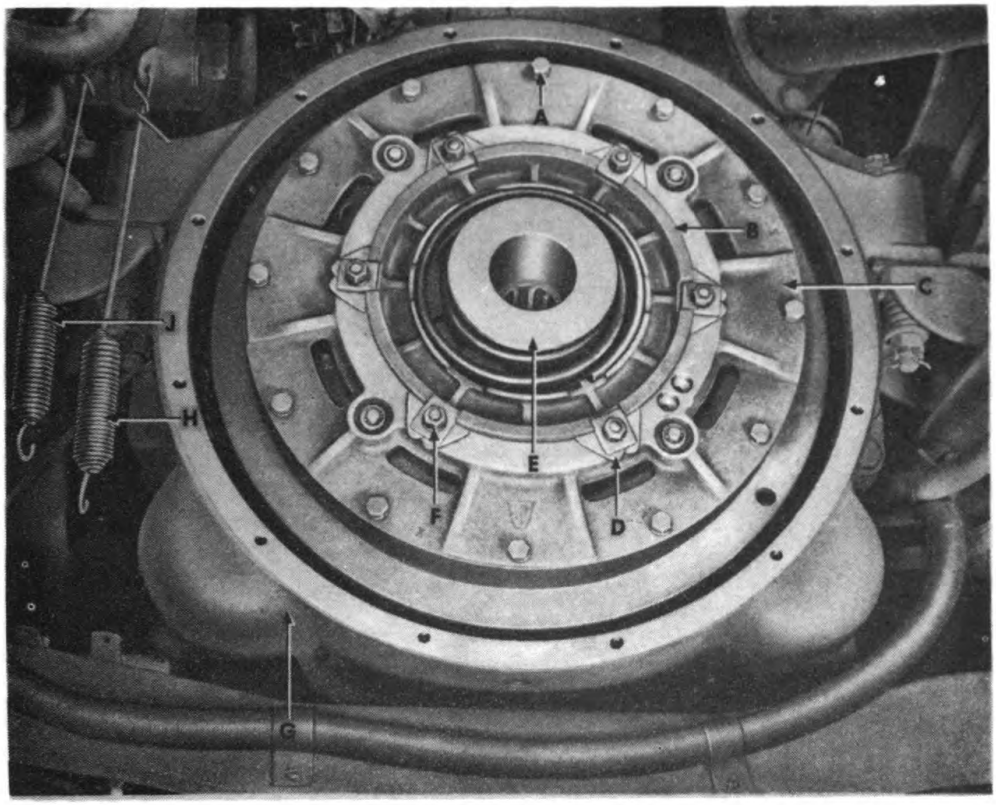
(d) Check fulcrum rings for flatness or excessive wear. If warped or badly worn, select two good fulcrum rings using new rings when necessary, and place one of them (cupped side up) over release sleeve.

(e) Arrange the 20 levers on fulcrum ring so that the ends of levers rest just inside the retaining rim of the flywheel ring. If any levers are worn, replace them.

(f) Place one $^{9}/_{32}$-inch ball in each hole in small end of each lever.

(g) Assemble the remaining fulcrum ring firmly and carefully over the sleeve. Be sure no ball bearings become displaced, and that none of the levers overlap each other.

(h) Place the coned pilot tool and a new snap ring over it. Always use a new snap ring, and make sure it is firmly seated in its slot by tapping it home with a staking tool. Then place the cupped tool over the snap ring, and drive the ring over the tool and onto the sleeve.



A—CLUTCH MOUNTING BOLT
B—ADJUSTING PLATE
C—PRESSURE PLATE ASSEMBLY
D—ADJUSTING SHIMS
E—CLUTCH RELEASE SLEEVE
F—FLYWHEEL RING STUD NUT
G—CLUTCH HOUSING
H—BRAKE PEDAL PULL-BACK SPRING
J—CLUTCH PEDAL PULL-BACK SPRING

RA PD 321335

Figure 102—Clutch Adjusting Plate and Shims

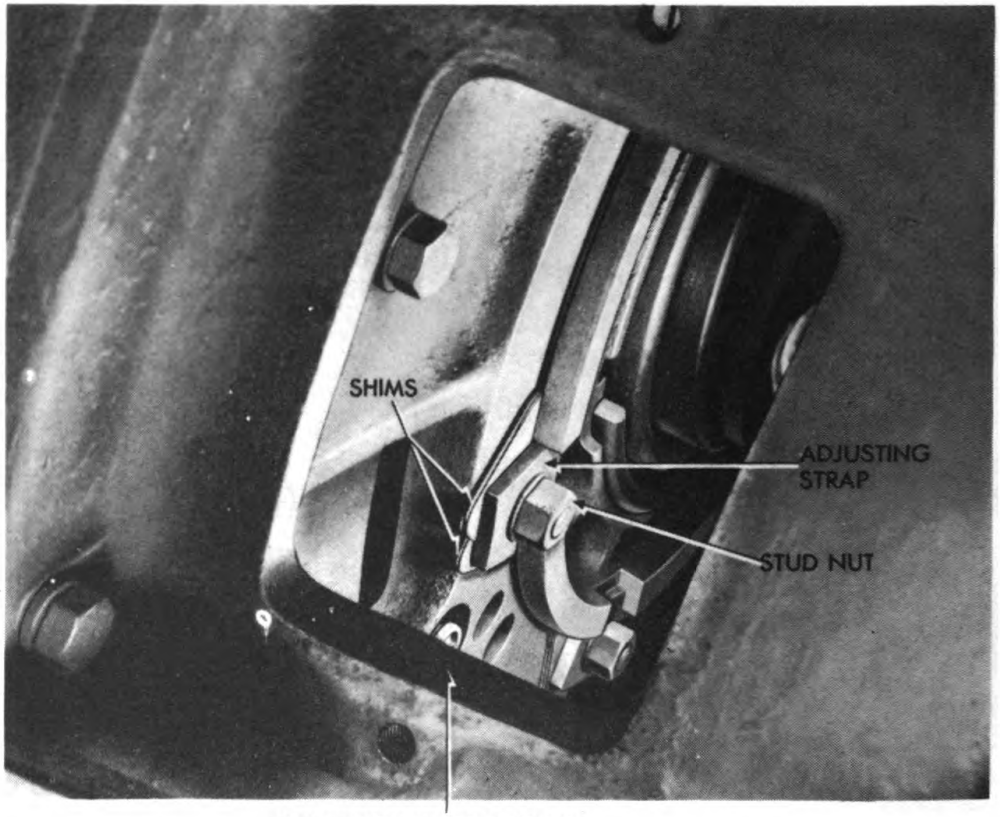
(i) The ends of the snap ring should not be in line with the keyways in the sleeve. Best results are obtained if the staking starts opposite the snap ring ends, and from this point works toward the ends.

(j) Test each of the 20 levers after assembly to make sure each lever has a ball bearing locking it in the fulcrum rings.

(k) Assemble the pressure plate into the four driving slots of the flywheel. When using an old plate, assemble with driving lug marked "0" in the driving slot marked "0."

(l) Turn the plate over, and compress clutch spring again.

(m) Assemble the four retractor springs over the studs, place the retainers over them, and compress sufficiently to permit installation of the retractor spring pins in the ends of the studs. The retainers must be placed with their dished sides up in order to lock the pins



RA PD 321368

Figure 103—Clutch Adjusting Strap and Shims, Bottom Inspection Cover Removed

in place. Use new retractor springs if old ones are out of shape. The coils must be open.

(n) Release the clutch from arbor press. It is now ready to be installed on the engine.

(o) Pressure plate must be free in slots of flywheel ring. Approximately 0.004 to 0.006 inch looseness should be provided.

(p) If new driven disks are used, be sure that each adjusting strap has eight shims under it.

(2) ALINING CLUTCH. When clutch is being assembled on engine, use special aliner (41-A-134-840) as shown in figure 101, to hold the disks in true alinement until holding cap screws are tightened.

(3) ADJUSTMENT. Clutch adjustment is made by means of shims, which prevent disturbance of the dynamic balance of the clutch (figs. 102 and 103). Adjustment for wear automatically restores spring pressure to its normal load. As facings wear, the clutch sleeve

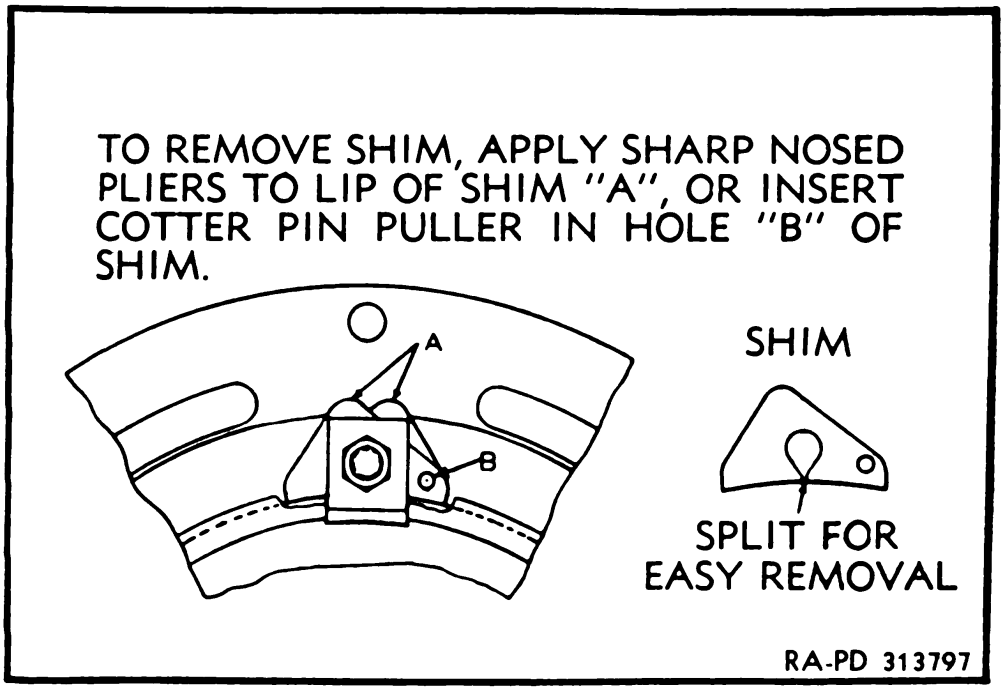


Figure 104—Clutch Shim Removal

moves toward the release bearing, thus reducing the clearance between bearing and sleeve (clutch in engaged position). This reduced clearance will result in a reduction of the pedal "lash," which is defined as the first easy movement of the clutch pedal. When the "lash" of clutch pedal becomes as low as ½ inch, the clutch needs adjustment immediately. Do not adjust the pedal linkage to correct pedal "lash," but proceed as follows:

(a) Block the pedal in released position. This is necessary, because otherwise the adjusting straps and studs may become bent or the threads of the stud or nut may become stripped.

(b) Back off all six adjusting strap nuts five full turns, working through the handhole cover in clutch housing.

(c) Remove the block to re-engage the clutch. This permits the adjusting plate to move out of contact with the adjusting shims.

(d) Remove one shim from under each adjusting strap using a pair of long-nosed pliers, or use a cotter pin puller in the small hole of the shim (fig. 104). Be sure that no portion of the shim is left between the adjusting plate and the flywheel ring; also be sure that the same number of shims are removed from under each strap. Enough shims should be removed to maintain dimension "A" in figure 105 at 1⅛ inch + 1/16 inch, — 0 inch. Each shim removed decreases dimension "A" by 7/64 inch.

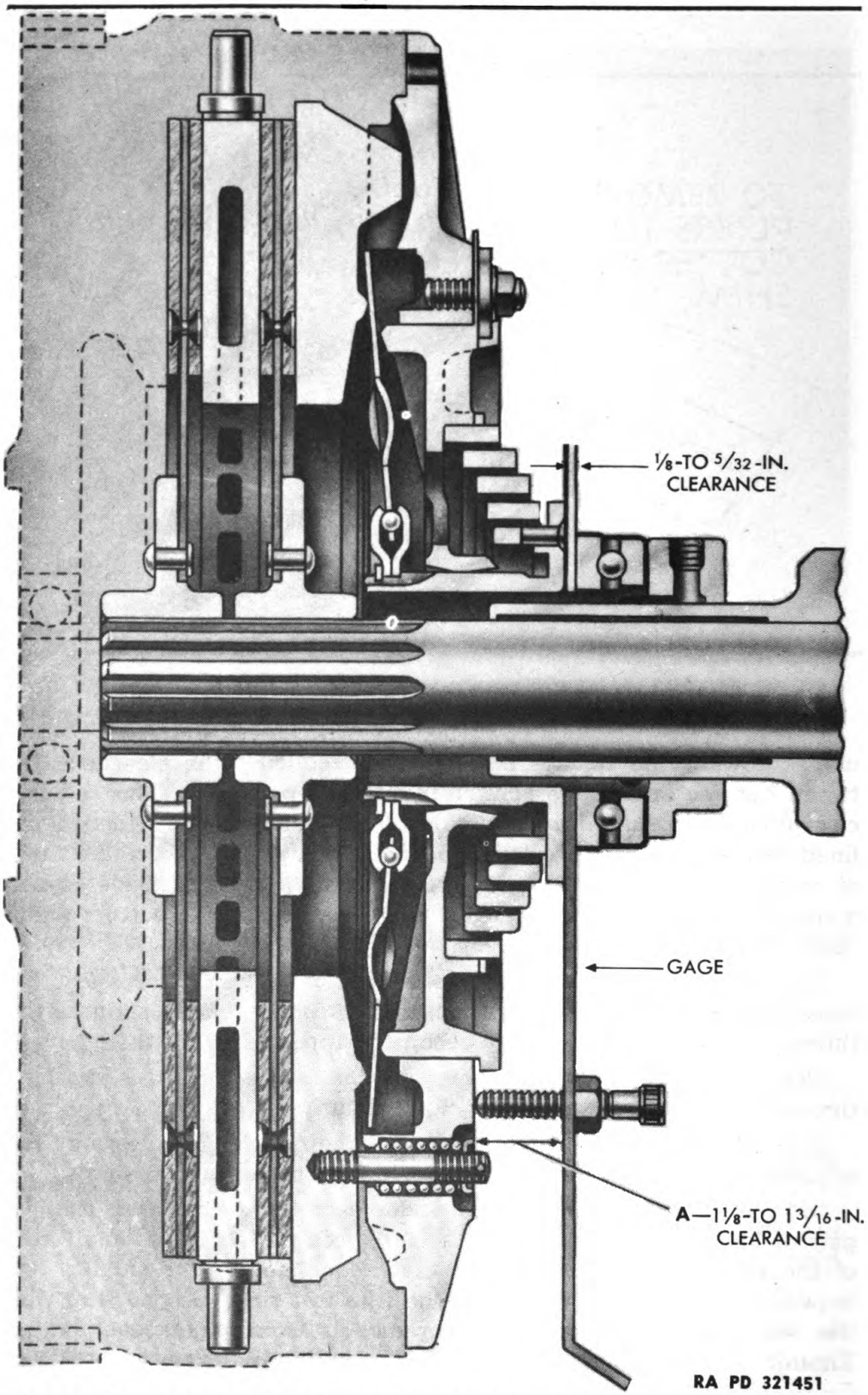


Figure 105—Cross Section, Showing Shim Adjustment of Clutch

(e) After removing the same number of shims from under each strap, block the clutch in released position to allow the adjusting plate to move into contact with the shims; then tighten each adjusting strap nut.

(f) Check adjustment, using gage to see that dimension "A" is $1\frac{1}{8}$ inch + $\frac{1}{16}$ inch, — 0 inch (fig. 105). If gage is not available, dimension "A" may be measured with a straightedge and scale. The straightedge is held in place by pushing the release bearing into contact with it.

(g) Check clearance between release bearing and clutch sleeve. This should not be less than $\frac{1}{8}$ inch or more than $\frac{5}{32}$ inch. If this clearance is not within the prescribed limits, adjust clutch pedal linkage. CAUTION: *Never adjust the pedal linkage until after properly adjusting the clutch, and then only when it is necessary.*

CHAPTER 7—FUEL SYSTEM

Section I

DESCRIPTION

56. DESCRIPTION AND OPERATION.

a. Description. The fuel injection system consists of fuel tanks and lines, fuel gage, fuel filters, air cleaners, fuel injector pump, fuel transfer pump, variable speed fuel pump governor, fuel pressure gage, starter burner, stop control solenoid, and fuel nozzles (figs. 106 and 109).

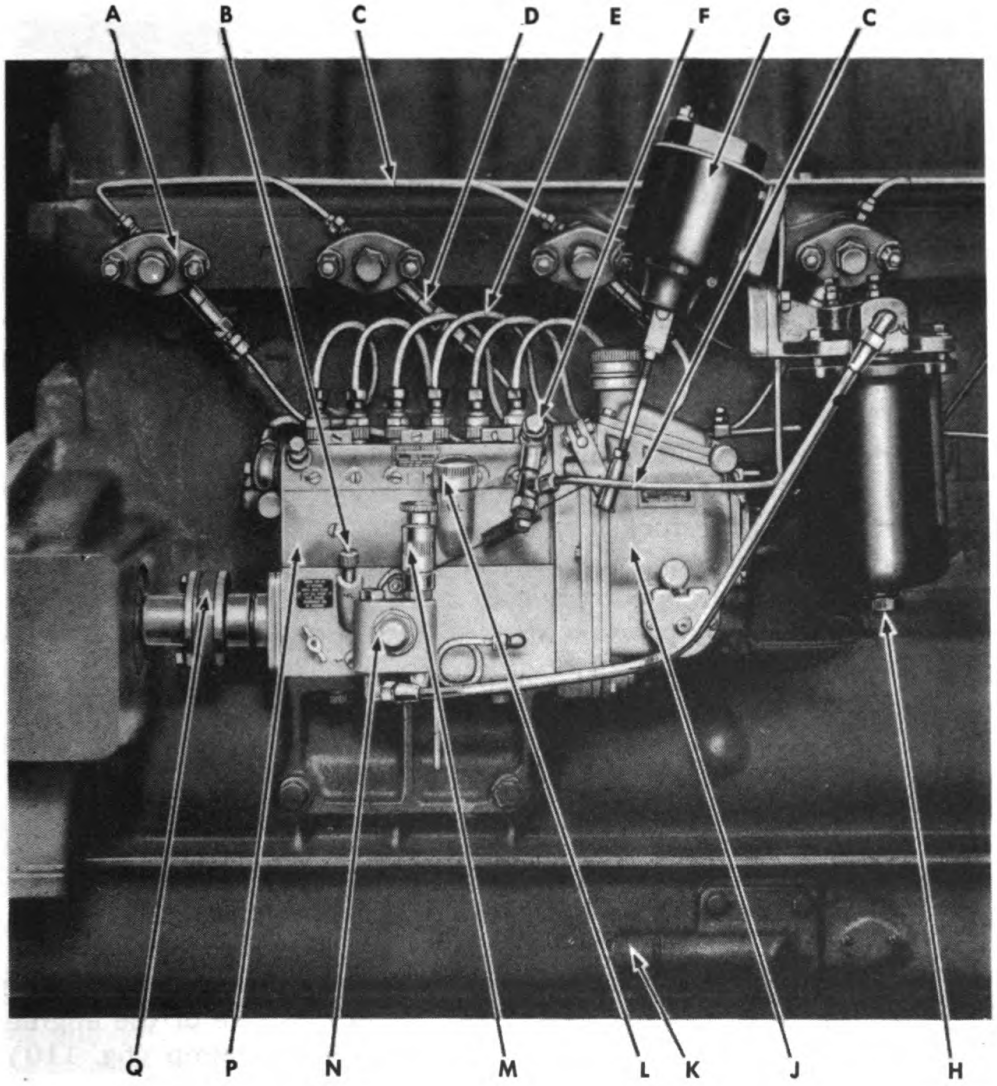
b. Operation. The fuel transfer pump draws fuel from the main supply tank through primary filters and delivers this fuel, through the fuel strainer, to the fuel injector pump under slight pressure. Clean air is drawn in through the air cleaners and intake manifold at the suction stroke, and is compressed to about 480 pounds per square inch during the compression stroke. This raises the temperature of the air above that of the ignition temperature of the fuel oil, so that when a metered charge of fuel is injected, as the piston approaches top center the fuel is ignited by compression heat. Leak-off return lines from the nozzles connect to the overflow line for return to the fuel tank.

c. Fuel Tanks and Lines.

(1) FUEL LINES. All fuel lines running between the tanks, fuel filters, and fuel pump are copper or flexible tubing covered with loom. Flexible tubing is used between fuel pump and frame to eliminate any danger of fuel line breakage due to vibration. For cleaning fuel lines, refer to TM 9-768.

(2) FUEL TANKS. Two 75-gallon fuel tanks, are located on the outside of the frame rail just below the cab, one on each side of the vehicle. Each tank is held in place by two straps which can be tightened by holding bolts. The vented fuel caps are held to the tank filler tube by a short chain attached to a bar to prevent cap from being lost or misplaced. The amount of fuel in either tank can be determined by turning fuel level switch on instrument panel, and observing fuel level gage reading. Gate valves in suction and return lines are opened to draw fuel from the tank in use. The gate valves to tank not in use must be kept closed.

d. Fuel Filters. As fuel leaves either of the fuel tanks, it passes through two screen-type filters located in the battery compartment. Fuel then passes through the fuel transfer pump mounted on the side



A—NOZZLE CLAMP PLATE
B—OIL LEVEL GAGE ROD
C—FUEL NOZZLE LEAKOFF MANIFOLD
D—NOZZLE AND HOLDER ASSEMBLY
E—CYLINDER LINE
F—OVERFLOW VALVE ASSEMBLY
G—STOP CONTROL SOLENOID
H—FUEL STRAINER ASSEMBLY
J—GOVERNOR ASSEMBLY
K—LUBRICATING OIL PRESSURE REGULATOR
L—OIL FILLER COVER
M—HAND PRIMER ASSEMBLY
N—FUEL TRANSFER PUMP ASSEMBLY
P—FUEL INJECTOR ASSEMBLY
Q—DRIVE COUPLING FLANGE DISK

RA PD 342087

Figure 106—Fuel Injection System

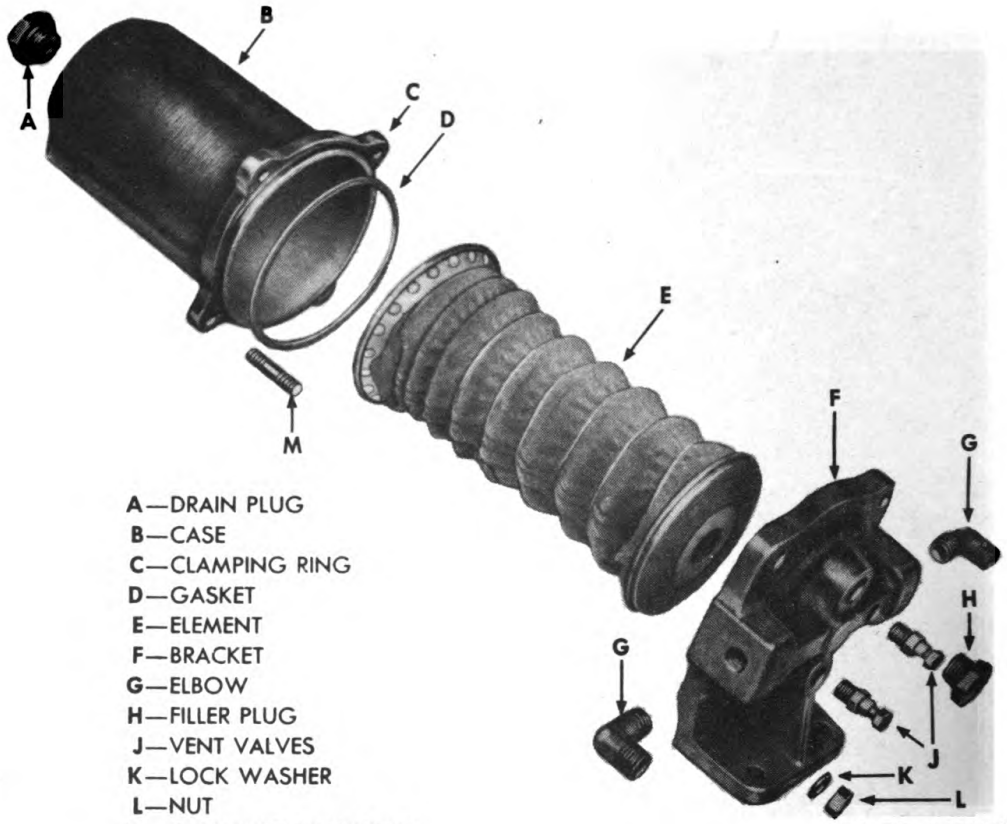
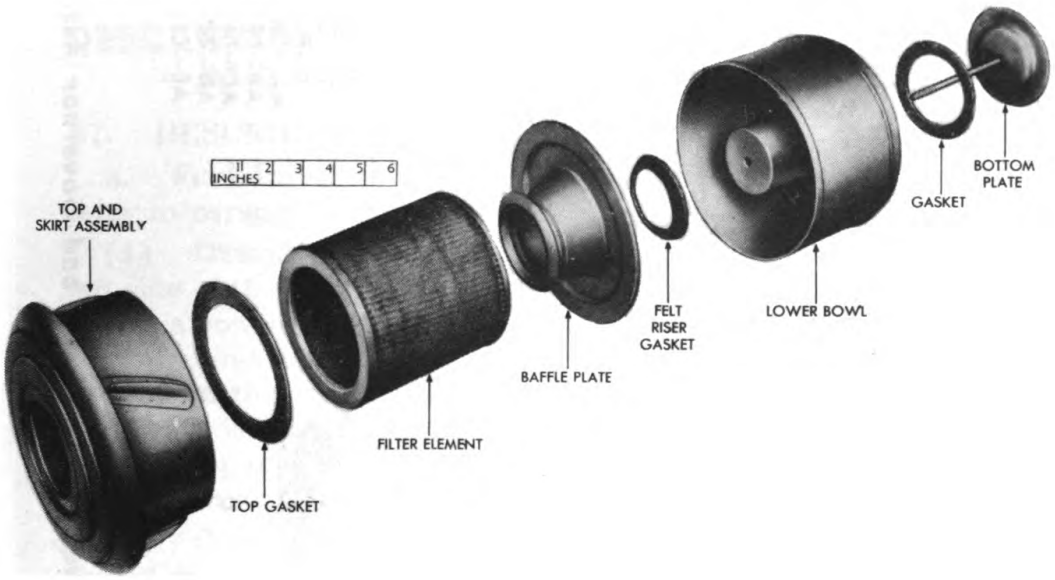


Figure 107—Fuel Strainer, Disassembled

of the fuel injector pump, and then to the fuel strainer (fig. 107). This fuel strainer is mounted on a bracket on the left side of the engine, immediately above and to the rear of the injector pump (fig. 110). This is also a screen type filter. Fuel passes from this strainer to the gallery of fuel injector pump, and is metered to the fuel nozzles which spray it into combustion chambers of engine.

e. Fuel Gage. The fuel gage is an electric, dial-type gage located on instrument panel and registers the amount of fuel in either tank. Just below this gage is a thumb switch which enables the operator to read the amount of fuel in either left or right fuel tank by moving the switch to the left or right. For checking operation and replacing defective parts, refer to TM 9-768.

f. Air Cleaners (fig. 108). Two oil-bath type air cleaners are mounted on the air intake manifold. Instructions are printed on the body of each air cleaner for cleaning, and a bead on the outside of the shell indicates proper oil level for oil sump. Oil capacity of each cleaner is 2 pints.



RA PD 321309

Figure 108—Air Cleaner, Disassembled

g. Starter Burner. The starter burner is mounted on the forward section of the air intake manifold. Its function is to enable the engine to start in low temperatures. The heating element burns fuel oil injected by means of a hand-operated pump on the dash on the left side of the instrument panel. The assembly consists of a spark coil, electrode, ground screw, nozzle, and pressure switch.

h. Stop Control Solenoid. This switch cuts off the fuel supply from injector pump when push button on the dash is depressed. It is connected to the fuel shut-off lever which operates the control rack in fuel injector pump, moving it to the zero or fuel cut-off position. As soon as the plunger of stop control solenoid releases its pull, the fuel shut-off lever is returned to its original position by a spring.

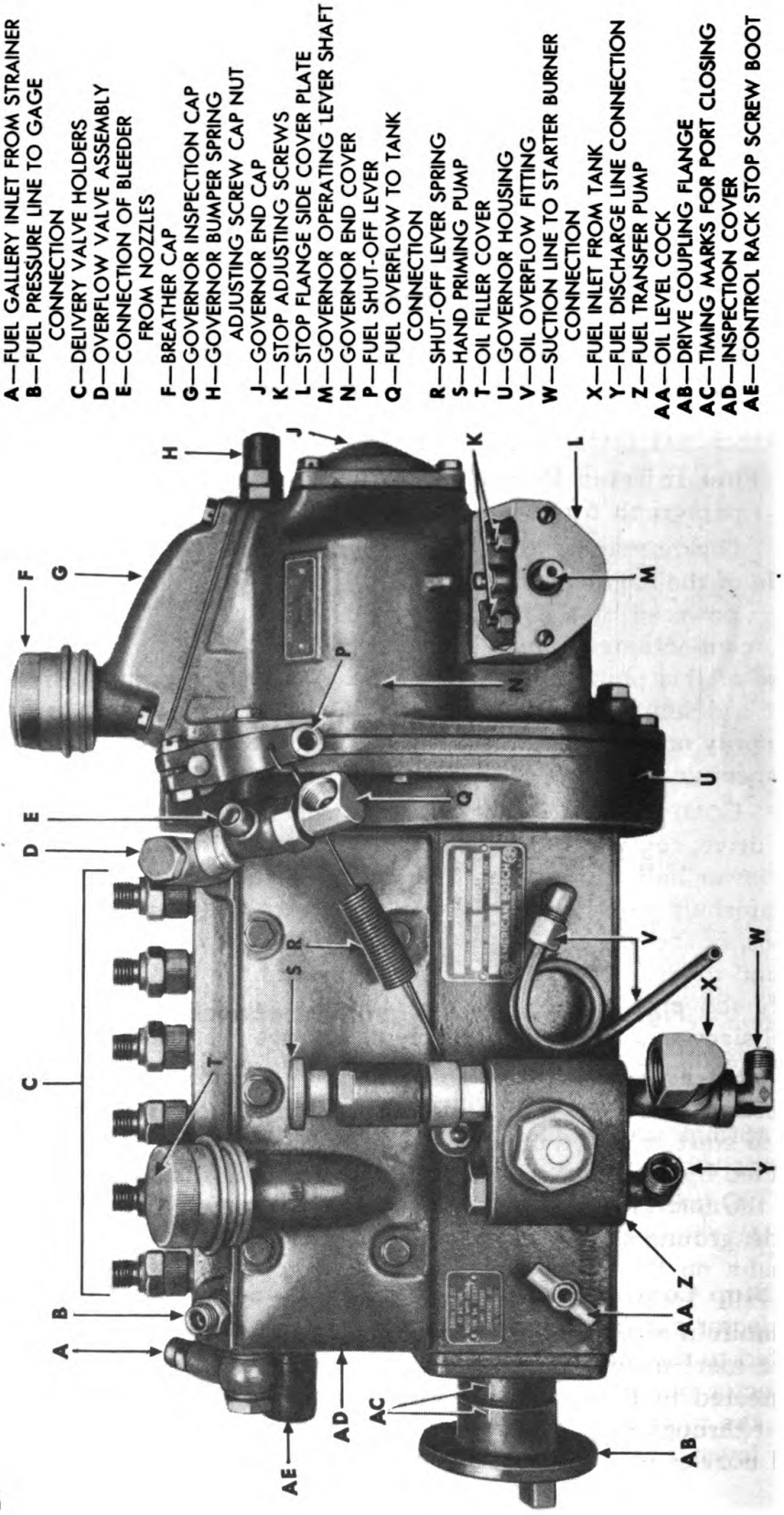


Figure 109—Close-up of Fuel Injector Pump and Governor Assembly

i. Fuel Injection System. Units of the injection system are described in detail as follows:

(1) Fuel injector pump (par. 57 a).
(2) Governor (par. 57 b).
(3) Fuel transfer pump (par. 57 c).
(4) Fuel nozzles (par. 77).

Section II

DESCRIPTION OF FUEL INJECTOR PUMP, GOVERNOR, AND FUEL TRANSFER PUMP ASSEMBLY

57. DESCRIPTION AND OPERATION.

a. Fuel Injector Pump (fig. 110). For differences in models, refer to paragraph 6 a.

(1) DESCRIPTION. The fuel injector pump is mounted on the left side of the engine, and is driven through a positive drive coupling which is powered by a chain from the camshaft. It is of the constant-stroke, cam-actuated, lapped-plunger type, having six outlets. The purpose of this pump is to meter the fuel accurately and deliver the fuel, at a definite moment, during a fixed time, under high pressure, to the spray nozzles which inject the fuel into combustion chambers of the respective cylinders of the engine.

(2) COMPONENTS. This type of injector pump, with self-contained drive, consists chiefly of a housing with camshaft compartment in the lower half and six pump element assemblies in the upper half. The camshaft runs in ball bearings supported by end plates. Felt cushions, in the closing plugs in housing base, facilitate lubrication of cams and roller followers of the tappet assemblies (fig. 122). Located directly above the felt cushions are the plunger and barrel assemblies, control sleeves with toothed segments, plunger return springs, spring seats, and the control rack. The upper part of the housing contains the fuel gallery, delivery valve assemblies with gaskets, delivery valve springs and holders, and nipple nuts for connection of the discharge tubes.

(3) OPERATION. The cams on camshaft operate the six plungers inside their respective barrels by means of tappets, rollers, and springs. The helix on the plunger controls the amount of fuel delivered to the nozzle. Relation of the helix of plunger to the port hole in the fuel manifold of the pump is controlled by a toothed segment on the plunger mechanism working in a toothed control rack which in turn is connected to the governor. The plunger compresses the fuel and forces it through the delivery valve, fuel tubes, and through the spring-loaded nozzles into the combustion chambers of each cylinder of the

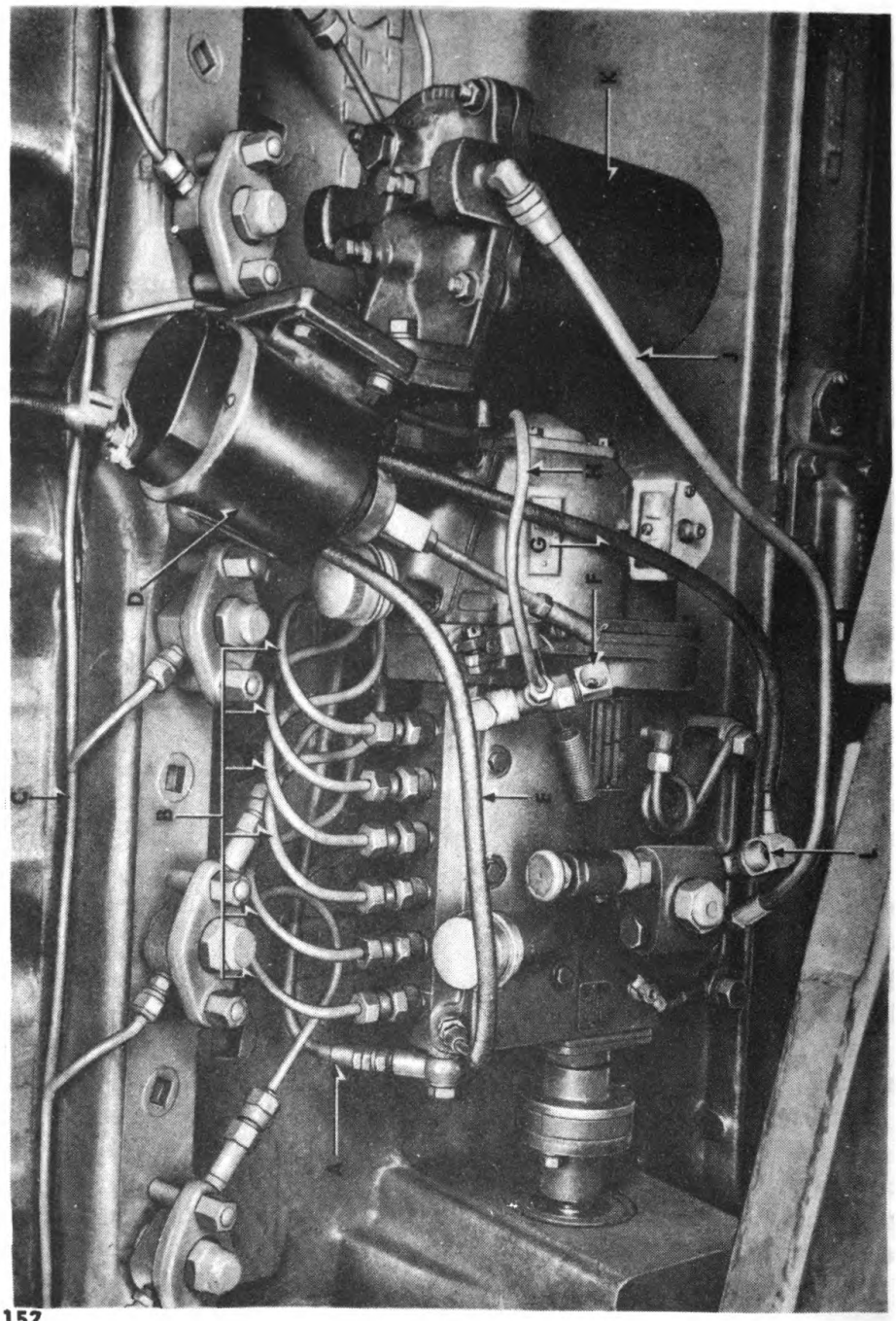


Figure 110—Close-up of Fuel Injector Pump and Governor Assembly, Showing Fuel Line Connections

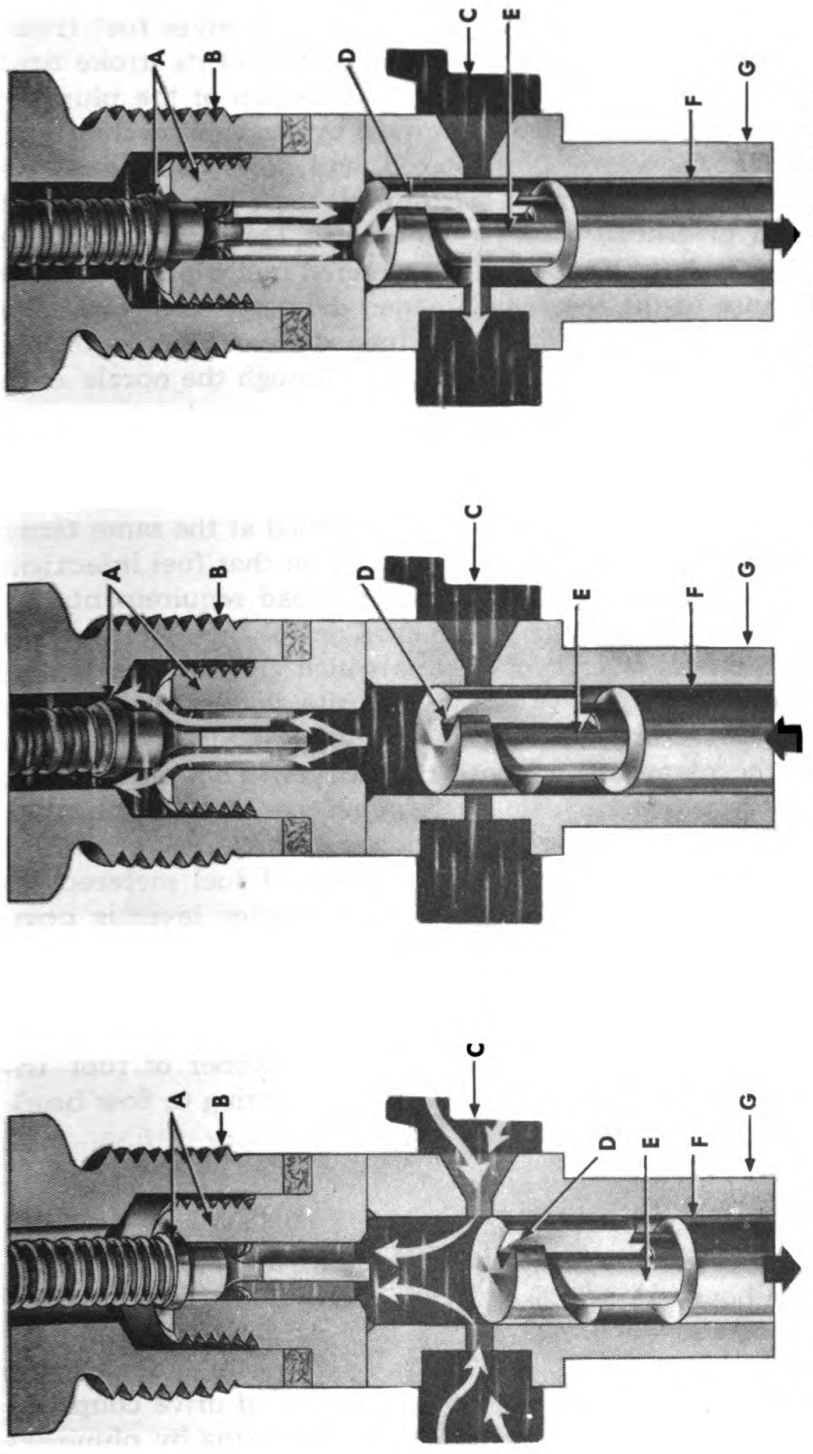


Figure 111—Fuel Injection Cycle

engine in proper time for combustion in firing order of the engine (1-5-3-6-2-4).

(a) Injection Cycle. Each pumping element receives fuel from the supply gallery when the plunger is at the bottom of its stroke and the two ports in the barrel are uncovered by the top of the plunger (F, fig. 111). As the plunger is forced upward by the cam mechanism, some of the fuel in the barrel is displaced, and flows back into the gallery through the two ports in the barrel until these ports are closed by the helix part of plunger passing the ports. This also traps the remaining fuel in the barrel, and it is this metered fuel which is forced under high pressure to lift the spring-loaded delivery valve from its seat (A, fig. 111). This metered fuel is then delivered through the fuel tube to the nozzle, and fuel is discharged through the nozzle into the combustion chamber. Delivery of fuel to delivery valve ceases at the instant the helix on the plunger uncovers the by-pass port in the barrel (G, fig. 111).

(b) Control Rack. The six plungers are turned at the same time by the movement of the control rack (fig. 112), so that fuel injection can be metered according to engine speed and load requirements as the control rack is moved by the governor. Control rack teeth mesh with teeth on segments of control sleeves which turn on the lower ends of pump barrels. The sleeves have opposite slots at their lower ends with which the cross flanges near the lower ends of plungers engage, so that the plungers turn with the sleeves. This means that when the control rack is pushed in by the governor, it turns plunger so as to meter more fuel to nozzles; and when control rack is pulled out, the plungers are turned so that the amount of fuel metered to the nozzles is proportionately reduced. The governor lever is connected by a linkage arm to the end of the control rack.

(c) Overflow Valve (fig. 137). When fuel pressure in the injector pump gallery builds up beyond a certain limit, the spring-loaded overflow valve located at the upper rear corner of fuel injector, opens to allow fuel rejected by the plunger setting to flow back to the tank through overflow line (fig. 110).

(4) DATA.

Make	American Bosch
Type	Lapped plunger, constant-stroke, cam-actuated, 6 outlets
Model (cast iron housing)	APE-6A-90QK-420S-527
Model (aluminum alloy housing)	APE-6A-90P-420-527
Mounting	Base-type
Drive	Gear and drive coupling
Internal timing	Indexed by port closing by plungers
Drive ratio (pump to engine speed)	1:2
Rotation	Counterclockwise, viewed from drive end
Camshaft designed for injection in firing order of engine	1-5-3-6-2-4

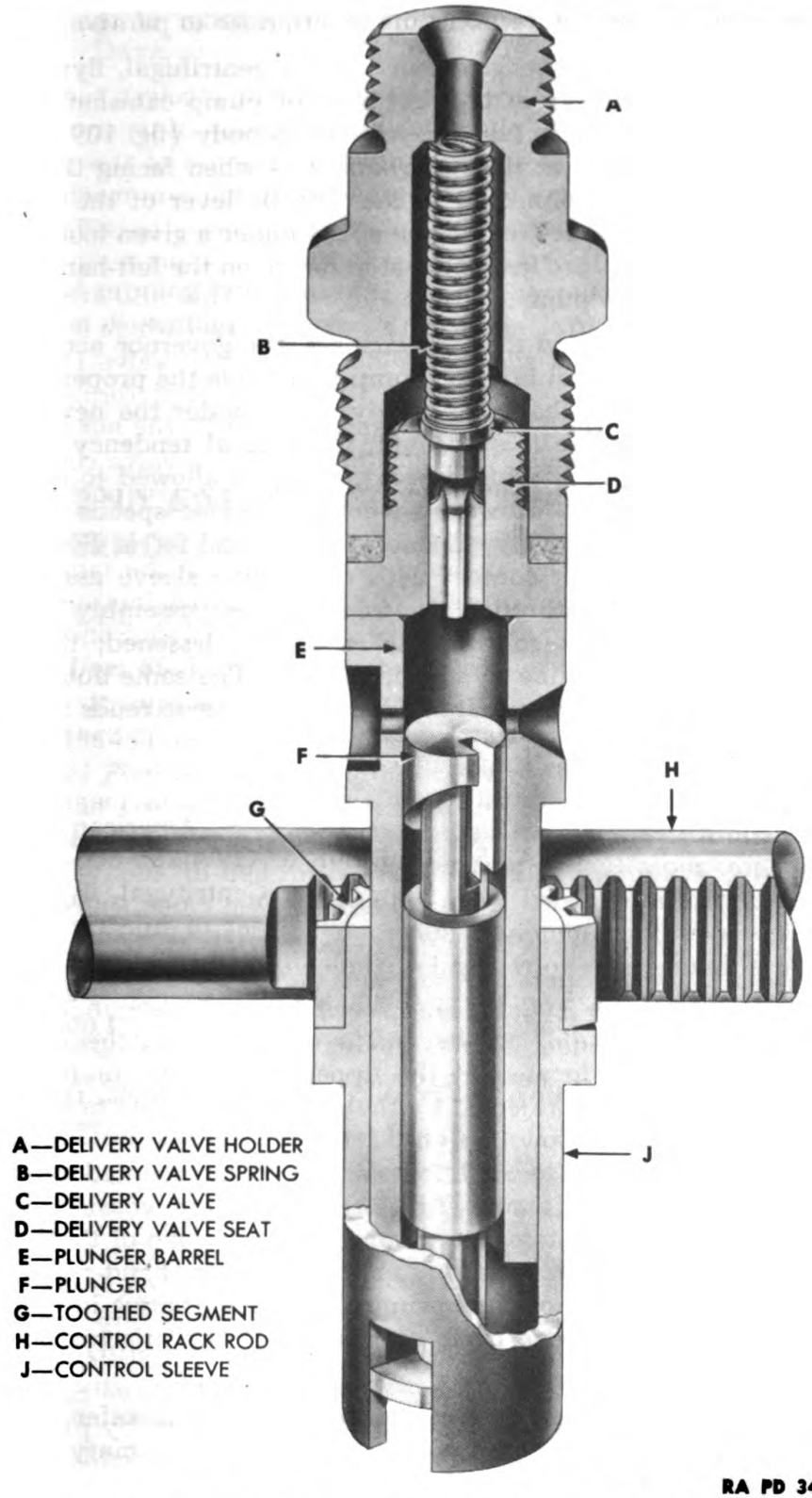


Figure 112—Pump Element and Control Rack

b. Governor. For differences in models, refer to paragraph 6 **b.**

(1) DESCRIPTION. The governor is of a centrifugal, flyweight-type, and is gear-driven from the fuel injector pump camshaft. It is mounted at the back of the fuel injector pump body (fig. 109). The operating lever, which is at the right-hand side when facing the governor end of pump, is connected to the throttle lever of the engine and is set to maintain a desired engine speed under a given load. The stop adjustment screws are inside the stop flange on the left-hand side, facing governor end of pump.

(2) OPERATION. When the load changes, the governor acts upon the control rack of the fuel injector pump to provide the proper quantity of fuel to maintain the same steady speed under the new load. If the load on the engine is decreased, the natural tendency of the engine is to speed up if the fuel injector pump is allowed to deliver the same amount of fuel. However, when the engine speeds up the governor flyweights move outward due to centrifugal force. Since the flyweights are in constant contact with the sliding sleeve assembly, this outward movement through the fulcrum yoke assembly moves the injector control rack so that fuel supply is lessened; thereby automatically holding engine to a steady speed. The same automatic action takes place to increase fuel injection when engine tends to slow down under increased load.

(3) DATA.

Make	American Bosch
Model	GVA-250-800-B-29S or GVA-250-800-BK-29
Type	Centrifugal, flyweight
Location	Rear of injector pump
Drive	Injector pump gear
Idle speed	500 rpm
Maximum speed under load	1,600 rpm

c. Fuel Transfer Pump. For differences in models, refer to paragraph 6 **a** (3).

(1) DESCRIPTION. The fuel transfer pump is mounted on the side of the fuel injector pump (fig. 109). This unit consists of a mechanically operated piston-type pump (driven by one of the lobes on the injector pump camshaft), and a separate hand-operated plunger-type priming pump. This priming pump is positive in operation regardless of the engine cycle or position of the injector pump camshaft.

(2) PURPOSE. The mechanically operated fuel transfer pump serves to draw fuel from the main supply tank, through primary filters, and to deliver this fuel through the fuel strainer located to the rear of pump assembly to the fuel injector pump.

(3) DATA.

Make	American Bosch
Type	AFP/K plunger, compensating variable stroke
Size	Large
Location	Side of injector pump
Mounting	Flange, stud-fastened
Drive	Injector pump camshaft
Type of priming pump	Hand, plunger, vertical
Location of priming pump	Over inlet valve

Section III

TEST AND ADJUSTMENTS OF FUEL INJECTOR PUMP, GOVERNOR, AND FUEL TRANSFER PUMP ASSEMBLY

58. FUEL INJECTOR PUMP.

a. Use of Test Stand.

(1) EQUIPMENT (fig. 113). The motor-driven test stand (17-S-15545) duplicates actual operating conditions as closely as possible. Fuel used in testing must always be clean, and of the same grade and viscosity as the fuel used in operation of vehicle. If pump can be operated, test it before disassembly, as described in succeeding subparagraphs, to determine which parts of pump are defective and what adjustments are necessary.

(2) INSTALL INJECTOR PUMP ON TEST STAND. With governor end cover removed, secure pump on test stand properly lined up with test stand drive. Leave the overflow valve in place. Connect fuel line for gravity feed into fuel gallery inlet of pump (fig. 114). Set idler pulley device for counterclockwise rotation.

b. Timing Fuel Injector Pump on Test Stand.

(1) CHECK NO. 1 ELEMENT PLUNGER CLEARANCE.

(a) Unscrew delivery valve holder from No. 1 element and remove delivery valve spring and valve (par. 62 o), but do not remove valve seat, plunger, or plunger barrel. Put back delivery valve holder without installing spring or valve, and tighten the holder firmly.

(b) Using a depth gage inserted down through the delivery valve holder, with its end kept in contact with the top of the plunger, observe movement of measuring rod through its cross bar as camshaft is turned.

(c) Measure and record the distance from top of the delivery valve holder to top of the plunger, where the plunger has been brought to its topmost position.

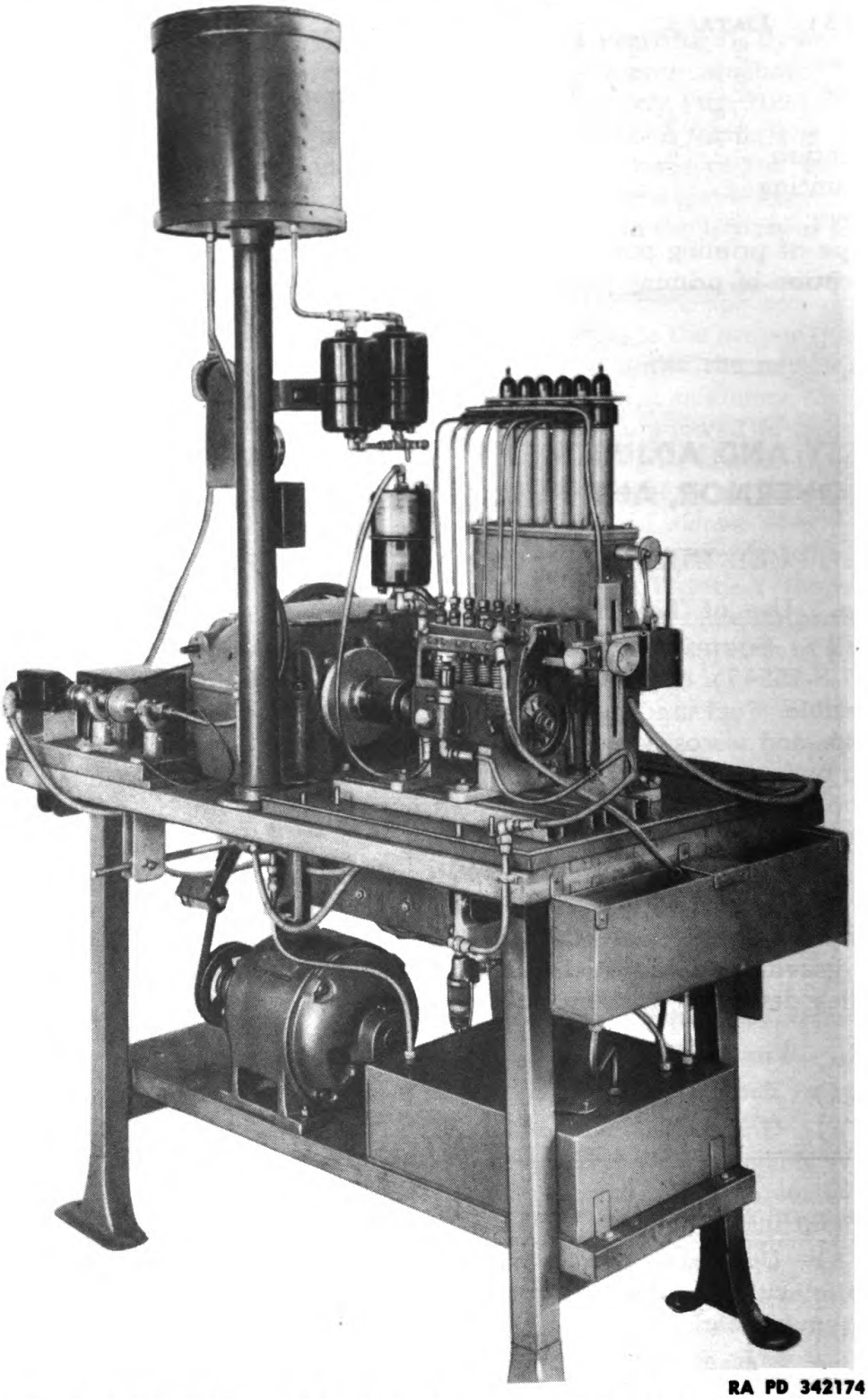


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Figure 113—View of Fuel Injector Pump Mounted on Test Stand

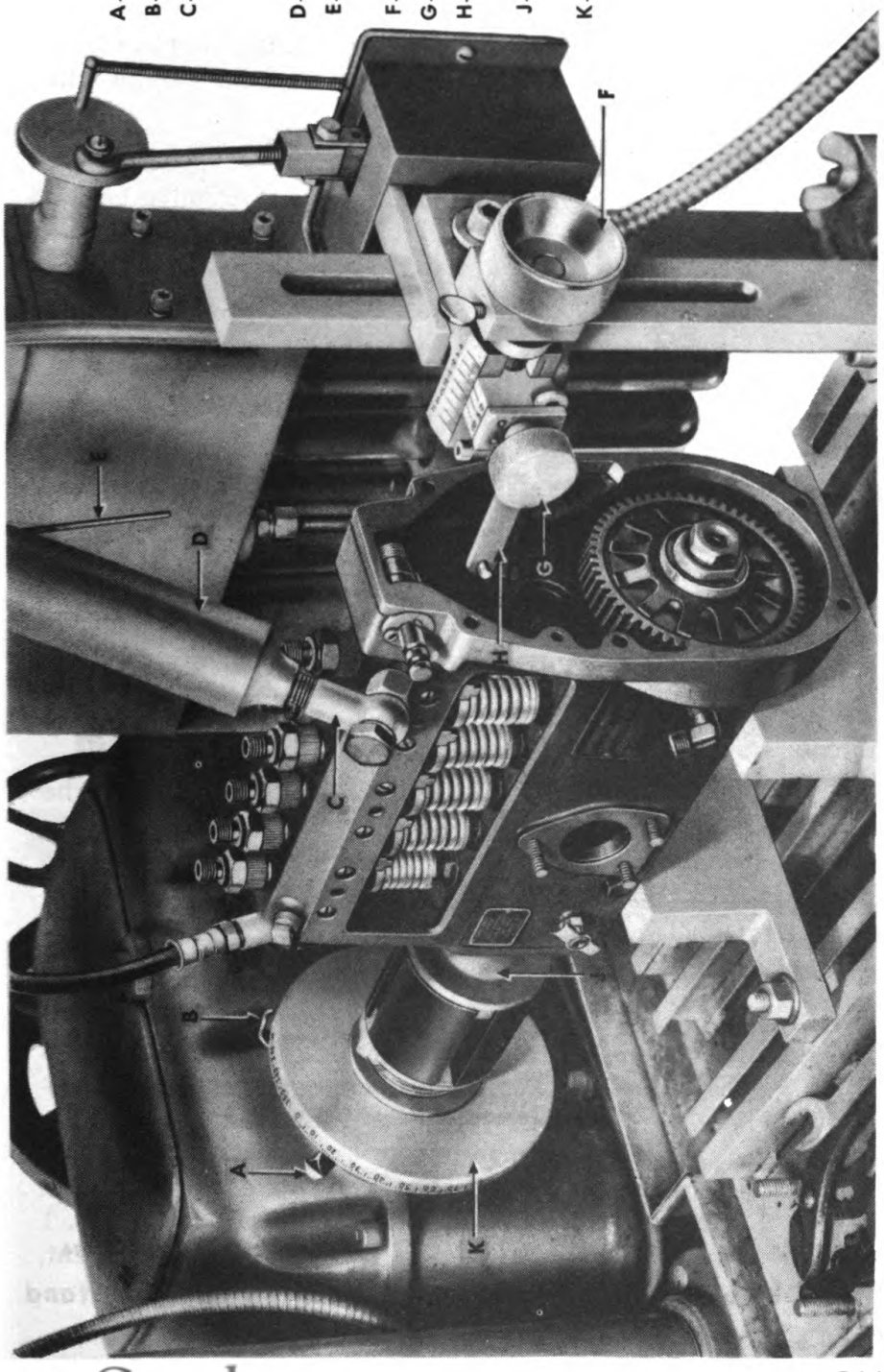

Figure 114—Set-up for Timing Fuel Injector Pump

(d) With the plunger at topmost position engage a screwdriver between the head of tappet adjusting screw and the lock nut, and lift the tappet assembly as far as it will go. Measure and record the distance from top of the delivery valve holder to top of the plunger.

(e) The difference between the measurement made in step *(c)* and that made in step *(d)* is the clearance between the bottom of the delivery valve seat and the top of the plunger when at its topmost position. This clearance must be 0.020 inch.

(f) Adjust tappet screw to obtain exactly 0.020-inch clearance, and after tightening lock nut, check to make sure that locking the screw has not affected the clearance setting.

(2) TIMING FUEL INJECTOR PUMP.

(a) Leave the delivery valve spring and valve out of valve holder of No. 1 element. Rotate pulley on variable speed drive, and turn camshaft until the No. 1 plunger is in its lowest position.

(b) Turn on fuel at filter, and bleed all air by means of valve on surge tank (fig. 114). Fuel will now flow up through the delivery valve holder of No. 1 element.

(c) Turn the camshaft counterclockwise, and as the flow diminishes, wipe or blow away fuel to determine the exact point at which fuel ceases. At this point, the port closing timing marks on coupling hubs (fig. 152) should be lined up. This establishes the port closing point on which the timing of fuel injection is based.

(d) Without turning camshaft, set the graduated disk (K, fig. 114) at zero by turning the wheel and slipping the clutch until pointer and zero mark coincide. NOTE: *There are two pointers for observation from either side. Use the most convenient pointer (A and B, fig. 114).*

(e) Recheck above setting before adjusting other elements.

(f) Check the port opening point of No. 1 element by turning the camshaft gradually in a counterclockwise direction. Check this port opening point and make a record of the number of degrees, as shown by the disk, from port closing to port opening.

(g) Remove delivery valve holder, and install delivery valve and spring which were removed in step (1) *(a)* above. Then put delivery valve holder back in place, tightening it firmly.

(h) Further rotation of camshaft will actuate the tappet of element for No. 5 cylinder of the engine, as the pump camshaft is designed for 1-5-3-6-2-4 firing order of the engine. Remove delivery valve and spring from No. 5 element; install delivery valve holder without the spring, as in step (1) *(a)* above, and determine the port closing for No. 5 element by the same procedure described for No. 1 element. This will be 60 degrees after port closing of No. 1 element, if properly timed.

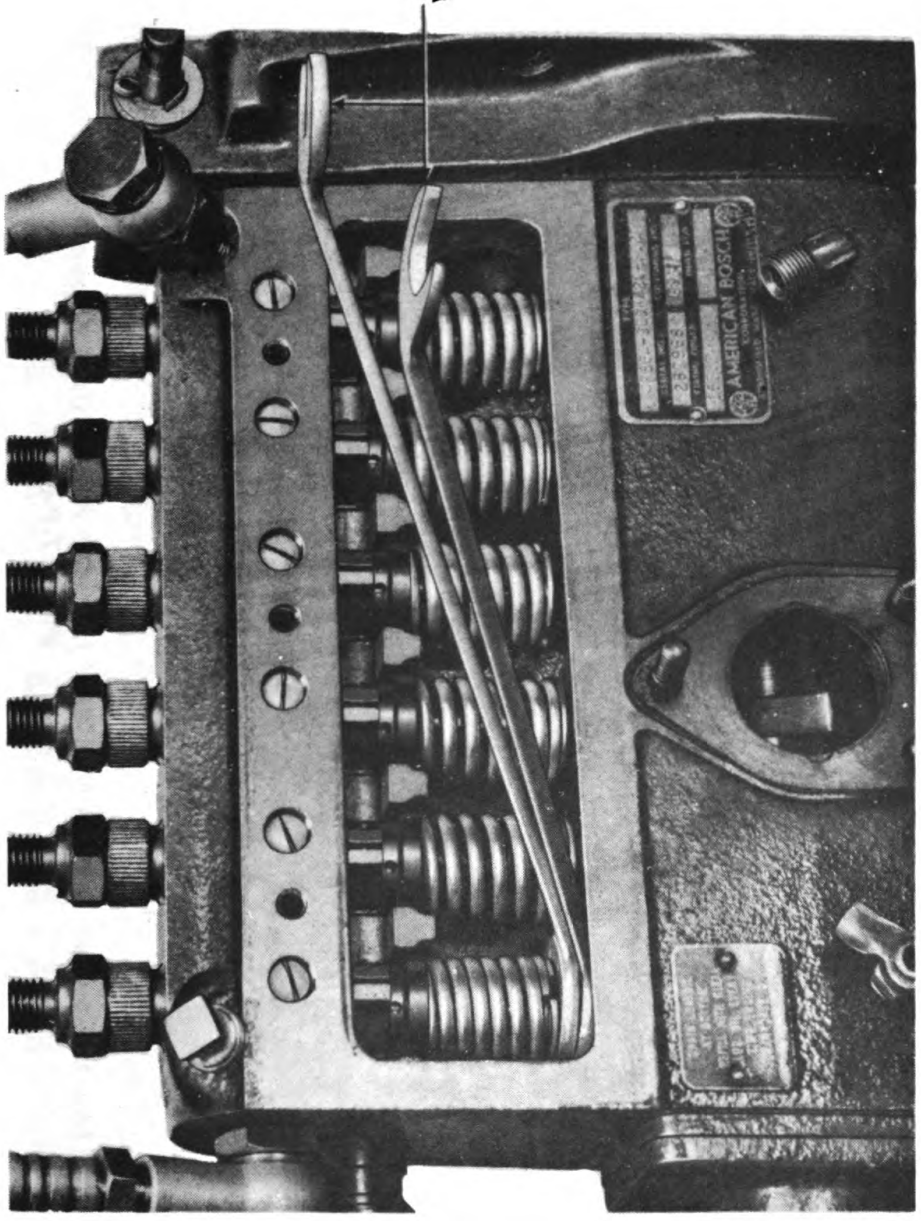

Figure 115—Adjusting Tappet for Proper Port Closing, Using Special Tappet Wrenches (41-W-3571)

A—SPECIAL CONTROL SLEEVE ADJUSTING PIN
B—CONTROL GEAR SEGMENT
C—CONTROL SLEEVE
D—PLUNGER BARREL

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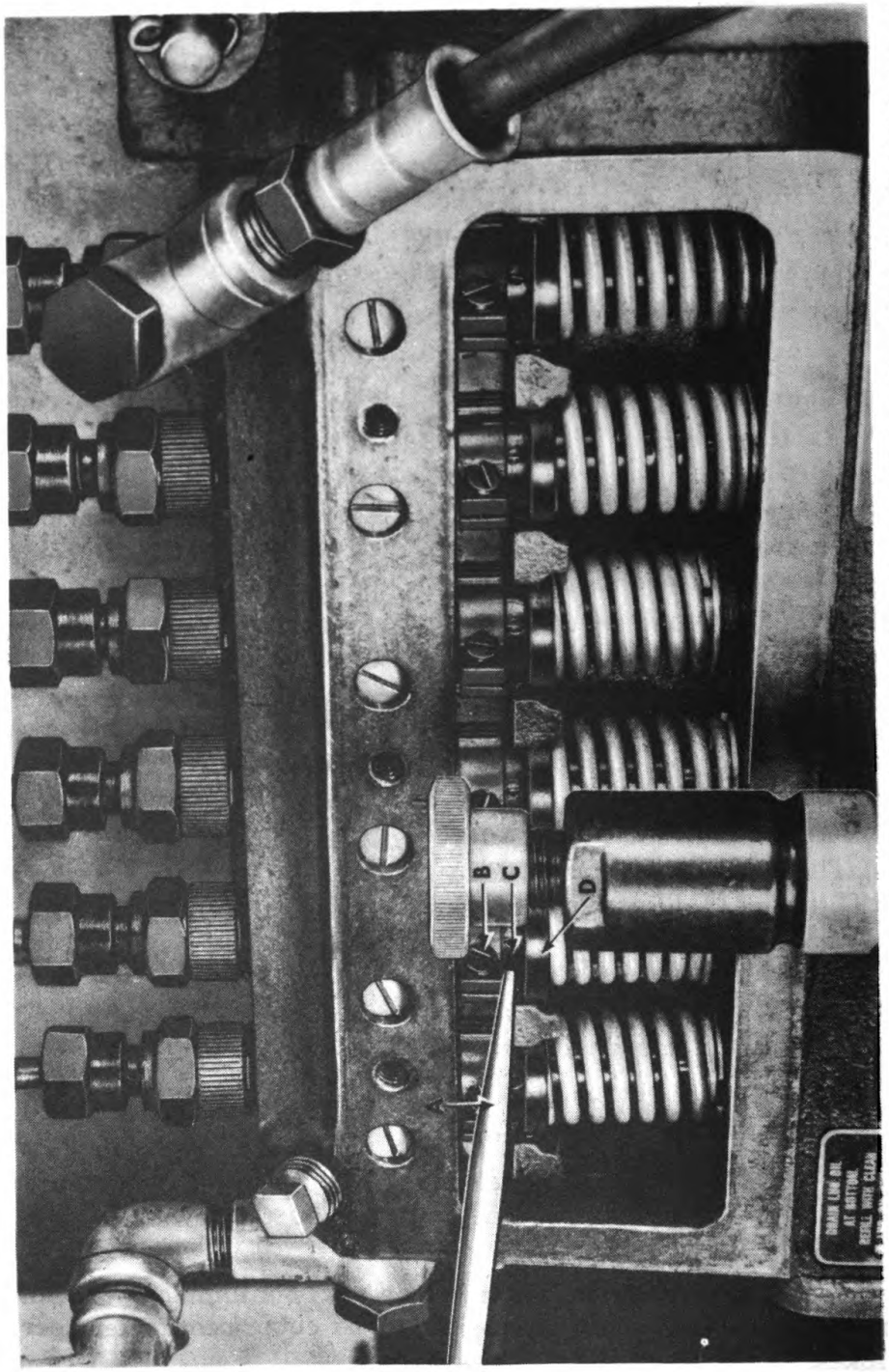


Figure 116—Set-up for Calibrating Fuel Injector Pump, Using Special Control Sleeve Adjusting Pin (17-P-853)

(i) If graduated disk deviates more than ½ degree from 60 degrees, correct by adjusting the tappet screw (fig. 115) and check after lock nut has been tightened. Angular travel from port closing to port opening for this element must not vary from that of No. 1 element by more than ½ degree. If it does, loosen clamp screw on the toothed segment, and using pin (17-P-853) (fig. 116), turn control sleeve slightly toward the right to shorten the period, or to the left to lengthen the period between port opening and port closing.

(j) After putting back delivery valve and spring in element for No. 5 cylinder, proceed to time the other four telements in the following order: Nos. 3, 6, 2, and 4. NOTE: *Port closings of elements in firing order are exactly 60 degrees apart, and the angular intervals between port closings and port openings must be the same for all six elements.*

c. Calibrating Fuel Injector Pump (figs. 117 and 118).

(1) Connect pump elements to fuel delivery tubes, using special wrench (41-W-1494-850) to tighten delivery tube nuts (fig. 119).

(2) Blow out all lines with compressed air before installing.

(3) Connect fuel transfer pump into supply line from tank, and connect line from transfer pump to filter at fuel gallery inlet (fig. 113).

(4) Connect control rack to the positioning device (H, fig. 114) with the rack at stop position (pulled all the way out), and the knurled wheel on positioning device adjusted at zero (G, fig. 114).

(5) Run pump for a short period before stand is operated for the purpose of taking readings. This is done by having control rack in stop position, which reduces load on test equipment. NOTE: *Control rack is in stop position when pulled all the way out or moved to the limit of its travel away from drive end of injector pump.*

(6) The counter is engaged by pushing the button marked "START" (fig. 117). Pushing this button engages both the counter and spray dispenser. The counter is so designed that it can be set for a predetermined number of revolutions; when this number of revolutions is reached it will kick out, stopping the spray at that point.

(7) Run pump enough to bring fuel well up in the calibration tubes (fig. 117).

d. Fuel Delivery Specifications.

(1) Set at 700 revolutions per minute and at 16.5 millimeters control rack position. Fuel volume must be 60 to 62 cubic centimeters per 400 strokes.

(2) Set at 250 revolutions per minute and at 8 millimeters control rack position. Fuel volume must be 12 to 16 cubic centimeters per 400 strokes.

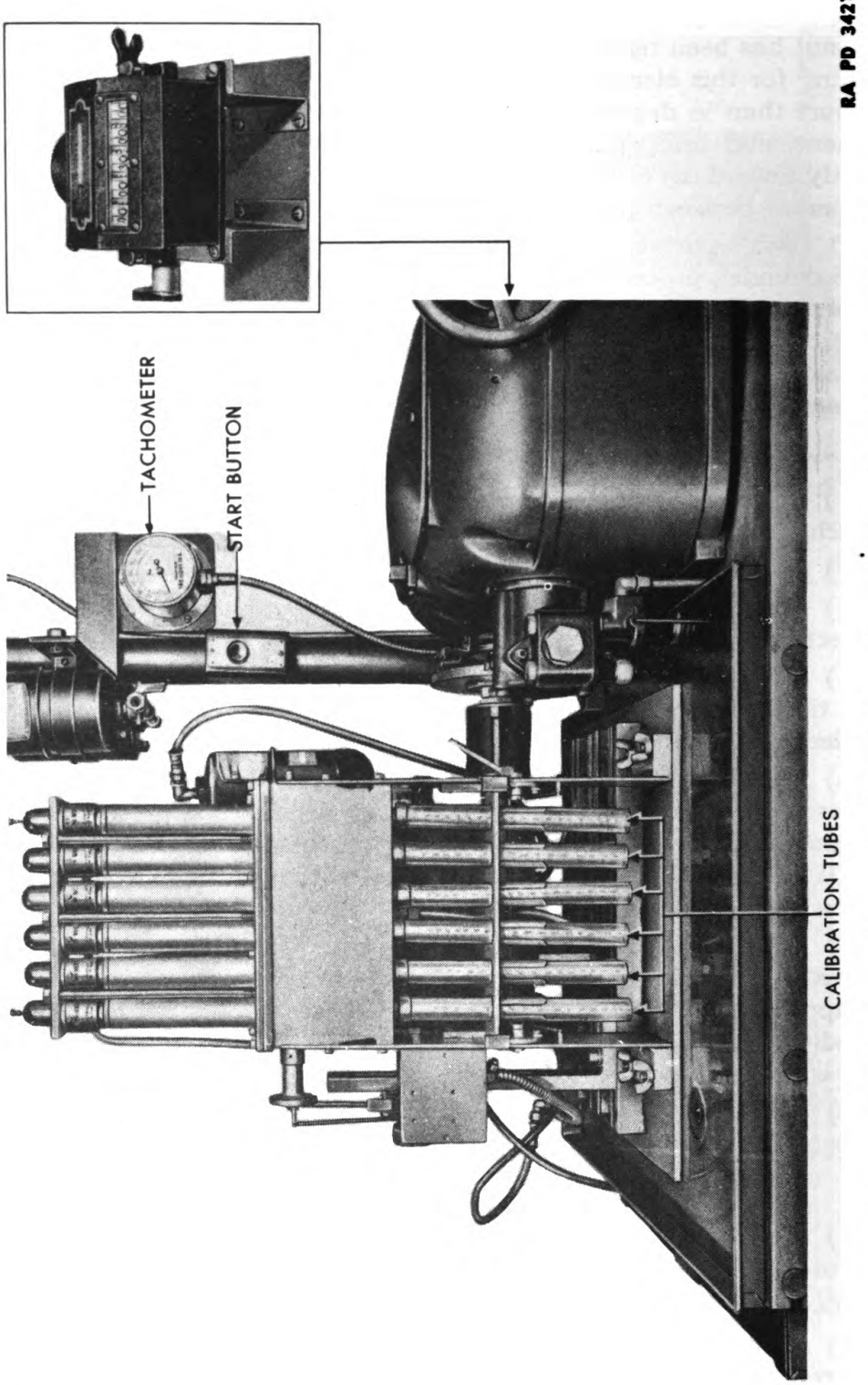
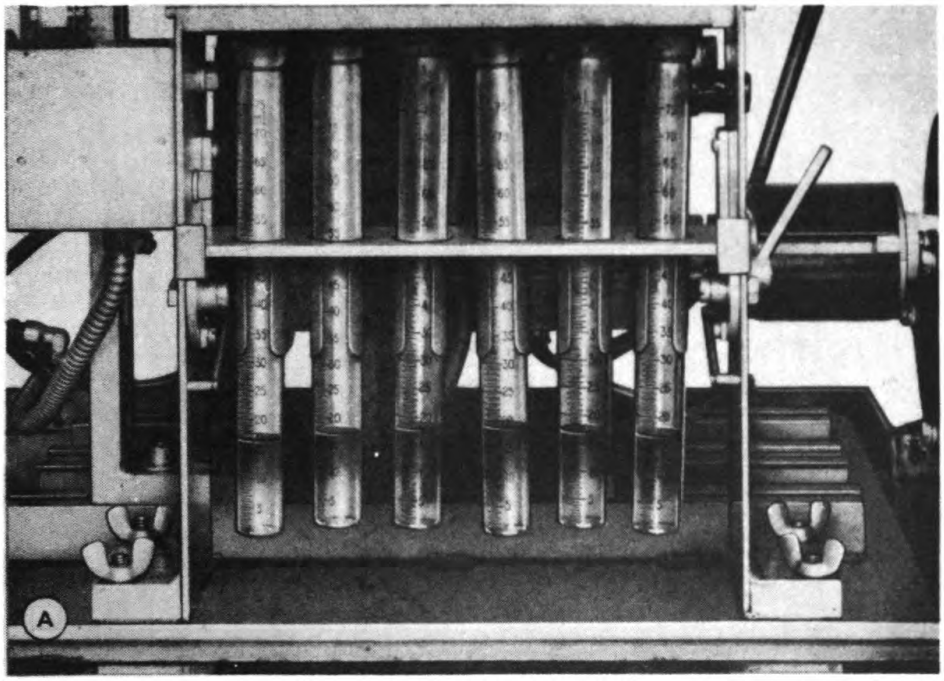
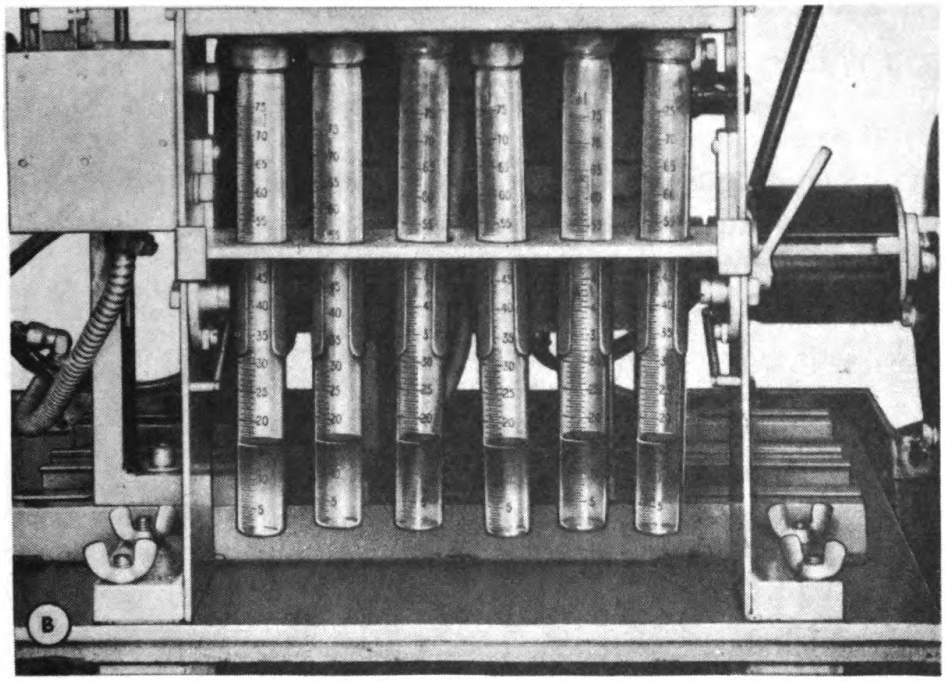


Figure 117—Rear View, Showing Set-up for Calibrating Fuel Injector Pump

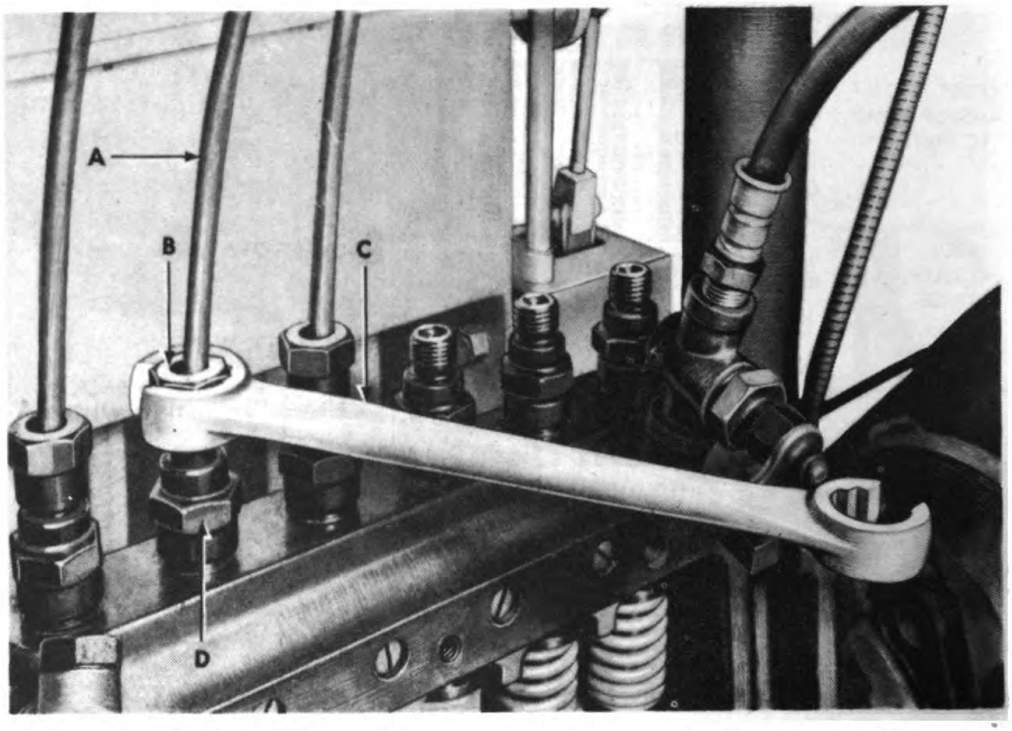


CALIBRATION TUBES—FIRST RUN



CALIBRATION TUBES—FINAL RUN RA PD 342218

Figure 118—Set-up Showing Steps in Calibration of Fuel Injector Pump



A—DELIVERY TUBE
B—DELIVERY TUBE NUT
C—SPECIAL WRENCH
D—VALVE HOLDER

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Figure 119—Set-up for Tightening Fuel Pump Delivery Tube Nut, Using Special Wrench (41-W-1494-850)

(3) Set at 250 revolutions per minute and at 17 millimeters control rack position; variation in any of the graduating tubes must not exceed 1.5 cubic centimeters.

(4) Check for no fuel delivery at 250 and 900 revolutions per minute, with governor operating lever at full stop position.

e. Corrections.

(1) When actual pump deliveries, measured during calibration test, show that one or more elements vary appreciably and cannot be adjusted to within the limits given in subparagraph **d** above, replace plungers and barrels in the defective elements (fig. 125).

(2) If variations of volume of fuel pumped by elements do not exceed the specifications (subpar. **d** above), but the over-all average differs appreciably at different rack settings, it indicates a defective condition within the pump that will require overhaul.

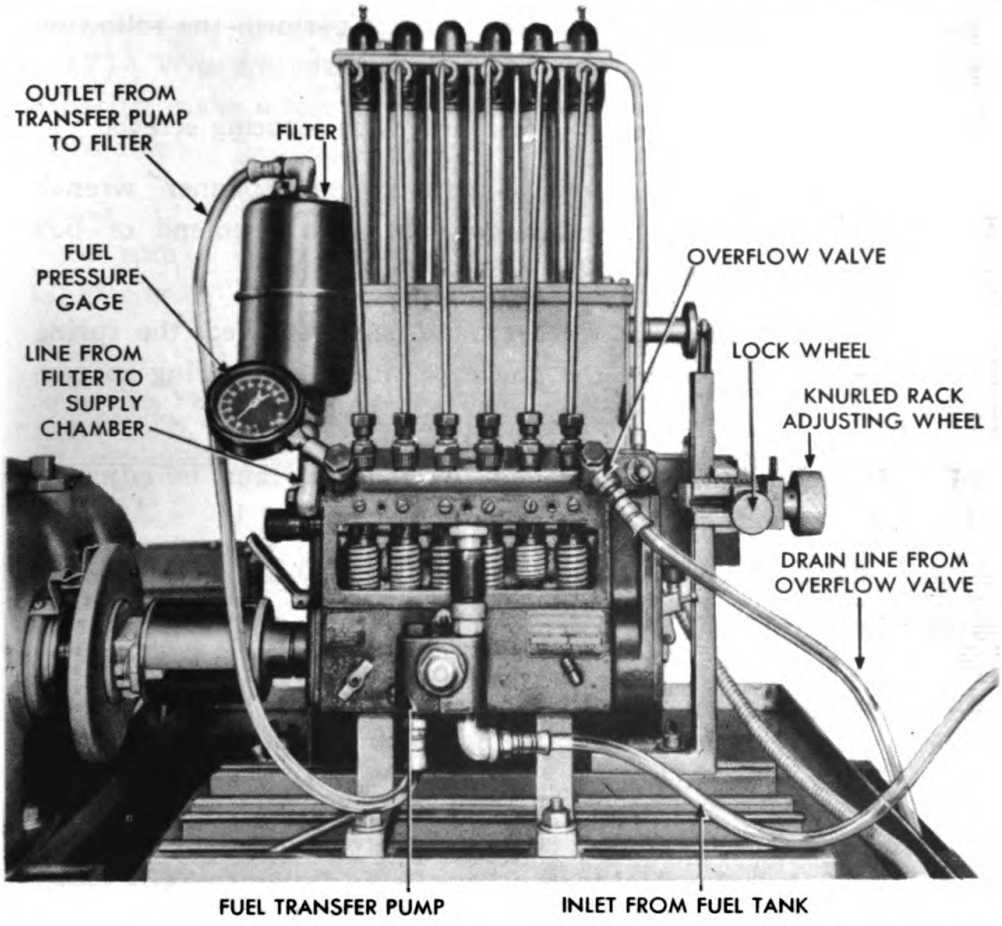


Figure 120—Set-up for Checking Overflow Valve

f. Testing Overflow Valve (fig. 120). While running calibration test, note the pressure reading on the gage mounted at end of fuel pump gallery. The correct pressure is 13 to 15 pounds. If overflow valve does not hold 13 pounds, disassemble and inspect it (par. 63 b (13)).

59. GOVERNOR.

a. Adjustments. There is no test that can be made of governor on test stand. Adjustment to required speed is made while engine is mounted on dynamometer stand or in the vehicle. For detailed procedure for adjusting governor, refer to paragraph 73 b.

b. Changing Governor Spring Without Removing Governor. If it becomes necessary to replace the governor spring, it will not be

necessary to disassemble the complete governor or remove the unit from the engine. To replace governor spring, perform the following steps:

(1) Remove end plate by unfastening four securing screws.

(2) Hold spring seat firmly with special spanner wrench (41-W-3247-75) and remove hexagon nut with open-end or box wrench, as shown in figure 140.

(3) After nut and lock washer have been removed, the spring seat can be withdrawn and the governor spring and spring spacers can be removed or replaced.

(4) After new spring is installed, the governor must be adjusted and tested according to instructions in paragraph 73 **b.**

60. FUEL TRANSFER PUMP.

a. Set-up for Test. Refer to figure 120, and observe the following steps to test the fuel transfer pump on the test stand:

(1) Disconnect discharge line from filter and run pump at 600 revolutions per minute to see that pump delivers oil; then stop.

(2) Disconnect suction line from fuel transfer pump and run long enough to expel oil from pump; then stop and connect the suction line only.

(3) Run pump at 60 revolutions per minute; pump should draw oil within 1 minute.

(4) Run again at 200 revolutions per minute; pump should draw oil within 45 seconds.

(5) Connect discharge line to filter. Connect line from filter to gage, disconnect gage from fuel injector pump, and use a short discharge line on which there is a valve, and which will drain into a measuring tube.

(6) Run pump at 600 revolutions per minute until there is a constant flow of oil entirely free of air, and bleed air from filter. With valve closed, pump should develop a pressure of 20 to 25 pounds per square inch. Pressure should drop very slowly when pump is stopped.

(7) With a graduated glass tube of about 1,000 cubic centimeters capacity, make a test for amount of oil delivered. Pump should test as follows:

Speed	Time	Pressure	Delivery
60 rpm	15 seconds	7.0 lb	42 cu cm
1,000 rpm	15 seconds	11.5 lb	250 cu cm

Section IV

DISASSEMBLY OF FUEL INJECTOR PUMP, GOVERNOR, AND FUEL TRANSFER PUMP ASSEMBLY INTO SUBASSEMBLIES

61. DISASSEMBLY INTO SUBASSEMBLIES.

a. Disconnect Governor End Cover (fig. 121).

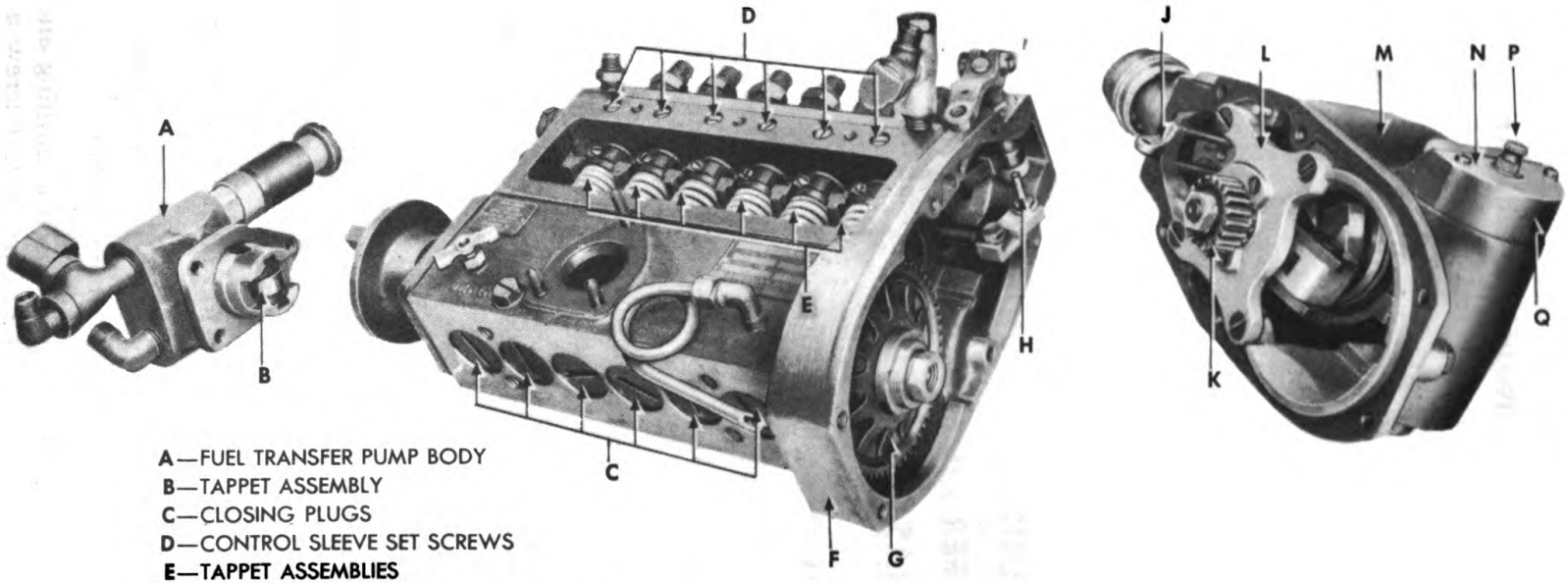
(1) Remove oil drain plug and drain all lubricating oil from governor. As there is an opening connection between fuel injector pump camshaft compartment and the governor, the governor end should be tilted downward so that all oil will be drained.

(2) Remove six fastening screws which hold governor end cover to housing. Four screws are located on the front side and two on the rear of the governor end cover.

(3) Carefully withdraw governor end cover 1 inch away from the housing and then slightly shift the governor assembly in a sideways movement toward the inspection cover side of injector pump, in order to disengage the control rod linkage pin from the extension arm of the fulcrum yoke assembly. The governor end cover is now free (fig. 121).

(4) Remove governor end cover gasket.

b. Remove Fuel Transfer Pump. Remove the three stud nuts and lock washers from flange of fuel transfer pump, and withdraw the unit from fuel injector pump housing. Remove the gasket.



A—FUEL TRANSFER PUMP BODY
B—TAPPET ASSEMBLY
C—CLOSING PLUGS
D—CONTROL SLEEVE SET SCREWS
E—TAPPET ASSEMBLIES
F—GOVERNOR HOUSING
G—GOVERNOR DRIVE GEAR AND SPRING DISK
H—CONTROL RACK (CONNECTING END)
J—EXTENSION ARM
K—GOVERNOR DRIVEN GEAR
L—BEARING BRIDGE
M—GOVERNOR END COVER
N—STOP FLANGE COVER PLATE
P—OPERATING LEVER SHAFT
Q—STOP FLANGE

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Figure 121—Fuel Injector Pump, With Governor End Cover and Fuel Transfer Pump Removed

Section V

OVERHAUL OF FUEL INJECTOR PUMP

62. TEST AND DISASSEMBLY.

a. Test. Refer to paragraph 58 and make tests to determine the extent of disassembly necessary to correct the deficiencies in the fuel injector pump.

b. General Precautions.

(1) Before starting to disassemble the fuel injector pump, wash exterior with dry-cleaning solvent, and dry with a clean, lint-free cloth.

(2) Do not disassemble in a dusty place or on a soiled bench.

(3) Clean bench and vise thoroughly and cover all working surfaces with clean, tough paper to protect internal parts from any contact with dust, dirt, or grease.

(4) Bear in mind that surface abrasions and blemishes can damage parts so they will not be fit for use.

(5) See that protection caps are installed, and that they remain on the pump when lines are disconnected.

c. Drain Sump and Remove Fittings (fig. 109).

(1) Remove drain plug at lower left-hand corner, and allow oil to drain from sump.

(2) Unscrew and remove overflow valve, flexible line and fittings, and emergency shut-off valve with elbow.

(3) Unscrew and remove overflow cock and pipe plug.

(4) Unscrew and remove flexible suction line from fuel transfer pump elbow.

(5) Take out two cap screws and lock washers, and remove pump support.

d. Remove Fuel Transfer Pump. Unscrew and remove three nuts and lock washers. Withdraw transfer pump from studs, and remove gasket. For disassembly of fuel transfer pump, refer to paragraph 69.

e. Remove Inspection Cover.

(1) Unscrew three short cap screws at top edge of cover, and remove lock washers.

(2) Unscrew and remove three long cap screws and lock washers.

(3) Pry cover loose and remove it, and remove gasket.

f. Remove Control Rack Stop Bushing. Unscrew bushing and remove it without disturbing seal disk, cotter pin, or slotted screw at

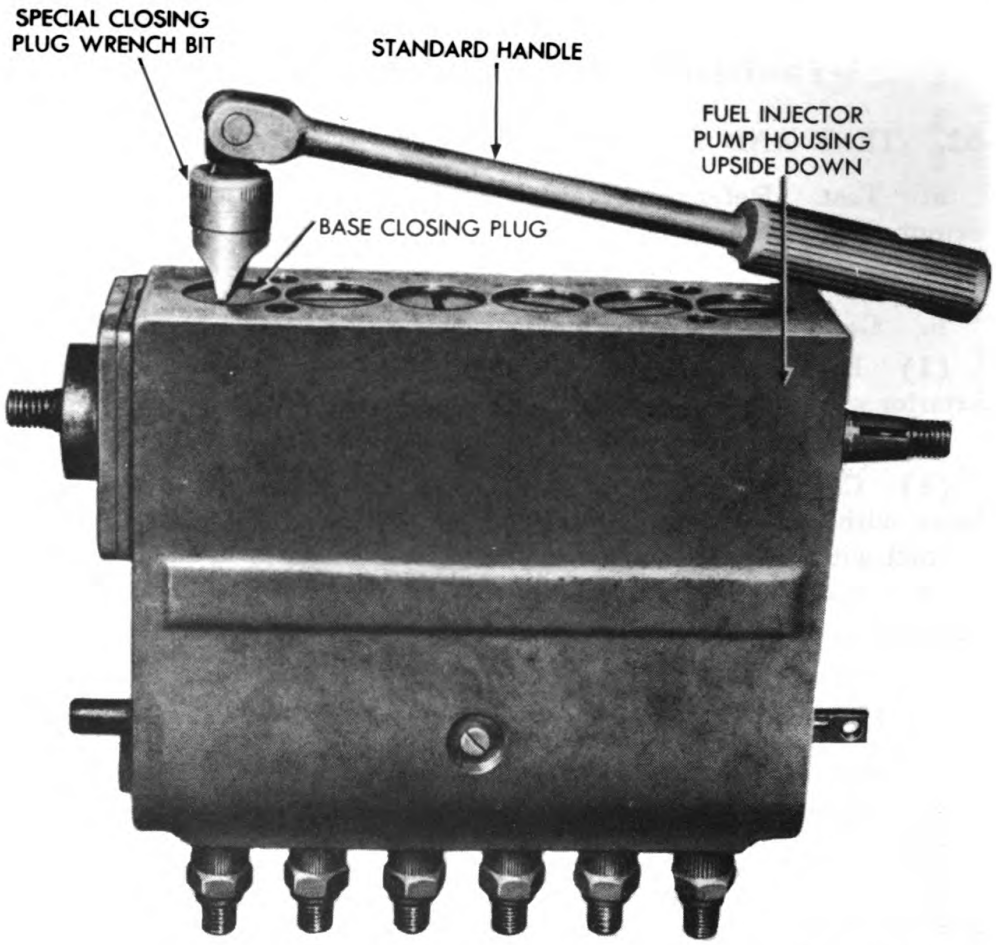

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Figure 122—Set-up for Removing Base Closing Plugs, Using Special Bit (41-B-647-50) and Handle

outer end of bushing. NOTE: *This assembly is a factory-adjusted stop for the control rack; if slotted screw is moved too far, it will prevent complete fuel shut-off.*

g. Insert Tappet Holders (fig. 127). Mount pump in vise equipped with soft metal jaw liners. While turning driven member by hand to rotate camshaft, insert a tappet holder (41-H-2374) between each tappet screwhead and lock nut as each tappet is raised.

h. Remove Base-closing Plugs. Turn pump upside down and clamp delivery valve holders in jaws of vise. Unscrew and remove six plugs and gaskets, using closing plug screwdriver bit (41-B-647-50) and socket handle as shown in figure 122.

i. Remove Drive Coupling Flange. Remove nut from end of camshaft and pull off drive coupling flange and key.

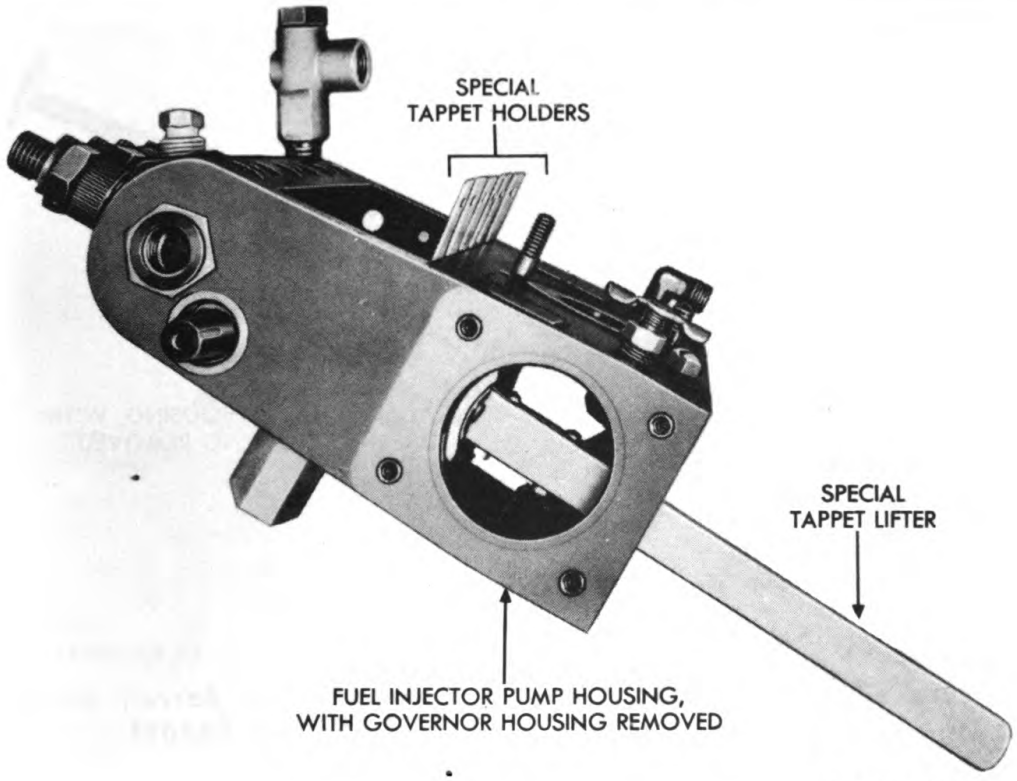


Figure 123—Set-up for Removing Tappet Holders (41-H-2374) Using Special Tappet Lifter (41-6-1396)

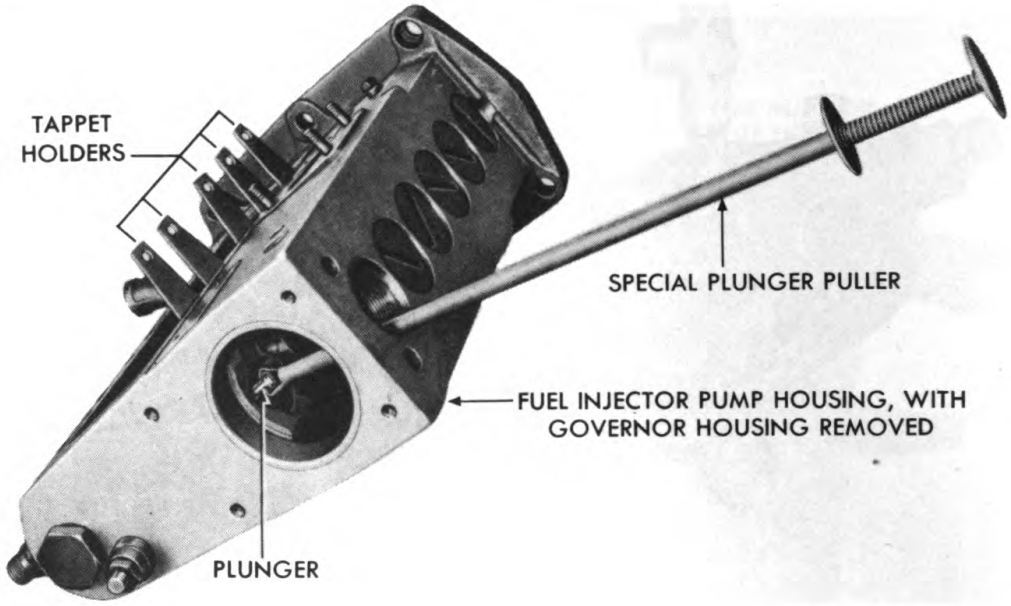
j. Remove End Cover and End Plate (fig. 122). Remove four screws. Pry end cover loose by inserting screwdrivers in cover notches. Remove end plate and gasket.

k. Remove Camshaft. Remove camshaft from gear end, including the ball bearings. Be careful not to strike shaft or bearings while withdrawing it from body.

l. Remove Tappets (fig. 123). With tappet-lifter tool (41-L-1396), spring its two fingers over tappet roller, push to compress plunger spring, and pull out tappet holder. Gradually release pressure on spring and withdraw tappet assembly. Remove other five tappets in the same manner.

m. Remove Plungers, Plunger Springs, and Lower Spring Seats.

(1) With puller (41-P-2951-45), carefully withdraw plunger from its barrel and out through closing plug hole (fig. 124), being careful that its lapped surface does not touch the pump body. Do not touch lapped surface of plunger with fingers.



RA PD 342183

Figure 124—Set-up for Removing Plunger From Barrel, Using Special Plunger Puller (41-P-2951-45) and Tappet Holders (41-H-2374)

(2) Remove plunger spring and lower seat.

(3) Remove plungers, springs, and seats from other elements in the same manner. CAUTION: *Plungers and plunger barrels, as well as delivery valves and valve seats, are mated due to their lapped fits and must be kept with their original mates.*

n. Remove Upper Spring Seats, Control Sleeves, and Toothed Segments (fig. 125).

(1) Lift out upper spring seat and control sleeve, with its toothed segment attached, through inspection opening. NOTE: *Unless replacement is necessary, let the toothed segment remain clamped to its control sleeve to preserve correct adjustment.*

(2) Remove spring seats and sleeves from all six elements.

o. Remove Delivery Valves (figs. 126 and 127).

(1) With pump held in vise, unscrew delivery valve holder and remove holder, gasket, and delivery valve spring.

(2) Using delivery valve extractor (41-E-538), withdraw valve and seat (fig. 127). Keep valve and seat together as they are mates.

(3) Remove the other five delivery valves in the same manner.

p. Remove Plunger Barrels (fig. 126).

(1) Remove barrel set screw and washer.

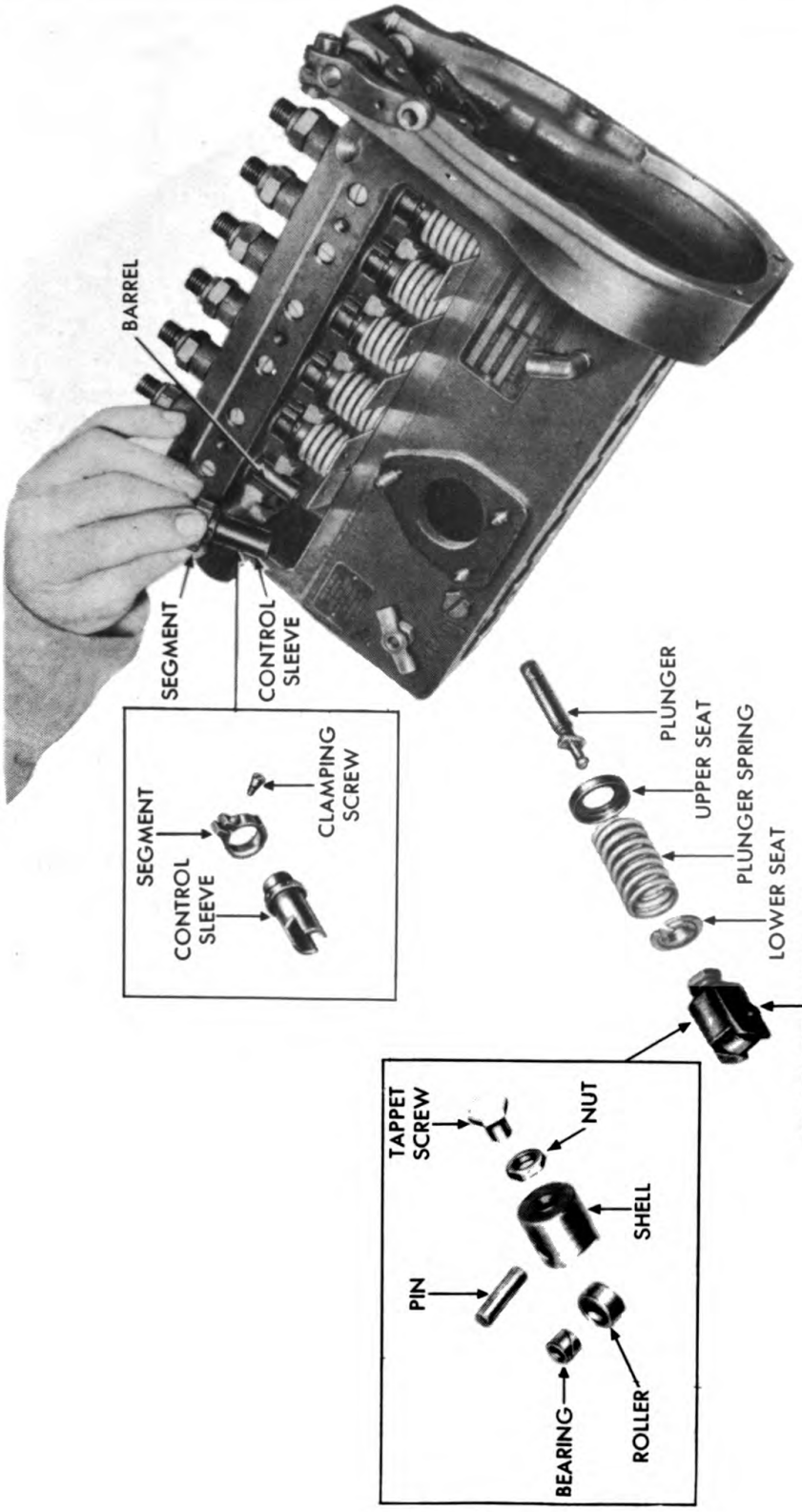
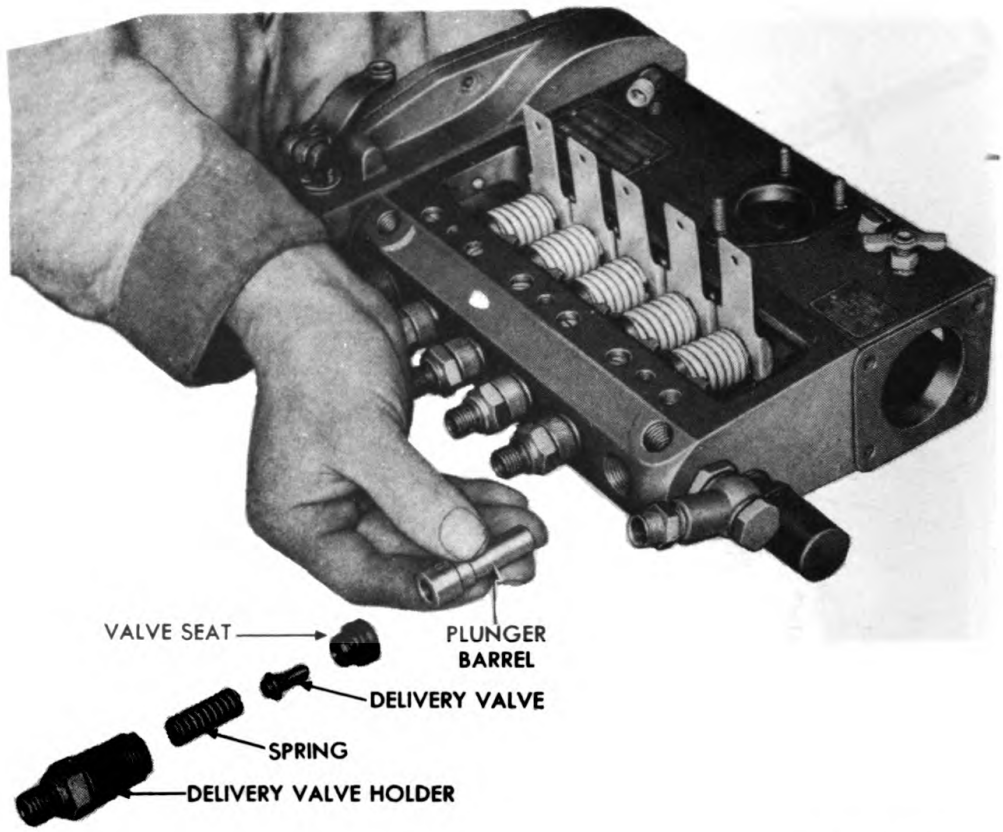


Figure 125—Removing Sleeve and Segment, Showing Tappet and Valve Disassembled



RA PD 342171

Figure 126—Removing Delivery Valve Parts

(2) Push up on lower end of barrel and lift it out.

(3) Remove other five barrels in same manner.

(4) Keep each barrel with its original plunger, as they are mated by lapped fits.

q. Remove Control Rack. Unscrew and remove control rack stop screw and securing screw (fig. 128). Withdraw rack from front end of housing (fig. 143).

63. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning.

(1) Wash all parts in clean fuel oil; then clean with dry-cleaning solvent, and dry with compressed air.

(2) When cleaning, make sure that matched parts of pumping elements are kept with the mating parts with which they were assembled.

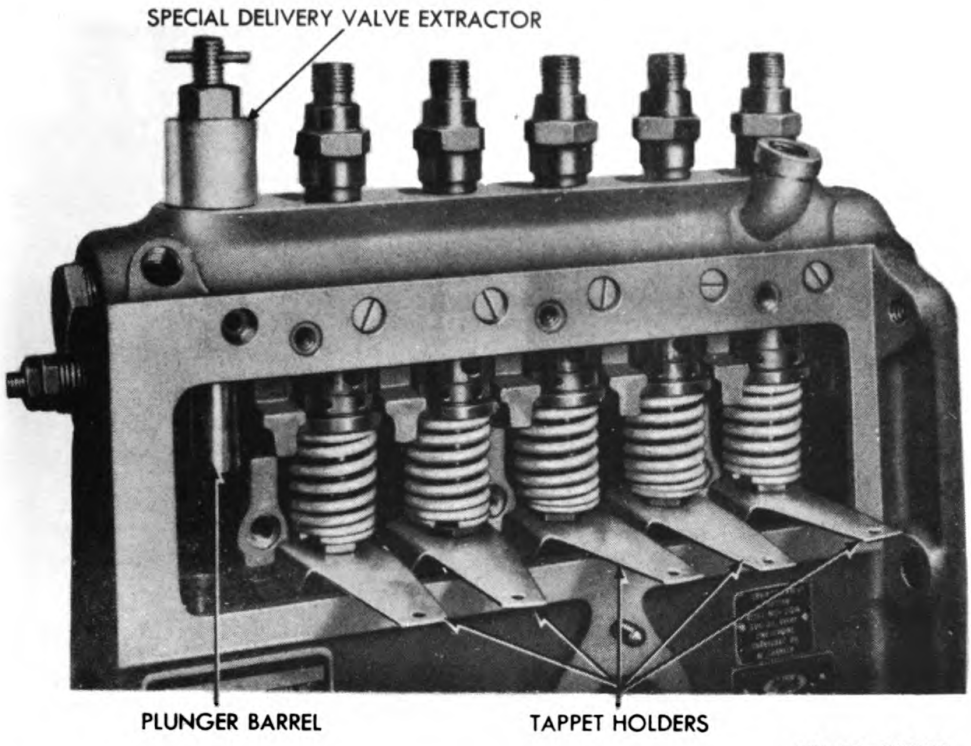


Figure 127—Set-up for Removing Delivery Valve Seat, Using Special Extractor (41-E-538)

(3) To protect lapped surfaces of plungers and delivery valve parts from acid stains, do not handle. If hands come in contact with these parts, clean the parts off at once with clean fuel oil to prevent acid corrosion.

b. Inspection and Repair.

(1) CONTROL RACK BUSHING.

(a) Inspection. Insert control rack in place and determine if there is any noticeable clearance or shake.

(b) Repair. Use rack bushing wrench (41-W-645-500), to remove and install outer threaded bushings at front and rear ends of pump body (fig. 129). Press out old inner bushings and press in new bushings. Line-ream inner bushings, using control rack bushing reamer (41-R-490) as shown in figure 130.

(2) CAMSHAFT (fig. 131).

(a) Inspection. Examine cams, keyway, and threaded end.

(b) Repair. If cam faces have slight blemishes, polish them with crocus cloth. If cams are badly roughened, or if defective keyway or threads cannot be reconditioned by the slight use of a fine file, replace the camshaft.

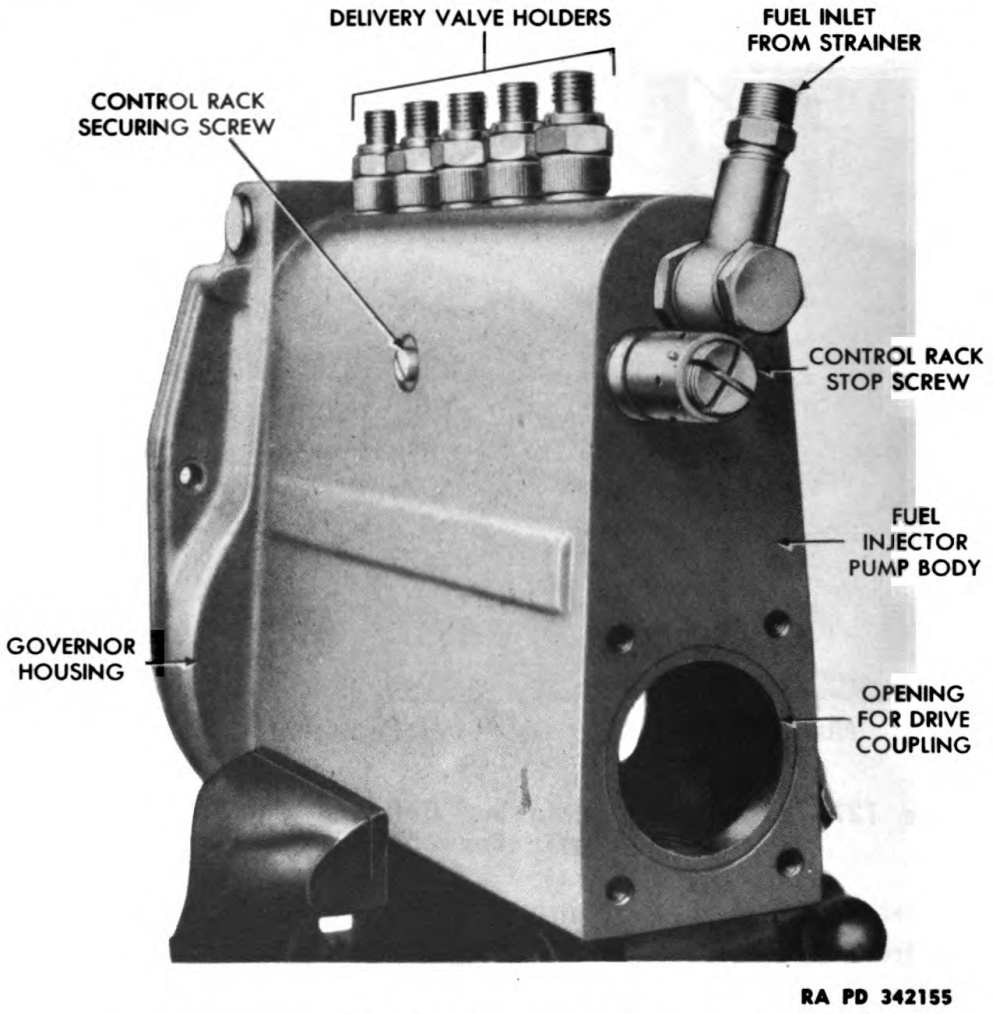


Figure 128—Front End of Fuel Injector Pump

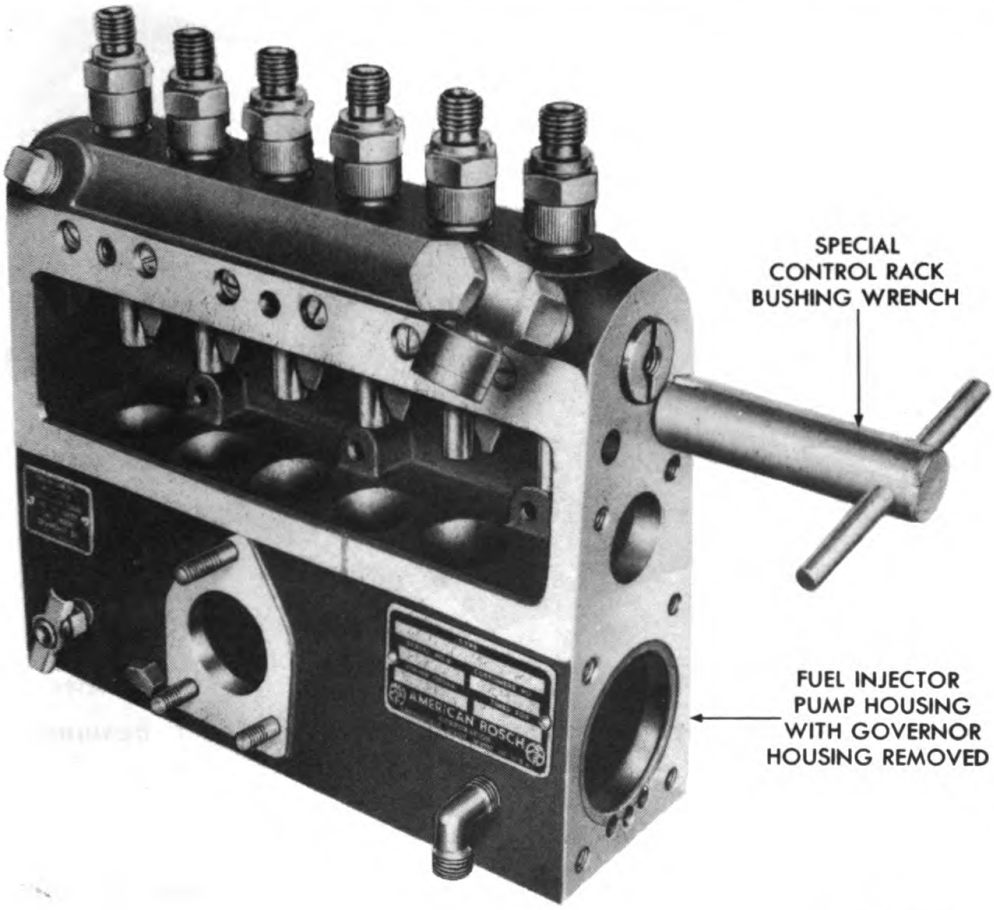
(3) CAMSHAFT BEARINGS.

(a) Inspection. Examine camshaft bearings for pitted or rough race or balls.

(b) Repair. Replace inner race, ball retainer, and outer race if any of the balls or races are worn, pitted, or show any tendency to bind. Remove inner race and ball retainer, using special puller (41-P-2905-18) and jaws (41-J-312) to press off inner race and oil thrower (fig. 132). When installing oil thrower and inner race on shaft, use special driver (41-T-3081-25) as shown in figure 133.

(4) END PLATE AND BEARING RETAINER.

(a) Examine bearing outer races, and replace if worn or pitted or whenever inner bearing race and ball retainer are replaced. Use special puller (41-P-2905-12) to remove outer races (fig. 134).



RA PD 342197

Figure 129—Set-up for Removing Control Rack Outer Bushings, Using Special Wrench (41-W-645-500)

(b) When installing new race, make sure bores and shoulders of end plate are entirely clean so that races will seat firmly against bore shoulder when pressed in place. Install new race, using special driver (41-D-2862-50) as shown in figure 135.

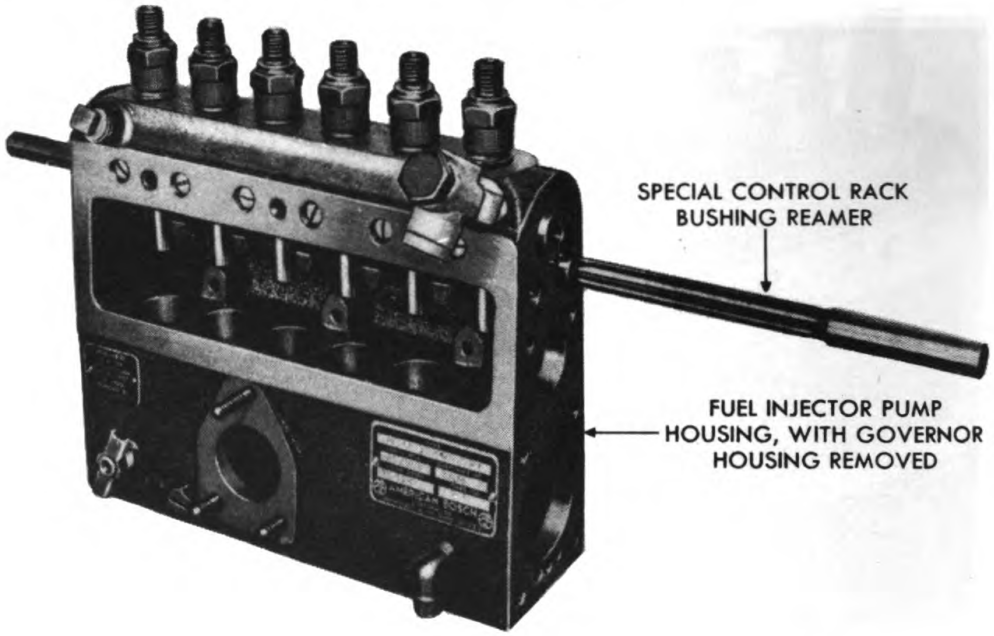
(c) Inspect oil seal at front bearing retainer for wear, damage, or leakage, and replace if defective; drive old seal out and press new retainer in place, with metal face toward bearing.

(5) TAPPET ASSEMBLIES (fig. 125).

(a) Examine head and threads of tappet screws for wear, and replace if worn or damaged.

(b) If there is a detectible looseness between tappet pin and bushing or between bushing and roller, replace defective parts.

(c) When installing new roller or bushing, press pin in place so that flattened end surfaces are at right angles to top of tappet shell.



RA PD 342194

Figure 130—Set-up for Reaming Control Rack Inner Bushings, Using Special Reamer (41-R-490)

(6) PLUNGERS AND BARRELS (fig. 126).

(a) Replace plungers and barrels which failed to meet the calibration test (par. 58 c).

(b) Inspect plungers and barrels of all six elements very carefully, not only for wear but for condition of their lapped surfaces. Use a magnifying glass to examine these parts, and look for any signs of corrosion or indication that lapped surfaces have been damaged by contact with some hard object.

(c) Do not attempt to recondition plunger or barrel. If plunger has lost its mirror-like appearance and looks dull or gray, replace plunger and barrel assembly.

(d) Edges of plunger helix must appear sharp under magnifying glass. If edge is nicked or scuffed or if surfaces are discolored or pitted by corrosion, replace plunger and barrel assembly.

(e) Examine the lapped top surface of plunger barrel. This surface is in contact with the bottom surface of the delivery valve seat and must withstand fuel injection pressure; therefore, this surface must form a perfect lap joint. Lap the surfaces on lapping plate. If a slight lapping does not show a perfect surface, replace both barrel and delivery valve assembly.

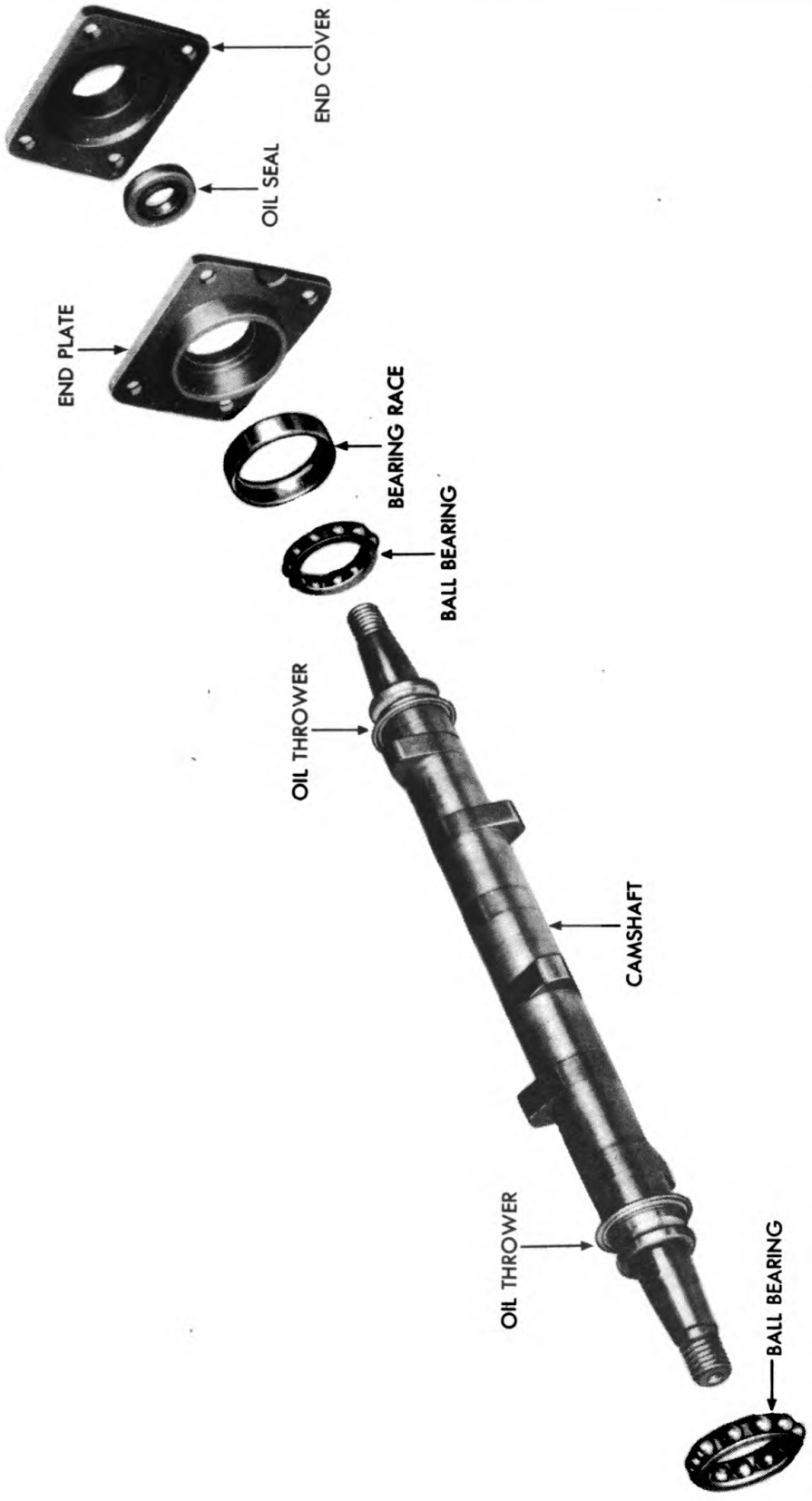
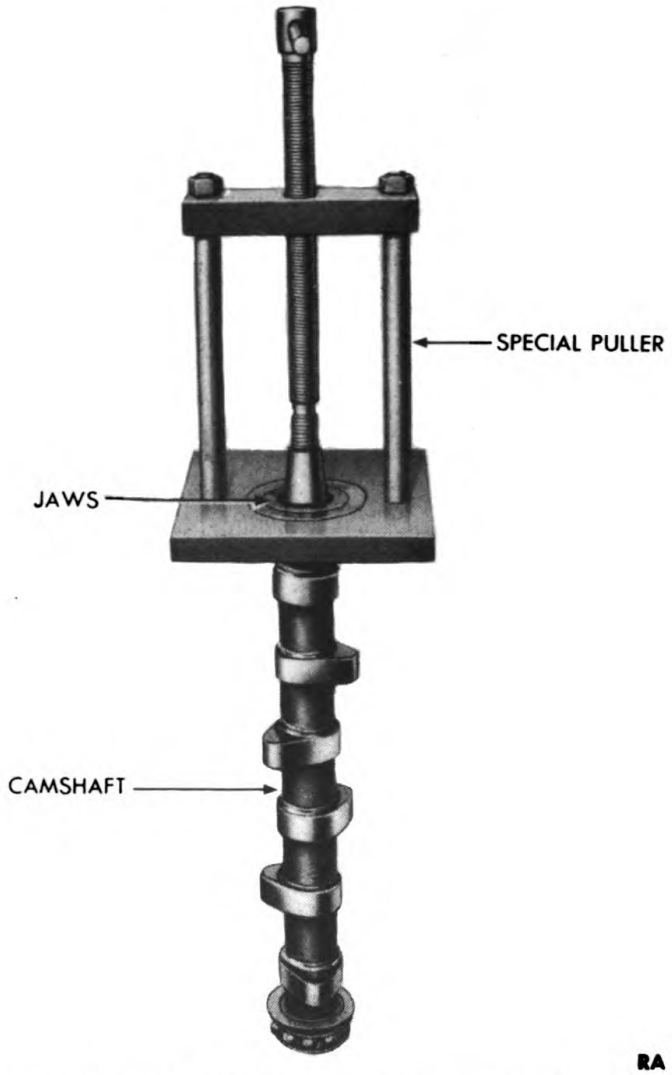


Figure 131—Fuel Injector Pump Camshaft, Disassembled



RA PD 342175

Figure 132—Set-up for Pulling Ball Bearing Inner Race From Camshaft, Using Special Puller (41-P-2905-18) and Jaws (41-J-312)

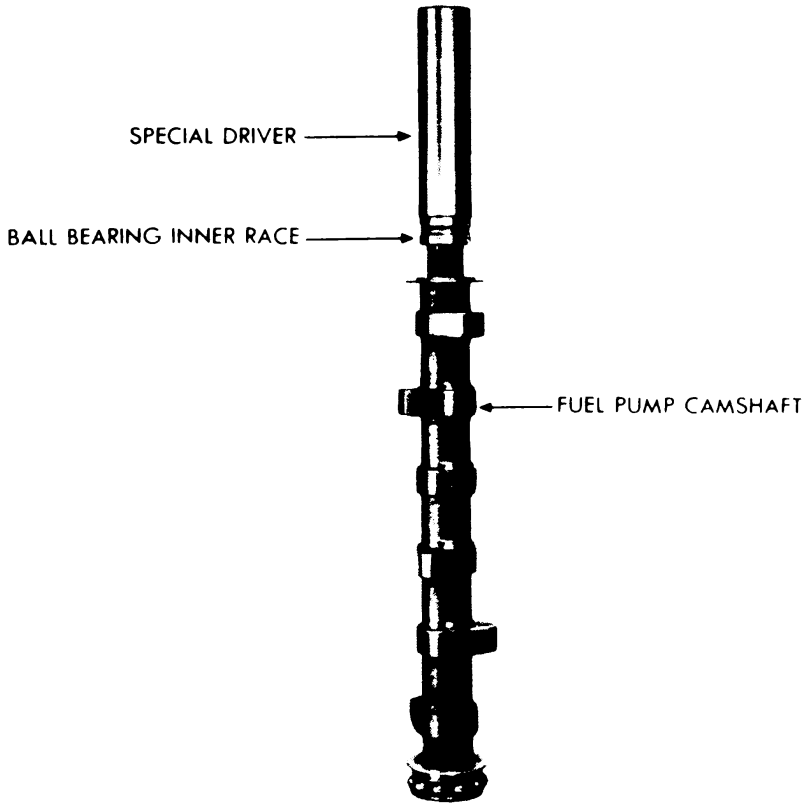
(7) DELIVERY VALVES (fig. 126).

(a) Use a magnifying glass and examine the bottom surface of valve seat which bears against the top of plunger barrel.

(b) Examine the conical surfaces of valve and seat and the bores in which the stems slide.

(c) See if defects on bottom surface of seat can be smoothed out by a slight lapping on a lapping plate.

(d) If lapping does not smooth out defects or surface of seat, or if either valve or seat has nicks, scratches, or corrosion pits, replace both parts.



RA PD 342170

Figure 133—Set-up for Installing Ball Bearing Inner Race on Camshaft, Using Special Driver (41-D-2862-100)

(e) Test delivery valve for leakage, using nozzle test stand (17-S-15550) and fixture (17-F-5550) as shown in figure 136.

(8) DELIVERY VALVE HOLDERS AND SPRINGS (fig. 126).

(a) Examine the springs minutely for nicks, cracks, pits, or scratches.

(b) Check holders for damaged threads.

(c) Replace any defective springs or holders.

(9) CONTROL SLEEVES AND TOOTHED SEGMENTS (fig. 126).

(a) Do not disturb position of segment on sleeve unless either part must be replaced.

(b) Examine guide slots in sleeve and teeth of segment.

(c) Replace sleeve if guide shows wear.

RA PD 342169

Figure 134—Set-up for Pulling Ball Bearing Outer Race From End Plate, Using Special Puller (41-P-2905-12)

(d) Replace segment if teeth are worn or otherwise damaged.

(e) When installing a new segment, place it on the sleeve with the center of toothed segment in line with center of the sleeve slot which has cut mark.

(10) CONTROL RACK.

(a) Examine teeth for wear or damage.

(b) Examine governor connecting end for any signs of damage, wear, or breakage.

(c) Replace rack if teeth are chipped, broken, or excessively worn, or if connecting end is worn, damaged, or broken.

(11) PLUNGER SPRINGS AND SPRING SEATS (fig. 125).

(a) Examine wire surface carefully for nicks, cracks, or pit marks.

(b) Replace springs which show any defects.

(c) Replace spring seats if worn or damaged.

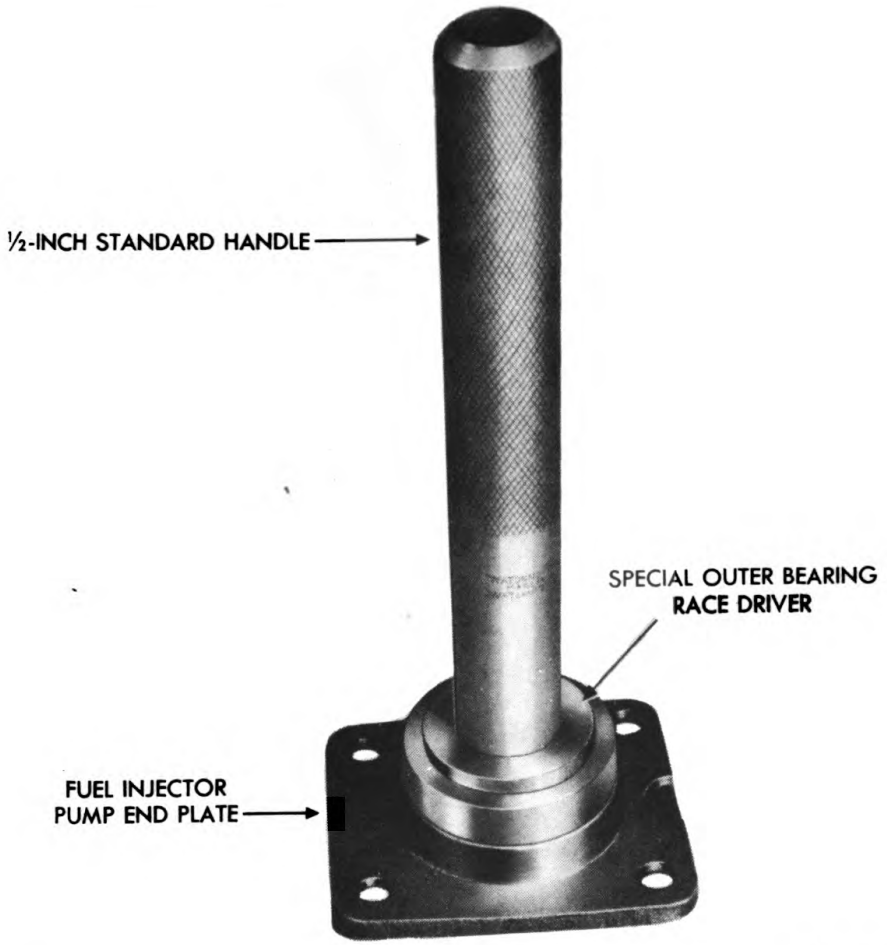


Figure 135—Set-up for Replacing Ball Bearing Outer Race in End Plate, Using Special Replacer (41-D-2862-50)

(12) BASE CLOSING PLUGS (fig. 122).

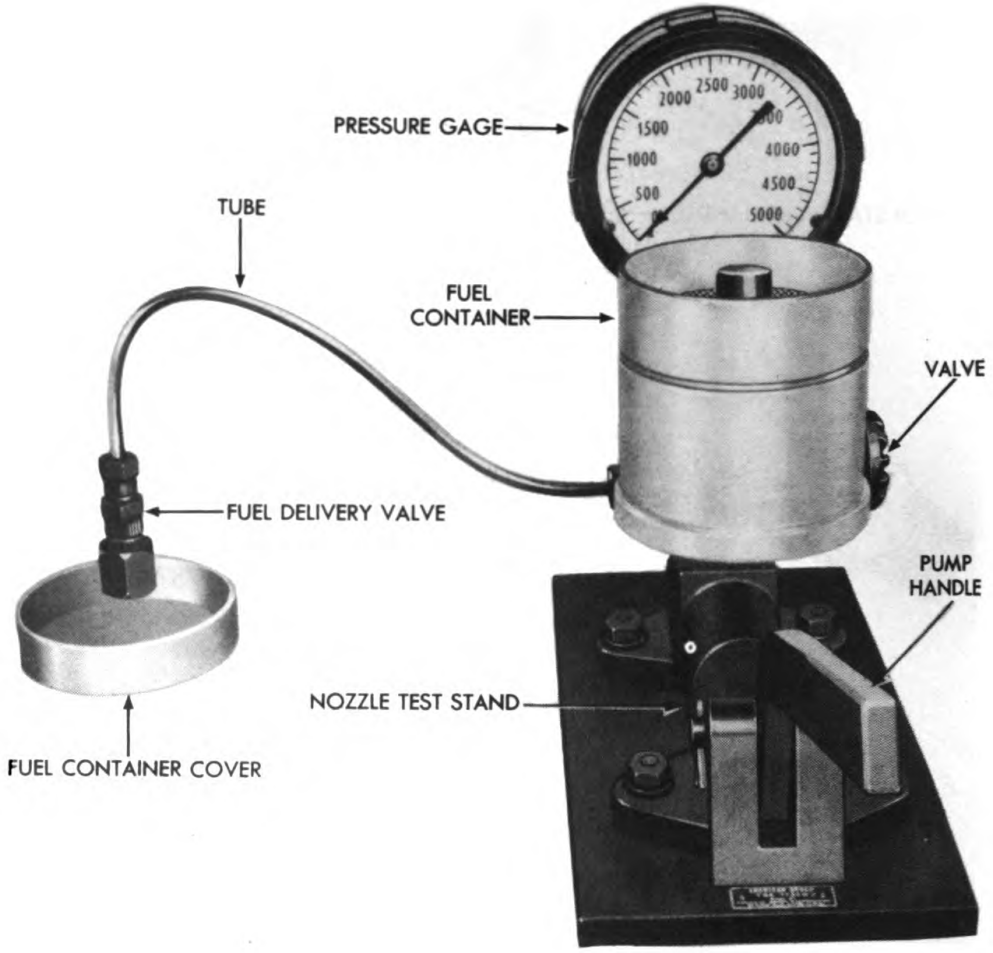
(a) Examine the thread and slot of each plug, and replace plug if thread is damaged or slot is worn so that removal or installation may be difficult.

(b) If felt cushions are worn, depressed, or show signs of disintegration, replace them.

(c) Remove and wash thoroughly any old felts that are to be kept in service.

(13) OVERFLOW VALVE (fig. 137).

(a) If valve was found to be unserviceable when pressure-tested for correct pressure of 13 to 15 pounds (par. 58 f), remove screw at end of body and take out spring and valve.



RA PD 342190

Figure 136—Set-up for Testing Fuel Delivery Valve for Leakage, Using Nozzle Test Stand (17-S-15550) and Special Fixture (17-F-5550)

(b) Replace spring if weak or broken.

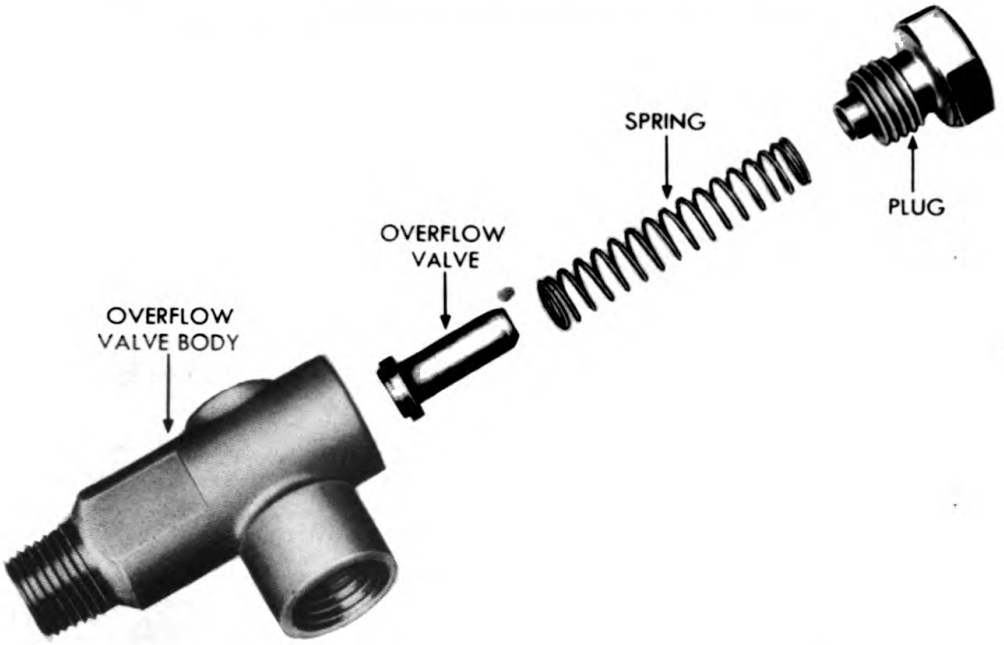
(c) If valve seat is defective, reface by a light cut in lathe, or replace valve and seat.

(14) FITTINGS AND ATTACHING PARTS.

(a) Examine threads on screws, plugs, and fittings.

(b) Inspect control lever and spring.

(c) Replace any part which is damaged.



RA PD 342204

Figure 137—Fuel Overflow Valve, Disassembled

64. ASSEMBLY.

a. General Precautions.

(1) CLEAN PARTS. Parts which have been repaired by lapping, or new parts, must be thoroughly cleaned. Rinse all parts in clean, filtered fuel oil just before assembly, but do not dry them.

(2) CLEAN BENCH AND TOOLS. See that the bench, vise, and all tools to be used are thoroughly cleaned and free from any foreign matter which can cause trouble by getting on lapped surfaces.

b. Install Control Rack.

(1) Mount pump vertically in vise, using jaw-liners.

(2) If control rack inner bushings were replaced, the threaded outer bushings must be installed. Screw bushings in until ends project ¼ inch from outer ends of body, using special bushing wrench (41-W-645-500) (fig. 129).

(3) Slide rack through bushings, with rack connecting end at mounting flange face and the seat in rack alined with securing screw hole.

(4) Insert and tighten securing screw.

(5) Make certain rack is free and has limit of travel permitted by slot.

c. Install Plunger Barrels.

(1) Drop one barrel into proper hole in top of pump housing, turning barrel so that set screw will engage in slot (fig. 125). Do not touch the lapped surface of barrel.

(2) Insert barrel set screw with new gasket and tighten. Barrel must have a slight vertical movement.

(3) Install the other five barrels in same manner.

d. Install Delivery Valves (fig. 126).

(1) Insert delivery valve and its mated valve seat in place at top of plunger barrel. Do not touch the lapped surfaces of either part with the fingers.

(2) Place new valve holder gasket over seat.

(3) Place valve spring over end of valve.

(4) Insert valve holder, and tighten down firmly.

(5) Install protecting cap so that dust cannot get into holder opening.

(6) Install other five valves in same manner.

e. Install Control Sleeves (fig. 125).

(1) Invert pump and secure it by clamping valve holders between jaws of vise with jaw liners.

(2) Center the control rack in pump body by sliding it forward or backward until center punch marks, on underside of rack ends, are about $\frac{1}{16}$ inch from end faces of pump body.

(3) With rack in position described in step (2) above, place control sleeve with toothed segment on plunger barrel, meshing the toothed segment with control rack so that clamping lugs face outward and at right angles to rack.

(4) Place upper spring, with recessed side upward, on control sleeve.

(5) Pass plunger spring through hole in base of pump, and drop it into position on control sleeve.

(6) Install other five control sleeves, springs, and seats in same manner.

f. Install Plungers and Lower Spring Seats.

(1) Attach plunger puller (41-P-2951-45) to flanged end of plunger (fig. 124).

(2) Place lower spring seat, with recessed side toward plunger flange, on plunger just above flange.

(3) Insert plunger through closing plug hole, using plunger puller (41-P-2951-45) to hold plunger (fig. 124). Insert plunger into its

related barrel, engaging the cut-marked end of cross flange with similarly marked slot in control sleeve.

(4) Release and withdraw plunger puller.

(5) Do not touch the lapped surfaces of plunger with the hands.

(6) Install other five plungers in the same manner, being sure each one is inserted in its related barrel.

g. Install Tappets.

(1) If original tappet screw adjustment was changed when pump was disassembled, readjust tappet screw, setting it well down in shell for entrance of tappet holder (41-H-2374).

(2) Grip roller with lifter tool (41-L-1396) (fig. 123), and insert tappet through closing plug hole so that projecting roller pin enters vertical guide in pump housing.

(3) Compress plunger spring sufficiently to insert tappet holder between tappet screwhead and lock nut; then withdraw lifter tool.

(4) Install the other five tappets in the same manner.

h. Install Camshaft.

(1) Insert camshaft with bearings assembled, through opening at gear end of pump housing.

(2) Install a new gasket, push end plate in position, and secure with four screws.

(3) Install key on shaft and slide drive coupling flange on shaft, fastening it on with washer and nut on end of shaft.

(4) Use a dial gage, mounted on rear end of housing, to check camshaft end play. End play must be 0.005 to 0.008 inch. To adjust end play, remove end plate, withdraw shaft, and after pressing off bearings, add or remove bearing adjusting washers at end of shaft between oil thrower and bearing. If assembly is tight with original washers installed, check for improperly seated bearing races before removing washers.

i. Install Base-closing Plugs.

(1) Make sure that felts are in position in plugs.

(2) Apply a film of heavy grease to the plug threads, and screw each plug into its proper socket.

(3) Use screwdriver adapter and handle to seat each plug (fig. 122).

j. Remove Tappet Holders.

(1) Place Woodruff key in camshaft keyway, and slide governor drive gear on shaft.

(2) Turning drive gear by hand, rotate camshaft, and as tappets are raised, remove tappet holders.

k. Adjust Control Rack.

(1) Mount the pump upright in vise with jaw liners.

(2) Screw control rack setting gage on control rack until inner face is against rear surface of pump.

(3) If adjusted correctly, the outer face of gage (marked "10") will be flush with threaded end of rack when rack is pushed inward to the limit permitted by the control rack stop screw (fig. 128).

(4) If gage face (marked "10") and end of rack are not flushed, remove gage and turn control rack stop screw in or out until rack extension agrees exactly with gage.

(5) Any reduction from this setting is made only when operating reasons require a lower setting.

l. Install Pump Support.

(1) Attach the pump support to bottom of pump, using four cap screws with lock washers.

(2) Install drain plug using a new gasket.

(3) Install oil level cock and oil overflow fitting as shown in figure 109.

m. Install Overflow Valve and Fuel Shut-off Valve.

(1) Screw overflow valve in gallery opening near rear end of pump body (fig. 109).

(2) Install fuel shut-off valve, with elbow, in gallery opening near front end of pump (fig. 109).

n. Install Control Rack Bushing.

(1) Install the bushing, assembled with slotted control rack stop screw, cotter pin, and sealed disk, by screwing it on the projecting end of the control rack outer bushing.

(2) If adjustment of control rack stop screw has been changed during disassembly, readjust it for correct setting. To make this adjustment, remove sealing disk and cotter pin, and turn stop screw so that its inner face is 1.165 inches from end of stop bushings. This dimension must be correct to provide 0.335-inch clearance for forward travel of rack from fully "ON" position to "SHUT-OFF" position.

(3) Replace cotter pin and sealing disk in end of bushing.

(4) Join the two ends of lock wire and clamp on the wire seal.

(5) Install rubber boot which protects control rack stop screw.

(6) Install governor drive gear and spring disks, as outlined in paragraph 68.

(7) Install fuel transfer pump as outlined in paragraph 72 a.

o. Time and Calibrate Elements. Time and calibrate pump elements as outlined in paragraph 58.

p. Install Inspection Cover.

(1) Install new gasket and position cover so that screw holes aline with those of pump housing.

(2) Insert three short cap screws, with lock washers, at top edge. Insert three long cap screws, with lock washers, at bottom. Tighten all six cap screws securely.

Section VI

OVERHAUL OF GOVERNOR

65. TEST AND DISASSEMBLY.

a. Test. Make a hand-test by turning gear, shaft, and control levers to make sure parts operate freely. Refer to paragraph 51 and note any irregular performance of governor when engine was tested on the dynamometer stand. Test and adjustment of the governor can be made when engine is undergoing dynamometer test or when engine is mounted in the vehicle (par. 73). If governor action was erratic in dynamometer test or if it cannot be turned freely by hand, disassemble the unit enough to locate and correct the cause of trouble. If damage is too extensive to repair, replace the governor.

b. Disassembly Into Subassemblies.

(1) REMOVE BUMPER SPRING AND OPERATING LEVER ASSEMBLIES.

(a) Remove inspection cover and gasket by taking out the four fastening screws.

(b) The governor adjustable bumper spring assembly consists of bumper spring, adjusting screw, lock nut, dust cap, and gasket. This assembly is set at factory and should not be changed. If necessary to remove bumper spring assembly, measurements must be taken so that the assembly can be installed in the same position from which it was removed.

(c) The position of the governor operating lever is important. Some governors have a scratch line across the end of the lever shaft which registers with a mark on the operating lever. On those governors where there are no marks on the operating lever or shaft end, a scratch mark must be made on the lever shaft before disassembly so that these two parts can be clamped together in their proper relative positions when governor is assembled. Remove operating lever by loosening clamp screw.

(d) Remove cover plates by unscrewing three screws.

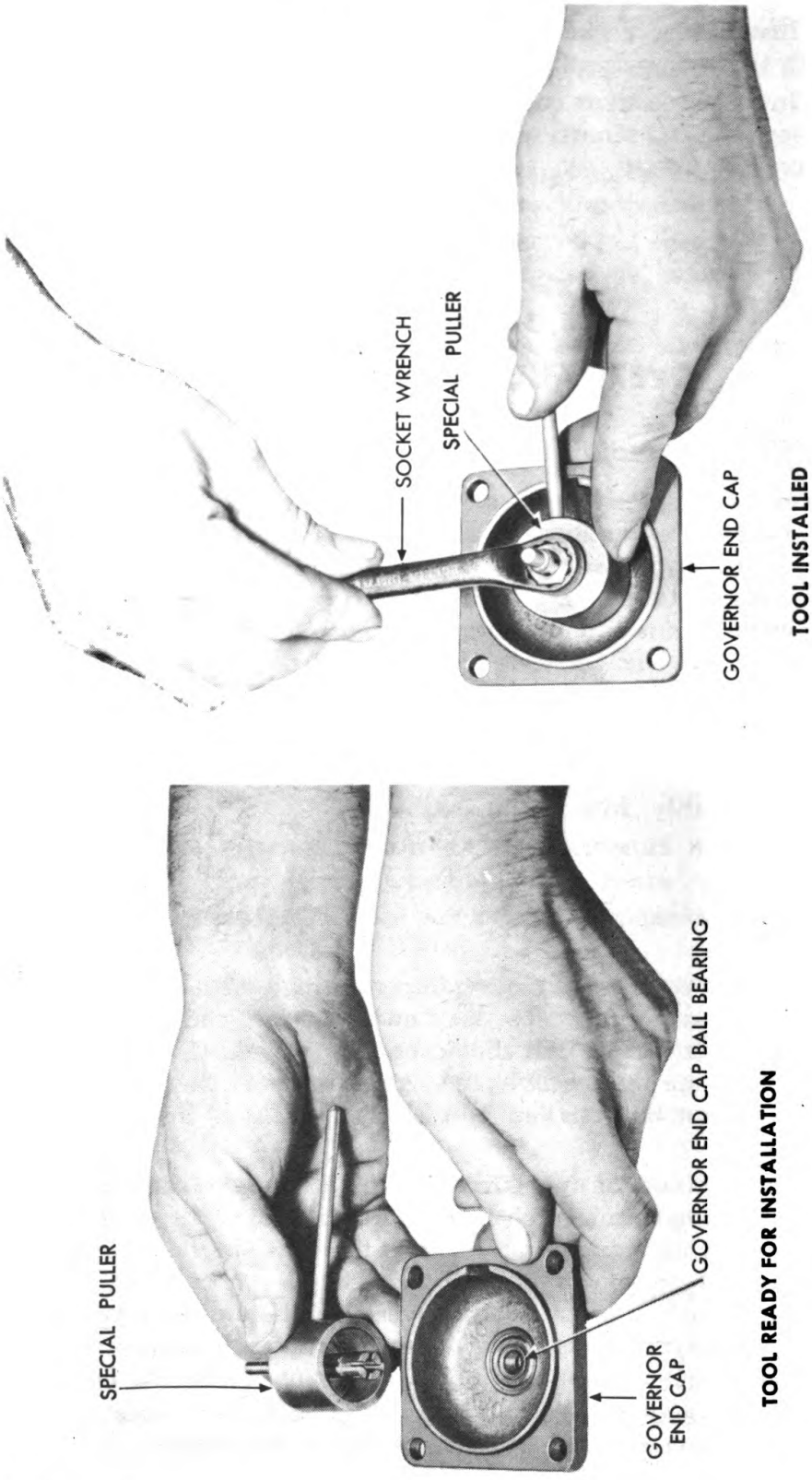
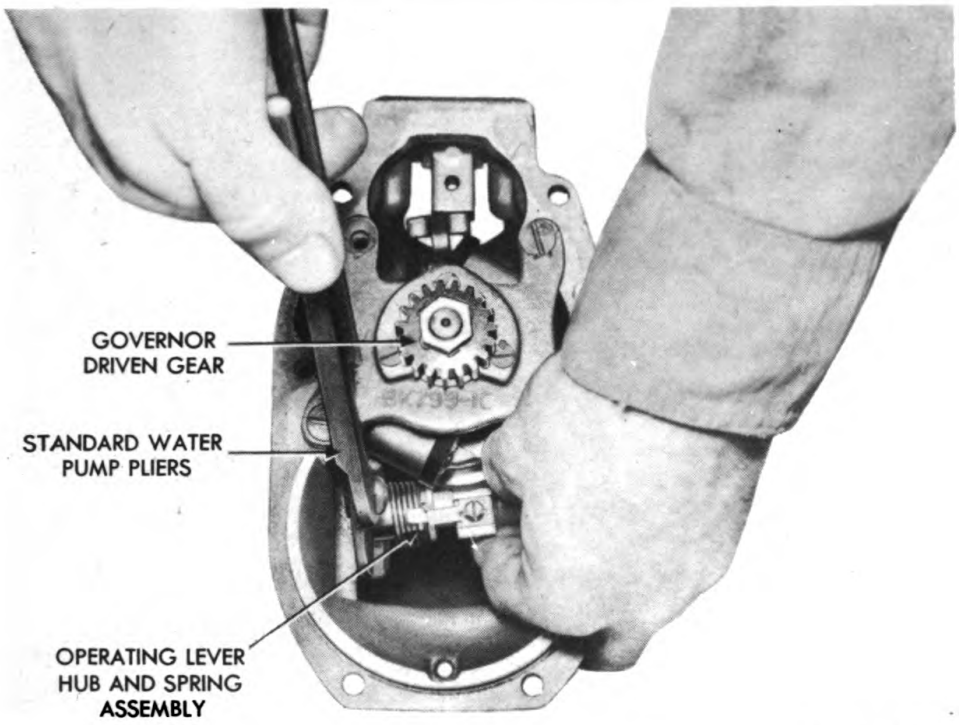


Figure 138—Removing Governor End Cap Ball Bearing, Using Special Puller (41-P-2900-30)



RA PD 342152

Figure 139—Removing Governor Operating Lever, Hub, and Spring

(e) Using $\frac{3}{16}$-inch hexagon socket wrench, remove set screw if one is used in the model governor on engine. If serrated shaft with no set screw is used, merely pull out shaft.

(f) Unscrew the four screws which hold bearing bridge to governor end cover, and carefully pull out the internal operating parts of the governor as a unit (fig. 141).

c. Disassembly of Subassemblies.

(1) GOVERNOR END COVER.

(a) Remove End Cap Ball Bearing. If necessary to remove end cap in order to replace the ball bearing in end cap, unscrew the four fastening screws, remove washers, and take off the end cap. Remove ball bearing, using special puller (41-P-2900-30) as shown in figure 138.

(b) Remove Operating Lever Assembly (fig. 139). Remove stop flange and dust cover by removing the three fastening screws. CAUTION: *Before disturbing the setting of stop adjustment screws (fig. 109), a measurement must be recorded so that they will be assembled in the same position.* Withdraw operating lever, spring, and hub as a unit (fig. 139).

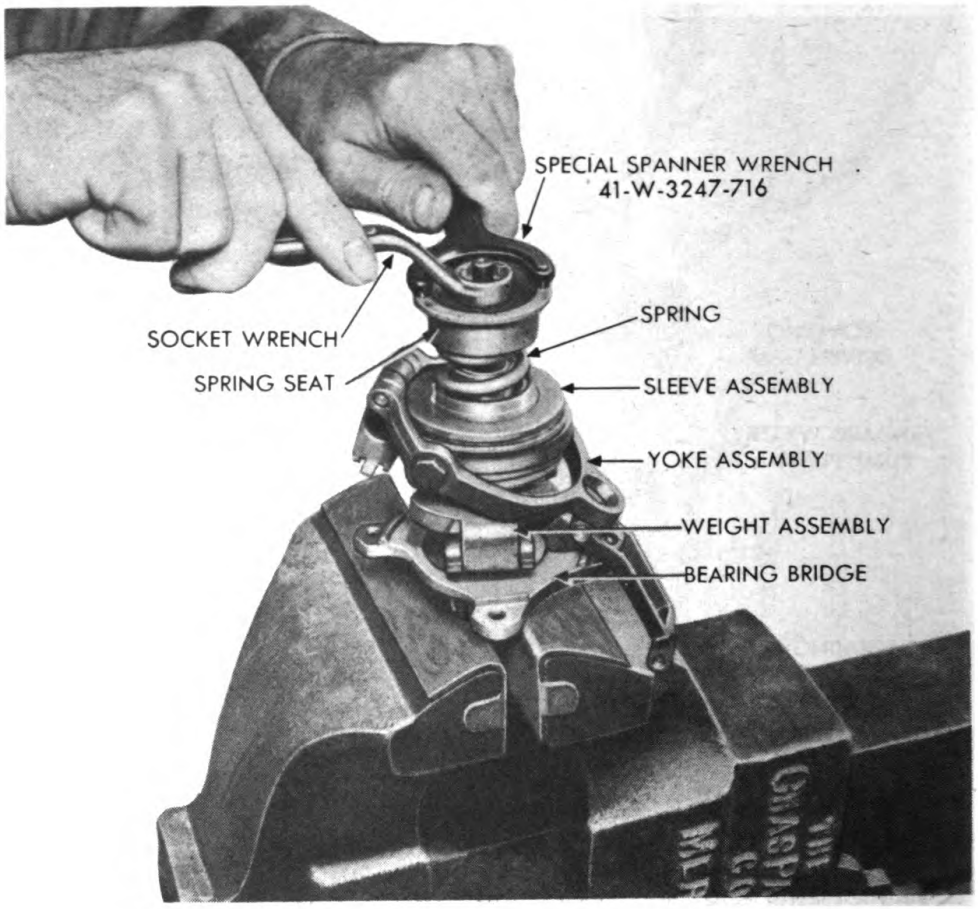


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Figure 140—Removing Governor Spring Seat Nut, Using Special Spanner Wrench (41-W-3247-716)

(c) Remove Spring and Fulcrum Yoke Assembly. Unfasten pivot screws to disengage fulcrum yoke assembly. Take out four screws which hold bearing bridge to governor end cover, and remove assembly as a unit. Mount assembly in vise, with copper jaws, so that vise holds the driven gear hexagon nut as shown in figure 140. Use socket wrench and special wrench (41-W-3247-716) to remove spring seat nut. Lift off spring seat, spacer, and governor spring, as shown in figure 141. Disengage sliding sleeve assembly from flyweight assembly. CAUTION: *Do not disengage these two assemblies unless necessary, as separating these parts might permit the balls of shaft bearings to drop out. No attempt must be made to disassemble either of these two subassemblies as their component parts are not serviceable.* Clamp other end of shaft in vise as shown in figure 142. Remove cotter pin, hexagon nut, and lock washer, and withdraw driven gear from shaft. Take off governor bearing bridge. If sleeve assembly

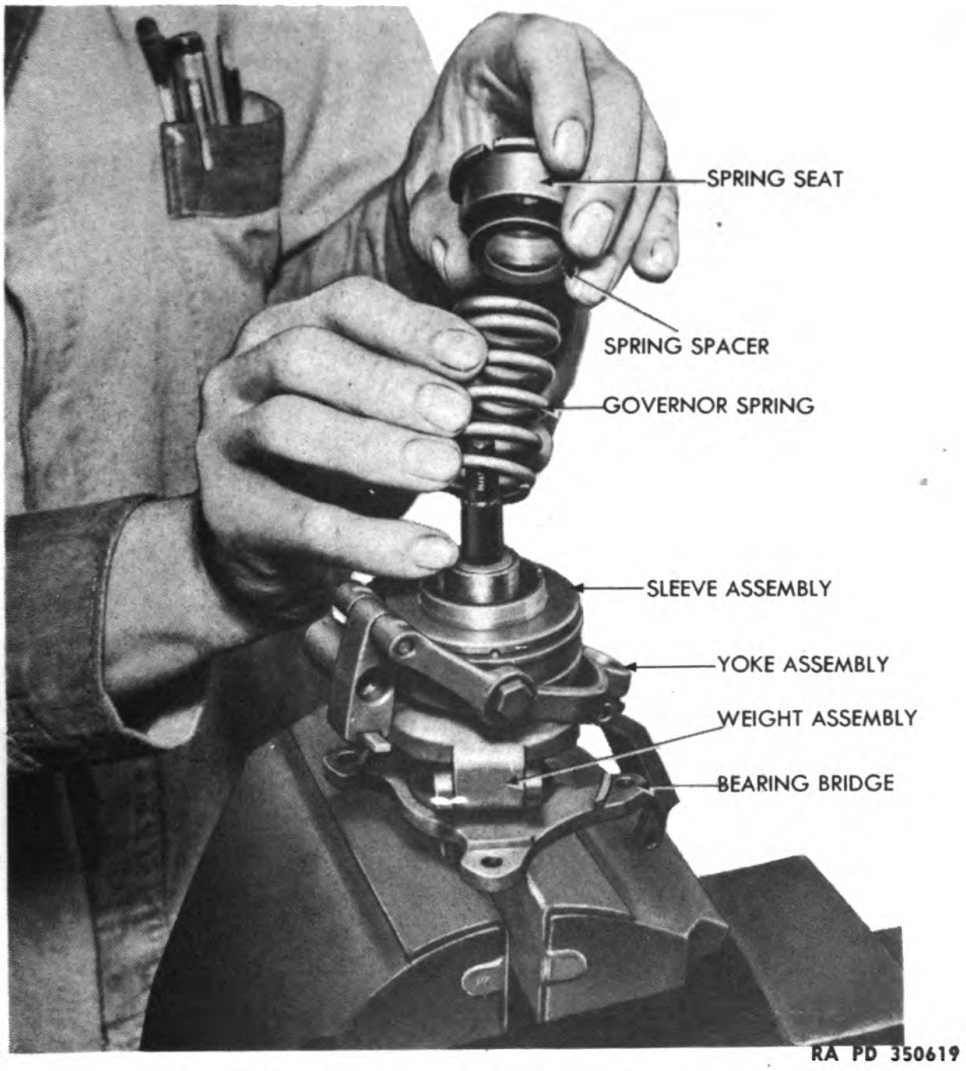


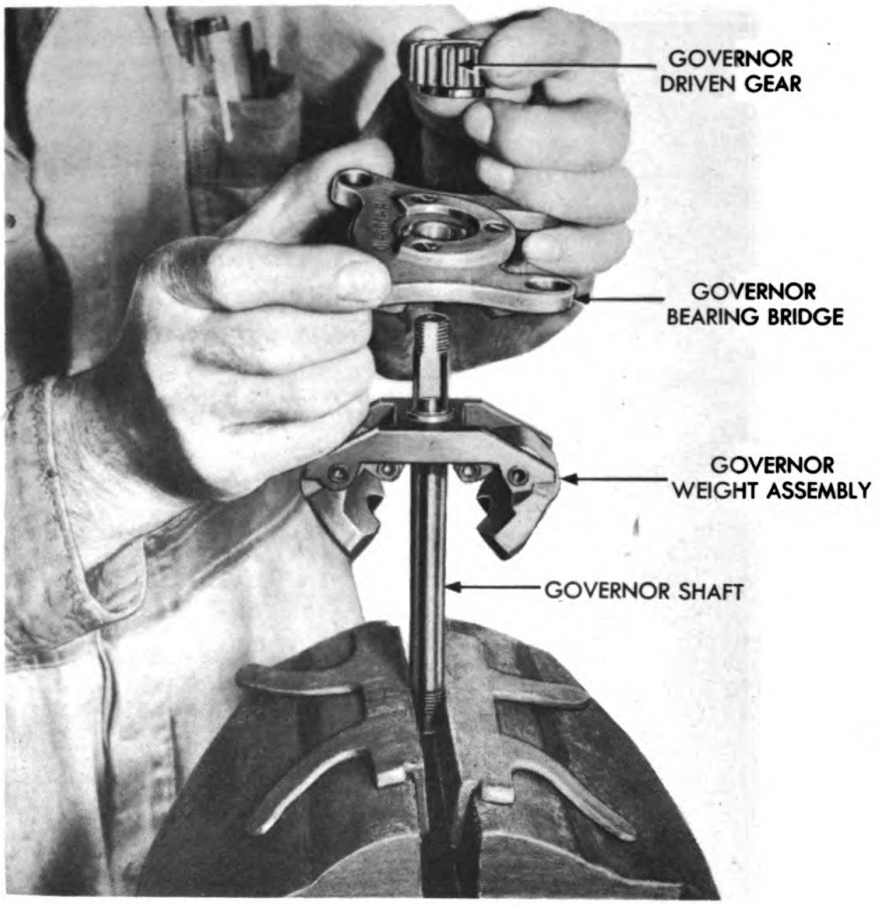
Figure 141—Removing Governor Spring Assembly

was separated from flyweight assembly and fulcrum yoke assembly removed, this will leave only the flyweight assembly to be removed from shaft.

(2) GOVERNOR HOUSING.

(a) Description. Internal parts of governor are made accessible by removing the governor end cover. The governor housing contains the drive gear, spring disk clutch, and control rack pin. It is not necessary to remove governor housing to repair the governor or fuel injector pump, even if necessary to remove the fuel pump camshaft.

(b) Remove Fuel Shut-Off Lever, Shaft, and Spring (fig. 143). The fuel shut-off shaft is located at the top of governor housing, and



RA PD 342162

Figure 142—Separating Bearing Bridge, Weight Assembly, and Driven Gear From Shaft

pulls out the control rack to cut off fuel supply when the stop control solenoid switch is operated at the dash. Remove nut from clamp bolt and take off fuel shut-off lever. Take out cotter pin in shaft and remove plain washer. Remove plain bearing, retaining washer, and ring. Remove shaft.

(3) Removing Drive Gear and Spring Disk.

(a) Remove hexagon nut and lock washer and unscrew the securing nut, using special spanner wrench (41-W-2573-25) and monkey wrench as shown in figure 144. With the securing nut removed, the lock washer, spring disk, adjusting spacer or spacers, and drive gear may be removed.

(b) To remove drive gear, use special puller (41-P-2924) and wrench as shown in figure 145.

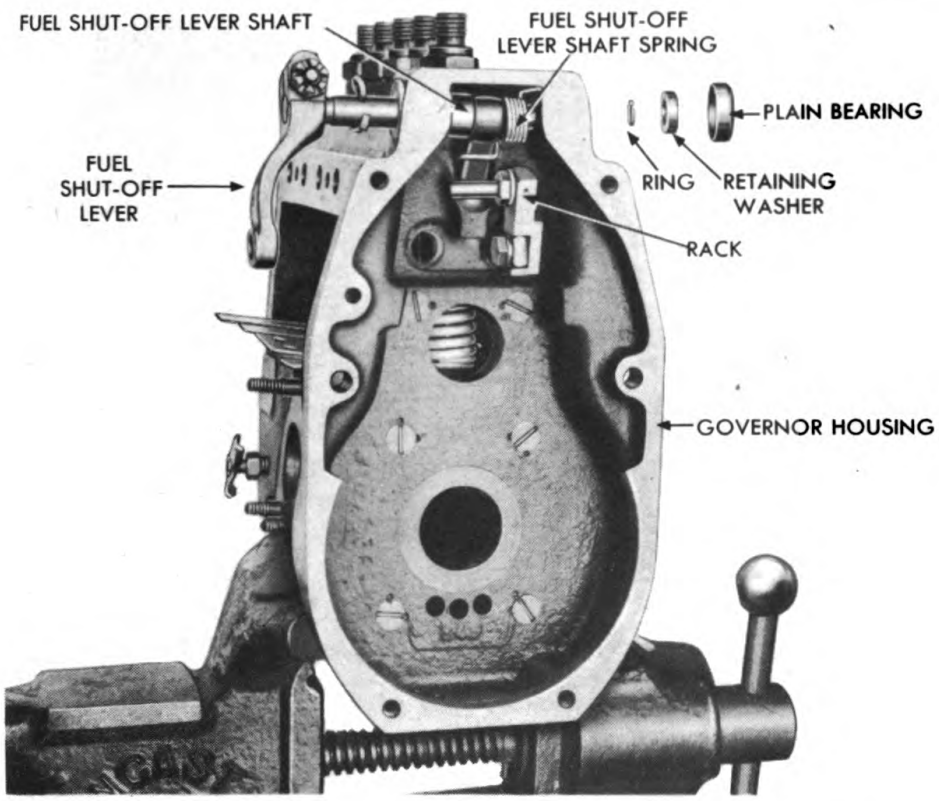


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Figure 143—Governor Housing, With Bearing and Washer Removed From Fuel Shut-off Shaft

(c) Withdraw the hub from the camshaft taper. CAUTION: *Never use an ordinary puller in the two threaded holes which are in some drive gears, as pulling against the spring disk with an ordinary puller will distort this spring.*

(d) The linkage arm between the fulcrum yoke extension arm and the injector pump control rack can be removed by unscrewing fastening screw.

66. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. Clean each individual part of governor in dry-cleaning solvent. See that springs are free from rust or corrosion, and that gaskets and washers are free from any adhesive substance after they are washed in solvent.

b. Inspection and Repair.

(1) Inspect all gaskets, screws, nuts, and washers, and replace any of them that show signs of damage.

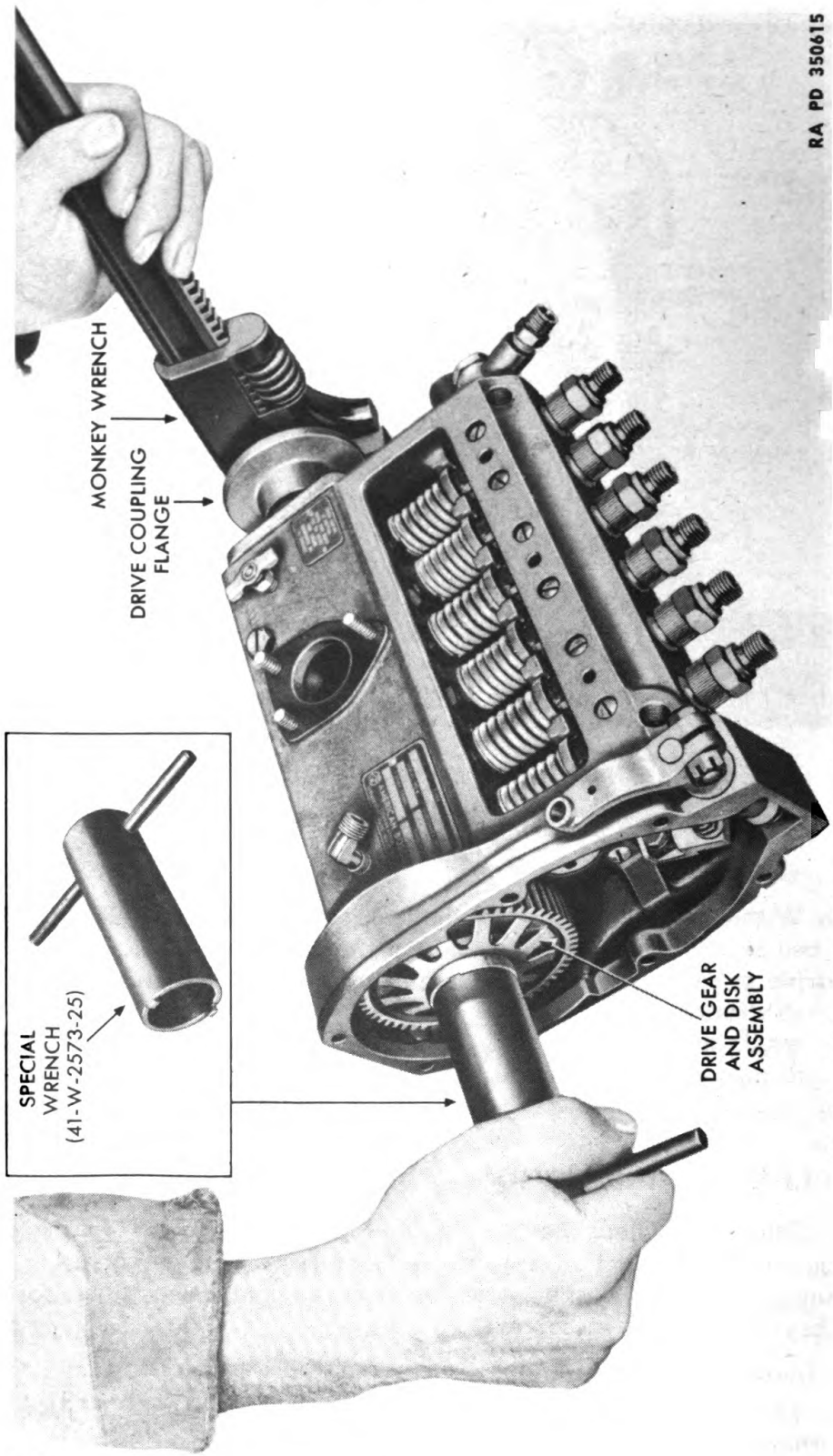

Figure 144—Removing Securing Nut From Governor Drive Gear, Using Special Wrench (41-W-2573-25) and Monkey Wrench

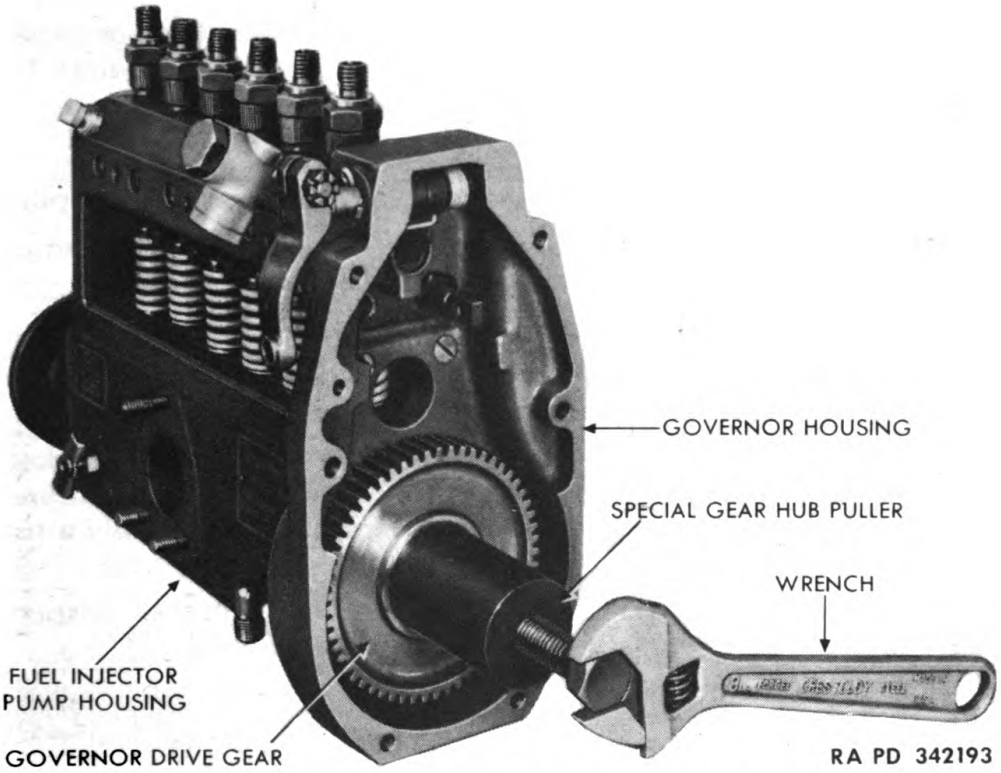

Figure 145—Set-up for Pulling Governor Drive Gear From Fuel Pump Camshaft, Using Special Puller (41-P-2924) and Wrench

(2) DRIVEN GEAR (fig. 139). Inspect for excessive wear, and replace if not in good condition.

(3) BALL BEARINGS (fig. 138). Inspect for wear, and replace if races are worn. Replace bearings having flattened or damaged balls.

(4) SPRINGS (fig. 140). See that governor spring and bumper spring are free from rust spots, corrosion, or breaks. Replace distorted or broken springs.

(5) SLIDING SLEEVE ASSEMBLY (fig. 141). Inspect condition of bearings. The two shaft bearings must not be loose, and the small balls in these bearings must all be in place.

(a) Check Clearance (fig. 141). There is a floating ring between the stationary thrust surfaces of the sliding sleeve assembly, and the two thrust bearing plates. The total clearance between these parts must not exceed 0.006 inch. In making check for proper clearance, the feeler gage must be inserted between the ring and either one of the bearing plates to get the advantage of a larger contact surface. Insert feeler gage far enough to go between the balls of bearing plates and the ring.

(b) Replace. Do not attempt to repair the sliding sleeve assembly. If clearance described above exceeds 0.006 inch, or other serious defect is found at inspection, the entire assembly must be replaced as a unit.

(6) FLYWEIGHT AND SHAFT ASSEMBLY.

(a) See that rollers are not worn or loose on their holding pins.

(b) See that flyweights move freely on pivot pins, but they must not be too loose. If worn or too loose, replace the assembly.

(7) FULCRUM YOKE ASSEMBLY (fig. 141).

(a) Inspect to see that there is not excessive play of linkage arm and pin with respect to the yoke, or between the hub and the yoke.

(b) See that extension piece is not distorted, and is firmly staked in place. If yoke is distorted or if the play between linkage arm and yoke and between hub and yoke is excessive, the whole assembly must be replaced as a unit.

(8) OPERATING LEVER SHAFT OIL SEALS AND BEARINGS. Inspect for wear or damage; replace if wear or damage is found.

(9) OPERATING LEVER AND SHAFT.

(a) Inspect to make sure pin is tight in place, and that stop plate sector is not loose on its shaft. Reamed inside diameter of shaft bushing is $\frac{3}{8}$ inch.

(b) See that hole in operating lever is not excessively worn.

(c) Inspect serrations on both the control lever and shaft for good condition. Replace if inspection reveals defects or if bushing is worn beyond the reamed inside diameter of $\frac{3}{8}$ inch. Ream new bushings to exactly $\frac{3}{8}$ inch.

(10) STOP ADJUSTMENT SCREWS AND NUTS. If these parts have been removed or replaced, make a note of such removal or replacement so that these parts will be reset in proper positions after governor and fuel injector pump assembly are installed on engine.

(11) DRIVE GEAR AND CLUTCH ASSEMBLY.

(a) Inspect drive gear for excessively worn or broken teeth.

(b) See that surface on face of gear which contacts spring disk, is smooth and clean.

(c) Insert hub into drive gear, and see that clearance between these two parts is not excessive to a point which would cause eccentric action. This is a lapped fit and gear should turn freely, but not fit loosely on shaft.

(d) If inspection shows that drive gear, spring disk, lock washer, or lock nut are damaged or badly distorted, replace damaged parts.

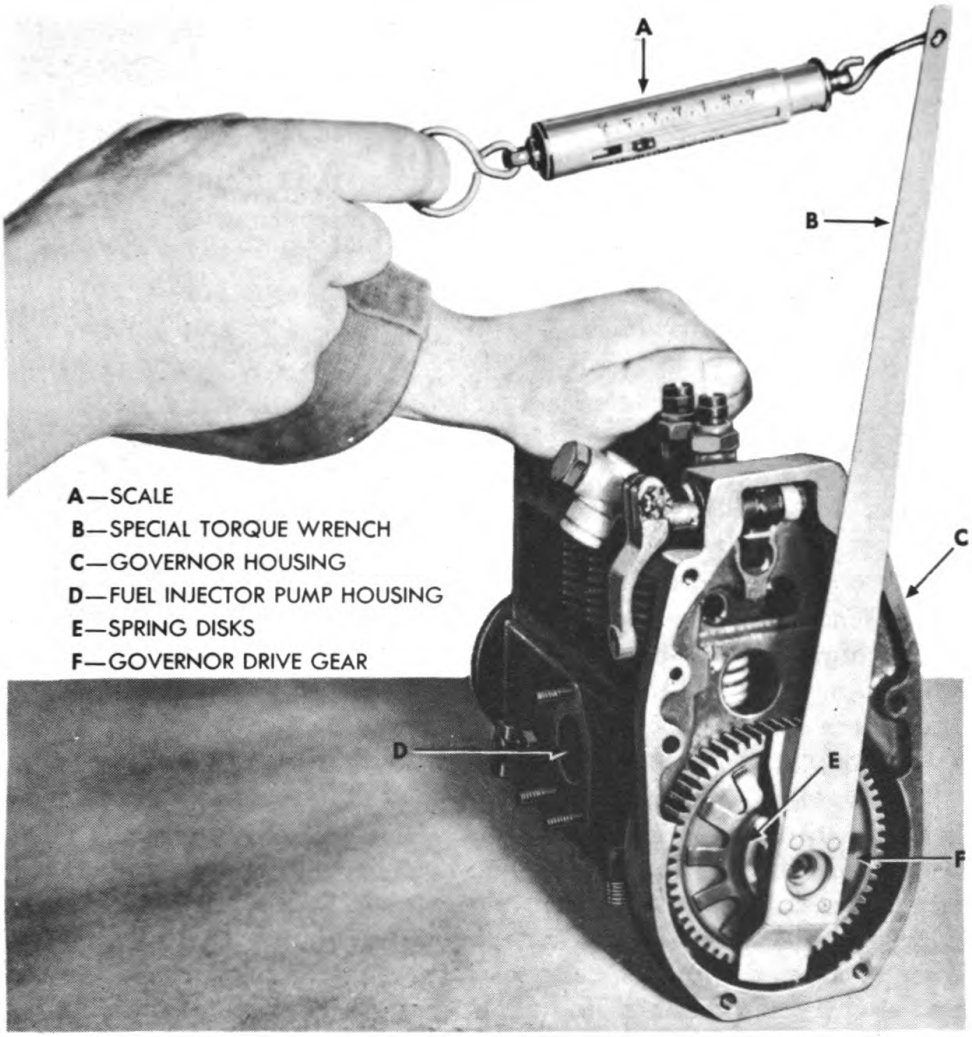

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Figure 146—Adjusting Tension of Governor Spring Disks, Using Special Torque Wrench (41-W-3628-50) and Scale (41-S-509)

67. ASSEMBLY OF GOVERNOR SUBASSEMBLIES.

a. General. Make a final check before starting assembly of subassemblies to see that all parts have been cleaned, inspected, and defective parts replaced. Ordinarily, it is not necessary to install governor housing as this part does not have to be removed to repair governor or fuel injector pump, even when it is necessary to remove the injector pump camshaft.

b. Assembly of Subassemblies.

(1) DRIVE GEAR AND SPRING DISK ASSEMBLY. Install drive gear, adjusting spacer or spacers, spring disk, lock washer, and secur-

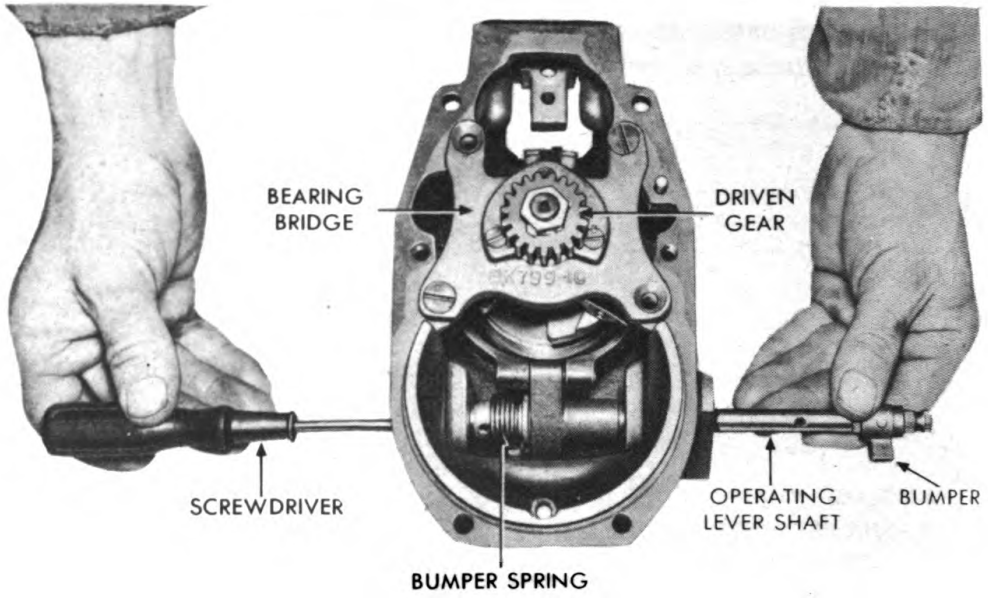

Figure 147—Inserting Operating Lever Shaft

ing nut; then install lock washer and hexagon nut. Mount the drive gear and spring disk assembly on the extending camshaft taper. No key is used, although a keyway is provided.

(a) Clearance Between Drive Gear Hub and Drive Gear. This clearance must be rechecked after hub has been securely tightened on camshaft taper. With ample clean lubricating oil between the hub and drive gear, the drive gear should rotate freely and easily without binding in any position. If necessary, the gear and its hub may be lapped slightly to eliminate binding, but not so that gear is noticeably loose on hub.

(b) Spring Disk Tension. With the securing nut firmly tightened, the clutch tension must be carefully checked using special torque wrench (41-W-3628-50) and scale (41-S-509) as shown in figure 146. Cover friction surfaces of drive gear and spring disk with lubricating oil. The gear should rotate with a steady, uniform pull of approximately 2¼ to 2¾ foot-pounds. If the tension is too great, install another shim. If gear moves too freely, remove sufficient shims to afford the proper slippage. The following three shim thicknesses are available: 0.035-inch, 0.049-inch, and 0.065-inch. Refer to SNL G-159.

(2) SLEEVE ASSEMBLY. Slide the sleeve assembly over the shaft of weight assembly. Pack bearings which are within sleeve assembly with special high-temperature grease.

(3) GOVERNOR SPRING. Install governor spring and slide it on spring seat, making sure that the proper number of spring spacers are used for correct adjustment (par. 73 b (7)).

(4) BEARING PLATE AND BRIDGE. Slide bearing plate on the opposite side of flyweight shaft, together with ball bearing and bearing bridge. These three parts are clamped together by clamping screws.

(5) DRIVEN GEAR. Assemble driven gear on shaft and firmly tighten in place with nut and lock washer.

(6) SPRING SEAT. Fasten assembly in vise as shown in figure 140, and using special spanner wrench (41-W-3247-716) and socket wrench, tighten the assembly firmly on shaft.

(7) FULCRUM YOKE ASSEMBLY. Fasten fulcrum yoke assembly to sliding ring of sleeve assembly by means of pivot screws and lock washers.

(8) OPERATING LEVER AND SPRING. Assemble the operating lever spring to the hub. The ends of the coil spring should straddle the spring plate which is an integral part of the hub. Spring must be so assembled that it will be under tension. Slide hub and spring assembly into fulcrum yoke hub so the spring straddles spring plate (fig. 139), and insert operating lever shaft as shown in figure 147.

(9) BUSHINGS. If necessary to install new lever shaft bushings in governor end cover, they must be carefully pressed into position and reamed with a $\frac{3}{8}$-inch straight reamer.

(10) OIL SEALS. New oil seals, which have been soaked for 24 hours in oil, must be pressed into position with an application of oil-resistant sealing compound on their outer circumference.

68. ASSEMBLY OF GOVERNOR FROM SUBASSEMBLIES.

a. General. Check over each subassembly to see that it is clean and has been properly assembled. Then proceed with assembly of governor.

b. Assembly.

(1) Place the internal mechanism, consisting of shaft and yoke assembly, in the governor end cover; fasten in place with the four bearing bridge screws.

(2) Slide the operating lever shaft assembly in place, being careful not to injure the shaft seals (fig. 147).

(3) Securely fasten hub for spring to shaft by means of set screw which has a pilot stud that fits into a hole in the operating lever shaft. Use a $\frac{3}{16}$-inch socket wrench for tightening the set screw. NOTE: *On late models, this set screw has been eliminated and is not required on the larger serrated shaft.*

(4) If control lever adjusting screws have been moved, reset them to their original positions according to measurement recorded at disassembly (par. 65 c (1) *(b)*).

(5) Secure the dust cover for stop flange with screw and lock washer.

Section VII

OVERHAUL OF FUEL TRANSFER PUMP

69. TEST AND DISASSEMBLY.

a. Test. Refer to paragraph 60 for test before disassembly. This test will determine the need for overhaul, and the extent of disassembly necessary to correct the diagnosed cause of malfunction. The fuel transfer pump may stop pumping due to dirt embedded in the valves. Springs of these same valves sometimes break, causing pump failure. Before disassembling the pump completely, valves should be inspected and cleaned when failure is noted during dynamometer test (par. 51) to determine if embedded dirt is the cause of failure. If pump fails after valves are cleaned, disassemble it to locate the cause.

b. Disassembly.

(1) REMOVE VALVES. Mount pump in vise, using jaw-liners. Unscrew and remove priming pump and remove gasket, spring, and inlet valve. Remove hexagonal screw and remove outlet valve assembly. NOTE: *Inlet and outlet valve parts are identical* (fig. 148).

(2) REMOVE PUMP PLUNGER. Unscrew and remove large retaining screw, and take out gasket, spring, and plunger.

(3) REMOVE TAPPET PARTS. Press tappet assembly down slightly to counteract the spring pressure, and push out tappet securing pin. Push tappet wrist pin from shell. Lift out roller, shell, spring, and spindle.

70. CLEANING, INSPECTION, AND REPAIR.

a. Clean. Wash all parts thoroughly in dry-cleaning solvent, and dry with compressed air. Blow compressed air through oil passages in housing and through fuel inlet and outlet openings.

b. Inspect.

(1) VALVE SEATS IN HOUSING. Examine seat surfaces carefully, and if not perfectly smooth and free from stain or corrosion, resurface (subpar. **c** (1) below).

(2) VALVES. Examine seating surface of both inlet and outlet valves, and if pitted or grooved, replace valve or resurface (subpar. **c** (2) below).

(3) SPRINGS. Inspect all springs carefully for broken or distorted coils. Replace any distorted, broken, or weak springs.

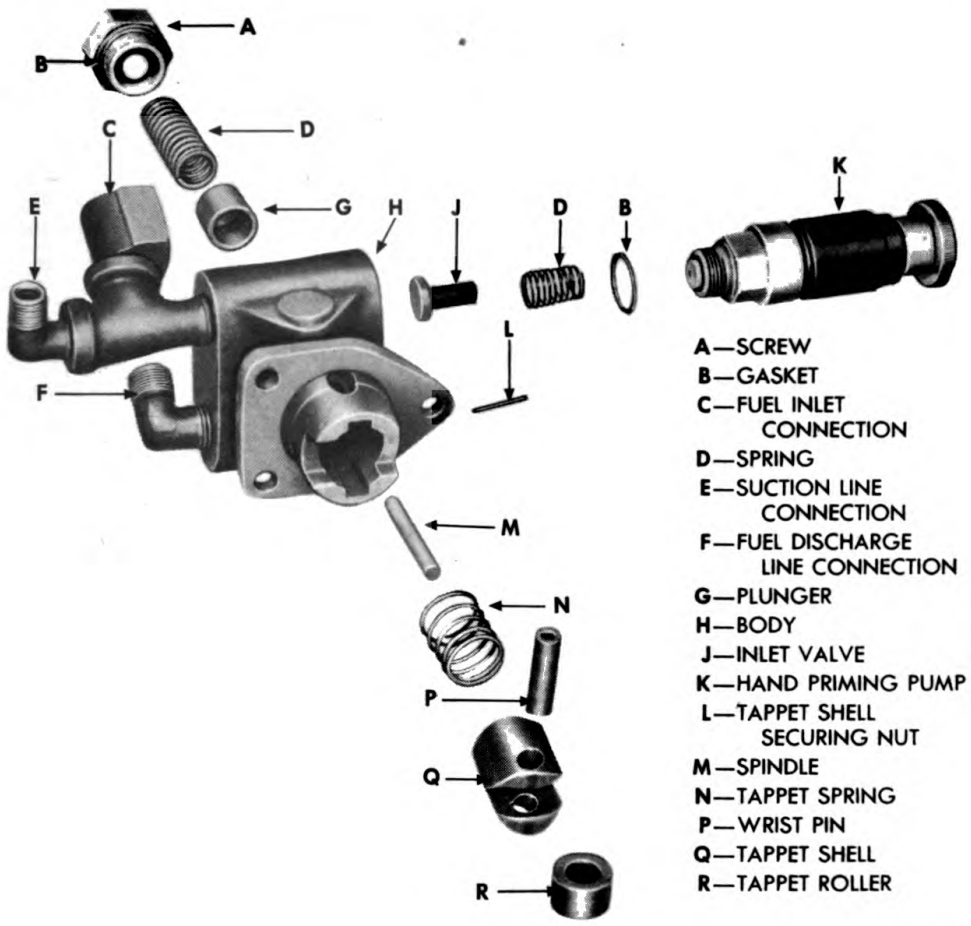

Figure 148—Fuel Transfer Pump, Partly Disassembled

(4) TAPPET PARTS. Examine all parts for wear or scoring.

(a) Roller and Pin. If there is any appreciable shake or looseness between roller and pin, replace both parts.

(b) Tappet Shell. If tappet shell is worn or scored, replace it.

(c) Housing Bore. If new tappet shell fits loosely in bore of housing or if bore is scored, replace housing.

(5) PLUNGER AND PARTS.

(a) Plunger and Spindle. Inspect plunger for any indications of pitting or scoring, and for possible distortion from hammering action of spindle. Replace plunger and spindle if either of these parts is worn or pitted.

(b) Housing Bore. Check plunger bore in housing and, if this bore is worn or scored, replace the housing.

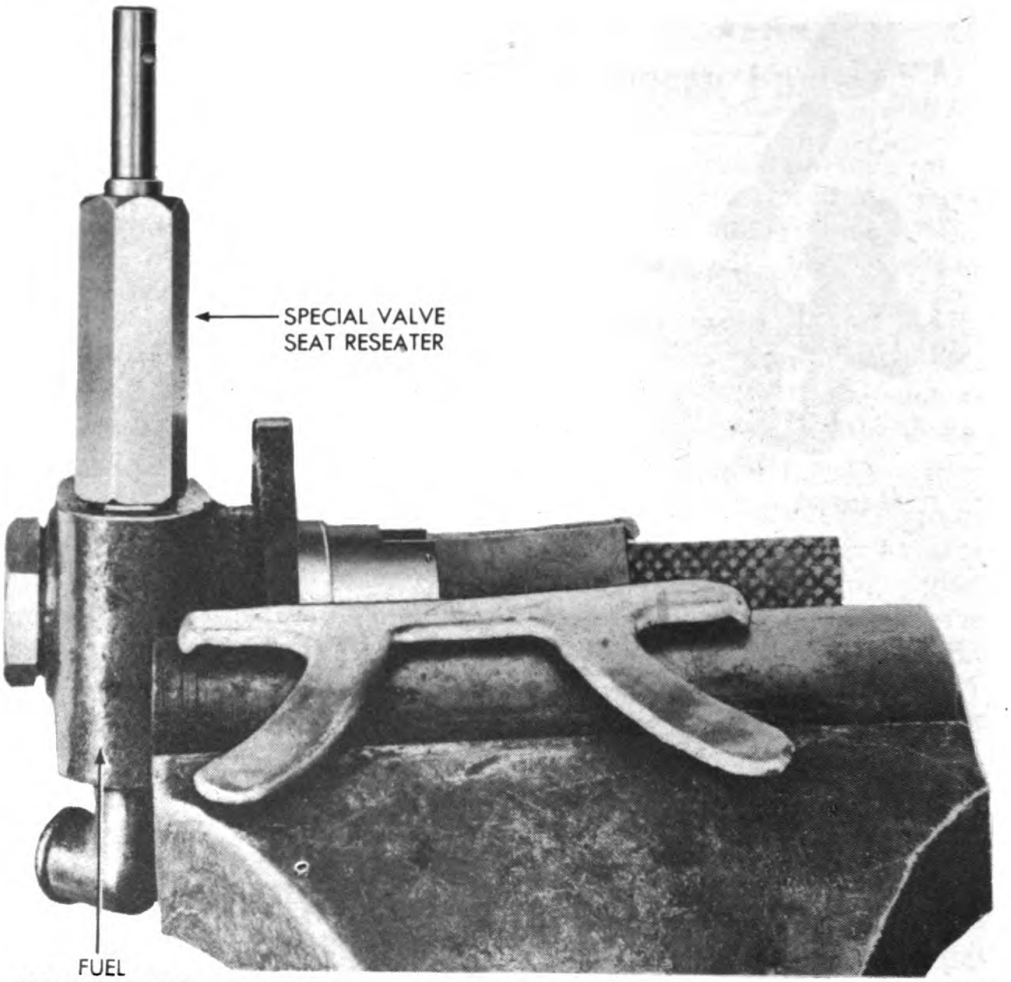

Figure 149—Set-up For Refacing Fuel Transfer Pump Valve Seat, Using Special Reseater (17-R-6072-150)

(6) HAND PRIMING PUMP. This pump cannot be disassembled for inspection or repair; if test proves it is defective, or if it does not function properly, replace the entire unit.

c. Repair.

(1) VALVE SEATS. When inspection shows that inlet or outlet valve seats need resurfacing, mount pump housing in vise and lap the seats with valve seat reseater (17-R-6072-150) as shown in figure 149. After lapping is finished, wash pump housing thoroughly in dry-cleaning solvent.

(2) VALVES. Chuck defective valve in a lathe, and reface it by taking a light cut off the seating surface.

71. ASSEMBLY.

a. Before Assembly. Rinse all parts in clean, well-filtered fuel oil before assembly, but do not dry parts.

b. Install Tappet. Place tappet roller in tappet shell and insert wrist pin. Insert tappet spring in housing and slide tappet shell over spring, compressing spring enough to insert securing pin through hole in tappet shell. Do not rivet ends of securing pin.

c. Install Plunger. Insert spindle through plunger bore, with end of spindle in contact with inner face of tappet shell. With the recess of spindle toward tappet side, slide plunger in bore and insert spring. Insert retaining screw with new gasket and tighten securely.

d. Install Valves. Insert inlet and outlet valves, head-foremost, in openings at top of pump housing, and slide a valve spring over the stem of each valve. Use new gasket and screw priming pump in right-hand (inlet valve) opening. Use new gasket and insert retaining screw in left-hand (outlet valve) opening. Tighten both priming pump and retaining screw. Install two pipe line elbows in bottom of pump (fig. 109).

Section VIII

ASSEMBLY AND TEST OF FUEL INJECTOR PUMP, GOVERNOR, AND FUEL TRANSFER PUMP ASSEMBLY

72. ASSEMBLY.

a. Install Fuel Transfer Pump. Turn camshaft of fuel injector pump so that flat side of lobe which drives the transfer pump is toward the opening. Install gasket and insert transfer pump in opening, with holes in flange over studs. Be careful to prevent tappet roller from falling out of transfer pump. Fasten the assembly in place with three stud nuts and lock washers.

b. Test Fuel Injector Pump and Transfer Pump. Mount the assembly on test stand, and repeat the tests for timing and calibration (par. 58 a and b). While assembly is on test stand, test the fuel transfer pump as outlined in paragraph 60. When both tests have proved satisfactory, mark the assembly "TESTED."

c. Install Governor End Cover.

(1) Install governor housing gasket.

(2) Install governor end cover assembly, making sure linkage pin fits into hole of the extension arm of fulcrum yoke assembly.

NOTE: *Before securing governor end cover to housing by means of fastening screws, make certain that drive gear does not assume a position where there is danger of the outer face of the gear rubbing on the bearing bridge. If teeth of gear rub, relocate the camshaft in fuel injector pump by shifting bearing spacers.*

(3) Secure governor operating lever with screw and lock washer. Install lever in same position from which it was removed.

(4) Install bumper spring adjusting screw assembly, which consists of spring with button and adjusting screw. Adjust to its original position and tighten lock nut to hold it in this position.

(5) Fasten inspection cover and gasket in place with screws.

(6) If governor end cap was removed, install it in position with gasket. Repack end cap bearing with ball and roller bearing grease. Secure end cap with four screws.

(7) Install side cover plate on governor stop flange with two screws and washers. NOTE: *Stake all housing and cover screws.*

d. Protect Assembly From Dust.

(1) Make sure that protecting caps are on all delivery valve holders to prevent dust from entering until pump is installed on engine.

(2) Make sure that all gallery and sump openings are closed.

(3) If the assembly is not being installed on engine immediately, plug the elbow opening at fuel transfer pump to prevent the entrance of dust or other foreign matter.

73. TEST AND ADJUSTMENT OF GOVERNOR.

a. Hand-Test. After governor end cover is installed, make hand-test by turning shaft and control levers to make sure parts operate freely. After assembly is installed on engine, test operation and adjust for speeds. Adjustment can be made with engine mounted on the dynamometer stand or in the vehicle.

b. Adjustment on Engine.

(1) Remove dust cover from stop flange (fig. 109).

(2) Remove the cap nut and withdraw adjusting screw as far as possible without allowing it to fall out.

(3) Add lubricating oil to injector pump until oil flows from the overflow fitting. The injector pump camshaft and governor compartments are interconnected. Execessive oil prevents satisfactory operation of governor; therefore, care must be taken not to add more oil than necessary to reach level of overflow fitting (fig. 109).

(4) Warm up the engine thoroughly before attempting to make any adjustments. Governor idling speed is 500 revolutions per minute; maximum engine speed under no load is 1,625 revolutions per minute.

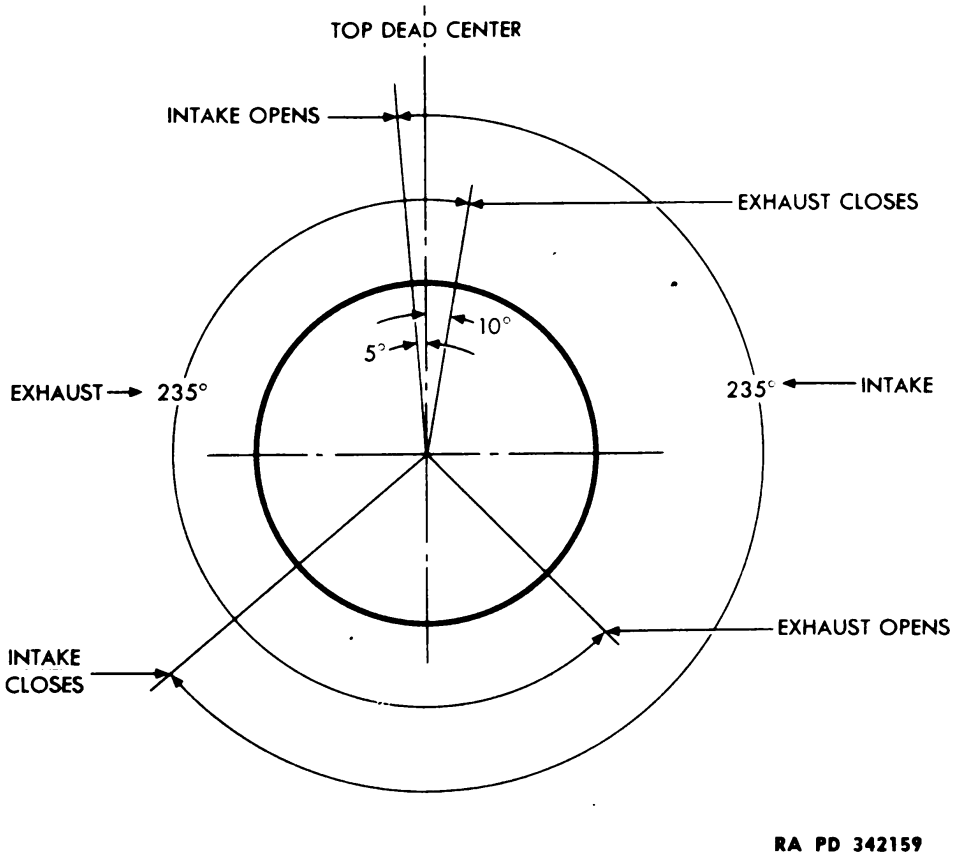

Figure 150—Flywheel Timing Diagram

(5) With no load on engine, move governor operating lever toward full load position until the stop plate on lever shaft contacts the full load forward stop adjustment screw (K, fig. 109). If speed is lower than 1,600 revolutions per minute, raise the forward stop adjustment set screw (K, fig. 109); if speed is over 1,625 revolutions per minute, lower the set screw to obtain an engine speed between 1,600 to 1,625 revolutions per minute. If engine has a surge, screw in the bumper spring adjusting screw (H, fig. 109) slightly until the governor mechanism is reasonably steady. After the correct high idling speed is obtained, secure the stop adjustment screw by means of lock nut, and recheck the speed.

(6) Move the control lever in the direction of less speed (toward the injector pump) until engine reaches correct idling speed. Hold operating lever in this position, and screw in rear stop adjustment screw (K, fig. 109) until lower end touches the stop on the operating lever shaft. Lock screw in this position; then recheck engine idling speed.

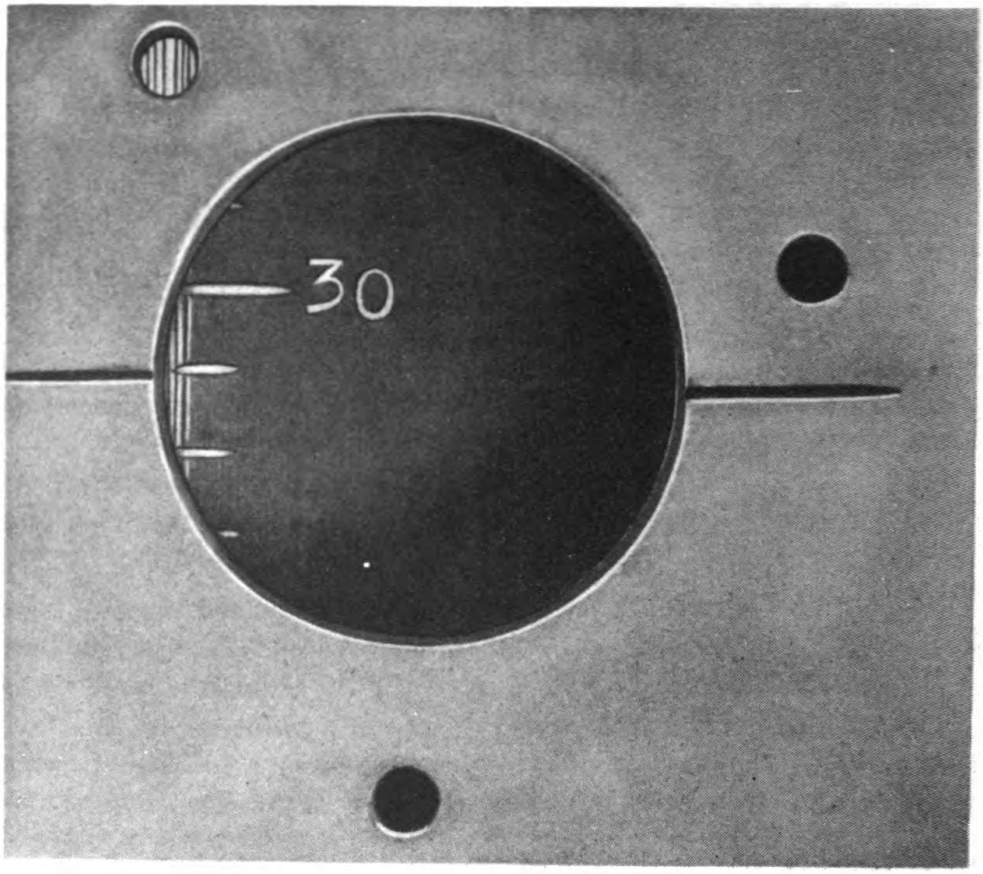

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Figure 151—Timing Marks on Flywheel

(7) In addition to the external adjusting screws, slight adjustments are possible by removing or adding adjusting spacers between the spring and the sliding sleeve assembly (fig. 141).

74. TIMING FUEL INJECTOR PUMP WITH THE ENGINE.

a. Flowing Method. Note the line on flywheel marked "DC" (dead center), and the graduations from this line which show degrees of crankshaft travel. From dead center, these lines are marked "30" and "40"; also marked every 2 degrees from 26 to 40 degrees (fig. 52).

(1) SPOTTING THE FLYWHEEL.

(a) Rotate flywheel by means of hand crank until the "DC" mark appears in timing hole in bell housing (fig. 151). Be sure the No. 1 piston is just completing the compression stroke, and beginning the expansion stroke (fig. 150). This is done by removing the nozzle from No. 1 cylinder, turning the engine over, and noting the point at which the compression ceases.

(b) Rotate engine in direction of degree graduation marks, which is the reverse to engine rotation, until the graduation mark "29" is directly in line with the mark in the center of the timing hole in bell housing (fig. 151). The crankshaft will then be spotted at 29 degrees before top dead center, at which point the fuel pump is set for port closing.

(2) Install pump assembly; tighten all attaching cap screws, but leave the rear half of coupling loose from the front half so pump shaft can be rotated while the drive shaft remains stationary. Note that disk of drive coupling is slotted so that loosening the two cap screws enables the marked disk to be moved for permanent timing adjustment (fig. 152). Connect all fuel suction and discharge pipes from fuel tank to pump. Install all fuel lines except the line to No. 1 cylinder.

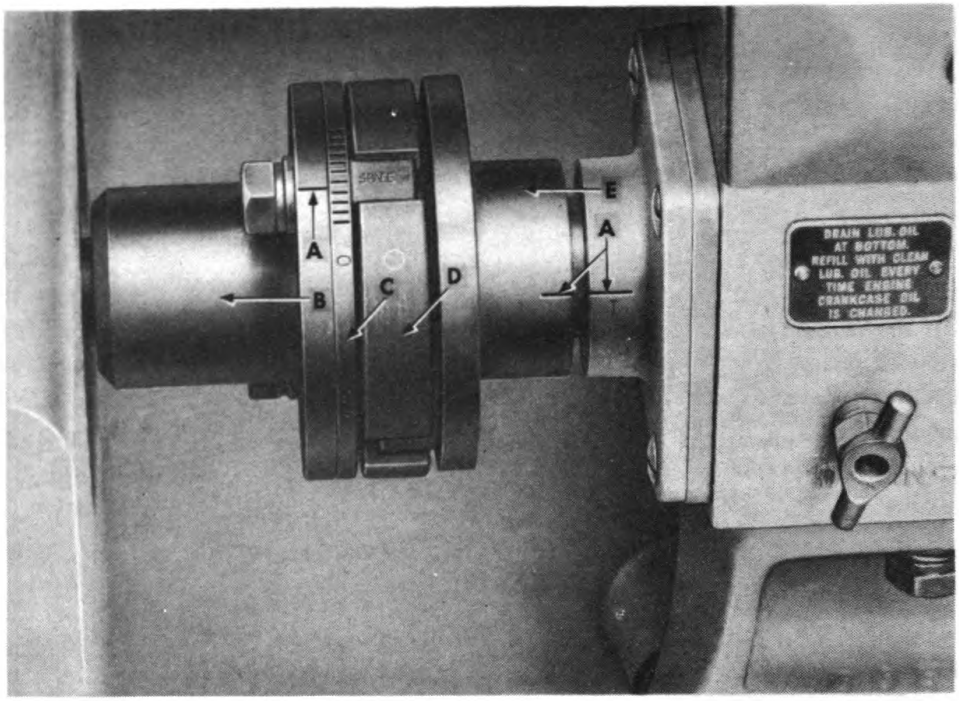
(3) With governor stop lever in wide-open or full-load position, prime the fuel transfer pump with hand-primer.

(4) Put governor stop lever in stop position, and remove pump delivery valve holder from No. 1 pumping unit. Remove delivery valve and spring, but do not remove the seat (fig. 126). Replace delivery valve holder finger-tight.

(5) Put governor stop lever in wide-open or full-load position. Fuel should now rush out of the delivery valve holder. Rotate pump shaft over the top and toward the engine by means of the rear half of coupling until flow of fuel stops. If fuel did not flow when governor stop lever was first opened, rotate shaft until fuel does; then back to a point so that flow is just off. Use hand priming pump to keep fuel pump manifold supplied with oil.

(6) Very carefully rotate shaft until fuel just barely flows, then back to a point at which flow is just barely shut off. Repeat this two or three times until a movement of less than $\frac{1}{64}$ inch on the circumference of the coupling will constitute the difference between the flowing of fuel and its stop. This determines the point where the pump plunger just closes the fuel port, and begins the period of building up pressure in the lines and nozzles so that injection can start; it is very important that this adjustment be minutely accurate.

(7) Connect the front and rear halves of the fuel pump coupling together with cap screws provided. But sure these screws are tight so that no slippage can occur but not so tight as to strip threads. Do not use a wrench over 6 inches long for tightening. Carefully note if any slight movement while tightening causes fuel to start flowing again from delivery valve holder; when screws are tight, no fuel should flow. The fuel injector pump is now timed to close the ports at 29 degrees before top dead center.



A—TIMING MARKS
B—FRONT HUB
C—ADJUSTABLE SLOTTED FLANGE
D—FLANGE DISK
E—REAR HUB

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Figure 152—Fuel Injector Pump Coupling

(8) Put governor stop lever in stop position again. Remove delivery valve holder, and install the delivery valve and spring. Install delivery valve holder and tighten firmly. Be careful not to get dirt, water, or any other foreign matter in or on any of these parts. CAUTION: *Do not tighten so tight as to distort fuel pump case.*

(9) Connect fuel line to pump No. 1 cylinder. Prime fuel lines, being sure the fuel pump, strainer, and all lines are full of fuel and contain no air.

(10) Start engine. If engine runs irregularly or one cylinder cuts out, check lines, filters, and fuel transfer pump for malfunction or blocked condition. After checking all points, if engine still runs irregularly, stop and recheck timing.

(11) After engine is operating smoothly and has been properly warmed up, stop the engine. With a light chisel and hammer, enlarge the single mark on front hub and put a corresponding mark on the other hub so that these two marks can be lined up at any future time without the necessity of again flowing the pump (fig. 152).

75. TIMING FUEL INJECTOR PUMP WITH THE ENGINE WHEN COUPLINGS ARE MARKED.

a. When engine was shipped from the factory, couplings were marked as shown in figure 152. Before removing the fuel pump assembly from the engine, these marks should be carefully checked. If they are dim or worn off, mark them clearly again so that they can easily be seen when unit is installed. To ensure correct timing, observe the following points when installing the unit on the engine:

(1) Spot the flywheel at the proper degree before top center as outlined in paragraph 74 **a** (1).

(2) Install pump assembly on engine, tightening all attaching screws but leaving rear half of coupling loose from the front half so that pump shaft can be rotated while the drive shaft remains stationary.

(3) Rotate rear half of coupling until the heavy mark on it lines up with the heavy mark on the front half of coupling.

(4) Install and tighten attaching screws which connect the two coupling halves. Make sure the marks are lined up perfectly, and that attaching screws are tight.

(5) Install all fuel piping.

(6) Prime fuel lines.

(7) Start the engine.

76. TIMING NEW FUEL INJECTOR PUMP WITH THE ENGINE.

a. On a new fuel injector pump, the dust shield and rear half coupling hub are marked at the point of port closing (fig. 152) so it will not be necessary to flow the pump. To install a new pump assembly, follow the procedure in paragraph 75. Start the engine and allow it to warm up thoroughly. Then stop engine, and with a light chisel and hammer, mark rear hub with a line corresponding with heavy mark on front hub so that these two marks can be lined up at any future time. If engine does not function properly when started, stop engine and check the markings of rear hub and dust seal making sure that these marks line up perfectly. Also check spotting of flywheel to see that No. 1 piston is at 29 degrees before top dead center when marks are lined up. If engine still runs irregularly after this check, flow the pump as outlined in paragraph 74. NOTE: *A new pump does not require timing or calibration on test stand, as it has been timed and calibrated at the factory; however, it may be necessary to test a new pump on stand because of possible damage or tampering.* For test on test stand, refer to paragraph 58 **b**.

Section IX

FUEL NOZZLES

77. DESCRIPTION AND DATA.

a. Description (fig. 153). Injection of fuel into engine cylinders is through six nozzles, one for each cylinder, and each connected by means of hydraulic tubes to an individual fuel injector pump element. Each nozzle consists of a nozzle holder assembly which forms a housing for an adjustable spring-loaded spindle. The pintle valve is held seated in its single-spray hole by spring pressure transmitted to its base through the spindle. Spring pressure is adjusted by pressure adjusting washers to permit the pintle to lift from its seat when fuel pressure reaches 2,000 pounds per square inch. During operation, the fuel charge from fuel injector pump enters nozzle body through a side connection which communicates with the pressure chamber directly behind the valve seat and pintle. It is here that the hydraulic pressure acts on the differential area of the pintle valve, moving it from its seat against the force of spring pressure. The nozzle pintle returns to its seat the instant hydraulic pressure drops, at the completion of the injector pump plunger pressure stroke. A small amount of fuel passes back through the fuel leak-off stud, and flows back into the fuel tank through a connecting overflow line.

b. Data.

Make	American Bosch
Type	Closed, pintle
Model	AKB 35S-508
Opening pressure	2,000 lb
Location	Cylinder heads, side

c. Purpose. The function of nozzles is to direct the metered quantity of fuel received from the fuel injector pump into the engine combustion chamber in a definite spray pattern, and in such a manner as to produce the most efficient engine performance.

78. TEST ON TEST STAND.

a. Test each nozzle for leaks and opening pressure before disassembly for overhaul. Use test stand (17-S-15550) as shown in figure 154. CAUTION: *Keep hands away from the spray to avoid serious injury. The fuel spray from a nozzle being tested has sufficient penetrating power to puncture the flesh.*

b. Connect Nozzle to Test Pump. Before connecting nozzle to pump for test, fill pump fuel container with well-filtered, clean fuel oil and prime the pump. To prime pump, close gage valve by turning

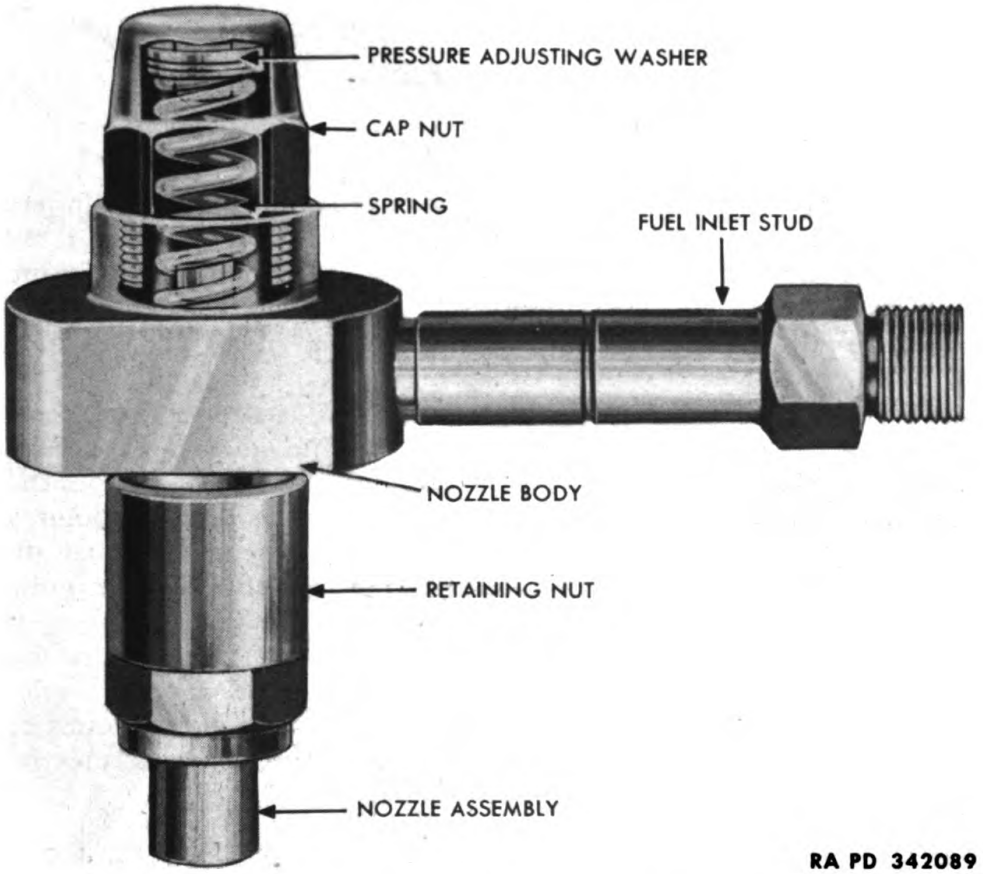
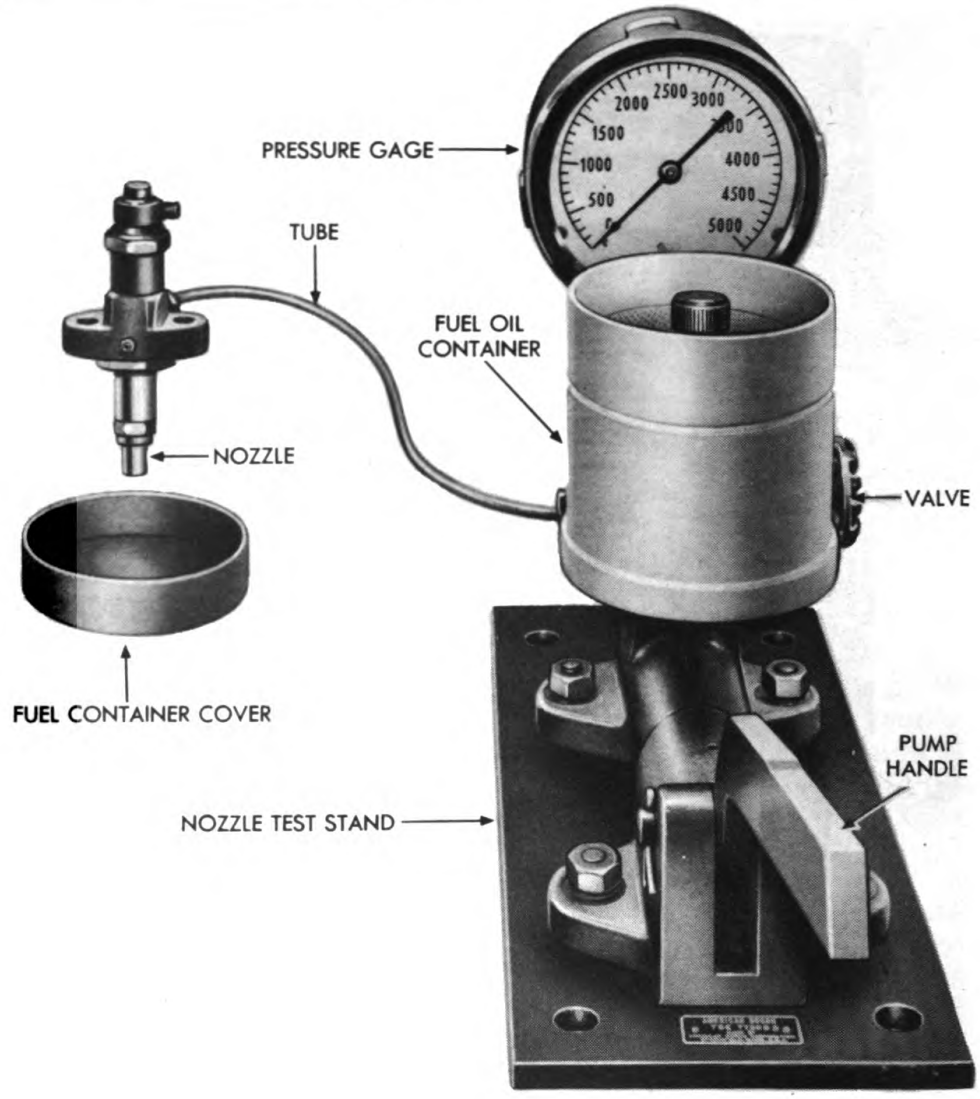


Figure 153—Cutaway View of Fuel Nozzle

clockwise, unscrew priming screw two turns, pump the lever until fuel oil comes out freely at priming screw, and then close the screw. Priming is necessary only when starting with a dry pump. Keep fuel oil container filled to avoid necessity for repeated priming. Attach nozzle holder body to the end of fuel line, making sure all connections are tight. Clean pintle end, which protrudes through body retaining nut, with a wire brush (fig. 156).

c. Test and Adjustment.

(1) OPENING PRESSURE. Pump the lever with quick strokes for a shock test of the nozzle. Open gage valve by turning in counterclockwise direction, and pump the lever with steady, even strokes until gage indicates pressure is 2,000 pounds per square inch; at this point the pintle will pop open, provided opening pressure is correct. If pintle opens above or below this point, adjust spring tension. Remove cap nut, and add adjusting washers to raise opening pressure; take out adjusting washer to lower opening pressure. Pressure-adjust-

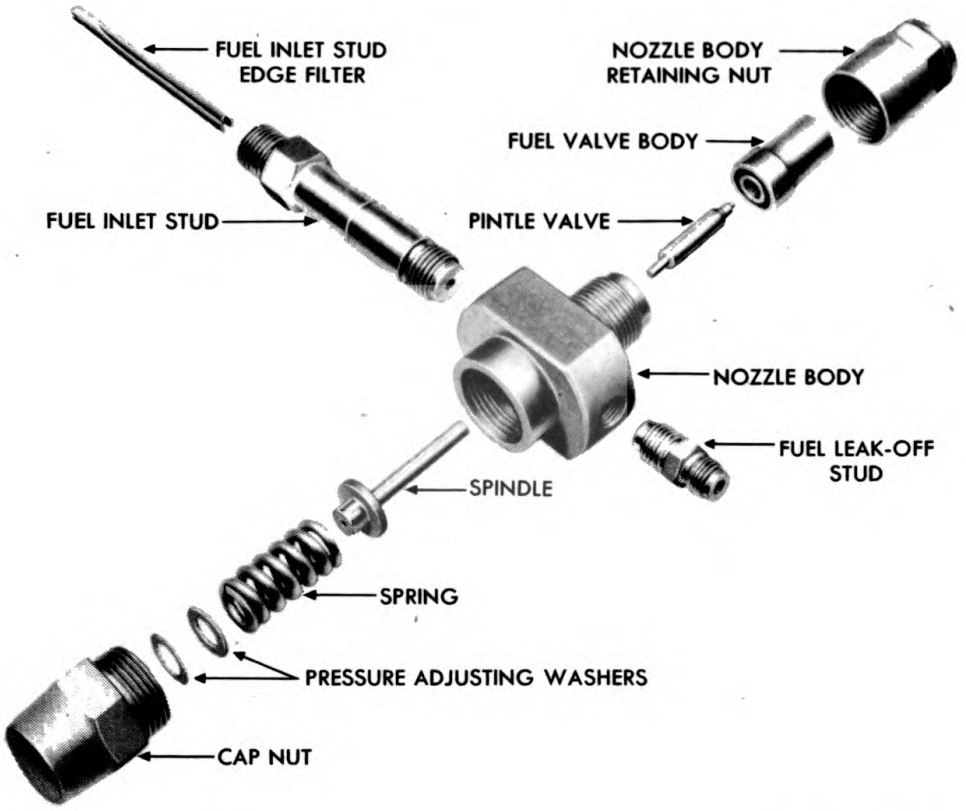


RA PD 342200

Figure 154—Set-up For Testing Nozzle Opening Pressure, Using Nozzle Test Stand (17-S-15550)

ing washers are available in the following thicknesses (measured in millimeters): 0.05-, 0.1-, 0.2-, 0.5-, 1.0-, 2.0-, and 3.5-inches (SNL G-159). Make several tests and set pressure as accurately as possible. New nozzles are shipped from factory set at 2,050 pounds per square inch.

(2) ADJUSTING SPRAY. The spray should be an 8-degree included angle and of uniform and regular pattern, free from uneven branches or streams and the same thickness of oil spray all around the oil spray cone, as it will appear at a point 2 to 5 inches from the



RA PD 342099

Figure 155—Fuel Nozzle, Disassembled

end of nozzle. An uneven or rough stream indicates a dirty nozzle hole or a dirty or defective pintle which must be polished with a pointed stick and soft cloth. If there is an "after-dribble" of oil out of the nozzle after the spray is completed, the nozzle hole and pintle are not clean and should be polished. If there is no leakage past the pintle when pressure is held within 300 pounds of 2,000 pounds opening pressure, the nozzle is tight. No adjustment is necessary if pressure has only dropped to 1,950 pounds per square inch.

79. DISASSEMBLY (fig. 155).

a. Preliminary Precautions. Before disassembling nozzles, bear in mind the following precautions:

(1) Do not mix parts. Keep them in sets so that the same parts taken from each nozzle will be assembled in the nozzle from which it was removed.

(2) Hard or sharp tools, emery paper, crocus cloth, grinding powder, or any other type of abrasive material must never be used.

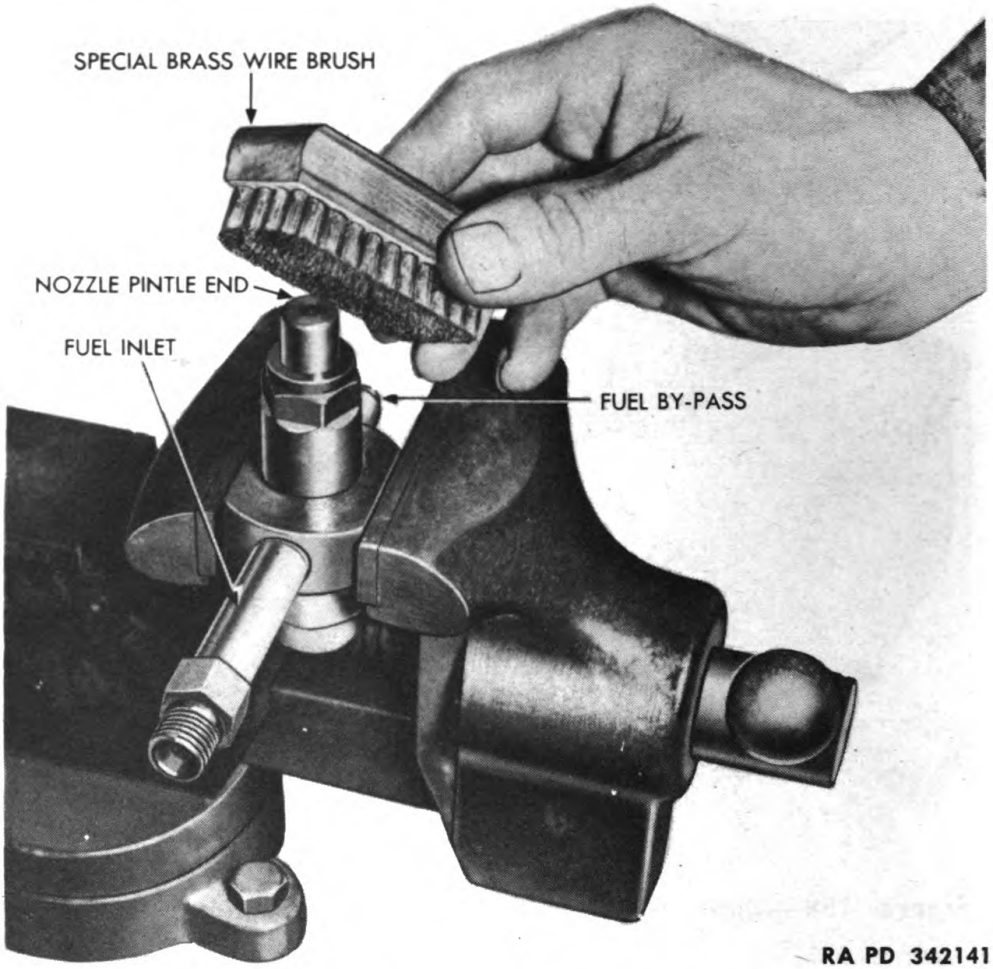


Figure 156—Cleaning Pintle End of Nozzle, Using Special Brass Wire Brush (38-B-982)

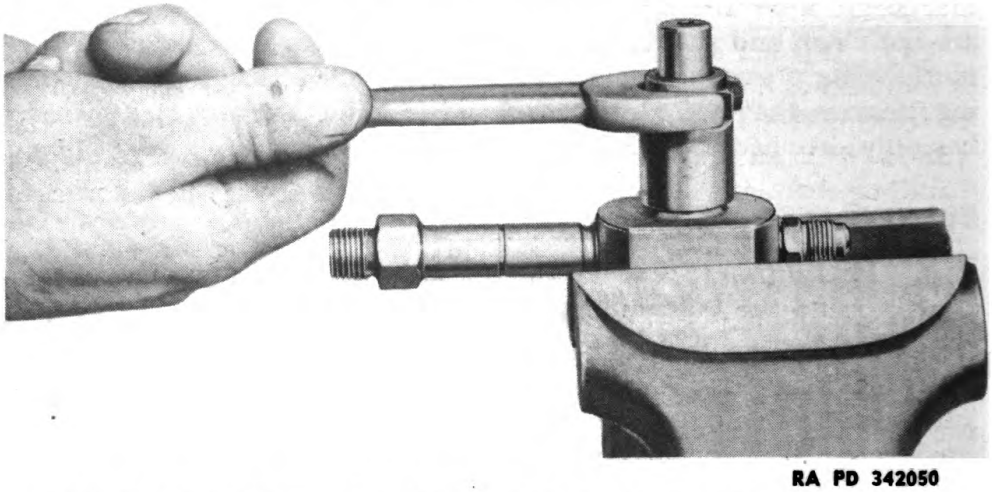


Figure 157—Removing Nozzle Body From Nozzle Holder

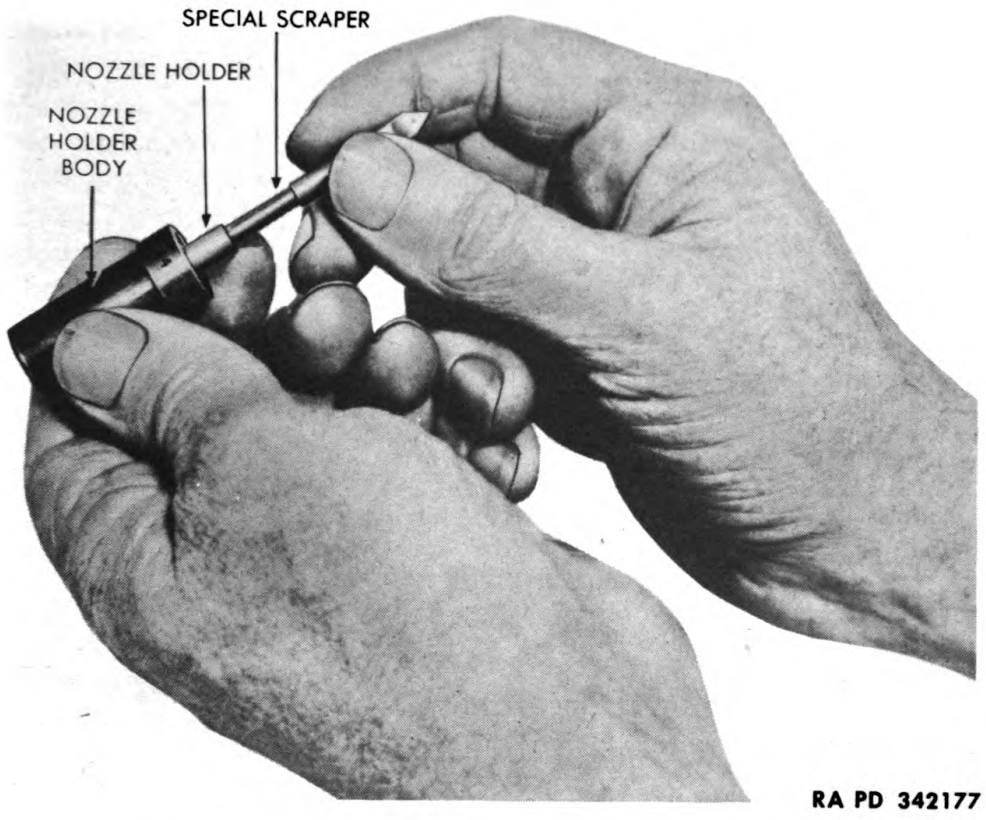
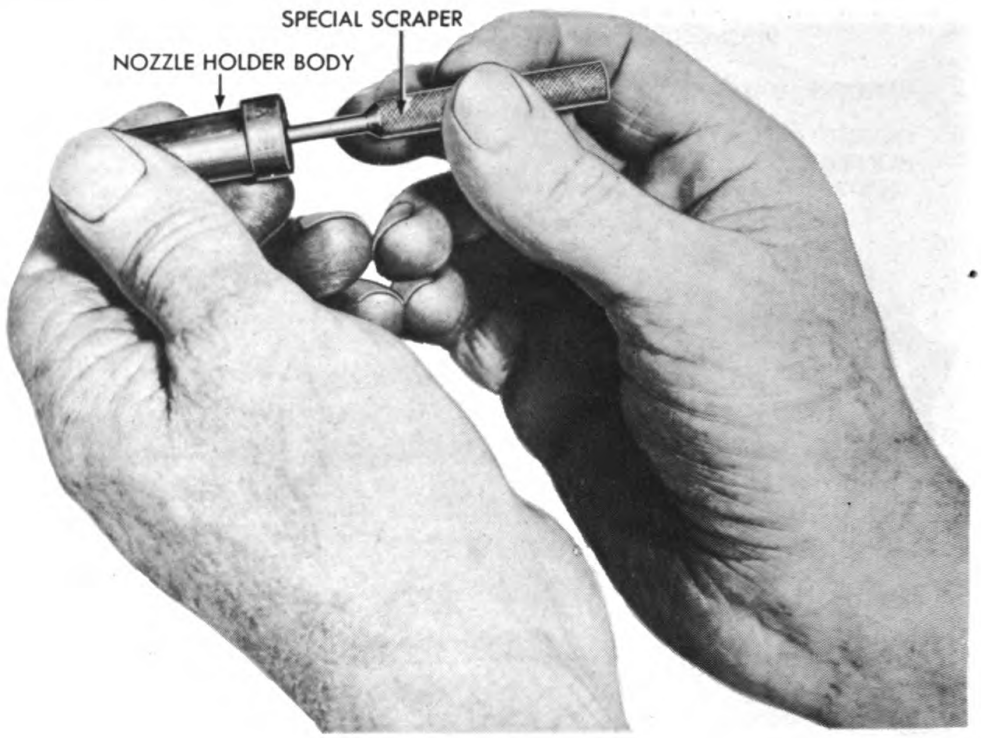


Figure 158—Cleaning Carbon From Nozzle Valve Seat, Using Special Scraper (17-S-250-65)

(3) Before assembling, wash and rinse all parts perfectly clean and smear with good clean lubricating oil or petrolatum so that valve will revolve freely. Nozzle retaining nut must be tightened securely.

(4) It is not necessary to disassemble nozzle if cleaning is all that is required to put it in serviceable condition. Use dry-cleaning solvent or carbon tetrachloride and clean with special brass-wire brush (38-B-982), on pintle end of nozzle as shown in figure 156. Avoid handling the pintle with fingers, especially after it has been thoroughly cleaned.

b. Disassembly (fig. 157). Using a vise with soft jaw liners, mount complete nozzle holder vertically with pintle pointed upward, being careful not to grip the cylindrical, machined portion of valve body. Unscrew nozzle body retaining nut and remove nut, pintle, and nozzle valve body as a unit. If carbon or a tight gasket prevents easy removal of body from nut, do not grip retaining nut in vise, but rest outer end of valve body on a brass bushing and drive nut free with a block of wood. Withdraw pintle from valve body. CAUTION: *Do*



RA PD 342176

Figure 159—Cleaning Carbon From Pressure Chamber of Nozzle, Using Special Scraper (17-S-250-65)

not use a pipe wrench or pliers, and do not apply heat to loosen parts. When pintle is removed, do not touch the lapped surfaces with the fingers. This precaution also applies to nozzle body holder and nozzle valve body. As parts are removed, soak them in carbon tetrachloride. Be careful to keep each pintle with its valve body as these are mated parts. Do not permit these parts to become damaged by contact with other parts or with any other object.

80. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. For trouble-free functioning of spray nozzles, cleanliness is of supreme importance. Spread some clean paper on the workbench and have available a clean dish or open container for clean fuel oil; one pint of fuel oil is sufficient. Also have a supply of soft, clean, lint-free wiping cloths, a clean squirt can of clean lubricating oil, and a jar of petrolatum.

(1) SPRAY NOZZLES. Spray nozzles must be cleaned by first soaking them in dry-cleaning solvent or carbon tetrachloride to soften the carbon and dirt.

(2) INTERIOR OF BODY. Interior of the body can be cleaned with a small strip of wood dipped in dry-cleaning solvent.

(3) SPRAY HOLE. Spray hole can be cleaned with a pointed piece of soft wood. Rub the nozzle valve with a clean, oil-soaked, soft, lint-free rag. CAUTION: *Do not use sharp tools, emery paper, crocus cloth, grinding powder, or abrasives of any kind.*

(4) VALVE SEAT. To clean carbon from nozzle valve seat, use special scraper (17-S-250-65) as shown in figure 158.

(5) PRESSURE CHAMBER. To clean carbon from pressure chamber of nozzle, use special scraper (17-S-250-25) as shown in figure 159.

b. Inspection and Repair.

(1) SPRING. Examine spring with a magnifying glass for surface cracks or corrosion-pitting. Replace spring if damaged or defective.

(2) BODY. Do not touch lapped surface of body with fingers. Examine surface with magnifying glass, and if it is rough, pitted, or scratched, replace body and mated pintle assembly; however, replacement may not be necessary if surface can be conditioned by slight lapping, using plate and lapping compound. Do not use valve-grinding compound. After lapping, make sure all compound is cleaned from body.

(3) NOZZLE HOLDER. Examine all threaded portions of nozzle holder body and using a magnifying glass, examine lapped surface of pintle end. If surface has minor pits or scratches which can be cleared up by lapping, use plate and lapping compound for this operation. If surface is in bad condition or if body is otherwise defective, replace it.

(4) OTHER PARTS. Examine all other parts of nozzle holder unit, and replace it if threads are damaged or other defects are found.

81. ASSEMBLY AND TEST.

a. Precautions. If more than one nozzle unit has been disassembled, arrange to completely assemble one nozzle before working on another, and thus avoid the possibility of mixing parts. Rinse parts in clean fuel oil just before assembly, but do not dry them.

b. Assembly.

(1) Insert fuel nozzle pintle into nozzle body, and insert nozzle body assembly into retaining nut; screw this assembly onto holder.

(2) Insert spring into nozzle cap nut, insert pressure adjusting washers, fit spring against spindle, and screw the cap nut onto holder.

(3) Install brass fuel line connection.

(4) Install spindle valve and holder fuel inlet stud, including edge filter.

(5) Use vise with jaw liners (fig. 157), and tighten nozzle retaining nut up hard.

c. Test. After assembly, test each nozzle on test stand (17-S-15550) as outlined in paragraph 78.

Section X

STARTER BURNER

82. DESCRIPTION AND DATA.

a. Description. The starter burner is mounted on the forward section of the air intake manifold (B, fig. 1). The heating element burns fuel oil injected by means of a hand-operated pump on the dash on the left side of instrument panel. When this pump is operated at the same time that the starter button is depressed, fuel oil is sprayed into the spark between high-tension and low-tension electrodes (fig. 160). This creates a flame inside the intake manifold, thereby supplying preheated air to the cylinders when low temperature is the cause of hard starting.

b. Data.

Make	Diamond T
Assembly part number	DT-BB-23349
Electrode gap	$\frac{3}{32}$ in.

83. DISASSEMBLY (fig. 161).

a. Electrical Parts. After taking out the four cap screws and removing the cover (fig. 162) disassemble the electrical components as follows:

(1) Remove high-tension cable and rubber insulating nipples. Remove ground wire and pressure switch to coil cable.

(2) Remove high-tension electrode by unscrewing. Be careful not to bend the electrode wire.

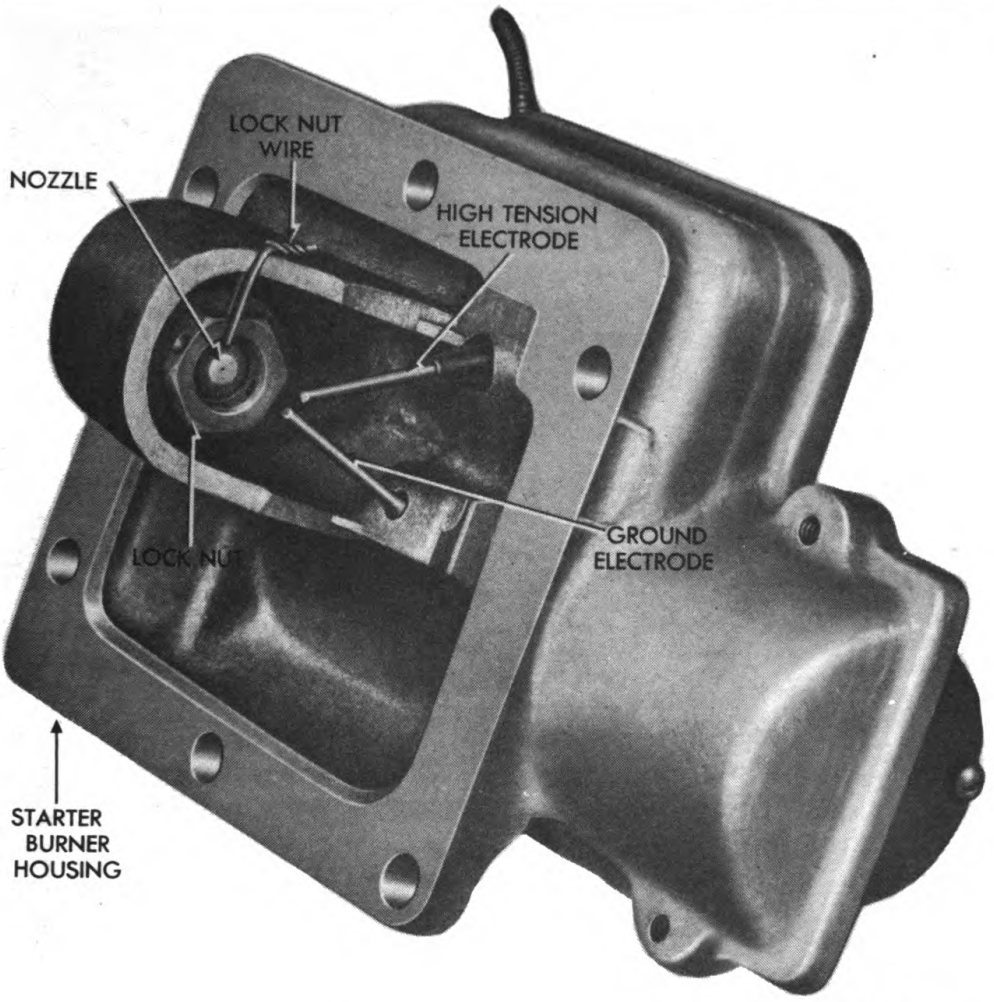
(3) Lift out spark coil and felt padding; then unscrew and remove ground electrode which is located underneath the spark coil.

(4) Remove pressure switch by unscrewing from tee.

(5) Take out two screws and remove metal cap from condenser. It is not necessary to remove condenser, as this part is not replaceable. Cap is removed only for inspection and cleaning.

b. Nozzle Parts. Turn housing over and remove nozzle assembly as follows:

(1) Remove lock wire which ties lock nut to body flange; then unscrew nozzle assembly, removing it from housing.



RA PD 321307

Figure 160—Starter Burner, Showing Nozzle and Electrodes

(2) Place the assembly in a vise, with vise holding the hexagon lock nut. Use a large machinist's screwdriver in slots of inlet stud, and unscrew.

(3) Place nozzle body in vise and unscrew adapter. Take out screen by unscrewing; then take out fuel nipple from nozzle head by unscrewing.

84. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. Clean body, paying special attention to nozzle opening, as dirt is most likely to accumulate at this point. Scrape out heavy dirt, and wash with dry-cleaning solvent. Check contact points and clean with No. 00 flint paper. Clean the fine-mesh screen and fuel nipple, and blow out fuel nipple hole. Do not use a needle or pin in fuel nipple hole.

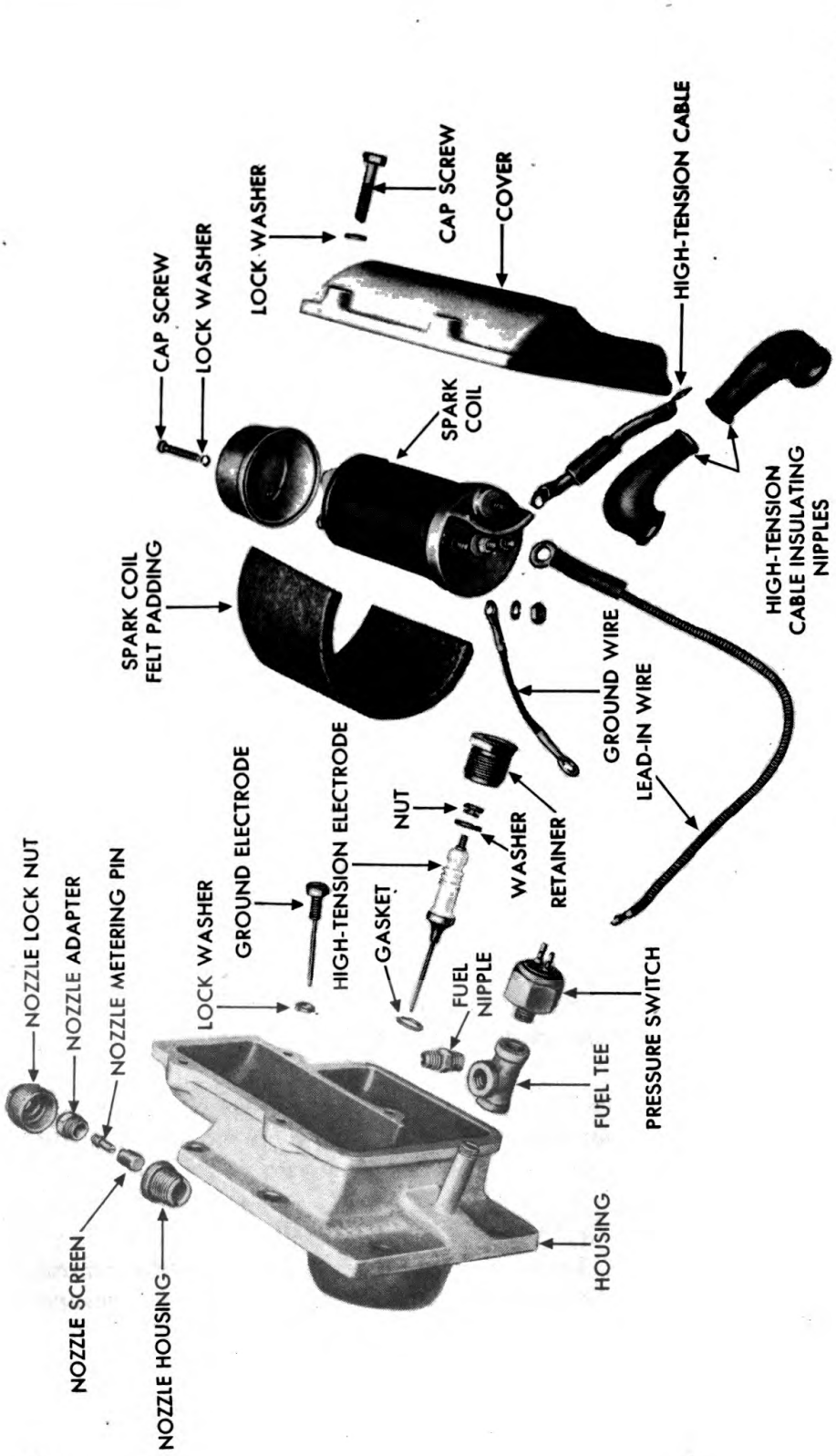
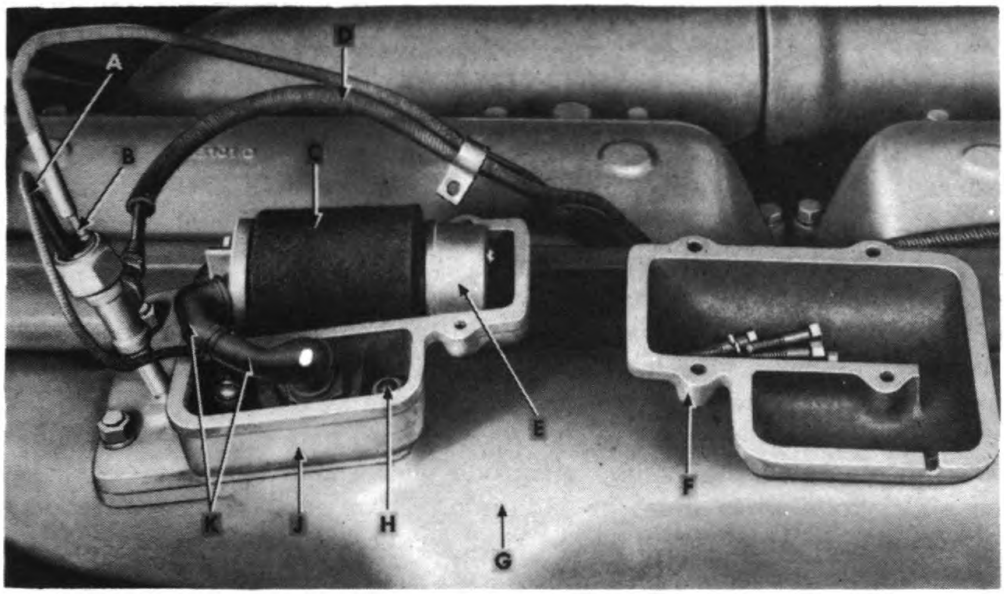


Figure 161—Starter Burner, Disassembled



A—PRESSURE SWITCH TO COIL CABLE
B—PRESSURE SWITCH TO JUNCTION BLOCK WIRE
C—FELT PADDING
D—FUEL LINE FROM HAND PRIMING PUMP
E—SPARK COIL
F—STARTER BURNER HOUSING COVER, REMOVED
G—AIR INTAKE MANIFOLD
H—HOUSING STUD
J—STARTER BURNER HOUSING
K—HIGH TENSION CABLE INSULATING NIPPLES

RA PD 321320

Figure 162—Starter Burner, With Cover Removed

b. Inspection and Repair.

(1) Inspect all connecting points, and check the contact points on back of spark coil housing.

(2) Inspect felt wrapper to see that it is not frayed or oil-soaked. This wrapper protects the coil from heat and vibration; if it is damaged or soaked, it must be replaced. Check electrodes for dryness to prevent a short across the gap.

85. ASSEMBLY.

a. Nozzle Parts. Assemble the nozzle assembly in the following order:

(1) Install fuel nipple in nozzle head and screw in with a small screwdriver, tightening to a snug fit. Do not overtighten.

(2) Install screen by screwing it in place with fingers.

(3) Screw assembly into adapter and tighten.

(4) Place lock nut in vise, screw above assembly into it, and tighten.

(5) Install entire nozzle assembly in starter burner housing; install lock wire through hole in housing and through top and bottom holes in lock nut, being careful that lock wire does not cover metering hole in fuel nipple.

b. Electrical Parts. Install electrical parts in the following order:

(1) Install ground electrode in opening of spark coil compartment, using screwdriver or socket wrench.

(2) Install high-tension electrode with the solid copper washer at the top, and grooved washer below the flange in porcelain body. Insert high-tension electrode assembly and fasten in place with retainer, but do not overtighten retainer as this may crack the porcelain. In spacing electrodes at firing end, do not bend high-tension electrode wire; always bend the ground electrode wire. Gap between ends of these electrode wires must be $^{3}/_{32}$ inch. Always make certain that gap comes directly in front, and that center of gap is in line with the hole in fuel nipple.

(3) Install cap over contact points, and tighten in place with two screws.

(4) Attach ground wire, high-tension cable, and pressure switch to coil cable, using plain washers, lock washers, and nuts.

(5) Wrap felt pad around spark coil housing so that bottom of this coil housing is protected, and insert coil assembly in body of starter burner.

(6) Attach ground wire to body, high-tension wire to high-tension electrode, and lay the pressure switch wire over side of body so that the slot in cover will fit over it.

(7) Install fuel tee on fuel pipe and install pressure switch. NOTE: *Starter burner housing cover need not be installed until ready to install the unit on intake manifold, as it will be necessary to install the two attaching nuts on the inside of starter burner housing before cover and outside attaching nuts are installed.*

86. TEST AND ADJUSTMENT.

a. Test. Starter burner may be tested before it is installed in the air intake manifold by inserting suction line in a fuel container, connecting cables to electrodes and operating the hand pump. Spray from the fuel nozzle should be spread slightly fan-shaped as it reaches the electrode gap; electrodes must be set so that center of spray enters the gap between electrodes. CAUTION: *When testing starter burner before installation, be cautious of the flame to avoid personal injury.*

b. Adjustment. With contact points properly installed, and gap between electrodes spaced at $^{3}/_{32}$ inch, the only adjustment required is to adjust the electrode retainers so that the gap is in line with the nozzle hole. Do not bend the high-tension electrode wire. Check gap between electrodes to make sure it is spaced to $^{3}/_{32}$ inch.

CHAPTER 8—COOLING SYSTEM

Section I

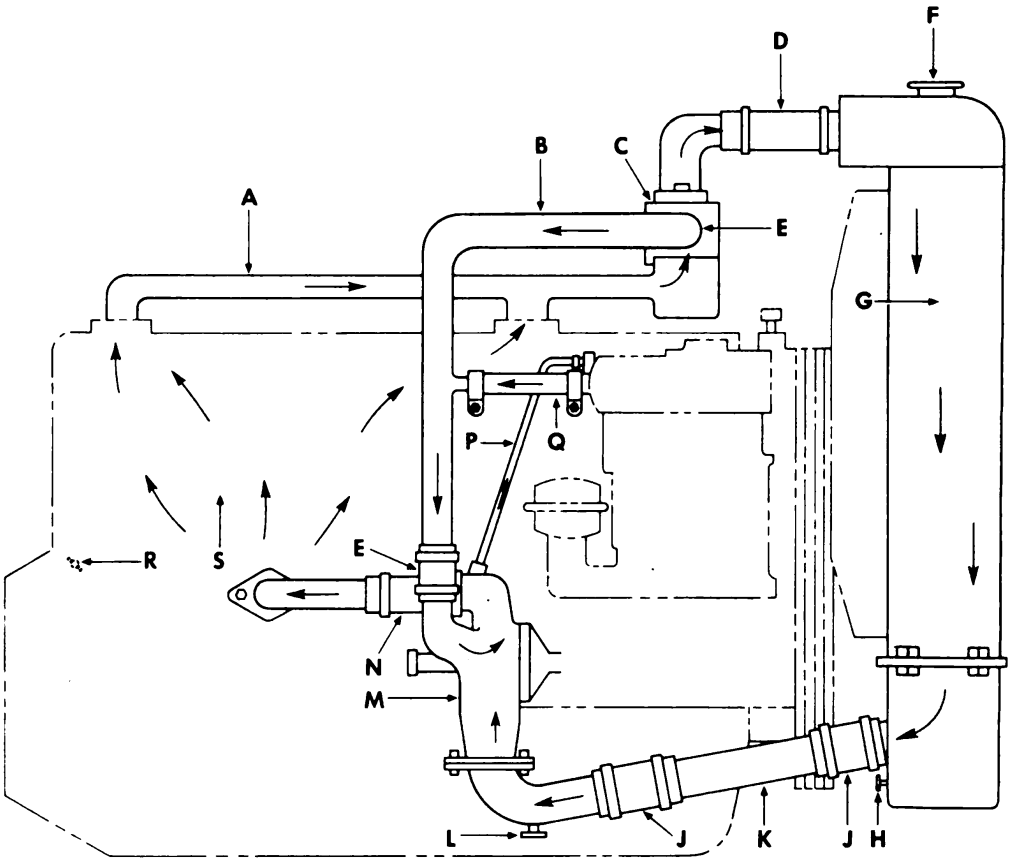
DESCRIPTION AND OPERATION

87. DESCRIPTION (fig. 163).

a. The cooling system consists of water passages in the engine, the water pump, thermostat, fan, radiator, temperature gage, pipes, and rubber tubing. Cooling water is drawn by water pump from radiator and passed through water jackets in the crankcase, and also through air compressor by-pass. Temperature of the water is regulated by a valve in the thermostat which operates by means of expansion and contraction of metals due to heat or cold. Capacity of cooling system is 62 quarts.

88. OPERATION.

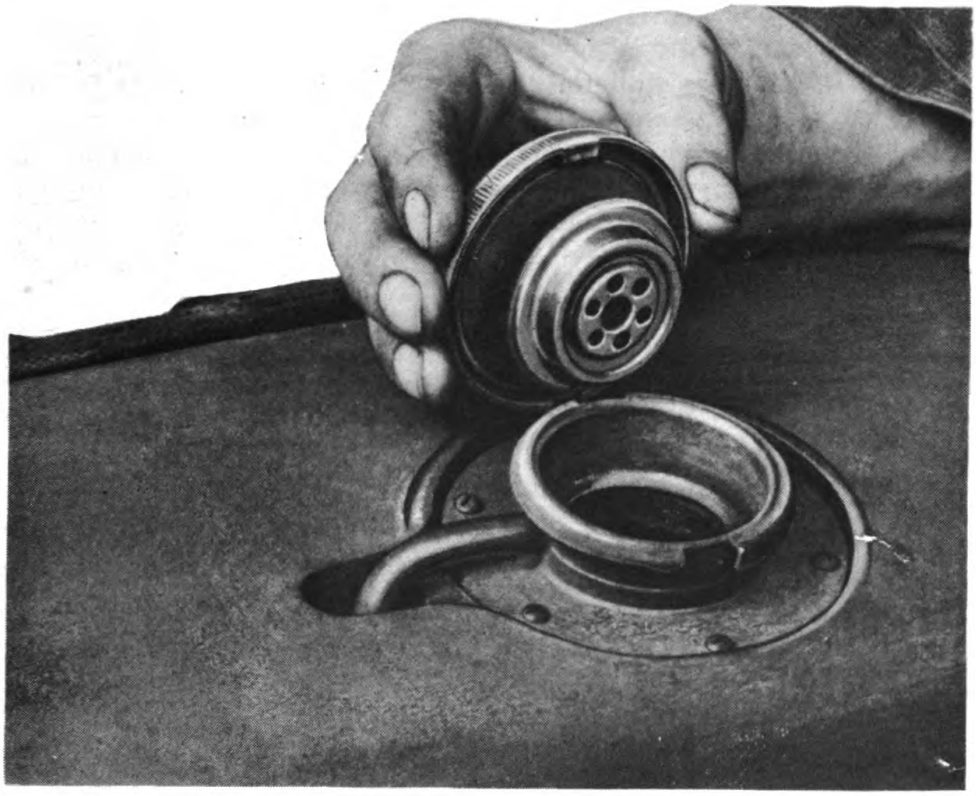
a. The water pump draws cooled water from the bottom tank of the radiator and pumps it through water passages in the engine block around the cylinders, through the air compressor, through the water outlet manifold and connecting hose, and to the top tank of the radiator. This is a pressure-cooling system, with a mechanism in the radiator cap to keep the internal pressure of the system slightly above atmospheric pressure (fig. 164). The radiator is always sealed unless



A—WATER OUTLET MANIFOLD
B—THERMOSTAT BY-PASS TUBE
C—THERMOSTAT HOUSING
D—RADIATOR WATER INLET HOSE
E—BY-PASS TUBE HOSE
F—RADIATOR FILL CAP
G—RADIATOR
H—RADIATOR DRAIN COCK
J—RADIATOR WATER OUTLET TUBE HOSE
K—RADIATOR WATER OUTLET TUBE
L—WATER PUMP INLET FITTING AND DRAIN COCK
M—WATER PUMP
N—WATER PUMP OUTLET HOSE
P—AIR COMPRESSOR INTAKE WATER LINE
Q—AIR COMPRESSOR EXHAUST NIPPLE HOSE
R—ENGINE WATER JACKET DRAIN COCK
S—WATER JACKET

RA PD 321315

Figure 163—Diagram of Cooling System



RA PD 342047

Figure 164—Pressure Radiator Cap

pressure increases beyond the setting limit, in which case the seal is broken, and vapor, air, or water escapes through the overflow tube until the internal pressure has been reduced to its normal pressure point.

Section II

CLEANING COOLING SYSTEM

89. CLEANING IN VEHICLE (fig. 163).

a. Materials and Tools. The cleaner and neutralizer, inhibitor, and tools required are listed and available under the following Federal Stock numbers:

	Federal Stock No.
COMPOUND, cleaning, 1 lb, 4 oz package	51-C-1568-500
COMPOUND, inhibitor, 2½ oz container	51-C-1600
GUN, radiator and engine block flushing, reverse flow-type	40-G-540
WRENCH, torque-indicating	41-W-3634

b. Corrective Service.

(1) CLEANING.

(a) Run engine, radiator covered if necessary, until temperature is up to operating range. Coolant shut-off cock to air compressor should be open for complete circulation during cleaning, flushing, and draining. Stop engine, remove radiator cap, and drain system by opening drain cocks in radiator and block. Coolants containing antifreeze compound will be saved or discarded as outlined in W.D. Circular No. 137, Section V, 16 June 1943.

(b) Allow engine to cool, close drain cocks, and pour cleaning compound (51-C-1568-500) into the radiator in the amount of two cans to every four gallons of cooling system capacity (eight cans for this system). Fill system with water.

(c) Place a clean drain pan to collect overflow, and use overflow to maintain level in radiator. Do not spill the solution on vehicle paint.

(d) Replace radiator cap and run engine at moderate speed covering radiator if necessary, so that radiator reaches a temperature of 180° F or above, but not boiling. Allow the engine to run at least two hours at 180° F so that cleaning solution may take effect. Do not drive vehicle or allow level in radiator to drop low enough to interfere with circulation.

(e) Stop the engine as often as necessary to prevent boiling.

(f) With the engine stopped, feel the radiator core with bare hand for cold spots, and watch temperature indicator. When there is no change in temperature for some time, drain the cleaning solution.

(g) If clogging of radiator core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (step (3) below), and repeat cleaning operation.

(h) If clogging of radiator core indicated by low temperature spots on core is not relieved, radiator core must be removed for mechanical cleaning. Mechanical cleaning may be accomplished by removing upper and lower tanks, and using a length of ⅛-inch welding rod to push out the clogging substance from water passages of core.

(2) NEUTRALIZING.

(a) Allow engine to cool, close drain cocks, and pour neutralizer compound (51-C-1568-500) into radiator in the amount of two cans to every four gallons of cooling system capacity (eight cans for this system). Fill system with water.

(b) Run engine, radiator covered if necessary, until radiator is up to operating temperature.

(c) Drain by removing cap and opening all drains.

(3) PRESSURE FLUSHING.

(a) Remove thermostat and hose which connects the engine block to radiator core.

(b) Clamp a convenient length hose to radiator core outlet opening, and attach another suitable length hose to radiator inlet opening, to carry away the flushing stream.

(c) Connect flushing gun (40-G-540) to compressed air and water pressure, and clamp the nozzle of gun in the hose attached to the radiator outlet opening.

(d) With radiator cap on tight, fill core with water. Turn on air pressure in short blasts to prevent core damage.

(e) Allow radiator to fill with water, and again apply air pressure in short blasts. Repeat this process until the water comes out clear.

(f) Clamp flushing gun nozzle firmly to a hose attached securely to engine water outlet opening. Fill engine with water, partly covering engine water inlet opening to facilitate complete filling, and pressure-flush the engine block.

(g) Turn on compressed air to blow out water and loose sediment. Repeat filling with water and blowing out with air until flushing stream comes out clear.

(h) For the most complete removal of sediment, repeat flushing of radiator core and engine block in the opposite direction.

(i) For badly clogged engine water jackets that do not respond to regular pressure-flushing, remove cylinder head studs, accessible water jacket covers, or core hole plugs; and with a suitable length of small copper tubing attached to flushing gun nozzle, flush jackets through jacket cover openings, stud, or core holes.

(j) Flush air compressor and other accessories connected to cooling system, following the same procedure as for radiator core.

(k) After completing the flushing operation and before connecting cooling system hose, clean off water connections of both radiator and engine block. Clean out radiator overflow pipe. Inspect, and if necessary, lubricate the water pump. Inspect, and if necessary, clean thermostat and radiator cap control valves. Check thermostat for proper operation before installation.

(l) Blow insects and dirt from radiator core air passages, using water if necessary to soften obstructions.

(4) LEAKS.

(a) After completing the flushing operation and before pouring the proper coolant into the cooling system, the entire cooling system must be examined for leaks. This is important because the cleaning solution uncovers existing leaks plugged with rust or corrosion.

(b) Correct all leaks found, to avoid foaming, loss of solution, and corrosion. Check tightness of cylinder head joint, using torque-indicating wrench.

(5) COOLANT SERVICE.

(a) When servicing for summer, refill system with clean water and add rust inhibitor (51-C-1600). Use one container of inhibitor to each four gallons of cooling system capacity (four containers for this system).

(b) When servicing for winter, refill system with clean water and sufficient antifreeze for protection to lowest temperature likely to be encountered. See TM 9-768 for antifreeze installation instructions.

c. General Information.

(1) Never mix cleaning solution with antifreeze or inhibitors.

(2) Before grinding valves, removing carbon, or when rebuilding engines, always clean the cooling system before it is disassembled.

(3) Cooling system clogging may be only one of the many causes of overheating.

Section III

WATER PUMP

90. DESCRIPTION AND DATA.

a. Description. The water pump is of the packless, centrifugal impeller-type, and is mounted on the right-hand side of the cylinder block (fig. 2). It is directly gear-driven by the camshaft gear, and has spring-loaded water seals which require no attention. The front bearings are lubricated from the timing gear compartment; rear bearings require regular lubrication. The impeller is inside the water pump body.

b. Data.

Make	Hercules
Type	Centrifugal impeller, packless
Model	88662-DS
Location	Right-hand side of cylinder block
Drive	Gear, from camshaft
Impeller location	Pump body

91. DISASSEMBLY (fig. 165).

a. Flexible Coupling. Remove castle nut from end of splined shaft, and pull off flexible coupling assembly. Remove cotter pins

and three castle nuts which hold flexible disk to rear hub. Remove three nuts and bolts which hold flexible disk to generator drive front hub, and take off flexible disk and drive cups.

b. Remove Body. Remove six cap screws and washers from flange, and pull body back from front half of pump. If splined shaft is stuck, use a brass drift on end of shaft and drive it out.

c. Remove Impeller. Remove the impeller by driving out impeller pin. This pin is tapered and can be driven out only one way, and installed only one way. If pin is bent or rusted so that it cannot be driven out, drill it out with a drill of proper length and size. Put in arbor press and press off impeller. From rear of impeller, compress snap wire, remove seal washer, spring guide, flexible seal, clamp ring, and spring. From front of impeller, remove spring, spring guide, flexible seal, clamp ring, seal washer, and snap ring.

d. Disassemble Impeller. From each end of impeller remove snap wire, seal washer, spring guide, and seal spring.

e. Remove Shaft Assembly.

(1) Remove snap ring from sleeve at drive gear end.

(2) Pull out the shaft assembly and in the order named, remove the lock nut, lock washer, bearing, tachometer drive gear and Woodruff key, oil slinger, bearing spacer, and bearing.

(a) To remove lock nut, bend back lugs of washer which fit in slots, and turn lock nut counterclockwise.

(b) To remove bearing and tachometer drive gear from shaft, press them off in arbor press; bearing and gear must be pressed off toward the spline, using special adapter (41-R-2374-435) as shown in figures 166 and 167.

(c) Before mounting shaft in press, install the castle nut on end of shaft upside down to protect shaft from damage.

(3) Do not remove oil seal unless it is to be replaced with a new seal. Drive old seal out with a punch and a hammer.

92. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. Clean all parts with dry-cleaning solvent and dry with compressed air.

b. Inspection.

(1) INSPECT BODY. Inspect body for cracks and excessive rust. Inspect brass coupling for line to air compressor, and see that threads

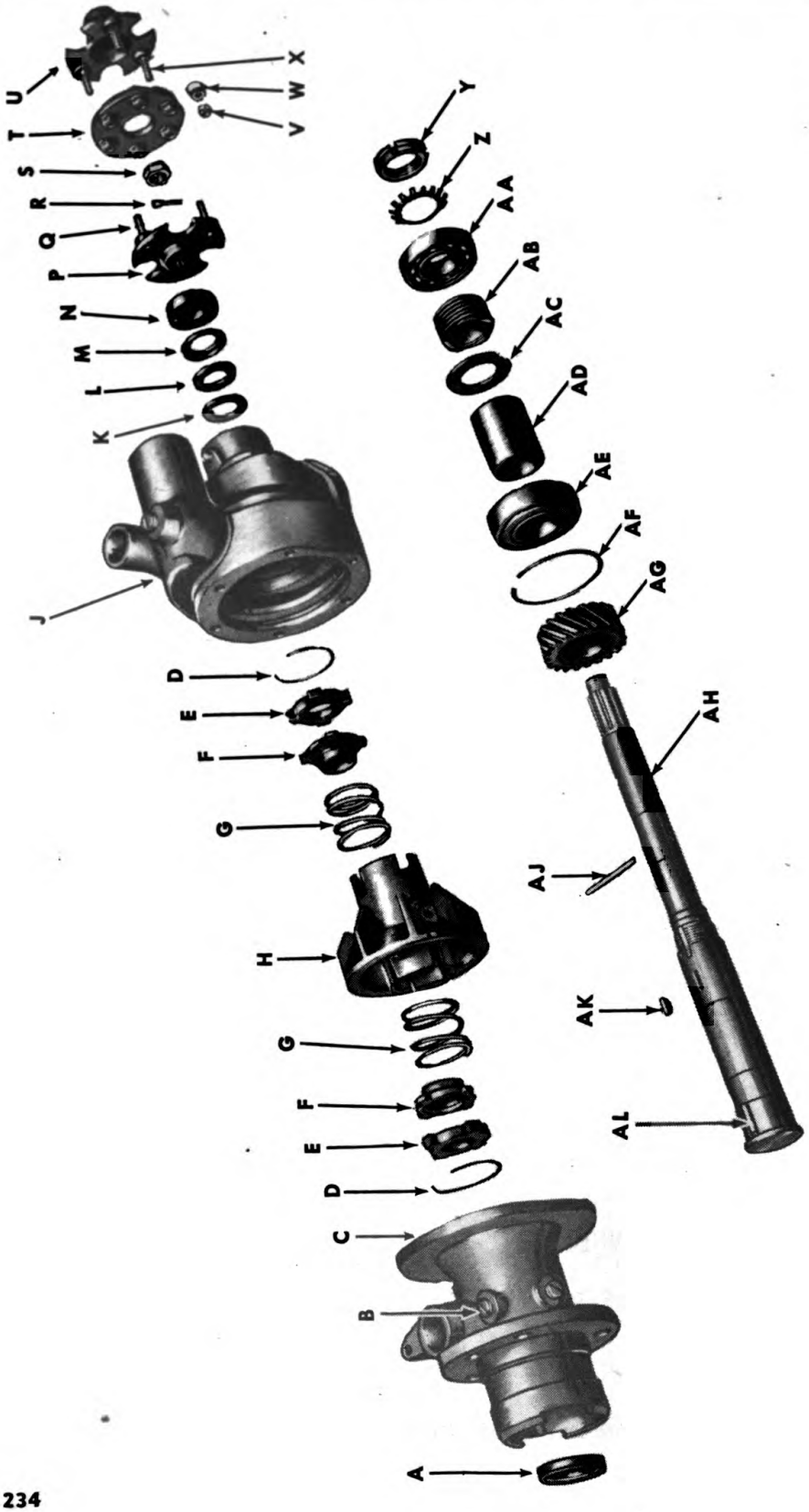


Figure 165—Water Pump, Disassembled

A—OIL SEAL
B—PLUG
C—BEARING SLEEVE
D—SNAP WIRE
E—SEAL WASHER
F—SEAL SPRING GUIDE
G—SEAL SPRING
H—IMPELLER
J—BODY
K—CORK WASHER RETAINER WASHER
L—CORK WASHER
M—CORK WASHER RETAINER
N—BALL BEARING, SPLINED END
P—FRONT GENERATOR DRIVE COUPLING HUB
Q—BOLT
R—COTTER PIN
S—NUT
T—FLEXIBLE DISK
U—REAR GENERATOR DRIVE COUPLING HUB
V—STUD
W—CUP
X—NUT
Y—BALL BEARING LOCK NUT
Z—LOCK WASHER
AA—BALL BEARING, REAR DRIVE SHAFT
AB—TACHOMETER DRIVE GEAR
AC—OIL SLINGER
AD—BEARING SPACER
AE—BALL BEARING
AF—SNAP RING
AG—DRIVE GEAR
AH—SHAFT
AJ—IMPELLER TAPER PIN
AK—WOODRUFF KEY, TACHOMETER GEAR
AL—WOODRUFF KEY, DRIVE GEAR

RA PD 342117B

Figure 165A—Legend for Figure 165

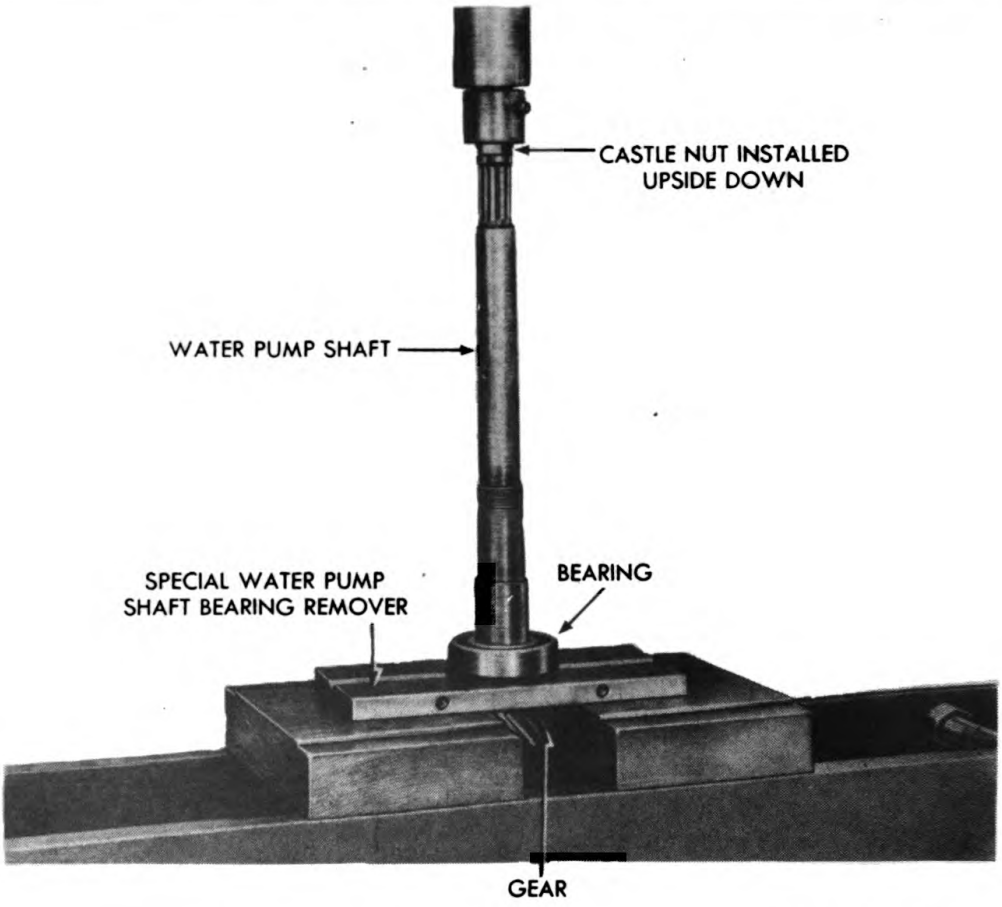
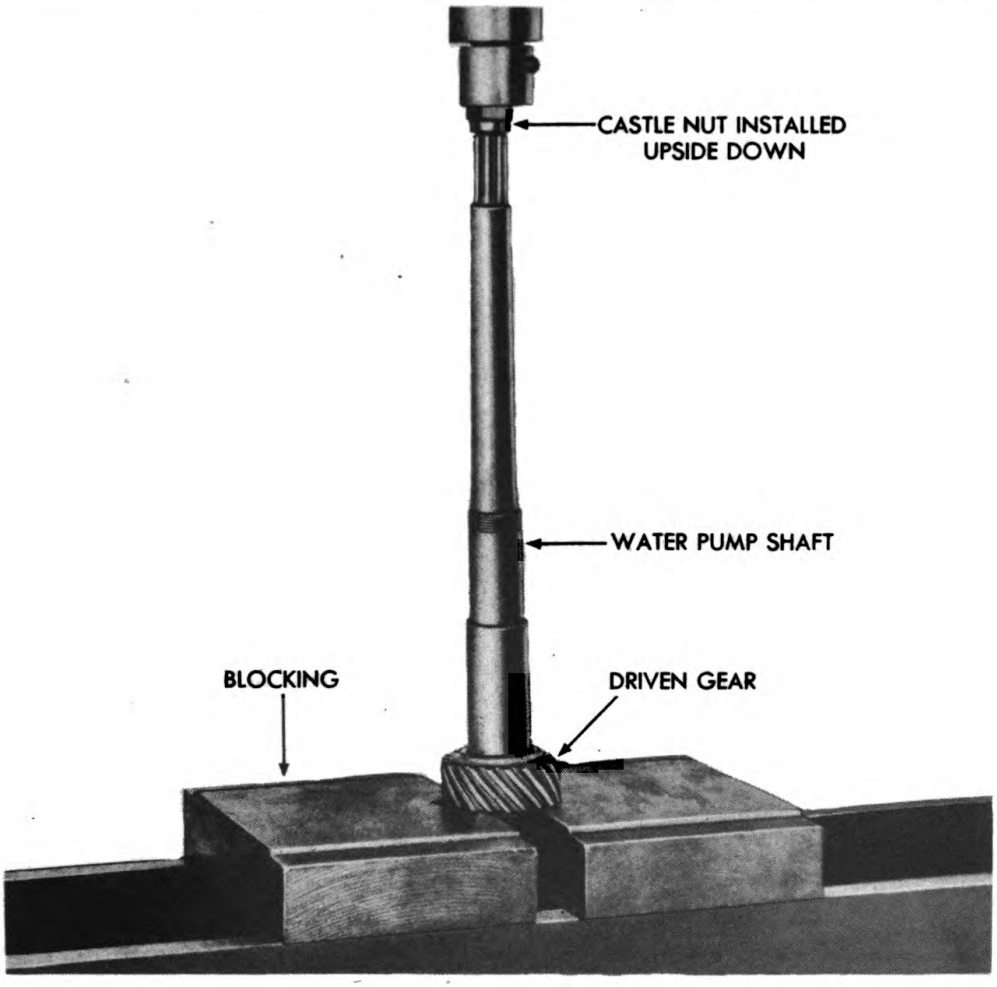


Figure 166—Set-up for Removing Bearing From Water Pump Shaft, Using Special Remover (41-R-2374-435)

in body at this connection are not stripped. Inspect seat in body which is contacted for water sealing by the carbon seal washer. If this seat is pitted, scored, or rough, it must be refaced until smooth as described in subparagraph **c** (5) below (fig. 168).

(2) INSPECT SLEEVE. Inspect sleeve casting for cracks and excessive rust. Inspect plugs and threads in plug openings. Examine oil seal for scoring or damage which may result in oil leaks. Remove damaged oil seal and replace as outlined in subparagraph **c** (6) below. Examine seal washer seat; if scored, reface it as outlined in subparagraph **c** (5) below (fig. 169).

(3) INSPECT IMPELLER. Examine casting for any signs of cracks or broken fins. Examine pin holes to make sure they have not been enlarged so as to cause impeller backlash. No backlash of impeller can be tolerated.

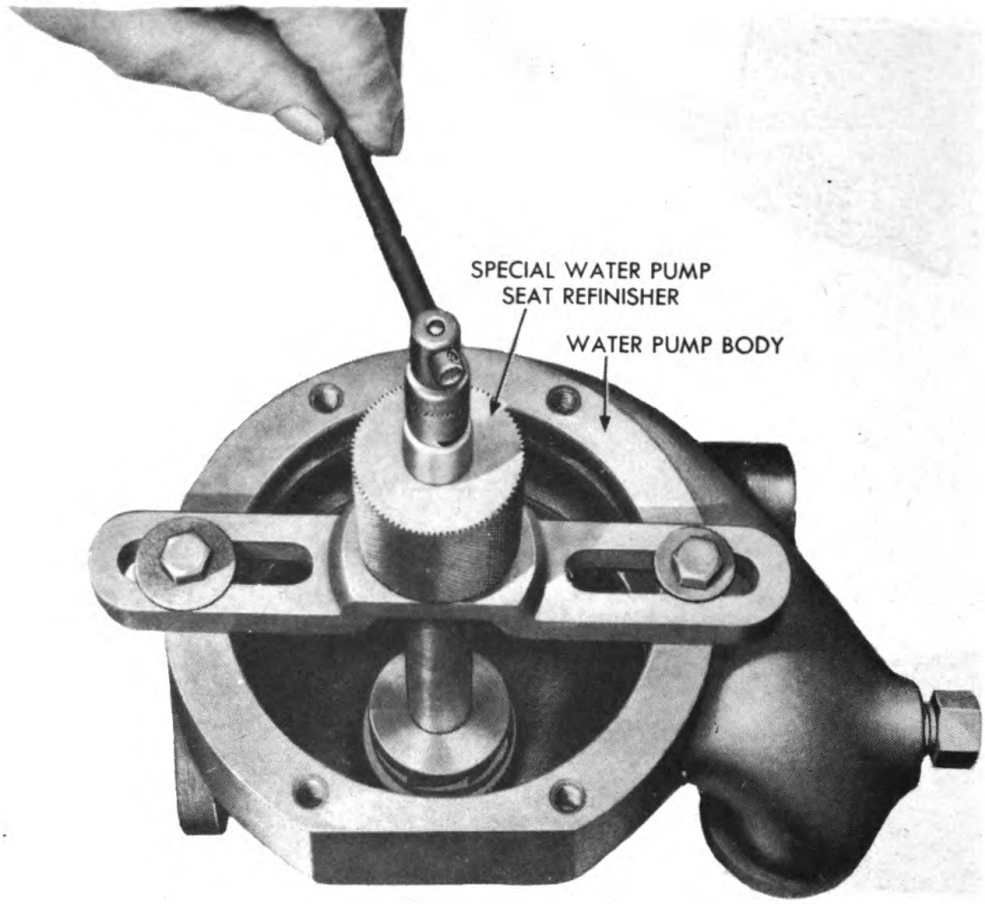


RA PD 342100

Figure 167—Pressing Driven Gear From Water Pump Shaft

(4) INSPECT SHAFT, GEAR, AND BEARINGS. Inspect threads and splines for any signs of nicks or stripped threads. Examine keyways and keys for scoring or rust. Inspect pin hole for any signs of wear. Diameter of shaft is 1.627 to 1.6275 inches; wear limit is 0.002 inch. Examine surface of shaft for wear or signs of excessive rust. Inspect gear for rust or worn teeth, and replace if badly rusted or damaged. Backlash should be 0.002 to 0.004 inch; if backlash is in excess of 0.005 inch, replace the gear. Inspect ring and bearings for rust or damaged bearing races or balls. Replace damaged parts. Inspect spacer and oil slinger for score marks or rust. Replace if unserviceable.

(5) INSPECT TACHOMETER DRIVE. Examine tachometer drive gear and shaft for broken teeth or damage. If this gear is damaged, it can be replaced; but if other parts of unit are damaged, the entire unit must be replaced.



RA PD 342206

Figure 168—Refacing Seal Washer Seat in Water Pump Body, Using Special Seat Refacer (41-T-3095-500)

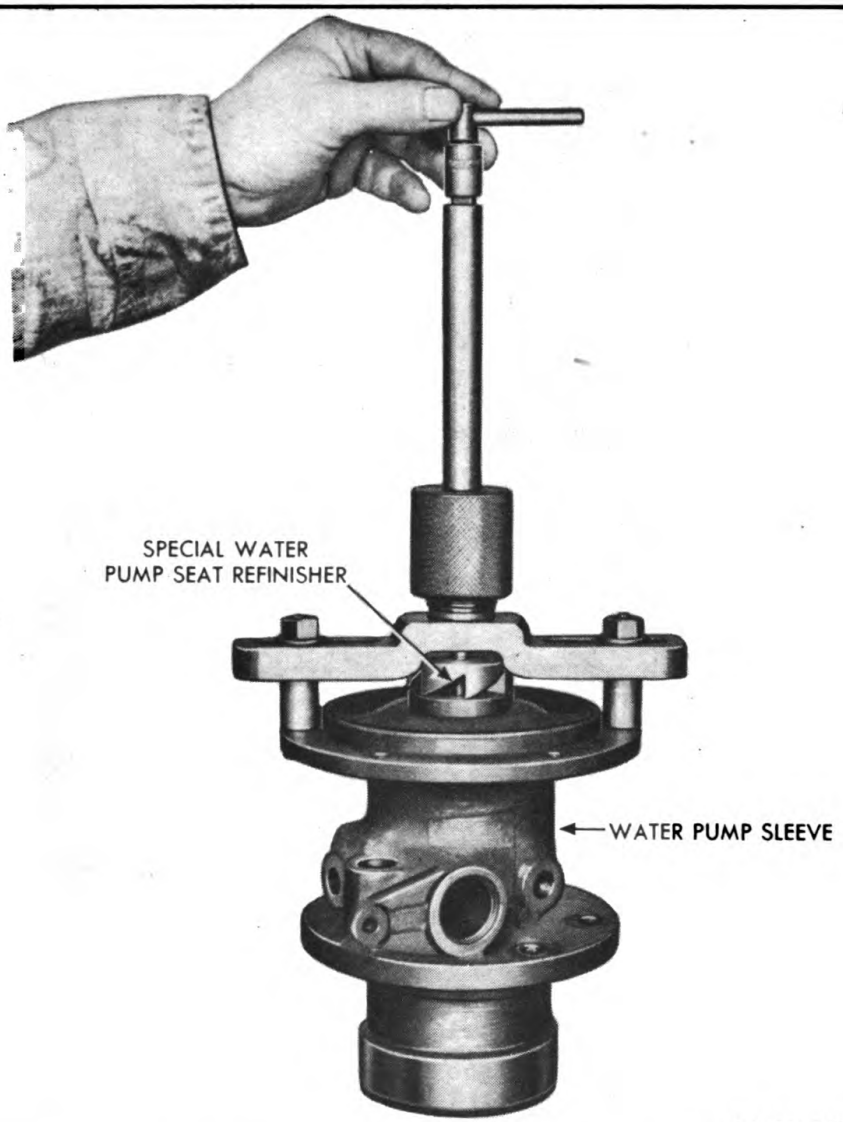
(6) INSPECT PARTS. Check bearings for wear, and replace if worn, excessively rusted, or damaged. Inspect springs and snap rings, and replace if defective or bent. When compressed to $^{11}/_{16}$ inch, the seal spring should have 18 to 21 pounds pressure. Inspect flexible disk for signs of rotting or breaks. Replace if broken or rotted. Examine drive cups and replace any that are dented or broken.

c. Repair.

(1) Replace the cork washer and cork retainer.

(2) Replace snap rings, guide, springs, or any other part showing excessive wear or rust which cannot be repaired.

(3) If shaft is badly worn or eaten by rust, or if worn pin hole is causing impeller backlash, replace the shaft.



RA PD 342207

Figure 169—Refacing Seal Washer Seat in Water Pump Sleeve, Using Special Seat Refacing Tool (41-T-3095-500)

(4) Repair minor cracks in impeller, body, or sleeve, by welding; but if there are large cracks or breaks or rust is causing leaks, replace the damaged part.

(5) If the seal washer seat in body or sleeve is pitted or scored even slightly so that seat is not perfectly smooth, reface the seat, using special water pump seat refacer (41-T-3095-500) as shown in figures 168 and 169.

(6) If oil seal in sleeve was removed on account of damaged condition, install a new oil seal, using standard ¾-inch socket and handle (41-H-1395-988) as shown in figure 170.

(7) Replace flexible rubber seal and seal washer with new parts.

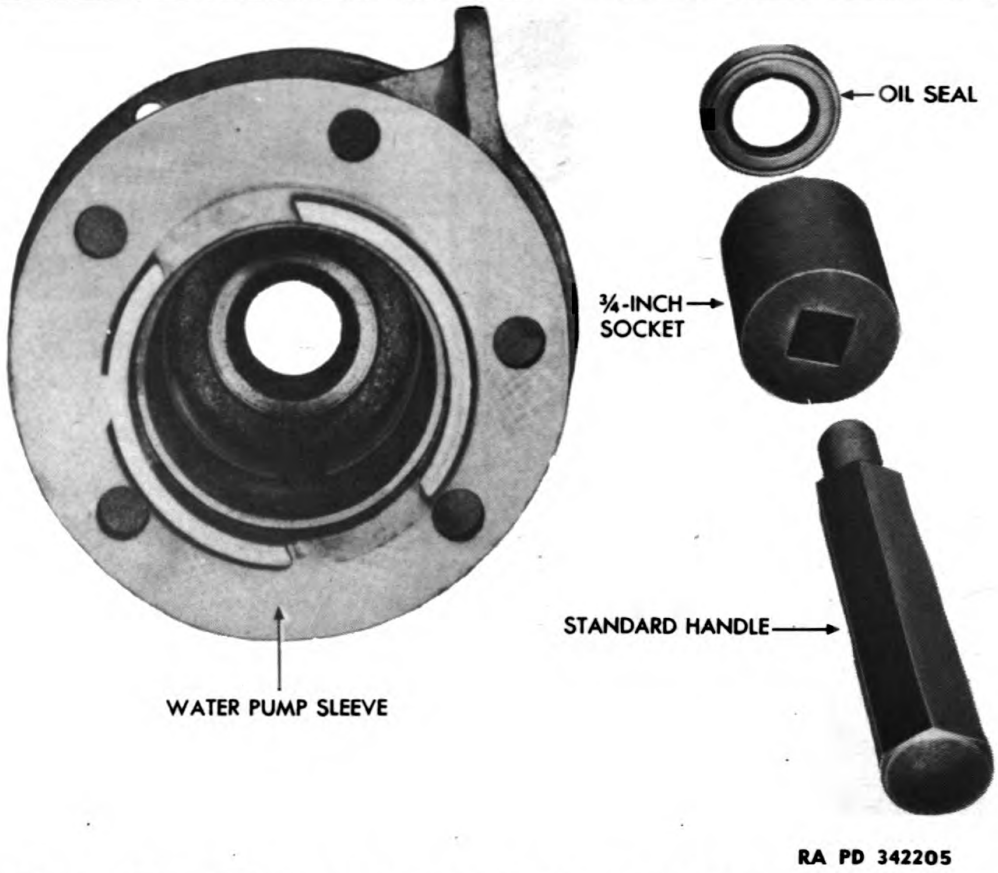


Figure 170—Tools Used To Install New Oil Seal in Water Pump Sleeve

93. ASSEMBLY.

a. Shaft Assembly.

(1) Install drive gear key, and press drive gear into place on arbor press.

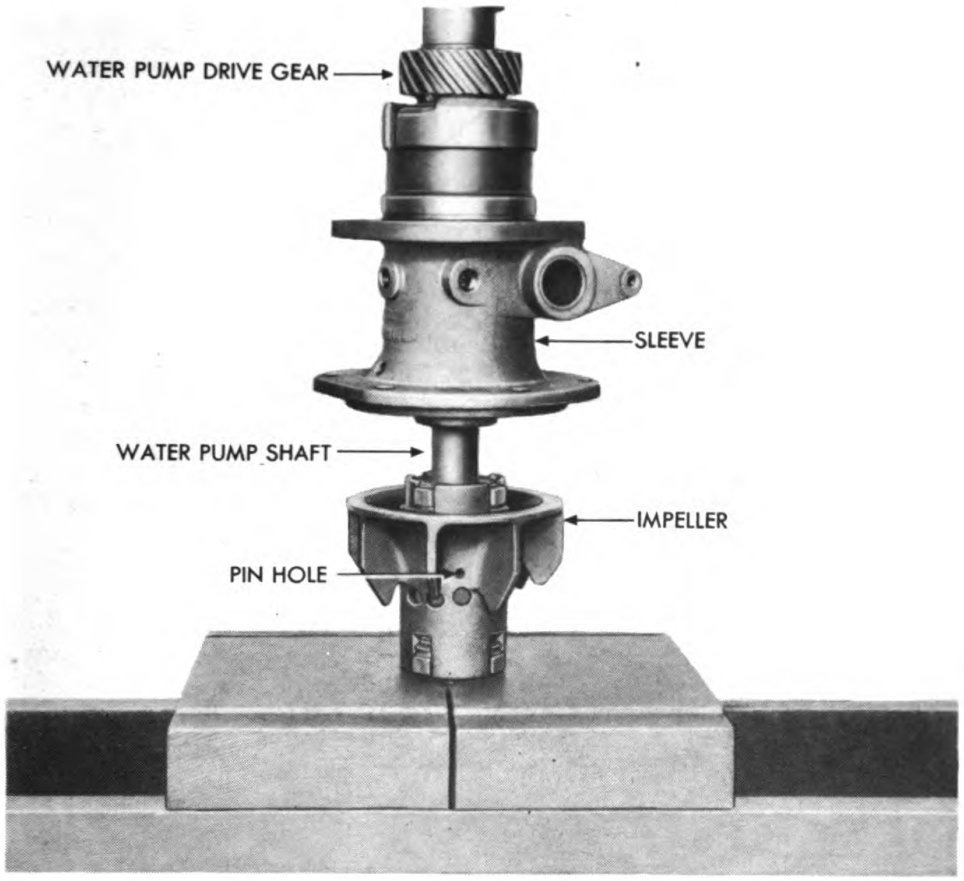
(2) In the order named, install the following parts on the shaft: rear bearing, spacer, oil slinger, Woodruff key and tachometer drive gear, front bearing, external-toothed lock washer, and lock nut. Then insert shaft in sleeve and install snap ring at drive gear end.

b. Impeller.

(1) In front end of impeller, install the following in the order named: the spring, spring guide with flexible seal, seal washer, and snap ring.

(2) In rear end of impeller, install the same parts in the same order as described in step (1) above.

(3) Press impeller onto shaft in arbor press as shown in figure 171. CAUTION: *The pin holes in the impeller and in the shaft are*



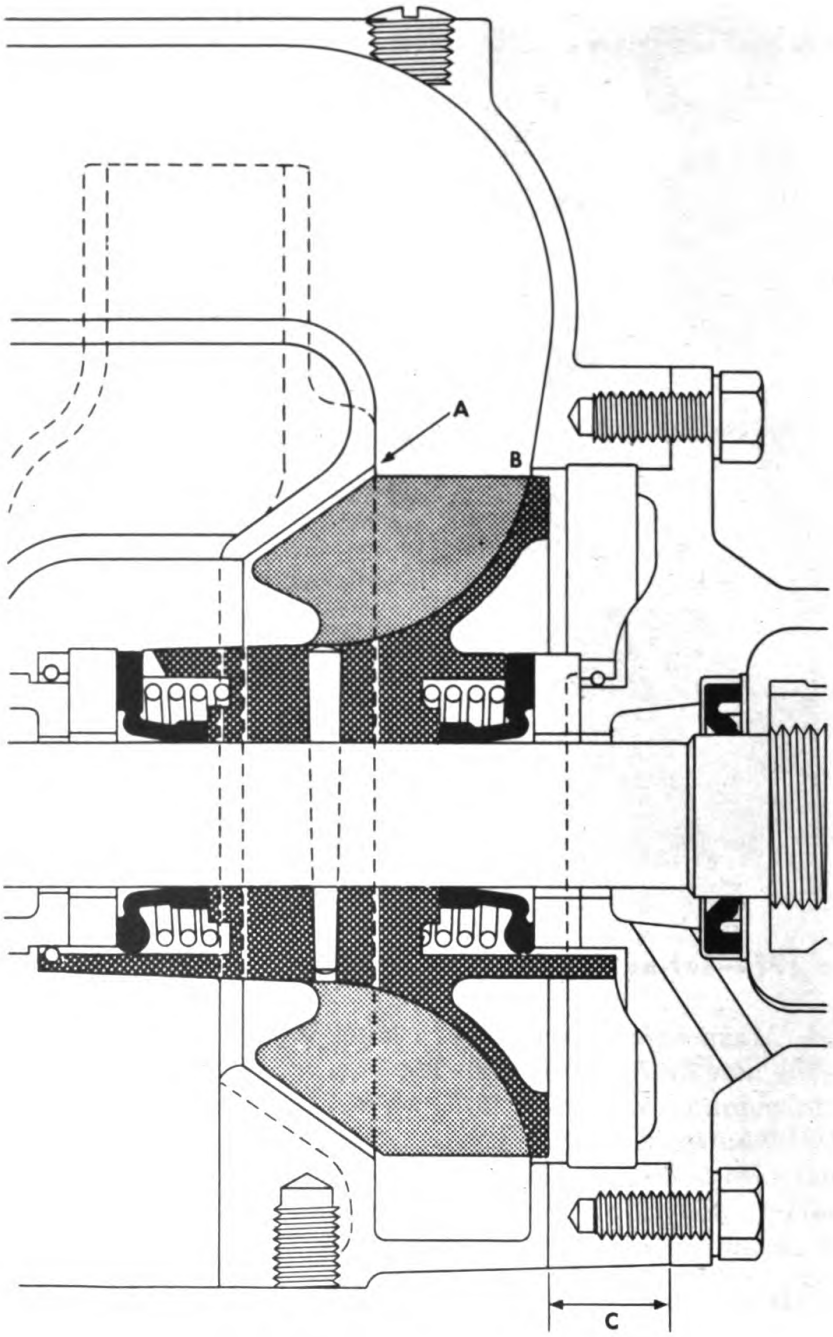
RA PD 342211

Figure 171—Set-up for Pressing Impeller on Water Pump Shaft

tapered. Make sure that these pin holes are lined up so that larger end of the hole in the impeller mates with larger end of the hole in the shaft, to maintain correct fit for tapered pin. Do not press impeller on too far, but press slowly, checking to see that it is pressed on just far enough to line up pin holes. If this line is not accurate, it may be necessary to use a No. 4 taper reamer to make room for tapered pin. Do not attempt to drive the pin in to aline the holes.

(4) Insert tapered pin through impeller and shaft, but make sure small end of pin is inserted into large end of tapered hole; otherwise the fit will be too tight and if pin is forced in the wrong way, damage will result, which may require replacement of impeller, shaft, and pin.

c. Impeller Clearance (fig. 172). Due to very close working clearances between the impeller and housing at "A" (fig. 172) and because the flow of water may be slowed down at "B," the impeller must be accurately located on shaft so as to provide the necessary



A—CLEARANCE BETWEEN IMPELLER AND HOUSING
B—WHERF FLOW OF WATER MAY BE IMPEDED
C—DISTANCE BETWEEN FRONT CRADLE AND FACE OF IMPELLER, 1 INCH

RA PD 342158

Figure 172—Sectional View of Water Pump

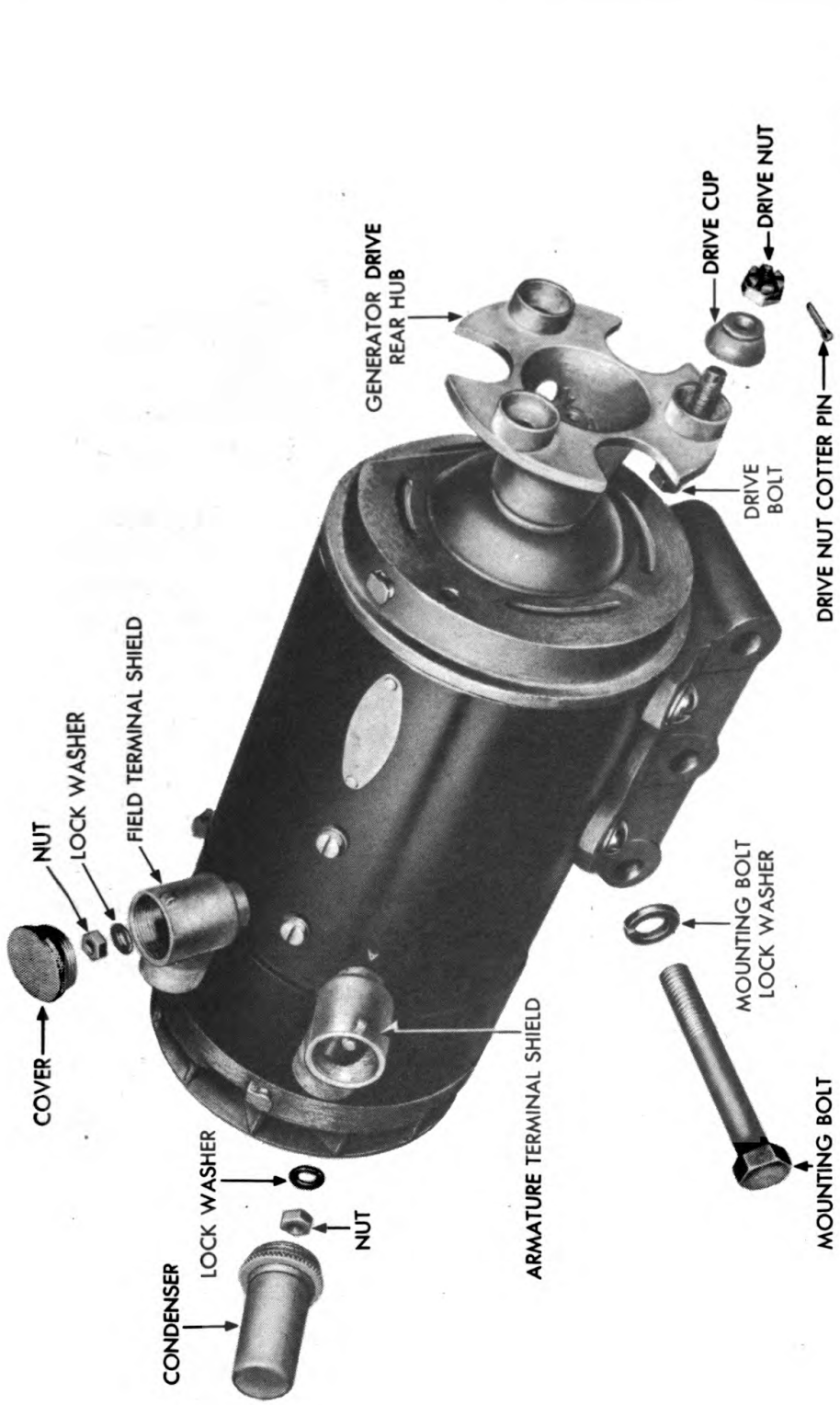


Figure 173—Generator Drive Hub

clearance at "A" and have the impeller lined up with housing at "B." When installing a new shaft, press impeller on until a dimension of 1 inch between front cradle and face of impeller is obtained at "C." Make sure impeller turns true and in balance, and that impeller pin is correctly and tightly installed so that it holds impeller without backlash. Clearance between pump body and impeller must not exceed 0.010 inch.

d. Body.

(1) Install body on splined shaft and press into place, using a new gasket.

(2) Fasten body to sleeve with six lock washers and cap screws.

e. Drive Coupling (fig. 173).

(1) Install cork retainer washer, cork washer, cork washer retainer, ball bearing, front generator drive hub (with drive cups), and castle nut and cotter pin on end of shaft.

(2) Install flexible disk and rear hub (with drive cups) and fasten front and rear drive hubs together with six castle nuts and cotter pins, three on studs of each hub. NOTE: *Install water pump and generator on engine before tightening nuts which hold front and rear coupling together, as rear coupling fits on the generator shaft.*

Section IV

RADIATOR

94. DESCRIPTION (fig. 174).

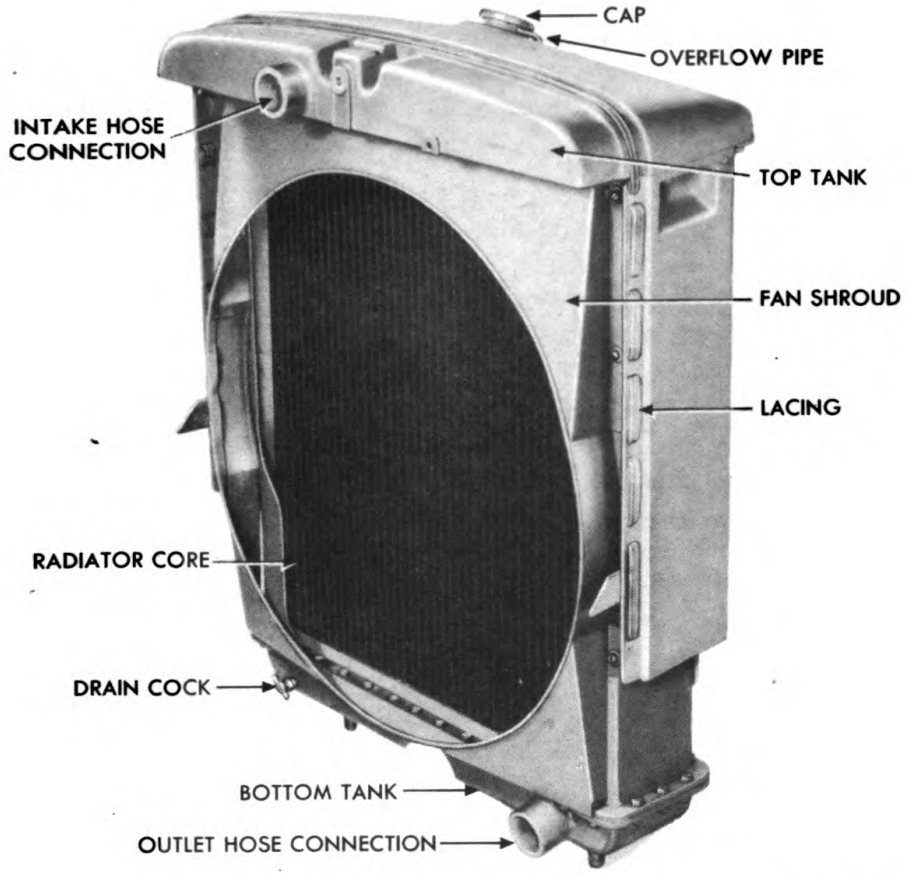
a. Description. The radiator is of the tube-and-fin type, and consists of the steel outer shell (top and bottom tanks, with side supports), the core assembly, sheet-metal fan shroud, and the filler cap which contains a mechanism to maintain proper pressure in the cooling system (fig. 164).

b. Data.

Make	Modine
Model	3758-102
Type	Finned-tube
Number of fins to inch	11
Frontal area	890.3 sq in.

95. DISASSEMBLY (fig. 175).

a. Air-test Before Disassembly. With filler cap in place, and inlet, outlet, and overflow pipes sealed, apply air pressure to about 6 pounds per square inch, and submerge the core in water to detect leaks by air bubbles. Mark leaks, remove seal from end of overflow



RA PD 342064

Figure 174—Three-quarter Rear View of Radiator

pipe making sure pipe is clear, and test the pressure at which filler cap allows venting. If leaks prevent a proper pressure test for the cap, make this test after leaks are repaired.

b. Remove Shroud. Remove the six screws which hold the shroud at the sides of the radiator shell. Remove four bolts which hold brush guard to top and bottom tanks. Remove overflow tube clip from right-hand side member.

c. Remove Tanks. Remove the bolts which hold the bottom tank to the assembly, and remove bottom tank and gasket. Remove bolts which hold radiator top tank to assembly, and remove top tank carefully, including the side castings. Remove cap from top tank by turning counterclockwise.

96. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. Clean radiator core assembly by placing in a tank containing a solution of soda and water heated to the boiling point.

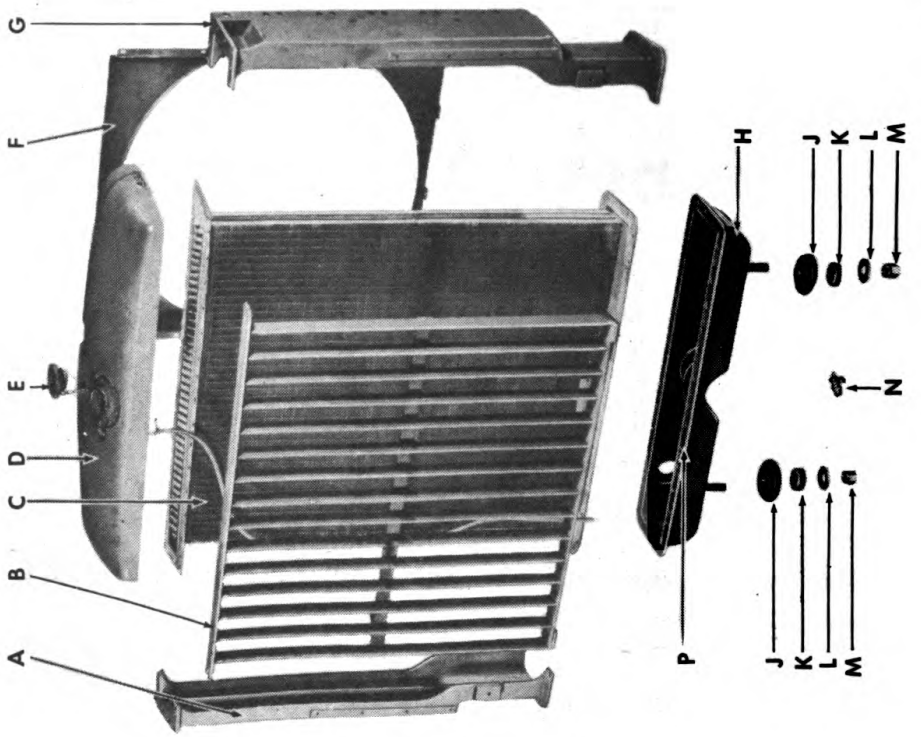


Figure 175—Radiator, Disassembled

Upon removal from solution, drain and blow compressed air through entire fin area to dislodge scale and dirt. If tubes are so badly clogged that they cannot be cleared in this manner, use a length of ⅛-inch welding rod to push out the clogging substances.

b. Inspection and Repair.

(1) INSPECTION. Inspect core assembly for any damage or defect that would interfere with cooling function of the radiator. Look for bent or crushed fins, bent or pinched tubes, and dented tanks. Inspect radiator cap, pressure cap, and pressure release mechanism in cap for dents or for clogging of the openings in the mechanism. Inspect outer shell and shroud for dents and breaks, and check for fit to core assembly. Check drain valve in bottom tank to see that it can be opened easily by hand.

(2) REPAIR. Straighten bent fins, working carefully with thin-nosed pliers. Solder or braze leaks, but do not allow more than 40 square inches of cooling surface to be blocked. If repairs would result in blocking more than 40 square inches of cooling surface, or more than 10 tubes would be rendered ineffective, replace the entire core assembly. If filler cap fails in pressure test (par. 95 **a**), replace the cap. If overflow pipe is blocked so that it cannot be cleared, replace it. If brackets or mounting studs are not secure, weld or braze.

97. ASSEMBLY AND TESTS.

a. Install Tanks. Install bolts which hold top tank and side members to core. Install gasket and bottom tank to assembly, and fasten with bolts.

b. Install Shroud and Brush Guard. Install overflow tube clip on right-hand side member. Install brush guard to bottom and top tanks and fasten with four bolts. Place shroud in position and install the six screws at sides of radiator shell.

c. Test with Air and Pressure Flushing. Repeat the air test outlined in paragraph 95 **a** and the pressure flushing outlined in paragraph 89 **b** (1), to make certain there are no leaks after assembly and that tubes are not clogged.

Section V

WATER OUTLET MANIFOLD AND THERMOSTAT

98. DISASSEMBLY (fig. 176).

a. Remove the Water Plug. Take out two cap screws and remove elbow and gasket. Take four nuts from studs, break thermostat housing loose from manifold, and lift housing off studs. Lift out the thermostat, and remove the gasket.

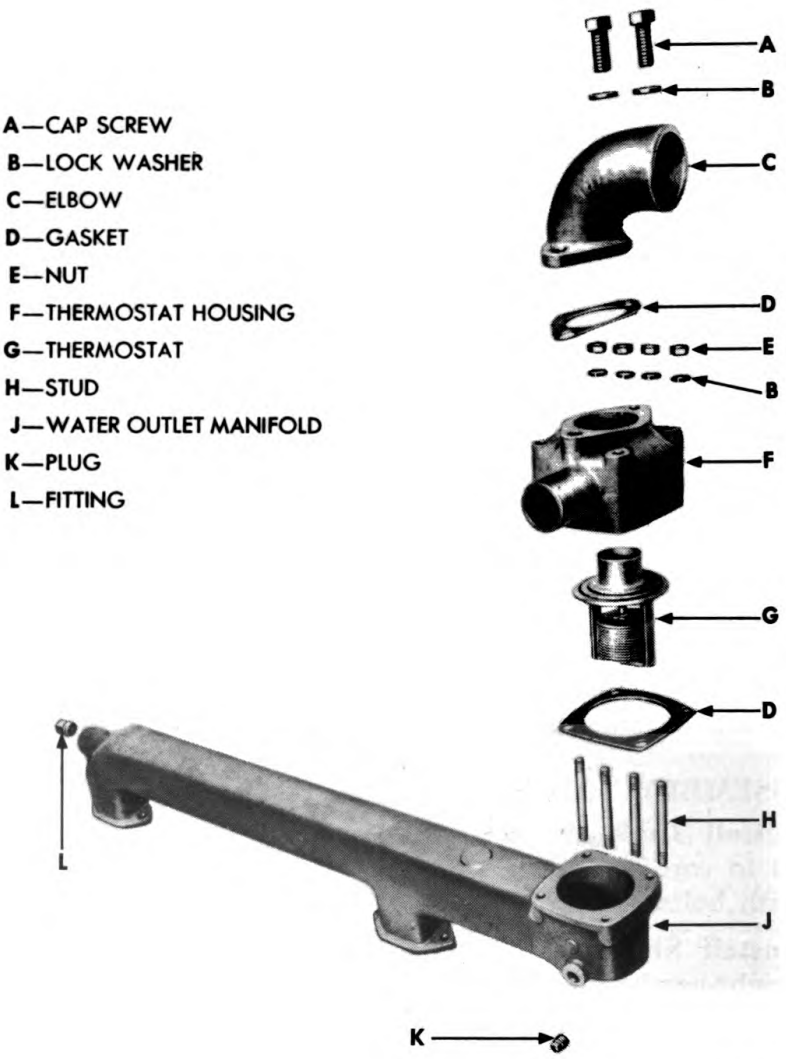


Figure 176—Water Outlet Manifold and Thermostat, Disassembled

99. CLEANING, INSPECTION, REPAIR, AND TEST.

a. Clean. Remove gaskets, clean all parts with dry-cleaning solvent, and blow out with compressed air. Clean all joint surfaces.

b. Inspect.

(1) WATER MANIFOLD AND CONNECTIONS.

(a) Check manifold sections, water elbow, and by-pass ports for cracks, excessive rust, or evidence of damage which may cause leaks.

(b) Check manifold joints for smooth, level surfaces. Replace any worn, cracked, or defective part.

(c) Weld manifold if there are small cracks or sand holes. If cracks or holes are too large to permit welding or if joint surfaces are not true, replace water manifold. See that all connecting surfaces are smooth and that hose connections are not rotted or cracked. Prepare new gaskets for use in assembly.

c. Test Thermostat. Place thermostat in a vessel which can be used to heat water. Heat water, testing temperature with a thermometer. Thermostat should begin to open within 5° F of 140° F, and should be fully open within 5° F of 165° F. If it fails to function within these temperature limits, replace it with a new thermostat.

100. ASSEMBLY.

a. Place thermostat in housing and install housing on studs; fasten in place with four lock washers and nuts. Install gasket and by-pass elbow and fasten in place with two cap screws. Install water plug which was removed from water outlet manifold.

Section VI

FAN ASSEMBLY

101. DESCRIPTION AND DATA.

a. Description. The fan has eight blades and is driven by three V-belts which also pass over a pulley to drive the air compressor. Fan belt tension is adjusted to 1-inch deflection in center area of belt between crankshaft pulley and air compressor pulley. Adjustment is made by means of an adjusting screw in the top of the fan bracket, after loosening clamp nut back of the fan assembly (fig. 180).

b. Data.

Make	Schwitzer-Cummins
Model	DX5928
Drive	3 V-belts from crankshaft pulley
Diameter	27 in.
Number of blades	8

102. DISASSEMBLY (fig. 177).

a. Remove blades from hub. Remove the lock wire from the groove in the rear of hub assembly. Unscrew the threaded cork retainer from rear of hub and remove cork, retaining washer, and gasket. Remove the cotter pin, nut, and clamp washer from the front of shaft. The spindle and shaft can then be removed from hub toward the rear.

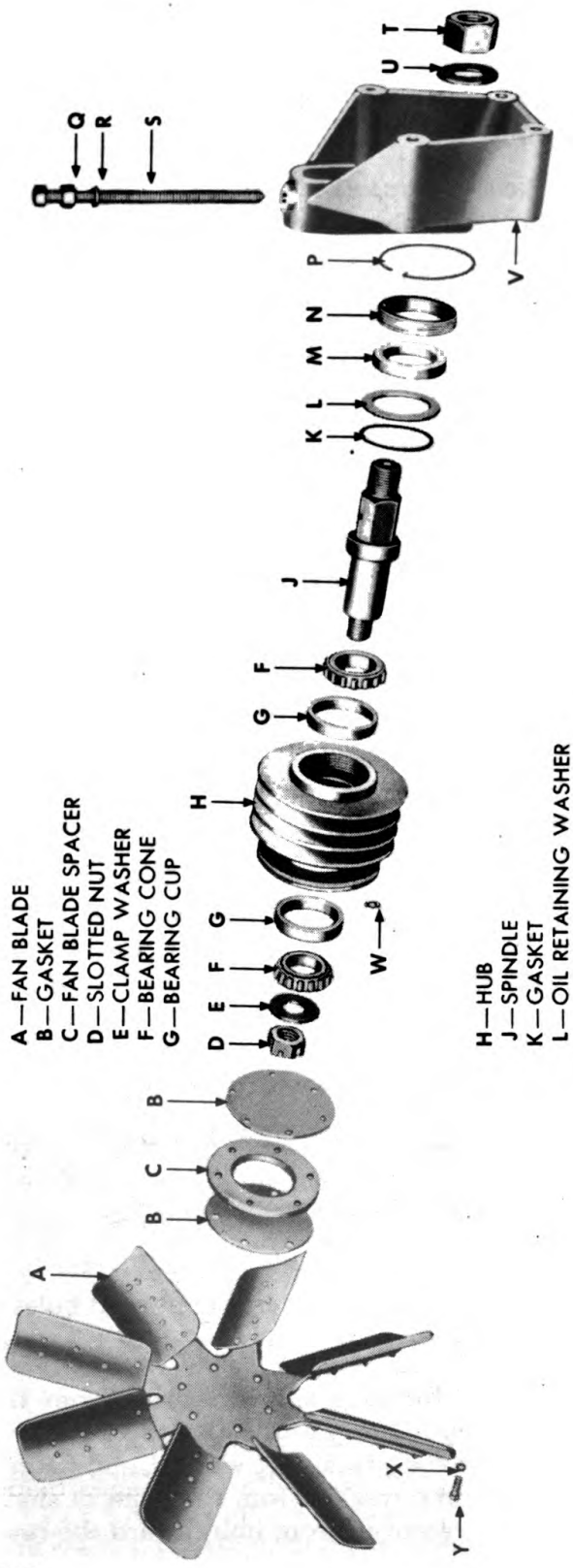
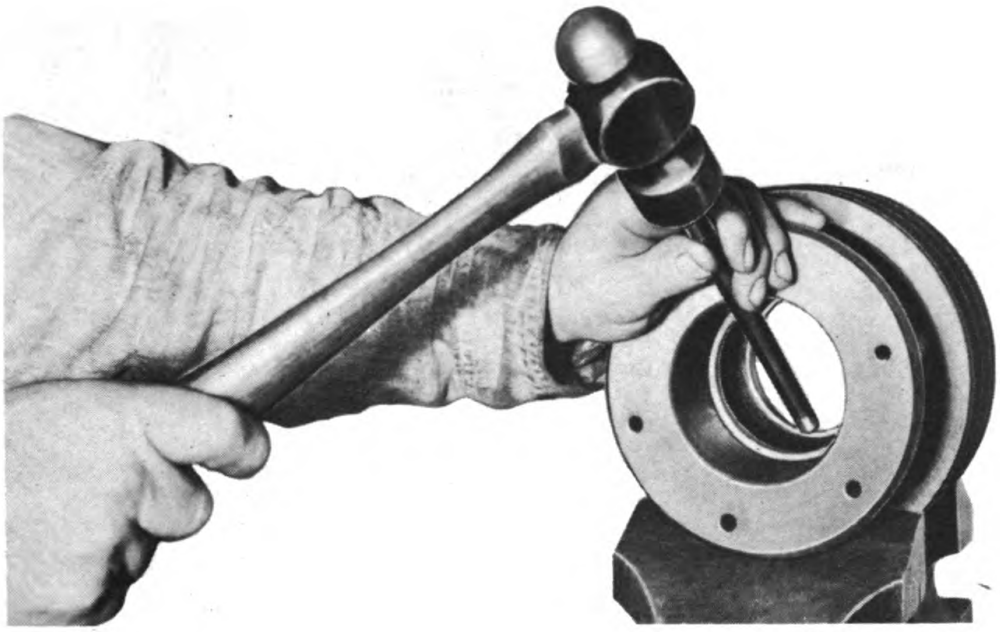


Figure 177—Fan Assembly, Disassembled



RA PD 342214

Figure 178—Removing Bearing Cup From Fan Pulley Hub

Press the rear bearing cone off the spindle. When removing spindle from hub, be careful not to drop the front bearing cone. The bearing cups are pressed in the hub. Remove bearing cups, using hammer and drift as shown in figure 178.

103. CLEANING, INSPECTION, AND REPAIR.

a. Cleaning. Wash the spindle, bearings, hub, and oil seal parts thoroughly in dry-cleaning solvent, removing all caked grease.

b. Inspection. Examine bearings for signs of pitting, scoring, cracking, or wear. Examine fan blades for bends or other damage. Examine bearing cups in fan pulley hub for any signs of wear or damage. Replace bearing cups if worn or damaged (figs. 178 and 179). Inspect fan bracket for any signs of cracks or damage at stud holes or adjusting screw. Replace bracket if cracked. Replace studs if any are bent excessively or have stripped threads.

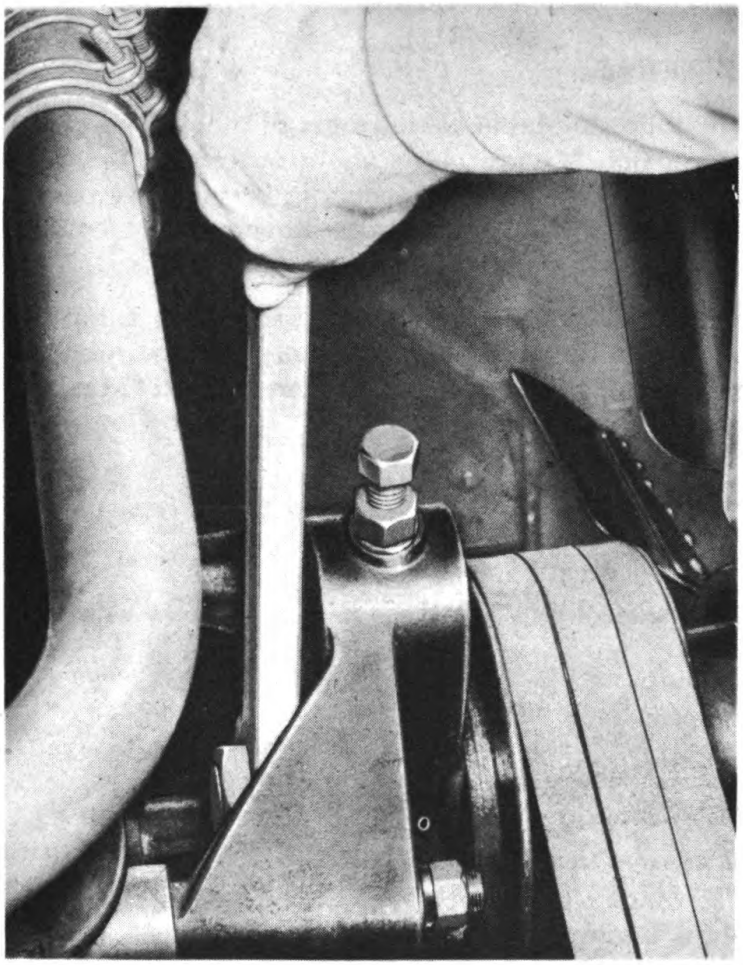
c. Repair. Replace all damaged parts. If blades are damaged or bent beyond ordinary repair possibilities, replace damaged blades. Coat bearings with grease before assembly.

RA PD 342219

Figure 179—Installing Bearing Cup in Fan Pulley Hub

104. ASSEMBLY AND ADJUSTMENT.

a. Assembly. Press bearing cups in hub using arbor press. Press rear bearing cone onto spindle. Install spindle and shaft on hubs from the rear. Install clamp washer, nut, and cotter pin on front of shaft. Install gasket, retaining washer, and cork on rear of hub and tighten the threaded cork retainer. Install lock wire in groove in rear of hub assembly. CAUTION: *After assembly, check to make certain*



RA PD 342215

Figure 180—Adjusting Fan Belt, Using Special Wrench (41-W-639-310)

the lock wire is properly positioned on the rear of the hub so that threaded cork retainer is held in position. Also see that hub is filled with proper lubricant. Install fan blades on hub.

b. Adjustment. The fan belt adjusting screw is on the back of fan bracket. Adjust belt tension so that belts have 1 inch finger-pressure deflection midway between crankshaft and air compressor pulleys. Use special wrench (41-W-639-310) (fig. 180).

CHAPTER IX

SERVICEABILITY STANDARDS

105. GENERAL.

a. The following table contains fits of moving parts for reference in making repairs. It consists mainly of new part sizes, running clearances, and wear limits for determining serviceable parts. Fits and clearances are specified as those necessary to meet conditions under which parts operate satisfactorily.

b. Wear limits in the column marked "Wear Limit at Complete Overhaul" are to be adhered to at time of engine rebuild. If engine is not being rebuilt, dimensions in column marked "Max. Wear Allowable" may be used.

106. ENGINE.

a. Cylinders.

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Bore	5.6245 to 5.6250 in.	0.012 in.	0.006 in.
Bore out-of-round	—	0.006 in.	0.006 in.
Bore taper	—	0.012 in.	0.006 in.
Oversize pistons available	0.020, 0.040, 0.060 in. and semi-finished	—	—
Press fit of sleeve in block (interference)	0.003 to 0.005 in.	—	—

b. Main Bearing Bores, Caps, and Bearings.

Warpage of machined parting surfaces, using straightedge and feeler	—	0.0035 in.	0.0035 in.
Torque tightness of bolts	260 ft-lb	—	—
I.D. of main bearings when installed at proper torque tightness	4.5040 to 4.5045 in.	—	—
I.D. of main bearing bore (less liner) when installed at proper torque tightness	4.852 to 4.853 in.	0.002 in.	0.002 in.
Clearance of main bearing to crankshaft	0.004 to 0.0055 in.	0.0045 in.	0.0015 in.
End play of crankshaft in bearings when installed	0.004 to 0.005 in.	0.009 in.	0.009 in.
Thickness of copper bead coating in bearing liner	$\frac{1}{32}$ in.	—	—

c. Crankshaft.

Main bearing journals:			
Diameter	4.499 to 4.500 in.	0.003 in.	0.002 in.

Serviceability Standards

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Authorized undersize bearings	0.020, 0.040, 0.060 in.	—	—
Out-of-round	—	0.003 in.	0.002 in.
Run-out of center main bearing when supported at each end	0.000 to 0.002 in.	0.003 in.	0.003 in.
Fillets radius	0.170 to 0.190 in.	—	—
Connecting rod journals:			
Diameter	3.309 to 3.310 in.	0.003 in.	0.002 in.
Authorized undersizes	0.020, 0.040, 0.060 in.	—	—
Out-of-round	0.000 to 0.001 in.	0.003 in.	0.0015 in.
Fillets radius	0.170 to 0.190 in.	—	—
Run-out limits	—	0.005 in.	0.002 in.
Run-out of flywheel mounting face	0.000 to 0.002 in.	0.002 in.	0.002 in.
Run-out of flywheel face when mounted on crankshaft	—	0.006 in.	0.006 in.
Generator drive pulley run-out	—	0.010 in.	0.010 in.
Balance crankshaft with flywheel and pulley to 1.0 in.-oz	—	—	—

d. Timing Chain and Sprockets.

Slack at center line of chain	—	3/8 in.	3/8 in.
Length of chain with rivets removed	39 in. (78 links)	—	—

e. Timing Gears.

Backlash of camshaft gear to crankshaft gear	0.001 to 0.002 in.	0.002 in.	0.002 in.
Teeth can be chipped 1/4-in. the length of wearing surface; chipped places must be ground	—	—	—

f. Camshaft.

Diameter of journals	2.371 to 2.372 in.	0.005 in.	0.002 in.
Allowable undersizes	None	—	—
Run-out of center journal when end journals are supported	—	0.001 in.	0.004 in.
Permissible wear of lobes from heel to toe	—	0.050 in.	0.050 in.

g. Camshaft Bearings and Bushings.

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
I.D. of bearings	2.374 to 2.375 in.	0.004 in.	0.002 in.
Undersize bearings available	None	—	—
Interference, O.D. of bushings to I.D. of case	0.0025 to 0.0045 in.	—	—
End play of camshaft when installed	0.005 to 0.008 in.	0.010 in.	0.010 in.

h. Tappet Guides.

I.D. of guides	0.8745 to 0.8755 in.	0.004 in.	0.002 in.
Clearance, tappet to guide	0.0005 to 0.002 in.	0.006 in.	0.004 in.
O.D. guide to I.D. bore clearance	0.0005 to 0.0025 in.	—	—
Diameter of tappet	0.8735 to 0.874 in.	—	—
Maximum surface removable from tappet	—	0.005 in.	0.005 in.

i. Valve Seats.

Width of valve seat	$\frac{13}{64}$ in.	—	—
Angle of seat	45 deg	—	—
Angle of relief (for narrowing width of valve seat)	60 deg	—	—
Valve seat diameter:			
Exhaust	$1\frac{15}{16}$ in.	—	—
Intake	$\frac{31}{32}$ in.	—	—

j. Valve Guides.

Exhaust:			
Dimension of bore	0.499 to 0.500 in.	0.005 in.	0.005 in.
Interference, O.D. of guide bushing to I.D. of bore	0.001 to 0.0025 in.	—	—
Intake:			
Dimension of bore	0.499 to 0.500 in.	0.003 in.	0.003 in.
Interference, O.D. of guide bushing to I.D. of bore	0.001 to 0.0025 in.	—	—

k. Valves.

Angle of seat	45 deg	—	—
Stem diameter	0.497 to 0.498 in.	0.004 in.	0.004 in.
Stem to guide clearance (intake)	0.0025 to 0.003 in.	0.004 in.	0.004 in.
Stem to guide clearance (exhaust)	0.0025 to 0.003 in.	0.003 in.	0.005 in.
Valve tappet clearance in bracket	0.001 to 0.0015 in.	—	—

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Rocker arm to valve stem clearance (intake)	—	0.010 in.	0.010 in.
Rocker arm to valve stem clearance (exhaust)	—	0.016 in.	0.016 in.
l. Valve Springs—Scale Readings.			
Outer springs:			
At 3 15/32 in: (minimum working height)	51 to 59 lb	—	—
At 2 31/32 in. (maximum working height)	89 to 99 lb	—	—
Inner springs:			
At 3 5/32 in. (minimum working height)	29½ to 35½ lb	—	—
At 2 21/32 in. (maximum working height)	54½ to 60½ lb	—	—
Free length, inner springs	4 in. ± 1/16 in.	—	—
Length, valve open, inner springs	2 21/32 in.	—	—
Free length, outer springs	4½ in. ± 1/16 in.	—	—
Length, valve open, outer springs	2 31/32 in.	—	—
m. Connecting Rods.			
Torque tightness of connecting rod nuts	263 ft-lb	—	—
Maximum warpage of machined parting surfaces	—	0.002 in.	0.002 in.
I.D. at crankshaft end	3.513 to 3.514 in.	0.002 in.	0.002 in.
I.D. of bearing (crankshaft end)	3.313 to 3.3135 in.	0.002 in.	0.0015 in.
Clearance, bearing to crankshaft	0.0035 to 0.0045 in.	0.0045 in.	0.0015 in.
Side clearance, bearing to crankshaft	0.005 to 0.012 in.	0.012 in.	0.012 in.
Maximum out-of-round (horizontal)	—	0.002 in.	0.002 in.
I.D. at piston end	2.249 to 2.250 in.	—	—
I.D. of bushing (piston end)	2.0005 to 2.001 in.	0.001 in.	0.001 in.
Interference, O.D. of bushing to I.D. of rod	0.001 to 0.003 in.	—	—
Fit of piston pin to bushing	0.0015 to 0.002 in.	0.001 in.	0.001 in.
Allowable twist (measured in 3 in.)	—	0.002 in.	0.002 in.
Balance rod, including piston to:	Within ½ oz	—	—
Total weight of rod	13 lb, 9½ oz	—	—

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Thickness of bearing shells (standard)	0.10025 to 0.1005 in.	—	—
Thickness of oversizes available	0.010 in. and 0.020 in.	—	—
Center-to-center length	12 in.	—	—
n. Pistons.			
Diameter, bottom of skirt	5.615 to 5.616 in.	—	—
Diameter, top of skirt	5.613 to 5.614 in.	—	—
Oversizes available	0.020, 0.040, 0.060 in., and semi-finished	—	—
Width of ring grooves:			
Groove No. 1 (top)	0.127 to 0.128 in.	0.003 in.	0.003 in.
Grooves Nos. 2, 3, and 4	0.1255 to 0.1265 in.	0.002 in.	0.002 in.
Grooves Nos. 5 and 6	0.2505 to 0.2515 in.	0.002 in.	0.002 in.
Diameters of ring lands:			
Top land	5.584 to 5.586 in.	—	—
Second and third lands	5.603 to 5.605 in.	—	—
Fourth and fifth lands	5.605 to 5.607 in.	—	—
Diameter, piston pins	1.9998 to 2.0000 in.	—	—
Oversizes available	0.005 in.	—	—
Piston pin bore diameter in piston	1.9998 to 2.0000 in.	—	—
Fit of piston pin in piston	0.0000 to 0.0005 in.	0.001 in.	0.001 in.
Clearance, piston to bore	0.0085 to 0.0125 in.	—	—
o. Piston Rings.			
Gap when fitted in piston	0.018 to 0.022 in.	—	—
Clearance of ring in piston groove	—	—	—
Groove No. 1 (top)	0.003 to 0.0045 in.	0.003 in.	0.003 in.
All other grooves	0.0015 to 0.003 in.	0.002 in.	0.002 in.
Width of rings (compression)	⅛ in.	—	—
Width of rings (oil control)	¼ in.	—	—

p. Rocker Arms and Shaft.

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Diameter of rocker arm shaft	0.855 to 0.856 in.	0.0125 in.	0.0125 in.
Maximum run-out of rocker arm shaft	0.000 to 0.002 in.	0.003 in.	0.003 in.
I.D. of bushing before reaming	0.856 to 0.857 in.	—	—
I.D. of bushing after reaming	0.8575 to 0.8585 in.	0.003 in.	0.003 in.
Clearance of shaft in rocker arm bushing	0.001 to 0.0015 in.	0.017 in.	0.017 in.
Interference, O.D. of bushing to I.D. of hole	0.001 to 0.003 in.	—	—
Length of bushing	1.373 to 1.378 in.	—	—

q. Face of Cylinder Heads.

Maximum allowable warpage per foot of length	—	0.010 in.	0.010 in.
Limit of surface grind to correct warpage	—	0.004 in.	0.004 in.
Permissible channeling before refacing	—	0.003 in.	0.003 in.

r. Face of Block.

Maximum allowable warpage	—	0.010 in.	0.010 in.
Limit of surface grind to correct warpage	—	0.004 in.	0.004 in.

s. Oil Pump.

Output of pump at 1,800 rpm	13 gal. per min	—	—
Allowable wear on end plates before regrinding	—	0.006 in.	0.006 in.
End play between gear and end plate	—	0.010 in.	0.010 in.
Limit of surface grind from plate	—	0.010 in.	0.010 in.
Bushing I.D., drive end	0.9995 to 1.0005 in.	0.002 in.	0.002 in.
Bushing I.D., non-driven end	0.7479 to 0.7505 in.	—	—
Drive shaft diameter	0.9985 to 0.9990 in.	0.002 in.	0.002 in.
Driven shaft diameter	0.7485 to 0.749 in.	0.002 in.	0.002 in.
Clearance between gear and housing	0.0005 to 0.001 in.	0.0015 in.	0.0015 in.
Gear backlash	0.006 to 0.010 in.	0.005 in.	0.005 in.
Body bore, scavenger and pressure pump gears	2.334 to 2.333 in.	—	—
Front cover, drive shaft bore	1.0005 to 0.9995 in.	—	—

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Front cover, intermediate shaft bore	0.7505 to 0.7495 in.	—	—
Body bore, drive shaft	0.7505 to 0.7495 in.	—	—
Body bore, idler shaft	0.7505 to 0.7495 in.	—	—
Body bore, intermediate shaft	0.938 to 0.937 in.	—	—
Rear cover bore, intermediate shaft	0.7505 to 0.7495	—	—
Rear cover bore, idler shaft	0.7505 to 0.7495 in.	—	—
O.D. of gears	2.3315 to 2.3310 in.	—	—
I.D. of gears	0.7505 to 0.7495 in.	—	—
Width of gears	1.000 to 0.999 in.	—	—
t. Oil Pressure Regulator.			
Scale reading	12 lb at 1⅞ in.	—	—
Free length of spring	2¼ in.	—	—
Clearance of piston in body	0.002 to 0.006 in.	0.004 in.	0.004 in.
Valve opens at	40 psi	—	—
u. Flywheel and Ring Gear.			
Nominal depth from surface of machined flange to face of clutch surface	2.9325 to 2.9425 in.	—	—
Permissible amount removable from clutch face of flywheel	—	0.045 in.	0.045 in.
Run-out of ring gear	—	0.005 in.	0.003 in.
Interference, I.D. of ring gear to O.D. of flywheel	0.020 to 0.025 in.	—	—
Balance flywheel to within	0.3 in.-oz	—	—
Clutch face run-out (measuring from bell housing)	—	0.005 in.	0.002 in.
Bell housing face run-out	—	0.004 in.	0.004 in.
Concentricity of flywheel to housing bore	—	0.006 in.	0.006 in.
Diameter, clutch pilot bearing bore in flywheel	1.1808 to 1.1803 in.	—	—
v. Clutch.			
Thickness of lined clutch plates	0.450 to 0.434 in.	0.284 in.	0.284 in.
Desired thickness	0.442 in.	—	—
Thickness of pressure plate	1.154 to 1.158 in.	0.015 in.	0.015 in.
Desired thickness	1.156 in.	—	—
Maximum amount removable, all surfaces	—	0.045 in.	0.045 in.

Serviceability Standards

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Maximum thickness of shim to compensate for refacing	—	0.015 in.	0.015 in.
Spring scale reading at $2\frac{13}{16}$ in.	460 lb min, 480 lb max	—	—
Balance, intermediate and driven plate	½ in.-oz	—	—
Balance, spring housing and pressure plate	½ in.-oz	—	—
Permissible wear from fingers	—	0.110 in.	0.110 in.
w. Water Pump.			
Diameter of shaft	1.627 to 1.6275 in.	0.002 in.	0.002 in.
Clearance between impeller and pump body	—	0.010 in.	0.010 in.
Spring pressure at $1\frac{1}{16}$ in.	18 to 21 lb	—	—
Gear backlash	—	0.004 in.	0.002 in.
x. Accessory Gear Assembly.			
Backlash of gears	0.002 to 0.004 in.	0.005 in.	0.005 in.

107. FUEL INJECTOR PUMP AND DRIVE.

a. General. Except for the fuel injector pump plunger to seat clearance and injector pump drive, no perceptible clearances can be tolerated for the precision parts of the fuel injector pump. Deviation from the original, precise, lapped fit can be determined only by operating efficiency when the assembled units are tested for correct performance.

b. Fuel Injector Pump.

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Plunger to delivery valve seat clearance at top of plunger stroke	—	0.020 in.	0.020 in.
Camshaft end play	0.005 to 0.008 in.	0.010	—
c. Injector Pump Drive.			
Wear limit	—	Play causing 2-degree variation from prescribed timing of injection	—
Drive shaft end clearance	—	0.004 in.	0.002 in.
Drive shaft bearing clearance	—	0.003 in.	0.0025 in.

108. GOVERNOR, FUEL TRANSFER PUMP, AND NOZZLES.

a. Governor.

Point of Measurement	Dimensions of New Parts	Max. Wear Allowable	Wear Limit at Complete Overhaul
Clearance between stationary thrust surfaces and thrust bearing plates	—	0.006 in.	0.005 in.
Clutch tension	2¼ to 2¾ ft-lb	—	—
Thicknesses of available clutch shims	0.035, 0.049, and 0.065 in.	—	—
Reamed I.D. of operating lever shaft bushings	⅜ in.	—	—

b. Fuel Transfer Pump. Tolerances are not perceptible. Worn or damaged tappet parts must be replaced. Valve seats can be refaced (par. 70 **c**).

c. Nozzles. No perceptible clearances can be tolerated for the precision parts of nozzles. Test for satisfactory performance (par. 78) is the only way to determine operating efficiency.

APPENDIX
REFERENCES

109. PUBLICATIONS INDEXES.

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

Introduction to Ordnance Catalog (explaining SNL system)	ASF Cat. ORD 1 IOC
Ordnance publications for supply index (index ASF Cat. 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 and index of administrative and supply publications (lists new AR's, changes and revisions, circulars, general orders and bulletins, T/O & E's, T/BA's, T/A's, MR's, RR's, Pamphlets, SB's, MWO's, and forms)	WD Pamphlet 12-6
List of Publications for Training (lists MTP's, FM's, TM's, TR's, WDTB's, firing tables and charts, lubrication orders, changes, recessions, cancellations, and supersessions)	FM 21-6
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

110. STANDARD NOMENCLATURE LISTS.

a. Vehicular.

Truck, trailer, 45-ton, tank transporter, M19	SNL G-159

b. Maintenance.

ORD 5, Antifriction bearings and related items	SNL H-12
ORD 5, Cleaning, preserving and lubricating materials; recoil fluids, special oils, and miscellaneous related items	SNL K-1

ORD 5, Elements, oil filter	SNL K-4
ORD 5, Lubricating equipment, accessories, and related dispensers	SNL K-3
ORD 5, Miscellaneous hardware	SNL H-2
ORD 6, Ordnance maintenance sets	SNL N-21
ORD 5, Soldering, brazing and welding materials, gases and related items	SNL K-2
ORD 5, Standard hardware	SNL H-1
ORD 5, Tires, tubes, tire valves and patches, etc.	SNL H-14
Tools, maintenance, for repair of automotive and semi-automotive vehicles:	
ORD 6, Tool-sets (special) automotive and semi-automotive	SNL G-27 (Section 1)
ORD 6, Tool-sets (common) specialists' and organizational	SNL G-27 (Section 2)

111. EXPLANATORY PUBLICATIONS.

a. Fundamental Principles.

Automotive brakes	TM 10-565
Automotive electricity	TM 10-580
Automotive power transmission units	TM 10-585
Basic maintenance manual	TM 37-250
Chassis, body, and trailer units	TM 10-560
Cooling systems: Vehicles and powered ground equipment	TM 9-2858
Diesel engines and fuels	TM 10-575
Driver selection and training	TM 21-300
Driver's manual	TM 21-305
Electrical fundamentals	TM 1-455
Fuels and carburetion	TM 10-550
Military motor vehicles	AR 850-15
Motor vehicle inspections and preventive maintenance services	TM 9-2810
Precautions in handling gasoline	AR 850-20
Radio fundamentals	TM 11-455
Sheet metal work, body, fender, and radiator repairs	TM 10-450

References

Standard military motor vehicles	TM 9-2800
Storage batteries, lead-acid type	TM 9-2857
b. Operation.	
45-ton tank transporter truck-trailer M19	TM 9-768
c. Maintenance and Repair.	
Cleaning, preserving, sealing, lubricating and related materials issued for ordnance materiel	TM 9-850
Maintenance and care of pneumatic tires and rubber treads	TM 31-200
Ordnance maintenance: Trailer, 45-ton, 12-wheel, M9 (component of truck, trailer, 45-ton tank transporter, M19)	TM 9-1768C
Ordnance maintenance: Truck, 12-ton, 6 x 4, M20 (component of truck, trailer, 45-ton tank transporter, M19): Power train, chassis, and auxiliary equipment	TM 9-1768B
Ordnance service in the field	FM 9-5
d. Protection of Materiel.	
Camouflage	FM 5-20
Decontamination	TM 3-220
Decontamination of armored force vehicles	FM 17-59
Defense against chemical attack	FM 21-40
Explosives and demolitions	FM 5-25
e. Storage and Shipment.	
Ordnance company, depot	FM 9-25
Ordnance storage and shipment chart—Group G—major items	SB 9-OSSC-G
Ordnance packaging and shipping (posts, camps, and stations)	TM 9-2854
Preparation of unboxed ordnance materiel for shipment	SB 9-4
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

INDEX

A

Page

Accessories
- installation 130
- removal 40

Adapter frame 38

Air cleaners
- description and operation 148
- inspection 22

Air compressor
- inspection 23
- removal 37

Air induction system 130

B

Bell housing
- cleaning 81
- inspection 31, 82
- installation 122
- removal 42
- trouble shooting 31

Bores, main bearing 254

Brake horsepower 131

Breather cap, inspection 23

Breather pipe assembly 37

Burner, starter (*See* Starter burner)

By-pass tube
- installation 129
- removal 42

C

Camshaft
- check end play 127
- description and operation 34
- disassembly, cleaning, inspection, and repair 63, 82
- installation 115, 189
- removal 47, 173
- serviceability standards 255

Camshaft bearings
- dimensions 62
- inspection 54, 59
- line-reaming 58
- repair 54
- replacement 58
- serviceability standards 254

Clutch
- alining and adjustment 142
- description, operation, and data 134
- removal 40

Clutch assembly
- cleaning, inspection, and repair 200
- overhauling 135

Clutch plate length aliner 17

Combustion chamber liners 54

Connecting rod assembly
- disassembly, cleaning, and inspection 66
- repair and assembly 71

Connecting rod bearings 34

Connecting rods
- installation 119
- serviceability standards 257

Coolant service 232

Cooling system
- cleaning 229
- corrective service 230
- description and operation 227
- general discussion 9
- inspection 21

Corrosion, excessive 52

Covers, removal
- cylinder head 44
- end 173
- (*See also* Crankcase gear cover)

Crank grab
- inspection 23
- removal 43

Crankcase
- capacity data 36
- description and operation 34

Crankcase breather cap 104

Crankcase gear cover
- assembly 103
- cleaning, inspection, and repair 102
- disassembly 101

Crankshaft
- assembly 66
- installation 115
- removal 47
- serviceability standards 254

Crankshaft run-out 64

Cylinder block
- assembly 63
- description and operation 34
- serviceability of face 259

Cylinder block casting
- inspection and repair 53
- overhauling 51

Cylinder bore liners 56

Cylinder bores 53

Cylinder head assemblies 128

C—Contd. Page

Cylinder heads
cleaning and inspection 87
description and operation 34
disassembly 84
removal 44
serviceability standards of face 259
Cylinders, serviceability standards 254

D

Drive chain, fuel pump
adjustment 124
installation 124
Drive coupling, assembly 244
Drive coupling flange 172
Drive gear
cleaning, inspection, and repair 200
removal 196
replacement 107
Drive pulley
inspection 23
removal 43
Driven disk
cleaning, inspection, repair, and assembly 136
disassembly 135
Driven gear, cleaning, inspection, and repair 199
Dynamometer
adjustment and run-in test 130
testing 32, 131

E

Electrical parts (starter burner) 226
Electrical system
inspection 21
preliminary instructions for run-in test 130
End plate, removal 173
Engine
assembly and general precautions 115
check for seizure due to internal damage 20
check signs of compression loss 21
data 35
description 4, 34
disassembly 36, 40
inspection 32
installation in stand 39
penalty run 133
preparation for shipment 133

Page

serviceability standards 254
special tools 11
starting 131
test run 132
trouble shooting 20, 27, 32
Engine oil system 35
Engine supports
disassembly, cleaning, and repair 100
inspection 23, 100
installation 129
removal of front 43

F

Fan assembly
adjustment 253
assembly 252
cleaning, inspection, and repair 251
data and disassembly 249
description 9, 249
removal of fan 37
Fan bracket 37
Flange coupling 97, 124
Flywheel
inspection and trouble shooting 31
installation 123
removal 42
spotting 210
Flywheel assembly
disassembly and cleaning 78
inspection and repair 79
Fuel filters, description and operation 146
Fuel gage, description and operation 148
Fuel injection equipment 35
Fuel injection system 151
Fuel injector pump
adjustment 157
assembly 187, 207
calibrating 7, 163
cleaning and repair 169
corrections 166
data 36, 154
description and operation 7, 151
disassembly 169, 171
inspection 24, 169
modifications 10
overhauling 171
testing 157, 171, 207
timing 7, 160, 210, 213

F—Contd. Page

Fuel injector pump—Contd.
trouble shooting 28
Fuel injector pump drive
disassembly, cleaning, inspection, repair, and assembly 95
serviceability standards 261
Fuel lines
description and operation 146
inspection 25
Fuel nozzles (*See* Nozzles, fuel)
Fuel pump drive 35
Fuel pump drive chain 44
Fuel pump sprocket (*See* Sprockets)
Fuel strainer, inspection 25
Fuel system
description 146
general discussion and operation 4
preliminary instructions for run-in test 131
Fuel tanks
description and operation 146
inspection 25
Fuel transfer pump
assembly 207
cleaning, inspection, and repair 204
data 157
description 8, 146, 156
disassembly into subassemblies and removal 169
inspection 25
modifications 10
operation 8
serviceability standards 262
set-up for test 168
testing and disassembly 204
Fulcrum yoke assembly 194

G

Gear cover
inspection 22
removal 44
Governor
adjustments 167, 208
assembly
from subassemblies 203
of subassemblies 201
changing spring without removing governor 168
cleaning, inspection, and repair 197
data 156
description 7, 156
disassembly
into subassemblies 169, 191
of subassemblies 193
models of 10
operation 8, 156
serviceability standards 262
testing 191, 208
trouble shooting 28
Governor and cover 26
Governor housing 195

H

Hand primer, inspection 25

I

Impeller (water pump)
assembly 240
clearance 241
inspection 236
Inspection cover
installation 191
removal 171

J

Journals
check wear 64
measuring 83
serviceability standards (connecting rod journals) 255

L

Leaks (cooling system) 231

M

Main bearings
description and operation 34
inspection and repair 65
installation 117, 119
removal 47
serviceability standards 254
Manifolds (intake and exhaust)
assembly 99
cleaning and repair 97
inspection 22, 97
removal 44
(*See also* Water outlet manifold)
Modifications 10

N

	Page
Nozzles, fuel	
adjustment	215
assembly	221
cleaning and repair	220
data	214
description	8, 214
disassembly	217, 219
inspection	26, 220
operation	8
serviceability standards	262
special tools	19
testing	214, 215, 221
trouble shooting	30

O

Oil filler	105
Oil filler cover, inspection	25
Oil filter assembly	24
Oil filter bracket	111
Oil filters	
cleaning and assembly	111
disassembly	110
Oil level cock	25
Oil lines	
cleaning, inspection, and repair	110
removal	42
Oil pan	
disassembly and cleaning	103
inspection, repair, and assembly	104
removal	45
Oil pan assembly	
inspection	23
installation	128
Oil pipe assembly	
installation	120
removal	45
Oil pressure regulator	
assembly	113
disassembly, cleaning, and inspection	111
inspection	24
Oil pump	
assembly	109
disassembly, cleaning, inspection, and repair	105
installation	119
removal	45
serviceability standards	259
Oil pump covers	107
Overflow valve	
modifications	10
testing	167

P

Piston assembly	
disassembly, cleaning, inspection	66
repair and assembly	71
Piston rings, serviceability standards	258
Pistons	
description and operation	34
installation	119
serviceability standards	258
Plunger barrels	
installation	188
removal	174
Plungers	
installation	188, 207
removal	173
Pressure plate assembly	
assembly and adjustment	139
disassembly	136
cleaning, inspection, and repair	138
Pressure-flushing	
cooling system	231
cylinder block	52
Pressure regulator, oil	46
Pumps	
adjustment of fuel injector	157
assembly	
fuel injector	187, 207
fuel transfer	207
oil	109
water	240
cleaning and repair	
fuel injector	169
fuel transfer	204
oil	105
water	233
data	
fuel injector	36, 154
fuel transfer	157
water	232
description and operation	
fuel injector	7, 151
fuel transfer	8, 151
oil	35
water	9, 232

P—Contd.

	Page
Pumps—Contd.	
disassembly	
fuel injector	171
fuel transfer pump	169
oil	105
water	232
inspection	
fuel injector	24
fuel transfer	25, 204
oil	105
water	233
installation	
oil	119
water	129
modifications	10
overhauling of fuel injector pump	171
removal	
fuel injector	171
fuel transfer	169
oil	45, 46
water	42
serviceability standards	
fuel injector	261
fuel transfer	262
oil	259
water	261
testing	
fuel injector	171
fuel transfer	204
trouble shooting	28

R

	Page
Radiator	
assembly and testing	247
cleaning, inspection, and repair	245
data and disassembly	244
description	9, 244
Reports and records	2
Rocker arm assembly, valve	
assembly	94
disassembly, cleaning, inspection, and repair	92
removal	44
serviceability standards of rocker arms and shaft	259

S

	Page
Serviceability standards	254
Shims, inspection	23
Shroud, removal	245
Solenoid, stop control	149
Sprockets	
installation of fuel pump	123
press driven on shaft	96
removal	44
serviceability standards	255
Starter burner	
adjustment	226
assembly	225
cleaning, inspection, and repair	223
data and disassembly	222
description	149, 222
installation	129
operation	149
testing	226
Stop control solenoid	26

T

	Page
Tachometer drive	
inspection	237
disassembly, cleaning, inspection, and repair	114
Tanks, removal	245
Tappet assemblies	179
Tappet holders, inserting	172
Tappets	
inspection	89
installation	189, 207
removal	51, 173
serviceability standards of guides	256
Thermostat	
installation of housing and elbow	129
removal	44
Throttle, definition of full	131
Thrust bearings	84
Thrust flanges	
installation	116
removal	48
Thrust plates, inspection	23
Timing chain, serviceability standards	255
Tool bit, setting	59
Tools	
for cleaning	229
improvised	19
special	11
Transmission, removal	40

T—Contd. Page

Trouble shooting
- before removal and during operation ... 27
- before removal or operation ... 20

V

Valve assembly
- inspection ... 87
- repair and assembly ... 92

Valve rocker arm assembly (*See* Rocker arm assembly, valve)

Valves
- cleaning and inspection
  - delivery ... 182
  - overflow ... 185
- description and operation of exhaust and intake ... 35
- installation
  - inlet and outlet ... 207
  - overflow ... 10
- modification of overflow ... 10
- removal of delivery valves ... 174
- repair
  - delivery ... 182
  - fuel transfer pump ... 206
  - overflow ... 135
- serviceability standards ... 256
- timing data ... 36

Viscometer instrument
- assembly ... 114
- disassembly, cleaning, inspection, and replacement ... 113
- inspection ... 24

W

Water outlet manifold
- assembly ... 249
- cleaning, inspection, repair, and testing ... 248
- disassembly ... 247
- removal ... 44

Water pump
- assembly ... 240
- cleaning, inspection, and repair ... 233
- data ... 232
- description ... 9, 232
- disassembly ... 232
- removal ... 42

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