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TM 9-1777A

WAR DEPARTMENT
U.S. Dept. of Army
TECHNICAL MANUAL
ORDNANCE MAINTENANCE
**HEAVY TRACTOR M1
(MHC TD-18)
ENGINE**
DECEMBER 12, 1942

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ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE U113

Prepared under the direction of the
Chief of Ordnance

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CONTENTS

	Paragraphs	Pages
SECTION I. Introduction	1-6	2-27
II. Engine trouble shooting and tune-up	7-22	28-35
III. Inspection of the engine in vehicle...	23-24	36-37
IV. Removal of engine from vehicle.....	25-36	38-52
V. Disassembly of engine.....	37-74	53-99
VI. Inspection of disassembled engine...	75	100-104
VII. Removal from engine, disassembly, repair and rebuilding of subassemblies	76-153	105-230
VIII. Assembly of engine.....	154-195	231-285
IX. Installation of engine in vehicle.....	196-208	286-294
X. Fits and tolerances.....	209-210	295-297
XI. Special tools and equipment.....	211-214	298-302
XII. References	215-216	303-304
INDEX		305-314

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Section I

INTRODUCTION

	Paragraph
Scope	1
Characteristics	2
The Diesel principle	3
Description of tractor systems	4
Data	5
Allocation of maintenance duties by echelons	6

1. SCOPE.

a. The instructions contained in this manual are for the information and guidance of personnel charged with the maintenance and repair of the Heavy Tractor M1. Information on the detailed construction of the tractor, disassembly and assembly procedure, inspection, maintenance and repair is contained in four Technical Manuals of the 1000 series, of which this is the first. These instructions are supplementary to those in the Field and Technical Manuals prepared for the using arm.

b. Information.

(1) This manual contains a general description of the engine, and instructions for trouble shooting and tune-up, inspection, removal, disassembly, assembly and installation of the engine. Removal, disassembly, inspection of parts, repair and rebuilding of engine components—not part of the systems treated in individual sections—are treated in a separate section (section VII). Fits and tolerances, special tools and equipment and references are likewise included in individual sections.

(2) TM 9-1777B contains full information on all engine accessories of the Heavy Tractor M1. It describes the cooling system, the fuel system and the electrical system.

(3) TM 9-1777C contains information on the power train, the track frame assembly and the seats of the Heavy Tractor M1.

(4) TM 9-1777D contains information on all other equipment of the vehicle.

2. CHARACTERISTICS.

a. General.

(1) The engines of lots 1, 2, 3 and 4 discussed in this text are basically the same. From time to time certain improvements have been made on the engine. Where these improvements affect the servicing of the engine, instructions will be given covering both operations. Major

INTRODUCTION

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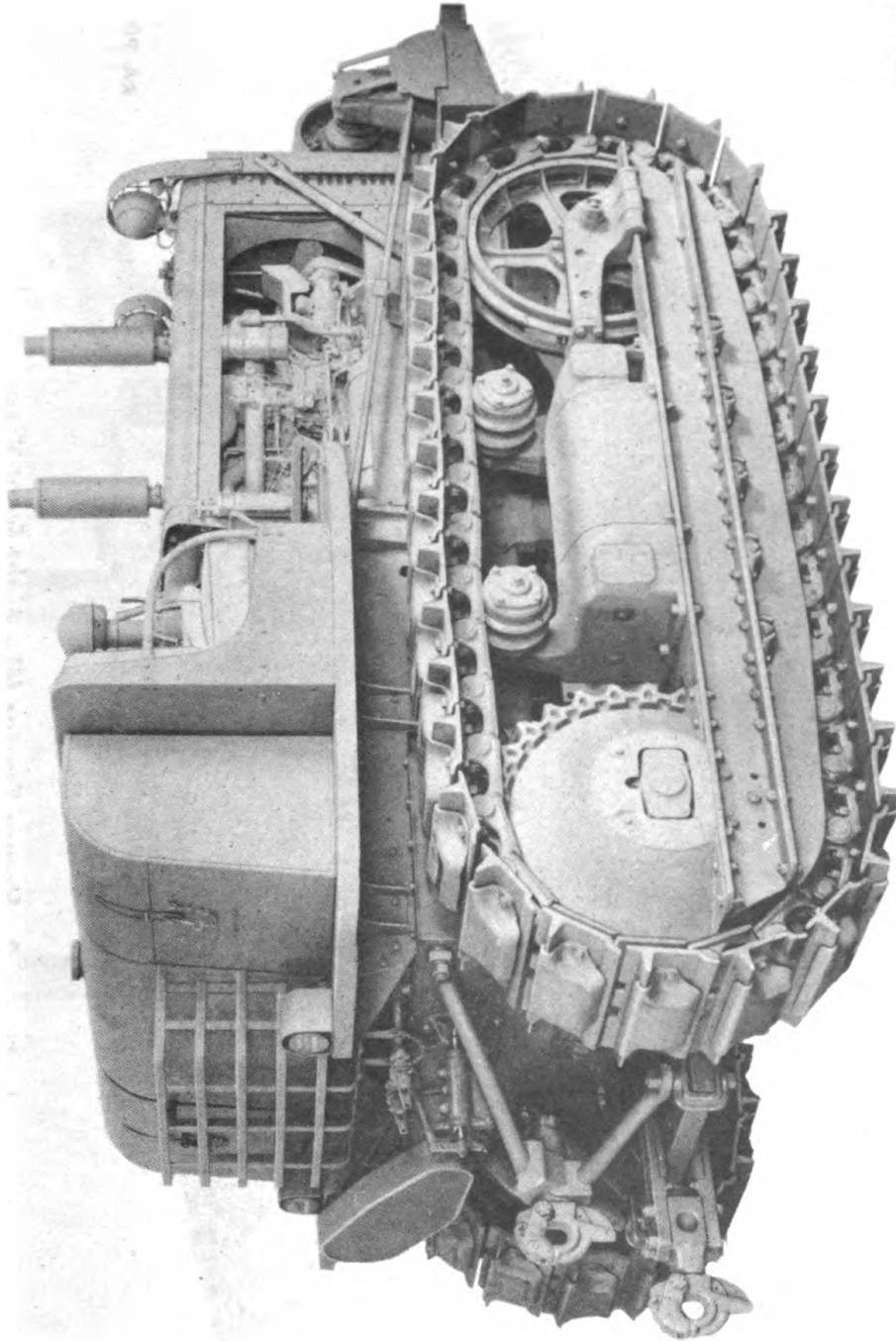
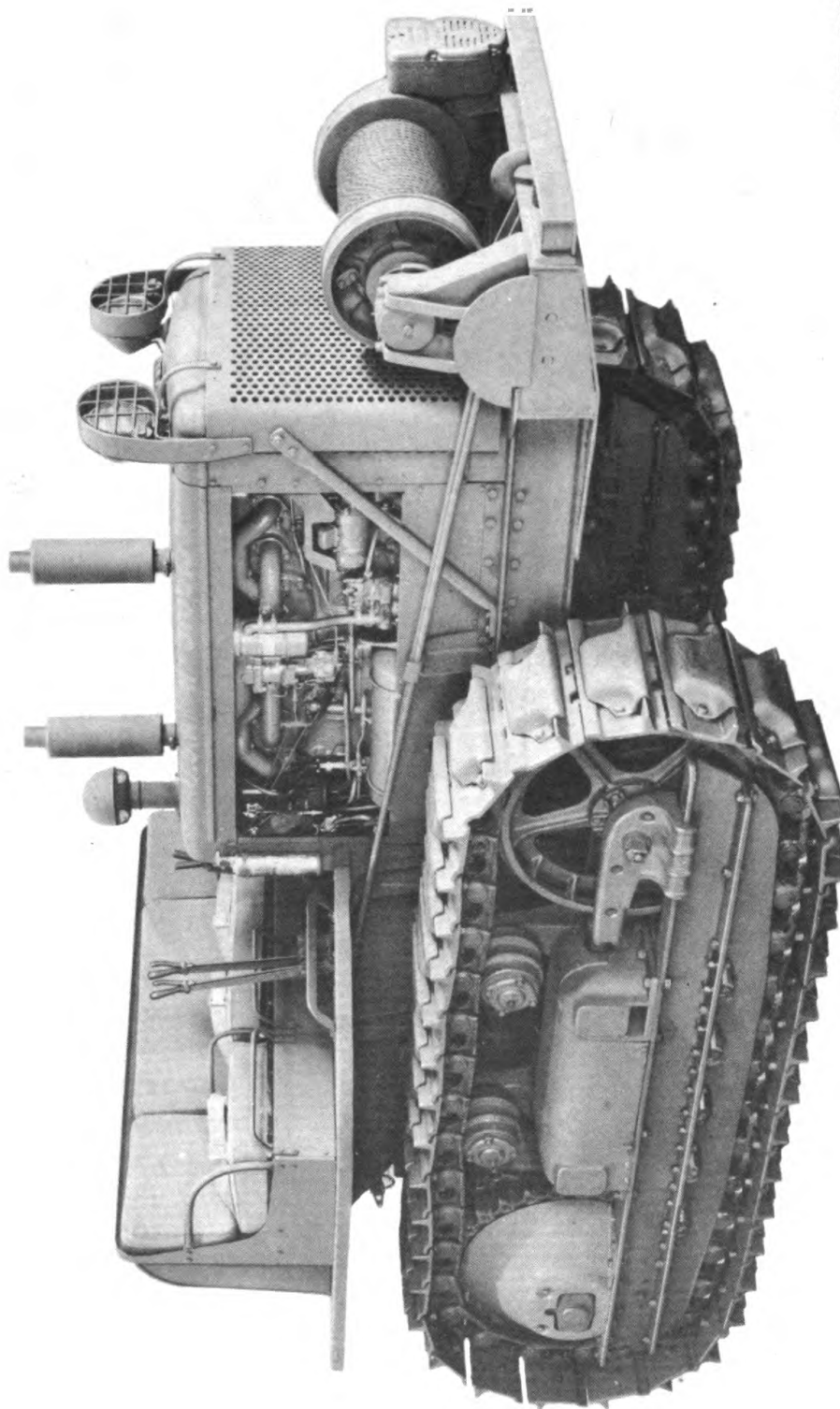


Figure 1—Heavy Tractor M1—Right Rear View

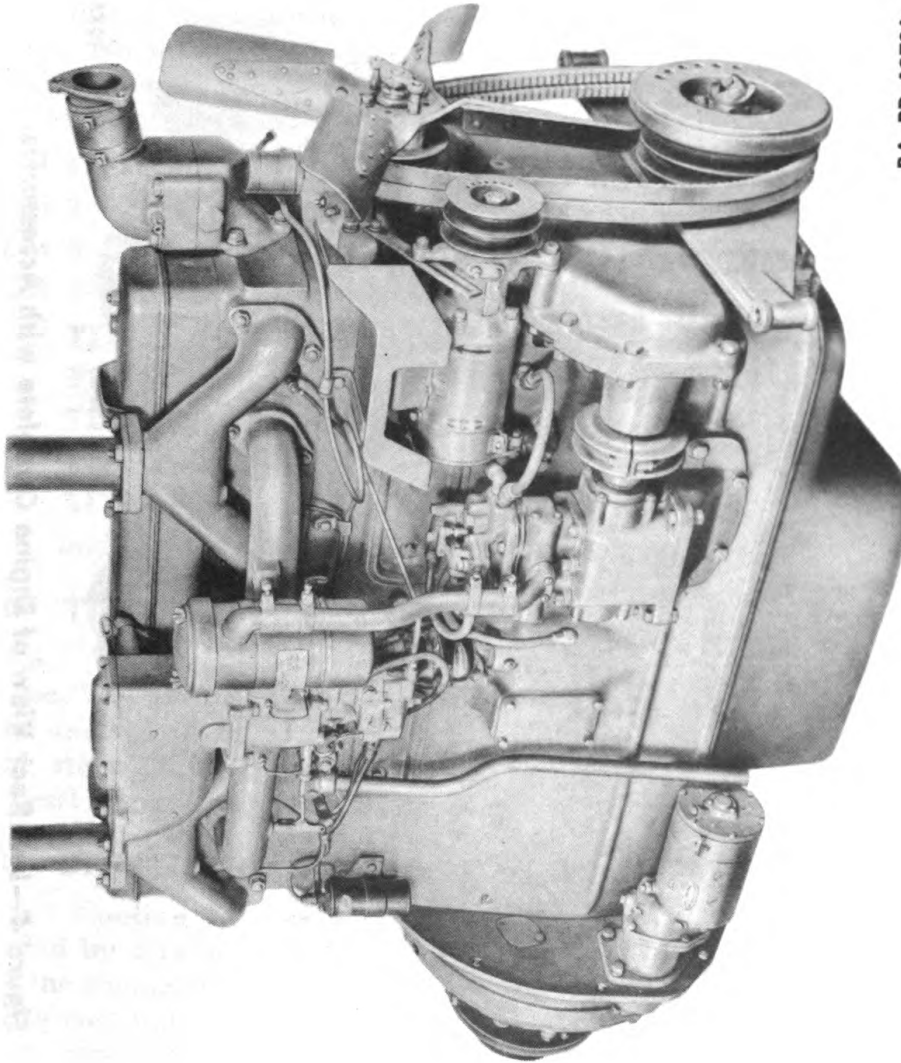
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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



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Figure 2—Heavy Tractor M1—Right Front View

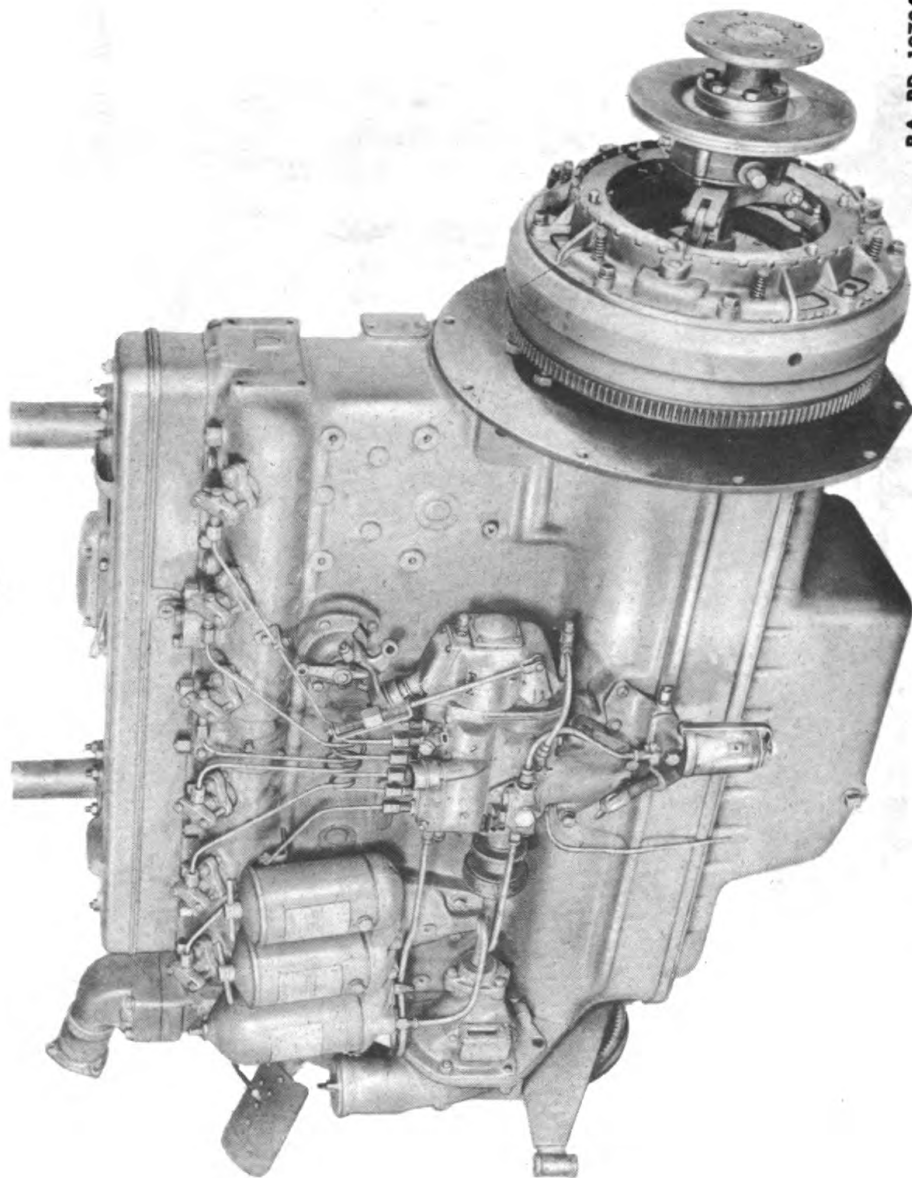
INTRODUCTION



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Figure 3—Right Front View of Engine Complete with Accessories

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12784

Figure 4—Left Rear View of Engine Complete with Accessories

INTRODUCTION

working parts such as cylinder heads, injection pump, injection nozzles, lubricating oil pump, water pump, cylinder liners with pistons, camshaft, etc., are replaceable and interchangeable on engines of all lots.

(2) Engine rotation is clockwise when viewed from the radiator end.

(3) Power from the engine is applied to the transmission through the clutch attached to the flywheel.

b. **Serial Numbers.** The engine serial number is stamped on the left side of the crankcase on a milled surface near the top of the crankcase. No attempt has been made to have the engine serial numbers conform with the tractor serial numbers. Engine serial numbers are as follows:

Lot 1 Engine No. TDRM 1741 to TDRM 2242, inclusive

Lot 2 Engine No. TDRM 2656 to TDRM 3682, inclusive

Lot 3 Engine No. TDRM 3775 to TDRM 4067, inclusive

Lot 4—Includes engine numbers:

TDRM 3796	TDRM 3824	TDRM 4051
TDRM 3803	TDRM 3825	TDRM 5055
TDRM 3807	TDRM 3826	TDRM 4062
TDRM 3812	TDRM 4049	TDRM 4064
TDRM 3815	TDRM 4050	TDRM 4065

and engine No. TDRM 4068 to TDRM 4861, inclusive.

3. THE DIESEL PRINCIPLE.

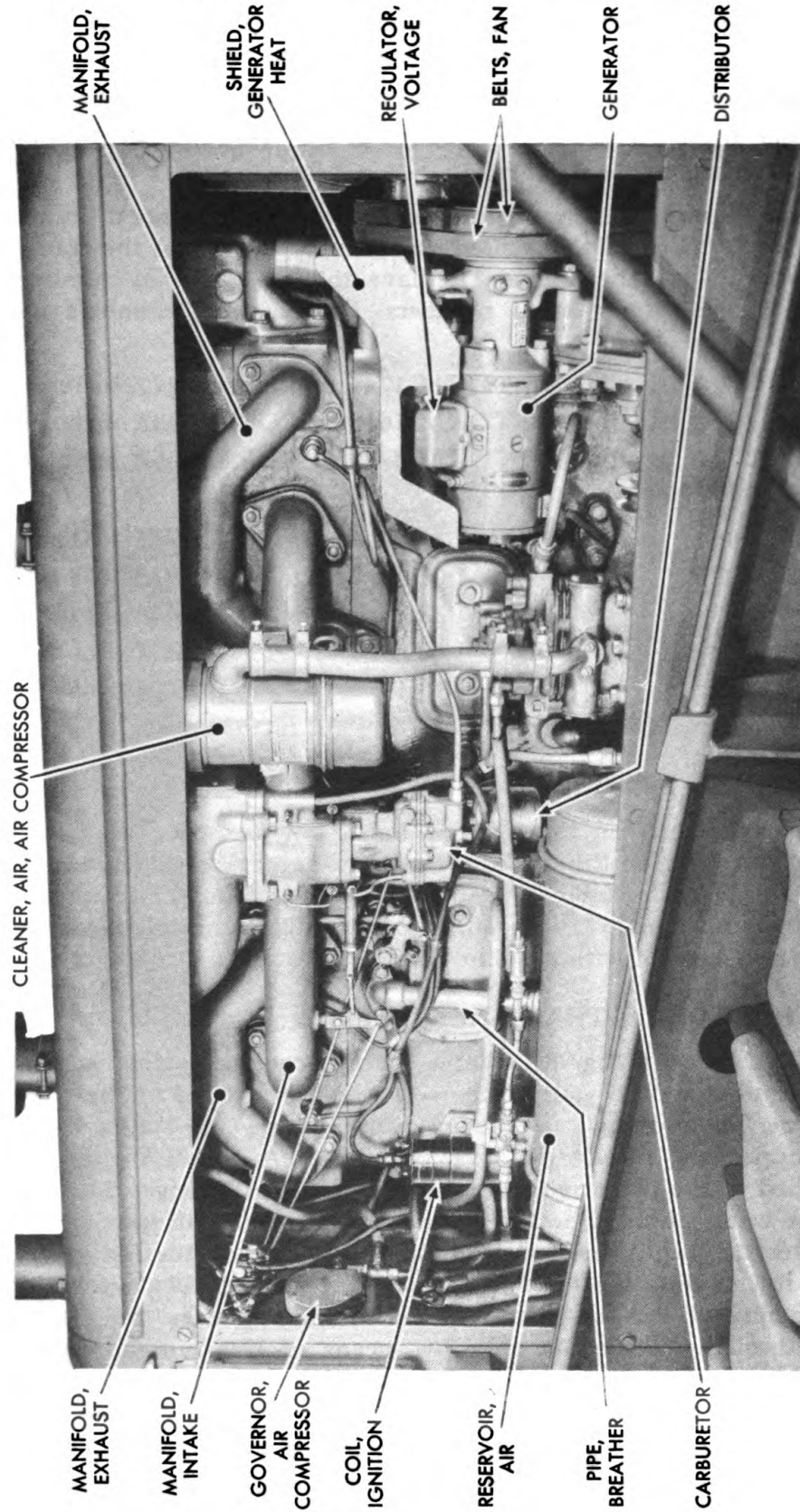
a. The engine used in the M1 tractors is a four-cycle, full Diesel type. The Diesel engine differs from the gasoline engine principally in the method used to introduce and ignite the fuel. Figure 7 illustrates the steps the four-cycle Diesel engine goes through and compares the Diesel engine operation with gasoline engine operation.

4. DESCRIPTION OF TRACTOR SYSTEMS.

a. **Cooling System** (fig. 8). Water for the cooling system is provided by a radiator of 27-gallon capacity which is located at the front of the engine. The radiator is of the fin- and flat-tube type construction, with cast upper and lower tanks with side plates. A double V-type fan belt, attached to the fan drive pulley at the crankshaft, drives both the fan and the water pump. The fan-drive pulley runs on ball bearings on a sleeve over the pump shaft. The pump is driven from the fan pulley through a full floating shaft. Thus the pump shaft assembly is relieved of carrying any of the fan belt load. When the engine is cool, water circulates through the engine only by means of the bypass. As the engine warms up, thermostatically controlled valves in the housing open and govern the amount of water traveling through the radiator.

b. **Cylinder Heads** (figs. 62, 69, 70 and 71). The engine has a front and a rear cylinder head, connected by a water manifold. Either the

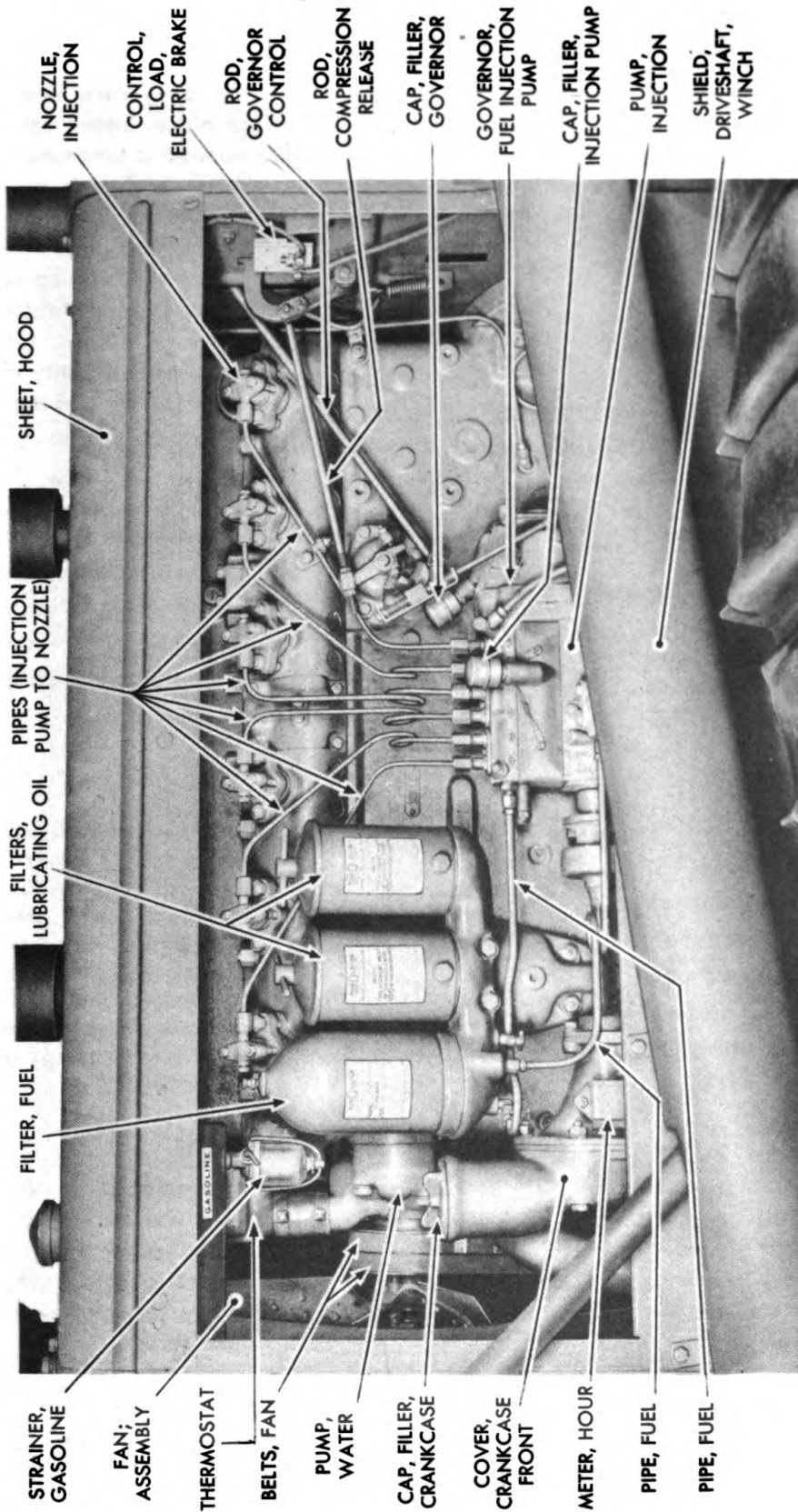
ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE



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Figure 5—Installed Engine—Right Side

INTRODUCTION



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Figure 6—Installed Engine—Left Side

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

GASOLINE

On downward stroke of piston, intake valve opens and atmospheric pressure forces air through carburetor where it picks up a metered combustible charge of fuel. The mixture goes past the throttle valve into cylinder-space vacated by the piston.

• • •

On upstroke of piston, valves are closed, and mixture is compressed usually to from 70 to 125 lbs. per sq. in., depending on anti-knock characteristics of the fuel.

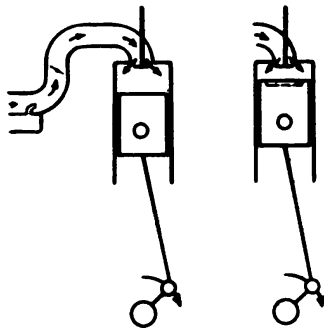
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Compressed fuel-air mixture is ignited by electric spark. Heat of combustion causes forceful expansion of cylinder gases against piston, resulting in power stroke.

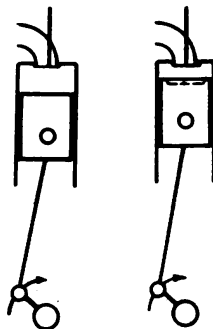
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Upstroke of piston, with exhaust valve open, forces cylinder gases out, making ready for another intake stroke.

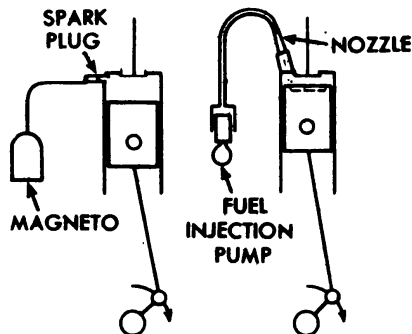
INTAKE STROKE



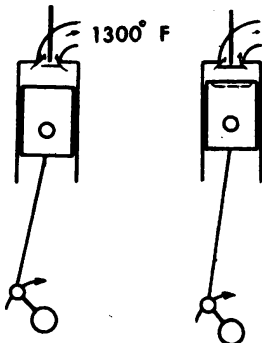
COMPRESSION STROKE



POWER STROKE



EXHAUST STROKE



DIESEL

On downward stroke of piston, intake valve opens and atmospheric pressure forces pure air into the cylinder-space vacated by the piston, there being no carburetor or throttle valve. Cylinder fills with same quantity of air, regardless of load on engine.

• • •

On upstroke of piston, valves are closed, and air in International Diesels is compressed to approximately 500 lbs. per sq. in.

• • •

High compression produces high temperature for spontaneous ignition of fuel injected near end of compression stroke. Heat of combustion expands cylinder gases against piston, resulting in power stroke.

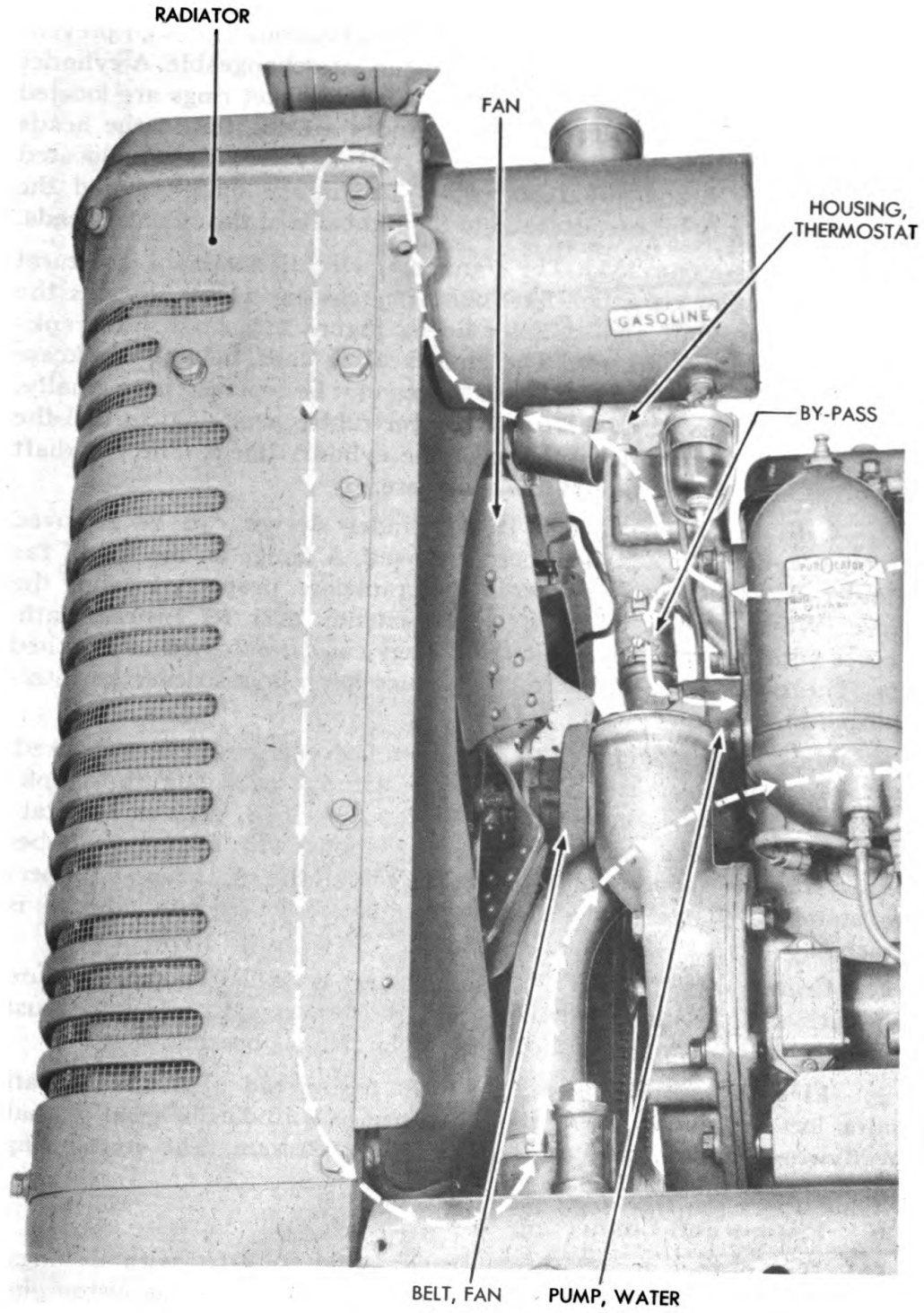
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Upstroke of piston, with exhaust valve open, forces cylinder gases out, making ready for another intake stroke.

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Figure 7—Comparison of Gasoline and Diesel Engine Cycles

INTRODUCTION



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Figure 8—Exterior Components of Cooling System

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

front or rear head can be removed independently of the other. While basically of uniform construction, slight modifications in design prevent the front and rear cylinder heads from being interchangeable. A cylinder head gasket is provided for each head. Copper gasket rings are located on top of the cylinder sleeves. Valve guides are located in the heads and are replaceable. Intake, exhaust and starting valves, likewise located in the cylinder heads, are replaceable. The intake manifold and the two exhaust manifolds are attached to the right side of the cylinder heads.

c. **Crankcase** (fig. 155). The crankcase, which is the main structural part of the engine, is a box-like, one-piece casting which contains the crankshaft, camshaft and cylinder liners. Figure 155 shows the crankcase in an inverted position. The main bearing caps, held to crankcase by studs, are fitted to the crankcase and cannot be replaced individually. Grooves are provided in the crankcase for rubber seal rings to seal the water compartment at the bottom of the cylinder liners. The camshaft is located in the right side of the crankcase.

d. **Cylinder Sleeves** (fig. 41). Cylinder sleeves can be removed after the cylinder heads have been removed. A flange on the top of the cylinder sleeve fits into a recess in the crankcase, properly locating the sleeve. Water cooling of each sleeve extends over its entire length. Sleeves with pistons, piston pins and rings can be obtained in matched sets. The pistons are fitted to the sleeves and should never be interchanged in the sleeves.

e. **Main Bearings** (fig. 118). The main bearings are the steel-backed, precision type and readily replaceable without removing the crankshaft. The main bearing caps are stamped 1, 2, 3, etc., to facilitate replacement in their proper respective positions, with stamped number toward the corresponding number on the side of the crankcase. Numbers are stamped on the surface of the crankcase where the oil pan is attached.

f. **Crankshaft** (fig. 121). The crankshaft is drilled for full pressure lubrication to the main and connecting rod bearings. Crankshaft thrust is taken through flanges on the center main (No. 4) bearing.

g. **Flywheel**. The flywheel is bolted to the end of the crankshaft and is located by two dowel pins. One of the boltholes is offset so that the flywheel can be assembled in only one position. The starter ring gear is shrunk on the flywheel.

h. **Pistons and Connecting Rods** (fig. 107).

(1) The pistons are of aluminum alloy and are fitted with six rings. Two oil control rings are used—one above and one below the piston pin. Three compression rings are located at the top of the piston and one special ring between the upper oil control ring and the compression rings.

(2) The piston pins are the full-floating type and are held in the piston by two retaining rings. An oversize piston pin is available to compensate for wear in the piston and the connecting rod bushing.

INTRODUCTION

- A - CROSS SHAFT OPERATING LEVER
- B - CROSS SHAFT JAW LEVER
- C - STARTING VALVE OPERATING CROSS SHAFT
- D - STARTING VALVE
- E - AUXILIARY CHAMBER
- F - SWITCH
- G - AIR VALVE
- H - AIR VALVE UPPER SEAT
- I - CARBURETOR SHUT-OFF VALVE LEVER
- J - SPARK PLUG
- K - CARBURETOR
- L - CAM ROLLER
- M - PISTON
- N - INTAKE VALVE
- O - AIR PASSAGE (FROM AIR CLEANER)
- P - AIR PASSAGE (TO CYLINDERS)
- Q - OPERATING ROD
- R - STARTING VALVE OPERATING CROSS SHAFT LEVER
- S - OUTER CONTROL LEVER
- T - OPERATING JAW (CROSS SHAFT AND CARBURETOR SHUT-OFF VALVE)
- U - CROSS SHAFT SPRING

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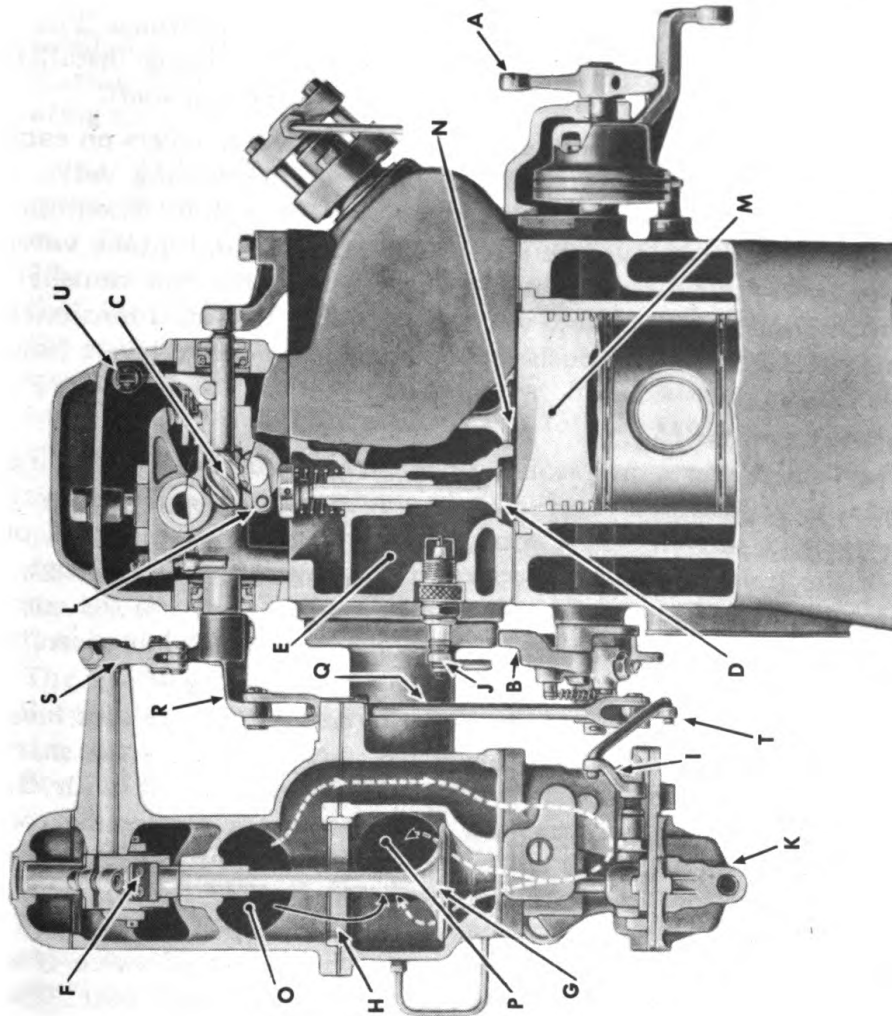


Figure 9—Starting System

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(3) The connecting rod is drilled from the connecting rod crankshaft bearing to the piston pin to provide lubrication at that point. The connecting rod bearing cap is not furnished separately. The upper and lower halves of the connecting rod bearing are identical. They are held in place by nibs which engage in the notches in the connecting rod and bearing cap.

i. **Gear Train and Gear Train Timing** (fig. 163). A completely enclosed train of six helical gears is mounted on the front end of the engine. The crankshaft gear drives an idler gear which in turn drives the camshaft gear and the injection pump drive gear. The camshaft gear drives the air compressor idler gear which in turn drives the air compressor drive gear. The camshaft and injection pump drive gears run at one-half the speed of the crankshaft. The crankshaft, idler, camshaft and injection pump drive gears are marked so that the engine can be correctly timed when overhauling it.

j. **Camshaft** (fig. 124). The camshaft is located in the right-hand side of the crankcase. It is held in place by a thrust plate bolted to the front end of the crankcase. The camshaft runs on four bearings. These bearings are reamed to size and need no reaming after being installed in the block. The lubricating oil pump is driven by the camshaft.

k. **Valve Operating Mechanism** (fig. 66). Two valve levers on each cylinder operate the exhaust and intake valves. The starting valve is operated by a cam arrangement. The entire valve and shaft assemblies and valve housing are removed as a unit. The exhaust and intake valve levers are pressure-lubricated through a passage from the rear camshaft bearing which leads to the hollow valve lever shaft. The oil drains back to the crankcase through the push rod openings. The valve levers have replaceable bushings.

l. **Starting System** (fig. 9).

(1) The vehicle starts on gasoline as a conventional gasoline engine. After a minute or two of operation it is converted to the Diesel cycle and operates as a full Diesel. A compression release lever mounted on the dash of the tractor allows the operator to convert the Diesel engine to the gasoline cycle. This is done simply by pulling down on the compression release lever. A number of things which will be explained in the following paragraphs take place when this conversion is made.

(2) When the operator pulls down on the compression release lever on the dash, the cross shaft operating lever (A) turns the cross shaft, which operates the cross shaft jaw lever (B), engaging it with the operating jaw (T). The operating jaw (T), through a connecting rod, releases the connecting link and shifts the carburetor shut-off lever (I), allowing gasoline to flow to the carburetor when starting the engine. At the same time that this operation takes place, the operating jaw (T) moves the operating rod (Q) which actuates the starting valve cross shaft lever (R). The starting valve operating cross shaft lever (R) turns the starting valve operating cross shaft (C) which operates the

INTRODUCTION

worm gear, turning the shaft on which the cam rollers (L) are mounted. As the cam rollers move down, they open the starting valves (D) of which there is one in each cylinder. Opening the starting valve (D) reduces the compression above the piston, exposing the spark plug (J) to the gas-air mixture which is drawn in from the carburetor (K).

(3) The starting valve operating cross shaft lever (R) also operates the outer control lever (S) which shifts the air valve (G) from the seat above the carburetor to the air valve upper seat (H). As the air valve (G) moves up, the switch (F) makes contact, closing the primary circuit from the ignition coil to the distributor. (The ignition coil and the distributor are not shown in this illustration.)

(4) With the engine converted to gasoline starting, air from the air cleaner (not shown) enters the manifold through the air passage (O) from the air cleaner and follows the white dotted line down through the carburetor where the gasoline is mixed with it. The gas-air mixture then passes through the air passage (P) to the cylinders through the intake valves (N). As the piston (M) travels through the compression stroke the gas-air mixture is forced past the starting valve (D) into the auxiliary chamber (E) where it is ignited by the spark plug (J). The starting valve (D) remains open at all times while the engine is operating on gasoline.

(5) When the engine is converted to Diesel operation by lifting the compression release lever on the dash, the operating jaw (T) is shifted and the cross shaft spring (U) shifts the whole starting mechanism. The starting valve (D) is closed and remains closed during the time that the engine is operating on the Diesel cycle. The switch (F) breaks the primary circuit from the ignition coil to the distributor so that the spark plug (J) becomes inoperative. Air is drawn through the air passage (O) from the air cleaner and follows the black arrow directly to air passage (P) to the cylinders.

m. Diesel Fuel System. Diesel fuel flows from the supply tank back of the driver's seat through the water trap—mounted on the left side of the engine—to the fuel supply pump. The fuel supply pump pumps the Diesel fuel through the fuel filter mounted on the crankcase. The Diesel fuel flows from the filter to the front end of the injection pump. The fuel injection pump injects the fuel through pipes to the nozzles. Surplus fuel flows from the injection pump through a check valve at the rear of the injection pump and is returned to the fuel supply tank. See TM 9-1777B for a detailed description of the fuel system.

n. Fuel Injection Pump.

(1) The duty of the fuel injection pump is to meter the fuel in accordance with engine load and speed demands and to deliver it to each injection nozzle at the right time. The fuel injection pump—with supply pump and variable speed type governor—is a compact unit assembly driven at half engine speed from the timing gear train. This

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

pump is mounted on the outside of the engine in an accessible position and can be readily removed and replaced as a complete assembly.

(2) The injection pump housing contains one plunger-type injection unit for each engine cylinder, all plungers being operated in proper time by a camshaft running on ball bearings in the lower part of the housing.

(3) The variable-stroke self-regulating, piston-type supply pump is mounted on the outside of the injection pump housing and is actuated by the injection pump camshaft. The supply pump draws fuel from the tank and forces it under pressure through a large double element filter into the suction chamber sump, which runs the full length of the injection pump. At one end of the sump is an overflow valve connected by return piping to the fuel tank. This valve is set to maintain a constant pressure in the injection pump.

o. Governor.

(1) The purpose of the governor is to serve as a means for pre-setting and maintaining within close regulation any desired engine speed within the nominal idling and nominal maximum speed range. It does so irrespective of engine load. In addition, the governor controls the engine idling speed to prevent stalling and controls the maximum speed to prevent racing.

(2) The governor is a fully enclosed unit rigidly mounted to one end of the fuel injection pump. A large gear is mounted on the end of the injection pump camshaft which extends into the governor housing and drives a smaller gear connected to the governor shaft. Through this combination of gears, the shaft is caused to travel at a higher speed than the injection pump camshaft. The centrifugal force exerted by the revolving weights causes a movement of the governor sleeve assembly. This movement is opposed by the compression of the governor springs. The amount of pressure exerted by the governor springs is regulated by the hand throttle on the dash. The governor is internally connected to the injection pump control rod.

p. Air Cleaner. The engine air cleaner is located immediately in front of the driver, on the center of the dash and cowl assembly. A screen in the air intake cap prevents flying leaves, etc., from entering the cleaner. Air passes through the air pipe assembly and the body assembly to the oil cup assembly, where heavy particles of dust and dirt settle in the oil in the oil cup. The air then passes upward through the screen and baffle assembly, the housed screen and the cleaning elements in the body, where the oil-impregnated element removes additional dust and dirt from the air. The air continues through the control housing and the front air cleaner pipe to the intake manifold on the engine. The air cleaner will be serviced by the using arm personnel.

q. Air Compressor Drive (fig. 26). The air compressor is driven

INTRODUCTION

by the air compressor drive which in turn is driven by the gear train at the front of the engine. The crankshaft gear drives an idler gear which drives the camshaft gear. The camshaft gear drives the air compressor idler gear which in turn drives the air compressor drive gear. The air compressor drive shaft and the air compressor coupling flange are secured together by a rubber coupling and a coupling cover. Should repairs or rebuilding be necessary, the air compressor drive can be removed from the engine while the engine is installed in the vehicle.

r. **Electrical System.** Two 6-volt storage batteries, located under the seat, are connected in series to maintain the voltage of the electrical system at 12 volts. The batteries are charged by a 12-volt Delco-Remy generator, which is located on the right side of the engine block and driven by the fan belts when the engine is running. The generator generates current for the stop lights, headlights, and blackout lights; also for the switches, the cranking motor and the ignition system (used for starting only). See TM 9-1777B for detailed descriptions of the components of the electrical and starting (ignition) systems.

s. **Engine Lubricating System (fig. 10).**

(1) The engine is equipped with a full pressure lubricating system. Drilled passages in the crankcase deliver the oil to the bearings and various other points to be lubricated. No external lines are used except the oil line leading to the oil pressure gage mounted on the dash.

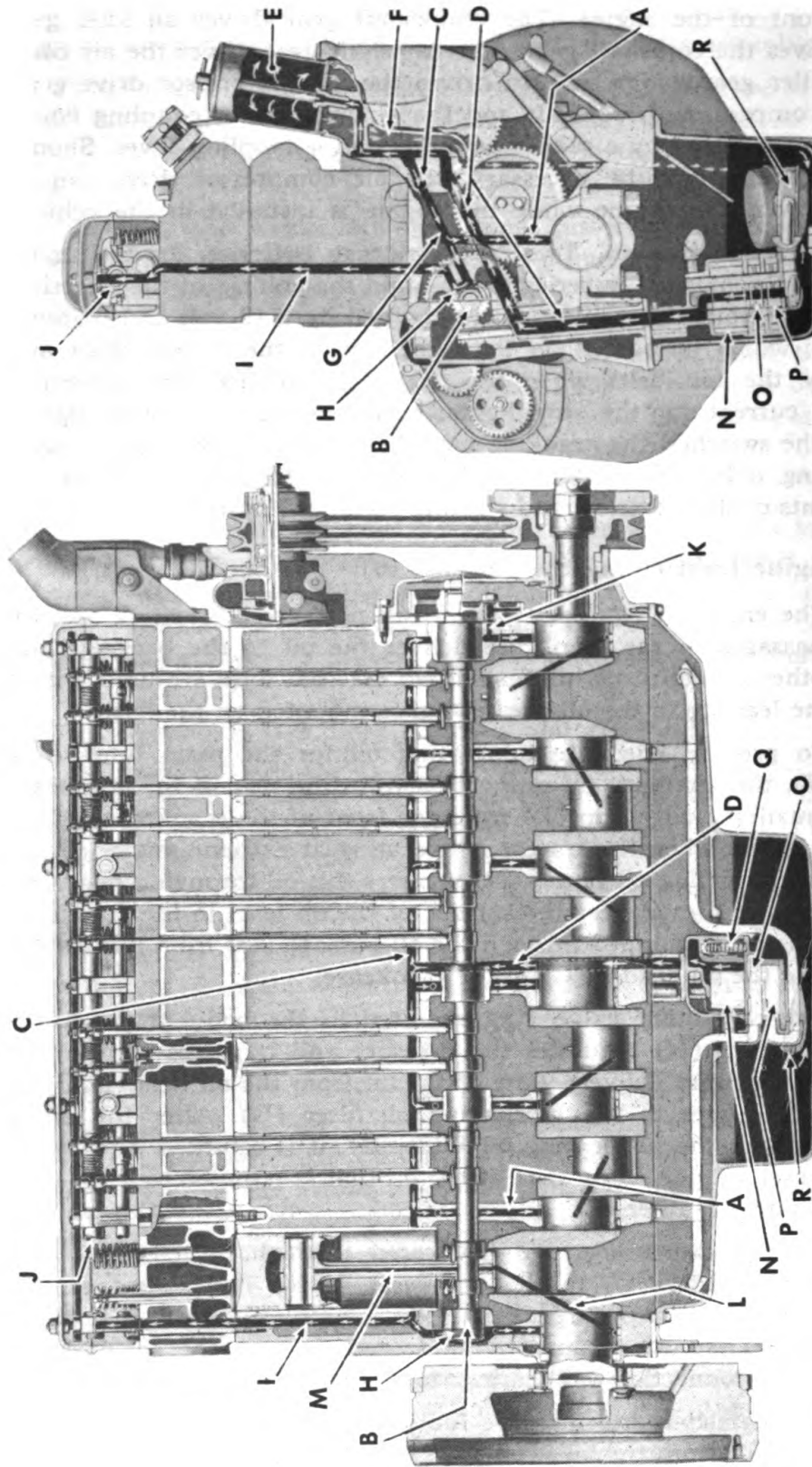
(2) To provide adequate lubricating oil for the main lubricating pump (N), the auxiliary oil pump (O) from the rear of the crankcase and the auxiliary oil pump (P) from the front of the crankcase deliver oil to the sump when the tractor is operating at extreme angles of tilt. The main lubricating oil pump (N) receives this oil through a float (R) which picks up the oil near the surface of the oil level in the crankcase oil pan. The oil is pumped through the oil passage (D) from lubricating oil pump to the oil header (C) in the crankcase.

(3) The regulating valve (Q) mounted in the body of the lubricating oil pump (N) regulates the pressure and bypasses the surplus oil which the pump delivers. Part of the oil from the oil header (C) in the crankcase goes to the lubricating oil filter (E). After the oil is filtered through the lubricating oil filter (E), it is returned directly to the crankcase oil pan. Only part of the oil that is pumped by the lubricating oil pump is filtered.

(4) The main bearings are lubricated through oil passages (A) from the oil header (C) in the crankcase to the main bearings. Oil passes through the oil passages (L) in the crankshaft to the connecting rod bearing. The piston pins are lubricated through the oil passages (M) from the connecting rod bearings to the piston pins.

(5) The camshaft bearings are lubricated through the oil passages (G) which lead from the oil header (C) to the main bearing and camshaft bearings. In the rear camshaft bearing journal (B) there is a slot

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12797

Figure 10—Engine Lubricating System

- A -- OIL PASSAGE FROM HEADER TO MAIN BEARING
- B -- CAMSHAFT
- C -- OIL HEADER IN CRANKCASE
- D -- OIL PASSAGE FROM LUBRICATING OIL PUMP TO HEADER
- E -- LUBRICATING OIL FILTER
- F -- OIL RETURN FROM LUBRICATING OIL FILTER
- G -- OIL PASSAGE TO CAMSHAFT AND MAIN BEARINGS
- H -- SLOT IN REAR CAMSHAFT JOURNAL
- I -- OIL PASSAGE FROM REAR CAMSHAFT BEARING TO VALVE LEVER ASSEMBLY
- J -- OIL PASSAGE IN VALVE LEVER SHAFT
- K -- OIL PASSAGE TO TIMING GEARS
- L -- OIL PASSAGE FROM MAIN BEARING TO CONNECTING ROD BEARING
- M -- OIL PASSAGE FROM CONNECTING ROD BEARING TO PISTON PIN
- N -- MAIN LUBRICATING OIL PUMP
- O -- AUXILIARY OIL PUMP FROM REAR OF CRANKCASE
- P -- AUXILIARY OIL PUMP FROM FRONT OF CRANKCASE
- Q -- REGULATING VALVE
- R -- FLOAT

INTRODUCTION

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(H) which allows oil to pass with each revolution of the camshaft from the oil passage (G) to the camshaft and main bearings to the valve levers. This oil passes up through the oil passage (I) from the rear camshaft bearing to the valve lever assembly to the oil passage (J) in the valve lever shaft.

(6) The timing gears are lubricated through the oil passage (K) to the timing gears.

5. DATA.

Engine model	International TD-18
Type	Four-cycle, in line
Number of cylinders	6
Bore	4¾-in.
Stroke	6½-in.
Total displacement, cu in.	691
Piston speed, ft per min	1,462
Direction of rotation—crank end	Clockwise
Speed range—rpm	425 to 1,350
Maximum engine speed—full load rpm	1,350
Maximum engine speed—no load, "A" series rpm	1,465
Maximum engine speed—no load, "K" series rpm	1,500
Horsepower maximum at 1,350 rpm	103*
Maximum torque	475 ft-lb at 650 rpm
Compression ratio—Diesel	14.2 to 1
Compression ratio—Gasoline	6.7 to 1
Firing order	1-5-3-6-2-4
Injection nozzle type	IHC
Carburetor	IHC type "C-12" (updraft)
Ignition system	12-volt Delco-Remy
Injection pump	{ Bosch series "A" Bosch series "K" (TDRM 4512 T4 and up)
Cylinders	Replaceable, wet type

6. ALLOCATION OF MAINTENANCE DUTIES BY ECHELONS.

a. **Definitions.** Echelons and words as used in this list of maintenance allocations are defined as follows:

(1) **SECOND ECHELON:** Line organization regiments, battalions, companies (first and second echelons).

(2) **THIRD ECHELON:** Ordnance light maintenance companies, ordnance medium maintenance companies, ordnance divisional maintenance battalions and post ordnance shops.

(3) **FOURTH ECHELON:** Ordnance heavy maintenance companies and service command shops.

*Corrected to sea level barometric pressure (29.92 in. of mercury) and 60 F, according to standard rating code.

INTRODUCTION

(4) **FIFTH ECHELON:** Ordnance base regiments, ordnance bases, arsenals and manufacturers' plants.

(5) **SERVICE** (including preventive maintenance) (par. 23 a. (1) and (2), AR 850-15. Oct. 6, 1942): Consists of servicing, cleaning, lubricating, tightening bolts and nuts and making external adjustments of subassemblies or assemblies and control.

(6) **REPLACE** (par. 23 a. (4) AR 850-15. Oct. 6, 1942): Consists of removing the part, subassembly or assembly from the vehicles and replacing it with a new or reconditioned or rebuilt part, subassembly or assembly, whichever the case may be.

(7) **REPAIRS** (par. 23 a. (3) and (5) in part. AR 850-15): Consists of making repairs to, or replacement of, the part, subassembly or assembly that can be accomplished without completely disassembling the subassembly or assemblies, and does not require heavy welding, or riveting, machining, fitting and/or balancing.

(8) **REBUILD:** (par. 23 a. (5) in part and (6) AR 850-15): Consists of completely reconditioning and replacing in serviceable condition any unserviceable part, subassembly or assembly of the vehicle, including welding, riveting, machining, fitting, alining, balancing, assembling and testing.

CLUTCH, MASTER, ASSEMBLY

	ECHELONS			
	2nd	3rd	4th	5th
Clutch assembly—service (adjust)	X			
Clutch assembly—replace	E	X		
Clutch assembly—repair		X		
Clutch assembly—rebuild (recondition)			E	
Control and linkage—replace	X			
Control and linkage—repair		X		

COOLING SYSTEM

Connections, radiator—service and replace	X			
Radiator assembly—replace	X			
Radiator assembly—repair		X		
Radiator assembly—rebuild			E	X

DRIVE, FINAL, ASSEMBLIES

Drive, final, assemblies—replace	E	X		
Drive, final, assemblies—repair		X		
Drive, final, assemblies—rebuild			E	X
Sprocket, final drive—replace	X			
Sprocket, final drive—repair		X		
Sprocket, final drive—rebuild (recondition)			E	X

See explanatory notes on page 27.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE
ELECTRICAL SYSTEM**

	ECHELONS			
	2nd	3rd	4th	5th
Battery—service, recharge or replace	X			
Battery—repair		X		
Battery—rebuild			E	X
Conduits, fuses, and wiring, electrical—replace	X			
Conduits and wiring, electrical—repair	E	X		
Lamps (all)—service and replace	X			
Lamps (all)—repair		X		
Switches (all)—replace	X			
Switches (all)—repair		X		

ENGINE

Bearings, connecting rod (inserts)—replace		E	E	X
Bearings, crankshaft (inserts)—replace		E	E	X
Belts, fan and generator—service (adjust) and replace X	X			
Block and cylinder sleeves assembly—rebuild (recon- dition)			E	X
Carburetor—service (adjust) and replace	X			
Carburetor—repair		X		
Carburetor—rebuild			X	
Coil, ignition—replace	X			
Condenser, distributor—replace	X			
Controls and linkage—replace	X			
Controls and linkage—repair		X		
Crankshaft—rebuild (recondition)			E	X
Distributor and cap assembly—replace	X			
Distributor assembly—repair		X		
Distributor assembly—rebuild			X	
*Engine assembly—replace	*	X		
Engine assembly—repair		X		
Engine assembly—rebuild			E	X
Fan assembly—service and replace	X			
Fan assembly—repair		X		
Filter, fuel—service (clean) and replace	X			
Filter, fuel—repair		X		
Filters, oil—service (clean) and replace	X			
Filters, oil—repair		X		
Flywheel assembly—replace		X		
Flywheel assembly—rebuild (recondition)			E	X
Gaskets, cylinder-head, manifold and oil pan—replace X	X			
Gears, timing, train—replace		X		
Generator assembly—service and replace	X			
Generator assembly—repair		X		

See explanatory notes on page 27.

INTRODUCTION

ENGINE (Continued)

	ECHELONS			
	2nd	3rd	4th	5th
Generator assembly—rebuild			X	
Governor assembly—service (adjust), replace or repair		X		
Governor assembly—rebuild			E	X
Head, cylinder, assembly—replace	X			
Head, cylinder, assembly—repair		X		
Head, cylinder, assembly—rebuild			E	X
Injector assembly—replace	X			
Injector assembly—repair		X		
Injector assembly—rebuild			E	X
Lines and connections, oil (external)—replace	X			
Lines and connections, oil (external)—repair	E	X		
Lines and connections, oil (internal)—replace or repair		X		
Manifold, exhaust and intake, assemblies—replace	X			
Manifold, exhaust and intake, assemblies—repair		X		
Manifold, exhaust and intake, assemblies—rebuild (recondition)			E	X
Motor, starter, assembly—replace	X			
Motor, starter, assembly—repair		X		
Motor, starter, assembly—rebuild			X	
Pan, crankcase oil—service (clean) and replace	X			
Pan, crankcase oil—repair		X		
Pistons and rings—replace		E	E	X
Plugs, spark—service (clean) and replace	X			
Plugs, spark (two-piece)—repair		X		
Points, distributor breaker—replace	X			
Pump, fuel, assembly—service and replace	X			
Pump, fuel, assembly—repair		X		
Pump, fuel, assembly—rebuild			X	
Pump, oil, assembly—replace	E	X		
Pump, oil, assembly—repair		X		
Pump, oil, assembly—rebuild			X	
Pump, water, assembly—service and replace	X			
Pump, water, assembly—repair		X		
Pump, water, assembly—rebuild			X	
Rod, connecting, assembly—replace		E	E	X
Sleeve, cylinder—replace		E	E	X
Thermostat—replace	X			
Valve, clearance—service (adjust)	X			
Wiring, ignition—replace	X			

EXHAUST SYSTEM

Muffler and pipes—replace	X
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See explanatory notes on page 27.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

EXTINGUISHER, FIRE

	ECHELONS			
	2nd	3rd	4th	5th
Extinguisher, fire (carbon dioxide—CO ₂)—replace	X			
Extinguisher, fire (carbon dioxide—CO ₂)—service (recharge) and repair		X		
Extinguisher, fire (carbon dioxide—CO ₂)—rebuild			E	X
Extinguisher, fire (carbon tetrachloride—CCl ₄)— service (refill) and replace	X			
Extinguisher, fire (carbon tetrachloride—CCl ₄)— repair		X		
Extinguisher, fire (carbon tetrachloride—CCl ₄)— rebuild			E	X

FRAME, TRUCK

Brace, diagonal, assemblies—replace	X			
Frame, truck, components—replace	X			
Frame, truck, components—repair		X		
Frame, truck, components—rebuild			E	X
Guides, rollers and brackets, truck frame—replace	X			
Guides, rollers and brackets, truck frame—repair		X		
Idler, front, assemblies—replace	X			
Idler, front, assemblies—repair		X		
Idler, front, assemblies—rebuild			E	X
Mechanism, track adjusting—service (adjust) and replace	X			
Mechanism, track adjusting—repair		X		
Mechanism, track adjusting—rebuild			E	X
Roller, track support, assemblies—replace	X			
Roller, track support, assemblies—repair		X		
Roller, track support, assemblies—rebuild			E	X
Spring, stabilizer, assembly—replace	X			
Spring, stabilizer, assembly—repair		X		
Spring, stabilizer, assembly—rebuild			E	X
Track assemblies—replace or repair	X			
Track assemblies—rebuild			E	X
Wheel, truck, assemblies—replace	X			
Wheel, truck, assemblies—repair		X		
Wheel, truck, assemblies—rebuild			E	X

FUEL SYSTEM

Cleaners and connections, air—service (clean) and replace	X			
Cleaners and connections, air—repair		X		
Lines and connections, fuel—service (clean) and replace	X			

See explanatory notes on page 27.

INTRODUCTION

FUEL SYSTEM (Continued)

	ECHELONS			
	2nd	3rd	4th	5th
Lines and connections, fuel—repair	E	X		
Tank, fuel, assemblies—service (clean) and replace	X			
Tank, fuel, assemblies—repair		X		

GEAR TRAIN AND MAIN FRAME ASSEMBLY

Bands, brake, steering clutch—service (adjust) and replace	X			
Bands, brake, steering clutch—repair (reline)		X		
Case, power take-off, assembly—replace	X			
Case, power take-off, assembly—repair		X		
Case, power take-off, assembly—rebuild			X	
Channels, side, main frame—replace	X			
Channels, side, main frame—repair		X		
Clutch, steering, assemblies—service (adjust)	X			
Clutch, steering, assemblies—replace or repair		X		
Clutch, steering, assemblies—rebuild			E	X
Controls and linkage (external)—replace	X			
Controls and linkage (external)—repair		X		
Controls and linkage (internal)—replace or repair		X		
Draw-bar assembly—replace	X			
Draw-bar assembly—repair		X		
Gear, bevel, assembly—service (adjust) and replace		X		
Guard, crankcase—replace	X			
Guard, crankcase—repair		X		
Hook, towing, front—replace	X			
Hook, towing, front—repair		X		
Pintle assemblies—replace	X			
Pintle assemblies—repair		X		
Pintle assemblies—rebuild			E	X
Support, pintle—replace	X			
Support, pintle—repair		X		
Transmission components—replace or repair		X		
Transmission components—rebuild			E	X

INSTRUMENTS AND GAGES

Instruments and gages—replace	X			
Instruments and gages—repair		X		
Instruments and gages—rebuild			E	X
Meter, hour, assembly—replace	X			
Meter, hour, assembly—repair		X		
Meter, hour, assembly—rebuild			E	X

See explanatory notes on page 27.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE
INSTRUMENTS AND GAGES (Continued)**

	ECHELONS			
	2nd	3rd	4th	5th
Odometer assembly—replace	X			
Odometer assembly—repair		X		
Odometer assembly—rebuild			E	X

SHEET METAL GROUP

Boxes, street plate and tool—replace	X			
Boxes, street plate and tool—repair		X		
Fender and support assemblies—replace	X			
Fender and support assemblies—repair		X		
Hood and doors—replace	X			
Hood and doors—repair		X		
Panel, dash and instrument, assembly—replace	X			
Panel, dash and instrument, assembly—repair		X		
Rack, luggage—replace	X			
Rack, luggage—repair		X		
Seat components—replace	X			
Seat components—repair		X		

VEHICLE ASSEMBLY

Tractor, heavy, M1 (TD-18, IHC)—service	X			
Tractor, heavy, M1 (TD-18, IHC)—rebuild (with serviceable assemblies)			X	E

AUXILIARY EQUIPMENT: BRAKE-CONTROL, AIR

Compressor, air, assembly—service and replace	X			
Compressor, air, assembly—repair		X		
Compressor, air, assembly—rebuild			E	X
Controls and linkage—replace	X			
Controls and linkage—repair		X		
Governor, air pressure, assembly—service (adjust) and replace	X			
Governor, air pressure, assembly—repair		X		
Governor, air pressure, assembly—rebuild			E	X
Lines and connections, air—replace or repair	X			
Tank, air, assembly—replace	X			
Tank, air, assembly—repair		X		
Valve, air brake, assemblies—replace	X			
Valve, air brake, assemblies—repair		X		
Valve, air brake, assemblies—rebuild (recondition)			E	X

See explanatory notes on page 27.

INTRODUCTION

BRAKE-CONTROL, ELECTRIC

	ECHELONS			
	2nd	3rd	4th	5th
Controller, electric, assembly—replace	X			
Controller, electric, assembly—repair		X		
Controller, electric, assembly—rebuild			X	
Resistance, load control, assembly—replace	X			
Resistance, load control, assembly—repair		X		
Socket, outlet, assembly—replace	X			
Socket, outlet, assembly—repair		X		
Wiring—replace or repair	X			

WINCH ASSEMBLY

Band, brake, safety—service (adjust) and replace	X			
Band, brake, safety—repair (reline)		X		
Bearings, drive shaft—replace	X			
Cable and hook assembly—replace	X			
Cable and hook assembly—repair		X		
Chain, winch drive—replace	X			
Chain, winch drive—repair		X		
Controls and linkage—replace	X			
Controls and linkage—repair		X		
Drum, brake, safety—replace	X			
Drum, brake, safety—repair		X		
Shaft, drive, assemblies—replace	X			
Shaft, drive, assemblies—repair		X		
Shaft, drive, assemblies—rebuild (recondition)			E	X
Winch assembly—replace	X			
Winch assembly—repair		X		
Winch assembly—rebuild			E	X

NOTES: Operations allocated will normally be performed in the echelon indicated by "X."

Operations allocated to the echelons as indicated by "E" may be accomplished by the respective echelons in emergencies only.

*The second echelon is authorized to remove and reinstall engine and transmission assemblies, transfer unit, controlled differential assembly and other items marked by asterisk. However, when it is necessary to replace an item marked by an asterisk with a new or rebuilt part, subassembly or unit assembly, the assembly marked by asterisk will not be removed from the vehicle by the second echelon until authorization is received from a higher echelon.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Section II

ENGINE TROUBLE SHOOTING AND TUNE-UP

	Paragraph
Scope	7
Facilities	8
Failure to start and hard starting (gasoline cycle)	9
Missing and backfiring (gasoline cycle)	10
Failure to change over to Diesel operation	11
Engine missing fire on one or more cylinders	12
Engine stalls frequently	13
Loss of power and uneven operation	14
Loss of oil pressure	15
Lack of compression	16
Smoky exhaust	17
Overheating	18
High oil consumption	19
Irregular firing of engine	20
Engine does not idle properly (Diesel)	21
Engine tune-up	22

7. SCOPE.

a. The trouble shooting procedure outlined in this section covers the engine, lubrication system, cooling system, fuel system and electrical and starting systems. Each paragraph in this section treats a condition or "symptom" with its possible causes and necessary corrective measures. A paragraph also outlines engine tune-up procedure.

8. FACILITIES.

a. The trouble shooting procedure outlined in this section should be followed on the completely assembled tractor, before any parts have been removed from the vehicle or the engine.

9. FAILURE TO START AND HARD STARTING (GASOLINE CYCLE).

a. Fuel System.

(1) Be sure valve is open.

(2) **GASOLINE SUPPLY.** Determine if there is sufficient gasoline in the tank. A small tube extends a short distance up inside the gasoline tank which makes it necessary that there be sufficient fuel in the tank to cover the end of the pipe.

ENGINE TROUBLE SHOOTING AND TUNE-UP

(3) **GASOLINE NOT REACHING CARBURETOR.** Remove gasoline strainer and clean. Remove gasoline line and clean. Remove screen retainer in carburetor (fuel system, TM 9-1777B) and clean.

(4) **WATER IN GASOLINE.** Drain fuel and water mixture from gasoline tank and gasoline strainer. Drain carburetor fuel bowl by removing plug in bottom of bowl. Fill gasoline tank with gasoline.

(5) **IMPROPER TIMING.** Check timing (electrical system, TM 9-1777B).

(6) **CARBURETOR FLOODING.** See if carburetor float valve is shutting off gasoline. Indication of trouble is gasoline dripping from the drip hole filler plug. Dirt on valve seat or worn valve seat will cause flooding. To replace valve cage assembly disconnect fuel line at the carburetor. Replace valve cage assembly and check as outlined in fuel system section, TM 9-1777B.

(7) **FLOAT LEVEL TOO HIGH.** Check float level and adjust as outlined in fuel system section, TM 9-1777B.

(8) **ENGINE PRIMED OR CHOKED TOO MUCH.** Remove spark plugs, wipe off any gasoline and dry them.

(9) **AIR VALVE NOT FUNCTIONING.** Remove cover on intake manifold housing and operate compression release lever to check operation of valve.

b. Loss of Energy in the Primary Circuit.

(1) **RESISTANCE IN CIRCUIT DUE TO LOOSE CONNECTIONS, DEFECTIVE LEADS, BURNED CONTACT POINTS, DEFECTIVE IGNITION SWITCH CONTACTS AND OPEN AND PARTLY OPEN IGNITION COIL PRIMARY WINDING.** Use wiring diagram given in TM 9-777 and check the circuit for defects. Replace ignition coil switch and ignition coil if defective.

(2) **CONDENSER SHORT-CIRCUITED LOW INSULATION RESISTANCE, HIGH SERIES RESISTANCE.** Replace condenser.

(3) **DISCHARGED BATTERIES.** Install fully charged batteries.

(4) **GROUNDING PRIMARY CIRCUIT AND COIL WIRING OR DISTRIBUTOR TERMINAL.** Check the wiring circuit for grounded condition.

(5) **MANIFOLD IGNITION SWITCH.** Check switch for broken contacts and replace if necessary.

c. Loss of Energy in Secondary Circuit.

(1) **DEFECTIVE HIGH TENSION WIRING.** Check wiring for broken or worn insulation.

(2) **DEFECTIVE CONNECTIONS IN HIGH TENSION CIRCUIT.** Check all connections to be sure they are tight and clean.

(3) **MOISTURE ON INSIDE OR OUTSIDE OF DISTRIBUTOR CAP.** Remove cap and dry off with clean cloth.

(4) **SPARK PLUGS FOULED, CRACKED OR OUT OF ADJUSTMENT.** Clean and check adjustment of spark plugs.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(5) **HIGH TENSION LEAKAGE ACROSS COIL HEAD, DISTRIBUTOR CAP, ROTOR OR SPARK PLUG PORCELAIN.** Clean all points where leakage might take place.

(6) **DEFECTIVE IGNITION COIL.** Check coil for shorted primary or secondary circuits and open or grounded secondary coil.

10. MISSING AND BACKFIRING (GASOLINE CYCLE).

- a. **First check steps in paragraph 42.**
- b. **Water in the Gasoline.** Drain gasoline and water mixture from system and refill with gasoline.
- c. **Air Leaks Around Intake Manifold.** Tighten manifold stud nuts.
- d. **Moisture in Distributor.** Remove distributor cap and dry it.
- e. **Improper Firing Order.** Check spark plug cables for correct installation at spark plugs and at distributor.

11. FAILURE TO CHANGE OVER TO DIESEL OPERATION.

- a. **Injection Pump Does Not Deliver Fuel.**
 - (1) **FUEL TANK EMPTY OR TANK SHUT-OFF VALVE CLOSED.** Refill fuel tank with fuel oil. Make sure valve is open.
 - (2) **FUEL SUPPLY SYSTEM AIR BOUND.** Bleed system. See TM 9-777.
 - (3) **FUEL SUPPLY LINES FOULED, DAMAGED OR LEAKING.** Clean fouled lines and repair or replace damaged lines. Tighten all connections.
 - (4) **WATER IN DIESEL FUEL.** Drain entire system and tank and refill with fuel oil. Bleed air from system.
 - (5) **FUEL OIL FILTER CLOGGED.** Remove filter and thoroughly clean.
 - (6) **FUEL OIL WATER TRAP CLOGGED.** Remove water trap, glass and screen, and clean.
 - (7) **AIR LOCK IN INJECTION PUMP.** Open vent cocks on the water trap, fuel filter and injection nozzles to bleed air from system.
 - (8) **FUEL SUPPLY PUMP DOES NOT DELIVER FUEL.** Remove supply pump, check and test as outlined in fuel system section, TM 9-1777B.
 - (9) **THROTTLE LINKAGE TO GOVERNOR LEVER LOOSE OR BROKEN.** Check and make necessary repairs.
 - (10) **DRIVE SHAFT TO PUMP BROKEN OR KEY ON SHAFT SHEARED OFF.** Check by seeing if pump shaft will turn when engine is stopped.
- b. **Starting Control Mechanism Not Functioning.**
 - (1) **AIR VALVE IN MANIFOLD NOT FUNCTIONING.** Remove housing cover and operate starting control mechanism to see if air valve is functioning.
 - (2) **STARTING VALVES NOT CLOSING.** Remove valve housing cover and observe operation of starting valves. Check clearance between cam rollers and starting valves.

ENGINE TROUBLE SHOOTING AND TUNE-UP

(3) **STARTING CONTROL LINKAGE BROKEN OR OUT OF ADJUSTMENT.** Check linkage for broken parts, missing cotter keys and pins. Check adjustment as outlined in paragraph 186.

(4) **STARTING VALVES WARPED.** Remove cylinder heads and replace warped starting valves.

12. ENGINE MISSING FIRE ON ONE OR MORE CYLINDERS.

- a. See paragraph 14.

13. ENGINE STALLS FREQUENTLY.

- a. See following paragraph 14 for trouble shooting.

14. LOSS OF POWER AND UNEVEN OPERATION.

- a. **First Check Probable Causes Outlined in Paragraph 11.**

- b. **Check the Following:**

(1) **DELIVERY VALVE DIRTY OR STICKING.** Remove delivery valves, clean and test as outlined in fuel system section, TM 9-1777B.

(2) **DELIVERY VALVE SPRING BROKEN.** Replace springs (TM 9-1777B).

(3) **INSUFFICIENT AIR TO ENGINE.** Clean air intake cap screen and be sure air pipe inside air cleaner is clean. Clean oil cup and refill with engine oil (seasonal grade).

(4) **CHECK ITEMS IN PARAGRAPH 10 TO DETERMINE LOSS OF POWER.**

(5) **GOVERNOR SPRINGS BROKEN.** Replace springs as outlined in TM 9-1777B.

(6) **ENGINE CLUTCH SLIPPING.** See TM 9-1777C.

(7) **INJECTION PUMP TIMING RETARDED.** See TM 9-1777B.

(8) **OVERHEATING OF ENGINE.** See paragraph 18.

15. LOSS OF OIL PRESSURE.

- a. **Check Oil Level.** Be sure the oil level is up to specified mark on gage rod.

- b. **Check Oil Pressure Gage and Line.** Remove oil gage and replace with one of known accuracy to be sure the oil gage is functioning. Check oil.

- c. **Check Main and Connecting Rod Bearings for Excessive Wear.** Remove oil pan and check bearing wear as outlined in paragraphs 98, 115 and 118.

- d. **Dirt in Regulating Valve.** Remove lubricating oil pump and clean valve and seat (par. 101).

- e. **Lubricating Oil Pump Regulating Valve Spring Broken or Weak.** Remove spring as outlined in paragraph 102 and check. Replace if broken or not up to correct tension.

- f. **Oil Pump Worn.** Remove oil pump and disassemble as outlined in paragraph 101 and check for wear.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

g. Camshaft Bearings Worn Excessively. Remove camshaft from the engine (par. 128). Install new bearings. See paragraph 158.

16. LACK OF COMPRESSION.

a. Check Valve Clearance. Valve levers hold valves open slightly, causing a lack of compression. If setting clearance (par. 193) does not correct trouble, lap or grind valves.

b. Valves Sticking. Gum and carbon on valve stems and in valve guides prevent the valves from closing properly. Remove cylinder heads. Clean valve guides and stems (par. 80). Grind or lap valves if necessary.

c. Worn Pistons, Sleeves, Piston Rings and Sticking Piston Rings. Remove piston assemblies and check wear on, pistons, piston rings and sleeves. Replace sticking rings. Replace worn sleeves.

d. Valves Burned, Warped or in Need of Grinding. Remove valves as outlined in paragraph 79. Replace warped valves and valves burned beyond the point where they can be ground. See paragraph 85.

e. Starting Valves Warped. Remove cylinder heads and replace warped starting valves.

17. SMOKY EXHAUST.

a. Improper Diesel Fuel Oil. Use fuel as specified in TM 9-777.

b. Injection Pump Incorrectly Timed to Engine. Check timing as outlined in TM 9-1777B.

c. Injection Nozzles Not Functioning Properly.

(1) Opening pressure is not properly adjusted or orifice in nozzle injector is plugged. Remove nozzle and test as outlined in TM 9-1777B.

(2) INJECTION NOZZLE LEAKS. Remove and test for leaking as outlined in TM 9-1777B.

d. Injection Pump Control Rod Stop Plate Adjustment Incorrect. See TM 9-1777B for correct adjustment.

18. OVERHEATING.

a. Insufficient Water in Cooling System. Check water level and add water if necessary. CAUTION: Do not put cold water in a hot radiator or in radiator when engine is running.

b. Fan Belt Slippage. Check tension on fan belt and adjust as outlined in cooling system section, TM 9-1777B.

c. Cooling System Clogged. Flush out radiator and engine.

d. Dirt and Trash on Outside of Radiator. Clean all dirt and trash from between the radiator tube fins with air or water pressure.

e. Improper Timing. If engine timing is advanced excessively, check engine timing as outlined in TM 9-1777B.

f. Thermostats Inoperative. Remove and test thermostats as outlined in cooling system section, TM 9-1777B.

ENGINE TROUBLE SHOOTING AND TUNE-UP

g. Lack of Lubricating Oil. Fill oil pan with the required amount of oil. Be sure that bearings have not been burned or the cylinder scored due to light lubrication.

19. HIGH OIL CONSUMPTION.

a. Check for Oil Leaks.

- (1) Valve lever housing.
- (2) Valve cover.
- (3) Side plates.
- (4) Dust seal at rear of oil pan.
- (5) Crankcase front cover.
- (6) Air compressor base and bracket.
- (7) Oil seals at front and rear ends of crankshaft. If oil seal at rear of crankshaft leaks, oil will be found in clutch compartment.
- (8) Welsh plug in crankcase at end of camshaft. If this plug leaks, oil will be found running down the rear support plate of the engine.
- (9) Crankcase oil pan.

b. Worn Piston Rings, Sleeves, Pistons and Sticky Piston Rings. Excessive smoke coming from the breather pipe on the side of the crankcase indicates that an excessive amount of oil is being used. Check the parts just mentioned and replace if necessary. Oil control rings may be clogged.

c. Worn Valve Guides. Excessive wear in the intake and exhaust valve guides will cause high oil consumption. Check for wear between valve guides and valve stems and replace if necessary.

20. IRREGULAR FIRING OF ENGINE.

- a. Check probable causes listed in paragraph 11.**
- b. Water Temperature too Low.** Check thermostats. Remove thermostats and test. See cooling system section, TM 9-1777B.
- c. Timing Retarded too Far.** See electrical system section, TM 9-1777B.

21. ENGINE DOES NOT IDLE PROPERLY (DIESEL).

- a. Pump Control Rod Sticky, Sluggish or Stuck.** Remove governor and check operation of control rod.
- b. Plunger Spring Broken.** Replace plunger spring (TM 9-1777B).
- c. Plunger Remains Suspended in Barrel.** Remove and free plunger as outlined in TM 9-1777B.
- d. Injection Pump Control Sleeve Damaged Due to Broken Plunger Spring.** Recondition or replace sleeve as outlined in TM 9-1777B.
- e. Gummy and Sticky Delivery Valves.** Remove delivery valves, test and replace, as outlined in TM 9-1777B.

TM 9-1777A
21-22

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

f. **Toothed Segment Securing Screw Loose.** Aline mark on toothed segment with mark on control sleeve and tighten screw securely. See TM 9-1777B.

22. ENGINE TUNE-UP.

a. The following steps outline the operations which should be followed in an engine tune-up. These steps point out the various parts of the engine to be checked, cleaned, timed or repaired, as needed.

(1) INJECTION PUMP.

(a) Remove the injection pump from the engine, place it on injection test stand and run a calibration test on the pump. Test the fuel supply pump as outlined in TM 9-1777B.

(b) Check the timing of the injection pump (TM 9-1777B).

(2) INJECTION NOZZLES.

(a) Remove and check the injection nozzles for leaks and opening pressure. Adjust and repair as outlined in TM 9-1777B.

(b) Remove the nozzle spacers and inspect for pitted or burned surfaces. Install new gaskets and replace spacers if necessary. See TM 9-1777B.

(3) CHECK OPERATION OF DIESEL THROTTLE CONTROL. Adjust friction on disk if necessary. Check the operation of the springs on the governor control rod. See TM 9-1777B.

(4) VALVES. Check clearance on intake, exhaust and starting valves. Make adjustments as outlined in paragraph 186.

(5) AIR CLEANER. Check the air cleaner and connections for possible leaks. Clean oil pan assembly on air cleaner and screen on air intake cap.

(6) FILTERS. Replace lubricating oil filter elements, cleaning the oil filter case assembly thoroughly. Clean and inspect the metal and cloth elements in the fuel filter. Replace the cloth element if torn. See TM 9-777.

(7) WATER TRAP. Remove water trap. Clean thoroughly and inspect screen for damage. See TM 9-1777B.

(8) CLEAN AND ADJUST SPARK PLUGS. Replace broken plugs. See TM 9-1777B.

(9) DISTRIBUTOR POINTS. Clean and adjust distributor points. See TM 9-1777B.

(10) CONDENSER AND IGNITION COIL. Check condenser and replace if necessary. Check ignition coil, replacing if necessary. See TM 9-1777B.

(11) ELECTRICAL CONNECTIONS. Check all electrical connections in both the high tension and low tension circuits of the ignition system. Check all switches.

(12) CHECK TIMING OF GASOLINE CYCLE. See electrical system section, TM 9-1777B.

ENGINE TROUBLE SHOOTING AND TUNE-UP

(13) **STARTING SYSTEM CONTROL AND LINKAGE.** Check the entire linkage of the starting system. See paragraph 186. Check starting valve clearance. See paragraph 186.

(14) **CARBURETOR.** Remove the screen retainer and clean it. Remove fuel bowl and check float level. Adjust if necessary. Check the float valve assembly for leakage. See TM 9-1777B.

(15) **COOLING SYSTEM.** Flush radiator with clean water, drain and refill with soft water if available. Check water pump packing, adjust packing nut or install new packing as needed. Check the fan belts for wear and replace if necessary. Check fan belt tension. See cooling system section, TM 9-1777B.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

Section III

INSPECTION OF THE ENGINE IN VEHICLE

	Paragraph
Periodic inspections	23
Inspection of installed engine in the vehicle	24

23. PERIODIC INSPECTIONS.

a. Detailed procedure is given in TM 9-777 for the following inspections:

- (1) **PRESTARTING INSPECTION.**
- (2) **DURING OPERATION.**
- (3) **AT THE HALT.**
- (4) **AFTER OPERATION.**
- (5) **PERIODIC INSPECTION.** Procedure is outlined for inspections after 50, 100, 200, 250 and 400 hours of operation.

24. INSPECTION OF INSTALLED ENGINE IN THE VEHICLE.

a. **Inspection of Engine While Operating on Gasoline Cycle.** Check the engine revolutions per minute with a tachometer placed on the end of the crankshaft. See paragraph 14 if revolutions per minute are not up to 800.

b. **Inspection of Engine While Operating on Diesel Cycle.** Change the engine to Diesel operation and allow it to operate for four or five minutes on a one-half to three-quarter open throttle.

(1) **BEARINGS AND PISTONS.** Listen for any unusual noises, such as pounding in time with the engine. This may indicate that a connecting rod is worn excessively or burned out. Piston slap also produces a similar noise. Follow procedure outlined in paragraph 16 and check to locate the source of the noise.

(2) **PISTON PINS.** A dull clicking noise indicates that the piston pins have worn excessively in the connecting rod bushings and pistons. Remove piston assembly as outlined in paragraph 107 and inspect for wear.

(3) **GEAR TRAIN.** Unusual noise at the front of the engine indicates that the timing gears are worn excessively. Remove front crankcase cover as outlined in paragraphs 131 and 132 and inspect for wear.

(4) **GENERATOR.** Squeaking noise indicates inadequate lubrication of the generator. Check generator bearings and bushings for wear as outlined in TM 9-1777B.

(5) **OIL PRESSURE.** Check oil pressure at full throttle. If low, see paragraph 15 to correct. Indicator needle should be in white area when the engine is running.

INSPECTION OF THE ENGINE IN VEHICLE

(6) **VALVES.** Uneven operation of the motor indicates sticking valves. Remove either the front or rear cylinder heads, or both, as indicated by the exhaust. Service cylinder head as outlined in paragraphs 78, 79, 80 and 81. Check valves to see that they are not sticking.

(7) **INJECTION NOZZLES.** White smoke at the exhaust when engine is warmed up and operating under load indicates that the nozzle is either leaking or has too low opening pressure. Open bleeder valves one at a time on the injection nozzles to locate the defective nozzle.

(8) **ENGINE SPEEDS.** Use a tachometer to check the maximum and idle speeds to be sure that they conform with specifications.

(9) **GOVERNOR CONTROL.** Observe tension on the throttle control to be sure it is sufficient to hold the throttle lever in position selected.

(10) **BREATHER PIPE.** Look for excessive smoke at the outlet of the breather pipe at the right-hand rear side of the crankcase. Excessive smoke indicates that the rings, pistons and sleeves are worn or piston rings are stuck in the piston grooves, or that openings in oil control rings are plugged. Remove piston assemblies as outlined in paragraph 107 and inspect.

(11) **GENERATOR.** Observe on the ammeter the charging rate when the service switch is in both high and low positions. If the generator is not charging properly, as specified, see TM 9-1777B.

(12) **LIGHTS.** Check the service and blackout switch in all positions and see that the lights are functioning. Replace any burned-out bulbs. Check the service and blackout stoplights.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

Section IV

REMOVAL OF ENGINE FROM VEHICLE

	Paragraph
Facilities	25
General precautions	26
Winch removal	27
Muffler removal	28
Hood sheet removal	29
Removal of radiator from engine	30
Crankcase guard removal	31
Preparation of clutch for removal with engine	32
Preparation of engine for removal	33
Engine support disconnection	34
Lifting engine from vehicle	35
Preparation of engine support and placing of engine	36

25. FACILITIES.

a. Before the engine is removed from the vehicle, an adequate support should be available, so the engine can be readily worked upon. An easily constructed engine support can be built as outlined in paragraph 36 (fig. 21). Facilities to store removed assemblies under cover should be provided.

26. GENERAL PRECAUTIONS.

a. Engine must never be removed from the tractor except for complete overhaul or for repairs or replacements which cannot be made when the engine is installed in the vehicle.

b. Be sure shut-off valve at Diesel fuel tanks is closed.

c. Be sure valve on gasoline strainer is shut off.

d. Be sure that cooling system is drained before removing radiator. See cooling system section, TM 9-1777B.

e. Disconnect ground cable from batteries. Batteries are located under driver's seat.

f. Steam-clean the engine before removal. It is important that the engine be steam-cleaned and all dirt removed from all exterior parts and accessories before the engine is removed from the tractor. This not only facilitates removal operations but prevents dirt from coming in contact with vital parts during subsequent operations.

27. WINCH REMOVAL.

a. Follow procedure for removal of winch as outlined in TM 9-1777D.

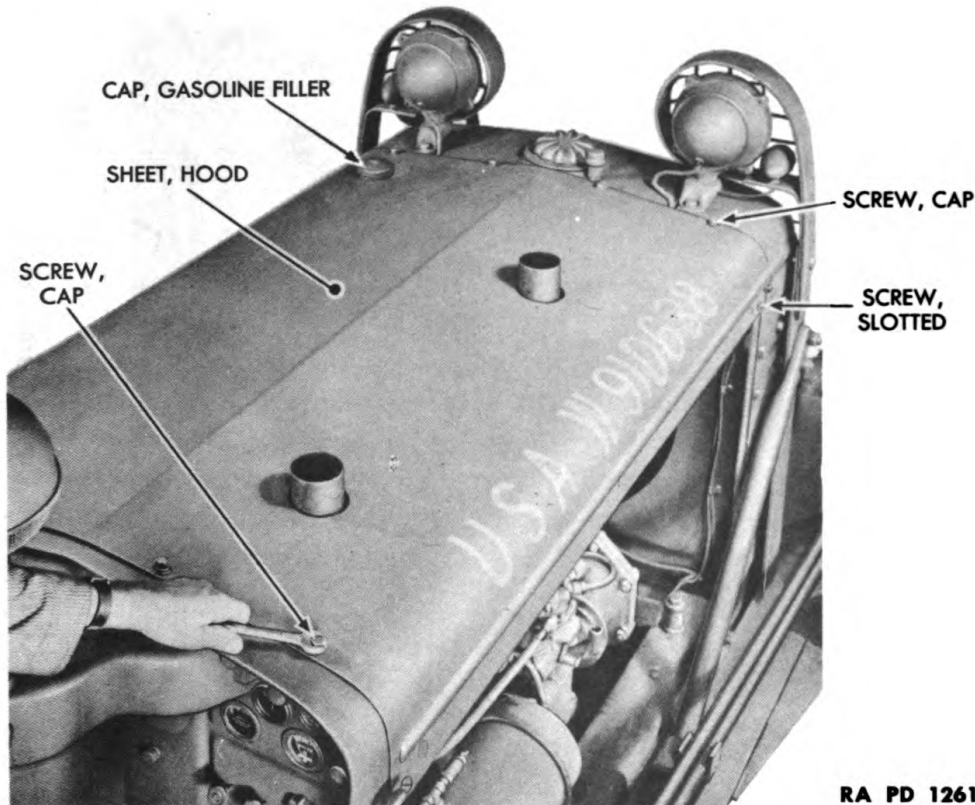
REMOVAL OF ENGINE FROM VEHICLE

28. MUFFLER REMOVAL.

a. Equipment.

WRENCH, open-end, $\frac{1}{2}$ -in.

b. Procedure. Loosen nut and cap screw which hold muffler clamp and muffler in place. Lift off muffler. Remove second muffler in same manner.



RA PD 12612

Figure 11—Hood Sheet Removal

29. HOOD SHEET REMOVAL (fig. 11).

a. Equipment.

SCREWDRIVER

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

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

b. Procedure.

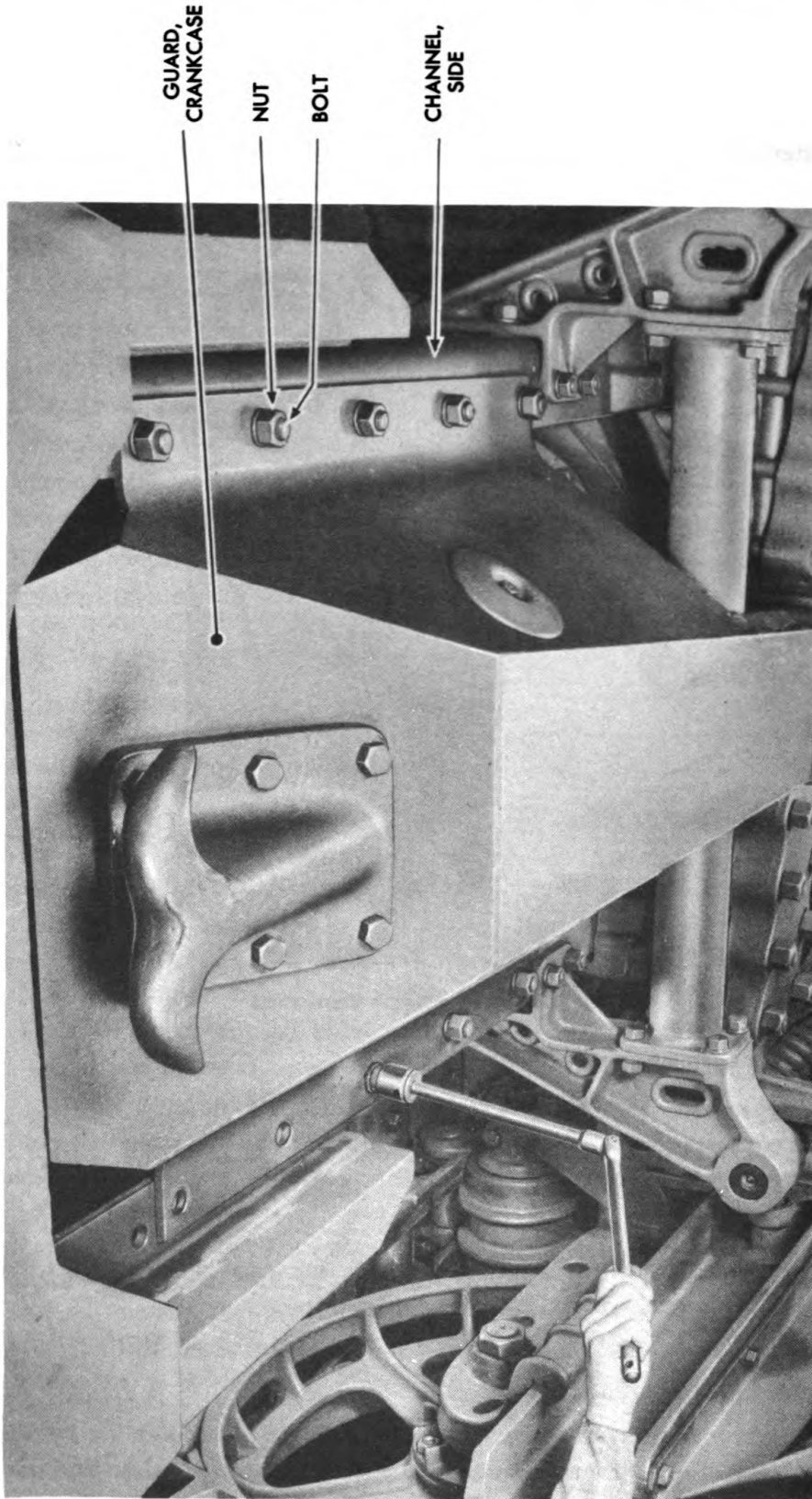
(1) REMOVE GASOLINE FILLER CAP. Filler cap is located at left front of hood sheet and can be removed by hand.

(2) REMOVE CAP SCREWS FROM TOP OF HOOD SHEET.

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

(a) Remove each cap screw. There are four cap screws at rear of hood sheet and four at front. Each cap screw has flat washer and lock washer.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12678

Figure 12—Crankcase Guard Removal

REMOVAL OF ENGINE FROM VEHICLE

(3) REMOVE CORNER SLOTTED SCREWS.

SCREWDRIVER

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

(a) Remove four slotted screws, lock washers and nuts which secure hood sheet at its four corners.

30. REMOVAL OF RADIATOR FROM ENGINE.

a. Follow procedure outlined in cooling system section, TM 9-1777B.

31. CRANKCASE GUARD REMOVAL (fig. 12).

a. Equipment.

HAMMER

WRENCH, socket, $1\frac{5}{16}$ -in.,
and spinner type handle

JACK

b. Procedure.

(1) SUPPORT CRANKCASE GUARD ON JACK.

JACK

(a) Unless sufficient manpower is available to lower crankcase guard, support weight of crankcase guard on jack so that guard will not fall out of position when bolts are removed.

(2) REMOVE FIVE NUTS AND LOCK WASHERS FROM EACH SIDE OF CRANKCASE GUARD.

HAMMER

WRENCH, socket, $1\frac{5}{16}$ -in.,
with spinner type handle

(a) Remove nuts and tap out bolts.

(3) REMOVE CRANKCASE GUARD. Lower jack so that crankcase guard will drop to ground or floor.

CAUTION: Mechanics should be careful to be out of way when guard is being lowered.

(4) DRAIN CRANKCASE OIL (fig. 95).

PLUG, square, $\frac{1}{2}$ -in.

WRENCH, box, $\frac{3}{4}$ -in.

(a) Remove front and rear magnetic drain plugs.

32. PREPARATION OF CLUTCH FOR REMOVAL WITH ENGINE.

a. To facilitate removal of the engine, the engine is removed with the engine clutch attached. The clutch is then removed from the engine.

b. Equipment.

WRENCH, box, 1-in.

c. Procedure.

(1) DISCONNECT CLUTCH RING FROM TRANSMISSION FLANGE. Follow removal of engine clutch procedure in TM 9-1777C, until clutch ring is disconnected from transmission flange.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

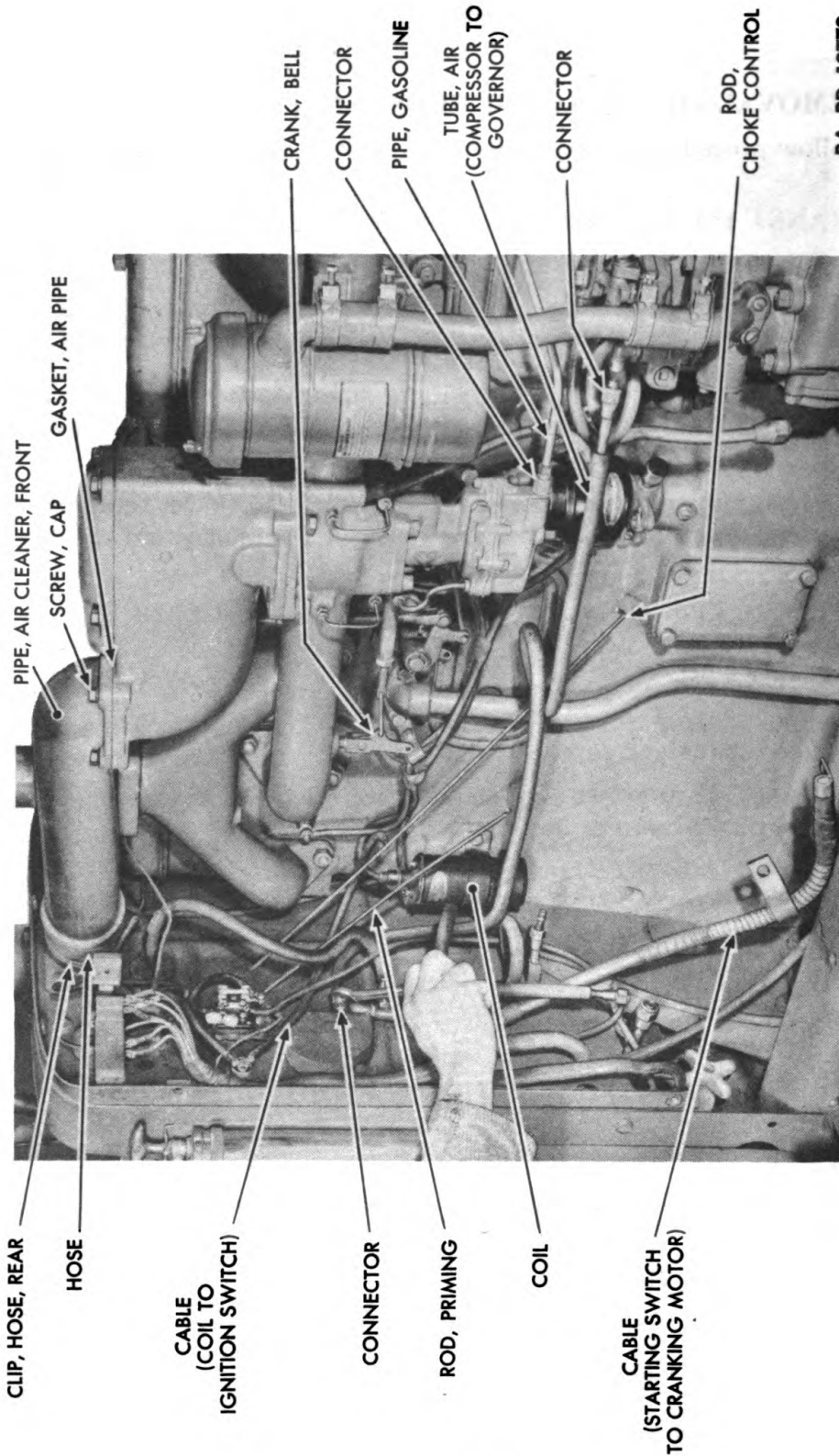


Figure 13—Removal of Compressor to Governor Air Tube

REMOVAL OF ENGINE FROM VEHICLE

(2) REMOVE CLUTCH SHAFT.

WRENCH, box, 1-in.

(a) Remove the bolt, nut and lock washer which hold the clutch lever on the clutch fork shaft. Then remove the clutch lever. Remove the Woodruff key from the end of the shaft.

33. PREPARATION OF ENGINE FOR REMOVAL.

a. Equipment.

PLIERS

SCREWDRIVER

WRENCH, box, $\frac{7}{16}$ -in.

WRENCH, open-end, $\frac{3}{8}$ -in.

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

WRENCH, open-end, $\frac{1}{2}$ -in.

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

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

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

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

WRENCH, ratchet, with
socket

b. Procedure.

(1) REMOVE CAP SCREWS WHICH SECURE DASH AND COWL ASSEMBLY TO REAR CYLINDER HEAD.

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

(a) Remove two cap screws and lock washers from driver's side of dash and cowl assembly. Then remove spacer between dash and cylinder head at each bolt.

(2) REMOVE AIR RESERVOIR. See TM 9-1777D.

(3) DISCONNECT CHOKE CONTROL ROD FROM BELL CRANK AT CARBURETOR (fig. 13).

PLIERS

(a) Remove cotter pin and lift rod from top hole of bell crank. Push rod back through dash.

(4) DISCONNECT PRIMING ROD FROM BELL CRANK AT REAR OF INTAKE MANIFOLD (fig. 13).

PLIERS

(a) Remove cotter pin and then remove rod from bell crank. Push rod back through dash.

(5) DISCONNECT STARTING SWITCH TO STARTING MOTOR CABLE FROM STARTING MOTOR (fig. 13).

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

WRENCH, ratchet, reversible,
 $\frac{3}{4}$ -in.

(a) Remove nut and lock washer which hold cable to starter. Remove cap screw and lock washer which hold cable clip and cranking motor to rear engine support.

(6) DISCONNECT CABLE (COIL TO IGNITION SWITCH) (fig. 13).

WRENCH, open-end, $\frac{3}{8}$ -in.

(a) Remove nut and lock washer which hold cable to coil.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(7) REMOVE AIR TUBE (COMPRESSOR TO GOVERNOR) (fig. 13).

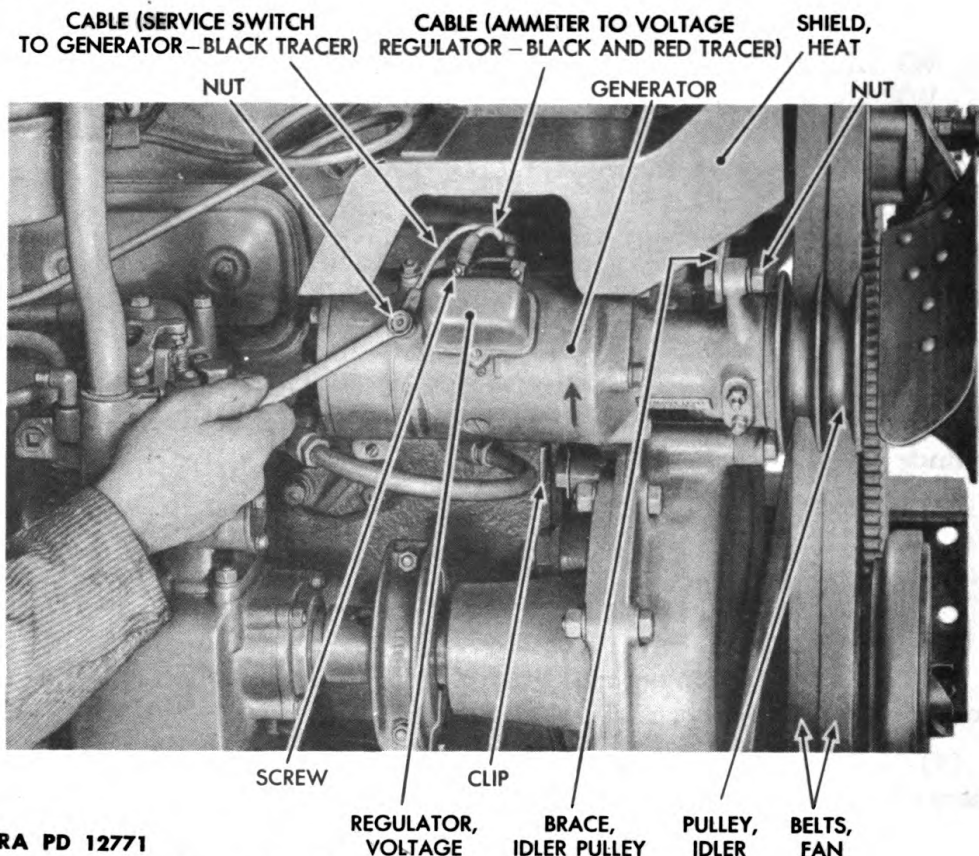
WRENCH, open-end, $\frac{5}{8}$ -in.

(a) Remove connectors at each end of tube. Then remove tube.

(8) REMOVE FRONT AIR CLEANER PIPE (fig. 13).

WRENCH, open-end, $\frac{7}{16}$ -in. WRENCH, open-end, $\frac{9}{16}$ -in.

(a) Loosen nut on rear hose clip. Remove four cap screws and lock washers which secure pipe to intake manifold housing. Remove pipe and air pipe gasket.



RA PD 12771

Figure 14—Disconnecting Cables from Generator

(9) DISCONNECT CABLE (SERVICE SWITCH TO GENERATOR) FROM GENERATOR (fig. 14).

SCREWDRIVER

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

WRENCH, box, $\frac{7}{16}$ -in.

(a) Loosen nut on idler pulley brace. Push generator toward engine to relieve fan belt tension and then remove fan belts from idler pulley.

(b) To provide access to cables without removing heat shield, pull generator away from engine. Remove nut holding service switch to generator cable (black tracer). Remove ammeter to voltage regulator cable from generator (black and red tracer).

(c) Pry cable clip open and remove cable.

REMOVAL OF ENGINE FROM VEHICLE

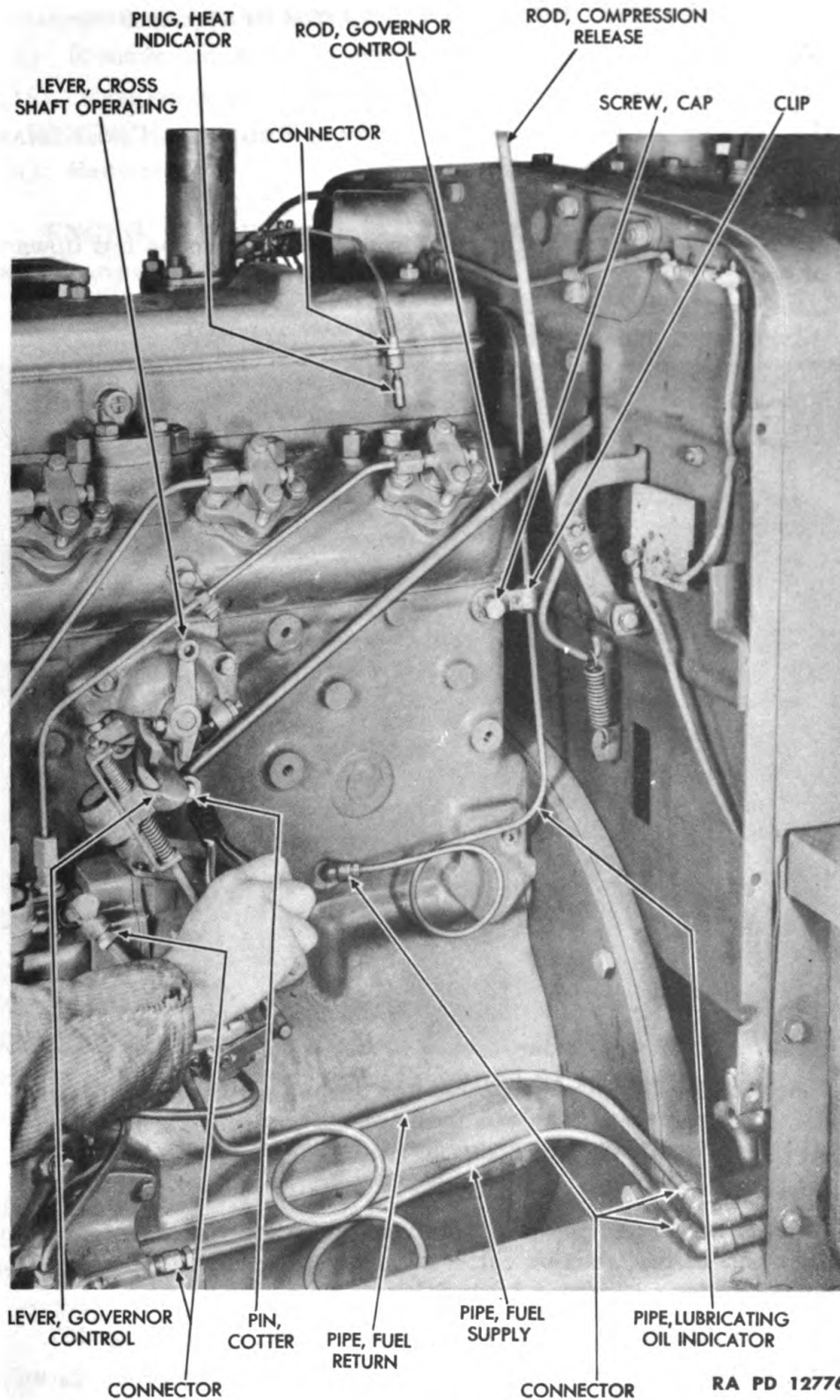


Figure 15—Disconnections at Left Rear of Engine

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(10) REMOVE HEAT INDICATOR PLUG FROM REAR CYLINDER HEAD
WRENCH, open-end, $1\frac{1}{16}$ -in.

(a) Remove connector. Then remove plug.

(11) DISCONNECT COMPRESSION RELEASE ROD FROM CROSS SHAFT
OPERATING LEVER (fig. 15).

PLIERS

(a) Remove cotter pin. Lift rod from lever and move rod upward,
out of way.

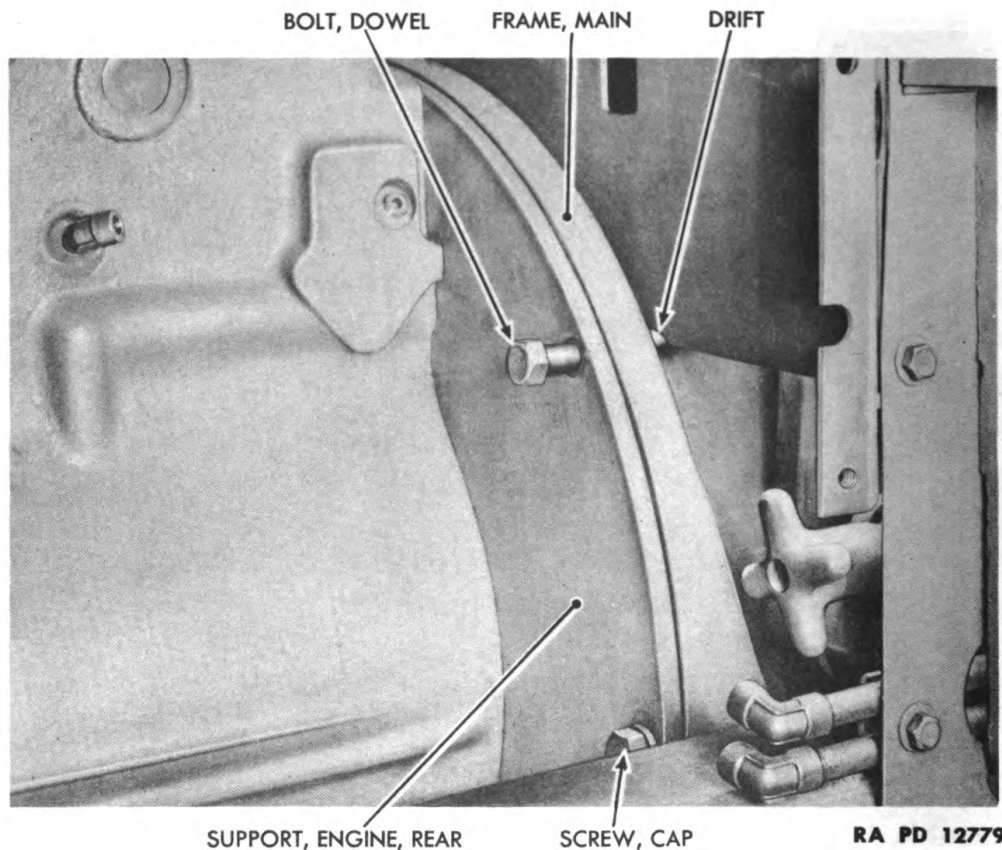


Figure 16—Removal of Dowel Bolt from Rear Engine Support

(12) REMOVE GOVERNOR CONTROL ROD (fig. 15).

PLIERS

(a) Remove cotter pin which holds rod to governor control lever.
At other end of rod, remove cotter pin from pin which holds adjusting
yoke to operator's governor control lever. Then remove rod.

(13) DISCONNECT LUBRICATING OIL INDICATOR PIPE (fig. 15).

WRENCH, open-end, $\frac{1}{2}$ -in. WRENCH, open-end, $\frac{3}{4}$ -in.

(a) Remove connectors at each end of pipe. Remove cap screw and
lock washer which hold pipe clip to crankcase.

REMOVAL OF ENGINE FROM VEHICLE

(14) REMOVE FUEL RETURN PIPE (fig. 15).

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

(a) Remove connectors at each end of pipe.

(15) REMOVE FUEL SUPPLY PIPE (fig. 15).

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

(a) Remove connectors at each end of pipe.

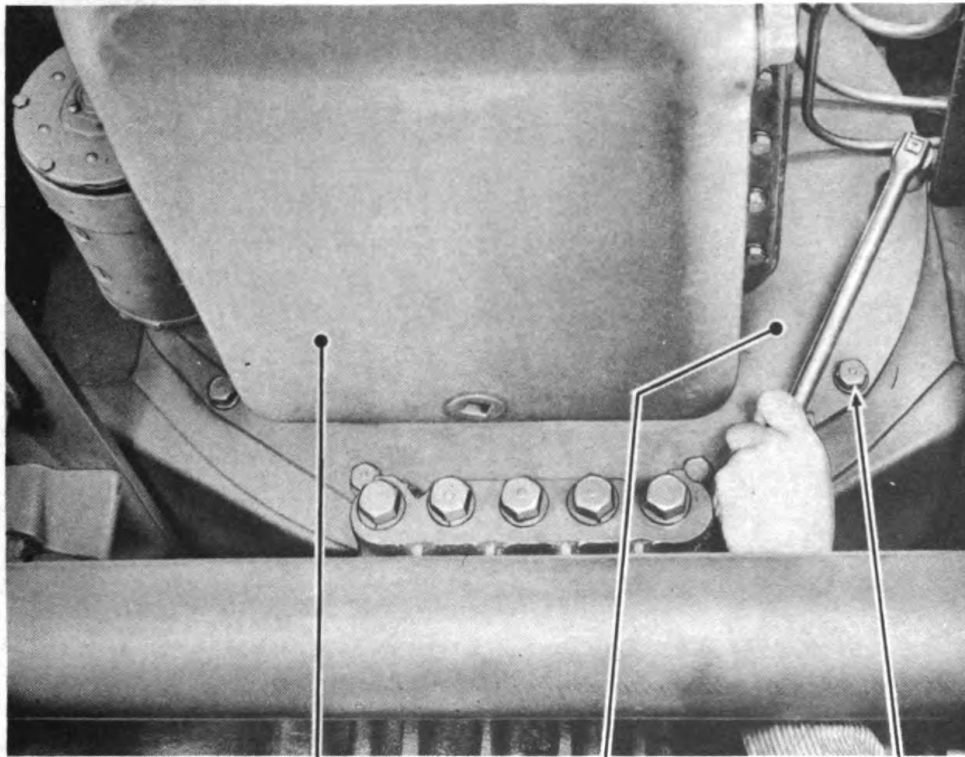
34. ENGINE SUPPORT DISCONNECTION.

a. Equipment.

DRIFT

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

WRENCH, socket, $\frac{7}{8}$ -in.,
with spinner type handle



RA PD 12688 PAN, CRANKCASE OIL SUPPORT, ENGINE, REAR SCREW, CAP

Figure 17—Removal of Rear Engine Support Cap Screws from Underneath Engine

b. Procedure.

(1) DISCONNECT FRONT ENGINE SUPPORT FROM MAIN FRAME SIDE CHANNELS.

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

WRENCH, socket, $\frac{7}{8}$ -in.,
with spinner type handle

(a) Remove bolt, shim (if used), nut and lock washer from each end of front engine support. Hold nuts with open-end wrench while removing bolts with socket wrench.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

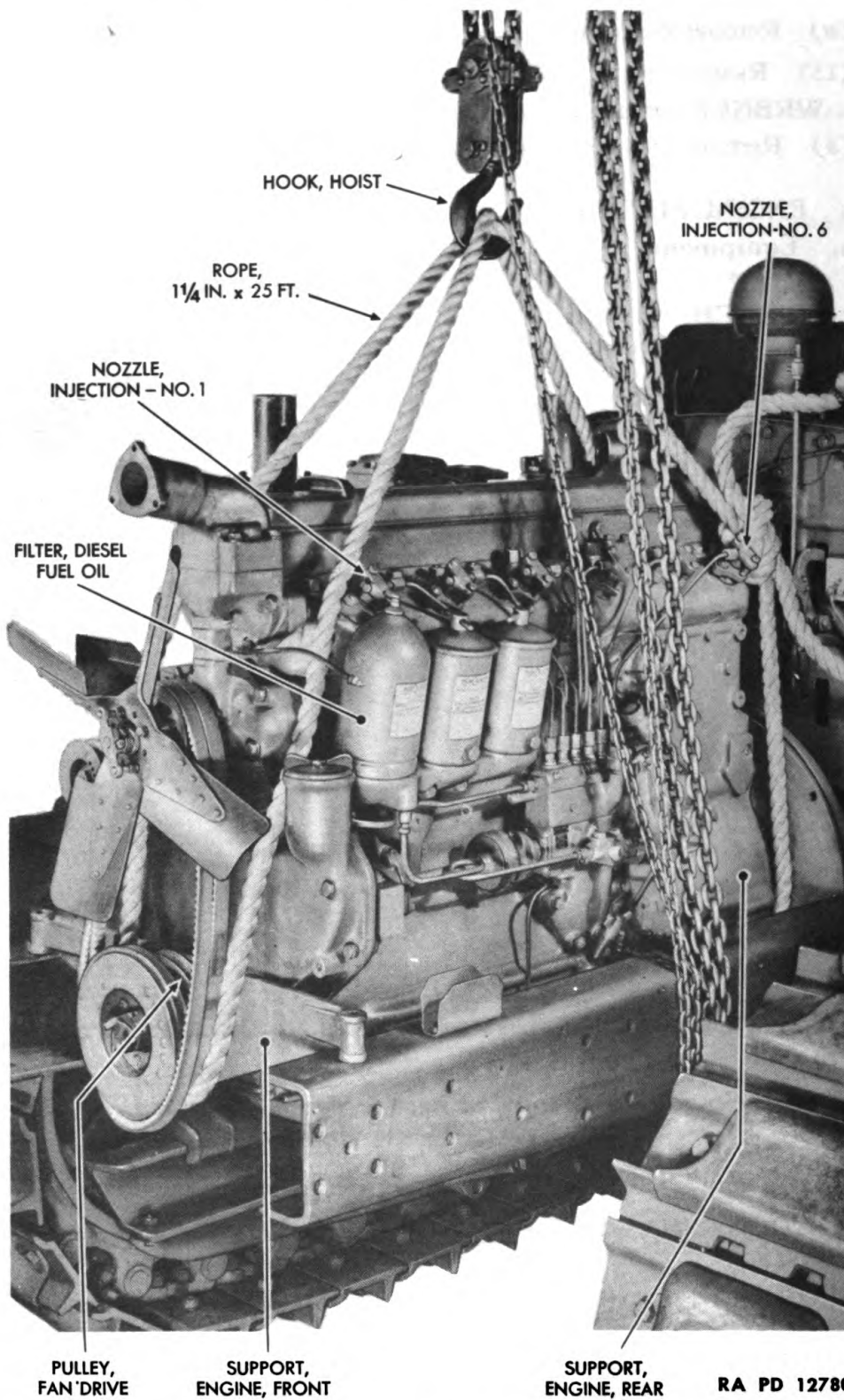
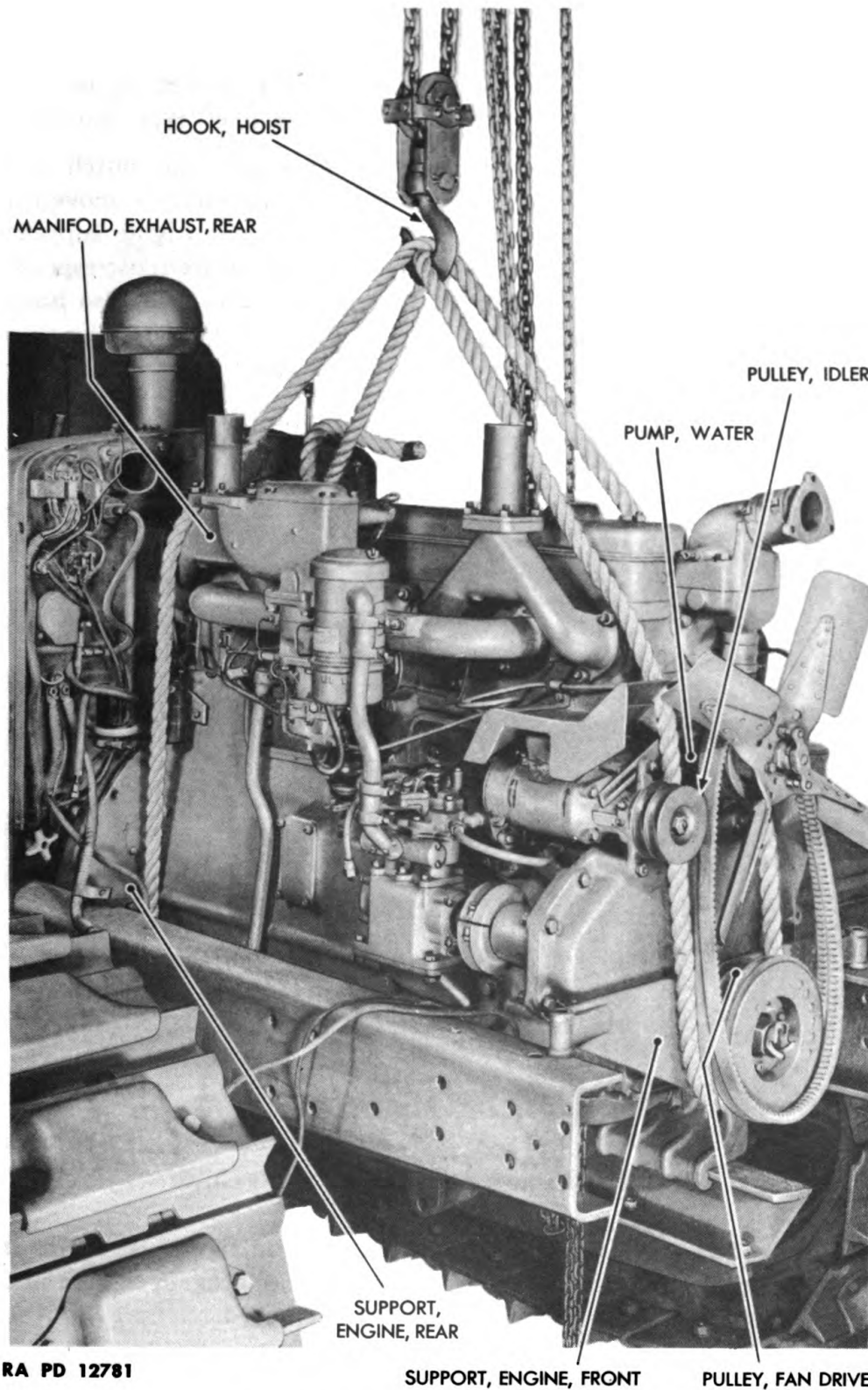


Figure 18—Position of Rope Sling on Left Side of Engine

REMOVAL OF ENGINE FROM VEHICLE



RA PD 12781

SUPPORT, ENGINE, FRONT

PULLEY, FAN DRIVE

Figure 19—Position of Rope Sling on Right Side of Engine

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(2) DISCONNECT REAR ENGINE SUPPORT FROM MAIN FRAME (figs. 16 and 17).

DRIFT

WRENCH, socket, 7/8-in.,
with spinner type handle

(a) Remove two dowel bolts which line up engine and clutch with transmission. From driver's side of dash and cowl assembly, remove nut and lock washer from dowel bolt in left side of rear engine support. Drive out bolt. Then remove bolt, lock washer and nut from corresponding position at right side of rear engine support. This bolt also holds clip. NOTE: On tractors built previous to TDR-3752 dowel pins were used in place of dowel bolts for alining the engine to the main frame.

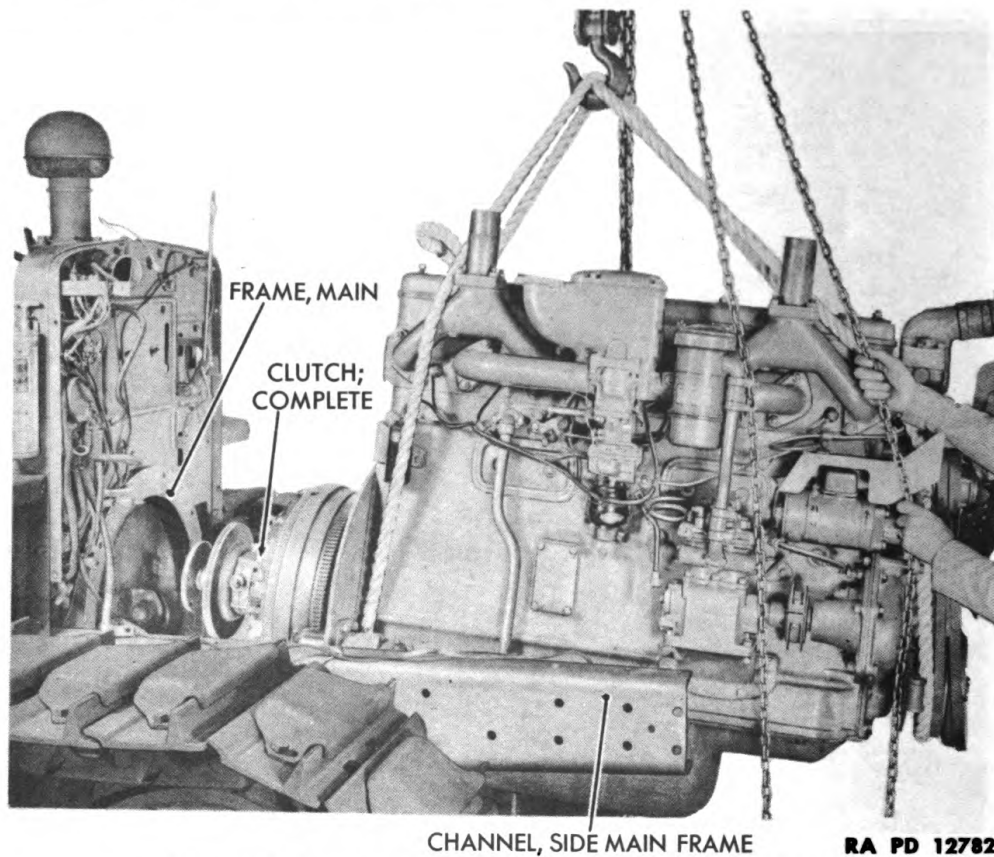
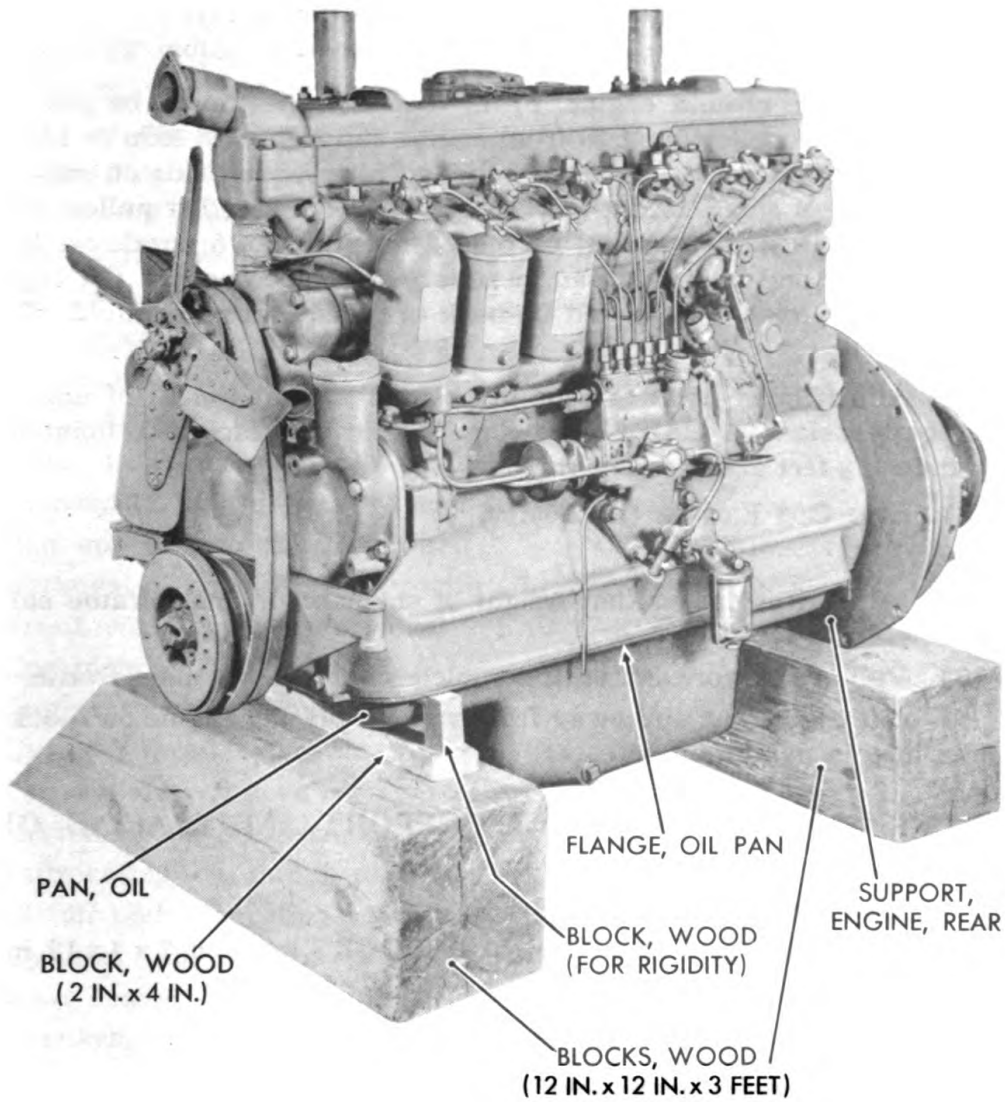


Figure 20—Removal of Engine from Vehicle

To remove dowel pin place nut on dowel pin and tighten as far as it will go. Remove nut and place washers under it and again tighten nut. Repeat procedure until dowel pin has been removed.

(b) Remove eight cap screws and lock washers from rear engine support. Two of these cap screws must be removed from driver's side of cowl and dash assembly (fig. 17).

REMOVAL OF ENGINE FROM VEHICLE



RA PD 12783

Figure 21—Engine Mounted on Blocks

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

35. LIFTING ENGINE FROM VEHICLE.

a. Equipment.

HOIST

SLING, rope, 1¼-in. size,
25 ft long

b. Procedure.

(1) PLACE ROPE SLING ON ENGINE (figs. 18 and 19).

ROPE, 1¼-in. size, 25 ft long

(a) Tie rope around engine. Front loop of rope should be placed under fan drive pulley, next to front engine support, with loop in front of No. 1 injection nozzle and Diesel fuel oil filter on left side of engine. On right side of engine, front loop should run between idler pulley and water pump. Rear loop should be placed back of No. 6 nozzle on left side of engine and under oil pan, next to rear engine support. On right side of engine, rear loop should be back of rear exhaust manifold. Tie rope securely. -

(2) Attach hoist hook to rope in position so that weight of engine is properly balanced. CAUTION: Rope should be attached to hoist no less than 2½ feet above top of engine.

(3) LIFT OUT ENGINE (fig. 20).

HOIST

(a) Lift out engine so that weight of engine is off main frame side channels.

(b) Pull engine forward until complete clutch clears main frame.

(c) Lift engine out and away from vehicle, placing engine on blocks as outlined in paragraph 36.

36. PREPARATION OF ENGINE SUPPORT AND PLACING OF ENGINE.

a. Equipment.

BLOCKS, wooden, 12 x 12 in.
x 3 ft, heavy wood (2)

BLOCKS, wooden, 2 x 4 x 12 in.
(3)

b. Procedure (fig. 21).

(1) Rest front end of oil pan on a 2 by 4 by 12-inch wooden block which is placed on top of heavy block or upon equivalent base of planks.

(2) Rest rear engine support on heavy block or upon equivalent base of planks.

(3) At front of engine, insert small blocks under oil pan flanges at each side of oil pan, in order to keep engine with accessories in a rigid position.

Section V

DISASSEMBLY OF ENGINE

	Paragraph
Facilities	37
General precautions	38
Air compressor air cleaner removal	39
Removal of intake manifold with carburetor attached	40
Cranking motor removal	41
Exhaust manifold removal	42
Ignition coil removal	43
Spark plug cable and spark plug removal	44
Distributor removal	45
Heat shield and generator removal	46
Air compressor removal	47
Fuel injection pump removal	48
Water trap removal	49
Lubricating oil filters and fuel filter removal	50
Hour meter removal	51
Thermostat housing and water outlet removal	52
Fan and water pump removal	53
Removal of fan drive pulley with vibration damper attached	54
Front engine support removal	55
Complete clutch removal	56
Engine flywheel removal	57
Cylinder head removal	58
Cross shaft and governor control removal	59
Crankcase oil pan removal	60
Lubricating oil pump removal	61
Piston and connecting rod removal	62
Cylinder sleeve removal	63
Rear engine support removal	64
Crankshaft and main bearing removal	65
Air compressor drive assembly removal	66
Camshaft removal	67
Fuel injection pump drive removal	68
Idler gear shaft removal	69
Crankcase front plate removal	70
Removal of miscellaneous parts from sides of crankcase	71
Valve tappet guide removal	72
Camshaft bearing removal	73
Crankcase stud removal	74

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

37. FACILITIES.

a. A clean, sheltered place should be available for the disassembly of the engine. Disassembled parts must be protected from the elements and stored where they may be covered and protected from dust and dirt.

b. The engine must be removed from the tractor and supported on wooden blocks, as outlined in section IV.

c. In addition to the special tools listed in section XI, a complete set of standard tools should be available. All the tools needed for each major operation are listed at the beginning of each paragraph. The tools for each step in each paragraph are likewise listed at the beginning of the step. A hoist is necessary to move the engine to the various positions required from time to time in the process of disassembly.

38. GENERAL PRECAUTIONS.

a. To facilitate disassembly of engine subassemblies and subsequent assembly of the engine, orderliness and cleanliness should be maintained in disassembling the engine.

b. Before starting to disassemble the engine, it should be carefully inspected to see that all dirt, oil or other accumulations have been removed. Instructions for removal of engine from tractor, section IV, paragraph 26, require that the engine be thoroughly steam-cleaned before it is removed. Use extreme care to protect interior of assemblies from dirt as they are removed from the engine.

c. Replace old gaskets with new ones. All traces of old gaskets should be removed before new gaskets are installed.

d. Use special tools as indicated to remove all parts having a tight or pressed fit. Such parts should not be pried off with screwdrivers or bars except when so instructed.

e. Handle bearings and other smooth working surfaces with care, protecting them from dirt or possible scoring.

f. Use racks to store removed valves, pistons and connecting rods. Place bolts, washers and small parts in receptacles. To simplify assembly, store all disassembled parts in order.

39. AIR COMPRESSOR AIR CLEANER REMOVAL (fig. 22).

a. Equipment.

SCREWDRIVER

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

b. Procedure.

(1) DISCONNECT AIR CLEANER FROM INTAKE MANIFOLD.

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

(a) Remove two cap screws and lock washers which secure air cleaner bracket to intake manifold.

DISASSEMBLY OF ENGINE

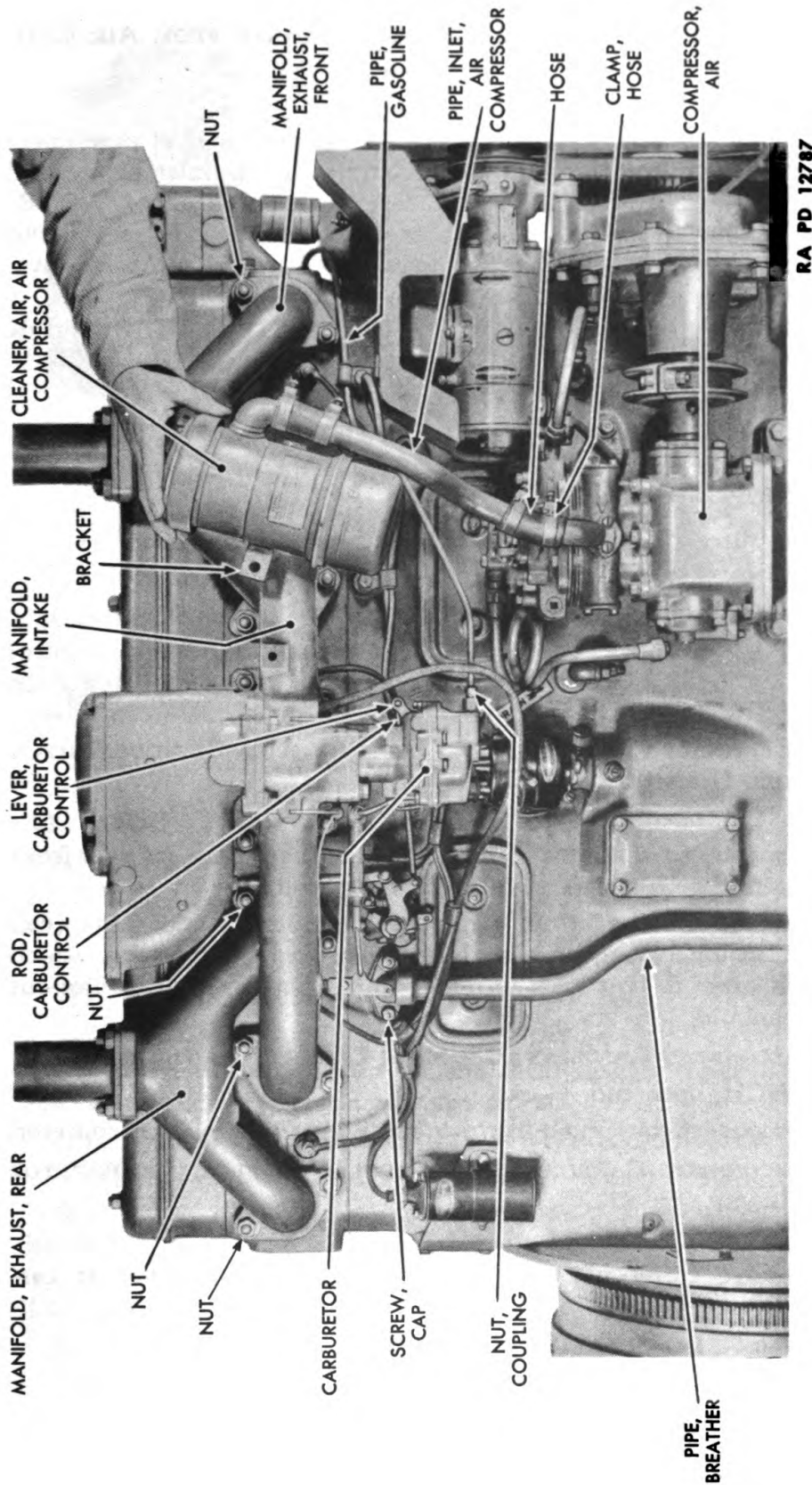


Figure 22—Air Compressor Air Cleaner Removal

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(2) DISCONNECT AIR COMPRESSOR AIR CLEANER FROM AIR COMPRESSOR.

SCREWDRIVER

(a) Loosen screw on lower clamp of air compressor inlet pipe lower hose. Work lower hose free from air compressor air inlet elbow and remove air cleaner with air inlet pipe and two hoses attached. NOTE: On lot 1 tractors the air compressor air cleaner is fastened directly to the air compressor with two slotted screws. Use a screwdriver to remove.

40. REMOVAL OF INTAKE MANIFOLD WITH CARBURETOR ATTACHED.

a. Equipment.

PLIERS

WRENCH, open-end, 1/2-in.

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

WRENCH, socket, 1 3/16-in.,
with speeder

b. Procedure.

(1) DISCONNECT AIR VALVE CONTROL ROD (fig. 136).

PLIERS

(a) Remove cotter pin from pin which connects air valve control rod to manifold outer control lever. Remove pin and remove rod from lever.

(2) DISCONNECT CABLE ASSEMBLY FROM IGNITION CUT-OUT SWITCH IN MANIFOLD HOUSING (fig. 136).

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

(a) Remove two slotted screws and lock washers from cover at front side of manifold housing. Remove cover and gasket.

(b) Remove cable (cut-out switch to distributor) and cable (coil to cut-out switch). Remove nut, lock washer and flat washer which secure each cable to its switch terminal within housing. Pull cables out through manifold.

(3) DISCONNECT GASOLINE PIPE FROM CARBURETOR (fig. 22).

WRENCH, open-end, 1/2-in.

(a) Disconnect coupling nut which holds gasoline pipe to carburetor.

(4) DISCONNECT CARBURETOR CONTROL ROD FROM CARBURETOR CONTROL LEVER (fig. 22).

PLIERS

(a) Remove cotter pin which holds control rod to lever at carburetor.

(5) REMOVE INTAKE MANIFOLD (fig. 22).

WRENCH, socket, 1 3/16-in., with speeder

(a) Remove eight nuts which hold intake manifold to cylinder head. There are two nuts at each end of manifold and four at center. Lift off manifold with carburetor attached. Remove three gaskets.

DISASSEMBLY OF ENGINE

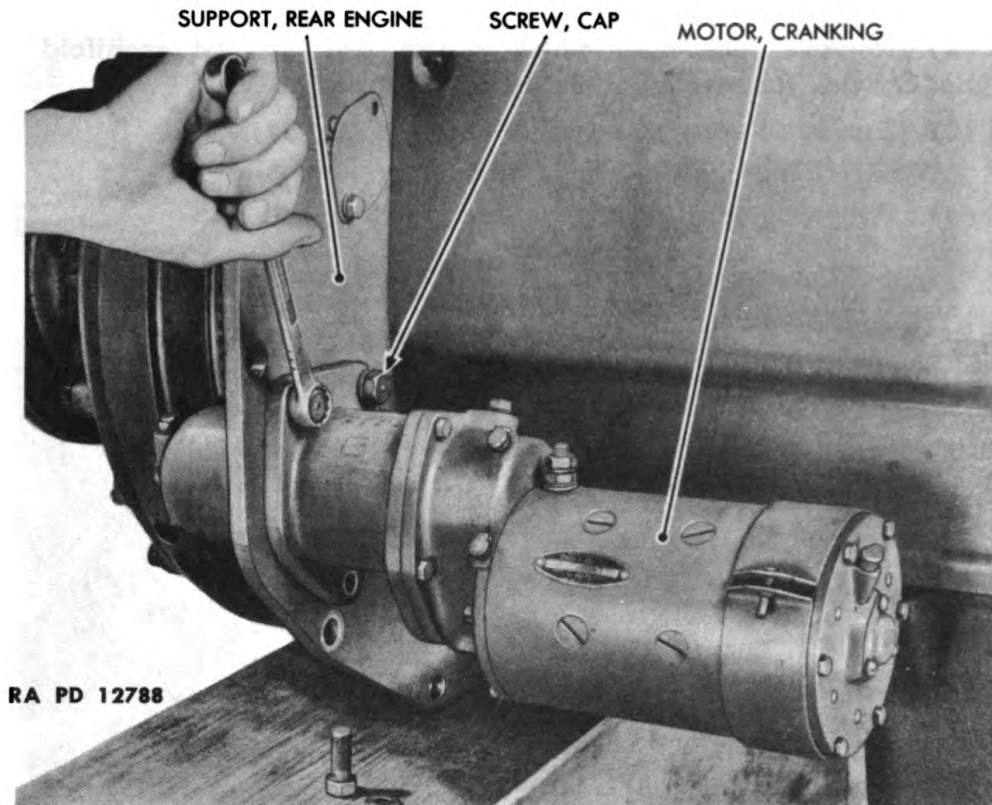


Figure 23—Cranking Motor Removal

41. CRANKING MOTOR REMOVAL (fig. 23).

a. Equipment.

WRENCH, box, $\frac{3}{4}$ -in.

WRENCH, socket, $\frac{9}{16}$ -in.,
and speeder

b. Procedure.

(1) REMOVE BREATHER PIPE (fig. 22).

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Remove two cap screws and lock washers which hold breather pipe to crankcase. Remove pipe and gasket.

(2) REMOVE CRANKING MOTOR AND CRANKING MOTOR CABLE CLIP.

WRENCH, box, $\frac{3}{4}$ -in.

(a) Remove three cap screws and lock washers which hold cranking motor to rear engine support. Lift off cranking motor.

42. EXHAUST MANIFOLD REMOVAL.

a. Equipment.

WRENCH, socket, $\frac{13}{16}$ -in., and speeder

b. Procedure.

(1) REMOVE REAR EXHAUST MANIFOLD (fig. 22).

WRENCH, socket, $\frac{13}{16}$ -in., and speeder

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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Remove four nuts which secure rear exhaust manifold to cylinder head. Remove manifold and two copper gaskets.

(2) REMOVE FRONT EXHAUST MANIFOLD (fig. 22).

WRENCH, socket, $1\frac{3}{16}$ -in., and speeder

(a) Follow same procedure outlined in step (1) above.

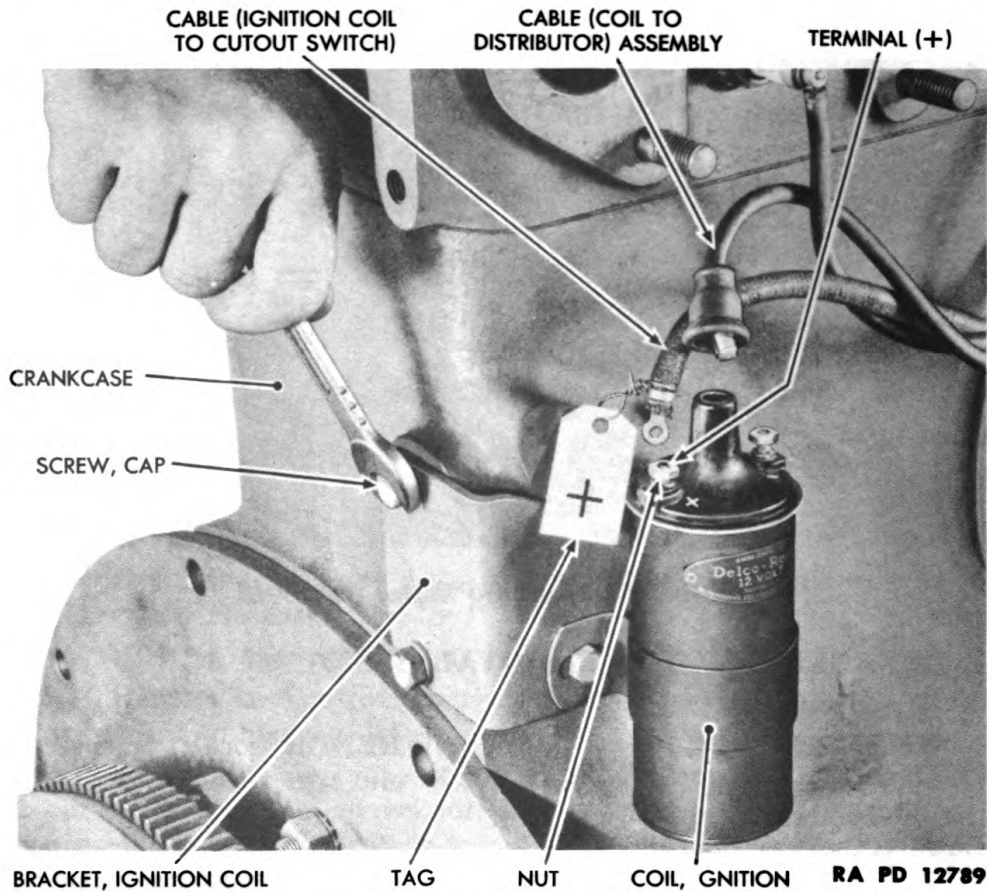


Figure 24—Ignition Coil Removal

43. IGNITION COIL REMOVAL (fig. 24).

a. Equipment.

WRENCH, open-end, $\frac{3}{8}$ -in.

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

b. Procedure.

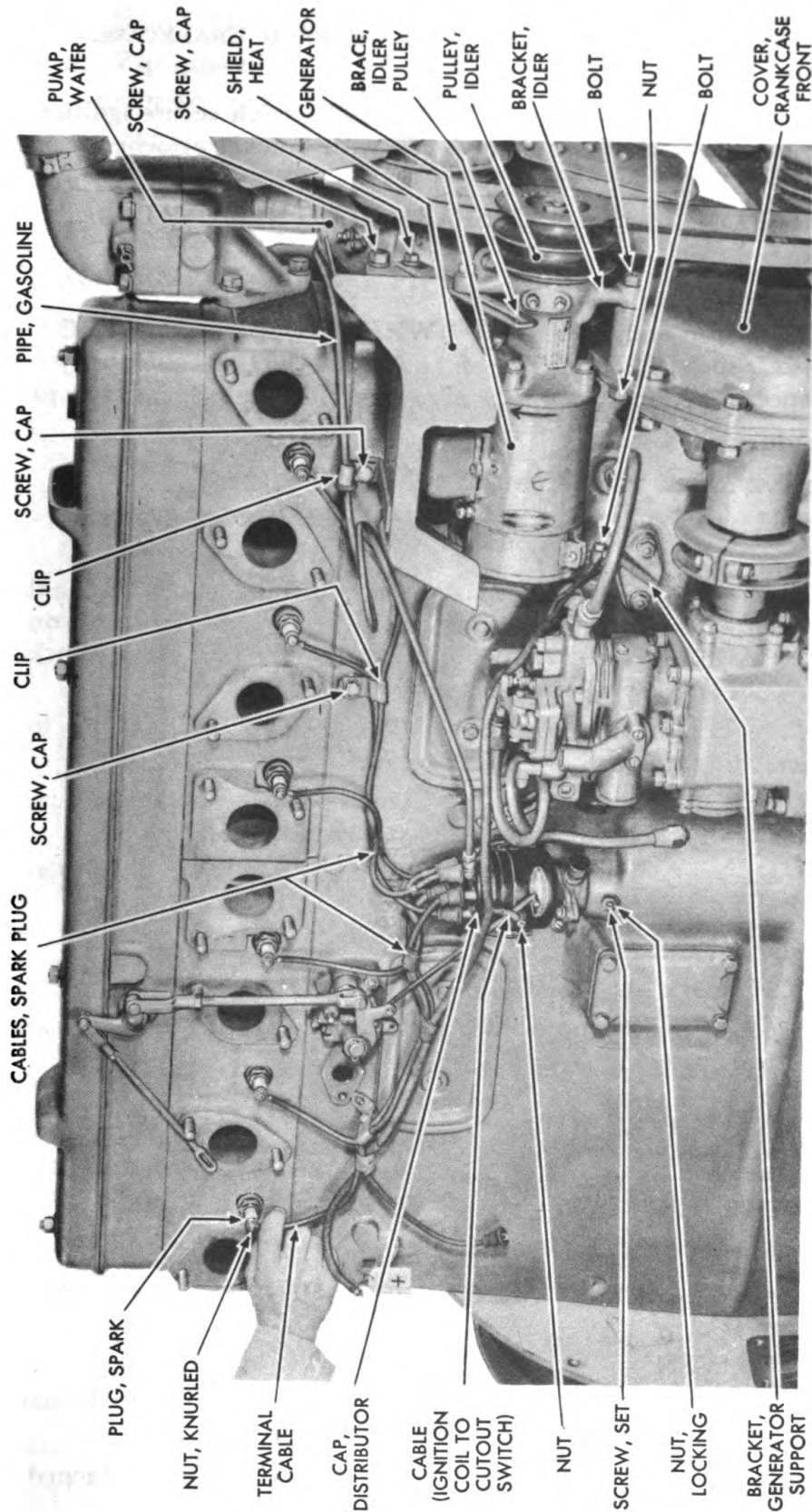
(1) DISCONNECT COIL TO DISTRIBUTOR CABLE ASSEMBLY FROM COIL. Pull cable assembly from coil.

(2) DISCONNECT IGNITION COIL TO CUT-OUT SWITCH CABLE FROM COIL.

WRENCH, open-end, $\frac{3}{8}$ -in.

(a) Remove nut which holds cable to coil terminal (+). After cable has been removed, replace lock washer and nut on terminal. Also, attach tag marked + to end of cable to facilitate correct installation.

DISASSEMBLY OF ENGINE



RA PD 12790

Figure 25—Spark Plug Cable Removal

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

- (3) REMOVE IGNITION COIL WITH BRACKET FROM CRANKCASE.
WRENCH, open-end, $\frac{9}{16}$ -in.

(a) Remove two cap screws and lock washers which secure ignition coil bracket to crankcase. Then remove coil with bracket attached.

44. SPARK PLUG CABLE AND SPARK PLUG REMOVAL
(fig. 25).

a. Equipment.

WRENCH, open-end, $\frac{3}{8}$ -in.
WRENCH, socket, $\frac{9}{16}$ -in.,
and speeder

WRENCH, spark plug (IHC
No. 32941-D or equivalent)

b. Procedure.

- (1) REMOVE SPARK PLUG CABLES.

WRENCH, open-end, $\frac{3}{8}$ -in.

WRENCH, socket, $\frac{9}{16}$ -in.,
and speeder

(a) Remove cables from six spark plugs, turning cable terminal and knurled nut by hand in counterclockwise direction. Replace nuts on spark plugs. CAUTION: Never use pliers to remove or tighten spark plug screws, since spark plug porcelain may become broken.

(b) Remove clip holding No. 1 and No. 2 spark plug cables to crankcase, removing cap screw and lock washer.

(c) Remove nut which holds cable (ignition cut-out switch to distributor) to distributor. Remove cable from distributor.

(d) Pull six spark plug cables and ignition coil cable from distributor cap.

- (2) REMOVE SPARK PLUGS (fig. 25).

WRENCH, spark plug (IHC No. 32941-D or equivalent)

(a) Use special spark plug wrench to loosen six spark plugs, as outlined in electrical system section, TM 9-1777B.

45. DISTRIBUTOR REMOVAL (fig. 25).

a. Equipment.

SCREWDRIVER

WRENCH, box, $\frac{9}{16}$ -in.

b. Procedure.

- (1) RELEASE SET SCREW WHICH SECURES DISTRIBUTOR BRACKET TO CRANKCASE.

SCREWDRIVER

WRENCH, box, $\frac{9}{16}$ -in.

(a) Loosen set screw locking nut. Then use screwdriver to loosen set screw, so that it is free from distributor bracket.

(2) REMOVE DISTRIBUTOR. Lift distributor, with bracket attached, from crankcase.

DISASSEMBLY OF ENGINE

46. HEAT SHIELD AND GENERATOR REMOVAL (fig. 25).

a. Equipment.

WRENCHES, open-end,
two, 1/2-in.

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

WRENCH, socket, 9/16-in.,
and speeder

WRENCH, socket, 3/4-in.,
and speeder

b. Procedure.

(1) REMOVE GASOLINE PIPE.

WRENCH, socket, 9/16-in., and speeder

(a) Remove cap screw and lock washer which secure heat shield bracket and pipe clip to crankcase. Remove gasoline pipe.

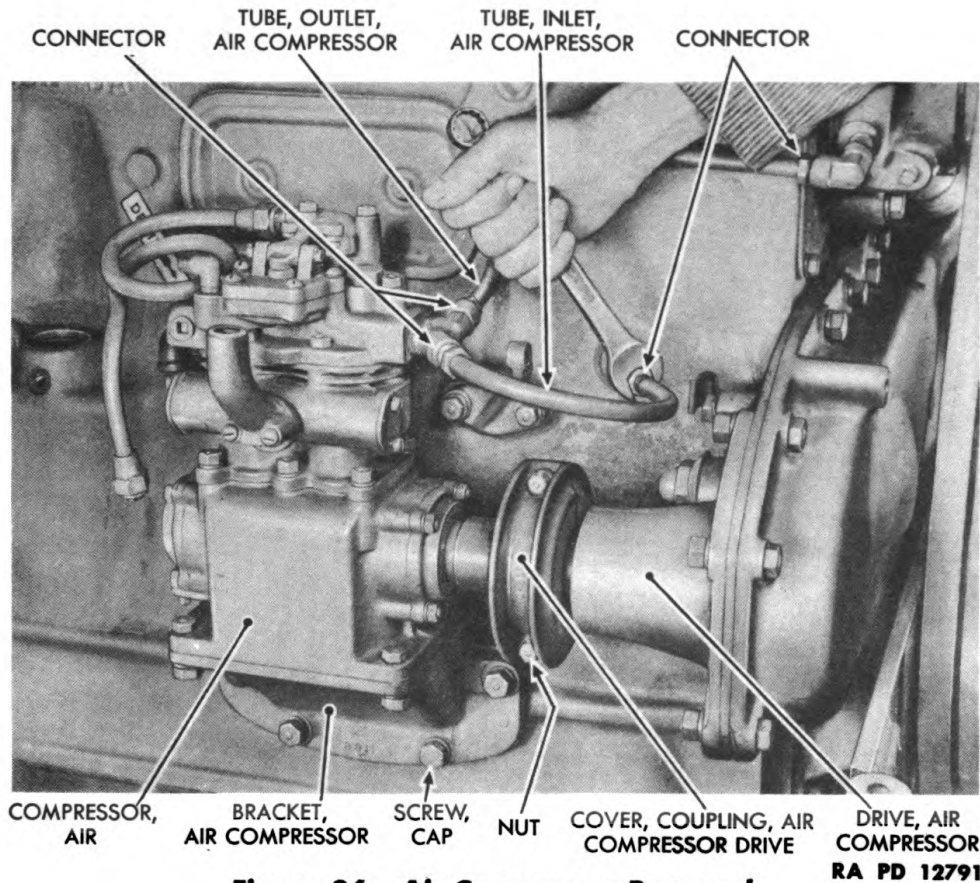


Figure 26—Air Compressor Removal

(2) REMOVE HEAT SHIELD.

WRENCH, socket, 9/16-in.,
and speeder

WRENCH, socket, 3/4-in.,
and speeder

(a) Remove cap screw and lock washer which hold idler pulley brace to water pump.

(b) Remove cap screw and lock washer which hold heat shield and water pump to crankcase. Remove heat shield.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

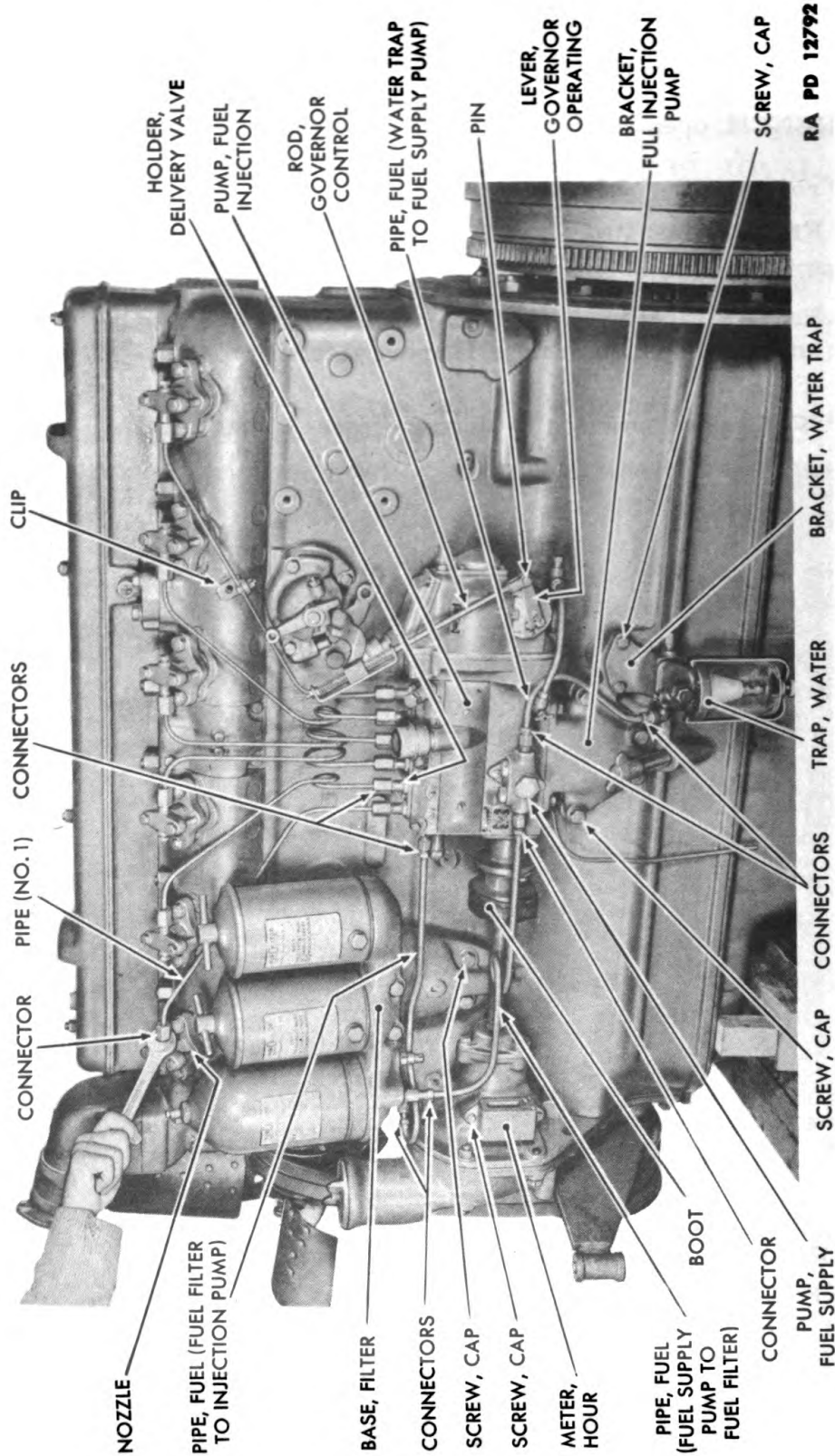


Figure 27 — Removal of Pump to Nozzle Pipes

DISASSEMBLY OF ENGINE

(3) REMOVE GENERATOR.

WRENCH, open-end, $\frac{1}{2}$ -in. WRENCH, socket, $\frac{3}{4}$ -in.,
WRENCH, open-end, $\frac{3}{4}$ -in. and speeder

(a) Remove bolt, nut and lock washer which hold idler bracket to front crankcase cover. Hold nut with open-end wrench and remove bolt, using socket wrench.

(b) Remove bolt, nut and lock washer which hold generator at rear to generator support bracket. Hold nut with open-end wrench and remove bolt with another open-end wrench. Lift out generator, idler bracket and idler pulley.

47. AIR COMPRESSOR REMOVAL (fig. 26).

a. Equipment.

WRENCHES, box, two, $\frac{1}{2}$ -in. WRENCH, socket, $\frac{1}{2}$ -in.,
WRENCH, box, $\frac{3}{4}$ -in. with speeder
WRENCH, open-end, $\frac{3}{4}$ -in.

b. Procedure.

(1) REMOVE AIR COMPRESSOR WATER INLET TUBE.

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

(a) Remove connectors at each end of tube. Then remove tube.

(2) REMOVE AIR COMPRESSOR OUTLET TUBE.

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

(a) Remove connectors at each end of tube. Then remove tube.

(3) REMOVE AIR COMPRESSOR DRIVE COUPLING COVER.

WRENCHES, box, two, $\frac{1}{2}$ -in.

(a) Remove two bolts, flat washers and lock washers which hold coupling cover and coupling on coupling flange gear and drive shaft gear.

(4) REMOVE AIR COMPRESSOR WITH BRACKET ATTACHED.

WRENCH, box, $\frac{3}{4}$ -in.

(a) Remove four cap screws and lock washers which hold air compressor bracket to crankcase. Lift air compressor with bracket attached from engine. Then remove air compressor bracket gasket.

48. FUEL INJECTION PUMP REMOVAL (fig. 27).

a. Equipment.

PLIERS WRENCH, open-end, $\frac{5}{8}$ -in.
SCREWDRIVER WRENCH, open-end, $\frac{3}{4}$ -in.
WRENCH, open-end, $\frac{9}{16}$ -in.

b. Procedure.

(1) REMOVE PIPES (FUEL INJECTION PUMP TO NOZZLES).

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Remove clips which hold No. 1 and No. 6 pipes to cylinder head.

(b) Disconnect connectors at each end of six pipes. Remove No. 1 pipe first, then pipes 2, 3, 4, 5 and 6 in sequence.

(c) Cover each delivery valve holder with cap or with tape as soon as pipe is removed. It is important that holders be covered so that dirt will not enter fuel injection pump.

(2) REMOVE FUEL PIPE (FUEL FILTER TO INJECTION PUMP).

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

(a) Remove connector at each end of pipe.

(3) REMOVE FUEL PIPE (FUEL SUPPLY PUMP TO FUEL FILTER).

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

(a) Remove connector at each end of pipe.

(4) REMOVE FUEL PIPE (WATER TRAP TO FUEL SUPPLY PUMP).

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

(a) Remove connector at each end of pipe.

(5) DISCONNECT GOVERNOR CONTROL ROD FROM GOVERNOR OPERATING LEVER.

PLIERS

(a) Remove cotter pin. Then remove pin and control rod from operating lever.

(6) REMOVE BOOT FROM SPACER.

SCREWDRIVER

(a) Pry off boot. This boot covers spacer between adjuster and flange on shaft.

(7) REMOVE FUEL INJECTION PUMP.

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

(a) Remove four cap screws and lock washers which hold fuel injection pump bracket to crankcase. Then lift off pump and bracket attached.

49. WATER TRAP REMOVAL (fig. 27).

a. Equipment.

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

b. Procedure. Remove two cap screws and lock washers which hold water trap bracket to crankcase. Lift off water trap with bracket attached.

50. LUBRICATING OIL FILTERS AND FUEL FILTER REMOVAL.

a. Equipment.

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle

DISASSEMBLY OF ENGINE

b. Procedure. Remove four cap screws and lock washers which hold filter base to crankcase. Lift off filter base with filters attached. Then remove gasket.

51. HOUR METER REMOVAL (fig. 27).

a. Equipment.

PLIERS, side-cutting

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

b. Procedure.

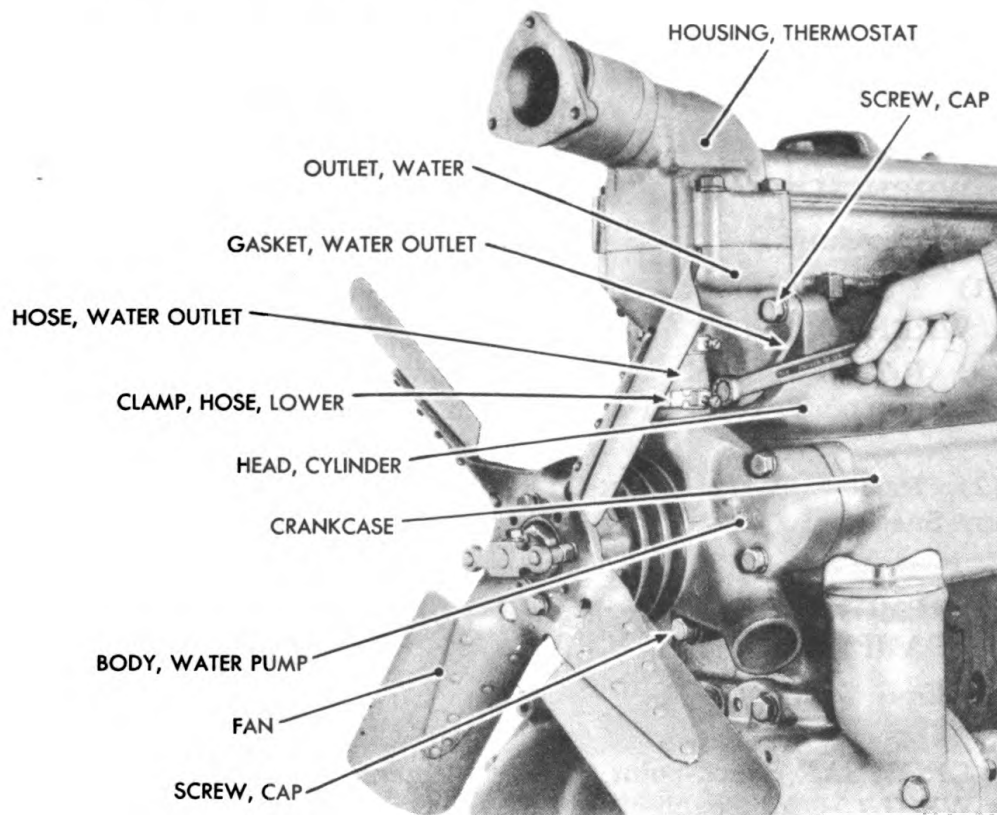
(1) BREAK WIRE SEAL.

PLIERS, side-cutting

(a) Break wire which seals cap screws.

(2) REMOVE HOUR METER.

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



RA PD 12793

Figure 28—Thermostat Housing and Water Outlet Removal

(a) Remove two cap screws and lock washers which secure hour meter to hour meter drive gear housing. Then remove hour meter and hour meter gasket.

(3) REMOVE HOUR METER DRIVEN GEAR ASSEMBLY. Lift assembly from housing.

DISASSEMBLY OF ENGINE

(2) REMOVE FAN DRIVE PULLEY WITH VIBRATION DAMPER ATTACHED.

CROWBAR, pinch-point, 3 lb

(a) Pry fan drive pulley and vibration damper from crankshaft.

55. FRONT ENGINE SUPPORT REMOVAL.

a. Equipment.

CROWBAR, pinch-point, 3 lb WRENCH, open-end, $\frac{7}{16}$ -in.

b. Procedure.

(1) REMOVE SUPPORT FROM CRANKCASE FRONT COVER.

CROWBAR, pinch-point, 3 lb

(a) Pry off front engine support.

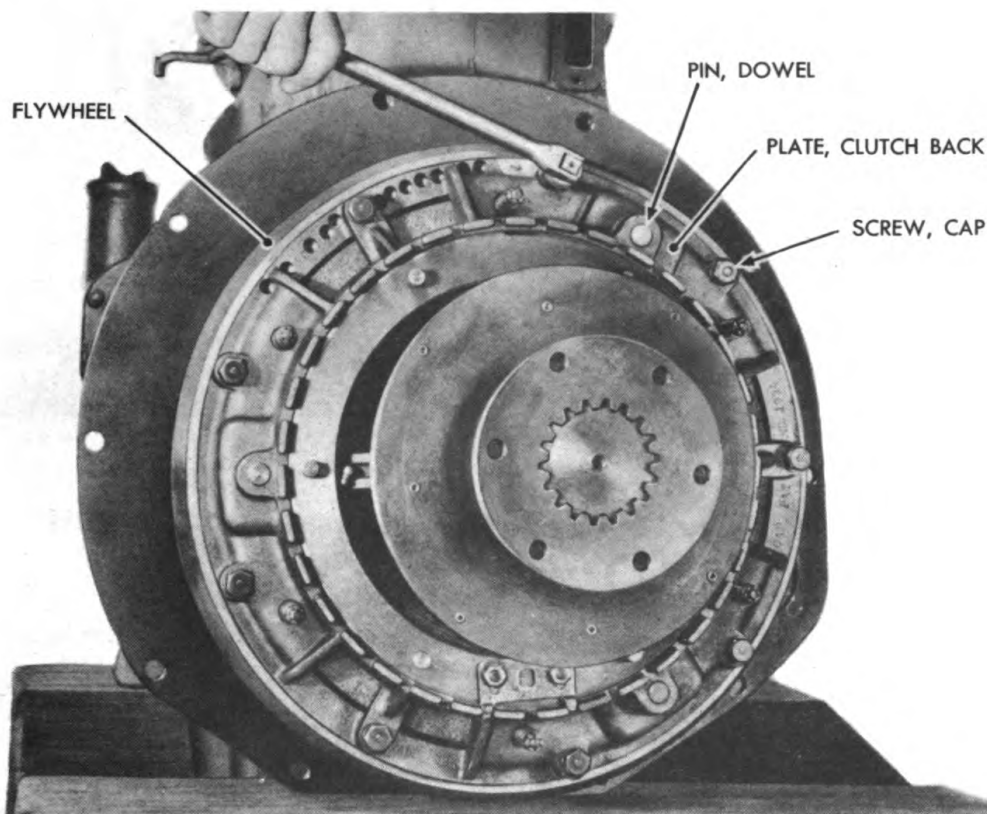


Figure 29—Clutch Assembly Removal RA PD 12794

(2) REMOVE LUBRICATOR.

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

(a) Remove lubricator from front engine support.

56. COMPLETE CLUTCH REMOVAL (fig. 29).

a. Equipment.

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) **DISCONNECT CLUTCH BACK PLATE FROM FLYWHEEL.**

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle

(a) Remove nine cap screws and lock washers which hold clutch back plate to flywheel.

(2) **REMOVE COMPLETE CLUTCH.** Lift complete clutch from flywheel.

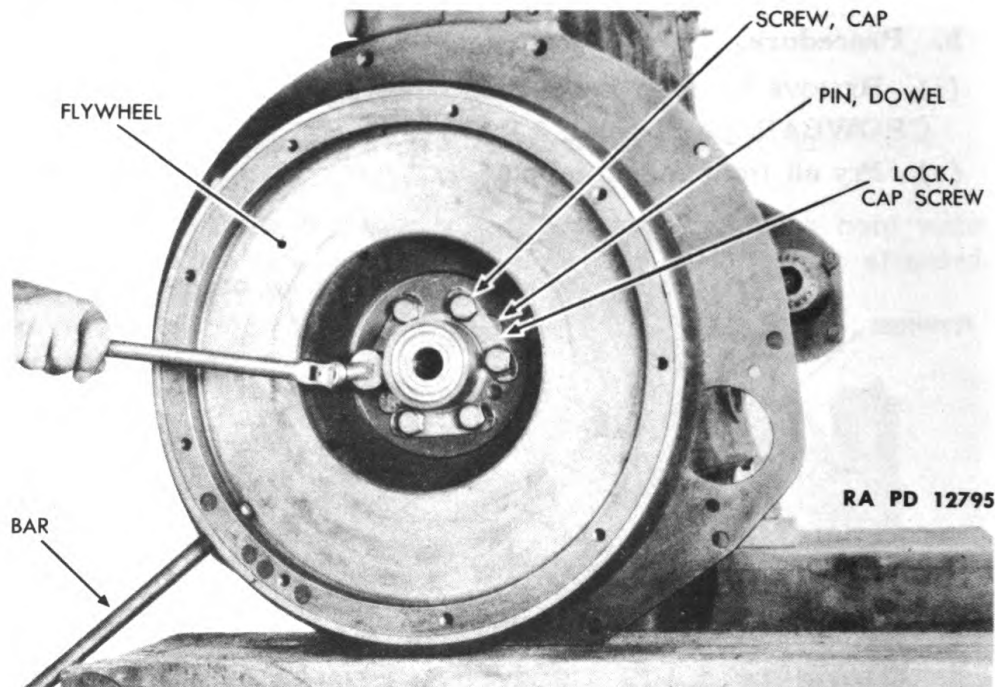


Figure 30—Engine Flywheel Removal

57. ENGINE FLYWHEEL REMOVAL (fig. 30).

a. Equipment.

BAR, steel

HOIST

SCREWDRIVER

WRENCH, socket, $\frac{7}{8}$ -in., and spinner type handle

WRENCH, socket, 1-in., and spinner type handle

b. Procedure.

(1) **UNLOCK CAP SCREW LOCKS.**

SCREWDRIVER

(a) Bend back cap screw locks from heads of cap screws. These locks also hold two dowel pins in place.

(2) **REMOVE CAP SCREWS WHICH SECURE FLYWHEEL TO CRANK-CASE.**

BAR, steel

WRENCH, socket, 1-in., and spinner type handle

DISASSEMBLY OF ENGINE

(a) Bar one of holes, located on outside of flywheel, to keep flywheel from turning while cap screws are being removed. Remove six cap screws and then remove three cap screw locks.

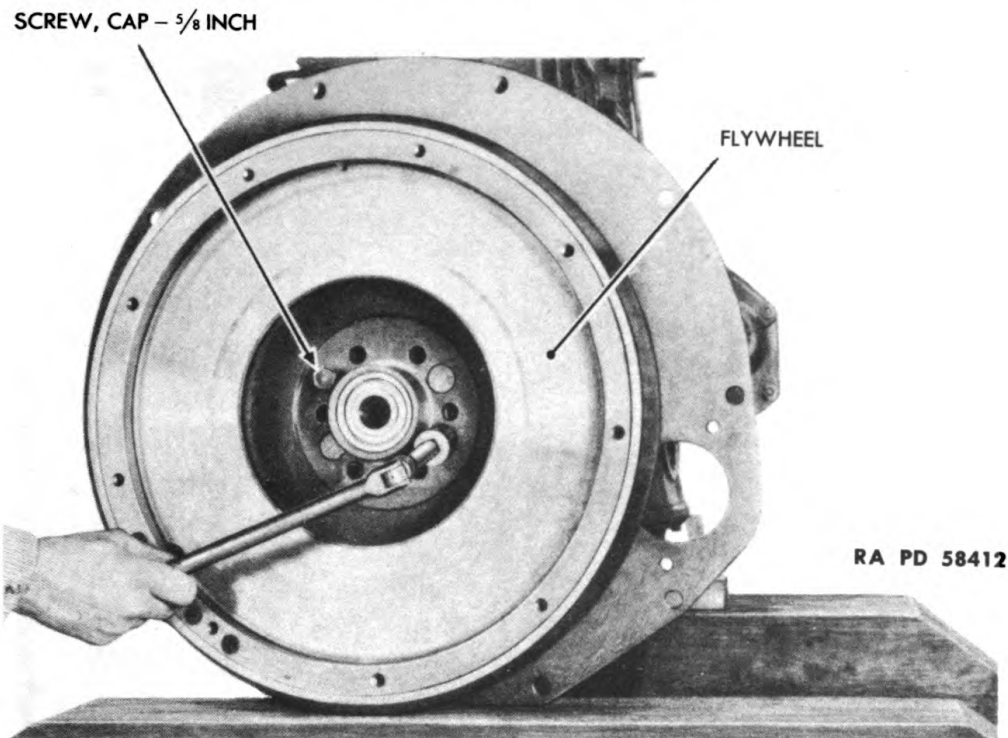


Figure 31—Pulling Flywheel from Crankshaft

(3) REMOVE FLYWHEEL WITH RING GEAR ATTACHED.

HOIST

WRENCH, socket, $\frac{7}{8}$ -in., and spinner type handle

(a) Insert two $\frac{5}{8}$ -inch cap screws into puller holes. Then tighten cap screws evenly, giving each one a quarter turn at a time, until flywheel is pulled from crankshaft. **CAUTION:** Because of weight of flywheel, a hoist should be used to lift it away from engine. Otherwise, extreme care should be taken when lifting the flywheel by hand.

58. CYLINDER HEAD REMOVAL.

a. Equipment.

HOIST

PLIERS

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

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

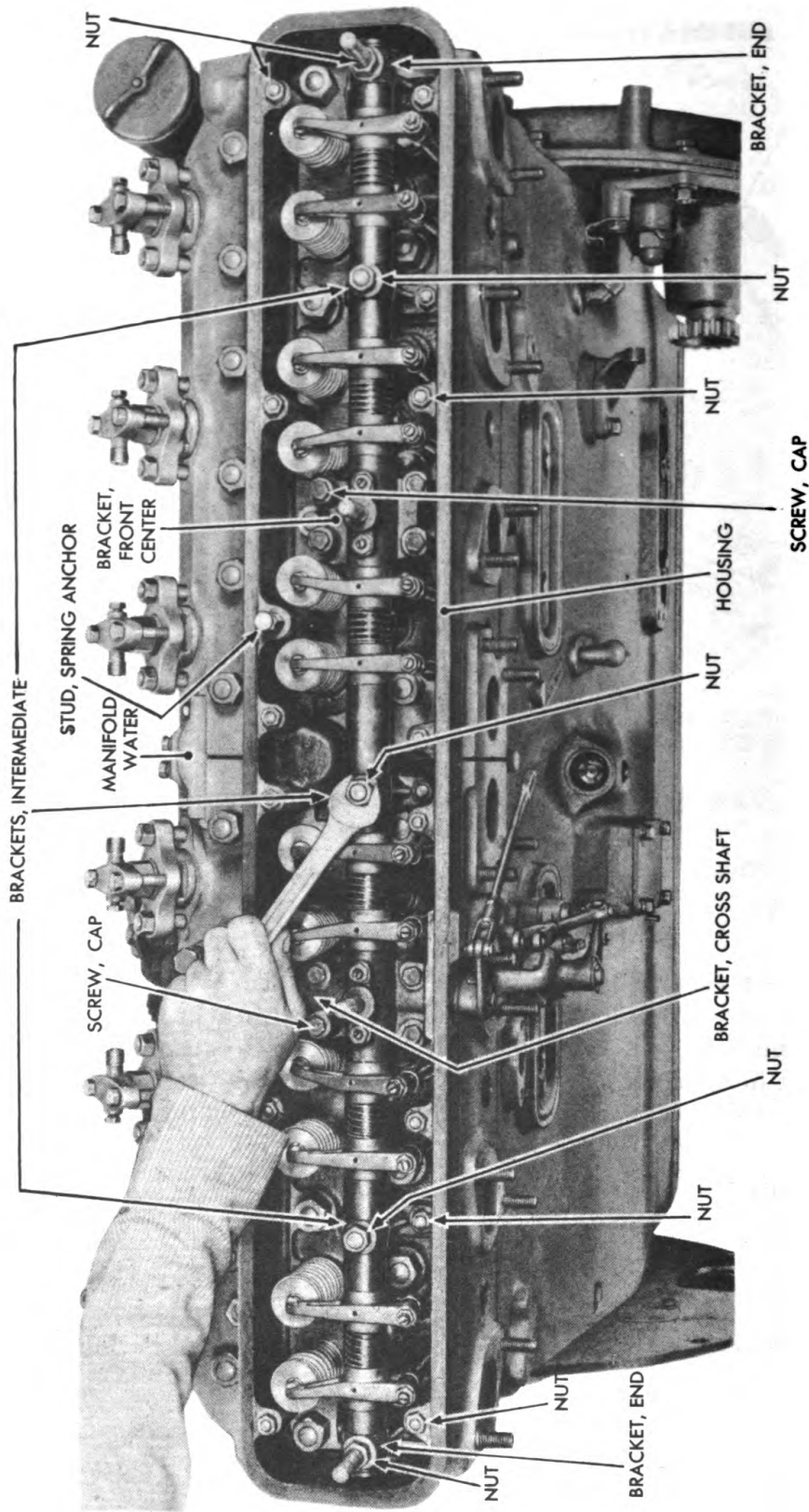
WRENCH, socket, 1-in., and spinner type handle

b. Procedure.

(1) REMOVE VALVE HOUSING COVER (fig. 63).

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

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE



RA PD 12800

Figure 32—Valve Lever Shaft and Bracket Removal

DISASSEMBLY OF ENGINE

(a) Remove four nuts and copper washers which hold cover to cylinder heads. Lift off cover; remove gasket and felt.

(2) **DISCONNECT CROSS SHAFT OPERATING ROD FROM CROSS SHAFT LEVER** (fig. 61).

PLIERS

(a) Remove cotter pin from pin which holds adjusting yoke to cross shaft lever. Remove pin.

(3) **REMOVE CROSS SHAFT SPRING** (fig. 32).

PLIERS

(a) Remove spring which connects inner lever to spring anchor stud.

(4) **REMOVE VALVE LEVER SHAFT BRACKET STUD NUTS** (fig. 32).

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

(a) Remove five nuts from center studs which hold end and intermediate brackets to cylinder heads.

(5) **REMOVE STUD NUTS FROM RIGHT SIDE OF VALVE SHAFT BRACKETS** (fig. 32).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(6) **REMOVE TWELVE NUTS FROM STUDS WHICH HOLD HOUSING IN PLACE** (fig. 32).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(7) **REMOVE CAP SCREWS FROM CROSS SHAFT AND FRONT CENTER BRACKETS** (fig. 32).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Remove four cap screws from cross shaft bracket and four cap screws from front center brackets. These cap screws hold brackets to cylinder heads.

(8) **REMOVE HOUSING WITH VALVE LEVER ASSEMBLIES** (fig. 32). Lift assembly upward and off cylinder heads. Remove housing gasket.

(9) **REMOVE WATER MANIFOLD** (fig. 32).

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

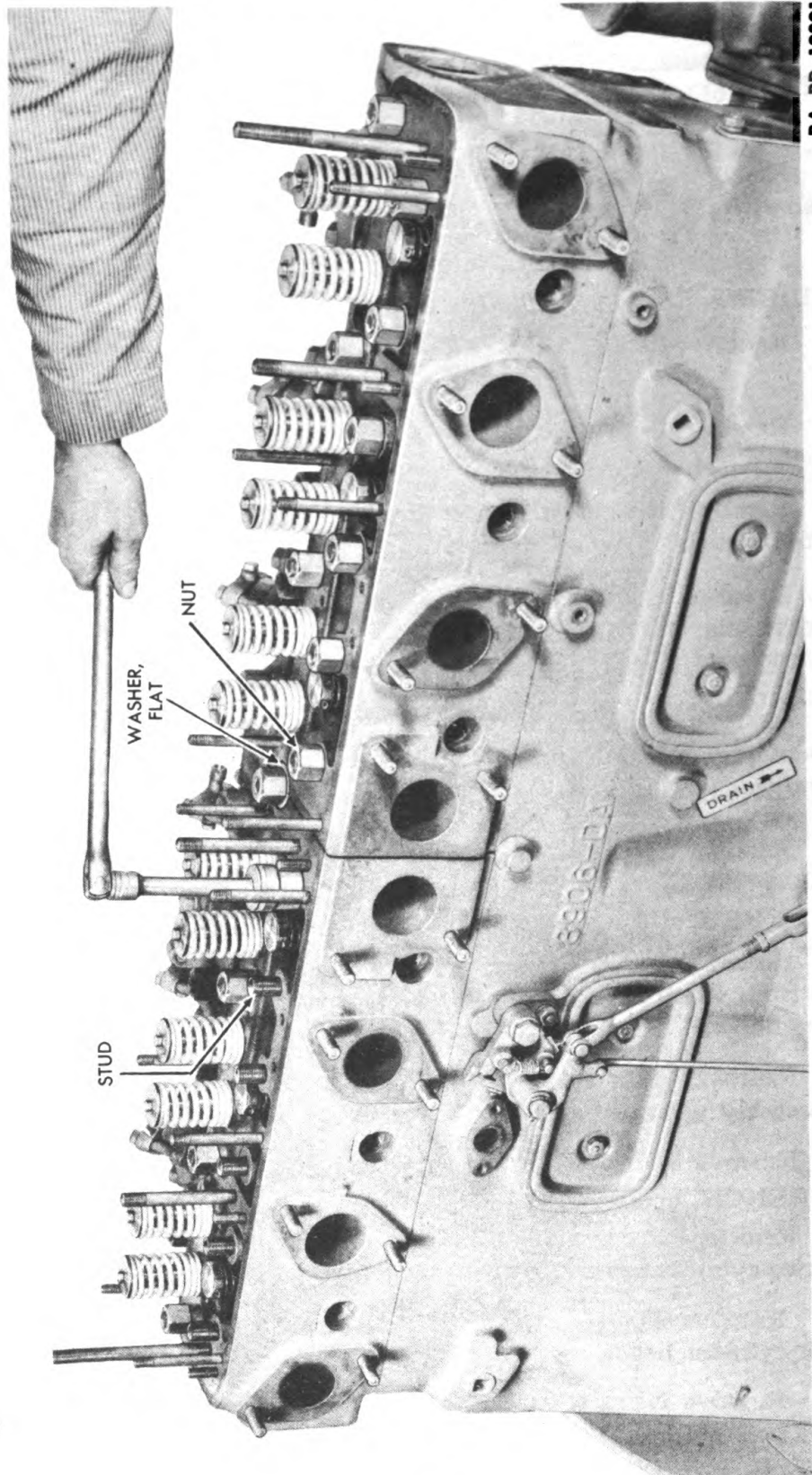
(a) Remove six cap screws and lock washers which hold manifold to the two cylinder heads. Remove water manifold and gasket.

(10) **REMOVE PUSH RODS** (fig. 67). Lift push rods from crankcase through cylinder heads.

(11) **REMOVE NUTS WHICH HOLD CYLINDER HEADS TO CRANKCASE** (fig. 33).

WRENCH, socket, 1-in., and spinner type handle with extension

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE



RA PD 12801

Figure 33—Cylinder Head Nut Removal

DISASSEMBLY OF ENGINE

(a) Remove 31 nuts which secure cylinder heads to crankcase studs. There is one row of studs on each side of cylinder heads and also a center row. Stud between two cylinder heads has flat washer between nut and cylinder heads.

(12) REMOVE CYLINDER HEADS (fig. 69).

HOIST

(a) Attach hoist to front and rear stud or cap screw of front cylinder head, replacing nuts on studs used. Then lift cylinder head upward from crankcase.

(b) Remove rear cylinder head in same manner.

(c) Remove cylinder head gaskets and gasket rings.

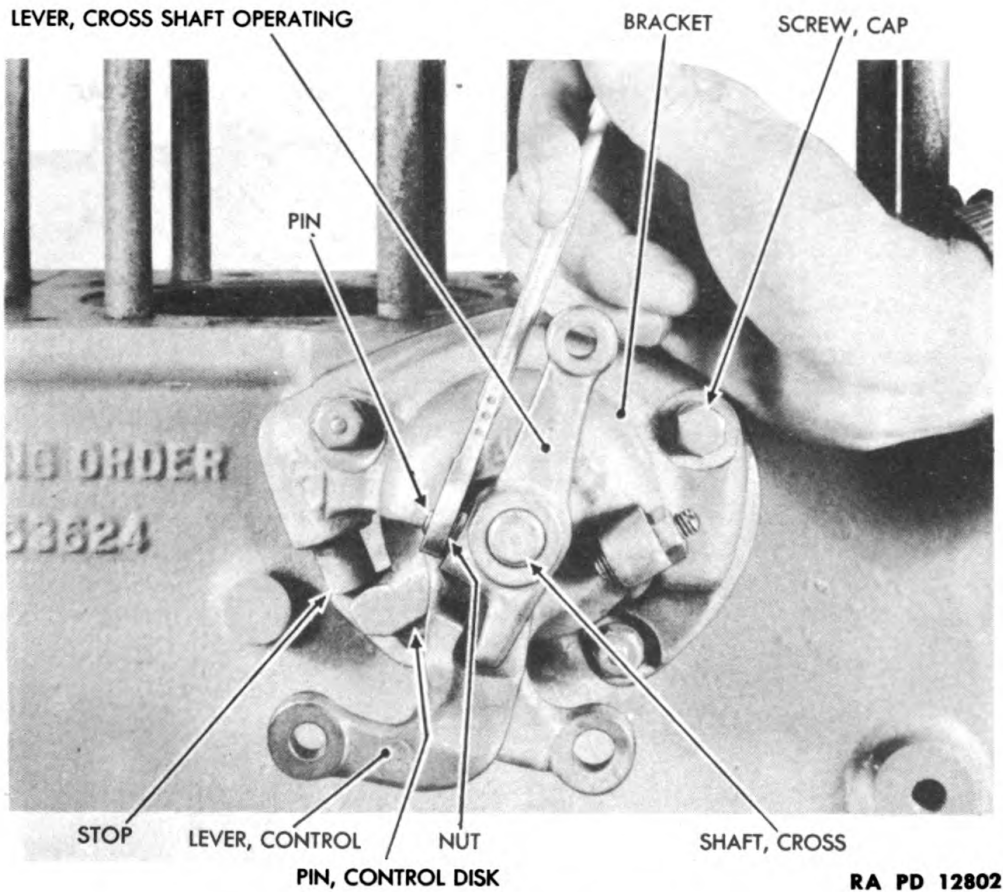


Figure 34—Cross Shaft Operating Lever Removal

59. CROSS SHAFT AND GOVERNOR CONTROL REMOVAL
(fig. 34).

a. Equipment.

PUNCH

WRENCH, box, 1/2-in.

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

WRENCH, socket, 9/16-in.,
and speeder

WRENCH, socket, 9/16-in.,
and spinner type handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) REMOVE CROSS SHAFT OPERATING LEVER.

PUNCH

WRENCH, box, 1/2-in.

(a) From left side of engine remove nut and lock washer from tapered pin which holds lever to cross shaft.

(b) Use punch to drive out pin.

(c) Lift off lever.

(2) REMOVE BRACKET AND CONTROL LEVER.

WRENCH, socket, 9/16-in., and spinner type handle

(a) Remove three cap screws and lock washers which hold bracket and control lever to crankcase. Then lift off bracket and control lever and attached parts.

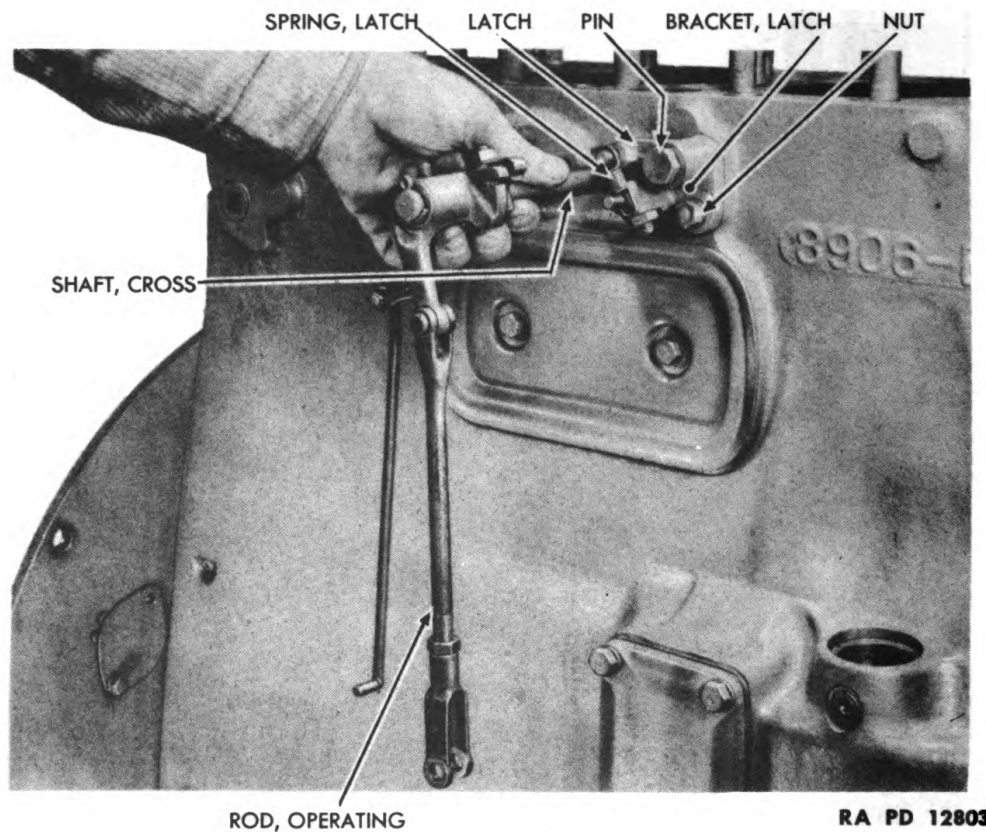


Figure 35—Cross Shaft Removal

(3) REMOVE CROSS SHAFT (fig. 35). From right side of crankcase, pull out cross shaft with operating rod and connecting parts attached.

(4) REMOVE LATCH SPRING (fig. 35).

(5) REMOVE THE LATCH (fig. 35).

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

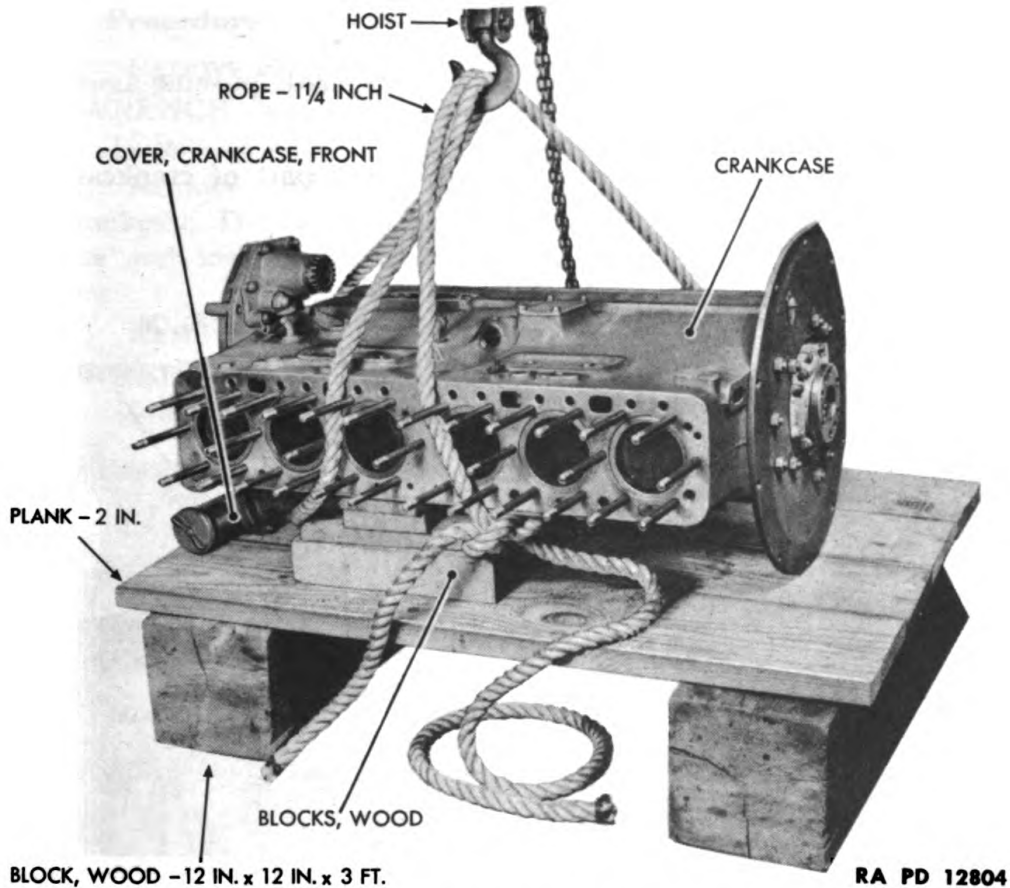
(a) Remove pin from latch. Then lift off latch.

DISASSEMBLY OF ENGINE

(6) REMOVE LATCH BRACKET (fig. 35).

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Remove nut and lock washer which hold latch bracket to crankcase stud. Then lift off latch bracket.



RA PD 12804

Figure 36—Placing Engine in Horizontal Position

60. CRANKCASE OIL PAN REMOVAL.

a. Equipment.

BLOCKS, wooden, (2 or 3)

HOIST

PLANK, 2-in.

SLING, rope

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

and spinner type handle

b. Procedure.

(1) PLACE ENGINE CRANKCASE AND ATTACHED PARTS ON ITS LEFT SIDE (fig. 36).

BLOCKS, wooden, (2 or 3)

HOIST

PLANK, 2-in.

SLING, rope

(a) Remove oil level gage from left side of crankcase.

(b) Support crankcase and attached parts on hoist by means of rope sling. Use rope recommended for use when removing engine from vehicle.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

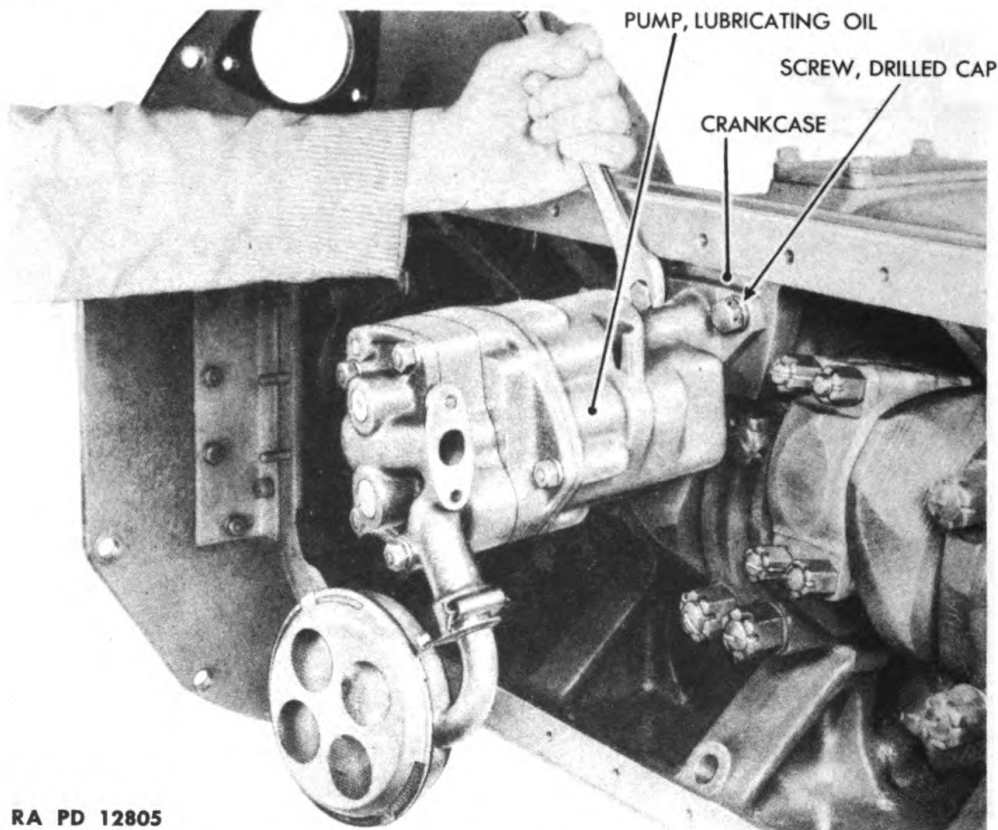
Place one loop of rope under rear of oil pan and another loop under crankcase front cover.

(c) Use two or three wooden blocks approximately 12-inch by 12-inch by 3-feet or equivalent, as a base, and cover them with 2-inch plank.

(d) Lower crankcase and attached parts on plank, pushing assembly over on its left side.

(e) Place small wooden blocks under upper part of crankcase to support crankcase in level horizontal position.

(f) Remove rope sling.



RA PD 12805

Figure 37—Lubricating Oil Pump Removal

(2) REMOVE CRANKCASE OIL PAN.

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) As shown in figure 126, remove 32 cap screws and lock washers and four stud nuts which hold oil pan to crankcase. There are three studs at rear of oil pan and one in front. Remove oil pan.

(3) REMOVE CRANKCASE OIL PAN GASKET. Take gasket off oil pan.

DISASSEMBLY OF ENGINE

61. LUBRICATING OIL PUMP REMOVAL.

a. Equipment.

PLIERS

WRENCH, open-end, or box,
1/2-in.

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

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

b. Procedure.

(1) REMOVE FRONT OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end,
1/2-in.

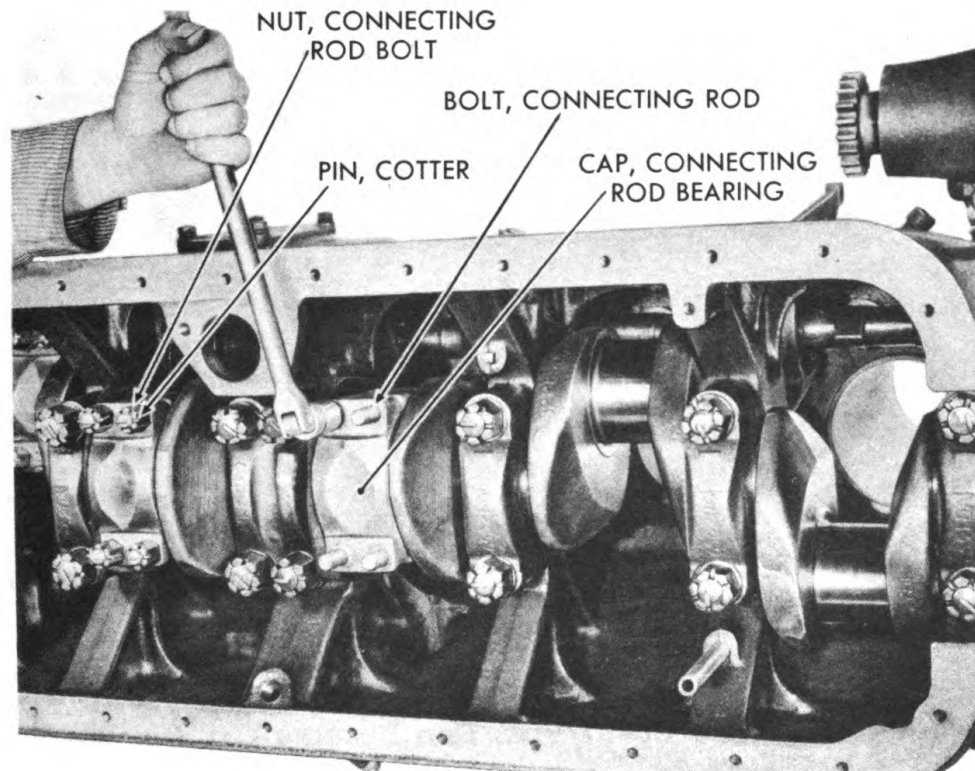
WRENCH, open-end, 9/16-in.

(a) Remove cap screw and lock washer which hold pipe bracket to crankcase. Disconnect pipe from oil pump cover, removing two cap screws and lock washers. Lift off front oil return pipe and remove gasket.

(2) REMOVE REAR OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end,
1/2-in.

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



RA PD 12806

Figure 38—Connecting Rod Bearing Cap Removal

(a) Remove cap screw and lock washer which hold pipe bracket to crankcase. Then disconnect pipe from lubricating oil pump upper housing, removing two cap screws and lock washers. Lift out pipe and gasket.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(3) REMOVE LUBRICATING OIL PUMP (fig. 37).

PLIERS

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

(a) Remove wire which locks drilled cap screws that hold pump to crankcase. Remove cap screws and lock washers, then lower pump from crankcase.

62. PISTON AND CONNECTING ROD REMOVAL.

a. Equipment.

HAMMER, rawhide

WRENCH, socket, 3/4-in.,
and spinner type handle

PLIERS

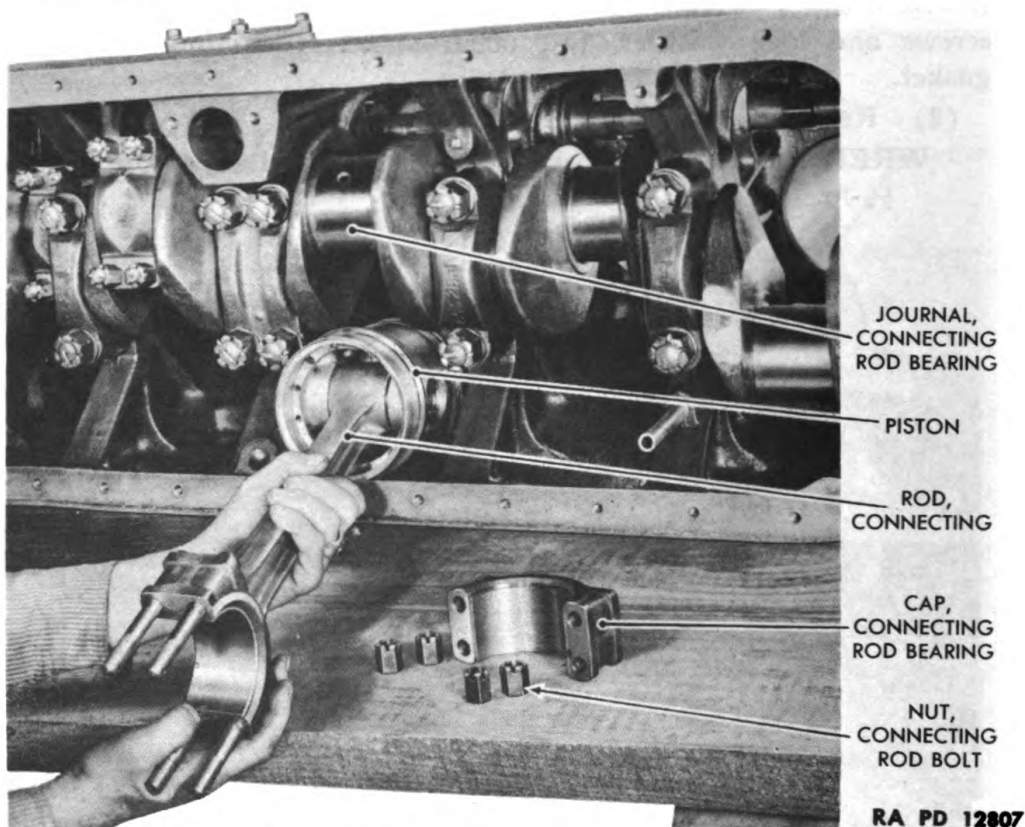


Figure 39—Pulling Out Connecting Rod and Piston

b. Procedure.

(1) REMOVE NO. 1 CONNECTING ROD BEARING CAP (fig. 38).

HAMMER, rawhide
PLIERS

WRENCH, socket, 3/4-in.,
and spinner type handle

- (a) Remove cotter pins which lock four connecting rod bolt nuts.
- (b) Remove four connecting rod bolt nuts.
- (c) Remove connecting rod bearing cap with lower connecting rod bearing attached. If necessary, tap cap lightly with rawhide hammer.

(2) REMOVE PISTON, CONNECTING ROD AND UPPER CONNECTING ROD BEARING (fig. 39).

DISASSEMBLY OF ENGINE

(a) Turn crankshaft until connecting rod bearing journal is in upright position, in order to provide maximum clearance for removal of connecting rod and piston. To turn over crankshaft, first install in end of crankshaft two of cap screws which were used to hold flywheel to end of crankshaft. Turn crankshaft by placing bar between two cap screws.

(b) Pull out connecting rod and piston, taking care not to damage them.

(3) REMOVE ALL OTHER PISTONS AND CONNECTING RODS BY FOLLOWING SAME PROCEDURE.

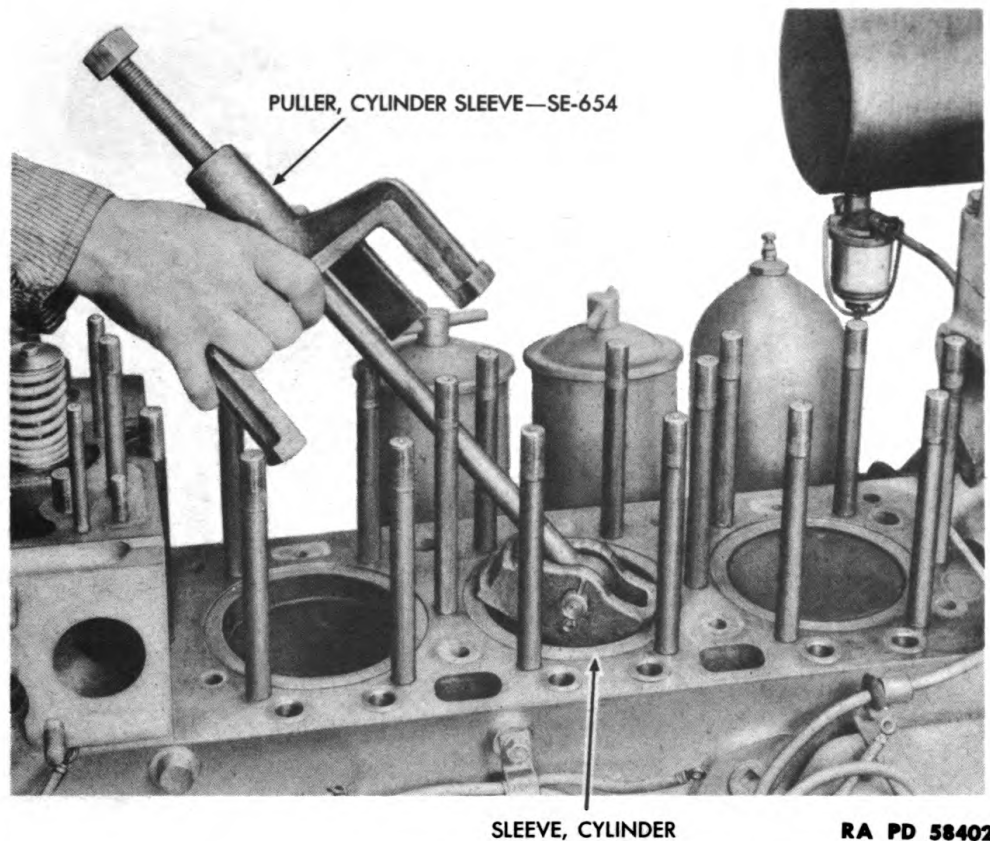


Figure 40—Cylinder Sleeve Puller Tool Installation

63. CYLINDER SLEEVE REMOVAL.

a. Equipment.

BLADE, knife

WRENCH, open-end, 1¼-in.

PULLER, cylinder sleeve (IHC
No. SE-654 or equivalent)

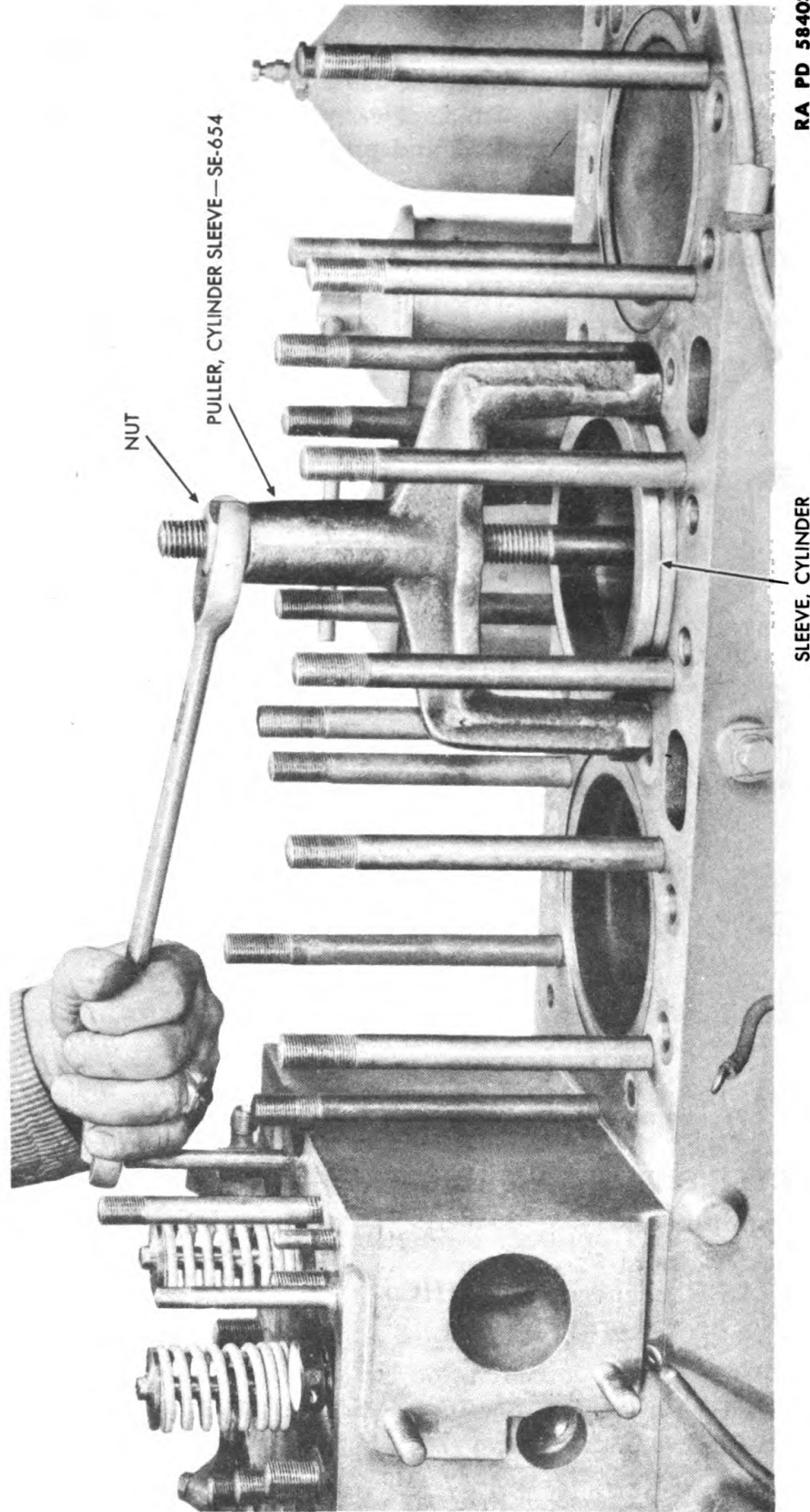
b. Procedure.

(1) INSTALL CYLINDER SLEEVE PULLER TOOL (fig. 40).

PULLER, cylinder sleeve re-
moving (IHC No. SE-654
or equivalent)

WRENCH, open-end, 1¼-in.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 58403

Figure 41—Cylinder Sleeve Removal

DISASSEMBLY OF ENGINE

(a) Install cylinder sleeve puller. First, run puller nut to top of puller rod and then insert lug end of rod into cylinder so that lug can be pulled against base of sleeve. Legs of tool "spider" should rest on crankcase around cylinder, so that tool nut is in center of cylinder. Then tighten tool nut.

(2) REMOVE CYLINDER SLEEVE (fig. 41). Continue tightening nut until sleeve is pulled loose from crankcase. Lift out tool and cylinder sleeve.

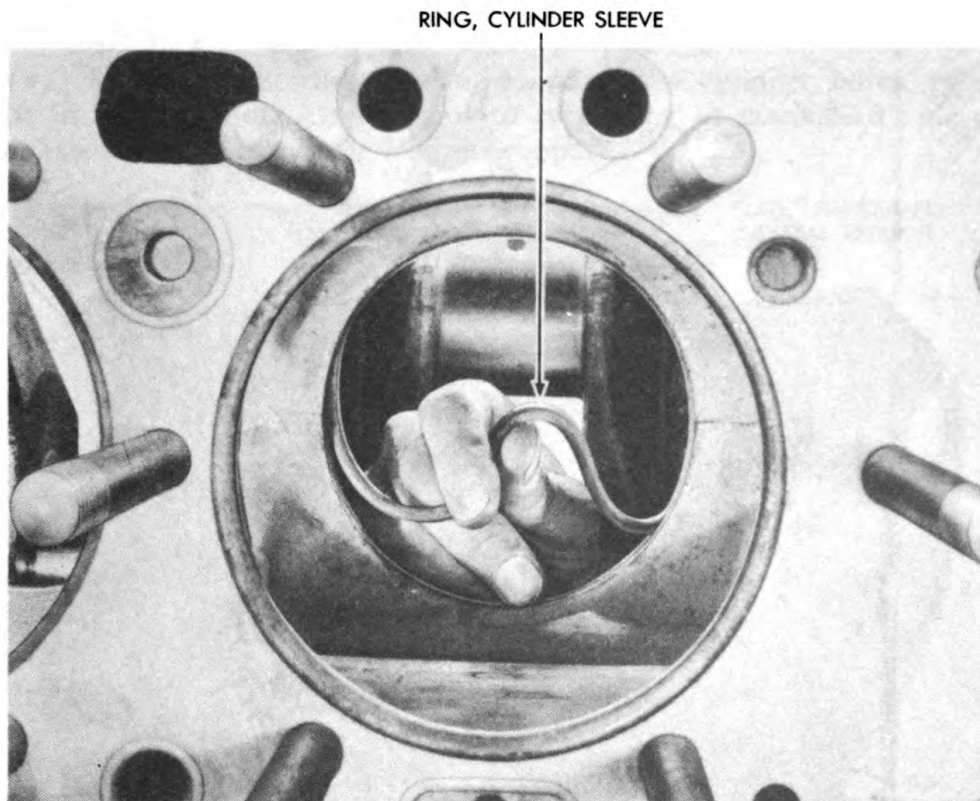


Figure 42—Cylinder Sleeve Ring Removal

RA PD 12808

(3) REMOVE CYLINDER SLEEVE RING (fig. 42).

BLADE, knife

(a) Pry cylinder sleeve ring free and then remove ring. Ring is located at bottom of cylinder wall.

(4) REMOVE ADDITIONAL SLEEVES IN SAME MANNER. When removing more than one sleeve, it is important to mark or systematically arrange sleeves to assure replacement in counterbores from which sleeves have been removed. When same sleeve is to be installed again in same counterbore, sleeve in crankcase should also be marked so that sleeve can be installed in its original position.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

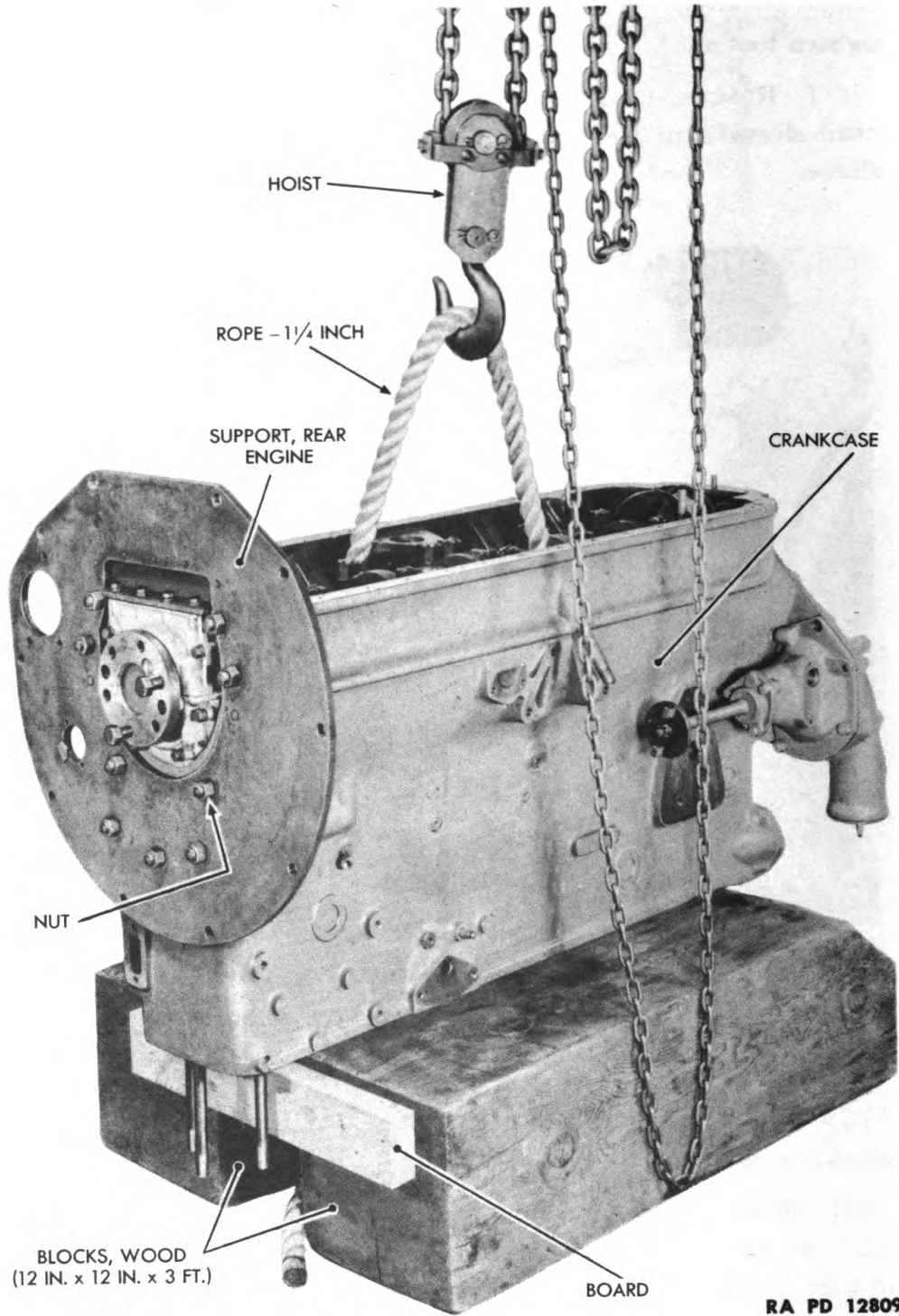


Figure 43—Crankcase in Inverted Position

DISASSEMBLY OF ENGINE

64. REAR ENGINE SUPPORT REMOVAL.

a. Equipment.

BLOCKS, wooden (2)
BOARDS
HOIST
ROPE, 1¼-in.

WRENCH, socket, 9/16-in.,
and speeder
WRENCH, socket, 1-in.,
and spinner type handle

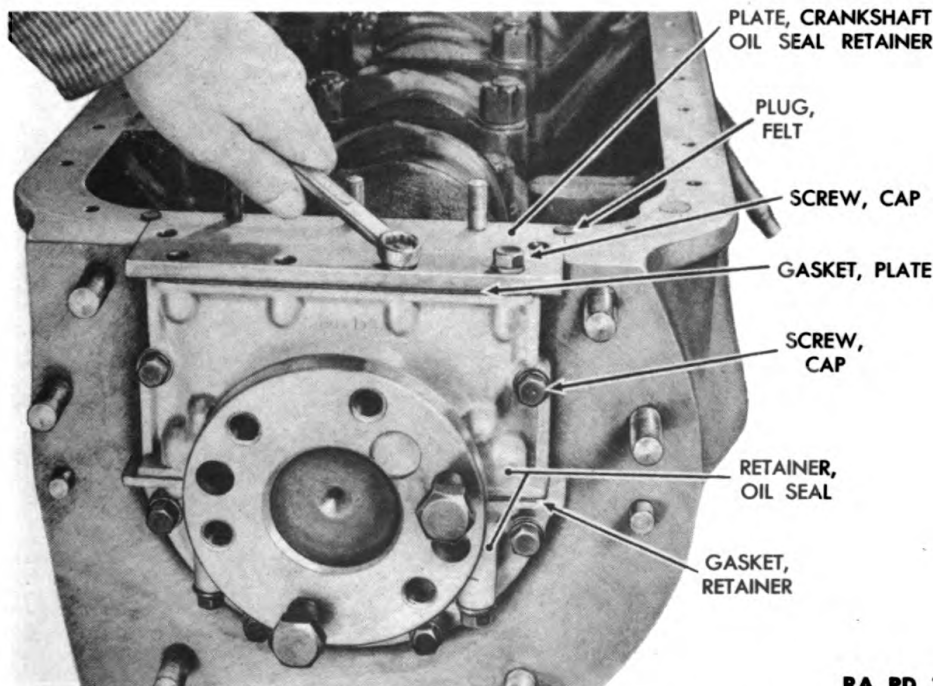
b. Procedure.

(1) PLACE CRANKCASE AND ATTACHED PARTS IN INVERTED POSITION (fig. 43).

BLOCKS, wooden (2)
BOARDS

HOIST
ROPE, 1¼-in.

(a) Make a sling through No. 3 and No. 4 cylinder bores, tying rope in square knot. Attach hoist to rope sling at crankshaft side of crankcase and lift crankcase from its support.



RA PD 12810

Figure 44—Crankshaft Oil Seal Retainer Plate Removal

(b) Rearrange two 12-inch by 12-inch by 3-foot wooden blocks (or other blocks as previously used) parallel to crankcase and lower crankcase down so studs enter between blocks, with blocks supporting each side of crankcase. Nail boards across each end of blocks as a precaution to keep blocks from moving out of position.

(2) REMOVE DUST SEAL.

WRENCH, socket, 9/16-in., and speeder

(a) Remove seven cap screws and lock washers which hold dust seal to crankcase and to rear engine support. Then remove dust seal and dust seal gasket.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(3) REMOVE REAR ENGINE SUPPORT.

WRENCH, socket, 1-in., and spinner type handle

(a) Remove nine nuts and lock washers which hold rear engine support to crankcase. Tap support loose from crankcase and then remove support.

65. CRANKSHAFT AND MAIN BEARING REMOVAL.

a. Equipment.

HAMMER
HOIST
PLIERS
SCREWDRIVER
WRENCH, box, $\frac{9}{16}$ -in.

WRENCH, box, or socket,
 $\frac{3}{4}$ -in., and speeder
WRENCH, open-end, $\frac{9}{16}$ -in.
WRENCH, socket, 1-in., and
spinner type handle,
heavy-duty

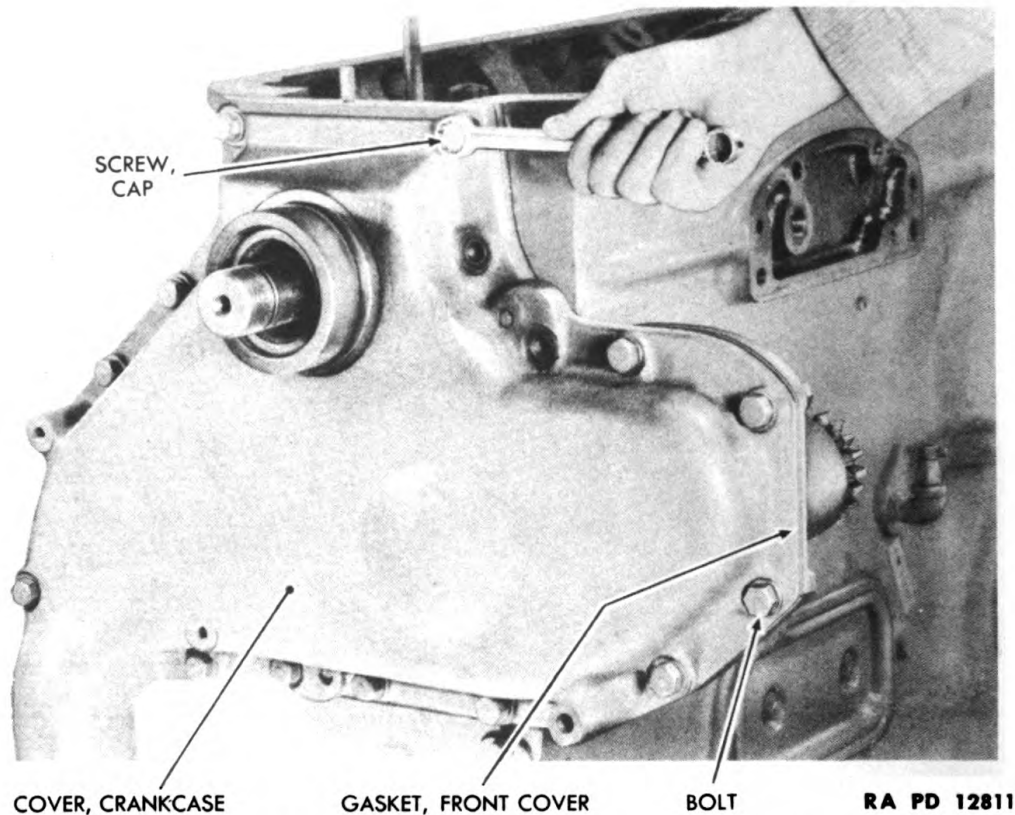


Figure 45—Crankcase Front Cover Removal

b. Procedure.

(1) REMOVE CRANKSHAFT OIL SEAL RETAINER PLATE (fig. 44).

WRENCH, box, $\frac{9}{16}$ -in.

(a) Remove four cap screws and lock washers which hold oil seal retainer plate to rear oil seal lower retainer. Then remove plate gasket and two felt plugs.

DISASSEMBLY OF ENGINE

(2) REMOVE OIL SEAL RETAINER.

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

(a) Remove six cap screws, lock washers and flat washers which hold oil seal retainer to crankcase. Also remove two cap screws, lock washers and flat washers which hold upper and lower retainers together. Then remove two retainer sections, two pieces of oil seal felt, two retainer gaskets and oil seal gasket.

(3) REMOVE CRANKCASE FRONT COVER (fig. 45).

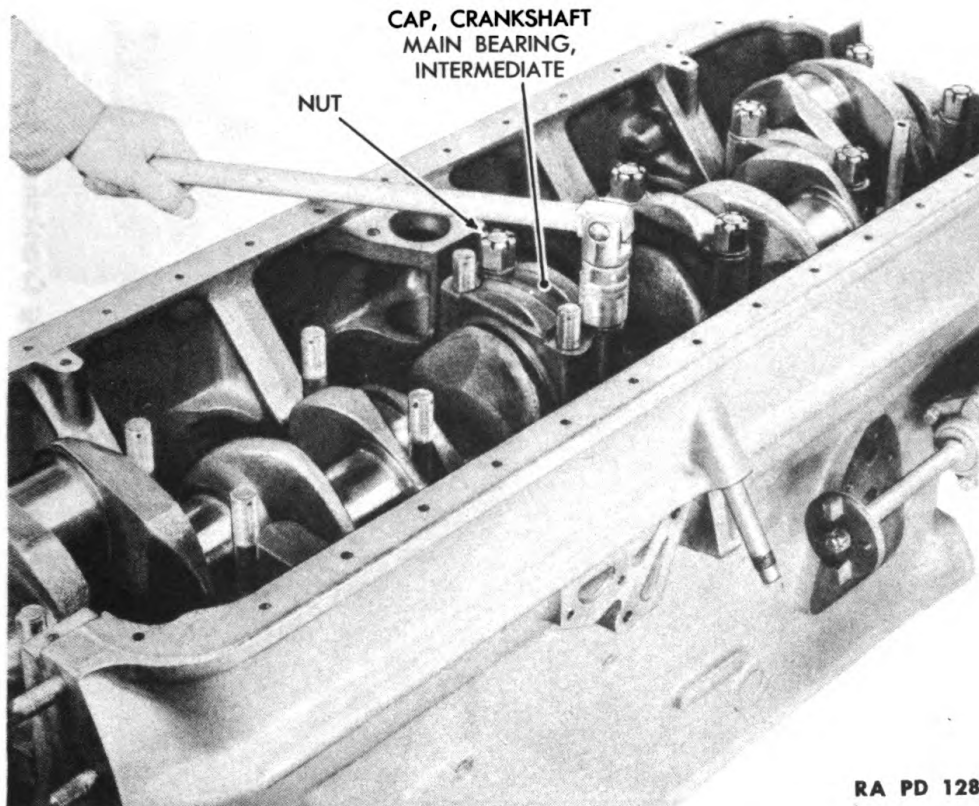
SCREWDRIVER

WRENCH, box, or socket,
 $\frac{3}{4}$ -in., and speeder

(a) Remove six cap screws and lock washers and eight bolts, nuts and lock washers which hold crankcase cover to crankcase.

(b) Pry cover loose from crankcase. Then lift off cover and remove gasket.

(c) Remove the two Woodruff keys and oil finger from the end of the crankshaft.



RA PD 12812

Figure 46—Crankshaft Main Bearing Cap Removal

(4) REMOVE CRANKSHAFT MAIN BEARING CAPS AND LOWER MAIN BEARINGS (fig. 46).

HAMMER
PLIERS

WRENCH, socket, 1-in., and
spinner type handle,
heavy-duty

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

RA PD 12813

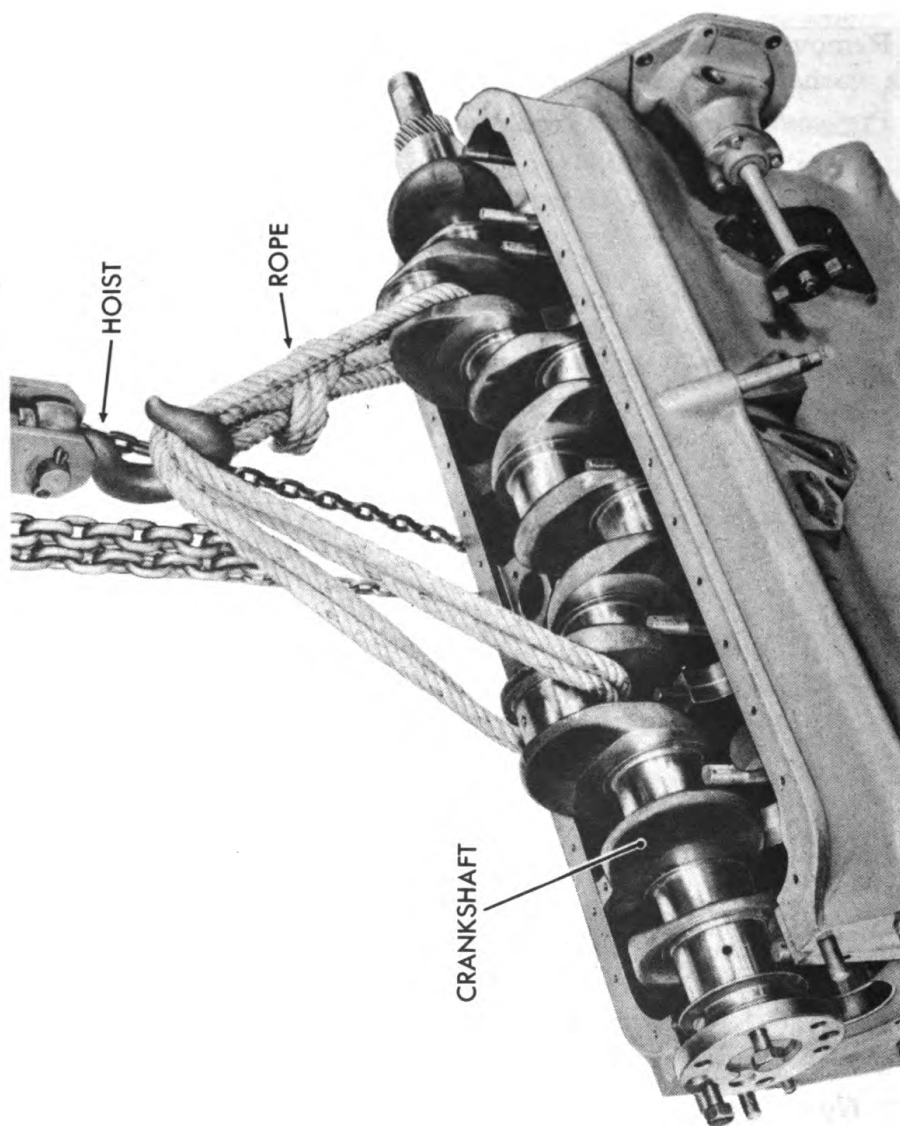


Figure 47 — Lifting Crankshaft from Crankcase

DISASSEMBLY OF ENGINE

- (a) Remove cotter pins from two nuts which secure main bearing cap to studs.
- (b) Remove two nuts from studs.
- (c) Tap the caps lightly to loosen them. Then lift off cap with lower bearing attached.
- (d) Remove remaining six bearing caps and lower main bearings in same way, except that four nuts must be removed to remove intermediate main bearing cap.
- (5) LIFT CRANKSHAFT FROM CRANKCASE (fig. 47).

HOIST

- (a) Place rope around second and fifth crankshaft connecting rod bearing journals. Attach rope to hoist and lift out crankshaft.
- (6) REMOVE UPPER MAIN BEARINGS. After crankshaft has been removed, remove upper main bearings from crankcase, sliding them in semicircle, toward nib. **CAUTION:** Identify or arrange bearings so they can be put back in their correct positions, if new bearings are not needed.

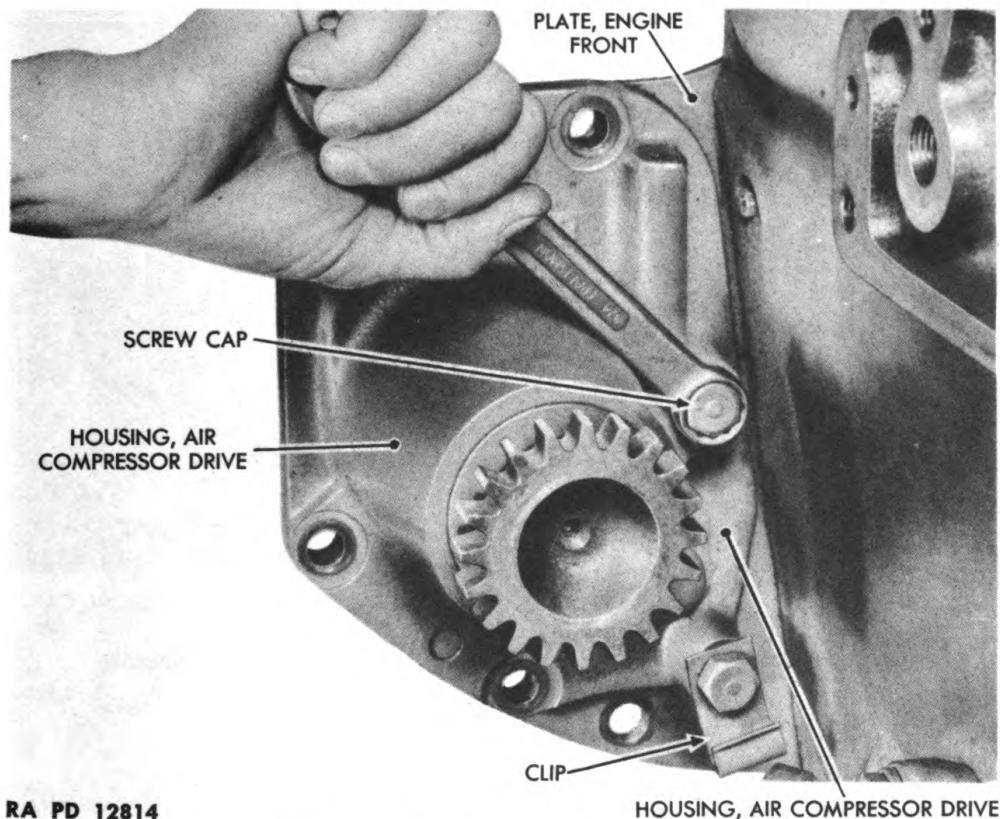


Figure 48—Air Compressor Drive Removal

66. AIR COMPRESSOR DRIVE ASSEMBLY REMOVAL.

a. Equipment.

HAMMER

WRENCH, box, $\frac{3}{4}$ -in.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) **DISCONNECT AIR COMPRESSOR DRIVE HOUSING FROM ENGINE FRONT PLATE (fig. 48).**

WRENCH, box, $\frac{3}{4}$ -in.

(a) Remove two cap screws and copper washers which hold housing to plate. The lower cap screw also holds clip to plate.

(2) **REMOVE AIR COMPRESSOR DRIVE WITH GASKET AND DOWEL PINS.**

HAMMER

(a) Tap assembly loose from engine front plate and lift off assembly. Remove gasket.

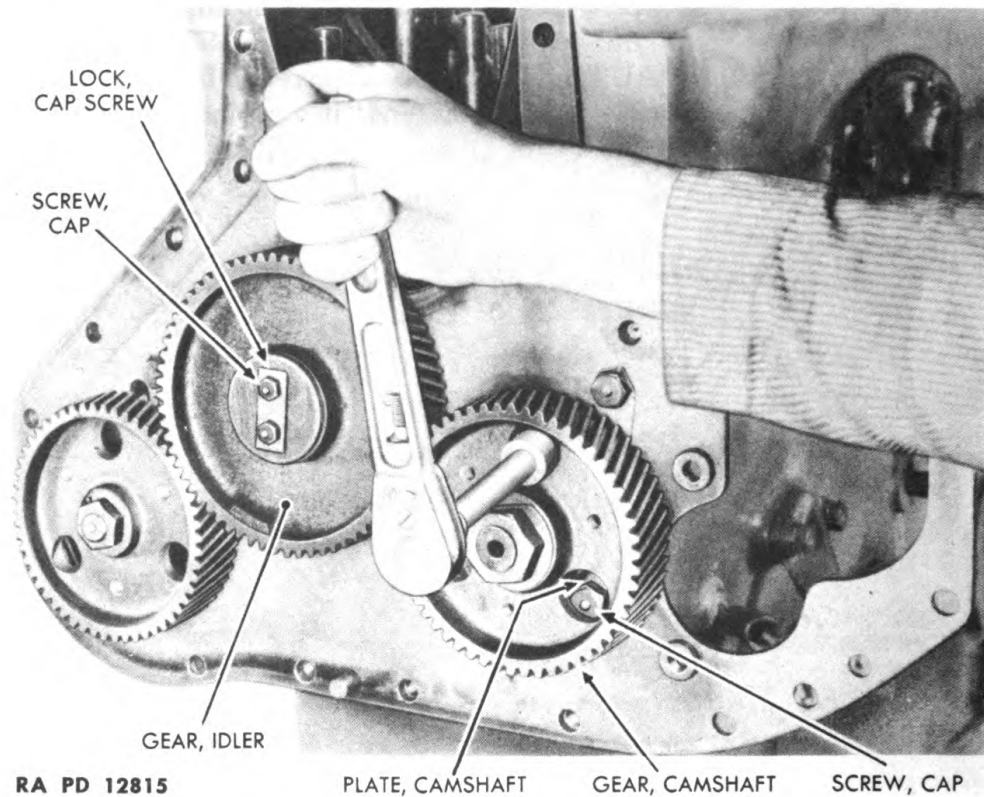


Figure 49—Disconnecting Camshaft Plate from Crankcase

67. CAMSHAFT REMOVAL.

a. Equipment.

WRENCH, ratchet, with $\frac{3}{4}$ -in. socket.

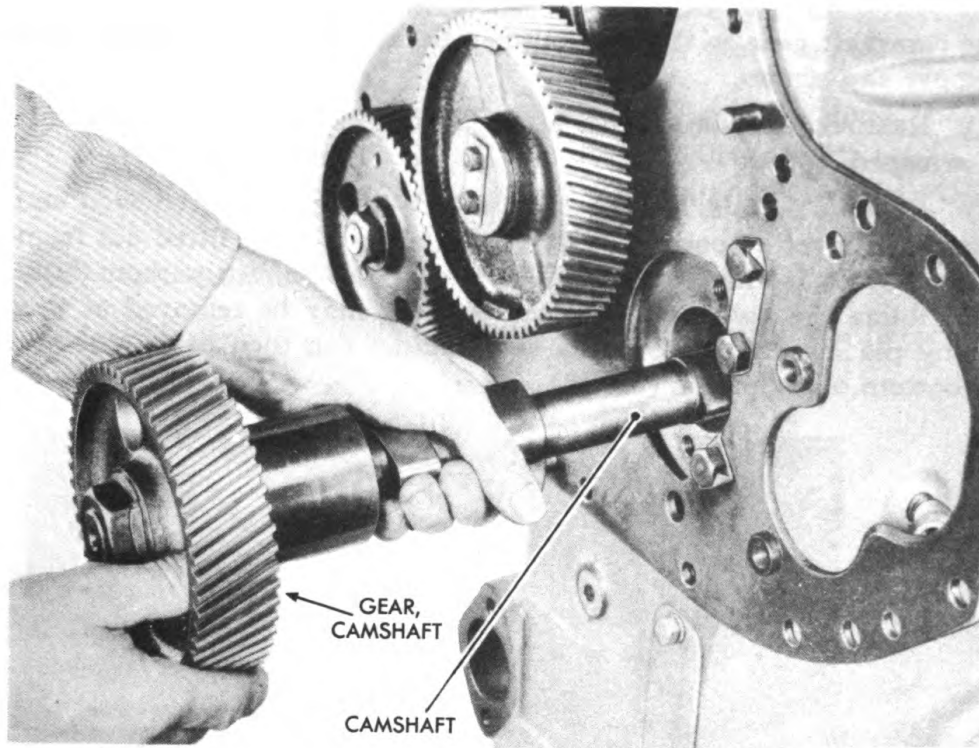
b. Procedure.

(1) **DISCONNECT CAMSHAFT PLATE FROM CRANKCASE (fig. 49).**

WRENCH, ratchet, with $\frac{3}{4}$ -in. socket

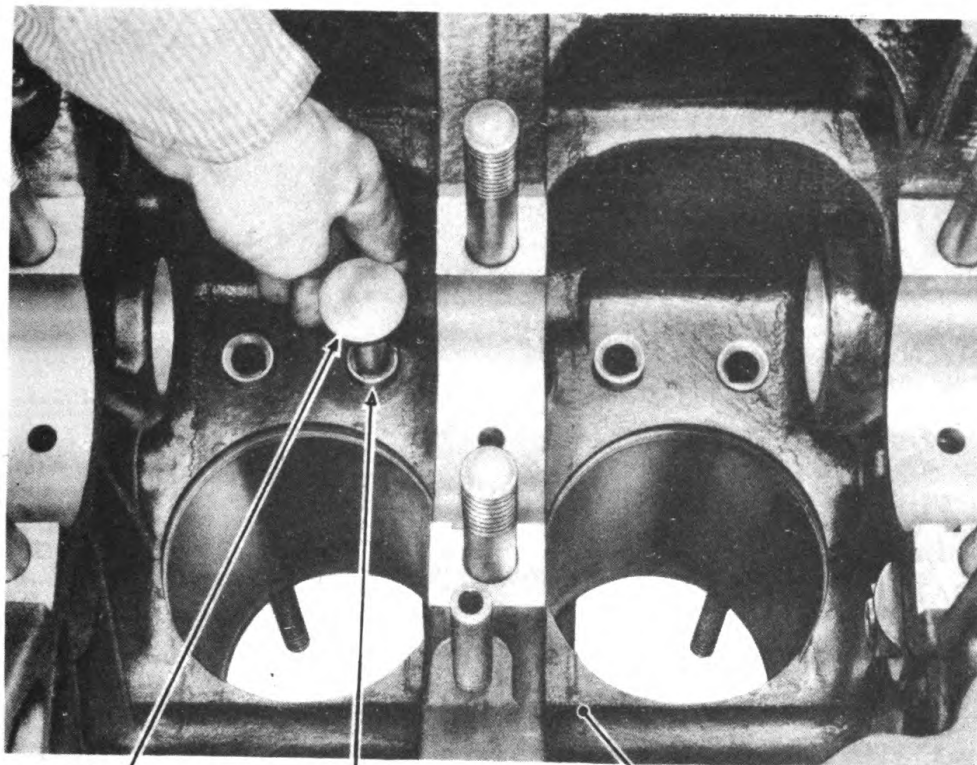
(a) Use wrench with extension to remove two cap screws and lock washers which hold camshaft plate to crankcase. It is necessary to

DISASSEMBLY OF ENGINE



RA PD 12816

Figure 50—Camshaft and Camshaft Gear Removal



RA PD 12817

Figure 51—Valve Tappet Removal

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

rotate camshaft gear so that wrench can be inserted through gear holes to remove cap screws.

(2) **REMOVE CAMSHAFT** (fig. 50). Pull out camshaft with camshaft gear attached.

(3) **REMOVE VALVE TAPPETS** (fig. 51). With camshaft removed and crankcase in inverted position, valve tappets can now be lifted out from guides. **NOTE:** If valve tappet guides are to be removed without fully disassembling the balance of the engine, they may be removed at this point by placing crankcase on its side. Guides can then be tapped out from bottom of crankcase (fig. 58).

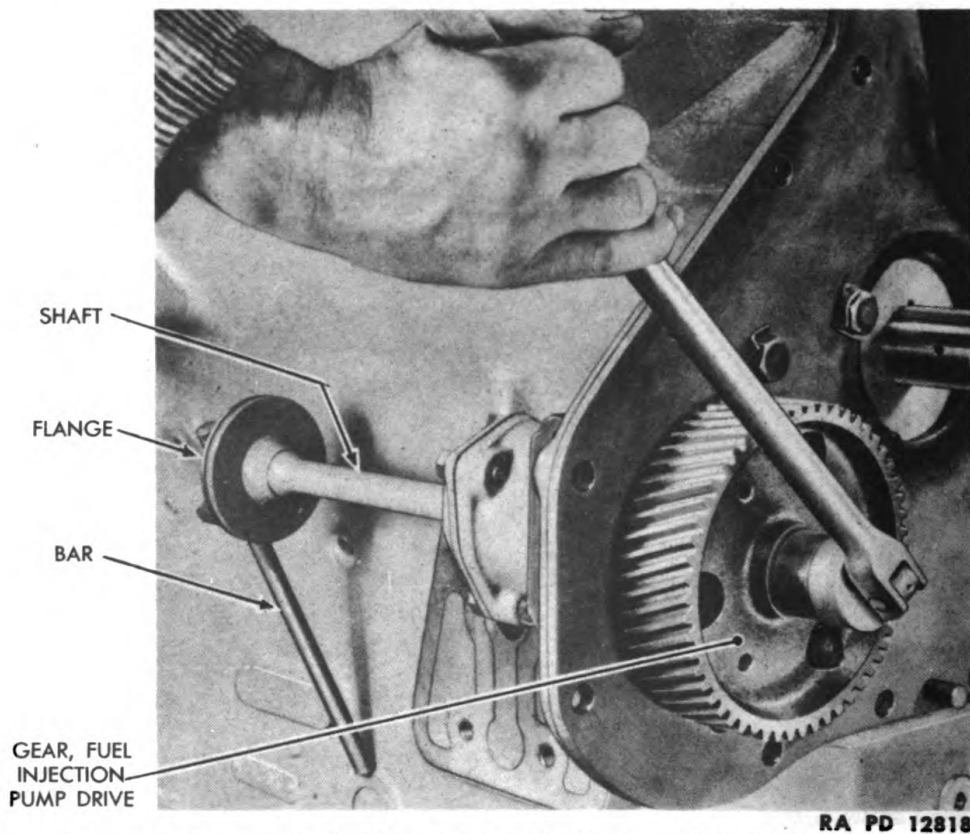


Figure 52—Fuel Injection Pump Shaft Gear Nut Removal

68. FUEL INJECTION PUMP DRIVE REMOVAL.

a. Equipment.

BAR
PULLER, gear
SCREWDRIVER
WRENCH, box, 1/2-in.

WRENCH, box, 3/4-in.
WRENCH, socket, 1 1/4-in.,
and spinner type handle

b. Procedure.

(1) **REMOVE IDLER GEAR** (fig. 49).

SCREWDRIVER

WRENCH, box, 1/2-in.

DISASSEMBLY OF ENGINE

(a) Pry cap screw lock back and then remove two cap screws which hold idler gear to idler gear shaft. Then lift idler gear from shaft.

(2) REMOVE FUEL INJECTION PUMP DRIVE SHAFT GEAR (fig. 52).

BAR

PULLER, gear

SCREWDRIVER

WRENCH, socket, 1 $\frac{1}{4}$ -in.,
and spinner type handle

(a) Pry back nut lock.

(b) Bar coupling flange so that shaft will not turn when gear nut is being removed.

(c) Remove nut which holds gear to shaft.

(d) Pull gear from shaft.

(e) Remove Woodruff key from end of shaft.

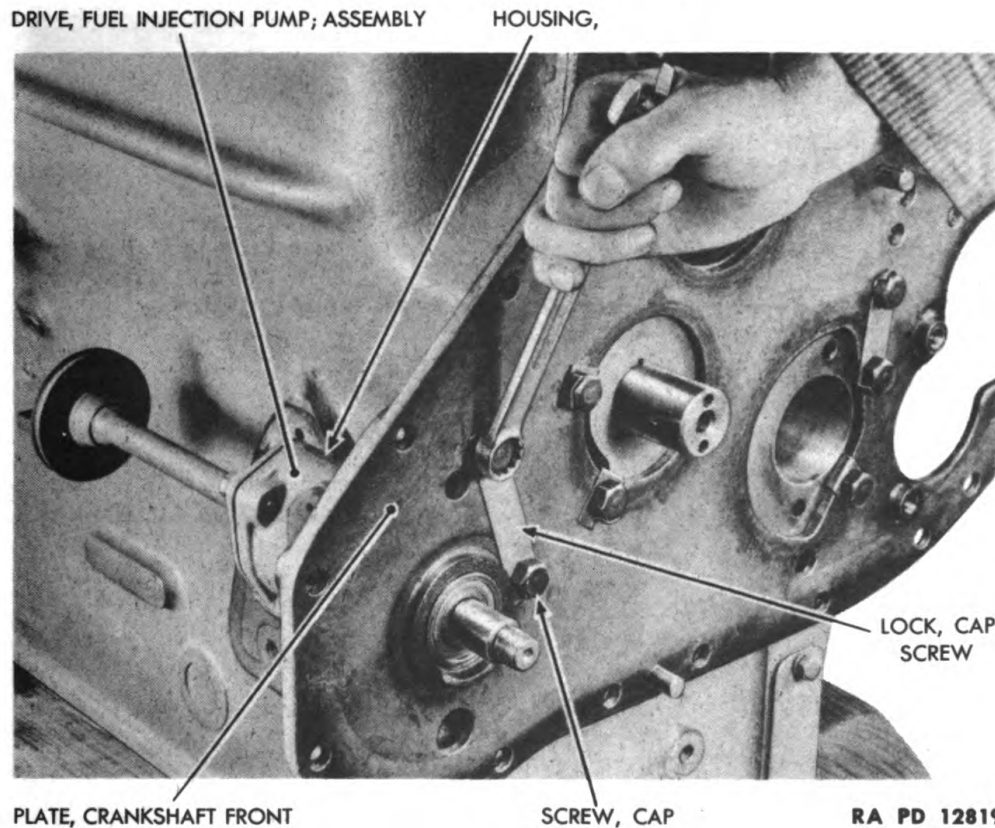


Figure 53—Fuel Injection Pump Drive Assembly Removal

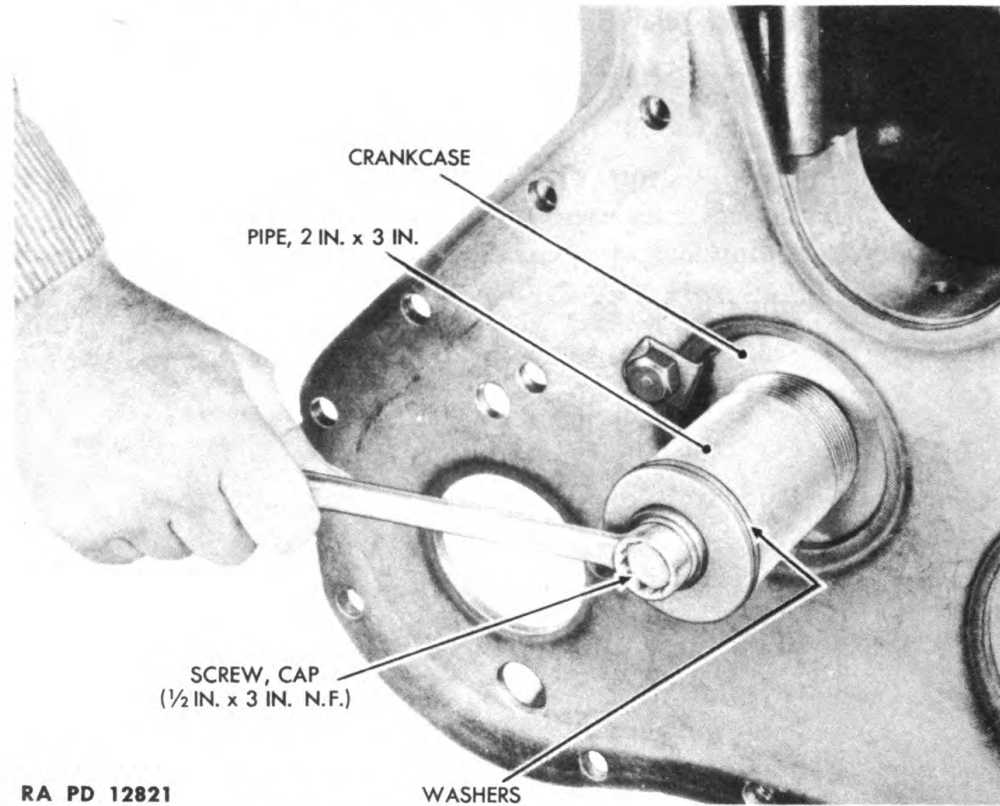
(3) REMOVE FUEL INJECTION PUMP DRIVE ASSEMBLY (fig. 53).

SCREWDRIVER

WRENCH, box, $\frac{3}{4}$ -in.

(a) Release bolt lock from two cap screws. Then, remove two cap screws which hold housing to crankcase front plate. Also remove housing gasket.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12821

WASHERS

Figure 54—Removing Idler Gear Shaft from Crankcase

69. IDLER GEAR SHAFT REMOVAL.

a. Equipment.

PULLER, idler gear shaft
SCREWDRIVER
WRENCH, box, 3/4-in.

WRENCH, socket, 1 1/8-in.,
and spinner type handle

b. Procedure (fig. 54).

(1) REMOVE SHAFT NUT.

SCREWDRIVER

WRENCH, socket, 1 1/8-in.,
and spinner type handle

(a) Pry back nut lock. Then remove nut.

(2) REMOVE IDLER GEAR SHAFT.

PULLER, idler gear shaft

WRENCH, box, 3/4-in.

(a) Use standard shaft puller or improvised means of pulling shaft, as shown in figure 54. A simple method, as illustrated, is to use piece of two-inch pipe, three inches long, placing it over end of shaft and attaching two or three large washers and 1/2-inch National Fine by three-inch cap screw, fully threaded, screwing cap screw into end of shaft. Then tighten cap screw until shaft is pulled from crankcase.

DISASSEMBLY OF ENGINE

70. CRANKCASE FRONT PLATE REMOVAL.

a. Equipment.

HAMMER
SCREWDRIVER

WRENCH, box, $\frac{3}{4}$ -in.

b. Procedure.

(1) RELEASE CAP SCREW LOCKS FROM CAP SCREWS (fig. 55).

SCREWDRIVER

(a) Pry four locks from heads of five cap screws.

(2) REMOVE CAP SCREWS.

WRENCH, box, $\frac{3}{4}$ -in.

(a) Remove five cap screws which secure front plate to crankcase. Remove four locks.

(3) REMOVE FRONT PLATE.

HAMMER

(a) Tap front plate loose from crankcase. Then lift off plate and remove front plate gasket.

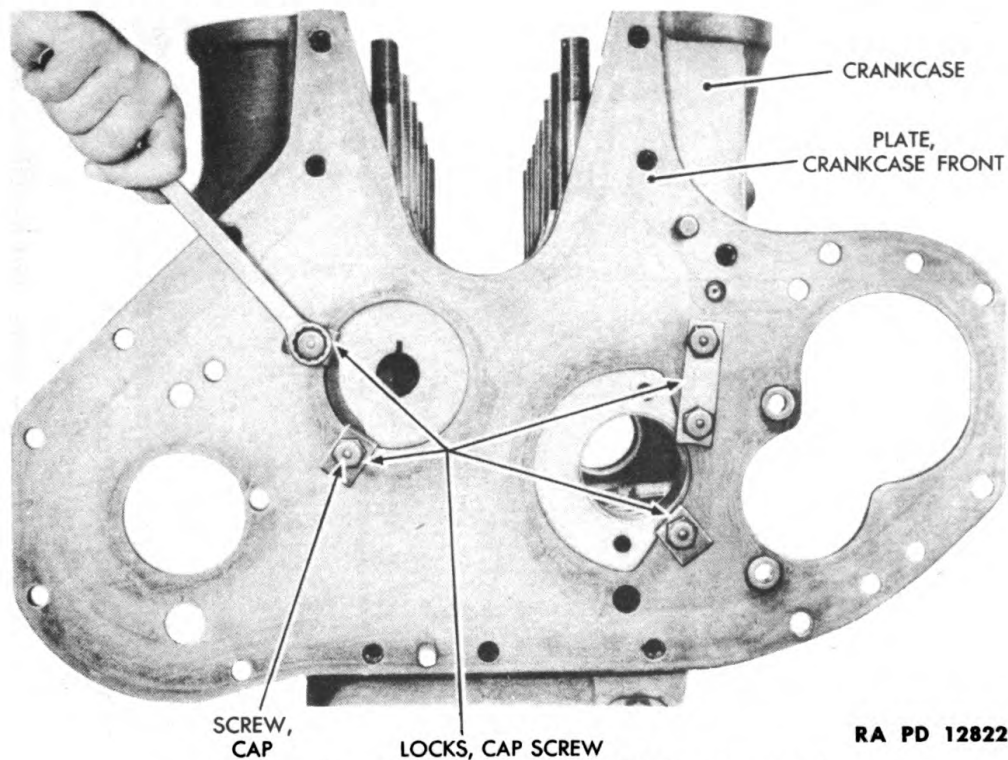


Figure 55—Crankcase Front Plate Removal

71. REMOVAL OF MISCELLANEOUS PARTS FROM SIDES OF CRANKCASE.

a. Equipment.

TOOL, oil gage sleeve
removing (steel bar)
WRENCH, box, $\frac{9}{16}$ -in.
WRENCH, open-end, $\frac{9}{16}$ -in.
WRENCH, open-end, $\frac{11}{16}$ -in.

WRENCH, pipe, adjustable
WRENCH, socket, $\frac{9}{16}$ -in., and
speeder
WRENCH, socket, $\frac{5}{8}$ -in., and
speeder

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

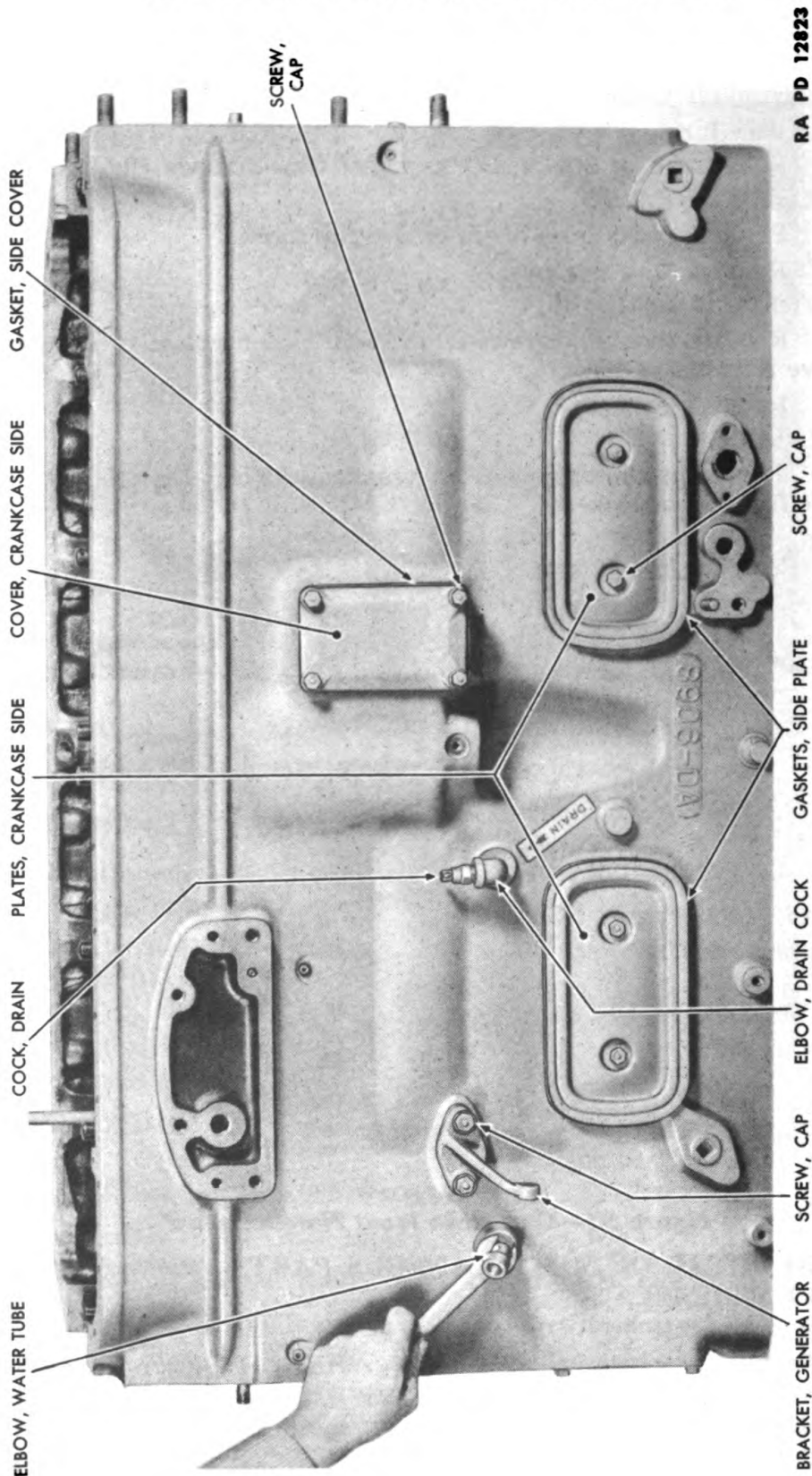


Figure 56—Water Outlet Elbow Removal

DISASSEMBLY OF ENGINE

b. Procedure.

- (1) REMOVE WATER TUBE ELBOW (fig. 56).
WRENCH, open-end, $1\frac{1}{16}$ -in.
 - (a) Unscrew elbow from right side of crankcase.
- (2) REMOVE GENERATOR BRACKET.
WRENCH, socket, $\frac{5}{8}$ -in., and speeder
 - (a) Remove two cap screws and lock washers which hold bracket to right side of crankcase. Remove bracket.
- (3) REMOVE TWO CRANKCASE SIDE PLATES.
WRENCH, socket, $\frac{9}{16}$ -in., and speeder
 - (a) At right side of engine remove two cap screws and lock washers which hold side plates to crankcase. Then remove two side plates and two side plate gaskets.
- (4) REMOVE CRANKCASE SIDE COVER.
WRENCH, socket, $\frac{9}{16}$ -in., and speeder
 - (a) Remove side cover from right side of crankcase, removing four cap screws and lock washers. Then remove side cover gasket.
- (5) REMOVE DRAIN COCK ELBOW AND COCK.
WRENCH, pipe, adjustable
 - (a) Unscrew elbow from right side of crankcase.
- (6) REMOVE OIL LEVEL GAGE SLEEVE (fig. 57).
TOOL, oil gage sleeve removing (steel bar)
 - (a) Use oil gage sleeve removing tool of a size which will fit over end of sleeve. Insert bar into crankcase and drive out sleeve.
- (7) REMOVE LUBRICATING OIL GAGE PIPE ELBOW (fig. 57).
WRENCH, open-end, $\frac{9}{16}$ -in.
 - (a) Unscrew elbow from left side of crankcase.
- (8) REMOVE CROSS SHAFT CONTROL DISK PIN (fig. 57).
WRENCH, pipe, adjustable
 - (a) Unscrew pin from left side of crankcase.
- (9) REMOVE OIL FILTER RETURN PIPE (fig. 57).
WRENCH, pipe, adjustable
 - (a) Remove oil filter return pipe from inside of crankcase.
- (10) REMOVE PLATE FROM FRONT END OF CRANKCASE (fig. 57).
WRENCH, box, $\frac{9}{16}$ -in.
 - (a) Remove two cap screws and lock washers which hold plate to front end of crankcase. Remove plate and gasket.

72. VALVE TAPPET GUIDE REMOVAL (fig. 58).

a. Equipment.

BAR, steel, long
HOIST

ROPE

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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

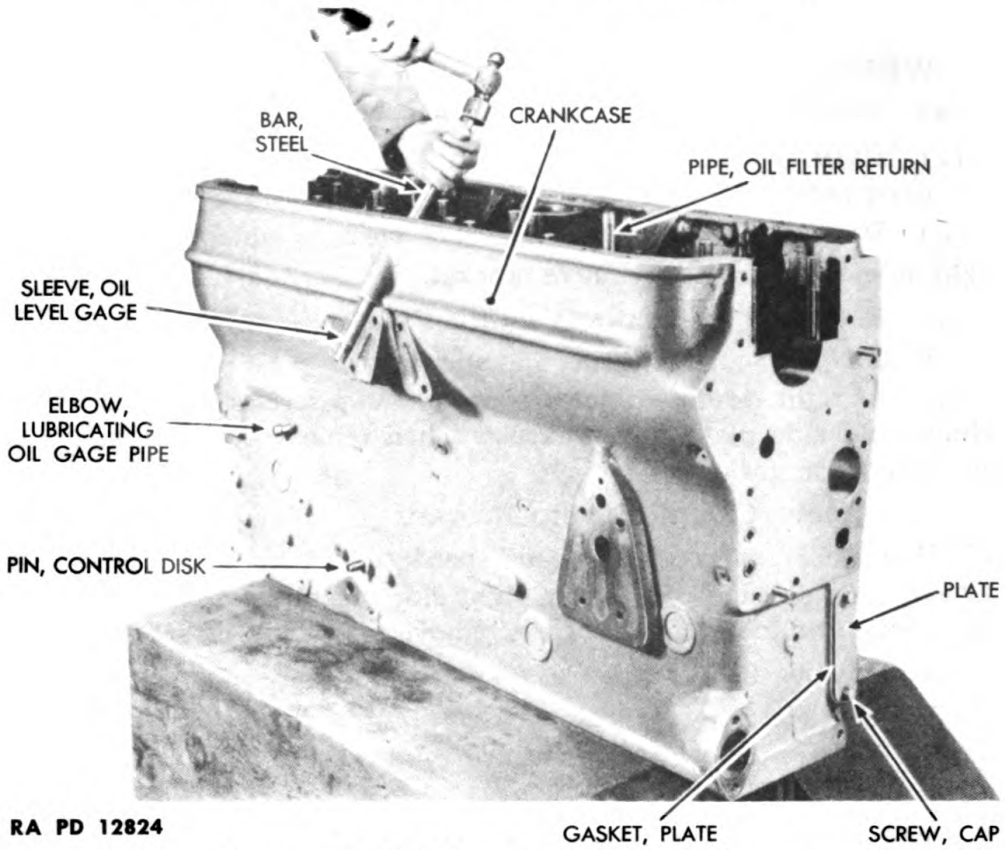


Figure 57—Driving Out Oil Gage Sleeve

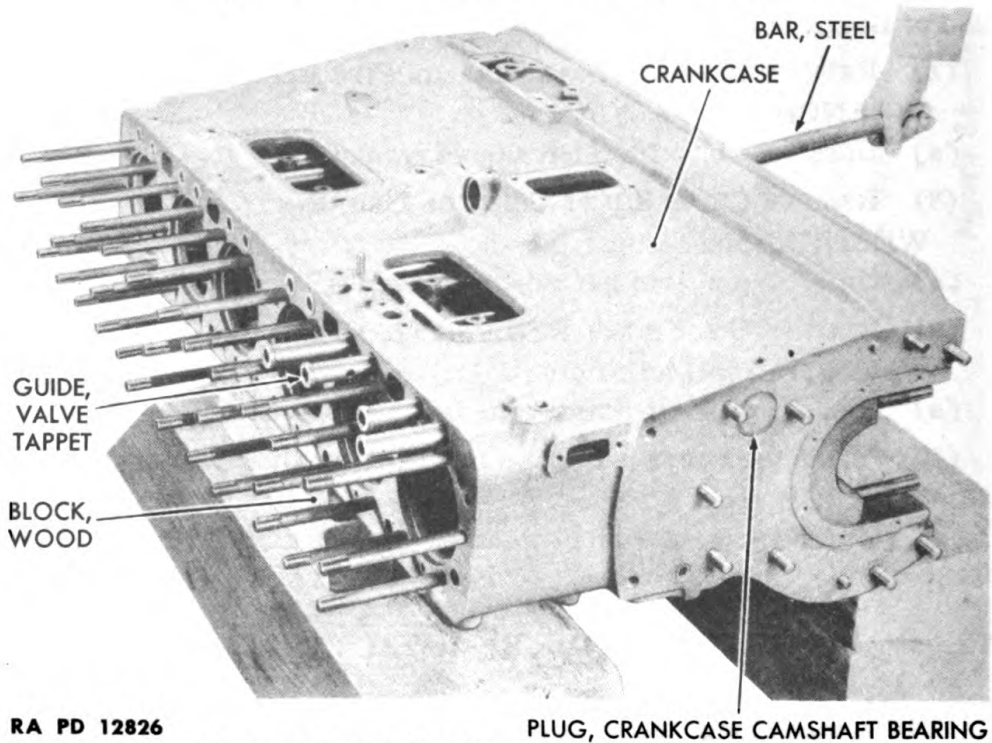


Figure 58—Valve Tappet Guide Removal

DISASSEMBLY OF ENGINE

b. Procedure.

(1) PLACE CRANKCASE ON ITS SIDE.

HOIST

ROPE

(a) Place rope sling through second and fifth cylinder bores, use hoist on rope to lift crankcase from its base and lower crankcase again, letting it turn on its side. Before removing hoist and rope, block up crankcase so it will be in level position.

(2) REMOVE VALVE TAPPET GUIDES.

BAR, steel, long

(a) Enter bar into bottom of crankcase and tap 12 guides loose. Then lift them out from top of crankcase.

73. CAMSHAFT BEARING REMOVAL.

NOTE: Unless inspection of camshaft bearings, as outlined in paragraph 128, indicates need for replacement of one or more camshaft bearings, they should not be removed from crankcase.

a. Equipment.

BAR, steel

CHISEL, hand, cold

b. Procedure.

(1) REMOVE CRANKCASE CAMSHAFT BEARING PLUG (fig. 58).

NOTE: If No. 4 camshaft bearing is to be removed, it is necessary to remove crankcase camshaft bearing plug. This step is not required for removal of other camshaft bearings. To remove plug, insert steel bar inside camshaft bearings and tap plug out of crankcase.

(2) REMOVE BEARING (fig. 59).

CHISEL, hand, cold

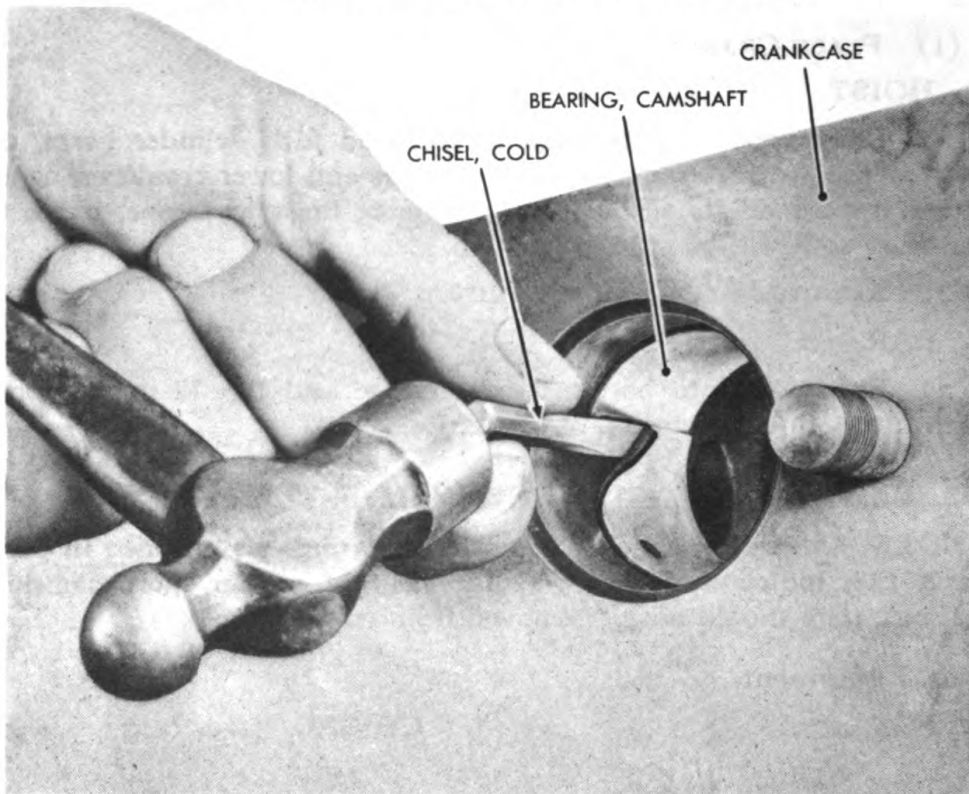
(a) Rest chisel at split in bearing and tap chisel until one side of bearing turns inward. Then tap edge of bearing until bearing is removed. Since bearings should never be removed unless they are to be replaced, damage to bearing is permissible. **CAUTION:** Do not allow chisel to cut crankcase.

(3) REMOVE ADDITIONAL CRANKSHAFT BEARINGS IN SAME MANNER OUTLINED IN STEP (2) ABOVE.

74. CRANKCASE STUD REMOVAL.

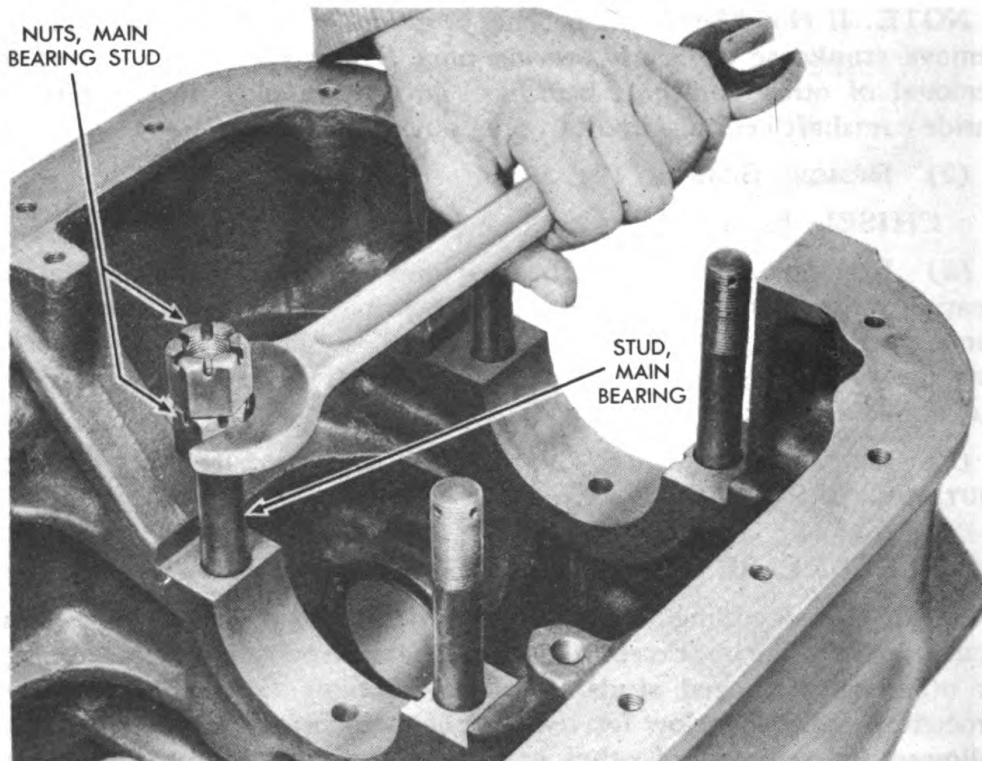
a. In disassembling engine, it should not be necessary to remove studs from crankcase, except when crankcase inspection discloses broken or otherwise damaged studs. In absence of standard stud removers, procedure outlined below for removal of main bearing stud can also be followed for removal of other crankcase studs, providing nuts which will fit studs are used.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12827

Figure 59—No. 4 Camshaft Bearing Removal



RA PD 12825

Figure 60—Main Bearing Stud Removal

DISASSEMBLY OF ENGINE

b. Equipment.

WRENCH, open-end, $1\frac{1}{8}$ -in.

c. Procedure. To remove main bearing stud, proceed as follows:

(1) ATTACH TWO MAIN BEARING STUD NUTS TO STUD WHICH IS TO BE REMOVED (fig. 60).

WRENCH, open-end, $1\frac{1}{8}$ -in.

(a) Tighten first nut on stud thread as tight as possible. Then tighten second nut on top of first one as securely as possible.

(2) REMOVE STUD.

WRENCH, open-end, $1\frac{1}{8}$ -in.

(a) Use wrench on lower stud nut, pulling in counterclockwise direction until stud is removed.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Section VI

INSPECTION OF DISASSEMBLED ENGINE

Paragraph

Inspection of engine subassemblies 75

75. INSPECTION OF ENGINE SUBASSEMBLIES.

a. The following inspection should be made before the subassemblies are disassembled.

b. All disassembled parts must be thoroughly cleaned in suitable SOLVENT, dry-cleaning, and should be inspected for wear, galling or breakage. Damaged parts must be replaced and all moving parts covered with a film of engine oil before assembly to provide initial lubrication.

Item	Inspection	Instructions
(1) Air cleaner.	(1) Check body assembly and oil cup assembly for dents causing leakage of air.	(1) Repair dents and replace defective parts.
(2) Intake manifold.	(2) Check manifold and housing for cracks or breaks. Check primer piping for breaks. Check air valve seating surfaces. Check ignition switch for clean contacts.	(2) See paragraph 145.
(3) Exhaust manifold.	(3) Check for cracks or breaks.	(3) Replace broken parts. See paragraph 80.
(4) Cylinder heads.	(4) Check for cracks between the valve seats. Check condition of valve seats. Check condition of valve guides. Check condition of valves. Check cylinder head for accumulation of foreign material in water cooling compartments. Check spring seating surfaces on upper spring seats for wear.	(4) Replace broken parts. See paragraph 80.
(5) Valve operating mechanism.	(5) Valve shaft and lever assembly—check for wear in valve lever bushings and on valve lever shafts. Valve lever adjusting screws—wear and fit in levers. Valve tappets—wear in push rod guides. Valve springs—check for tension.	(5) See paragraph 92.

INSPECTION OF DISASSEMBLED ENGINE

Item	Inspection	Instructions
(6) Starting valve mechanism.	(6) Check cam rollers for wear. Check oil seals in valve housing. Check starting valve springs for tension. Check linkage for wear.	(6) See paragraph 92.
(7) Carburetor.	(7) Check valve and cage assembly for leaks. Check float level. Check shaft and lever assembly for wear in fuel bowl. Check primer. Check body and fuel bowl for damage. Inspect float for punctures.	(7) See fuel system section, TM 9-1777B.
(8) Fuel injection pump.	(8) Housing—check for distortion and cracks. Check control rod bushings for wear. Camshaft assembly—inspect lobes of camshaft, threaded ends and keyway and inner bearing races. End plates—inspect outer bearing races. Tappet assembly—inspect for excessive wear between tappet pins, roller bushings and rollers and head of tappet screw for wear. Plunger and barrel assembly—inspect plunger for wear. Delivery valve and seat—check seating surface on valve for corrosion and scratches. Control sleeve and toothed segment—inspect toothed segment for damage. Plunger spring and spring seats—inspect springs for scratches and corrosion. Inspect spring seats for distortion and wear. Closing plugs and felt cushions; inspect cushions for wear. Delivery valve holders and spring—inspect threads on holder. Inspect springs for scratches and pitting. Pipe plugs—inspect plugs for damage.	(8) See fuel system section, TM 9-1777B.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Item	Inspection	Instructions
(9) Governor.	(9) Linkage — inspect for wear. Gears—worn, chipped or broken teeth. Ball bearing—inspect for wear. Governor spring—inspect for corrosion and pitting. Operating lever shaft bushings and oil seal—inspect for wear. Governor weight roller pins and bearing—inspect for wear. Sleeve assembly—inspect for wear in bearing. Inspect cam plate surface for wear.	(9) See fuel system section, TM 9-1777B.
(10) Fan and water pump.	(10) Pump housing for damage. Ball bearings for wear. Pump shaft thrust bushing for wear. Pump shaft—inspect for wear. Check for worn impeller.	(10) See cooling system section, TM 9-1777B.
(11) Thermostat housing.	(11) Check thermostats for opening temperature and for holes in elements.	(11) See cooling system section, TM 9-1777B.
(12) Crankcase.	(12) Check for cracks or damage. Check for dirt and lime in cooling water passages.	(12) Clean crankcase and flush out passages. See TM 9-850.
(13) Cylinder sleeves.	(13) Check for wear with cylinder bore gage.	(13) Replace worn sleeve.
(14) Piston and connecting rods.	(14) Inspect pistons for wear. Inspect piston pins for wear in piston and connecting rod bushings. Inspect connecting rod bearing for checks, scoring and wear.	(14) See paragraph 109.
(15) Crankshaft and main bearing.	(15) Check crankshaft for out-of-round. Check crankshaft for scoring. Check crankshaft for wear. Inspect main bearings for cracks, checks and wear.	(15) See paragraphs 118 and 124.
(16) Camshaft and bearings.	(16) Check bearings for wear. Check camshaft bearing journals for wear. Check cams for wear.	(16) See paragraph 128.
(17) Gear train.	(17) Check gears for backlash. Check idler gear bushing and shaft for wear. Check for chipped or broken teeth.	(17) Use feeler gage to check clearance between gears. See section X.

INSPECTION OF DISASSEMBLED ENGINE

Item	Inspection	Instructions
(18) Fuel oil filter.	(18) Check cloth element for tears. Check metal element for damage.	(18) See TM 9-777.
(19) Water trap.	(19) Check screen for damage.	(19) See fuel system section, TM 9-1777B.
(20) Electrical and starting systems.	(20) Inspect generator for ground, open field, shorted field open-circuited armature, armature short circuit. Inspect brushes and brush springs for tension and brush rings. Inspect insulators for bent or broken cap screws or for bent, battered studs and damaged threads. Inspect insulation on leads and broken strands in leads.	(20) See electrical system section, TM 9-1777B.
(21) Cut-out relay.	(21) Inspect electrical settings of relay.	(21) See electrical system section, TM 9-1777B.
(22) Cranking motor.	(22) Check commutator brushes for wear. Inspect armature for ground open circuits and short circuits. Inspect field insulation for breaks. Inspect bearings and bushings for wear.	(22) See electrical system section, TM 9-1777B.
(23) Service lighting switch.	(23) Inspect generator field resistance coil for broken wire and deteriorated mica. Inspect dimmer resistance coil for faulty insulation.	(23) See electrical system section, TM 9-1777B.
(24) Distributor.	(24) Inspect points for roughness, burned surfaces and pits. Check condenser condition. Inspect cam for wear. Inspect cap and rotor for chips, cracks and burned places.	(24) See electrical system section, TM 9-1777B.
(25) Radiator.	(25) Inspect for leaks in tubes. Inspect for bent fins. Inspect for dirt in tubes and upper and lower tanks.	(25) See cooling system section, TM 9-1777B.
(26) Air compressor drive.	(26) Inspect for wear in drive shaft bushings. Inspect idler gear and shaft for wear. Inspect drive gear for wear.	(26) See paragraph 137.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Item	Inspection	Instructions
(27) Fuel injection pump drive.	(27) Inspect bearings for wear. Inspect drive shaft keyways for damage.	(27) See paragraph 68.
(28) Lubricating oil pump.	(28) Inspect for wear the following—body and idler gears, pump body with shaft, pinion, upper housing, regulating valve, drive shaft, lower housing, cover, auxiliary body and idler gears. Check regulating valve spring for tension.	(28) See paragraph 103.
(29) Instruments and controls.	(29) Inspect operation of instruments. Inspect switches for damage.	(29) See electrical system section, TM 9-1777B.

Section VII

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

	Paragraph
General	76
Cylinder head construction	77
Cylinder head removal	78
Cylinder head disassembly	79
Cleaning and inspection of disassembled cylinder head parts	80
Cylinder head overhaul	81
Valve seat grinding	82
Valve refacing	83
Valve lapping	84
Assembly of cylinder heads	85
Check of cylinder heads before installation	86
Cylinder head installation	87
Construction of valve lever assemblies and housing	88
Inspection of installed valve lever assemblies	89
Removal of valve lever assemblies and housing	90
Disassembly of valve lever assemblies and housing	91
Cleaning and inspection of valve lever assemblies and housing parts	92
Overhaul of valve lever assemblies	93
Assembly of the valve lever assemblies	94
Installation of parts in valve lever housing	95
Installation of valve lever assemblies and housing	96
Inspection of installed crankcase oil pan	97
Crankcase oil pan removal	98
Crankcase oil pan cleaning and inspection	99
Crankcase oil pan installation	100
Lubricating oil pump removal	101
Lubricating oil pump disassembly	102
Lubricating oil pump inspection	103
Lubricating oil pump overhaul	104
Assembly of lubricating oil pump	105
Lubricating oil pump installation	106
Piston and connecting rod removal	107
Piston and connecting rod disassembly	108
Piston and connecting rod inspection	109
Piston and connecting rod overhaul	110
Assembly of pistons and connecting rods	111
Checking piston and connecting rod assemblies before installation	112

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

	Paragraph
Piston and connecting rod installation	113
Connecting rod bearing removal	114
Connecting rod bearing inspection	115
Connecting rod bearing installation	116
Main bearing removal	117
Main bearing inspection	118
Main bearing installation	119
Cylinder sleeve removal	120
Cylinder sleeve installation	121
Removal of crankshaft gear from the crankshaft	122
Crankshaft removal	123
Inspection of removed crankshaft	124
Crankshaft installation	125
Camshaft, valve tappet and tappet guide removal	126
Camshaft disassembly	127
Removed camshaft, valve tappet and tappet guide inspection ...	128
Camshaft, valve tappet and tappet guide installation	129
Fan drive pulley and vibration damper overhaul	130
Crankcase front cover removal	131
Crankcase front cover overhaul	132
Crankcase front cover installation	133
Air compressor drive removal	134
Air compressor drive disassembly	135
Air compressor drive coupling inspection	136
Inspection and overhaul of air compressor drive parts	137
Assembly of air compressor drive	138
Inspection of air compressor drive before installation	139
Air compressor drive installation	140
Flywheel and ring gear overhaul	141
Intake manifold removal	142
Intake manifold disassembly	143
Cleaning intake manifold and housing parts	144
Inspection and overhaul of intake manifold and housing parts ...	145
Assembly of intake manifold	146
Intake manifold installation	147
Exhaust manifold removal	148
Removed exhaust manifold inspection	149
Exhaust manifold installation	150
Engine air cleaner inspection	151
Engine air cleaner removal	152
Engine air cleaner installation	153

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

76. GENERAL.

a. Subassemblies of the engine which are not major components of the fuel, lubrication, cooling, electrical and starting systems are treated in this section. For other components, refer to fuel, lubrication, cooling, electrical and starting system sections, TM 9-1777B.

b. This section covers removal from engine, disassembly, cleaning and inspection, overhaul, assembly and installation on engine, as may be required for the components included.

c. The procedure for removing any components from the engine in the process of complete engine disassembly is covered in section V. Similarly, the procedure for installing any component in the process of complete engine assembly is covered in section VIII.

77. CYLINDER HEAD CONSTRUCTION.

a. Two cylinder heads—each covering three cylinders—are used in the engine. They are securely bolted to the crankcase and are joined together at the center by the water manifold. Cylinder heads are designed to cool the valves, fuel injection nozzles and precombustion chambers. The adjacent intake and exhaust valves are paired to simplify manifold arrangement and improve gas passage.

78. CYLINDER HEAD REMOVAL.

NOTE: Valve lever assemblies do not have to be removed from the cylinder heads to replace a valve spring. See paragraph 90.

a. Equipment.

HOIST

PLIERS

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

WRENCH, open-end, $1\frac{1}{16}$ -in.

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

WRENCH, open-end, $\frac{7}{8}$ -in.

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

and speeder

**WRENCH, socket, $\frac{9}{16}$ -in.,
and spinner type handle**

**WRENCH, socket, 1-in.,
and spinner type handle**

**WRENCH, spark plug
(No. 32941-D, or equivalent)**

b. Procedure.

(1) **REMOVE HOOD SHEET.** See paragraph 29.

(2) **REMOVE INTAKE MANIFOLD.** See paragraph 142.

(3) **REMOVE EXHAUST MANIFOLDS.** See paragraph 148.

(4) **DISCONNECT IGNITION WIRES FROM SPARK PLUGS.**

(5) **REMOVE SPARK PLUGS.**

WRENCH, spark plug (No. 32941-D, or equivalent)

(a) **Use spark plug tool, wrench, to remove plugs.**

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

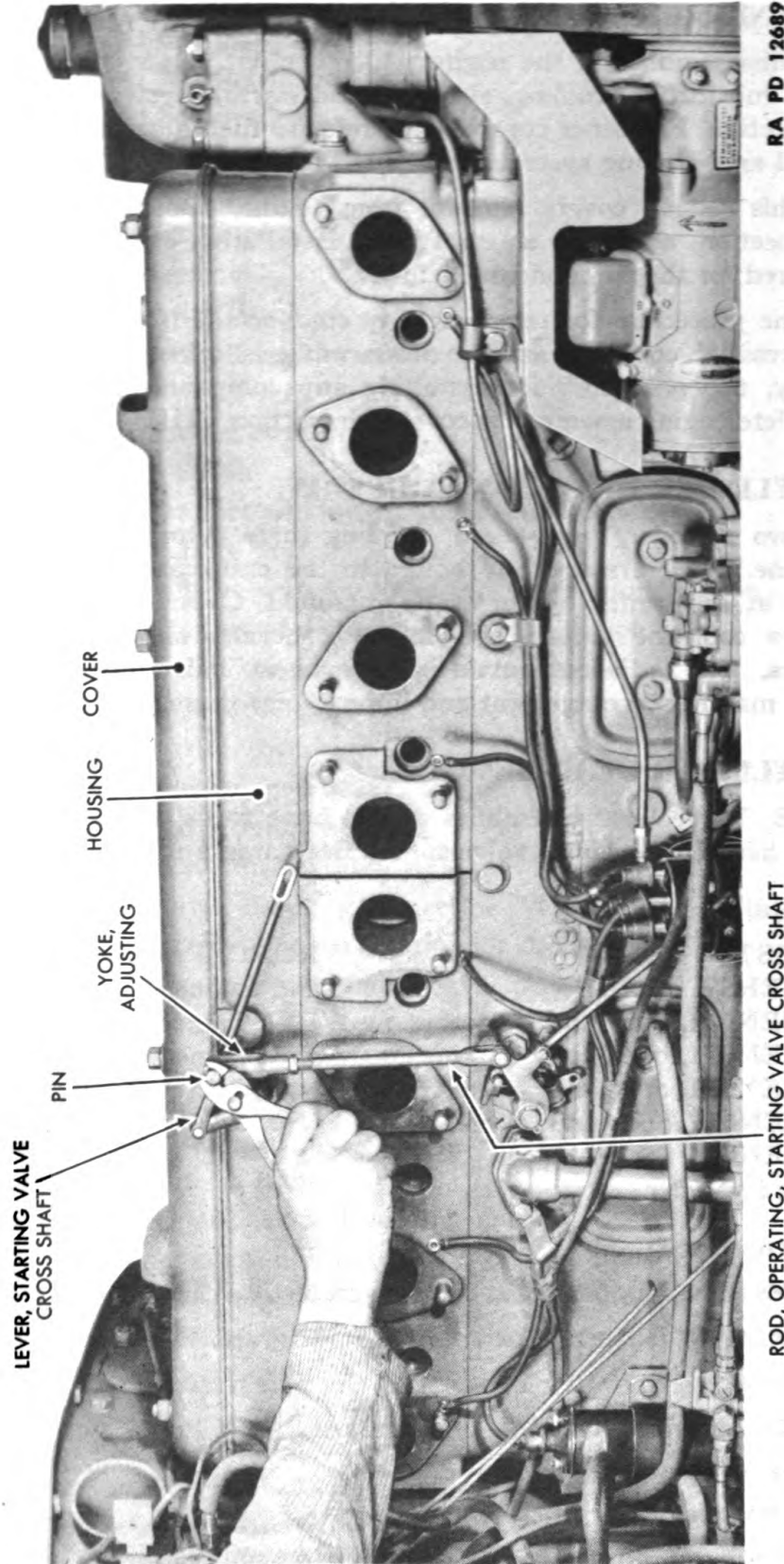


Figure 61—Disconnecting Starting Valve Cross Shaft Operating Rod

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(6) DISCONNECT CROSS SHAFT OPERATING ROD FROM CROSS SHAFT LEVER (fig. 61).

PLIERS

(a) Remove cotter pin from pin which holds adjusting yoke to cross shaft lever. Remove pin.

(7) DISCONNECT THERMOSTAT HOUSING AND WATER OUTLET ASSEMBLY.

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

(a) Remove three cap screws and lock washers which hold water outlet to cylinder head. Water outlet gasket should be removed when cylinder head is lifted off.

(8) REMOVE FUEL INJECTION PUMP TO NOZZLE PIPES.

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

(a) Disconnect pipe connectors at each end of each of six pipes. To remove No. 1 and No. 6 pipes, it is necessary to remove clip which holds each pipe to cylinder head. Remove cap screw which holds each clip to cylinder head. Place caps or tape on injection fuel pump delivery valve holders.

(9) REMOVE HEAT INDICATOR CABLE AND ELEMENT FROM LEFT REAR SIDE OF CYLINDER HEAD (fig. 62).

WRENCH, open-end, 1 1/16-in. WRENCH, open-end, 7/8-in.

(a) Holding plug with wrench, use another wrench to remove connector. Then pull out element.

(10) REMOVE WATER MANIFOLD (fig. 62).

WRENCH, socket, 9/16-in., and spinner type handle

(a) Remove six cap screws and lock washers which hold water manifold in place on cylinder head. Remove water manifold and gasket.

(11) DISCONNECT CROSS SHAFT THRUST BRACKET FROM REAR CYLINDER HEAD (fig. 62).

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

(a) Remove two cap screws and lock washers which secure bracket to rear cylinder head.

(12) DISCONNECT REAR CYLINDER HEAD FROM DASH AND COWL ASSEMBLY.

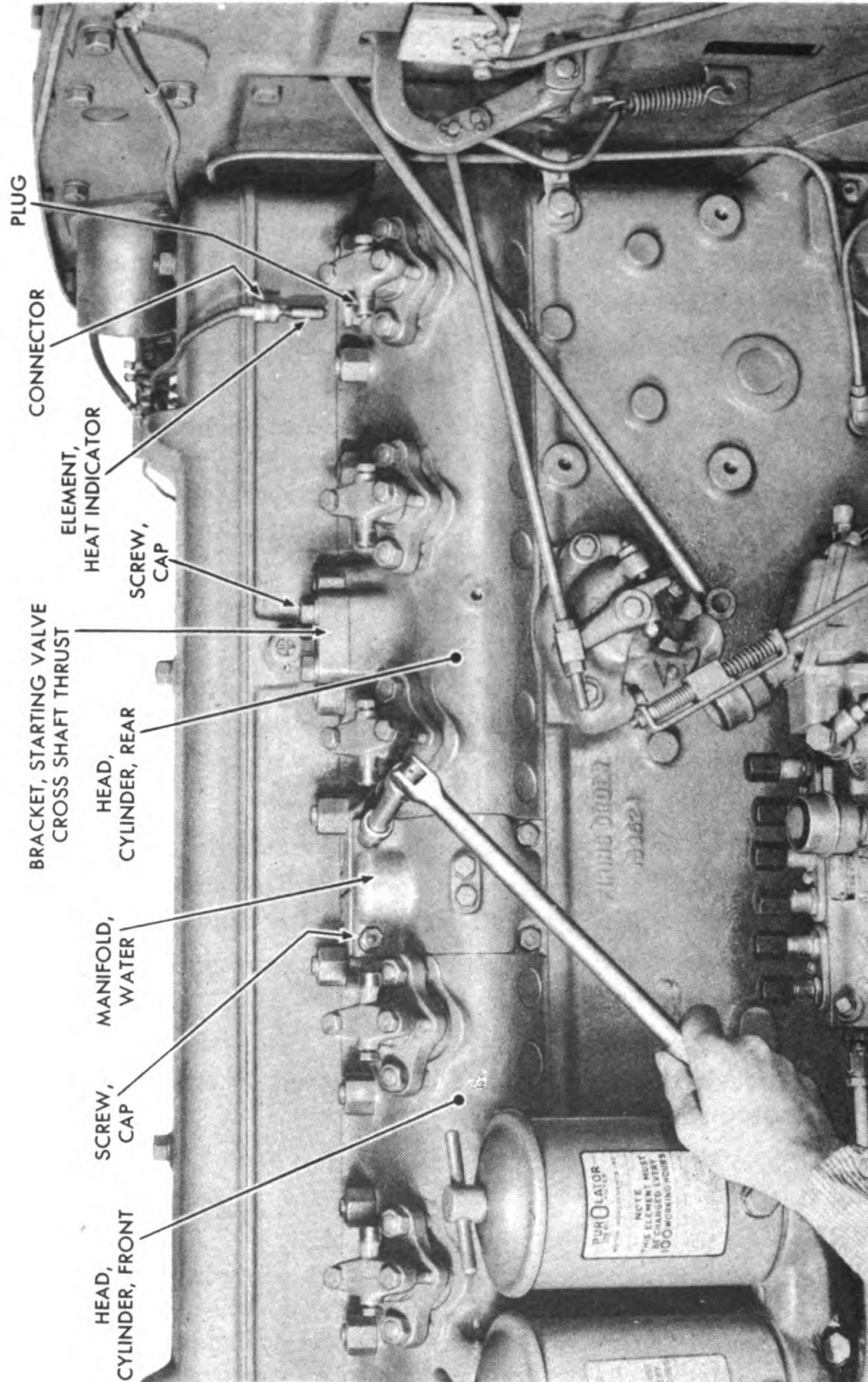
WRENCH, open-end, 3/4-in.

(a) Remove two cap screws and lock washers from driver's side of dash and cowl assembly. These cap screws hold cylinder head to dash and cowl assembly and have spacers between dash and head. Second cap screw is located in corresponding position on other side of air cleaner.

(13) REMOVE VALVE HOUSING COVER (fig. 63).

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

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE



RA PD 12690

Figure 62 — Water Manifold Removal

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

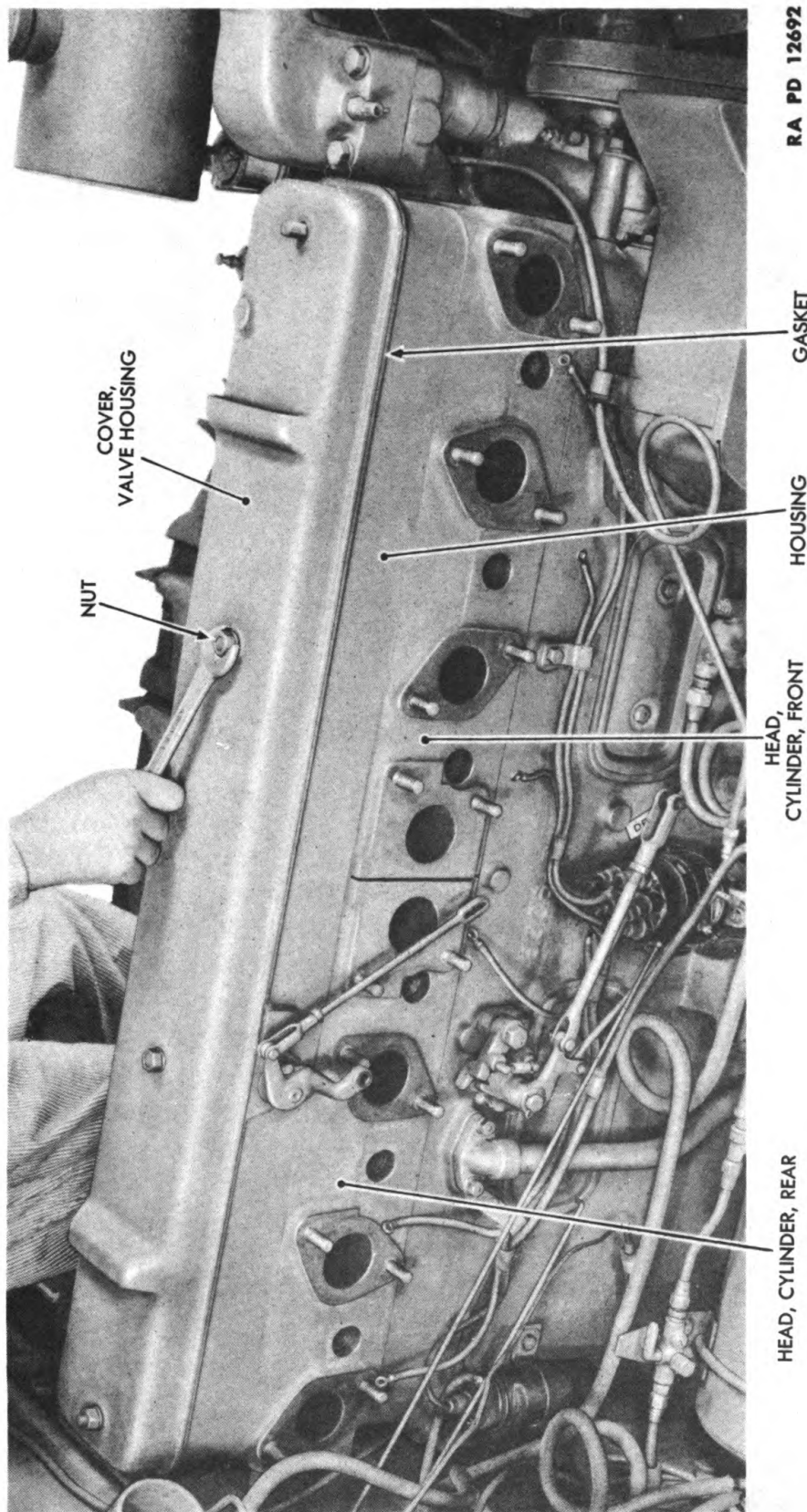


Figure 63—Valve Housing Cover Removal

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

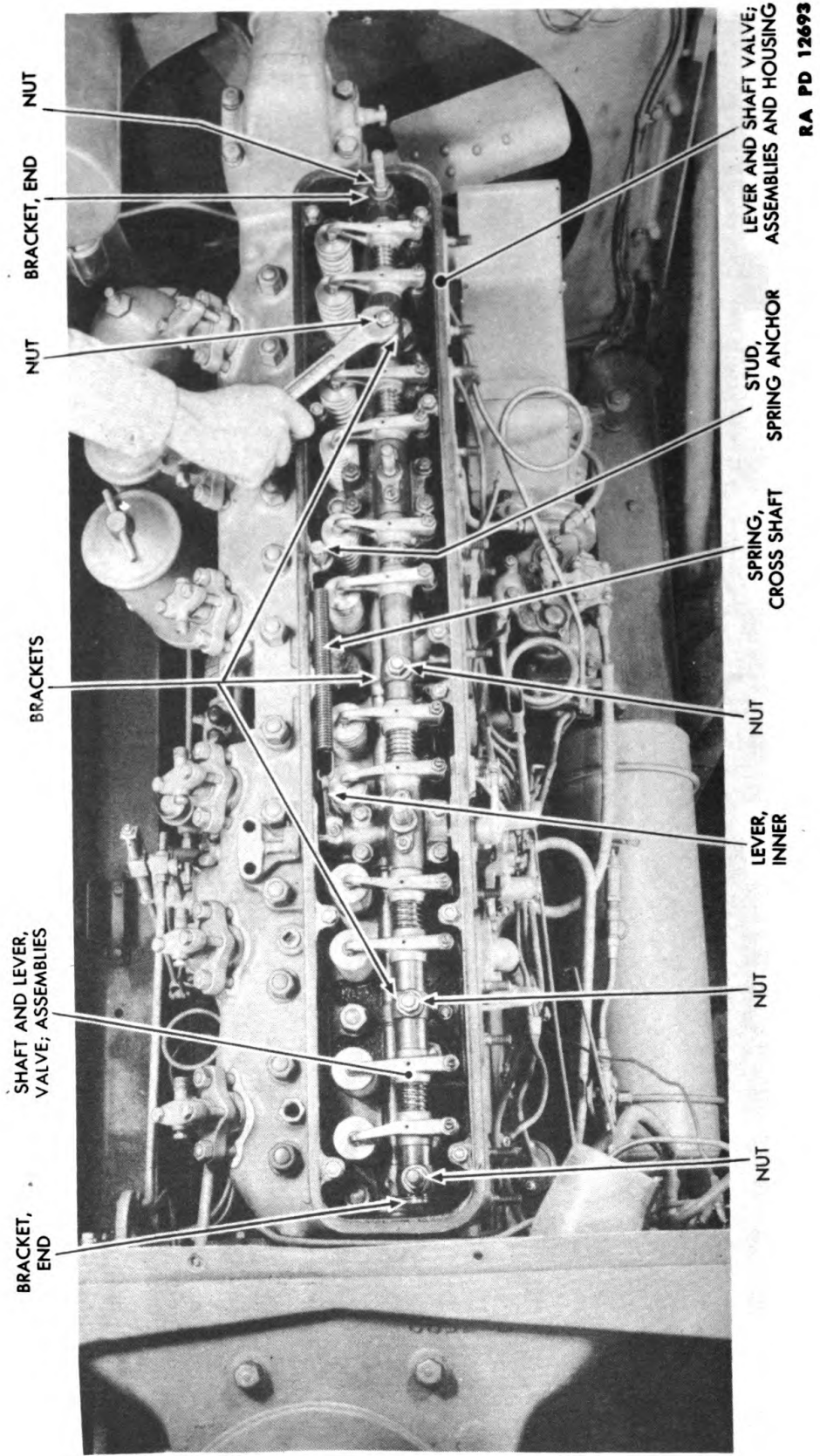


Figure 64— Valve Lever Assembly Removal

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REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(a) Remove four nuts and copper washers which hold cover to cylinder heads. Lift off cover and remove gasket and felt.

(14) REMOVE VALVE LEVER SHAFT BRACKET STUD NUTS (fig. 64).

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

(a) Remove nuts from center studs which hold end and intermediate brackets to cylinder heads.

(15) REMOVE CROSS SHAFT SPRING (fig. 64).

PLIERS

(a) Use pliers to remove spring which connects inner lever to spring anchor stud.

(16) REMOVE STUD NUTS FROM RIGHT SIDE OF VALVE SHAFT BRACKETS (fig. 65).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Use socket wrench to remove five nuts.

(17) REMOVE 12 NUTS FROM STUDS WHICH HOLD HOUSING IN PLACE (fig. 65).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Use socket wrench to remove nuts.

(18) REMOVE CAP SCREWS FROM CROSS SHAFT AND FRONT CENTER BRACKETS (fig. 65).

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Use socket and spinner type handle wrench to remove four cap screws from cross shaft brackets and four cap screws from front center brackets. These cap screws hold brackets to cylinder heads.

(19) REMOVE HOUSING WITH VALVE SHAFT AND LEVER ASSEMBLIES (fig. 66). Lift assembly upward and off cylinder heads.

(20) REMOVE THE PUSH RODS (fig. 67). Push rods can be lifted out when valve lever assemblies and housing have been removed.

(21) REMOVE NUTS WHICH HOLD CYLINDER HEADS TO CRANKCASE (fig. 68).

WRENCH, socket, 1-in., and spinner type handle

(a) Cylinder heads are secured to crankcase with nuts on 31 crankcase studs. There is one row of studs on each side of cylinder heads and also a center row. Stud between two cylinder heads has flat washer beneath nut. Remove all nuts.

(22) REMOVE CYLINDER HEADS (fig. 69).

HOIST

(a) Attach hoist to front and rear stud of front cylinder head, replacing nuts on studs used. Then lift cylinder head upward and off crankcase.

(b) Remove rear cylinder head in same manner.

(c) Remove cylinder head gaskets.

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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

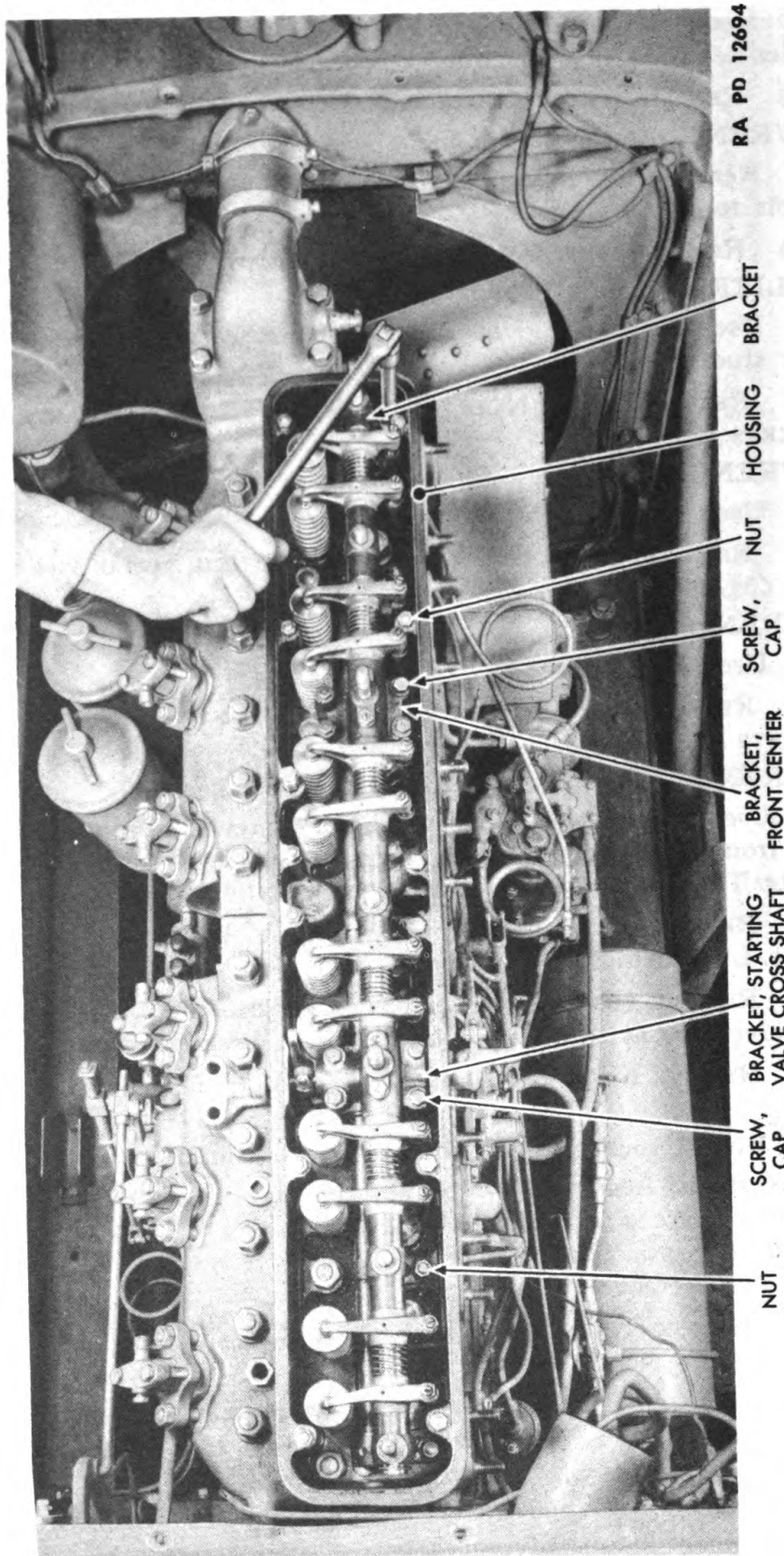


Figure 65—Removal of Valve Lever Shaft Bracket Nuts from Valve Shaft Bracket

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

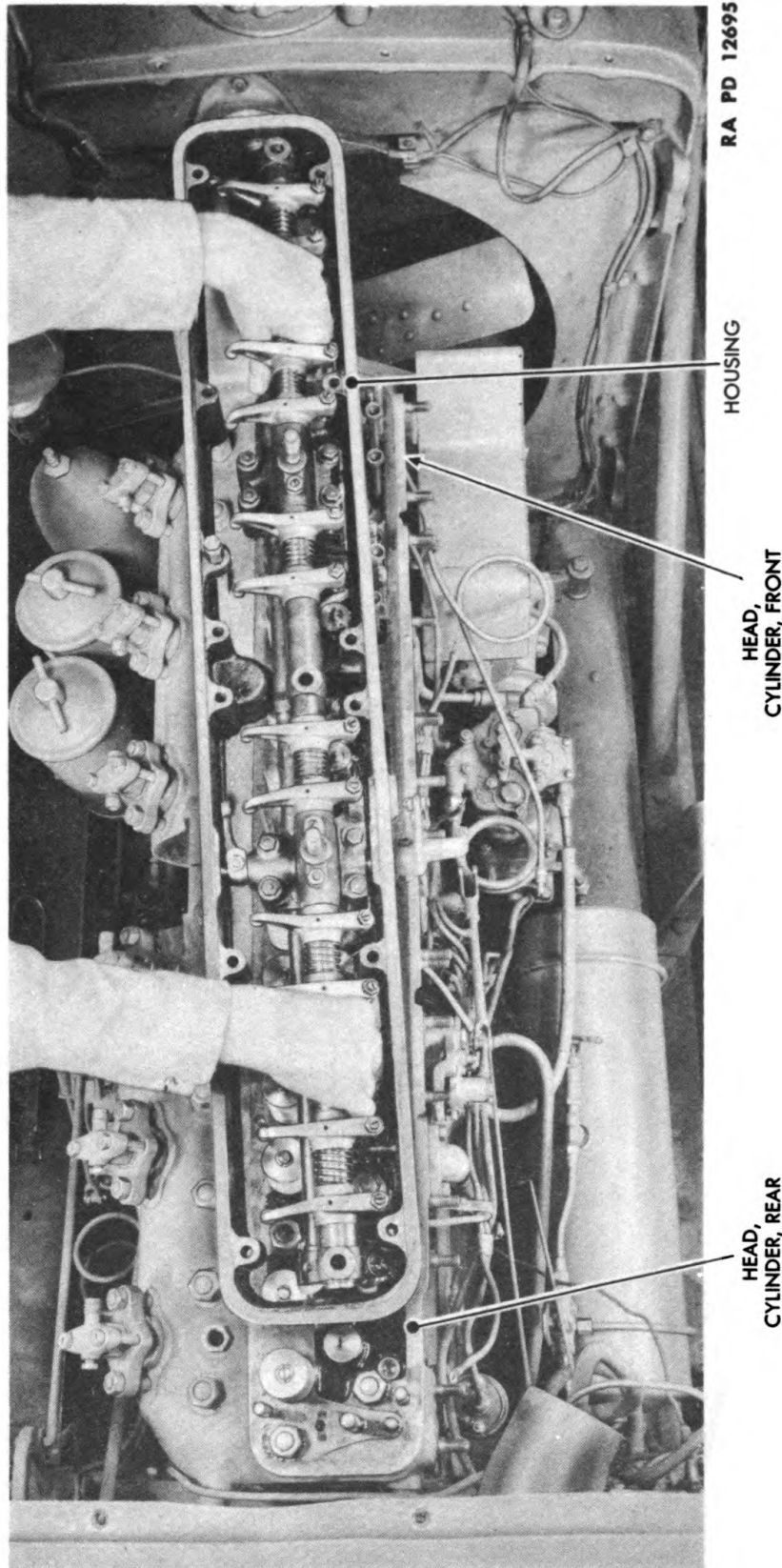
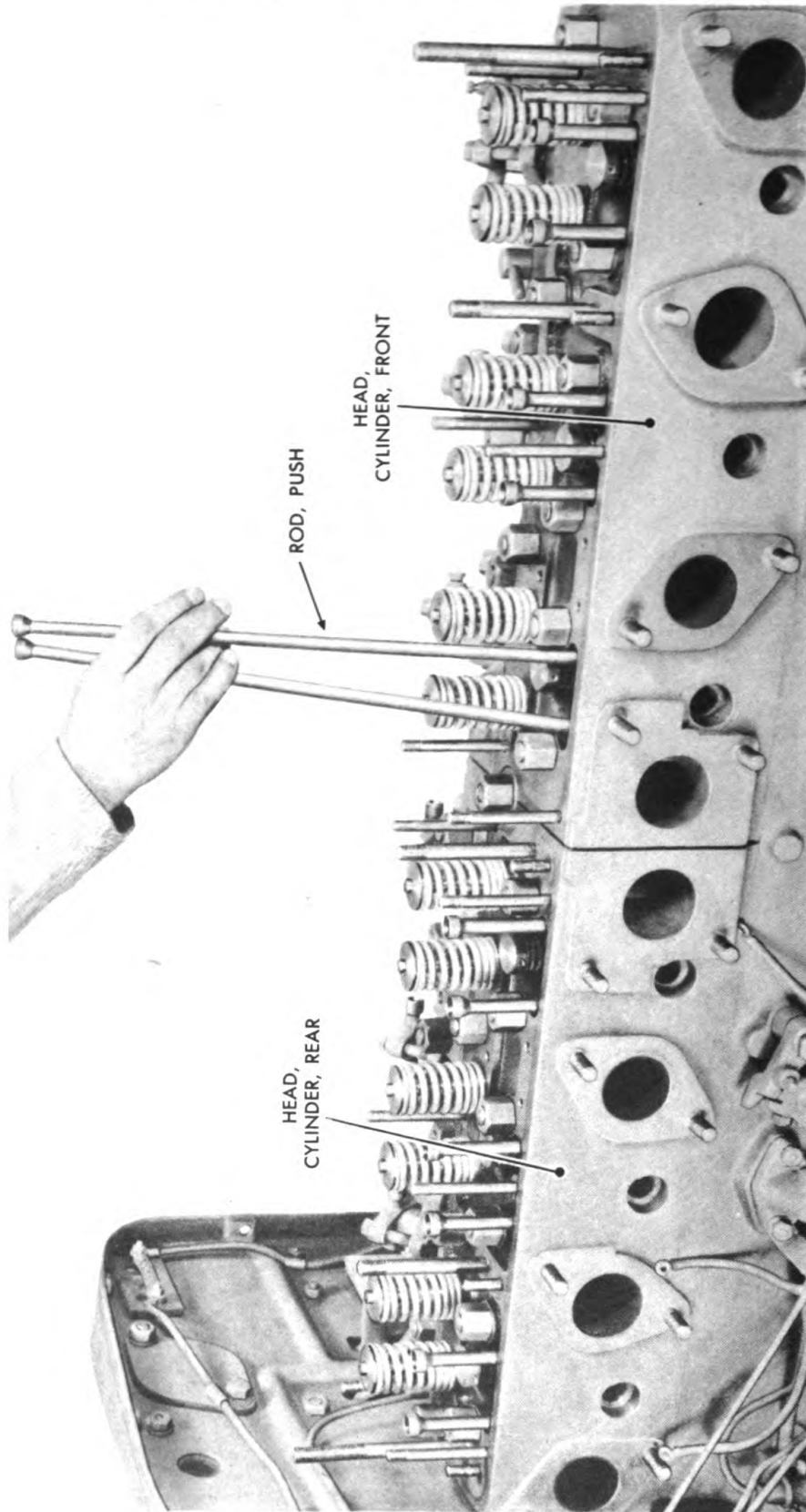


Figure 66 — Valve Shaft, Lever Assembly and Housing Removal

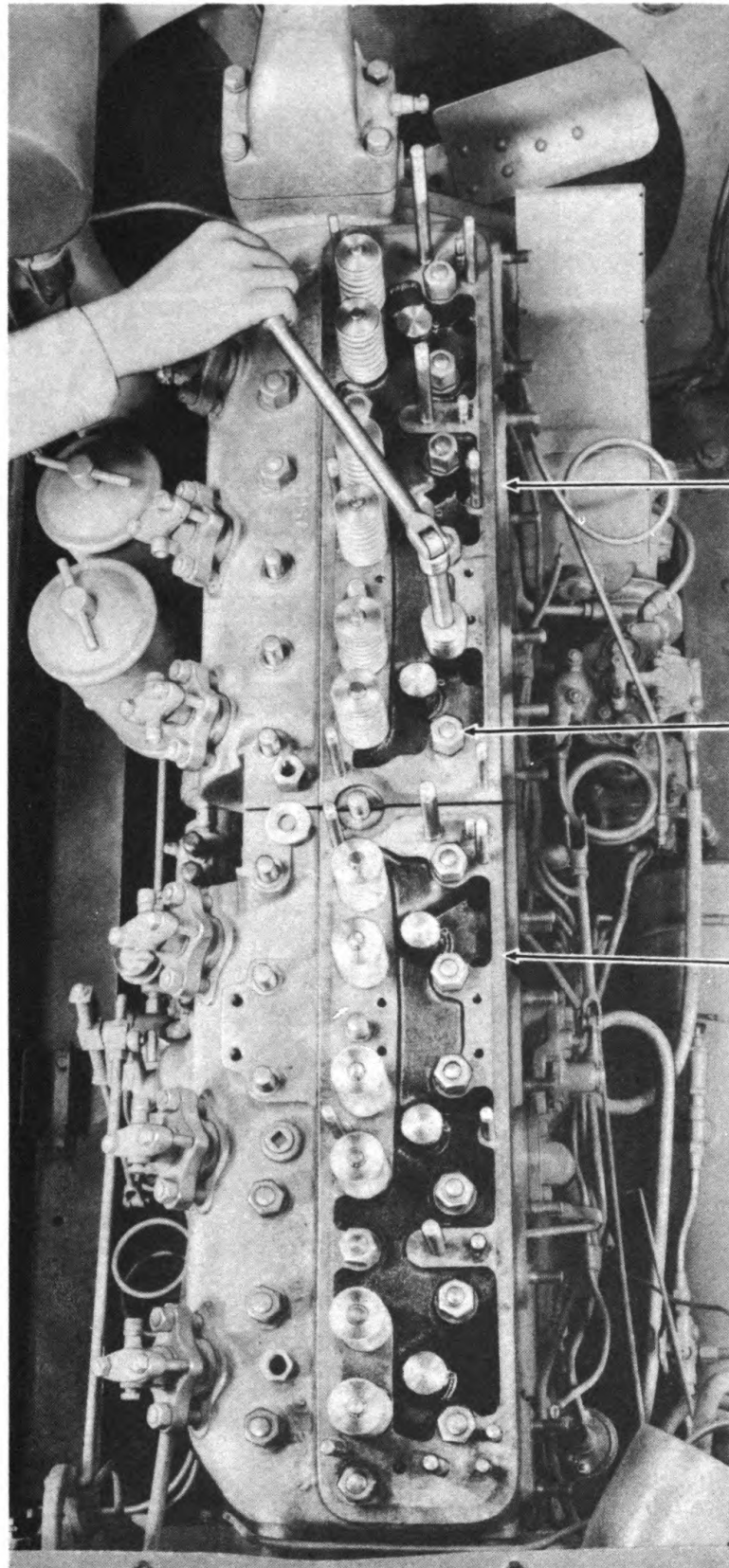
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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12696

Figure 67 — Push Rod Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**



RA PD 12697

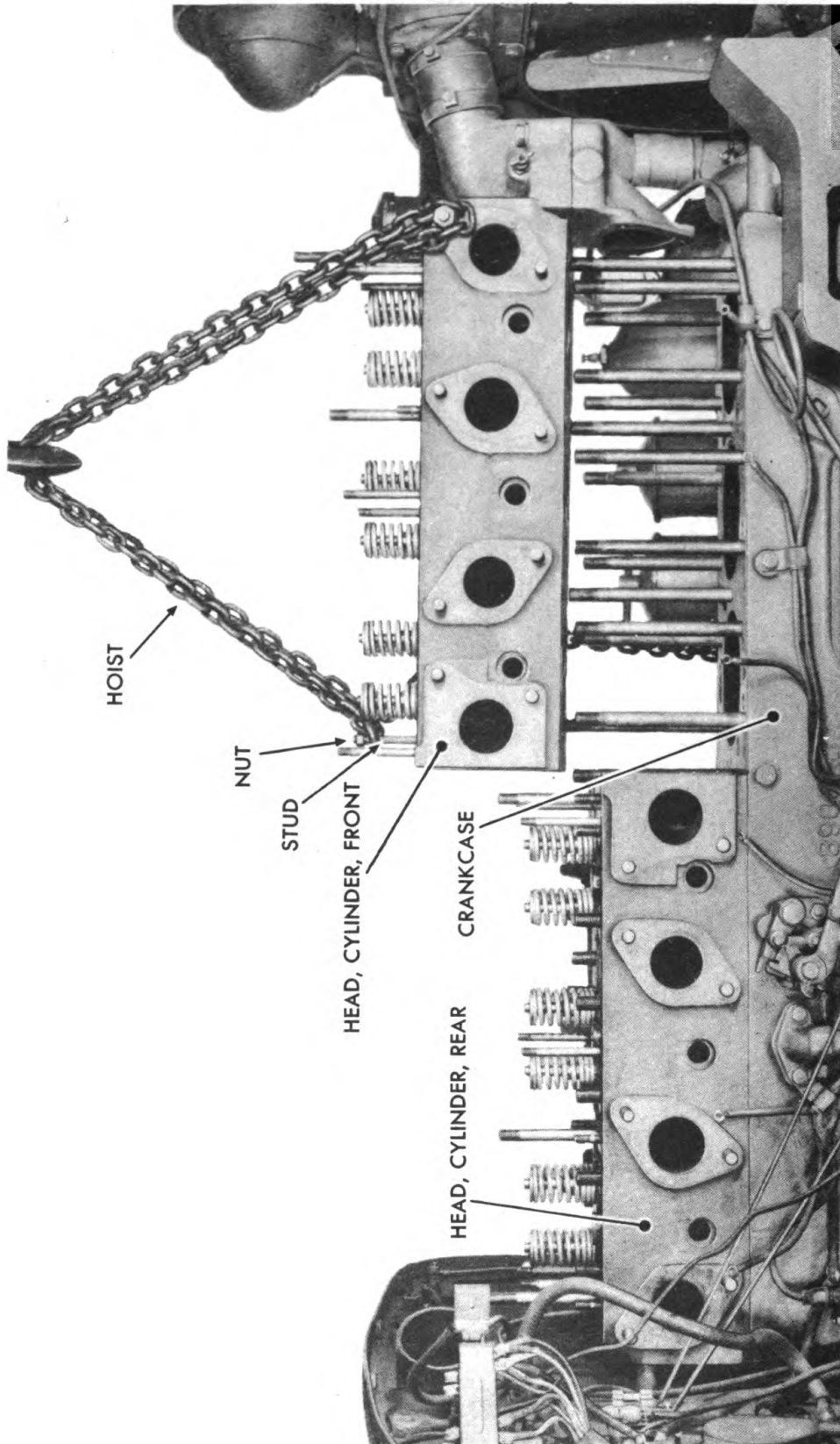
HEAD, CYLINDER, FRONT

NUT

HEAD,
CYLINDER, REAR

Figure 68 — Removal of Nuts from Cylinder Head

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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12698

Figure 69 — Removal of Front Cylinder Head from Crankcase

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

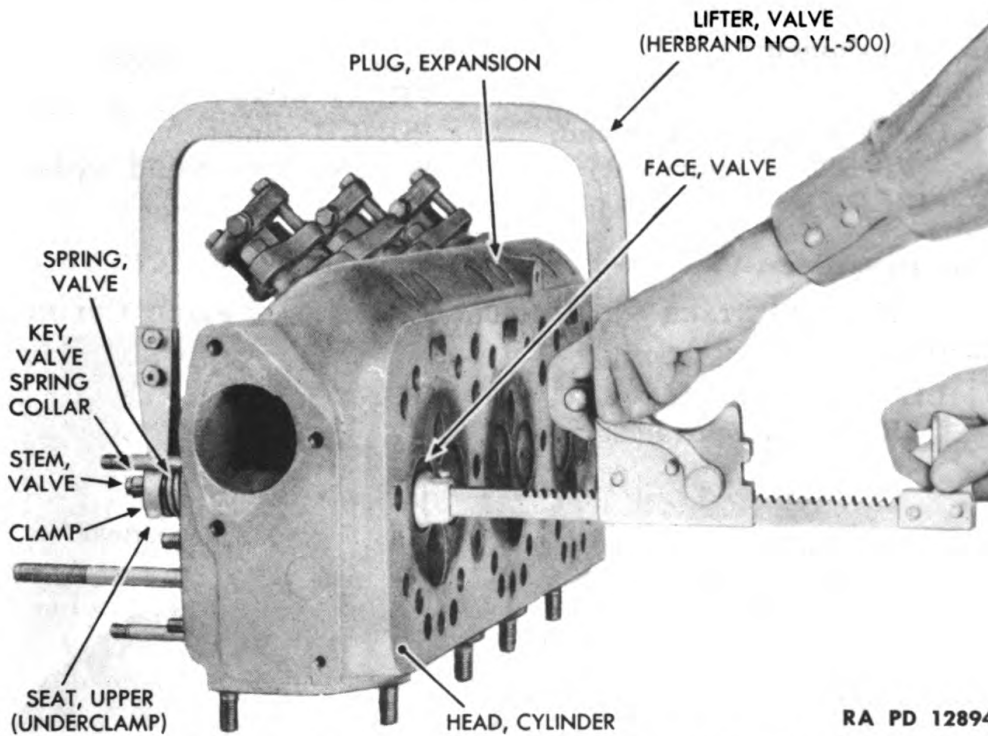


Figure 70—Compressing Valve Springs with Valve Lifter

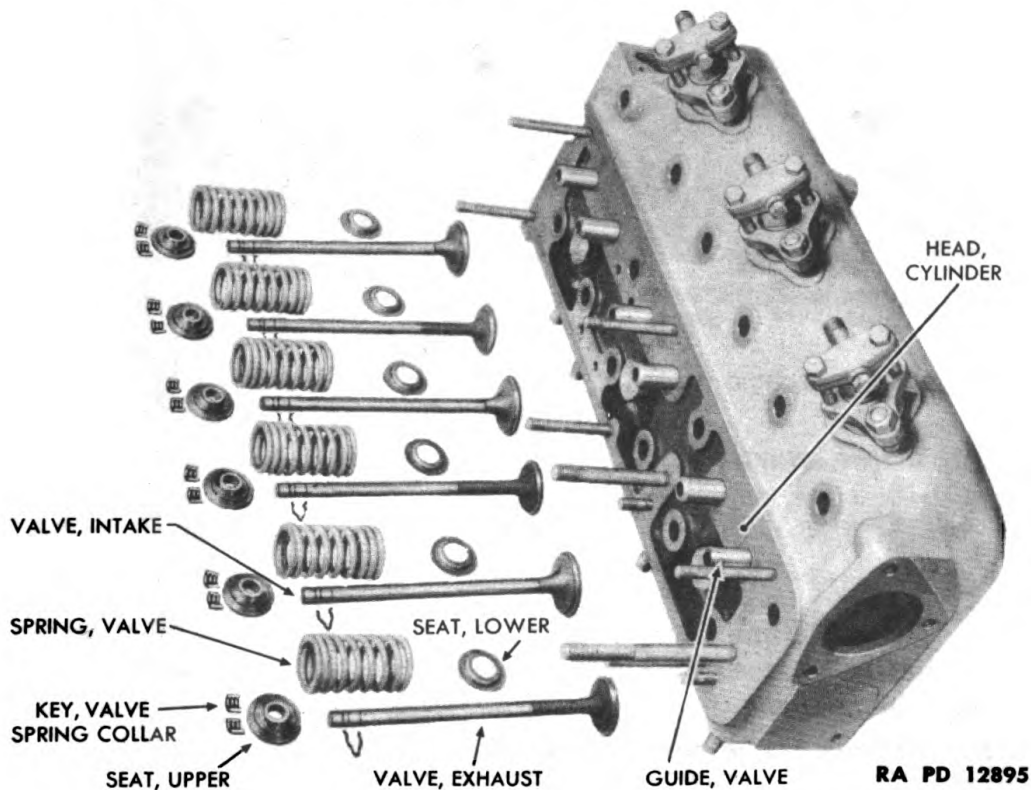


Figure 71—Removed Intake and Exhaust Valve and Related Parts

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

79. CYLINDER HEAD DISASSEMBLY.

a. Equipment.

BAR, steel
LIFTER, valve (Herbrand,
VL-500, or equivalent)
PLIERS

PRESS, arbor
PUNCH, center
WRENCH, open-end, 3/4-in.

b. Procedure.

(1) REMOVE INTAKE AND EXHAUST VALVES FROM FRONT CYLINDER HEAD (figs. 70 and 71).

LIFTER, valve (Herbrand,
VL-500, or equivalent)

PUNCH, center

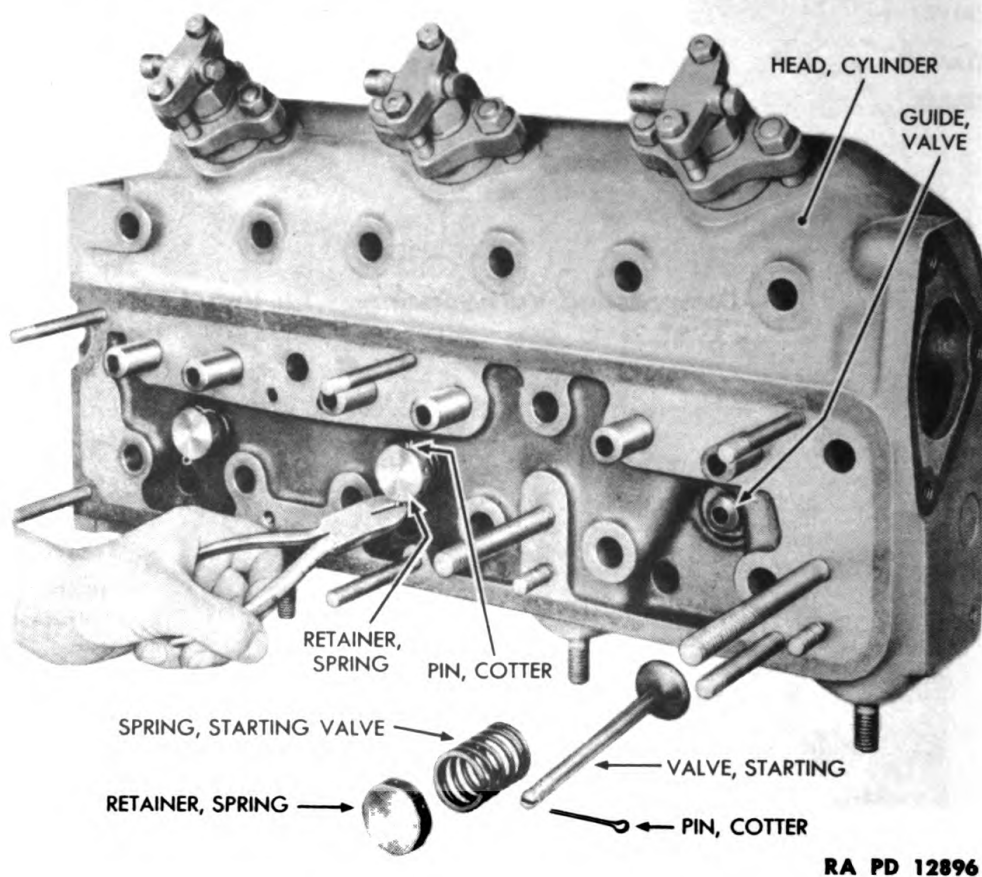


Figure 72—Starting Valve Removal

(a) Using Herbrand valve lifter VL-500, or equivalent, place clamp end of tool over upper seat of one valve. Then turn crank of tool until spring is compressed.

(b) Remove valve spring collar keys. Release the valve lifter and remove.

(c) Remove upper spring seat.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

- (d) Remove valve spring.
- (e) Remove retainer from valve.
- (f) Remove valve from underneath side of cylinder head.
- (g) Remove lower seat from upper side of cylinder head.
- (h) Remove remaining intake and exhaust valves in same manner.

CAUTION: Tap identifying number of dots on face of each valve to insure replacement in same position in which it was originally installed.

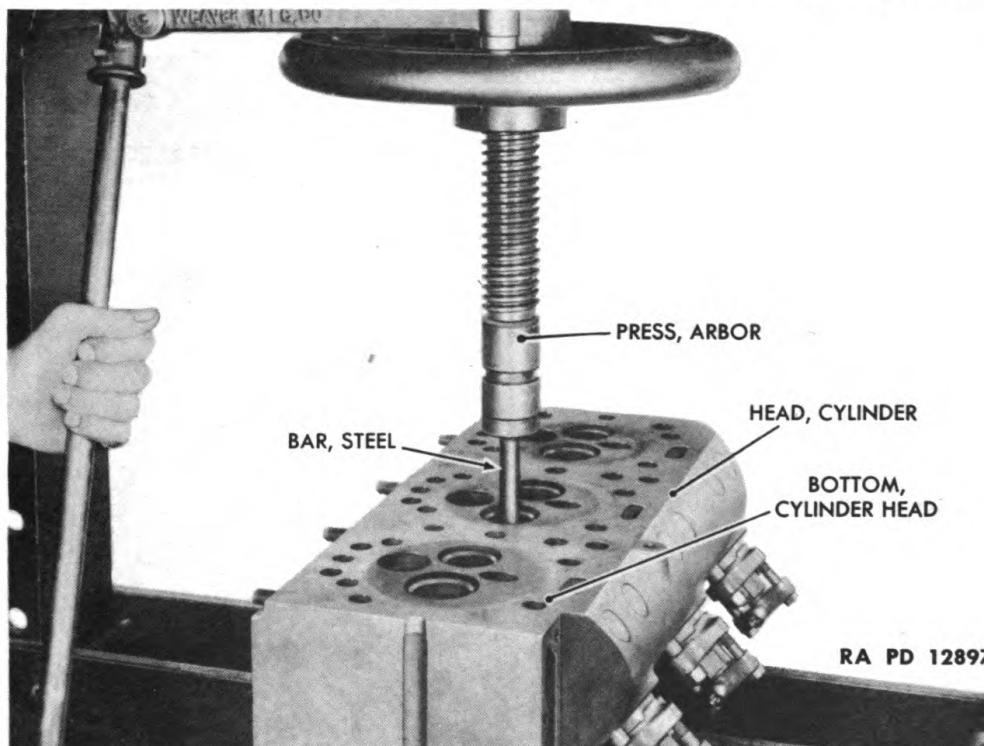


Figure 73—Pressing Out Intake Valve Guide

- (2) REMOVE STARTING VALVES (fig. 72).

PLIERS

(a) Remove cotter pin from one of spring retainers which locks retainer in position on end of starting valve. Then unscrew spring retainer by hand and remove spring. Valve can then be lifted out from underneath side of cylinder head.

- (b) Remove remaining starting valves in same manner.

- (3) REMOVE INTAKE AND EXHAUST VALVE GUIDES (fig. 73).

BAR, steel

PRESS, arbor

(a) Do not remove guides until they have been cleaned as in paragraph 80 b (7) and checked for wear. Remove only those guides that must be replaced. Place cylinder head in arbor press, or another suit-

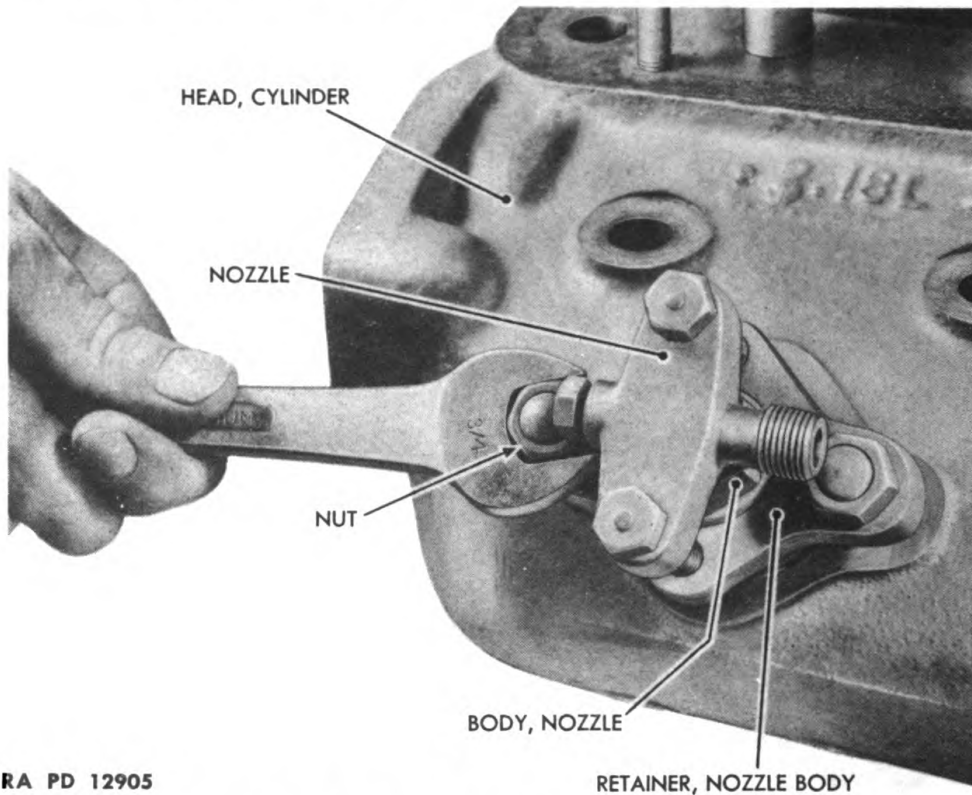
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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

able press, and place steel bar of slightly smaller diameter than guide over guide. Then press guide through head by pressing sleeve and guide from bottom side of head. Remove remaining intake and exhaust valve guides in same manner.

(4) **REMOVE STARTING VALVE GUIDES** (fig. 73). Follow same procedure outlined above to remove starting valve guides.

(5) **REMOVE NOZZLE, NOZZLE BODY AND NOZZLE BODY RETAINER** (fig. 74).

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



RA PD 12905

RETAINER, NOZZLE BODY

Figure 74—Removing Nozzle, Nozzle Body and Retainer from Cylinder Head

(a) Remove two nuts which hold body retainer to cylinder head studs. Remove nozzle, nozzle body and nozzle body retainer with dust seal left out, spacer gasket, spacer and second spacer gasket. **NOTE:** Lot 1 tractors did not have nozzle body and nozzle body retainer seals.

(b) Remove remaining nozzles and related parts in same manner.

(6) **DO NOT REMOVE EXPANSION PLUGS** (fig. 75).

(a) There are six one-inch expansion plugs in nozzle side of each cylinder head and one expansion plug at one end of each cylinder head. These plugs should not be removed except in rare instances when freez-

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

ing up of cylinder head would blow out or loosen plugs without cracking cylinder head. In such cases, plug can be removed with punch.

(7) OIL HEADER PLUG SHOULD NOT BE REMOVED.

(8) FOLLOW SAME PROCEDURE TO DISASSEMBLE REAR CYLINDER HEAD.

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

(a) In addition to seven steps outlined above in disassembling the rear cylinder head, remove operating cross shaft thrust bracket. It is screwed to the rear cylinder head by two cap screws and lock washers.

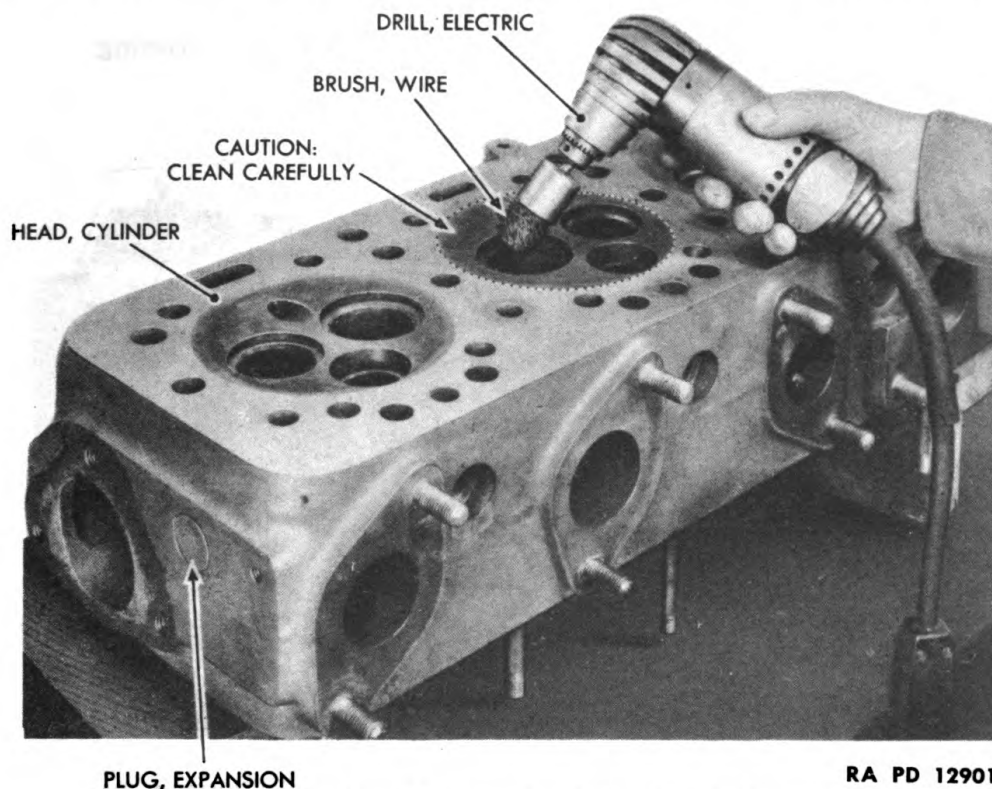


Figure 75—Cleaning Carbon from Cylinder Head

80. CLEANING AND INSPECTION OF DISASSEMBLED CYLINDER HEAD PARTS.

a. Equipment.

AIR, compressed

BLOCKS, wooden

BRUSH, wire

CLEANER, valve guide
(Hall No. 19047 or
equivalent)

DRILL, electric, portable,
 $\frac{1}{4}$ -in.

GRINDER, valve refacing

HOSE

KNIFE, putty

SOLVENT, dry-cleaning

TESTER, spring, special valve
and clutch (IHC No. SE-
1057 or equivalent)

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

- (a) Wash all of these parts in SOLVENT, dry-cleaning.
- (6) INSPECT CYLINDER HEAD.
- (a) Examine cylinder head for cracks, particularly between exhaust, intake and starting valve openings.
- (7) CLEANING OF VALVE GUIDES.
BLOCKS, wooden
CLEANER, valve guide
(Hall No. 19047 or
equivalent)
DRILL, electric, portable,
1/4-in.
FLASHLIGHT

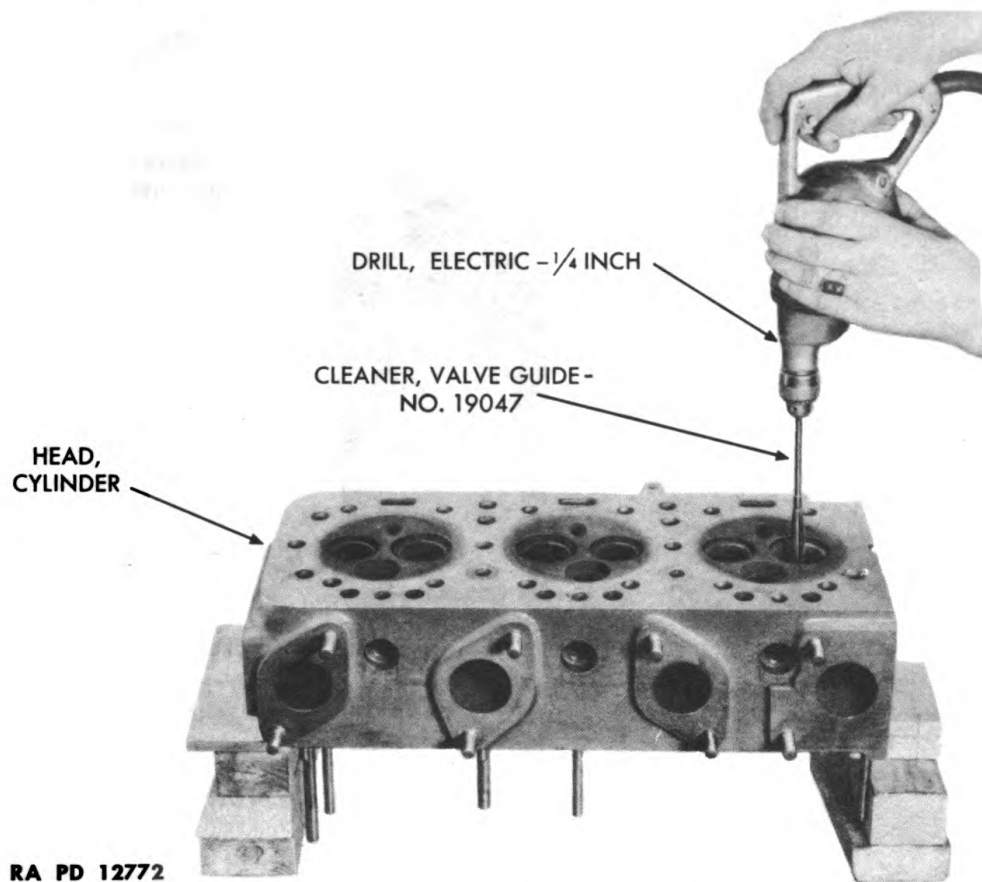


Figure 77—Cleaning Intake Valve Guide

(a) Insert valve guide cleaner in electric drill. Expand tool cleaner $\frac{1}{16}$ -inch larger than valve guide size by adjusting hexagon nut on end of cleaner. Clean valve guide by moving cleaner up and down inside valve guide. Check to see that guides are shiny when operation is completed. This may be done by shining flashlight into valve guide from underneath cylinder head.

(8) TEST VALVE SPRING PRESSURE (fig. 78).

TESTER, spring, special, valve and clutch (IHC No. SE-1057
or equivalent)

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

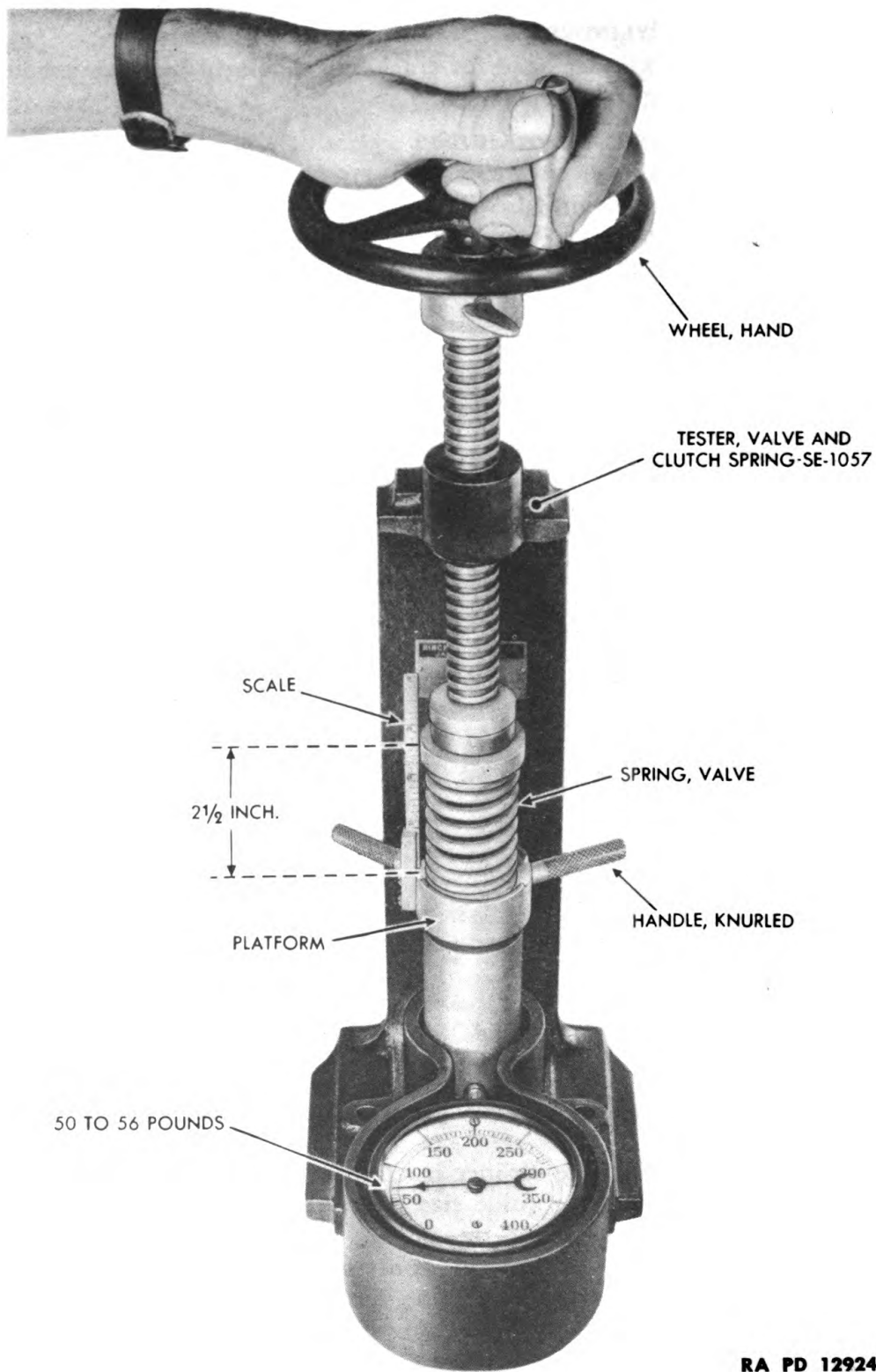


Figure 78—Testing Valve Spring Pressure

RA PD 12924

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(a) Inspect springs carefully for rust and pits. Pits in valve springs are often small and hard to see, so extreme care must be given in inspecting for pit. Springs showing evidence of pitting must be replaced.

(b) Place each valve spring in special valve and clutch spring tester, to check spring pressure. Place spring on platform as near center as possible. Then turn handwheel, compressing spring to desired height, reading height on scale at side of platform. This scale reads from bottom up. With spring compressed to desired height, move one of knurled handles in platform to and fro to release any friction that may exist in hydraulic cylinder. After moving handle, recheck height on scale at left of spring. Knurled stop collar directly below handwheel may then be run down against body casting snugly, and the thumbscrew in collar tightened. The first spring may then be removed and other springs tested simply by turning handwheel until stop collar comes up against body casting again. Same procedure is then followed in breaking friction and reading pressure gage. Each intake and exhaust valve spring should measure $2\frac{1}{2}$ inches when compressed, with 50 to 56 pounds pressure. Starting valves should measure $1\frac{1}{4}$ inch when compressed with $26\frac{3}{4}$ pounds pressure. If a spring does not meet standards, it should be replaced by a new part. Free length of exhaust and intake valve spring should measure $2\frac{7}{8}$ inches. Free length of starting valve spring should measure $1\frac{45}{64}$ inch. However, after it is out, spring may "set" and be slightly less, which is permissible, providing spring meets compression test. NOTE: Two types of intake and exhaust valve springs have been used on tractors. The older type measures $3\frac{1}{16}$ inches, free length, and should test 62 to 68 pounds when compressed to $2\frac{1}{2}$ inches.

(c) Replace broken valve springs.

(9) INSPECT VALVES.

(a) Place each valve in its respective guide and check for excessive play, which is evidence that valve guides should be replaced, providing valves appear in good condition.

(b) Examine valves for scoring from movement in guides and replace worn valves.

(c) Examine seating surface of valve for pitting. Also examine valve seating surface in cylinder head for pitting.

(d) Install each valve, in turn, in chuck of valve refacing grinder (fig. 84). Valve should run true, otherwise it is warped and should be replaced by a new valve.

81. CYLINDER HEAD OVERHAUL.

a. Equipment.

BAR, brass

PRESS, arbor

REAMER, valve (IHC No.

SE-640 or equivalent)

WRENCH, adjustable, tee
handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

- (1) **DISASSEMBLE THE CYLINDER HEAD.** Follow procedure outlined in paragraph 127.
- (2) **CLEAN AND INSPECT ALL PARTS.** Follow procedure outlined in paragraph 128.
- (3) **CLEAN VALVE GUIDES** (fig. 77). See paragraph 80 b (7).
- (4) **INSTALLING NEW VALVE GUIDES** (figs. 79 and 80).

DRIFT, brass

PRESS, arbor

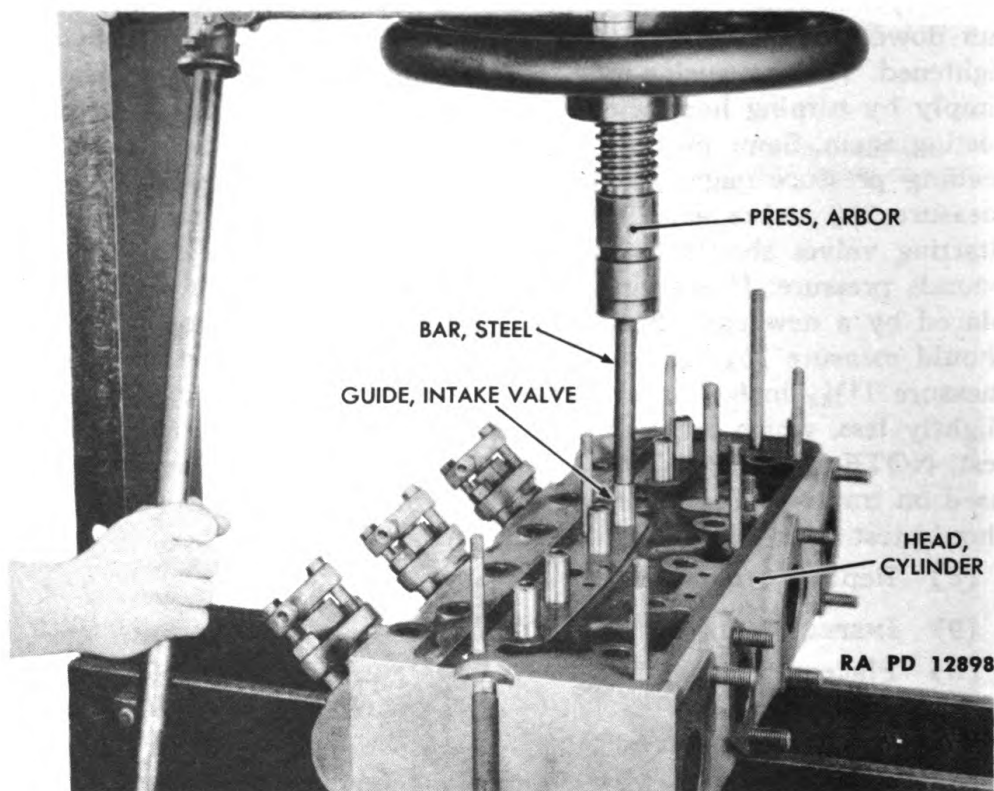


Figure 79—Pressing Intake Valve Guide into Cylinder Head

(a) When inspection, outlined in paragraph 80, discloses need for new valve guides, they should be pressed into top of cylinder head. Position guide with sharp, chamfered end out. Place brass drift of slightly smaller diameter than guide over guide and press guide into position.

(b) Exhaust and intake valve guides should be pressed into cylinder head so that distance from top of guide to top of cylinder head measures $1\frac{3}{8}$ inch. Starting valve guides should be pressed below the surface of head so that distance from top end of guide to top surface of cylinder head measures $1\frac{5}{16}$ inch.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(5) REAMING VALVE GUIDES (fig. 81).

REAMER, valve (IHC No. SE-640 or equivalent)

WRENCH, adjustable, tee handle

(a) The valve guides used for replacement service are furnished reamed to size. After the valve guide has been installed in the head, it often happens that the diameter inside the valve guide has been decreased at the point where it sets in the cylinder head. Use a reamer and adjust it so it will just start taking a cut when it is run through a

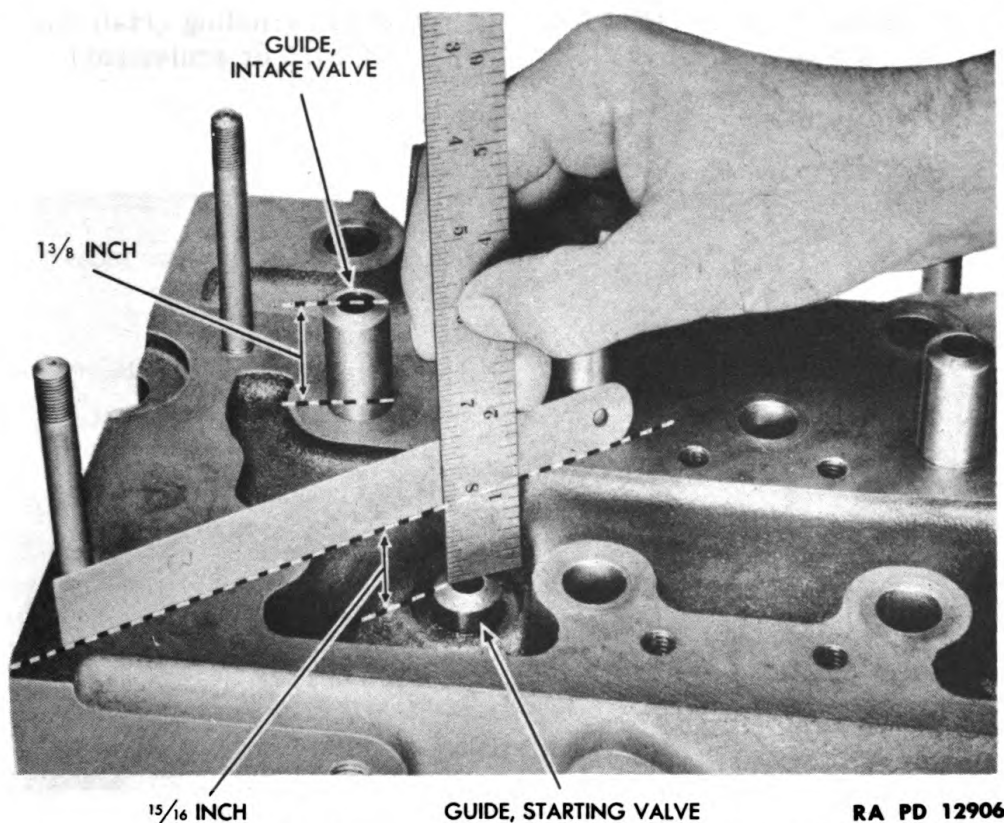


Figure 80—Measuring Position of Starting Valve Guide in Cylinder Head

valve guide that has not been installed in the engine. Insert the reamer in the installed valve guide and run it the full length of the guide and remove any material which would interfere with the operation of the valve. Diameters of the valve stems are 0.4325-inch for the intake valves and 0.4315-inch for the exhaust valves. Clearance between valve stem and valve guide should be 0.003-inch for intake valves and 0.004-inch for exhaust valves.

(6) OVERHAUL OF NOZZLES. See fuel system section, TM 9-1777B.

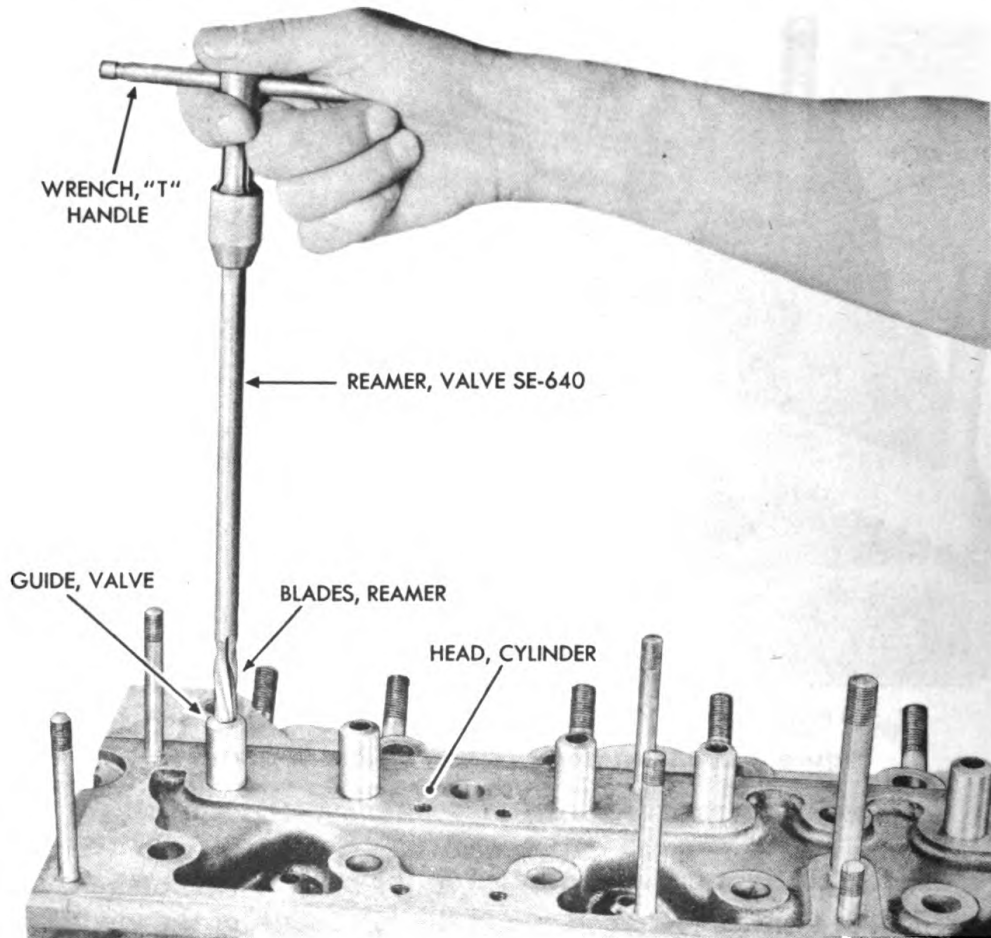
**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

82. VALVE SEAT GRINDING.

a. Equipment.

GRINDER, valve seat
 INDICATOR, valve seat
 TOOL, pilot (Hall No. C-5
 or equivalent)
 TOOL, pilot (Hall No. C-7
 or equivalent)
 WHEEL, grinding (Hall No.
 C-1245 or equivalent)
 WHEEL, grinding (Hall No.
 C-5015 or equivalent)

WHEEL, grinding (Hall No.
 C-5045 or equivalent)
 WHEEL, grinding (Hall No.
 C-5075 or equivalent)
 WHEEL, grinding (Hall No.
 HX-6415 or equivalent)
 WHEEL, grinding (Hall No.
 HX-6445 or equivalent)
 WHEEL, grinding (Hall No.
 HX-6475 or equivalent)



RA PD 12907

Figure 81—Valve Guide Reaming

b. Procedure.

- (1) INSERT PILOT TOOL INTO INTAKE VALVE GUIDE.

TOOL, pilot (Hall No. C-5
 or equivalent)

TOOL, pilot (Hall No. C-7
 or equivalent)

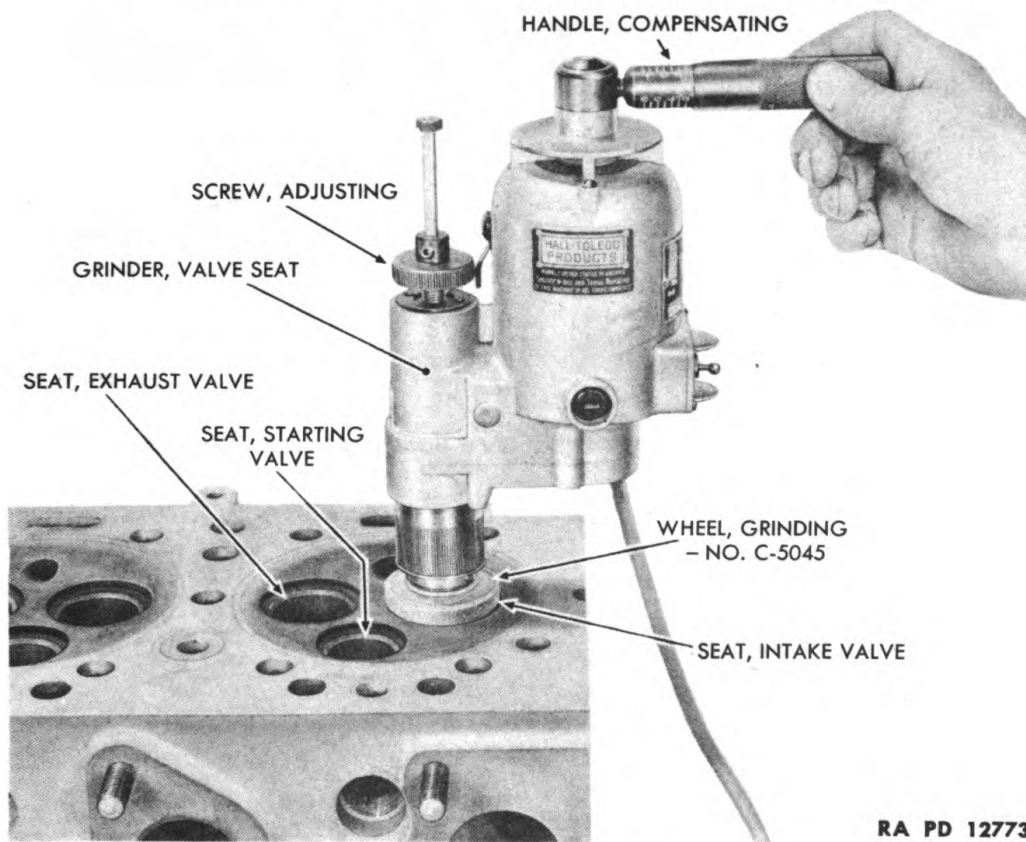
REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(a) Pilot tool C-7 may be used for both intake and exhaust valve guides. Pilot tool C-5 should be used for starting valve guides. Drop pilot straight down into valve guide. Tighten pilot collect. Do not wring or wind pilot into valve guide.

(2) GRIND VALVE SEATS (fig. 82).

GRINDER, valve seat
 INDICATOR, valve seat
 WHEEL, grinding (Hall No. C-1245 or equivalent)

WHEEL, grinding (Hall No. C-5045 or equivalent)
 WHEEL, grinding (Hall No. HX-6445 or equivalent)



RA PD 12773

Figure 82—Intake Valve Seat Grinding

(a) Attach grinding wheel C-5045—when grinding exhaust valve seats, use wheel HX-6445, wheel C-5045 on intake valve seats and wheel C-1245 on starting valve seats—to valve seat grinder.

(b) Place valve seat grinder on pilot and hold compensating hand, with straight pressure on end of handle, to compensate for overhanging weight of grinder. Do not rest weight of hand or forearm on handle.

(c) Turn adjusting screw clockwise until grinding wheel just clears valve seat. Then check this adjustment by rotating grinder around pilot with compensating handle. Balance grinder as outlined above. Start motor, turn adjusting screw one notch and allow wheel to make cut

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

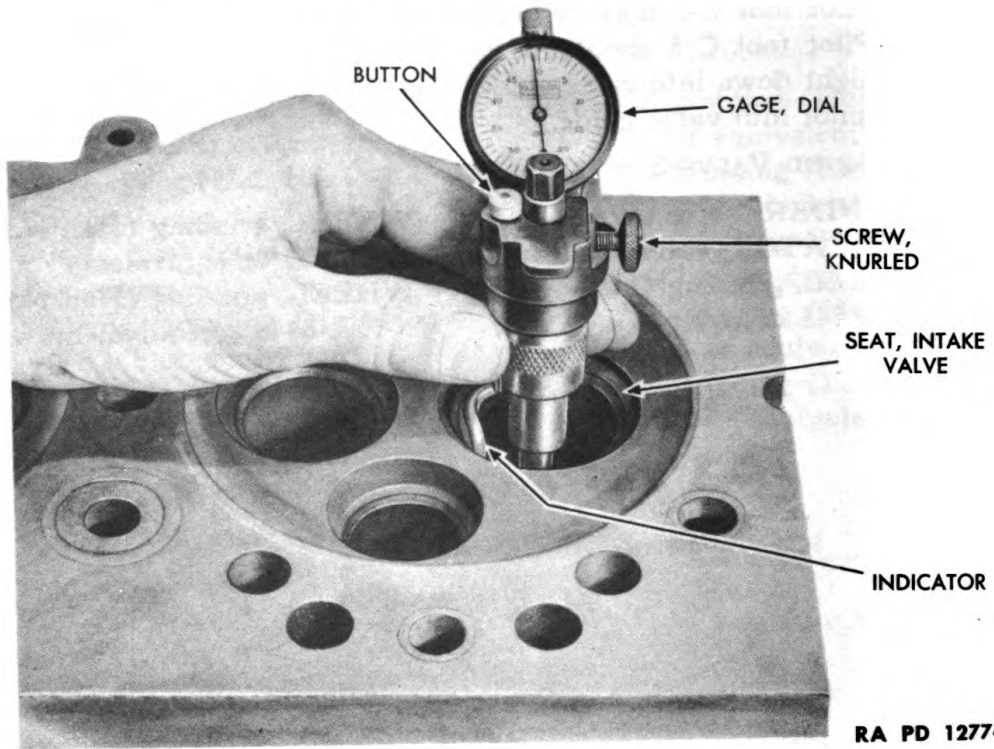


Figure 83—Checking Valve Seat Concentricity

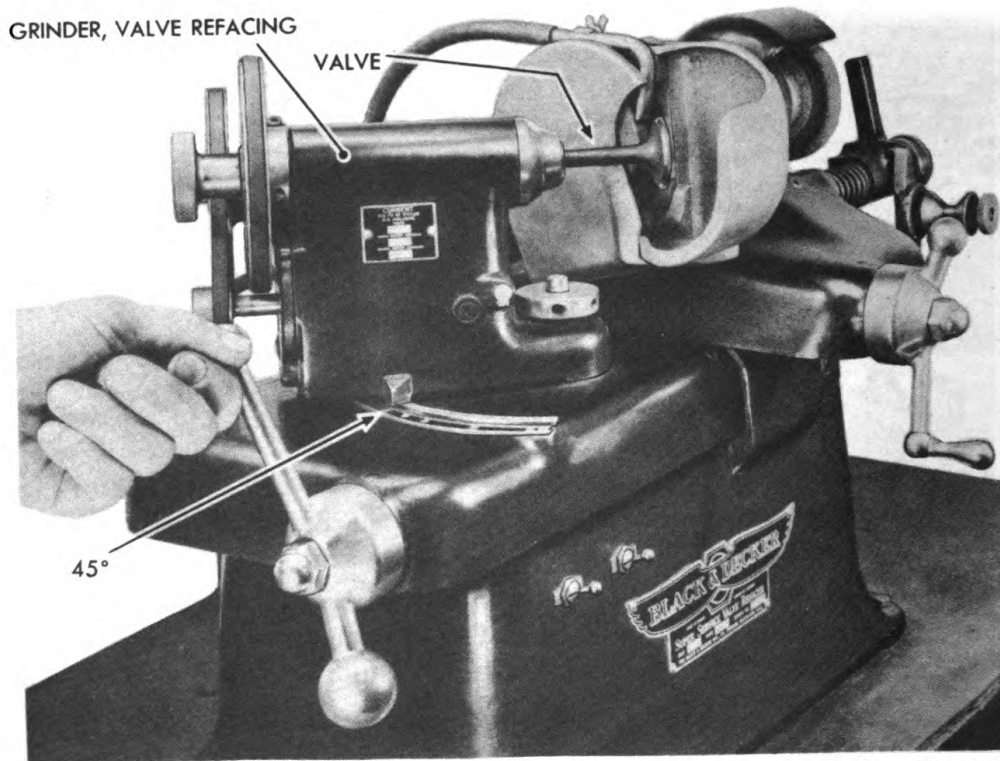


Figure 84—Valve Refacing

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

completely around valve seat. Repeat this operation until valve seat is cleaned up. Allow grinder to continue running until it cuts itself free. Shut off motor and allow grinder to stop before removing it from pilot.

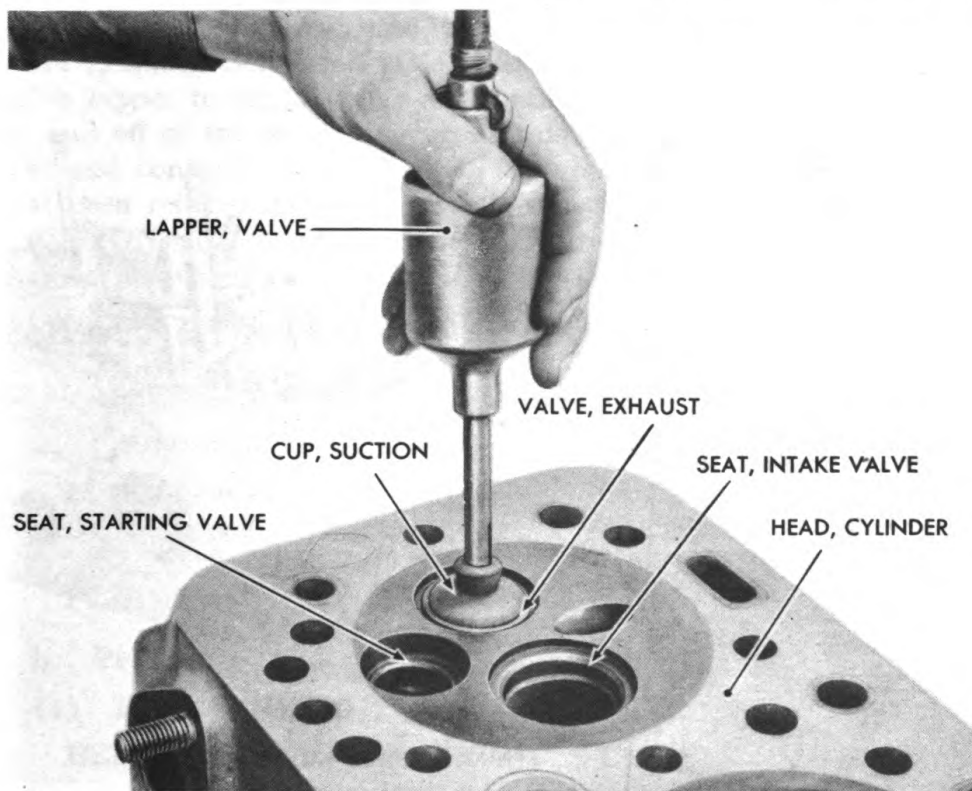
(d) Clean off all dust resulting from grinding operation.

(3) **CHECK VALVE SEAT** (fig. 83).

INDICATOR, valve seat

TOOL, pilot (Hall No. C-7 or equivalent)

(a) Check accuracy of work performed by placing valve seat indicator on pilot. Lock knurled screw while holding down on button. Set



RA PD 12902

Figure 85—Valve Lapping

dial to zero. Turn sleeve on indicator through one revolution, using thumb and forefinger. If seat is properly ground, reading will be within one one-thousandth of an inch (0.001-in.).

(4) **CHECK EXHAUST AND INTAKE VALVE SEATS FOR WIDTH.**

WHEEL, grinding (Hall No. C-5015 or equivalent)

WHEEL, grinding (Hall No. HX-6415 or equivalent)

WHEEL, grinding (Hall No. C-5075 or equivalent)

WHEEL, grinding (Hall No. HX-6475 or equivalent)

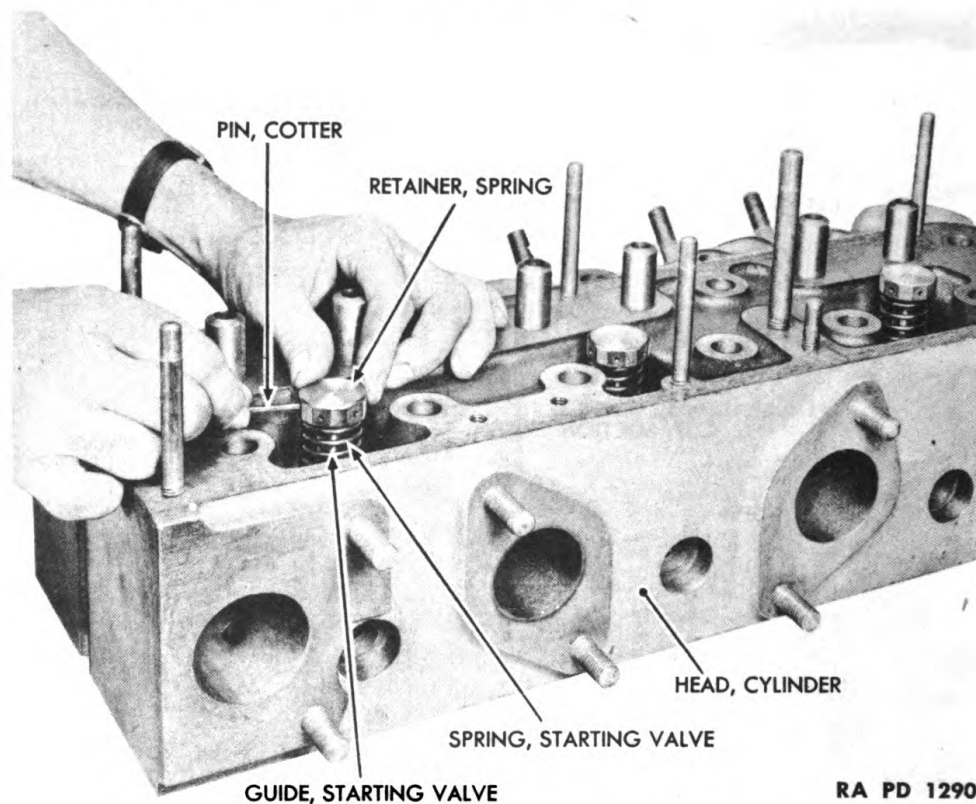
(a) Valve seat width should measure $\frac{3}{32}$ inch (exhaust and intake

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

only). If valve seat is wider than $\frac{3}{32}$ inch after grinding it will be necessary to narrow seat to this dimension.

(b) Use wheels (C-5015 and C-5075 for intake, and HX-6415 and HX-6475 for exhaust) to remove excess material from head immediately above and below edge of valve seat to bring valve seat to $\frac{3}{32}$ -inch width. Wheels C-5015 and HX-6415 remove material from head at top of valve seat. Wheels C-5075 and HX-6475 remove material from valve seat inside valve parts. Use same procedure for grinding as outlined in refacing valve seats in step (2) above.

(5) For any of the operations listed in this paragraph equivalent tools of other manufacturers may be used.



RA PD 12909

Figure 86—Starting Valve Installation

83. VALVE REFACING (fig. 84).

a. Equipment.

GRINDER, valve refacing

b. Procedure.

(1) Use a valve refacing grinder for this operation. Black and Decker type KW is illustrated. Insert valve in refacer. Before beginning refacing operation, rotate valve in refacer and check its movement for "wobble," which is evidence that valve is bent and should be replaced

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

with new part. If this check reveals that valve is straight, proceed to reface it. Adjust refacer to 45-degree angle. Then reface valve until it is entirely clean, with all pits removed.

- (2) Reface all remaining valves in same manner.

84. VALVE LAPPING (fig. 85).

a. Equipment.

COMPOUND, valve grinding, LAPPER, standard valve
fine

b. Procedure.

(1) Coat valve seat and valve with small quantity of standard valve grinding compound (fine grade). Attach suction cup of standard valve lapper to top of valve and, with lapper in operation, move valve on and off of the seat, using up and down motion on lapper. Lap until seat and contact surface of valve are uniformly lapped. If valves have just been refaced, lapping will dull shiny appearance of refaced valve. **CAUTION:** Thoroughly remove all traces of valve lapping compound when operation is completed.

- (2) Lap remaining valves in same manner.

85. ASSEMBLY OF CYLINDER HEADS.

a. Equipment.

BENCH, work SOLUTION, soap
LIFTER, valve (Herbrand WRENCH, open-end, 3/4-in.
VL-500 or equivalent) WRENCH, torque, 3/4-in.
PLIERS

b. Procedure.

- (1) **INSTALL STARTING VALVES (fig. 86).**

BENCH, work PLIERS

(a) Place cylinder head on its side on work bench and insert one valve into guide in cylinder head, positioning it firmly against valve seat. **NOTE:** Each starting valve must be replaced in valve guide from which it has been removed.

(b) Install starting valve spring in position over valve guide on top of cylinder head.

(c) Screw spring retainer tightly onto end of valve. Then back up retainer on valve. Cotter pin, inserted in spring retainer, will pass through slot in end of valve stem. Lock cotter pin.

- (d) Install remaining starting valves in same manner.

- (2) **INSTALL INTAKE AND EXHAUST VALVES (figs. 70 and 71).**

LIFTER, valve (Herbrand, No. VL-500 or equivalent)

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(a) Insert valve in same guide in which it was originally installed, seating valve firmly against valve seat.

(b) Insert lower seat over valve guide from top of cylinder head.

(c) Install retainer on valve stem, positioning it next to guide. Retainer will slip into first groove on valve stem when valve spring is released into its natural position.

(d) Place valve spring over valve stem and on lower seat. Place damper end of spring next to cylinder head. The first three coils are closer than the remaining coils on the damper end.

(e) Place upper seat over valve spring.

(f) Install Herbrand valve lifter, with clamp end over upper valve seat and spring, and with end of lifter gear resting on valve face. Then tighten lifter until spring is compressed.

(g) Position two valve spring collar keys in two top grooves of valve stem, with taper toward cylinder head.

(h) Release compression on valve spring so that upper seat slips over collar keys. Remove valve lifter.

(i) Install remaining exhaust and intake valves in same manner.

(3) **INSTALL NOZZLES (fig. 74).**

SOLUTION, soap

WRENCH, torque, $\frac{3}{4}$ -in.

(a) In following order, install spacer gasket, spacer (with side stamped "UP" toward top of cylinder head), second spacer gasket and nozzle body retainer dust seal in one of nozzle openings of cylinder head.

(b) Install nozzle body retainer dust seal. First coat dust seal with soap solution so seal will slip over retainer without damage. Install nozzle with nozzle body retainer attached. Place two nuts on cylinder head studs and tighten them to 45 foot-pounds pressure.

(c) Install remaining nozzle assemblies in same manner.

(4) **INSTALL EXPANSION PLUGS WHERE PLUGS HAVE BEEN REMOVED (fig. 75).**

(a) In the event that any expansion plugs have been removed from cylinder head, new plugs must be installed. Place plug in position in plug hole and tap center with a steel bar slightly smaller in diameter than the plug to expand plug in head.

86. CHECK OF CYLINDER HEADS BEFORE INSTALLATION.

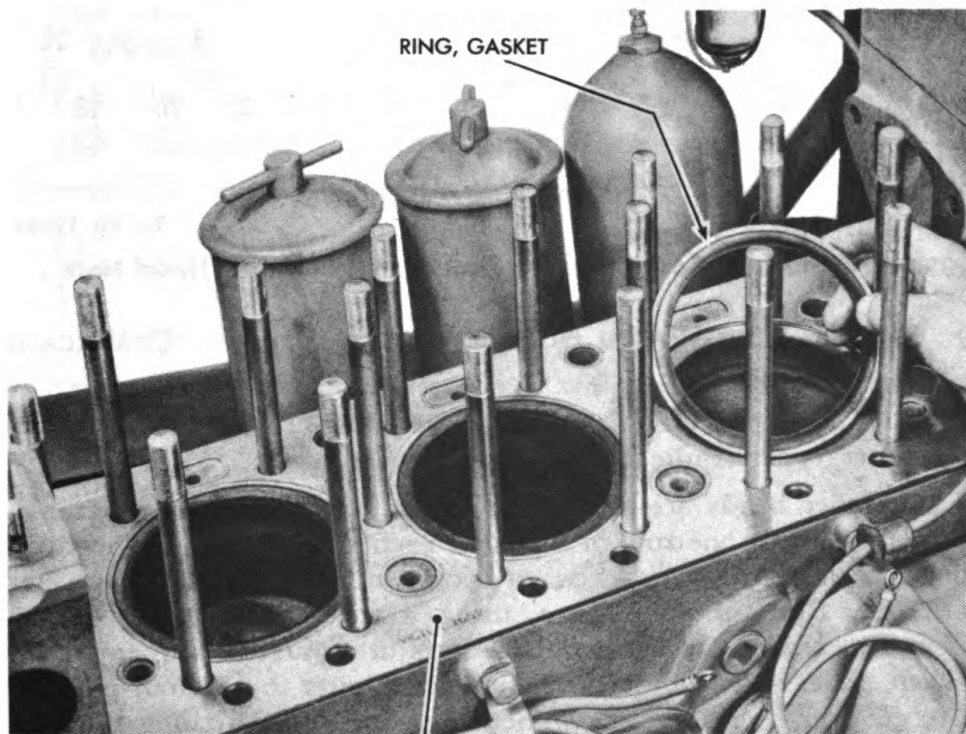
a. Before installing cylinder heads, they should be checked carefully to see that all carbon has been removed and that all passages are clean. Check all valves, valve springs and other parts for efficient operating condition and complete assembly as outlined in paragraph 85.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

87. CYLINDER HEAD INSTALLATION.

a. Equipment.

- | | |
|--|--|
| HOIST | WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle |
| PLIERS | WRENCH, socket, 1-in., and spinner type handle |
| VARNISH, shellac | WRENCH, spark plug |
| WRENCH, open-end, $\frac{9}{16}$ -in. | WRENCH, torque |
| WRENCH, open-end, $\frac{11}{16}$ -in. | |
| WRENCH, open-end, $\frac{3}{4}$ -in. | |
| WRENCH, socket, $\frac{9}{16}$ -in., and speeder | |



GASKET, CYLINDER HEAD, FRONT

RA PD 12699

Figure 87—Cylinder Head Gasket Installation

b Procedure.

- (1) INSTALL CYLINDER HEADS IN POSITION (fig. 69).

HOIST

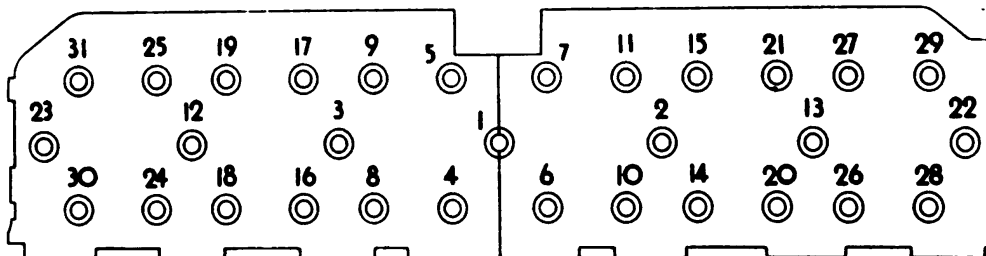
(a) Remove all traces of old gaskets from crankcase. Install new rear cylinder head gasket. Be sure it is in correct position with openings opposite openings in crankcase and then install gasket rings with flat side down in cylinders 4, 5 and 6. NOTE: Old rings which do not have ridge worn from top may be annealed for reuse. Otherwise, install new rings. To anneal old rings, place the rings into flame until red hot, and then immerse red hot rings in water.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(b) Use hoist attached to front and rear studs on rear cylinder head, with nuts replaced on studs used. Lift rear cylinder head into position on crankcase.

(c) Install front cylinder head gaskets, gasket rings and front cylinder head by following same procedure.

(d) Place edge of steel rule across finished surfaces at intake ports at center of engine. Be sure the two surfaces are in line. Cylinder heads can be shifted a little to bring them in line if necessary.



RA PD 12939

Figure 88—Proper Sequence for Tightening Cylinder Head Nuts

(2) INSTALL NUTS WHICH HOLD CYLINDER HEADS TO CRANKCASE (figs. 68 and 88).

WRENCH, socket, 1-in., and WRENCH, torque spinner type handle

(a) Cylinder heads are secured to crankcase by nuts on 31 crankcase studs. There is one row of studs on each side of cylinder head, in addition to center row. Stud between two cylinder heads has flat washer beneath nut. Run up nuts. Then, using wrench, tighten nuts to 100 foot-pounds, exercising care to tighten nuts in numerical sequence (fig. 88). Then, repeat same procedure, tightening nuts to 150 foot-pounds. Finally, go over nuts in same numerical sequence, tightening them to 170 foot-pounds.

(3) INSTALL PUSH RODS (fig. 67). Place push rods in position.

(4) CONNECT CROSS SHAFT THRUST BRACKET TO REAR CYLINDER HEAD (fig. 62).

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

(a) Place cross shaft thrust bracket in position on cylinder head, installing two cap screws and lock washers and tightening cap screws.

(5) INSTALL NEW HOUSING GASKET.

VARNISH, shellac

(a) Varnish attaching side of gasket and when varnish becomes tacky, but not thoroughly dry, place it in position on bottom of housing, exercising care to have gasket in correct position.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(6) PLACE VALVE SHAFT AND LEVER ASSEMBLY AND HOUSING IN POSITION ON CYLINDER HEADS (fig. 66).

(7) INSTALL CAP SCREWS IN CROSS SHAFT BRACKET AND FRONT CENTER BRACKET (fig. 65).

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Install four cap screws in cross shaft bracket and four cap screws in front center brackets. These cap screws hold brackets to cylinder heads.

(8) INSTALL 12 NUTS ON STUDS WHICH HOLD HOUSING IN PLACE (fig. 65).

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Use wrench to tighten nuts.

(9) INSTALL STUD NUTS IN RIGHT SIDE OF VALVE SHAFT.

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Use wrench to tighten five nuts.

(10) INSTALL VALVE SHAFT BRACKET STUD NUTS (fig. 64).

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

(a) Install nuts on center studs which hold end and intermediate brackets to cylinder heads and tighten.

(11) INSTALL CROSS SHAFT SPRING (fig. 64).

PLIERS

(a) Install spring which connects inner lever to anchor stud.

(12) ADJUST VALVES.

GAGE, feeler

(a) Insert feeler gage between valve stem and valve lever. Clearance should be 0.018-inch (par. 193).

(13) INSTALL VALVE HOUSING COVER (fig. 63).

VARNISH, shellac

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

(a) Varnish new cover gasket to housing, installing gasket when varnish is tacky but not quite dry. Be sure gasket is installed in correct position. Install strip of felt over studs and valve lever. Then install cover and secure it to housing with four copper washers and nuts and tighten nuts.

(14) SECURE CYLINDER HEAD TO DASH AND COWL ASSEMBLY.

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

(a) Insert two cap screws and lock washers through dash and cowl assembly from driver's side, install spacer on each cap screw and install cap screws in rear cylinder head. Second cap screw is located in cor-

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

responding position on other side of air cleaner. Tighten cap screws.

(15) **CONNECT CROSS SHAFT THRUST BRACKET TO REAR CYLINDER HEAD (fig. 62).**

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

(a) Place cross shaft thrust bracket in position on cylinder head, installing two cap screws and lock washers and tightening cap screws.

(16) **INSTALL WATER MANIFOLD.**

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Install new gasket and then place water manifold in position between front and rear cylinder heads. Install six cap screws and lock washers and tighten them.

(17) **INSTALL HEAT INDICATOR CABLE AND ELEMENT TO LEFT REAR SIDE OF REAR CYLINDER HEAD.**

WRENCH, open-end, $1\frac{1}{16}$ -in.

(a) Insert element into cylinder head opening and tighten connector.

(18) **INSTALL FUEL INJECTION PUMP TO NOZZLE PIPES.**

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

(a) Remove caps or tape which have been used to protect fuel injection pump delivery valve holders. Install pipes, tightening connectors at delivery valve holders and at nozzles. Attach clips on No. 1 and No. 6 pipes to cylinder head and tighten cap screw which holds each clip to cylinder head.

(19) **SECURE THERMOSTAT HOUSING AND WATER OUTLET ASSEMBLY TO CYLINDER HEAD.**

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

(a) Install new water outlet gasket. Install three cap screws and lock washers and tighten them.

(20) **CONNECT CROSS SHAFT OPERATING ROD TO CROSS SHAFT LEVER (fig. 61).**

PLIERS

(a) Install pin which holds adjusting yoke to cross shaft lever. Install cotter pin and lock cotter pin.

(21) **INSTALL SPARK PLUGS.**

WRENCH, spark plug

(a) Use spark plug wrench to install plugs.

(22) **CONNECT IGNITION WIRES TO SPARK PLUGS.** See electrical system section, TM 9-1777B.

(23) **INSTALL EXHAUST MANIFOLDS.** See paragraph 150.

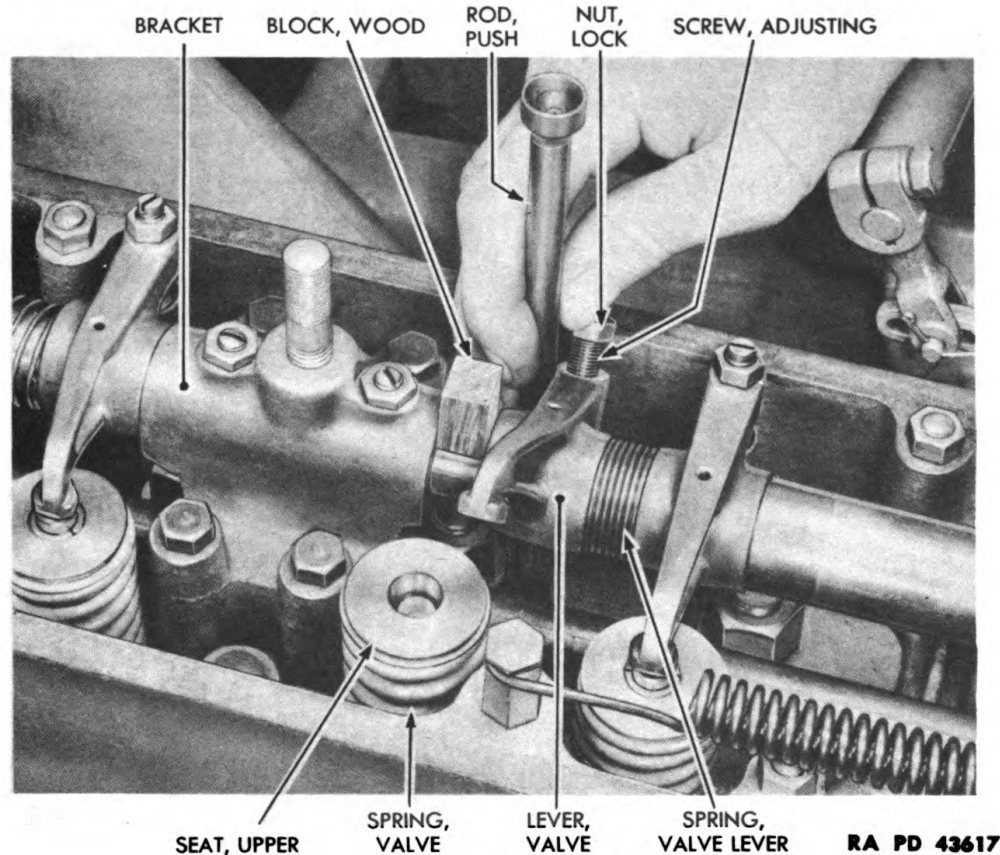
(24) **INSTALL INTAKE MANIFOLD.** See paragraph 147.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

- (25) INSTALL HOOD SHEET. See paragraph 204.
- (26) INSTALL MUFFLERS. See paragraph 205.

88. CONSTRUCTION OF VALVE LEVER ASSEMBLIES AND HOUSING (fig. 64).

a. The housing of the valve lever assemblies is mounted on top of the front and rear cylinder heads. The rear shaft supports four valve levers and is supported by an end bracket, the cross shaft bracket and an intermediate bracket. The center shaft supports four valve levers and is supported by the cross shaft bracket, an intermediate bracket and the front center bracket. The front shaft supports four valve levers and is supported by the front center bracket, an end bracket and an intermediate bracket. Valve levers are held in correct alinement on the shaft by means of spacers and valve lever springs. The valve levers are operated by the push rods, and the valve levers in turn operate the intake and exhaust valves.



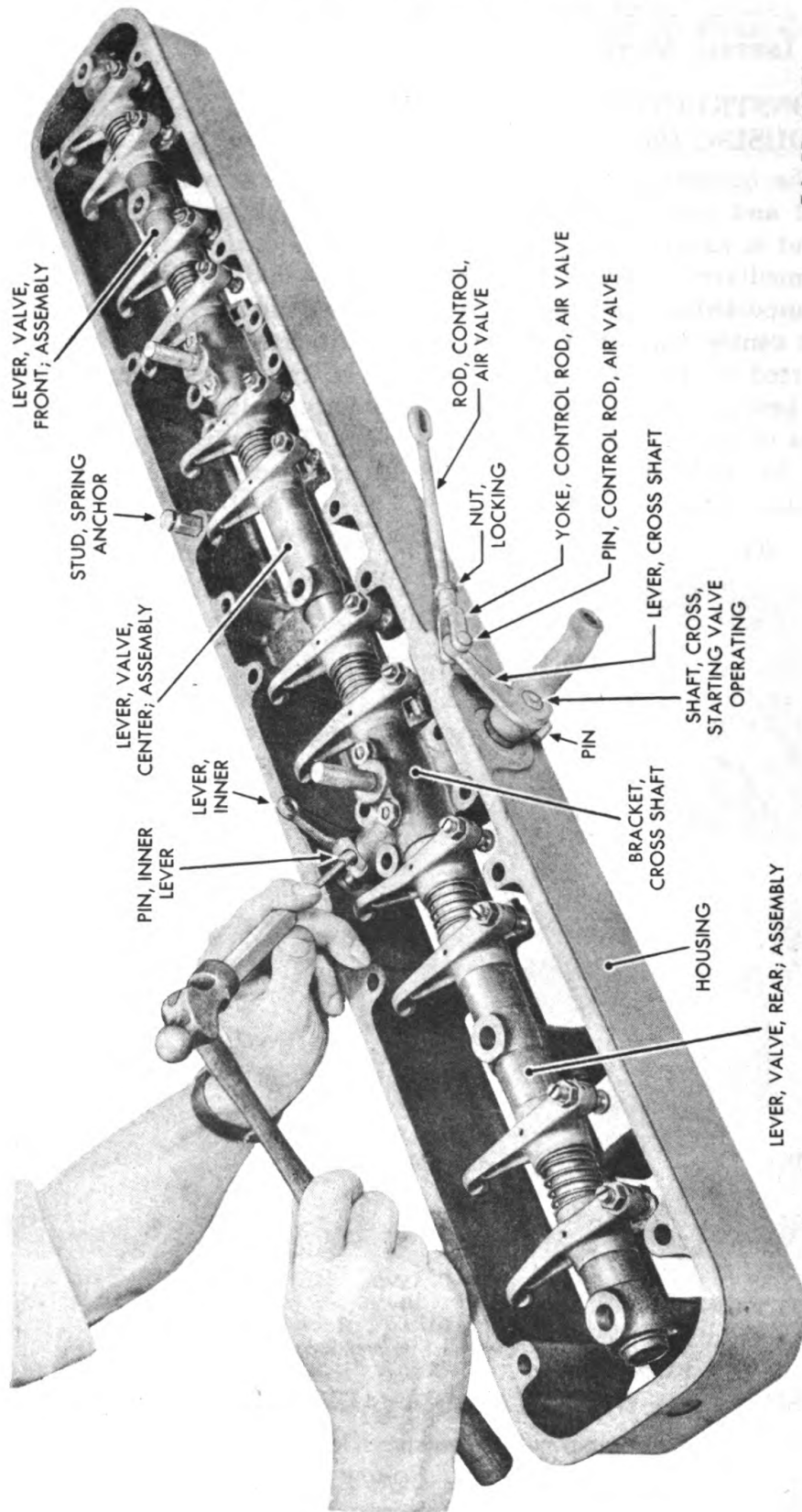
RA PD 43617

Figure 89—Valve Spring Replacing

89. INSPECTION OF INSTALLED VALVE LEVER ASSEMBLIES.

a. Intake and exhaust valve clearance can be checked between the valve levers and the valve stems. Follow the procedure outlined in paragraph 193.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12876

Figure 90—Starting Valve Cross Shaft Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

90. REMOVAL OF VALVE LEVER ASSEMBLIES AND HOUSING.

- a. Follow the procedure for removal of cylinder heads (par. 78).
b. If a valve spring must be replaced, it is not necessary to remove valve lever assemblies and housing. To replace a valve spring, proceed as follows:

(1) **REMOVE VALVE HOUSING COVER.** Remove four nuts and copper washers which hold cover to cylinder heads. Use a $\frac{3}{4}$ -inch open-end wrench. Lift off cover and remove gasket and felt.

(2) **POSITION PISTON ON TOP DEAD CENTER OF COMPRESSION STROKE UNDER VALVE TO BE REMOVED.**

(3) **LOOSEN LOCK NUT** (fig. 89). Use a $\frac{1}{2}$ -inch open-end wrench to loosen adjusting screw lock nut. Then turn valve adjusting screw to left, using a screwdriver, until end of screw strikes valve lever.

(4) **COMPRESS VALVE LEVER SPRING** (fig. 89). Depress valve and pull lever, compressing valve lever spring. Place a wood block between valve lever and bracket.

(5) **REMOVE PUSH ROD** (fig. 89). Lift out push rod and turn valve lever up, so valve spring will come off.

(6) **REMOVE VALVE SPRING** (fig. 89). Depress upper spring seat, remove keys and lift off the upper seat and valve spring.

(7) **INSTALL NEW VALVE SPRING.** Position spring with damper end next to cylinder head. Install upper valve seat, depress seat and spring and insert keys in groove in end of valve stem.

(8) **INSTALL PUSH ROD.**

(9) **REMOVE WOODEN BLOCK.** Remove block, allowing valve lever to return to position over push rod and valve. Depress valve slightly, if necessary to allow lever to return to position.

(10) **ADJUST VALVE CLEARANCE.** See paragraph 193.

91. DISASSEMBLY OF VALVE LEVER ASSEMBLIES AND HOUSING.

a. Equipment.

BAR, steel
DRIFT
DRIFT, brass
PLIERS
PRESS, arbor
PULLER, stud

SCREWDRIVER
SLEEVE
WRENCH, box, $\frac{1}{2}$ -in.
WRENCH, open-end, $\frac{7}{16}$ -in.
WRENCH, open-end, $\frac{1}{2}$ -in.
WRENCH, open-end, $\frac{9}{16}$ -in.

b. Procedure.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(1) REMOVE STARTING VALVE OPERATING CROSS SHAFT (fig. 90).

DRIFT, brass

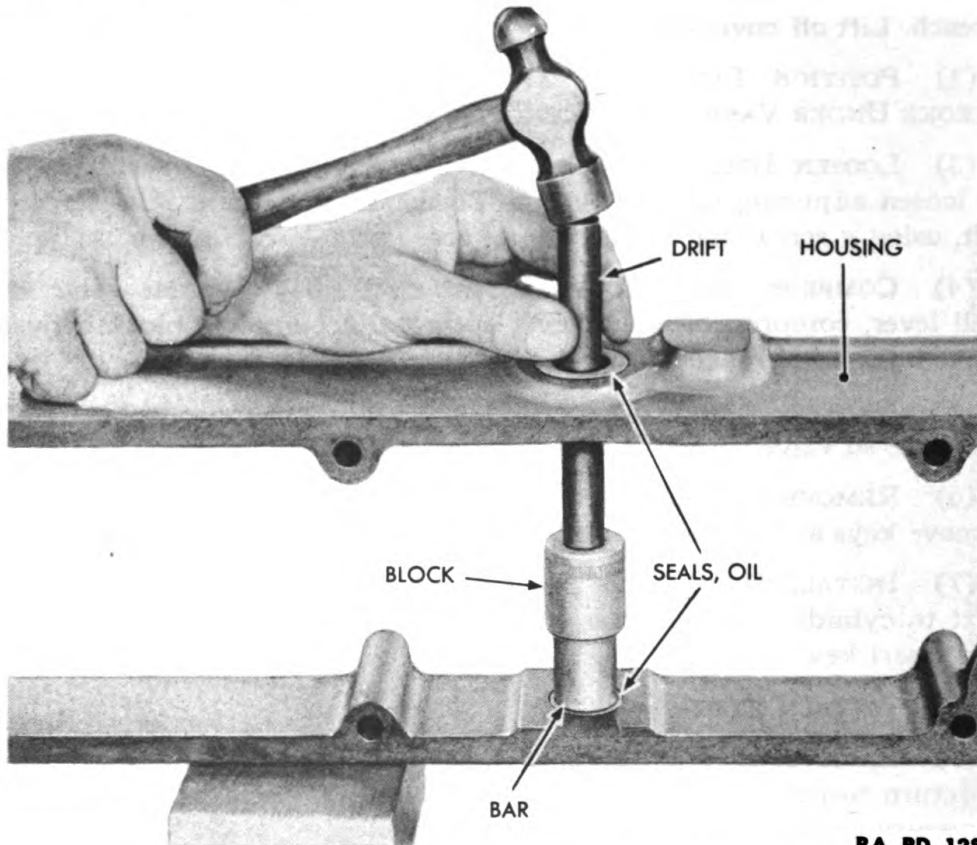
WRENCH, open-end, $\frac{7}{16}$ -in.

PLIERS

WRENCH, open-end, $\frac{1}{2}$ -in.

WRENCH, box, $\frac{1}{2}$ -in.

(a) Remove nut from inner lever pin which holds cross shaft in housing. Drive out pin.



RA PD 12877

Figure 91—Removing Oil Seal from Lever Housing

(b) Pull out cross shaft and remove inner lever.

(c) Remove air valve control rod from cross shaft lever, removing cotter pin from air valve control rod. Then remove pin, rod and air valve control rod yoke from lever.

(d) Release rod locking nut from yoke. Unscrew rod from yoke.

(e) Remove nut and lock washer from pin which holds cross shaft lever to starting valve cross shaft. Drive out pin. Remove cross shaft lever from cross shaft.

(2) LIFT VALVE LEVER ASSEMBLIES FROM HOUSING.

(3) REMOVE SPRING ANCHOR STUD.

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

- (a) Remove spring anchor stud from housing.
- (4) REMOVE TWO OIL SEALS FROM HOUSING (fig. 91).

BAR, steel

DRIFT

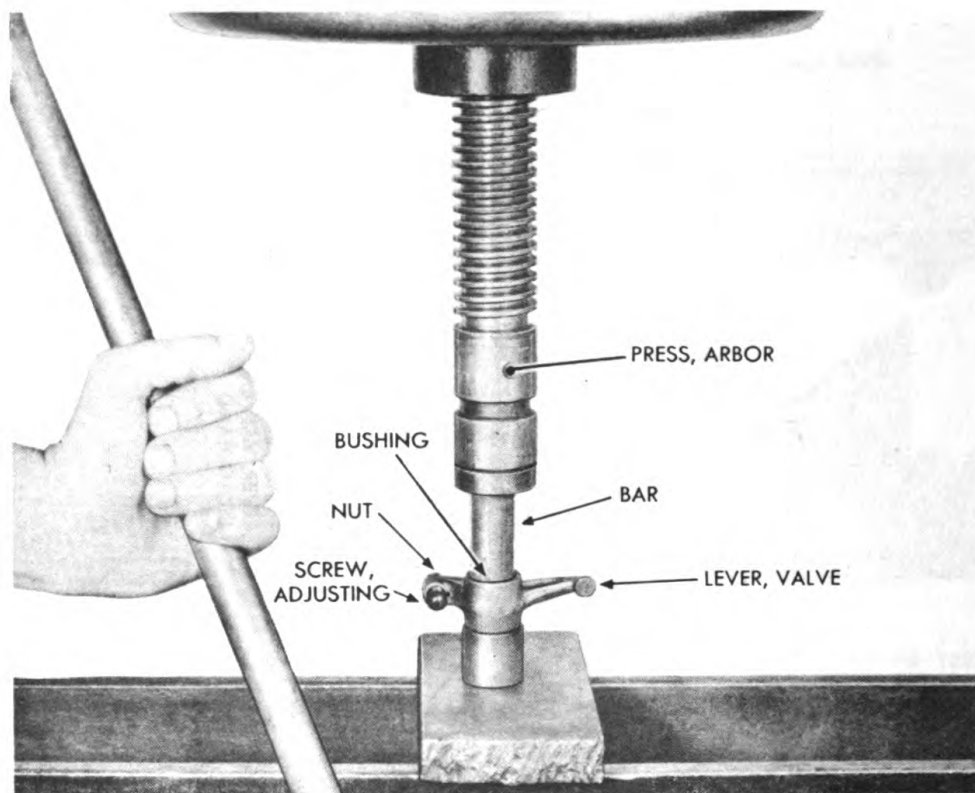
(a) Use steel bar, smaller in diameter than oil seal, to drive oil seals from each side of housing. Enter drift through opposite seal opening to drive sleeve which drives out seal.

(b) Remove oil seal from opposite side of housing in same manner.

(5) REMOVE FRONT CENTER BRACKET AND CROSS SHAFT BRACKET (fig. 92).

SCREWDRIVER

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



RA PD 12879

Figure 93—Pressing Out Valve Lever Bushing

(a) Loosen lock nuts on two set screws on front center bracket. Then loosen set screws. Pull out front valve lever shaft and attached parts. Also remove front starting valve shaft.

(b) Loosen lock nuts on two set screws on cross shaft bracket. Then loosen set screws. Remove center valve lever shaft and attached parts and starting valve shaft. Also remove rear valve lever shaft and attached parts and remove rear starting valve shaft. Then remove starting valve shaft gear from cross shaft bracket.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(6) DISASSEMBLE FRONT VALVE LEVER ASSEMBLY (fig. 92).

SCREWDRIVER

(a) Remove retainer ring from end of shaft. Then remove four valve levers, two valve springs, three spacers and two brackets.

(7) REMOVE PARTS FROM CENTER VALVE LEVER SHAFT (fig. 92). Remove four levers, two springs, two spacers and bracket from center of valve lever shaft.

(8) REMOVE PARTS FROM REAR VALVE LEVER SHAFT (fig. 92).

SCREWDRIVER

(a) Remove retainer ring from end of shaft. Then remove four valve levers, two springs, two spacers and two brackets from rear valve lever shaft.

(9) DISASSEMBLE VALVE LEVERS (fig. 93).

PRESS, arbor

WRENCH, open-end, 1/2-in.

SLEEVE

NOTE: Valve levers should not be disassembled until thoroughly inspected as outlined in paragraph 89. If the inspection reveals the necessity of replacing adjusting screws or bushings, procedure is as follows:

(a) Remove adjusting screw nut. Remove adjusting screw. Follow same procedure for all valve levers.

(b) Remove valve lever bushing by placing sleeve of slightly smaller diameter than bushing over bushing. Then place valve lever and sleeve in position in arbor press and press out bushing. This same procedure should be followed to remove bushings from other valve levers, as required.

(10) REMOVE PARTS FROM BRACKETS (fig. 92).

PULLER, stud

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

NOTE: Studs and adjusting screws on brackets should be inspected, as outlined in paragraph 92, and not removed unless inspection reveals need of new parts.

(a) If necessary to remove stud from center or cross shaft bracket, use standard stud puller.

(b) If necessary to remove adjusting screw from one of brackets, use wrench to loosen nut and then remove screw.

(11) REMOVE ROLLERS FROM STARTING VALVE SHAFTS (fig. 92).

NOTE: Rollers should not be removed from shafts unless inspection procedure outlined in paragraph 89 discloses the necessity of new parts being installed.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

92. CLEANING AND INSPECTION OF VALVE LEVER ASSEMBLIES AND HOUSING PARTS.

a. Clean all parts thoroughly in SOLVENT, dry-cleaning. Dry all parts thoroughly, using compressed air if available.

b. **Inspect All Parts.**

(1) **INSPECT ALL VALVE LEVER BUSHINGS.** Install levers on their proper shafts and check for excessive play of bushing on shaft. Install new bushings when play is excessive (par. 93).

(2) **INSPECT VALVE LEVER ADJUSTING SCREWS.** If nut on adjusting screw is loose, check screw for tight fit. If screw is loose, it should be replaced.

(3) **CHECK VALVE LEVER SPRINGS.** Examine all springs for breakage, rust and pits. Replace if present.

(4) **CHECK VALVE LEVER SHAFTS.** Examine shafts for appearance of wear or scoring at bearing points. When excessive wear results in too much play after valve levers are installed, shafts should be replaced, providing valve lever bushing has been replaced.

(5) **INSPECT BRACKET SET SCREWS AND STUDS.** Check for stripped threads on bracket set screws, installing new screws when this condition is found. Also examine center and cross shaft bracket studs for stripped threads, installing new parts when this condition is encountered.

(6) **INSPECT STARTING VALVE SHAFTS.** Examine rollers of three sections starting valve shaft for excessive wear, which will be evidenced by excessive play on pins. Install new pins and roller when play is excessive.

(7) **INSPECT STARTING VALVE GEAR.** Examine gear for broken, worn or chipped teeth, installing new part if any of these conditions appear.

93. OVERHAUL OF VALVE LEVER ASSEMBLIES.

a. **Equipment.**

PRESS, arbor
REAMER
SLEEVE

WISE
WRENCH, open-end, 7/16-in.

b. **Procedure.**

(1) **CLEAN AND INSPECT ALL PARTS.** Follow procedure outlined in paragraph 92.

(2) **INSTALL NEW PARTS.** Install new parts to replace all parts found to be defective when making inspection outlined in paragraph 92. Install new gaskets and oil seals.

(3) **INSTALL NEW BUSHINGS IN VALVE LEVERS, AS REQUIRED (fig. 93).**

BAR, steel
PRESS, arbor

WISE
WRENCH, open-end, 7/16-in.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(a) Press bushing into valve lever. Place new bushing in position over valve lever, with steel bar of slightly larger diameter than bushing on top of bushing. It is important that bushing be positioned so that oil-holes line up with oilholes in lever and with long center oil groove of bushing pointing toward end of lever. Place bushing and sleeve in arbor press and press bushing into position.

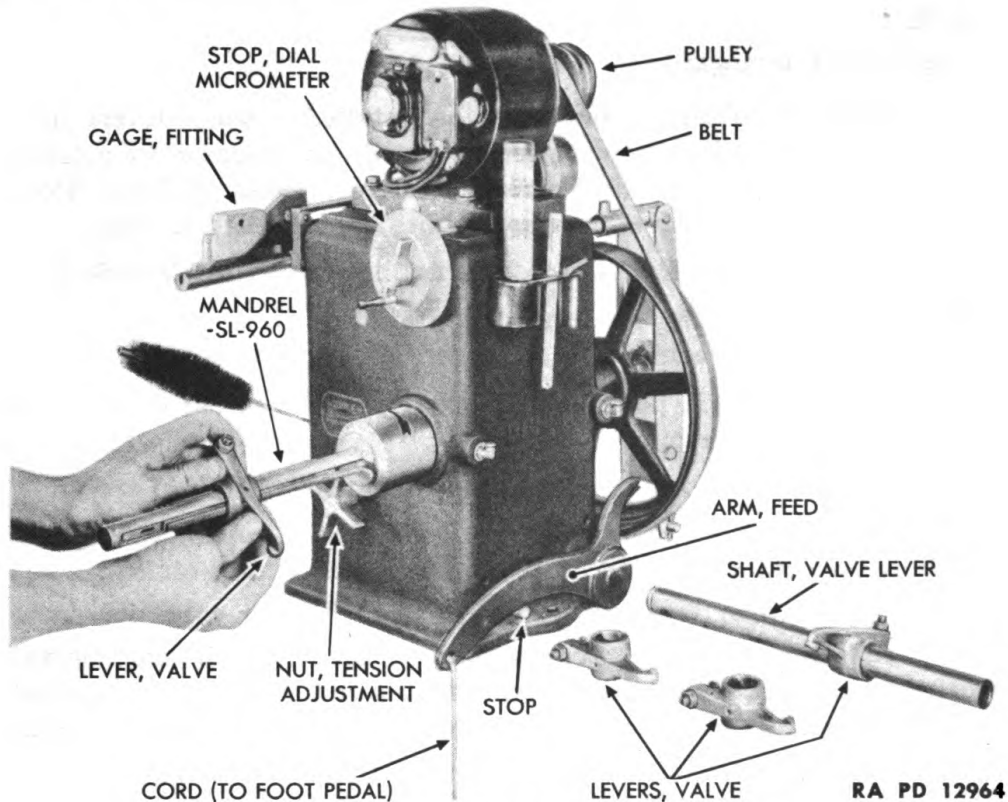


Figure 94—Valve Lever Bushing Honing

(4) **HONING VALVE LEVER BUSHING** (fig. 94). Proceed as in instructions given for honing connecting rod bushing, with the exception that mandrel No. SL-960 or equivalent is used for this operation. Clearance between bushing and valve lever shaft is 0.0015- to 0.002-inch.

94. ASSEMBLY OF THE VALVE LEVER ASSEMBLIES.

a. Equipment.

CHISEL, hand, cold
HAMMER
SCREWDRIVER

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

b. Procedure.

(1) **ATTACH PARTS TO BRACKETS** (fig. 92).

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) If new studs must be installed on center or cross shaft brackets, attach two $\frac{3}{4}$ -inch nuts to top of studs, locking them together. Then use wrench on top nut to install stud.

(b) If new set screws are to be installed on brackets, install screw and jam nuts.

(2) **ATTACH ADJUSTING SCREWS AND LOCK NUTS TO VALVE LEVERS (fig. 92).**

SCREWDRIVER

(a) If new adjusting screws are to be installed on valve levers, install them, making sure that they are screwed well into lever before attaching shaft lever assembly to cylinder head. Attach lock nut by hand. Do not tighten it until after valve lever assemblies are installed in engine.

(3) **INSTALL NEW ROLLERS AND PINS ON STARTING VALVE LEVER SHAFT, AS NEEDED (fig. 92).**

CHISEL, hand, cold

(a) Place rollers in position and insert pins. Then use chisel to lock pinholes of shaft over pins.

(4) **ASSEMBLE FRONT VALVE LEVER ASSEMBLY (fig. 92).**

**HAMMER
SCREWDRIVER****WRENCH, open-end, $\frac{9}{16}$ -in.**

(a) Tap retainer ring into groove in end of front valve lever shaft.

(b) Insert front valve lever into end bracket, with starting valve shaft hole in bracket at right as you face ring end of shaft. Position valve lever shaft so that set screw recess in opposite end of shaft is in vertical position.

(c) Place outer spacer ($2\frac{3}{32}$ -in. wide) on shaft.

(d) Place right-hand valve lever onto shaft with adjusting screw at left as you look at shaft from retainer ring end. **NOTE:** All other valve levers should be similarly positioned.

(e) Place spring on shaft.

(f) Place straight valve lever on shaft.

(g) Place intermediate spacer on shaft.

(h) Place intermediate bracket on shaft, with base stud hole toward valve lever adjusting screw side.

(i) Place intermediate spacer on shaft.

(j) Place straight valve lever on shaft.

(k) Place spring on shaft.

(l) Place left-hand valve lever on shaft.

(m) Insert front starting valve shaft into front end bracket.

(n) Place ends of front starting valve shaft and front valve lever shaft into front center bracket. Tighten set screw which secures front

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

valve lever shaft in front end bracket. Be sure end of screw engages notch in shaft. Then tighten jam nut.

(5) ASSEMBLE REAR VALVE LEVER ASSEMBLY (fig. 92).

SCREWDRIVER

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

(a) Identical parts are used in the rear valve lever assembly and in the front valve lever assembly, except for the shaft bracket. They should be assembled in a similar manner, except that following order should be observed in assembling the rear valve lever assembly:

1. Install retainer ring on shaft, the shaft into end bracket, outer spacer, left-hand valve lever, valve spring, straight valve lever, intermediate spacer, intermediate bracket, intermediate spacer, straight valve lever, valve spring and right-hand valve lever.

2. Place rear starting valve shaft into rear end bracket.

3. Insert ends of rear starting valve shaft and rear valve lever shaft into cross shaft bracket. Tighten cross shaft set screw on rear valve lever shaft. Tighten set screw jam nut.

(6) ASSEMBLE CENTER VALVE LEVER ASSEMBLY (fig. 92).

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

(a) Position center valve lever shaft with bracket set screw recess upward and with intermediate bracket hole in shaft nearest to cross shaft bracket.

(b) Beginning with cross shaft bracket end of shaft, install following parts: left-hand valve lever, valve spring, straight valve lever, outer spacer, intermediate bracket, center spacer, straight valve lever, valve spring and right-hand valve lever.

(c) Position front end rear starting valve shafts with rollers under valve lever shaft. Install gear in cross shaft bracket end of center starting valve shaft and insert gear and center valve starting shaft into cross shaft bracket.

(d) Insert center valve lever assembly in cross shaft bracket and tighten cross shaft set screw into center valve lever shaft recess. Then tighten jam nut.

(e) Insert center starting valve shaft and center valve lever shaft into front center bracket. Tighten set screw of bracket into recess in center valve lever bracket. Tighten jam nut. NOTE: Starting valve operating cross shaft, air valve control nut and attached parts, housing, and other parts disassembled should not be assembled at this point, but should be installed on engine when engine is reassembled.

95. INSTALLATION OF PARTS IN VALVE LEVER HOUSING.

a. Equipment.

BAR, steel

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

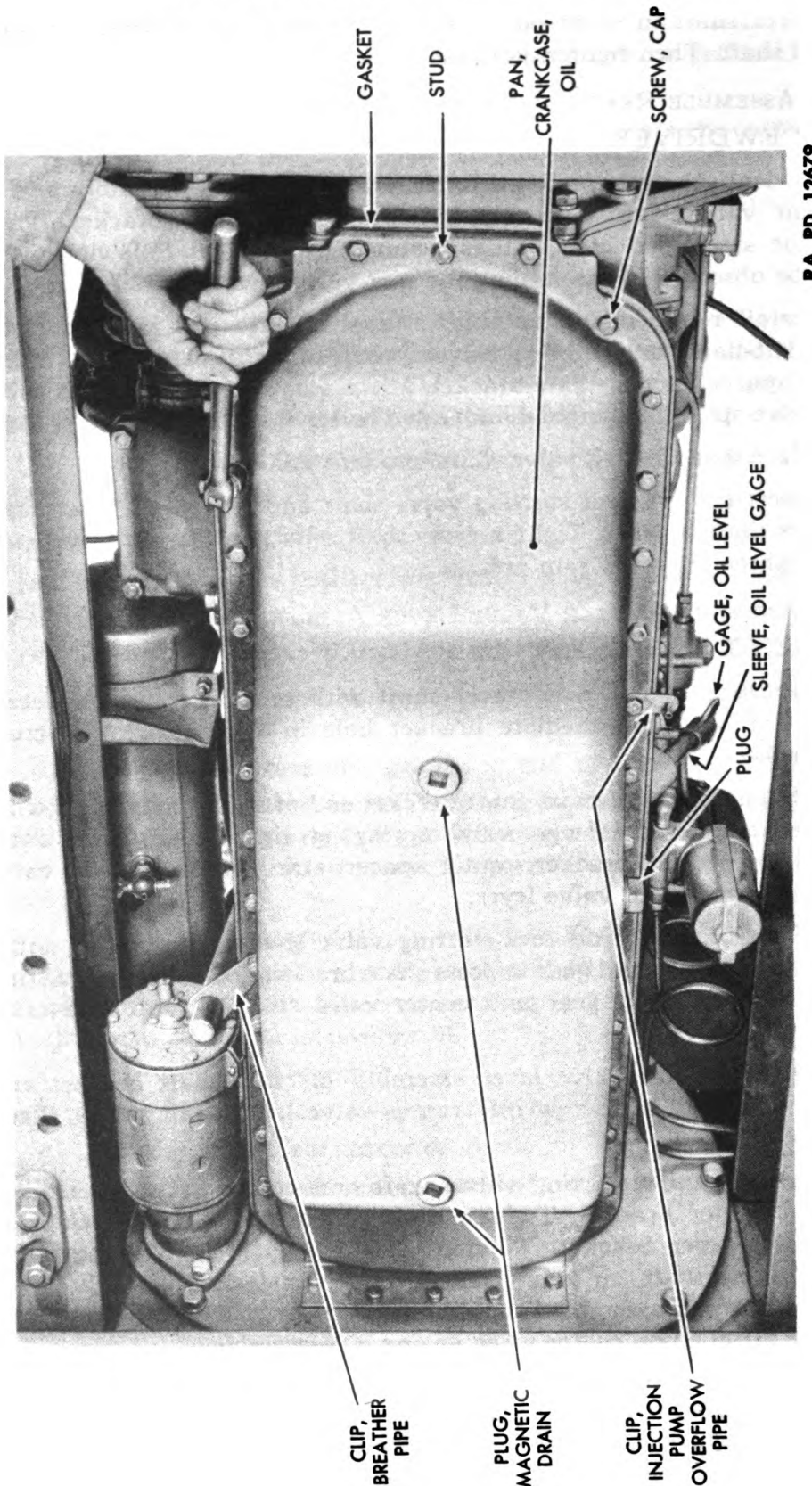


Figure 95—Crankcase Oil Pan Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

b. Procedure.

**(1) INSTALL NEW OIL SEALS IN SIDES OF VALVE LEVER HOUSING.
BAR, steel**

(a) Position oil seal with lip toward inside of housing, with oil seal over opening on outside of housing. This is the reverse of removal procedure pictured in figure 91. Use steel bar of slightly smaller diameter than oil seal and drive oil seal into position in housing. Install oil seal on opposite side of housing in similar manner.

**(2) INSTALL SPRING ANCHOR STUD.
WRENCH, open-end, $\frac{9}{16}$ -in.**

(a) Use wrench to tighten stud in housing.

**96. INSTALLATION OF VALVE LEVER ASSEMBLIES AND
HOUSING.**

a. Follow the procedure for installation of cylinder heads (par. 87, step b (3) through to the end of the paragraph).

b. Check intake and exhaust valve clearance. Follow the procedure outlined in paragraph 193.

97. INSPECTION OF INSTALLED CRANKCASE OIL PAN.

a. In addition to periodic inspections, whenever the tractor is laid up for service, the crankcase oil pan should be inspected for leaks at the gasket. Drain plugs should be checked for tightness.

98. CRANKCASE OIL PAN REMOVAL (fig. 95).

a. Equipment.

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle, with extension

b. Procedure.

(1) REMOVE CRANKCASE GUARD. See paragraph 31.

(2) REMOVE OIL PAN.

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle, with extension

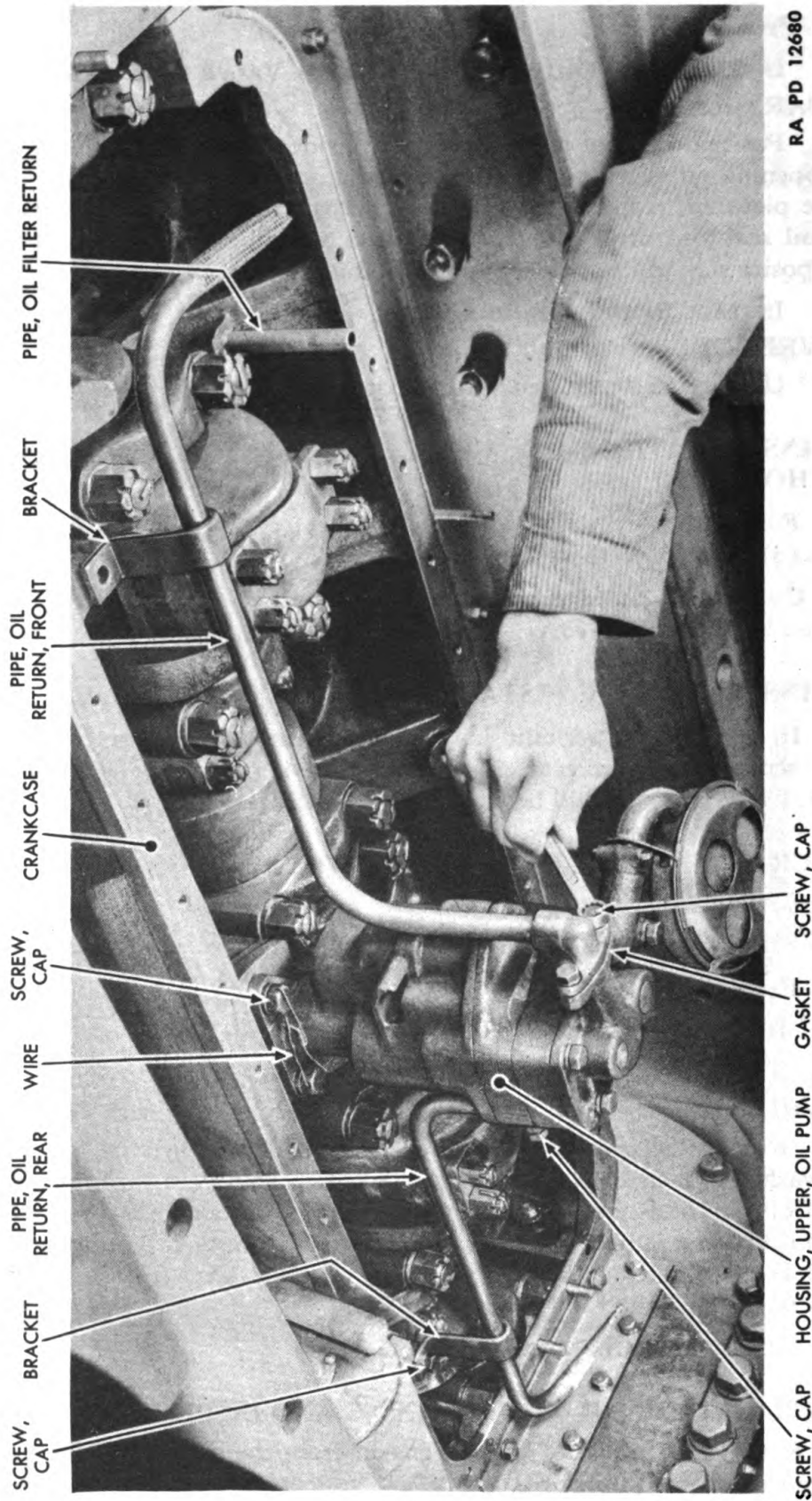
(a) Remove 32 cap screws and lock washers and four stud nuts and lock washers which hold oil pan to crankcase. There are three studs at rear of oil pan and one in front. To remove stud nuts and cap screws at rear of oil pan, it is necessary to use extension on wrench. Also, two men should be available to lift oil pan away from crankcase after all cap screws and nuts have been removed.

(3) REMOVE CRANKCASE OIL PAN GASKET.

99. CRANKCASE OIL PAN CLEANING AND INSPECTION.

a. Remove all traces of the old gasket from the oil pan. Then wash out the pan thoroughly in SOLVENT, dry-cleaning.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12680

Figure 96 — Lubricating Oil Pump Front Oil Return Pipe Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

100. CRANKCASE OIL PAN INSTALLATION.

a. Equipment.

COMPOUND, joint and thread WRENCH, socket, $\frac{9}{16}$ -in., and
speeder, with extension

b. Procedure (fig. 95).

(1) INSTALL NEW CRANKCASE OIL PAN GASKET.

COMPOUND, joint and thread WRENCH, socket, $\frac{9}{16}$ -in., and
speed, with extension

(a) Remove all traces of old gasket. Use slight amount of joint and thread compound on surface of oil pan for placing gasket in position, so that gasket will not slip out of place.

(2) INSTALL OIL PAN TO CRANKCASE. Two men are required to lift oil pan in position on crankcase. Install 32 cap screws and lock washers, three rear stud nuts and lock washers and front stud nut and lock washer. Tighten and use extension on wrench to tighten rear cap screws and nuts.

(3) INSTALL CRANKCASE GUARD. See paragraph 206.

101. LUBRICATING OIL PUMP REMOVAL.

a. Equipment.

PLIERS WRENCH, open-end, $\frac{9}{16}$ -in.
WRENCH, box, or open-end, WRENCH, open-end, $\frac{3}{4}$ -in.
 $\frac{1}{2}$ -in.

b. Procedure.

(1) REMOVE CRANKCASE GUARD. See paragraph 31.

(2) REMOVE CRANKCASE OIL PAN. See paragraph 98.

(3) REMOVE FRONT OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end, WRENCH, open-end, $\frac{9}{16}$ -in.
 $\frac{1}{2}$ -in.

(a) Remove cap screw and lock washer which hold pipe bracket to crankcase. Disconnect pipe from oil pump cover, removing two cap screws and lock washers. Lift off front oil return pipe and remove gasket.

(4) REMOVE REAR OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end, WRENCH, open-end, $\frac{9}{16}$ -in.
 $\frac{1}{2}$ -in.

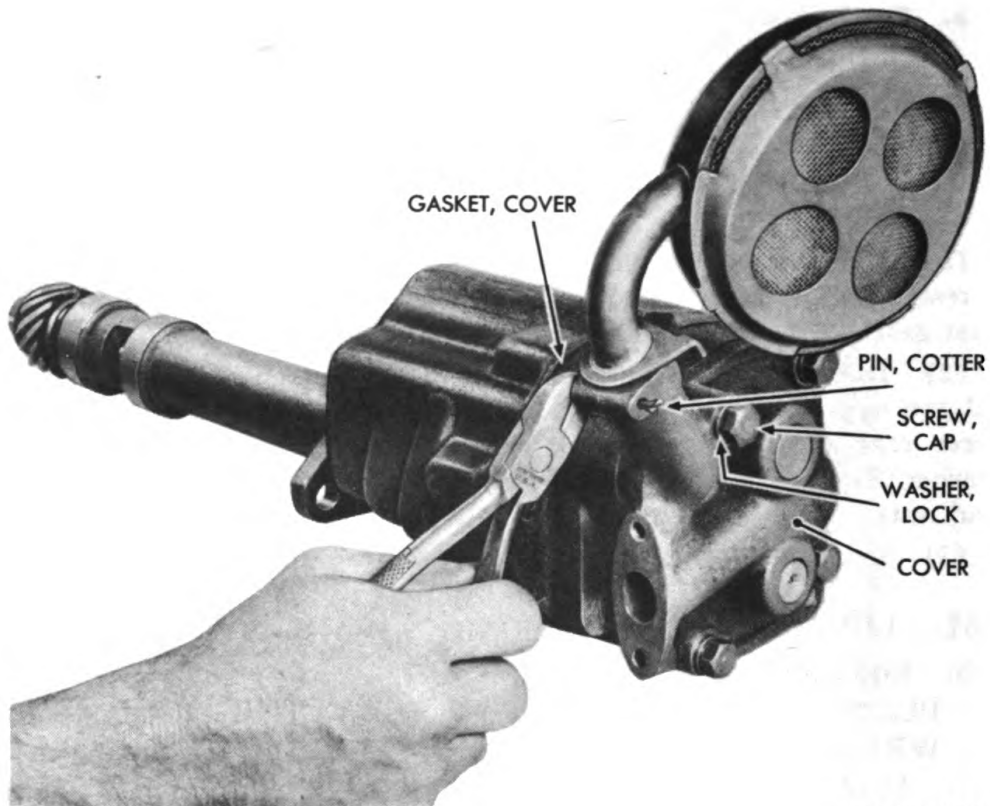
(a) Remove cap screw and lock washer which hold pipe bracket to crankcase. Then disconnect pipe from lubricating oil pump upper housing, removing two cap screws and lock washers. Lift out pipe and gasket.

(5) REMOVE LUBRICATING OIL PUMP (fig. 96).

PLIERS WRENCH, open-end, $\frac{3}{4}$ -in.

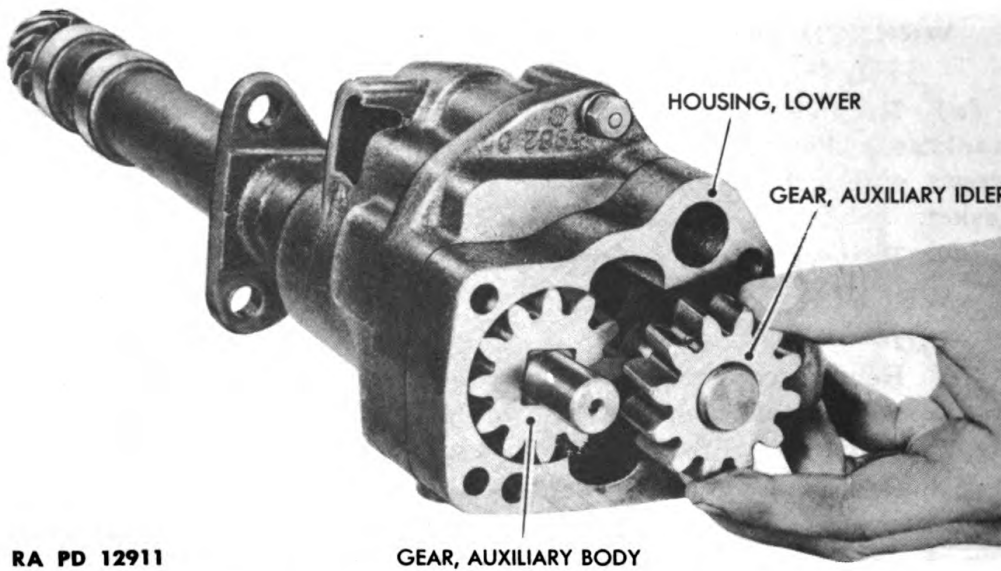
(a) Remove wire which locks drilled cap screws that hold pump to crankcase. Remove cap screws and lock washers, then lower pump from crankcase.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12910

Figure 97—Lubricating Oil Pump Float Removal



RA PD 12911

**Figure 98—Lubricating Oil Pump Auxiliary Idler
and Body Gear Removal**

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

102. LUBRICATING OIL PUMP DISASSEMBLY.

a. Equipment.

HAMMER, brass

PLIERS

PUNCH

ROD, brass

WISE, with copper jaws

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

b. Procedure.

(1) REMOVE FLOAT (fig. 97).

PLIERS

(a) Remove cotter pin which holds float to cover. Remove float.

(2) REMOVE COVER (fig. 97).

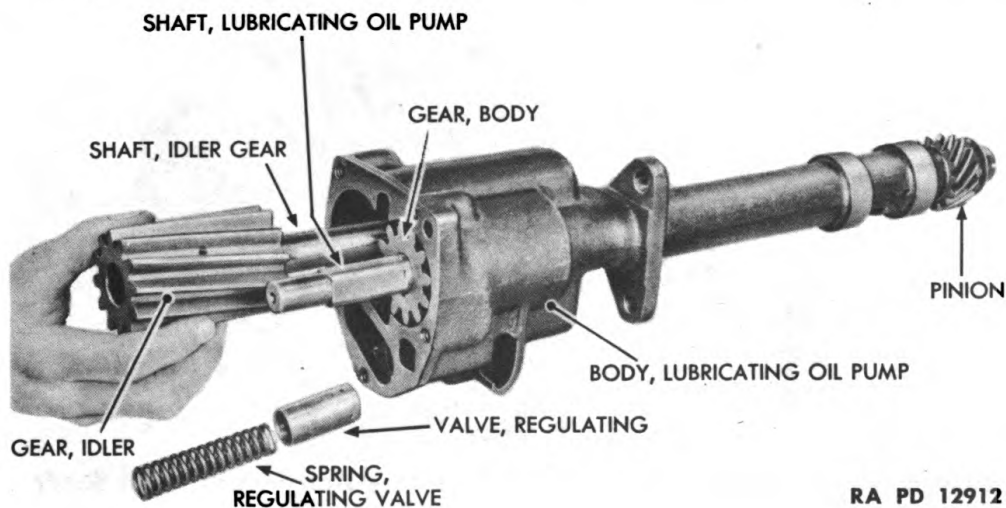
WRENCH, open-end, $\frac{9}{16}$ -in.

(a) Remove four cap screws and lock washers which hold cover to lower housing. Lift off cover and cover gasket.

(3) LIFT OUT AUXILIARY IDLER GEAR AND AUXILIARY BODY GEAR (fig. 98).

(4) LIFT OFF LOWER HOUSING (fig. 98).

(5) REMOVE AUXILIARY GEARS FROM LOWER HOUSING (fig. 98). Lift out auxiliary idler gear and auxiliary body gear and then remove lower housing.



RA PD 12912

Figure 99—Lubricating Oil Pump Idler Gear Removal

(6) REMOVE UPPER HOUSING.

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

(a) Remove cap screw and lock washer that hold upper housing to pump body and lift off housing.

(7) REMOVE REGULATING VALVE. Lift out regulating valve and spring from body.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

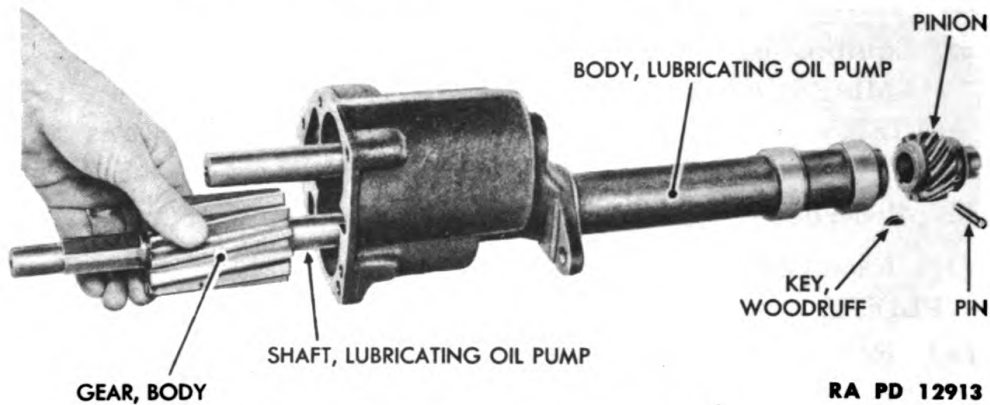


Figure 100—Lubricating Oil Pump Shaft Removal

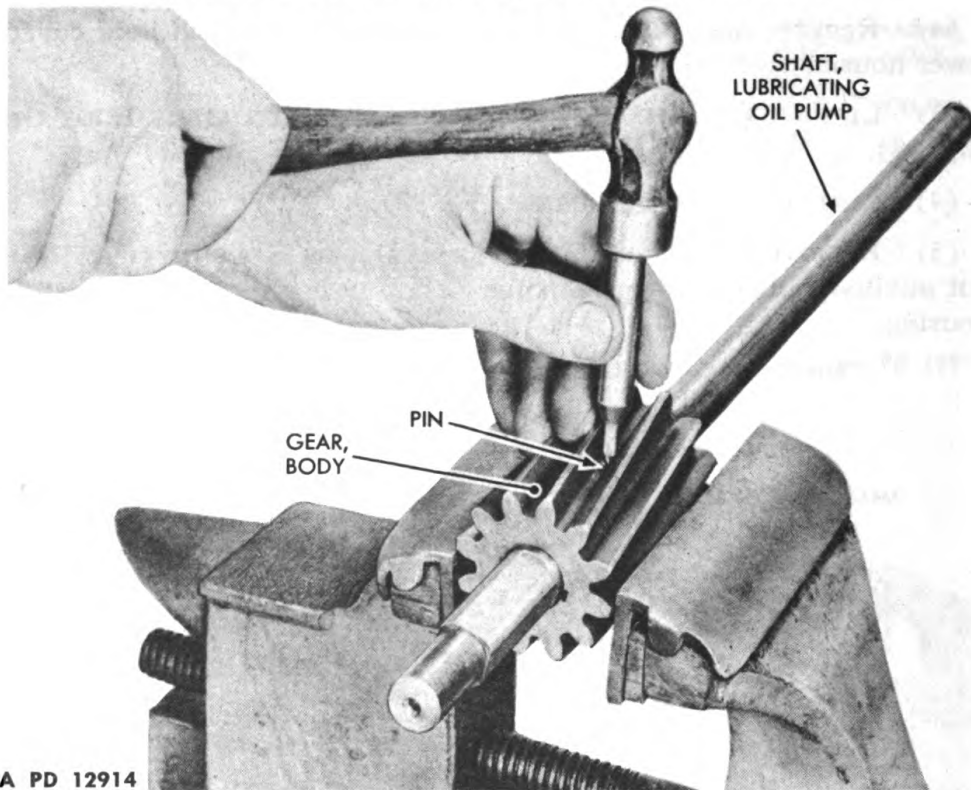


Figure 101—Removing Lubricating Oil Pump Body Gear from Shaft

(8) REMOVE IDLER GEAR (fig. 99). Lift out idler gear and then remove upper housing gasket.

(9) REMOVE SHAFT WITH BODY GEAR (fig. 100).

PUNCH

WISE, with copper jaws

ROD, brass

(a) Place pump body between copper jaws of vise. Then drive out pin which holds pinion to shaft.

(b) Drive pinion from shaft. Remove Woodruff key.

(c) Lift out shaft with body gear attached.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(10) REMOVE BODY GEAR FROM SHAFT (fig. 101).

HAMMER, brass

PUNCH

(a) Do not remove body gear from shaft until clearance has been checked (par. 103 b (2)). Drive out pin which secures body gear to shaft. Remove body gear from shaft. Remove Woodruff key.

(11) DO NOT REMOVE IDLER SHAFT FROM BODY (fig. 101). Body and idler shaft are available as an assembly. In the event that shaft wears, body likewise will wear. Therefore both parts should be replaced.

103. LUBRICATING OIL PUMP INSPECTION.

a. Equipment.

GAGE, feeler

SOLVENT, dry-cleaning

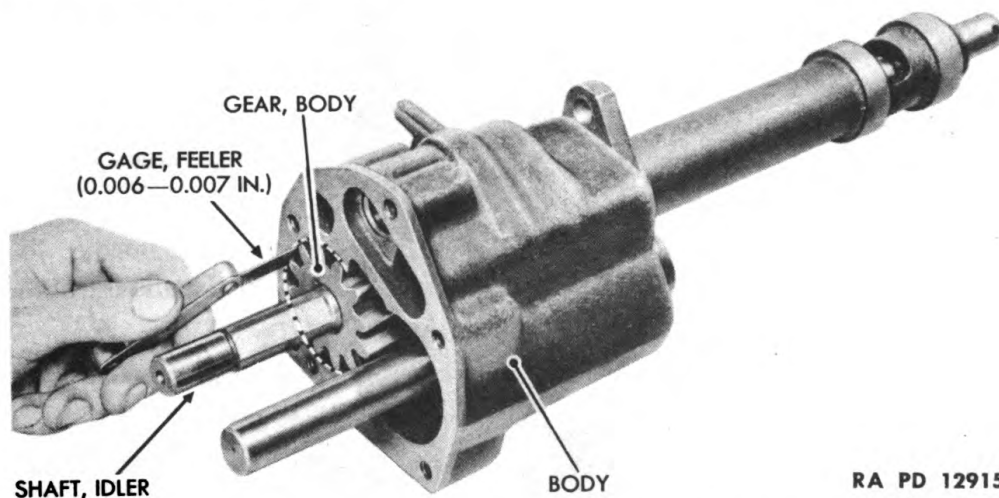
TESTER, spring, special valve
and clutch (IHC No. SE-
1057 or equivalent)

b. Procedure.

(1) CLEAN ALL PARTS.

SOLVENT, dry-cleaning

(a) All parts of lubricating oil pump should be washed thoroughly in SOLVENT, dry-cleaning.



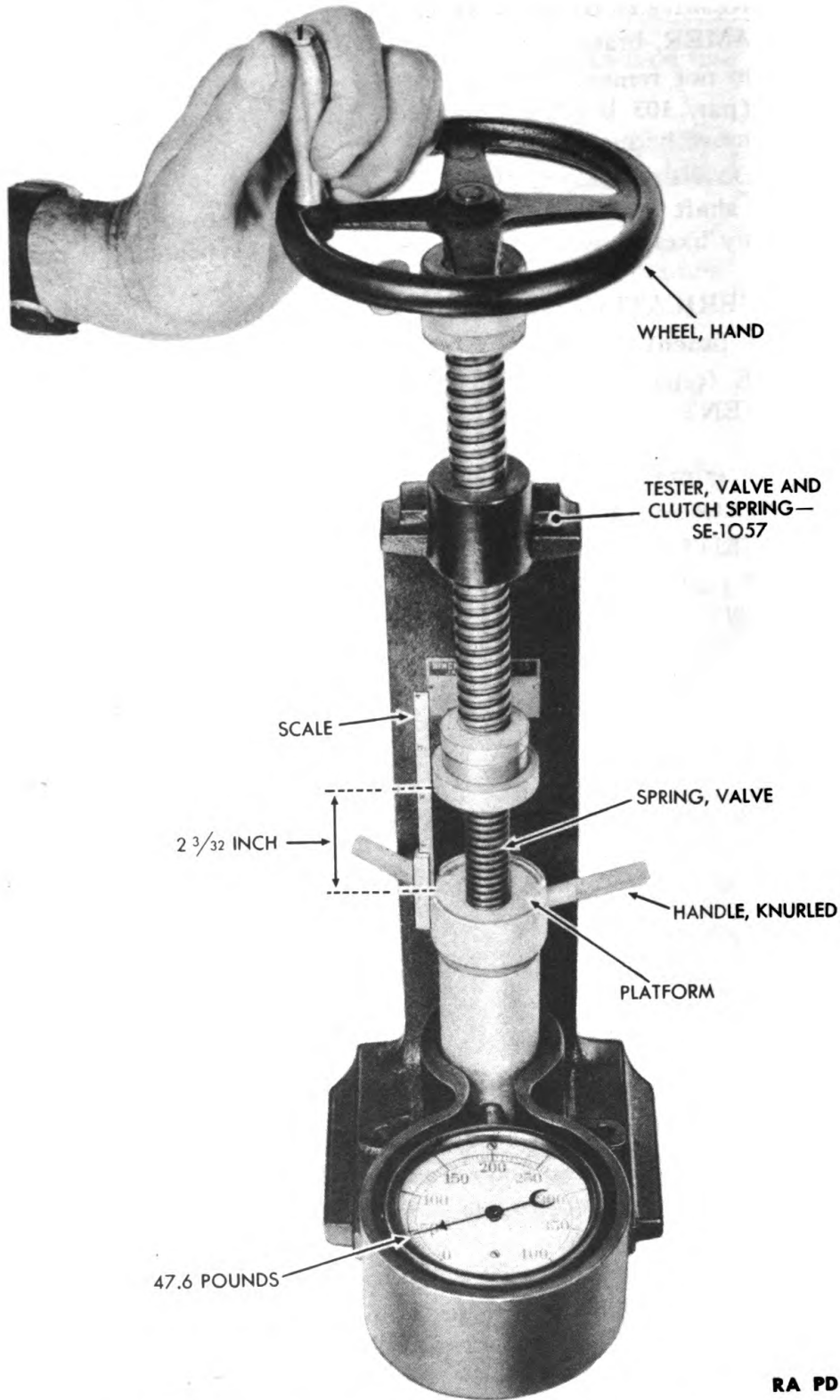
**Figure 102—Checking Clearance Between Lubricating Oil
Pump Body Gear and Body**

(2) INSPECT LUBRICATING OIL PUMP SHAFT, BODY AND IDLER GEARS AND BODY (fig. 102).

GAGE, feeler

(a) Before removing body gear from shaft, insert shaft and body gear into body, then check for excessive play, placing feeler gage between body gear and body. Place feeler gage between body gear and pump body and turn gear through one complete revolution while holding gage in one position. Move gage around body by its own width and again turn through one revolution. Repeat operation until entire distance

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12925

**Figure 103—Lubricating Oil Pump Pressure Regulator
Valve Spring Testing**

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

around body has been checked. New gear and new body clearance is 0.006- to 0.007-inch.

(b) Check body for evidence of wear from body gear and, if wear is evident, replace body by new part, along with shaft. NOTE: If oil pressure is low with no cause, as outlined in paragraph 15 on trouble shooting, play in lubricating oil pump shaft may be the cause.

(c) Check end of body gear for scoring, which might be caused by wear on upper housing.

(d) Check for worn, broken or chipped gear teeth on idler gear and body gear. Replace defective parts with new gears.

(e) Insert idler gear on body shaft and into body gear. Check clearance between idler gear and housing, in similar manner to which clearance between body gear and housing was checked. Clearance between new gear and new body is 0.006- to 0.007-inch.

(3) INSPECT UPPER HOUSING.

(a) Check surface of upper housing for wear from idler and body gears. If wear is present, and oil pressure is inadequate, with all other possible causes eliminated, as outlined in paragraph 15 on trouble shooting, new upper housing should be installed.

(4) INSPECT AUXILIARY IDLER GEAR AND BODY GEAR. Examine both gears for broken, chipped or worn teeth. Install new gears if gears used are defective.

(5) INSPECT LOWER HOUSING. Examine lower housing for wear from auxiliary body and idler gears. Install new housing if excessive wear is present.

(6) INSPECT LOWER AUXILIARY BODY AND IDLER GEARS. Check gears for worn, broken or chipped teeth. Replace defective gears with new parts.

(7) INSPECT COVER. Check cover for wear from lower auxiliary idler and body gears. Install new cover if wear is found to be excessive.

(8) INSPECT REGULATOR VALVE SPRING (fig. 103).

TESTER, spring, special valve and clutch (IHC No. SE-1057 or equivalent)

(a) Place spring in special valve and clutch spring tester and test spring pressure. Place spring on platform as near center as possible. Then turn handwheel, compressing spring to desired height, reading height on scale at side of platform. This scale reads from bottom up. With spring compressed to desired height, move one of knurled handles in platform to and fro to release any friction that may exist in hydraulic cylinder. After moving handle, recheck height on scale at left of spring. It should test 47.6 pounds at $2\frac{3}{32}$ -inch length. Free length of spring should be $3\frac{3}{32}$ -inch.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

104. LUBRICATING OIL PUMP OVERHAUL.

a. **Disassemble Lubricating Oil Pump.** Follow procedure outlined in paragraph 102.

b. **Inspect Lubricating Oil Pump Parts.** Follow procedure outlined in paragraph 103.

c. **Replace Defective Parts.**

(1) All parts found to be defective in inspection outlined in paragraph 103 must be replaced by new parts.

(2) Install new gaskets throughout.

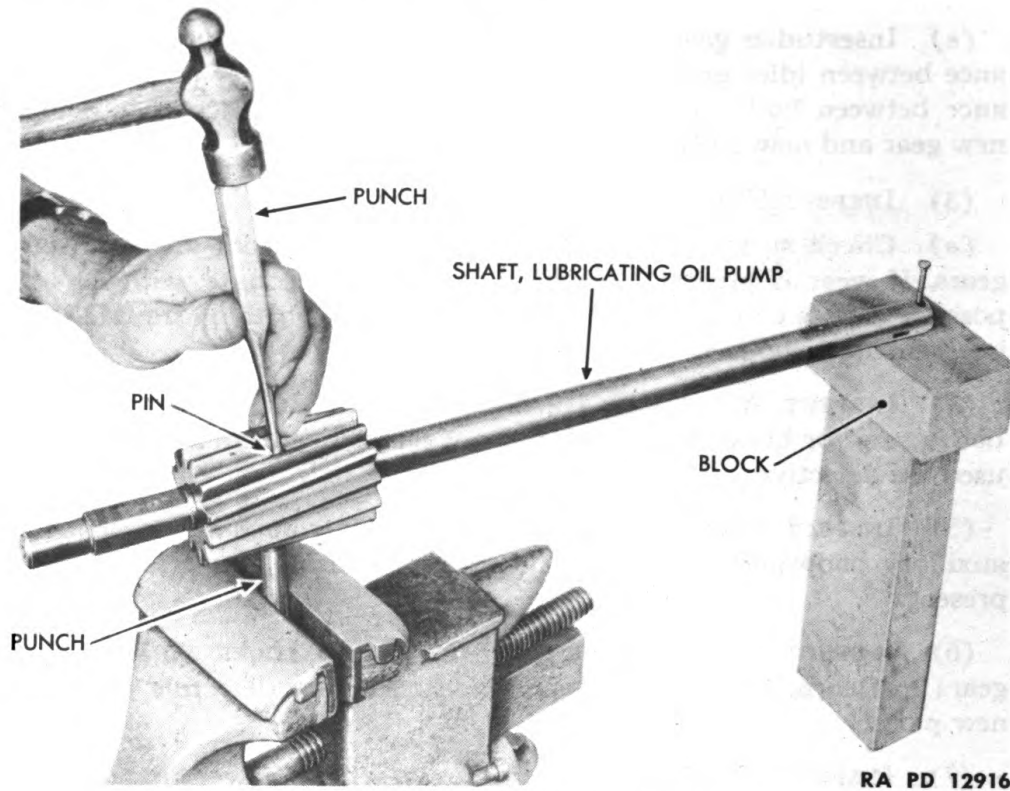


Figure 104—Locking Pin Which Holds Lubricating Oil Pump Body Gear on Shaft

105. ASSEMBLY OF LUBRICATING OIL PUMP.

a. **Equipment.**

BLOCKS

GAGE, feeler

HAMMER, rawhide

PUNCH, large

PUNCH, small

WISE

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

b. **Procedure.**

(1) **INSTALL BODY GEAR TO SHAFT** (fig. 104)

BLOCKS

WISE

PUNCHES, (2)

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(a) Place Woodruff key in shaft. Place gear over square end of shaft, lining up pinhole in gear with hole in shaft. Tap pin into position.

(b) Place small punch in vise and rest one end of pin on punch. Rest opposite end of shaft on blocks. Then use second punch to lock pin in gear. Next, turn gear over and lock other end of pin. **CAUTION:** Exercise care not to damage gear when using punch to lock ends of pin.

(2) PLACE SHAFT AND BODY GEAR IN POSITION IN BODY.

(3) INSTALL PINION.

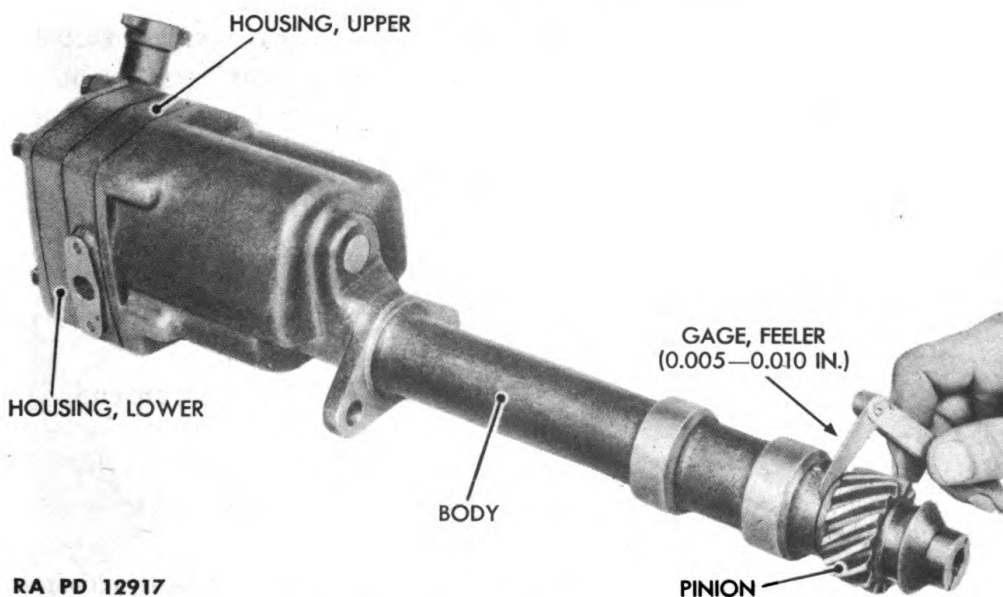
HAMMER, rawhide
PUNCHES (2)

VICE

(a) Place Woodruff key in shaft and position pinion on shaft so that its slot is in alignment with key. Tap pinion in place so that pinhole in pinion lines up with pinhole in shaft.

(b) Install pin which holds pinion to shaft. Lock ends of pin. To do this, place one punch in vise, rest one end of pin on punch and then use another punch to lock end of pin. Turn shaft over and lock other end of pin.

(4) PLACE IDLER GEAR ON IDLER GEAR SHAFT.



RA PD 12917

**Figure 105—Checking End Clearance Between Pump
Body and Pinion Gear**

(5) INSTALL REGULATING VALVE AND SPRING. Insert flat end of valve into body and then insert valve spring.

(6) INSTALL UPPER HOUSING. Install new upper housing gasket if available. However, since this gasket serves as shim, do not attempt to cut new gasket. If new gasket is not available, it is preferable to use old

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

one. Then place upper housing in position and secure with cap screw and lock washer.

(7) **INSTALL AUXILIARY IDLER AND BODY GEARS.** Place auxiliary idler gear on idler gear shaft and auxiliary body gear on pump shaft.

(8) **INSTALL LOWER HOUSING.** Position lower housing and gasket on upper housing.

(9) **INSTALL COVER.**

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

(a) Install new cover gasket if available. However, do not attempt to cut new gasket, since this gasket also serves as shim. If new gasket is not available, use old gasket. Then install cover and secure with four cap screws and lock washers.

(10) **CHECK CLEARANCE BETWEEN PUMP BODY AND PINION** (fig. 105).

GAGE, feeler

(a) Place feeler gage between end of pump body and pinion with pinion pulled away from body as far as it will go. This clearance should be 0.005- to 0.010-inch.

(11) **CHECK CLEARANCE BETWEEN PUMP BODY AND END OF PUMP BODY GEAR.** Pull pinion away from pump body and measure clearance. Push pinion toward pump body as far as it will go and measure clearance. The difference between these two figures gives the amount of clearance between pump body and pump body gear. This clearance should be 0.003- to 0.005-inch.

106. LUBRICATING OIL PUMP INSTALLATION.

a. Equipment.

PLIERS
WIRE

WRENCH, box, or open-end,
 $\frac{1}{2}$ -in.

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

b. Procedure.

(1) **REMOVE IGNITION DISTRIBUTOR.** Follow procedure outlined in paragraph 45. It is necessary to remove distributor before installing lubricating oil pump. Engine should then be turned to top dead center of compression stroke of No. 1 cylinder. To do this, follow procedure outlined in electrical system section, TM 9-1777B.

(2) **INSTALL LUBRICATING OIL PUMP IN POSITION IN ENGINE** (fig. 96). Place oil pump in position in engine so that distributor drive slots in end of pinion gear are approximately parallel with crankshaft, with offset toward engine when pinion is fully engaged with gear on camshaft.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(3) SECURE LUBRICATING OIL SUMP TO ENGINE (fig. 96).

PLIERS

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

WIRE

(a) Install two drilled cap screws and lock washers which hold lubricating oil pump to crankcase and tighten nuts. Then insert wire through drilled cap screws and lock wire.

(4) INSTALL REAR OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end, 1/2-in.

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

(a) Place rear oil return pipe in position with new gasket installed where pipe connects to upper housing. Secure pipe to upper housing with two cap screws and lock washers, tightening cap screws. Secure pipe bracket to crankcase, tightening cap screw and lock washer.



RIGHT SIDE OF ENGINE

RA PD 12687

Figure 106—Piston and Connecting Rod Removal

(5) INSTALL FRONT OIL RETURN PIPE (fig. 96).

WRENCH, box, or open-end, 1/2-in.

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

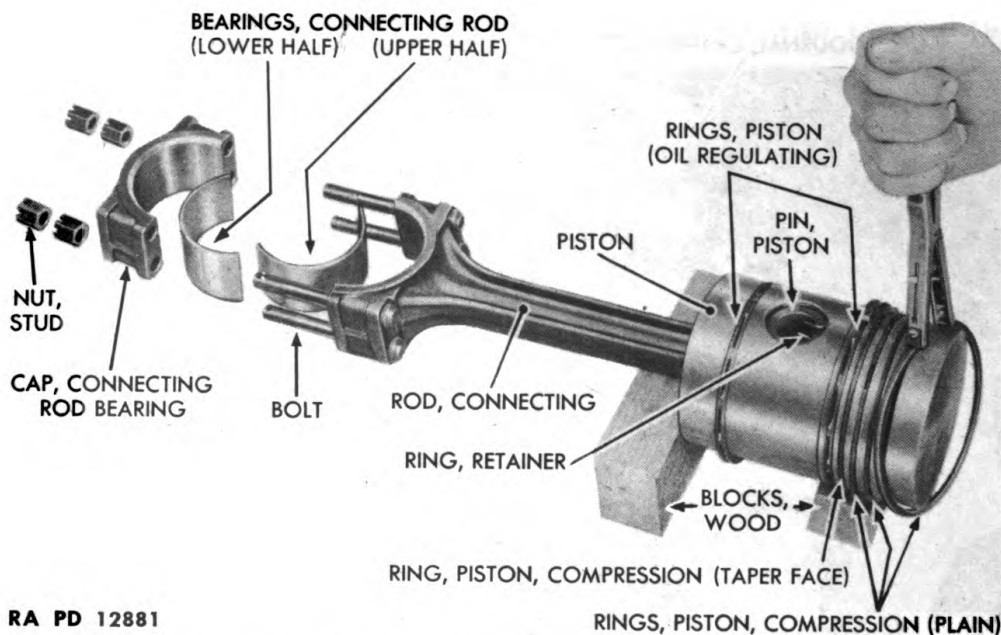
(a) Install new gasket at oil pump cover and attach front oil return pipe, tightening two cap screws and lock washers. Tighten cap screw and lock washer which hold pipe bracket to crankcase.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

- (6) INSTALL CRANKCASE OIL PAN. See paragraph 100.
- (7) INSTALL CRANKCASE GUARD. See paragraph 206.
- (8) TIME DISTRIBUTOR WITH ENGINE. See electrical system section, TM 9-1777B.

107. PISTON AND CONNECTING ROD REMOVAL (fig. 106).

- a. Place Compression Release Lever in Gasoline Cycle Position.
- b. Remove Spark Plug Corresponding to Piston and Connecting Rod Which Is Being Removed.
- c. Remove Crankcase Guard. See paragraph 31.
- d. Remove Crankcase Oil Pan. See paragraph 98.
- e. Remove Connecting Rod Bearing. See paragraph 114.



RA PD 12881

Figure 107—Removing Piston Rings from Piston

f. Crank Engine Until Crankshaft Journal for Connecting Rod Being Removed Is in Extreme Right Position. The accurate extreme right position for crankshaft journal can be determined by removing flywheel mark cover on rear engine support and cranking engine until "PP 2 & 5" mark appears on flywheel. NOTE: This procedure is for pulling pistons 2 and 5. The flywheel is similarly marked for pistons 1 and 6 and for 3 and 4.

g. Pull Out Connecting Rod and Piston from Left Side of Crankshaft (fig. 106). Exercise caution so that piston and ring are not damaged when being removed.

h. Remove Balance of Pistons and Connecting Rods in Same Manner.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

108. PISTON AND CONNECTING ROD DISASSEMBLY.

a. Equipment.

BAR, steel

BLOCKS, small wooden

DRIFT, brass

HAMMER, brass

PLIERS

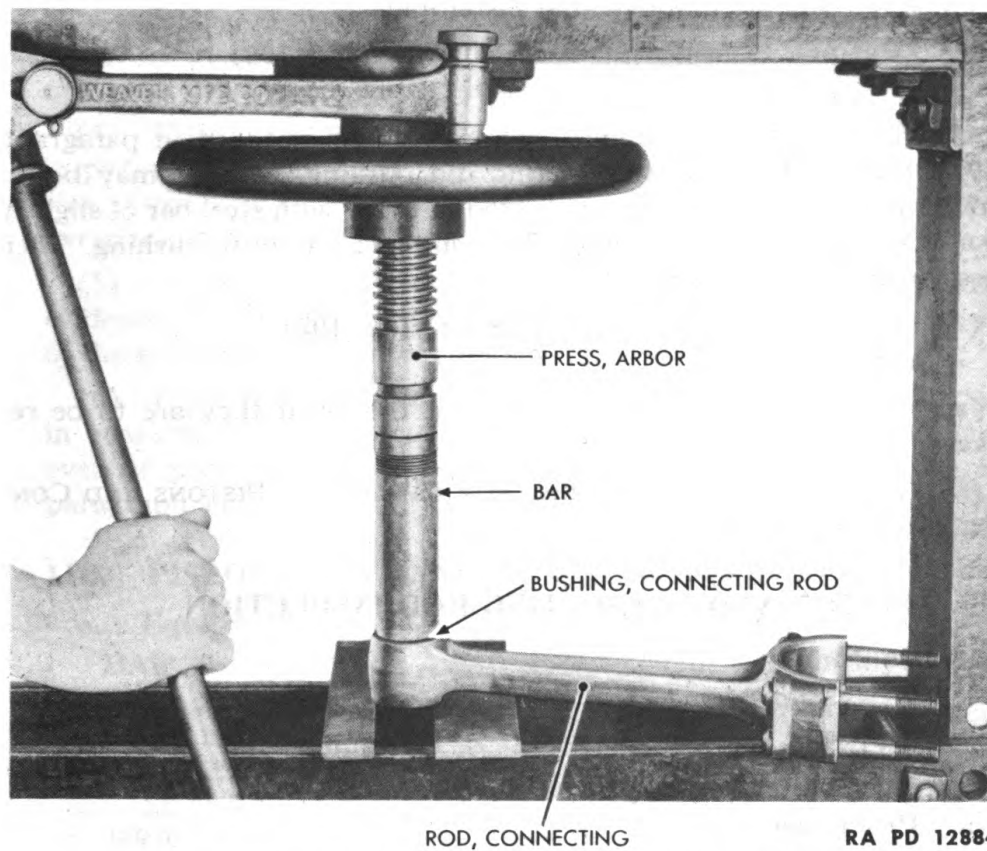
PRESS, arbor

TOOL, piston ring expanding
(IHC No. SE-1115 or
equivalent)

b. Procedure.

(1) PLACE PISTON AND CONNECTING ROD ON WORK BENCH AND SUPPORT CONNECTING ROD AND PISTON ON SMALL WOODEN BLOCKS SO THAT PISTON CLEARS BENCH (fig. 107).

BLOCKS, small wooden



RA PD 12884

Figure 108—Pressing Out Connecting Rod Bushing

(2) REMOVE LOWER HALF OF CONNECTING ROD BEARING FROM BEARING CAP (fig. 107).

(a) Rotate bearing on cap so that bearing nib slides away from cap, until bearing can be removed.

(3) REMOVE PISTON RINGS (fig. 107).

TOOL, piston ring expanding (IHC No. SE-1115 or equivalent)

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Use piston ring expanding tool to remove six piston rings, removing top ring first and remaining five rings in order. Hold ring up from underneath piston and place tool in position and expand ring so it can be removed.

(4) REMOVE RETAINER RINGS (fig. 107).

PLIERS

(a) Remove retainer ring from each side of piston pin.

(5) REMOVE PISTON PIN (fig. 107).

DRIFT, brass

(a) If piston pin cannot be removed by hand, drive pin end from piston and connecting rod. **CAUTION:** Exercise extreme caution not to damage piston when performing this operation. Heating the piston in hot water will aid in removal of piston pin.

(6) REMOVE CONNECTING ROD BUSHING (fig. 108).

BAR, steel

PRESS, arbor

(a) If inspection of connecting rod bushing, outlined in paragraph 109, shows need for new connecting rod bushing, bushing may be removed as follows: Place connecting rod in press, with steel bar of slightly smaller diameter than bushing. Position steel bar over bushing. Then press bushing out of connecting rod.

(7) REMOVE CONNECTING ROD BOLTS (fig. 107).

HAMMER, brass

(a) Tap out connecting rod bolts, in the event they are to be replaced.

(8) FOLLOW SAME PROCEDURE FOR REMAINING PISTONS AND CONNECTING RODS.

109. PISTON AND CONNECTING ROD INSPECTION.

a. Equipment.

AIR, compressed

SOLVENT, dry-cleaning

**TOOL, piston ring groove
cleaning**

V-BLOCK

b. Procedure.

(1) THOROUGHLY CLEAN ALL PARTS.

AIR, compressed

SOLVENT, dry-cleaning

**TOOL, piston ring groove
cleaning**

(a) All component parts of each piston and connecting rod assembly should be thoroughly washed in **SOLVENT, dry-cleaning**.

(b) Clean all passages in oil regulating rings thoroughly.

(c) Use groove cleaning tool or broken piston ring which fits ring grooves to clean carbon from ring grooves.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(d) Be sure oil passage from connecting rod bearing to bushing is open and clean. After washing, blow out passage.

(e) Check to see that all openings in piston under oil regulating rings are open and clean. Blow out with compressed air.

(2) **INSPECT PISTON AND SLEEVE.** Measure inside sleeve with inside micrometer at top and bottom of sleeve. Take readings at right angles to determine if sleeve is out-of-round. Piston can be checked with outside micrometer. If, when rings were removed from piston, piston was scored, new piston and sleeve must be installed, together with new pin, new bushing and new rings.

(3) **INSPECT PISTON RINGS.** Visual examination will not necessarily reveal whether or not piston rings should be replaced by new parts. Trouble shooting procedure, outlined in paragraph 19, must be followed before engine is disassembled, to determine whether or not new rings are to be installed. However, whenever new pistons are to be installed, new rings likewise are to be used.

(4) **CHECK OPERATION OF PISTON PIN IN PISTON.** Fit piston pin in piston and check movement of piston on pin. If play is noticed, over-size piston pin should be installed, as outlined in paragraph 110. If oversize pin has already been in service, it will be marked "+5" on end.

(5) **INSPECT CONNECTING ROD BEARINGS.** Examine each bearing for evidence of scoring, chipping or cracking. Install new bearing when any of these conditions are encountered.

(6) **CHECK OPERATION OF PISTON PIN IN BUSHING.** Place piston pin in connecting rod bushing and check for play, which is evidence that oversize piston pin should be installed. For installation procedure, see paragraph 110.

110. PISTON AND CONNECTING ROD OVERHAUL.

a. Equipment.

BAR, steel	TOOL, burnishing, connecting
BAR, Sunnen quick check rod	rod bushing (IHC No.
bending	SE-941 or equivalent)
BLADES, reamer (IHC No.	WISE
SE-949-5)	WRENCH, open-end, 7/8-in.
PRESS, arbor	

b. Procedure.

(1) **CLEAN AND INSPECT DISASSEMBLED PARTS.** Clean and inspect all component parts of each piston and connecting rod assembly as outlined in paragraph 109.

(2) **INSTALL NEW PARTS AS NEEDED.** In addition to procedure outlined in remaining steps of this paragraph, refer to paragraph 111 for procedure to install other new parts, which inspection has proved necessary.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(3) INSTALL NEW CONNECTING ROD BUSHINGS, AS NEEDED (figs. 108 and 109).

BAR, steel
PRESS, arbor

TOOL, burnishing, connecting
rod bushing (IHC No.
SE-941 or equivalent)
WRENCH, open-end, $\frac{7}{8}$ -in.

(a) Remove old bushing, as outlined in paragraph 108.

(b) Place connecting rod in arbor press, with bushing in position over connecting rod. Then place steel bar of slightly larger diameter than bushing over bushing and press bushing into position. Bushing must be placed so that oilhole is in alinement with oil passage in connecting rod.

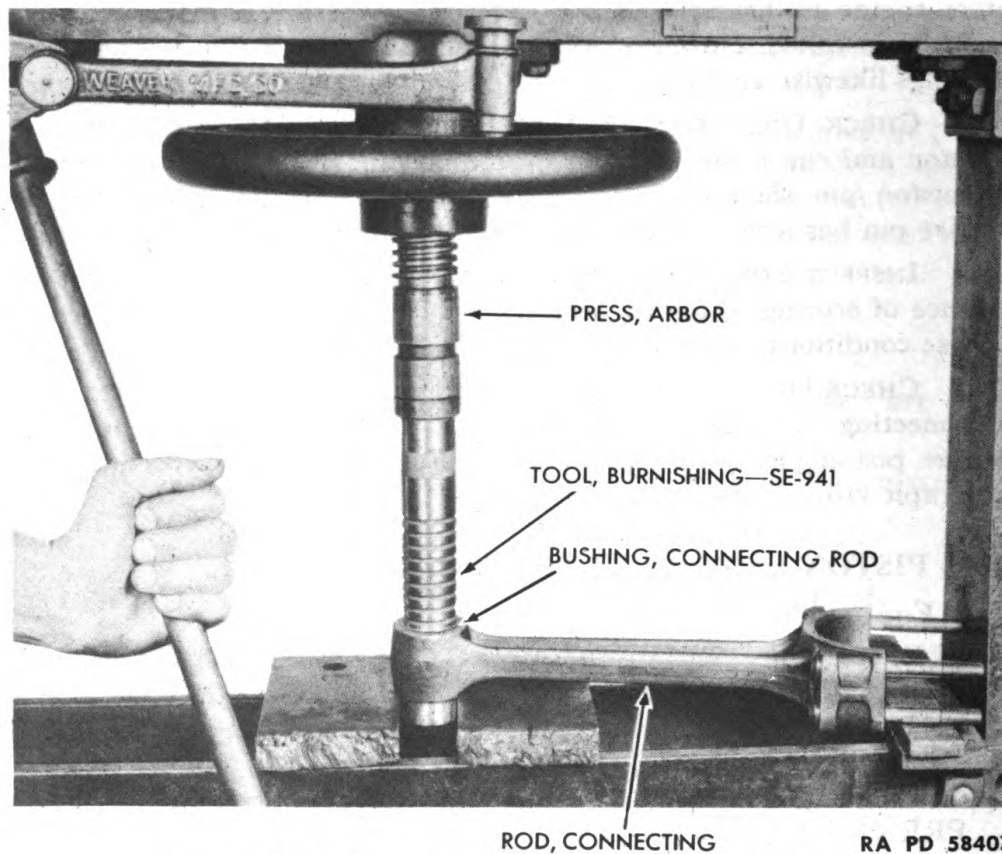


Figure 109—Burnishing Connecting Rod Bushing

(c) Using arbor press, force burnishing tool through connecting rod bushing. Tool should be pressed all the way through bushing.

(d) Hone connecting rod bushings to size, following procedure outlined in step (5) below.

(e) Standard piston pin diameter limits are from 1.6250- to 1.6253-inch, with clearance limits of 0.0003- to 0.0005-inch in connecting rod

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

bushing. Diameter limits for oversize piston pins are 1.6301- to 1.6304-inch, with same clearance limits as standard piston pins.

(4) INSTALL NEW PISTON PINS AS NEEDED.

(a) When new piston is being installed, new piston pin must be installed, which is supplied in set matched with piston.

(b) When piston is worn from operation on piston pin, when piston pin is worn or when connecting rod bushing is worn, an oversize piston pin should be installed, as outlined in step (5) below.

(5) TO INSTALL AN OVERSIZE PISTON PIN (fig. 110).

(a) Place belt on low speed side of pulley. This is side of pulley toward machine. Use mandrel selector, placing it in connecting rod to determine which mandrel is to be used. Mandrel is No. SL-1600 or equivalent. Install mandrel in machine. Take two of new oversize piston pins marked "+5", place them in setting fixture and tighten nut.

(b) Place setting fixture with piston pins, as shown at (1), so that upper bar rests on (D) and slot (B) fits snugly on (C).

(c) Hold gage as shown at (2), with index finger of left hand on stop (F) and thumb on (E), sliding part (E) back with thumb until setting fixture becomes snug in position shown. Remove hand from setting fixture and then tighten nut (G) as indicated at (3) and remove setting fixture. **NOTE:** To check setting, place setting fixture on gage and push it forward without forcing. Mark on slide should line up with zero on scale.

(d) Place connecting rod on gage, as shown at (4), and place as far forward as it will go easily. *Do not force it.* Be sure that connecting rod is held straight on gage. Scale will indicate amount of stock to be removed in thousandths of an inch to bring hole to zero or same size as pin.

(e) With motor on grinder turned on, turn dial to left, retracting stone within mandrel. Place connecting rod on mandrel and depress foot pedal until feed arm hits stop. Then grasp bushing end of the rod firmly with both hands and stroke connecting rod back and forth slowly, turning dial to right until you feel stone start to cut. Take a few strokes to permit stone to set. Stop motor and remove connecting rod from mandrel.

(f) Note reading on dial and then advance dial to right by number of thousandths of an inch, as shown on gage fitting, so honing will remove material and bring connecting rod bushing to same size as piston pin. **NOTE:** Each number on dial represents one one-thousandth of an inch. When dial is advanced from one number to next, stone has been set to expand one one-thousandth of an inch. Dial should never be set for more than 0.010-inch cut at a time, since this is full range of automatic stone feed-up.

(g) Start motor and again work connecting rod back and forth over full length of stone until it has completed cutting material in bushing

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

and brought bushing to size for which dial has been set. Be sure to keep connecting rod bushing square with mandrel. **NOTE:** By turning tension adjustment to right or left, automatic stone feed-up is set to feed out stone under any cutting tension from very light to very heavy. Cutting tension may be increased or decreased at any time by simply turning tension adjustment nut to right or left. A little practice will show right tension for job.

(h) Remove connecting rod from mandrel, with motor still running, and brush out inside of bushing with brush attached to machine.

(i) Place connecting rod on gage fitting and check. It will be found that another honing operation is necessary to remove excess material and bring inside diameter of bushing to zero. Repeat operations in order to bring bushing to zero.

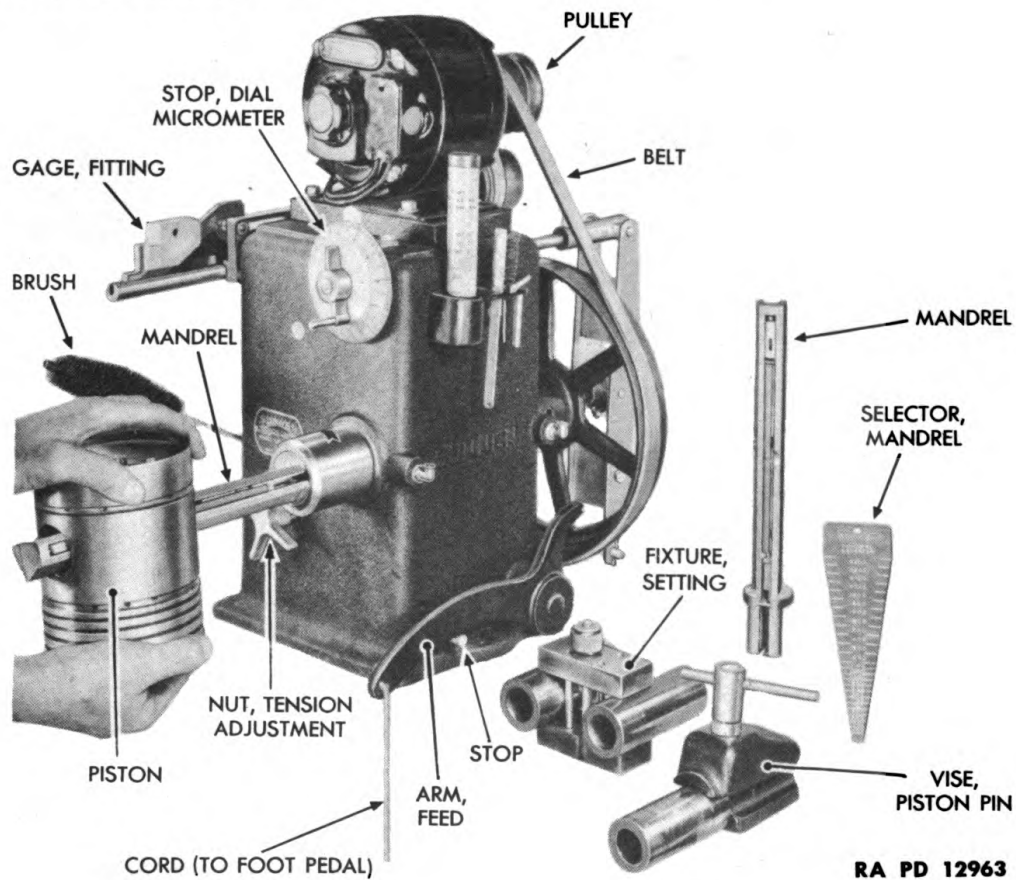


Figure III—Piston Pin Bushing Honing

(j) Piston pin in connecting rod must be given 0.0003- to 0.0005-inch clearance. Note reading on dial as it was obtained on final honing when bushing was brought to zero on gage fitting. Advance dial three points to five points to right and hone as outlined above. Try rod on piston pin clamped in piston pin vise on bench to check for fit. By advancing dial one point mandrel is advanced 0.0001 inch.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(k) Hone the piston for the oversize piston pin (fig. 111). Follow same procedure above with exception of step (i). Piston must be honed to give clearance of 0.0001 to 0.0003 inch.

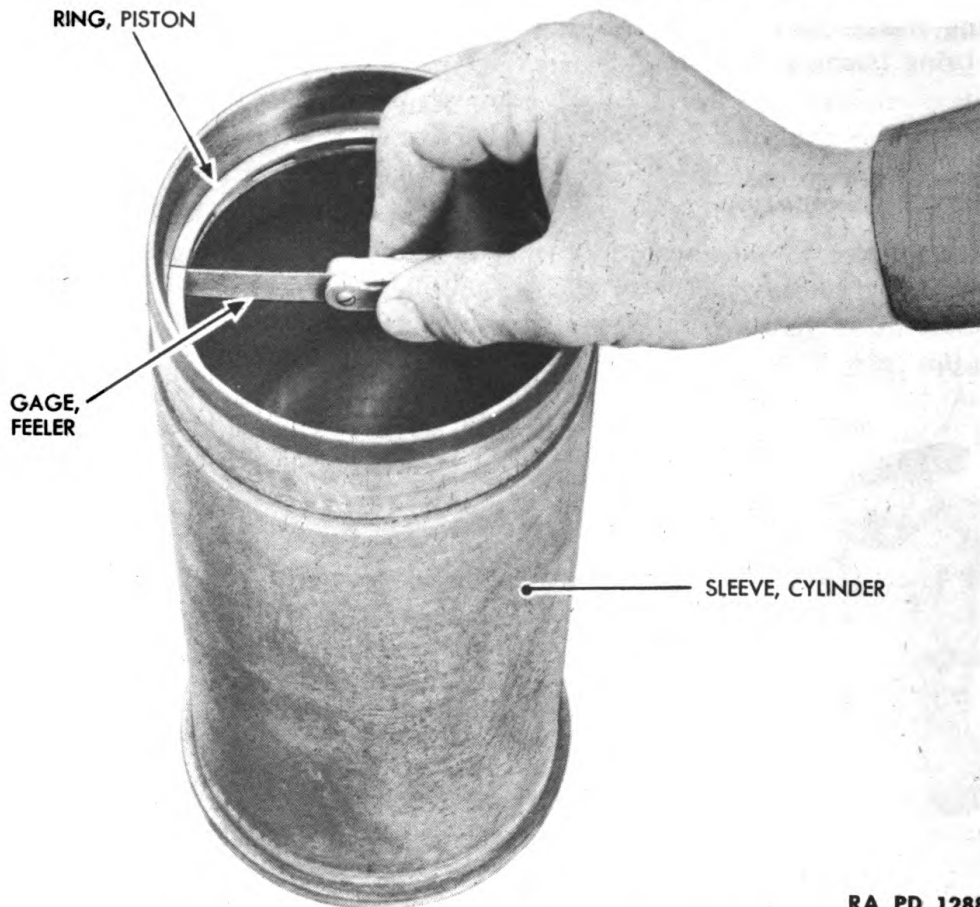
111. ASSEMBLY OF PISTONS AND CONNECTING RODS.

a. Equipment.

**GAGE, feeler
PLIERS**

**TOOL, piston ring expanding
(IHC No. SE-1115 or
equivalent)**

WATER, boiling hot



RA PD 12889

Figure 112—Checking Piston Ring Clearance in Cylinder Sleeve

b. Procedure.

(1) **INSTALL PISTON PIN.**

PLIERS

WATER, boiling hot

(a) Heat piston in boiling hot water until it has expanded sufficiently for piston pin to enter freely into piston pin hole of piston without pressing or tapping. Place connecting rod in position in piston with bushing in alignment with piston pin hole in piston. Then install piston pin.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

RA PD 12890

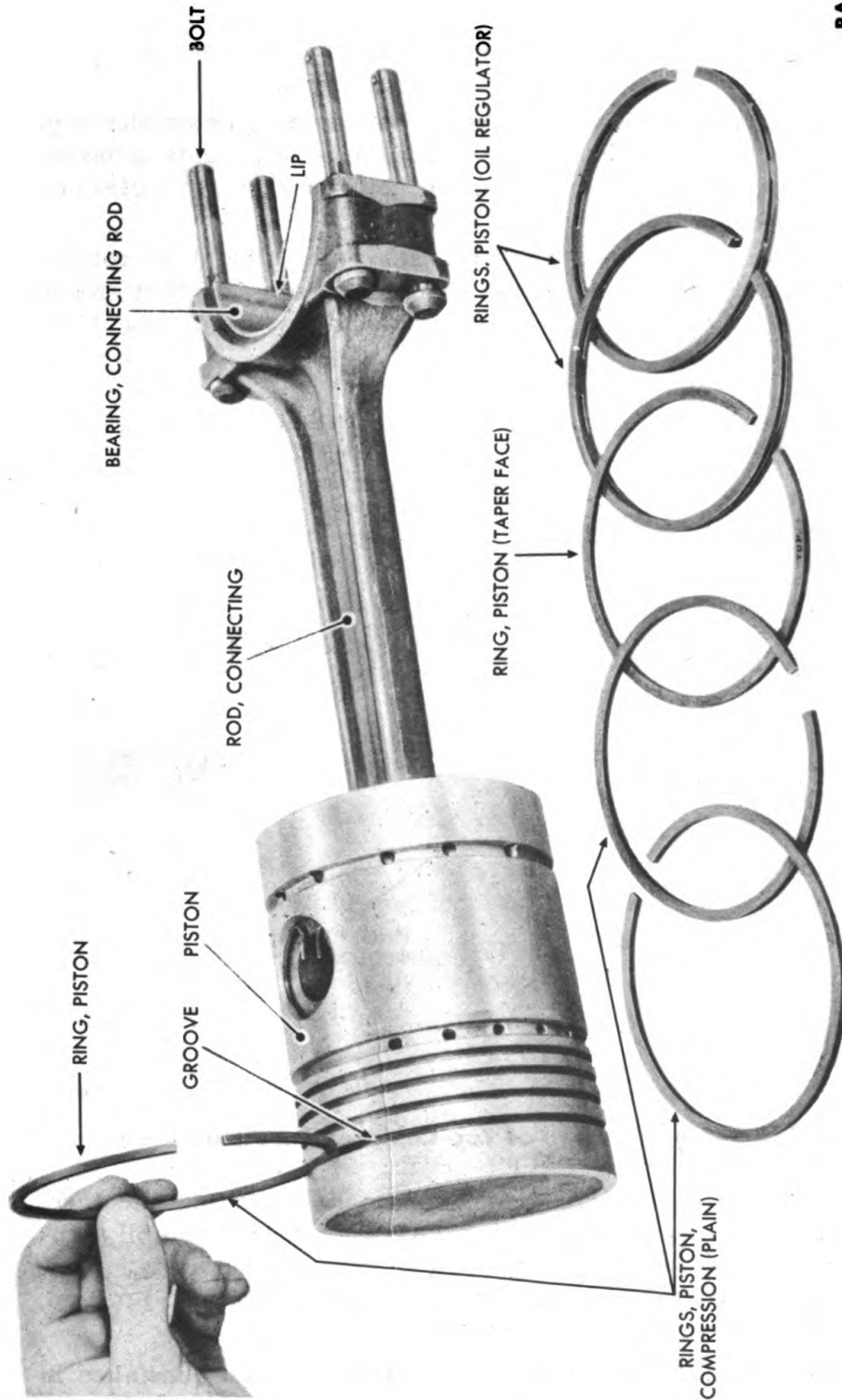


Figure 113—Checking Piston Ring in Groove for Binding

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**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(b) Squeeze ends of two retainer rings together, installing ring in piston at each end of piston pin to hold pin in position.

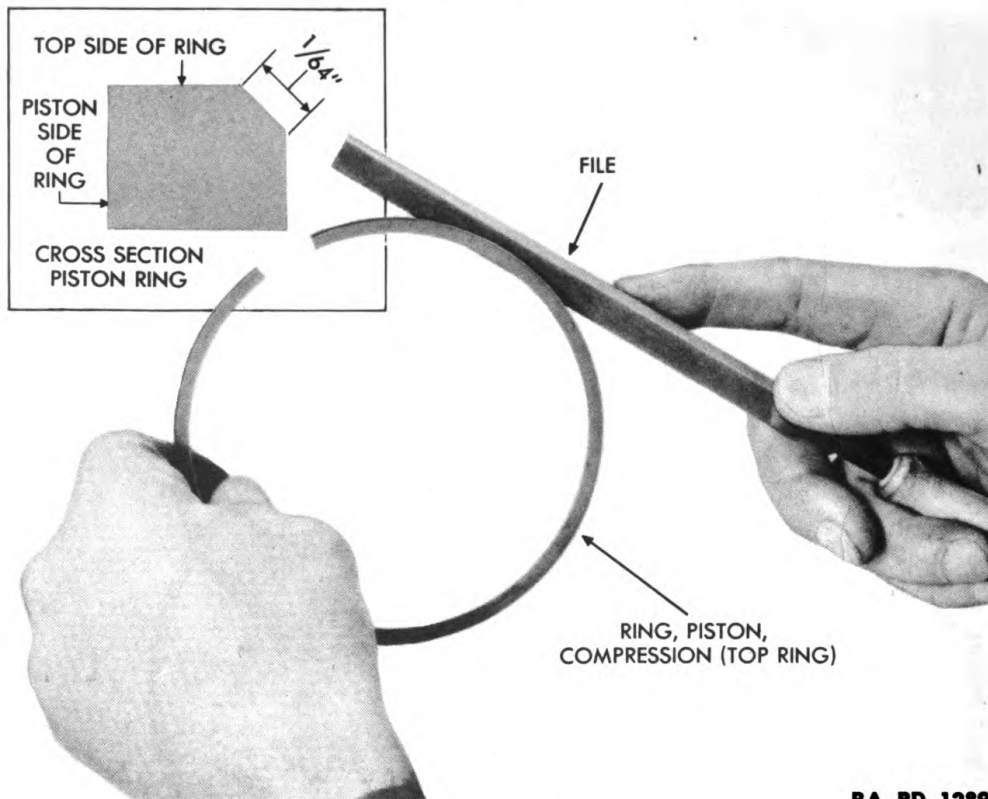
(2) **INSTALL PISTON RINGS** (fig. 112).

GAGE, feeler

TOOL, piston ring expanding
(IHC No. SE-1115 or
equivalent)

(a) In turn, insert each piston ring in bottom of cylinder sleeve in which ring is to operate. Then check clearance between ends of piston ring. Gap for top compression ring should be from 0.010- to 0.018-inch and for all other rings from 0.010- to 0.020-inch.

(b) Before installing each ring on piston, ring should be rotated around outside of piston in its proper groove to make sure that groove is clean and that ring will not bind in groove at any point (fig. 113).



RA PD 12891

Figure 114—Filing Top Edge of Top Compression Piston Ring

(c) Use piston ring expanding tool, to expand each ring and then, in turn, place each ring in its proper groove. First install two oil regulator piston rings in two piston grooves of piston, then install compression piston ring (taper face) with side marked "TOP" up, and, finally, install three compression rings (plain).

CAUTION: (fig. 114). When new piston rings are being installed in used piston for operation in used sleeve, wear on sleeve might ordinarily

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

cause noisy performance and possible breakage of ring lands of piston, when top ring reaches top of stroke. Therefore, top edge of piston ring should be filed off so that its sharp edge is eliminated.

(3) **INSTALL UPPER HALF OF CONNECTING ROD BEARING** (fig. 113). Slide bearing into position on connecting rod so that bolt lip fits notch in connecting rod.

(4) **INSTALL FOUR CONNECTING ROD BOLTS** (fig. 113).

HAMMER, brass

(a) Tap connecting rod bearings into position.

(5) **ASSEMBLE REMAINING CONNECTING ROD AND PISTON ASSEMBLIES IN SAME MANNER.**

112. CHECKING PISTON AND CONNECTING ROD ASSEMBLIES BEFORE INSTALLATION.

a. When installing a piston and connecting rod assembly which was originally used in the engine, the assembly must be installed in the same cylinder sleeve from which it was removed.

b. When a new piston, or new piston and connecting rod assembly, is to be installed, together with a new cylinder sleeve, pistons and sleeves are produced in matched sets, and must be installed accordingly.

113. PISTON AND CONNECTING ROD INSTALLATION.

a. **Equipment.**

COMPRESSOR, piston ring **VICE**
SCREWDRIVER

b. **Procedure.**

(1) **INSTALL PISTON RING COMPRESSOR ON PISTON RING** (fig. 167). Place piston and connecting rod in vise and install ring compressor on piston.

(2) **SLIDE PISTON INTO CYLINDER SLEEVE FROM LEFT SIDE OF CRANKSHAFT** (fig. 168). Place piston into cylinder sleeve with numbered side of connecting rod toward camshaft side of engine, with compressor resting on base of sleeve. **NOTE:** The crankshaft journal must be in its extreme right position. Push connecting rod and piston upward into position until piston ring compressor is pushed from piston. Remove piston ring compressor.

(3) **INSTALL CONNECTING ROD BEARINGS.** See paragraph 116.

(4) **INSTALL REMAINING PISTONS AND CONNECTING RODS BY FOLLOWING THE SAME PROCEDURE.**

(5) **INSTALL CRANKCASE OIL PAN.** See paragraph 100.

(6) **INSTALL CRANKCASE GUARD.** See paragraph 206.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

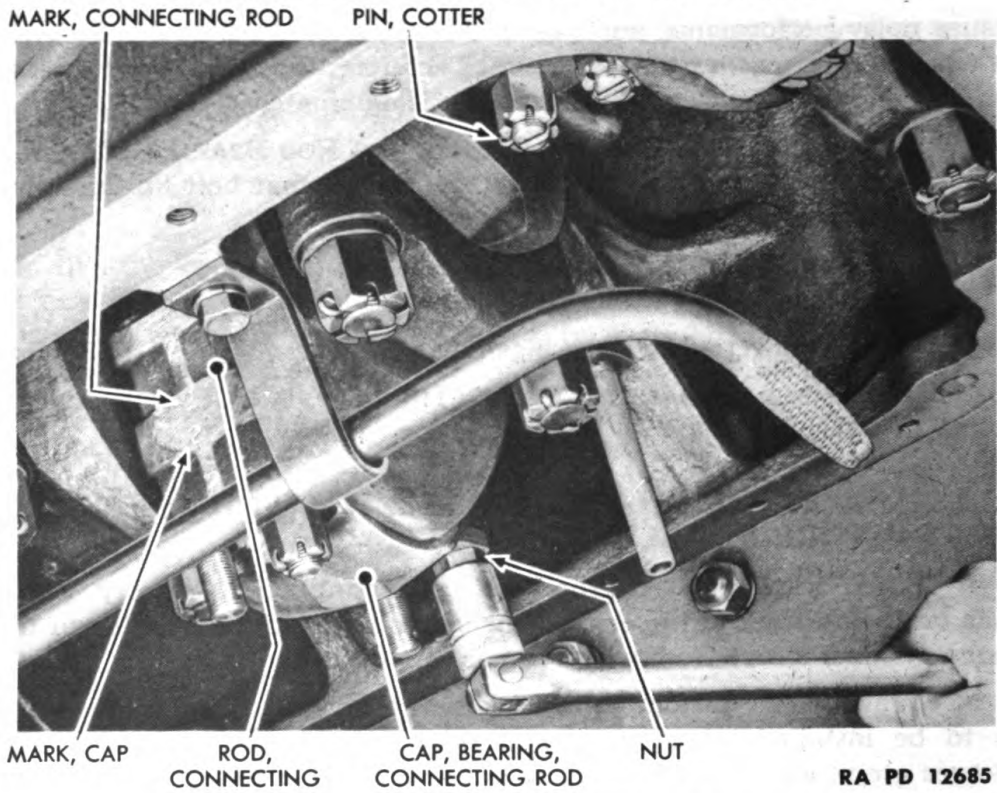


Figure 115—Connecting Rod Bearing Cap Removal

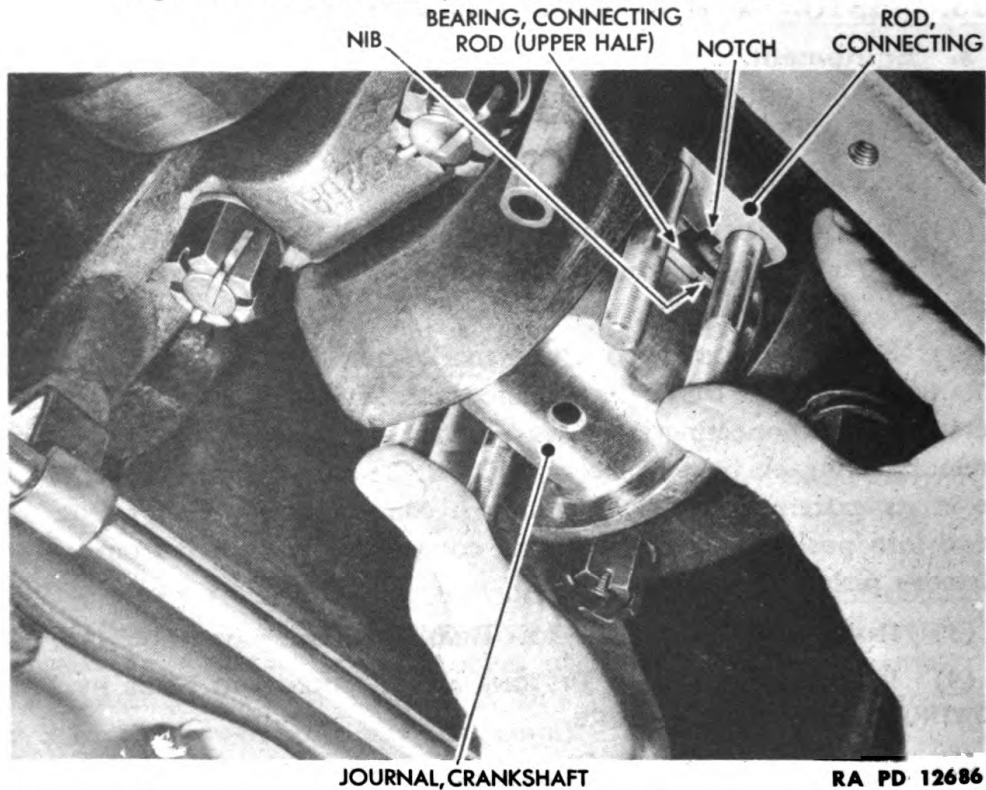


Figure 116—Removal of Upper Half of Connecting Rod Bearing

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

114. CONNECTING ROD BEARING REMOVAL.

a. Equipment.

PLIERS

WRENCH, socket, $\frac{3}{4}$ -in.,
and spinner type handle

b. Procedure.

- (1) REMOVE CRANKCASE GUARD. See paragraph 31.
- (2) REMOVE CRANKCASE OIL PAN. See paragraph 98.
- (3) REMOVE CONNECTING ROD BEARING CAP (fig. 115).

PLIERS

WRENCH, socket, $\frac{3}{4}$ -in.,
and spinner type handle

(a) Remove cotter pins from four bearing cap nuts and then remove nuts. Lift out cap with lower half of connecting rod bearing.

(4) REMOVE UPPER HALF OF CONNECTING ROD BEARING (fig. 116). Push connecting rod and piston upward, by hand, until upper half of connecting rod bearing can be slipped around crankshaft journal and removed.

- (5) REMOVE OTHER CONNECTING ROD BEARINGS IN SAME MANNER.

115. CONNECTING ROD BEARING INSPECTION.

a. Connecting rod bearings should be carefully checked for scoring, chipping and wear. Replace all defective bearings.

116. CONNECTING ROD BEARING INSTALLATION.

a. Equipment.

PLIERS

WRENCH, torque

WRENCH, socket, $\frac{3}{4}$ -in.,
and spinner type handle

b. Procedure.

(1) INSTALL UPPER HALF OF CONNECTING ROD BEARING (fig. 116). Be sure all surfaces are wiped clean and bearing is lubricated properly. Then place upper half of connecting rod bearing in position on crankshaft. Pull connecting rod and piston down so that notch in connecting rod fits over nib of bearing.

- (2) INSTALL LOWER HALF OF CONNECTING ROD BEARING (fig. 115).

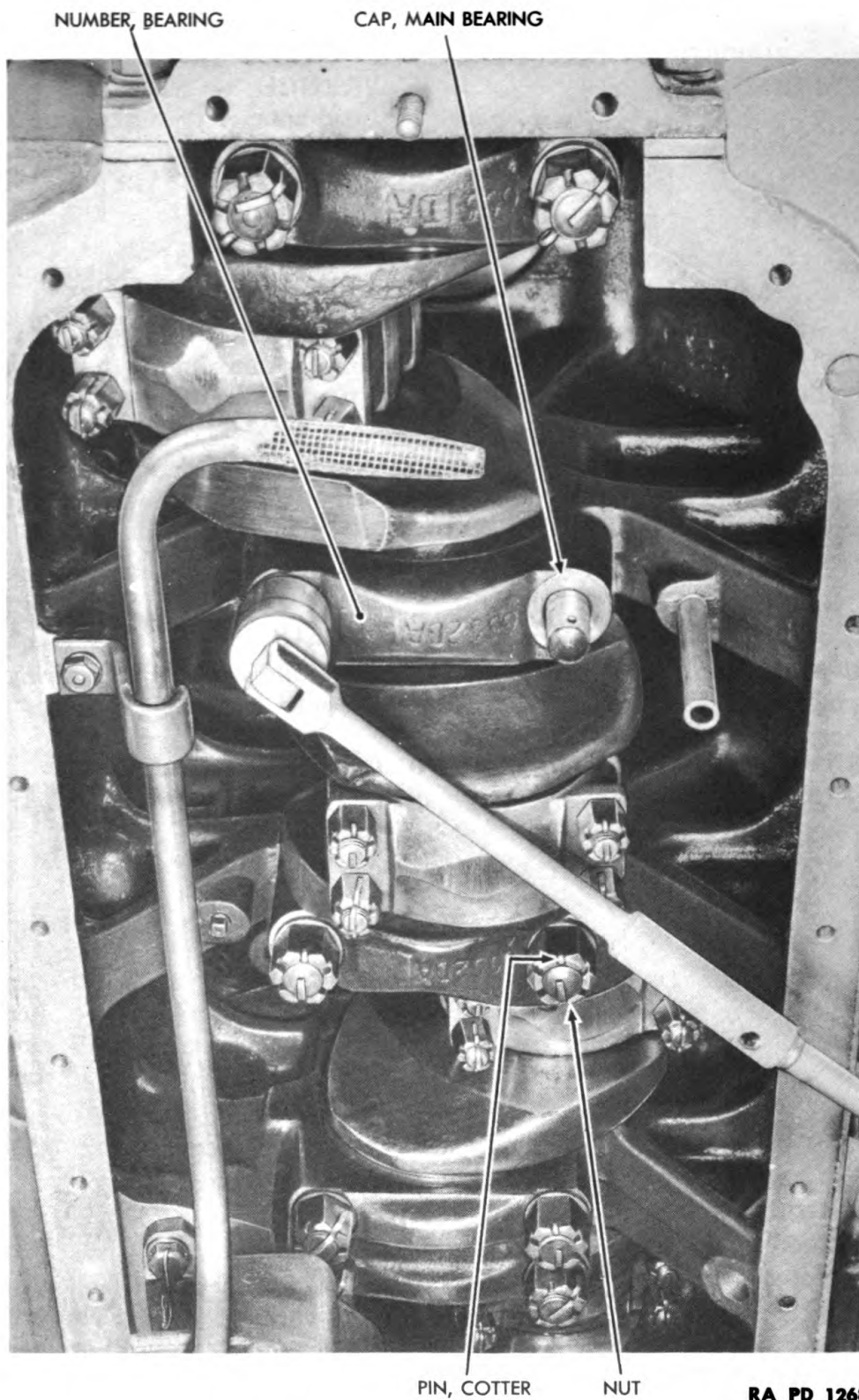
PLIERS

WRENCH, torque

WRENCH, socket, $\frac{3}{4}$ -in.,
and spinner type handle

(a) Place lower half of connecting rod bearing in position on connecting rod bearing cap, with bearing nib fitting into notch of cap. Install cap in position on connecting rod, so that number stamped on cap corresponds with number stamped on right side of connecting rod. Install four nuts which hold cap to connecting rod. Tighten and run up nuts. Then tighten nuts to 70 foot-pounds tension. If cotter pin holes in

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12681

Figure 117—Main Bearing Cap Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

nuts do not line up with holes in connecting rod studs, tighten nuts still further until holes are in alignment. Install cotter pins through nuts, bolts and lock pins.

- (3) INSTALL OTHER CONNECTING ROD BEARINGS IN SAME MANNER.
- (4) INSTALL CRANKCASE OIL PAN. See paragraph 100.
- (5) INSTALL CRANKCASE GUARD. See paragraph 206.

117. MAIN BEARING REMOVAL.

a. Equipment.

PLIERS

STRIP, brass

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

WRENCH, socket, $1\frac{1}{8}$ -in.,
and spinner type handle

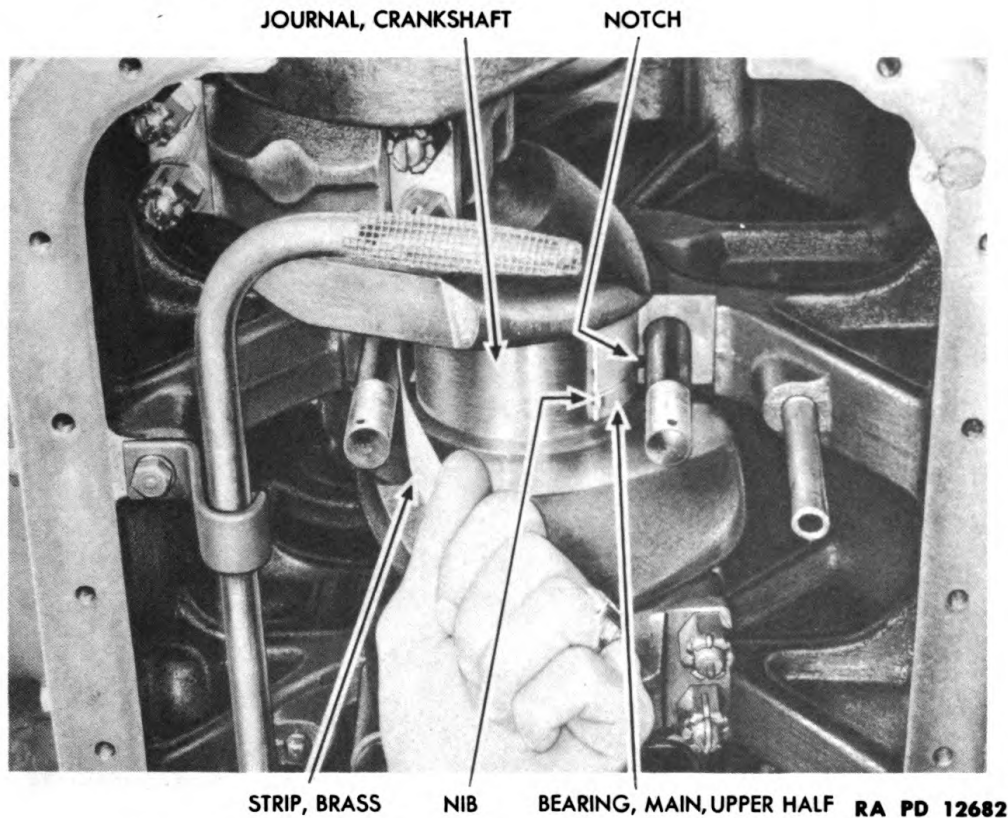


Figure 118—Removal of Upper Half of Main Bearing

b. Procedure.

- (1) REMOVE CRANKCASE GUARD. See paragraph 31.
- (2) REMOVE OIL PAN. See paragraph 98.
- (3) REMOVE MAIN BEARING CAP (fig. 117).

PLIERS

WRENCH, socket, $1\frac{1}{8}$ -in.,
and spinner type handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Remove cotter pins which lock two nuts that hold cap to crankcase. Use wrench with extension to remove two nuts and flat washers. Tap cap loose and lift it out. Lower half of main bearing will come out with main bearing cap.

(4) REMOVE UPPER HALF OF MAIN BEARING (fig. 118).

STRIP, brass

(a) Push upper half of main bearing out, entering brass strip from right side of crankshaft journal, so it will push upper half of main bearing around and free of crankshaft.

(5) REMOVE OTHER MAIN BEARINGS.

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

(a) Repeat this procedure to remove all other main bearings, except No. 4 and No. 7 (bearing caps are numbered on right side and are placed in corresponding positions with numbers on crankcase).

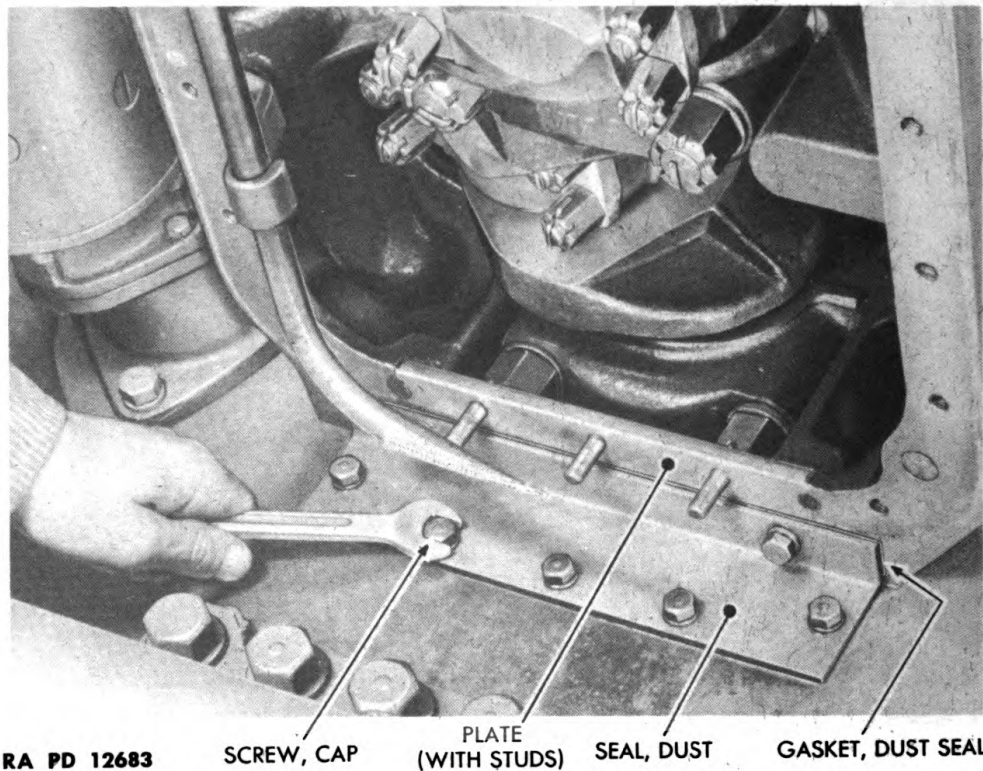


Figure 119—Dust Seal and Plate Removal

(b) To remove No. 4 main bearing it is necessary that lubricating oil pump first be removed (par. 101).

(c) To remove No. 7 main bearing it is necessary to remove dust seal and plate (fig. 119). To do this, remove seven cap screws and lock washers which hold dust seal to rear engine support and to plate. Then lift out dust seal gasket and plate with studs.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

118. MAIN BEARING INSPECTION.

a. Inspect upper and lower halves of main bearings for evidence of scoring, chipping and wear. Replace all defective bearings.

119. MAIN BEARING INSTALLATION.

a. Equipment.

WRENCH, open-end, $\frac{9}{16}$ -in. WRENCH, torque
WRENCH, socket, $1\frac{1}{8}$ -in.,
and extension

b. Procedure.

(1) **INSTALL UPPER HALF OF MAIN BEARING** (fig. 118). Push bearing around crankshaft, so that nib on one end of bearing engages with notch in crankcase.

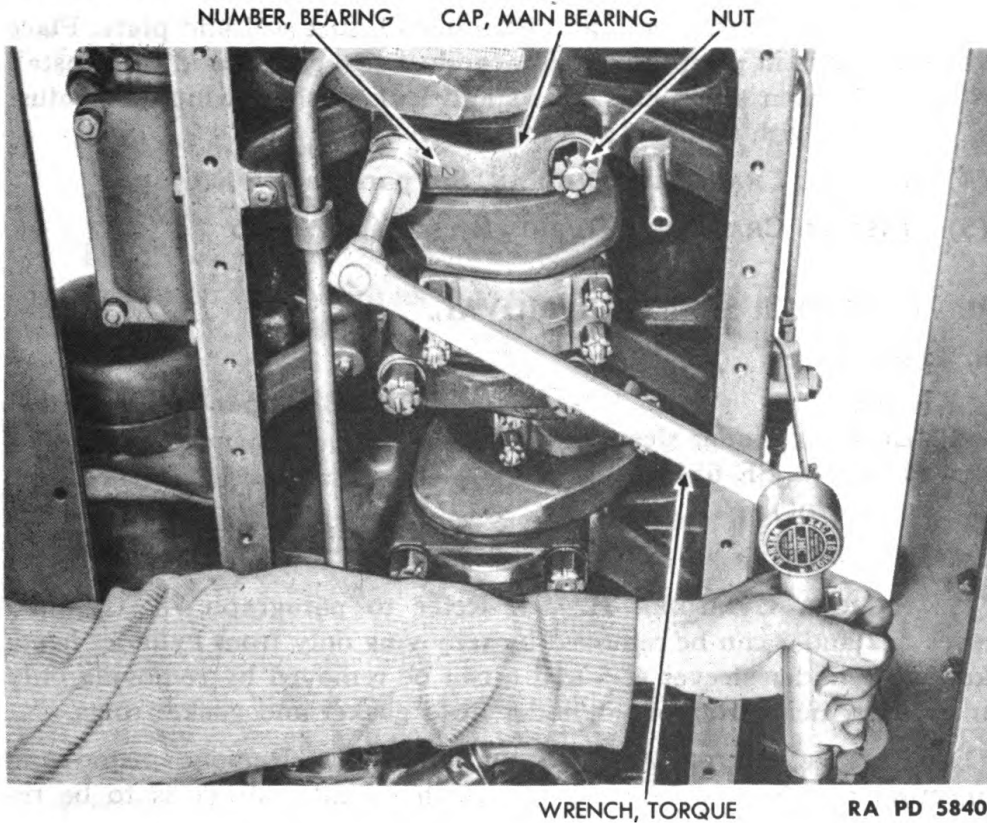


Figure 120—Tightening Main Bearing Cap Nut with Tension Wrench

(2) **INSTALL LOWER HALF OF MAIN BEARING** (figs. 119 and 120).

WRENCH, socket, $1\frac{1}{8}$ -in., WRENCH, torque
and extension

(a) Place lower half of main bearing in position on main bearing cap with bearing nib fitting into cap slot. Install cap on crankcase studs, with bearing number toward right side of engine opposite corresponding

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

number which is stamped on crankcase. Install flat washers and two nuts, tightening them to 150 foot-pounds. Install cotter pins in nuts and lock pins. **CAUTION:** If cotter pin holes in nuts and studs do not line up when nut has been tightened to 150 foot-pounds, tighten nut still further to line up holes.

(3) INSTALL ALL MAIN BEARINGS.

WRENCH, open-end, $\frac{9}{16}$ -in. **WRENCH**, torque

(a) Repeat same procedure to install all main bearings except No. 4 and No. 7. Tighten to 150 foot-pounds.

(b) Install No. 4 main bearing as outlined in **b** (1) and (2) of this paragraph, except that it is secured to crankcase studs by means of four washers and nuts. Tighten to 150 foot-pounds. Then install lubricating oil pump, following procedure outlined in paragraph 106.

(c) To install No. 7 main bearing, follow the procedure outlined in step **b** (3) of this paragraph, and then install dust seal and plate. Place plate with studs in position, install new dust seal gasket and then install dust seal. Tighten seven cap screws and lock washers which hold dust seal and plate with studs in position.

(4) INSTALL CRANKCASE OIL PAN. See paragraph 100.

(5) INSTALL CRANKCASE GUARD. See paragraph 206.

120. CYLINDER SLEEVE REMOVAL.

a. Equipment.

KNIFE

WRENCH, open-end, $1\frac{1}{4}$ -in.

PULLER, cylinder sleeve
(IHC No. SE-654 or
equivalent)

b. Procedure.

(1) REMOVE CYLINDER HEADS. Refer to paragraph 78. Cylinder sleeves 1, 2 and 3 can be removed by removing only front cylinder head. Likewise, cylinder sleeves 4, 5 and 6 can be removed by removing only rear cylinder head. Remove cylinder head gasket and gasket rings.

(2) REMOVE PISTON AND CONNECTING ROD. Remove piston and connecting rod from cylinder from which cylinder sleeve is to be removed (par. 107).

(3) INSTALL CYLINDER SLEEVE PULLER TOOL (fig. 40).

TOOL, cylinder sleeve puller **WRENCH**, open-end, $1\frac{1}{4}$ -in.
(IHC No. SE-654 or
equivalent)

(a) Install cylinder sleeve puller tool. First, run puller nut to top of puller rod. Then lower lug end of rod into cylinder so that lug can be lifted against base of sleeve. Rest legs of tool "spider" on crankcase

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

around cylinder, so that tool nut is in center of cylinder. Then tighten tool nut.

(4) **REMOVE SLEEVE** (fig. 41). Continue tightening nut until sleeve is pulled upward and loose from cylinder wall. Lift out tool and cylinder sleeve.

(5) **REMOVE CYLINDER SLEEVE RING** (fig. 42).
KNIFE

(a) Pry cylinder sleeve ring free and then remove ring. Ring is located at bottom of cylinder wall.

(6) **REMOVE ADDITIONAL SLEEVES IN SAME MANNER.**

NOTE: When removing more than one sleeve, it is important to mark or systematically arrange sleeves to assure replacement in counterbores from which sleeves have been removed. When same sleeve is to be installed again in same counterbore, sleeve and crankcase should also be marked so that sleeve can be installed in its original position.

121. CYLINDER SLEEVE INSTALLATION.

a. Equipment.

BLOCK, wooden
or

MALLET, rawhide

SOLUTION, soap and glycerine

b. Procedure.

(1) **INSTALL CYLINDER SLEEVE RING** (fig. 42).

BLOCK, wooden
or

MALLET, rawhide

(a) It is good practice to place the cylinder sleeve in position in the crankcase before installing a cylinder sleeve ring, in order to check for fit.

(b) Remove the cylinder sleeve and install cylinder sleeve ring after dipping it in a soap solution made up of one pint of water, one-half ounce of glycerine and one tablespoonful of soap flakes. Coat the outside tapered end of the cylinder sleeve where it enters that part of the crankcase holding the cylinder sleeve ring.

(c) Place the cylinder sleeve in the crankcase and tap into place, if necessary, using a block of wood or a rawhide mallet. **CAUTION:** Be sure that the cylinder sleeve ring has not been forced out of its groove when the cylinder sleeve was installed.

(2) **INSTALL PISTON AND CONNECTING ROD.** Install piston and connecting rod in cylinder in which sleeve has been installed (par. 113).

(3) **INSTALL ADDITIONAL SLEEVES IN SAME MANNER.**

CAUTION: When installing more than one sleeve, if sleeves have been previously used in engine, sleeves and crankcase should have been marked when sleeves were removed, so that sleeves can be installed in their original positions.

(4) **INSTALL CYLINDER HEADS.** See paragraph 87.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

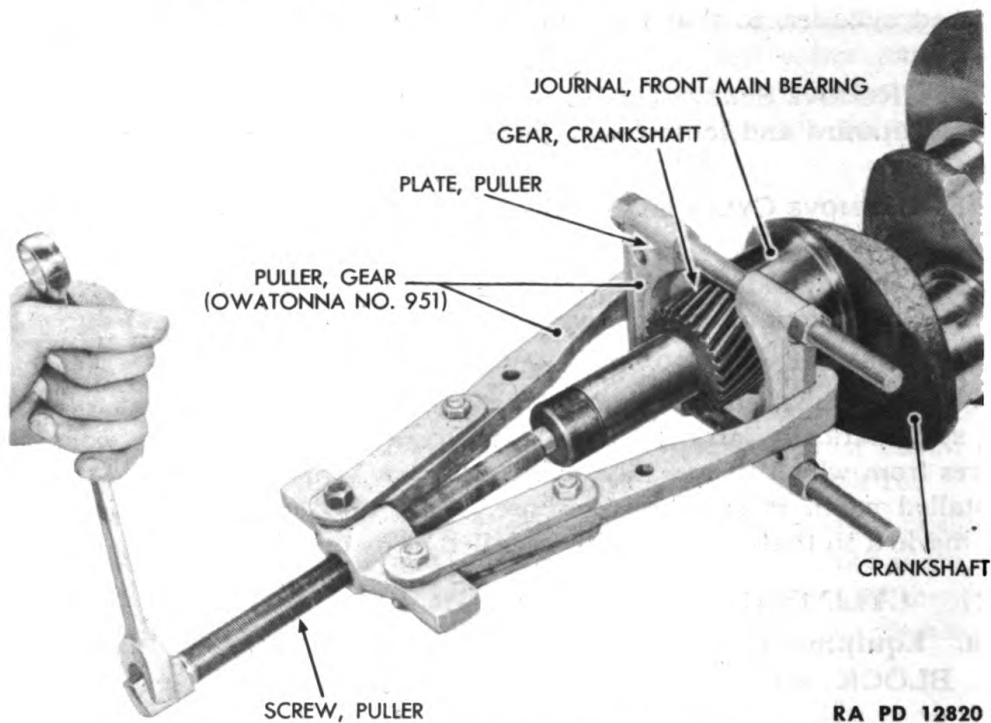


Figure 121—Removing Gear from Crankshaft

122. REMOVAL OF CRANKSHAFT GEAR FROM THE CRANKSHAFT.

a. Equipment.

PULLER, gear (Owatonna No. 951 set or its equivalent)

WRENCH, open-end, $\frac{7}{8}$ -in.

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

b. Procedure.

(1) ATTACH PULLER PLATE (fig. 121).

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

(a) Place puller plate between crankshaft gear and front main bearing journal. Tighten bolt nuts.

(2) ATTACH PULLER (fig. 121).

PULLER, gear (Owatonna No. 951 set or its equivalent)

WRENCH, open-end, $\frac{7}{8}$ -in.

(a) Place puller box under puller plate. Screw down puller screw, until gear is removed.

123. CRANKSHAFT REMOVAL.

a. The crankshaft cannot be removed from the engine while the engine is installed in the tractor. To remove the crankshaft, refer to section IV, Removal of engine, and section V, Disassembly of engine.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

RA PD 12916



Figure 122 — Checking Crankshaft Journals for Wear

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

124. INSPECTION OF REMOVED CRANKSHAFT.

a. Equipment.

MICROMETER

b. Procedure.

(1) INSPECT MAIN AND CONNECTING ROD JOURNALS (fig. 122).

MICROMETER

(a) Check diameter of each main and connecting rod journal, making two checks of each journal, one at right angles to other and in each instance moving micrometer across entire width of journal to check for evidence of wear.

(2) INSPECT CRANKSHAFT GEAR FOR WORN, BROKEN OR CHIPPED TEETH (fig. 122). Replace with new gear when above conditions are encountered.

(3) REGRIND CONNECTING ROD AND MAIN BEARING JOURNALS, IF NECESSARY. Connecting rod and main bearing journals which are worn may be reground, providing regrinding equipment is available. 0.030-inch undersize bearings are available and can be used if there is sufficient material in the crankshaft for grinding, so that undersize bearings will fit. **NOTE:** Because of the seven-main-bearing construction of this crankshaft, there should be no occasion for crankshaft to bend and therefore require straightening.

125. CRANKSHAFT INSTALLATION.

a. The crankshaft must be installed with the engine removed from the tractor, as outlined in section VIII, Assembly of engine.

126. CAMSHAFT, VALVE TAPPET AND TAPPET GUIDE REMOVAL.

a. The camshaft, valve tappets and tappet guides cannot be removed when the engine is installed in the tractor. To remove camshaft, refer to section IV, Removal of engine, and section V, Disassembly of engine.

127. CAMSHAFT DISASSEMBLY.

a. Equipment.

PLATE, gear puller (IHC
No. SE-662-A or equivalent)

PULLER, gear (IHC No.
SE-624 or equivalent)

PUNCH

WISE, with copper jaws

WRENCH, open-end, 1 $\frac{1}{16}$ -in.

WRENCH, open-end, 1 $\frac{1}{2}$ -in.

b. Procedure.

(1) REMOVE NUT FROM END OF CAMSHAFT.

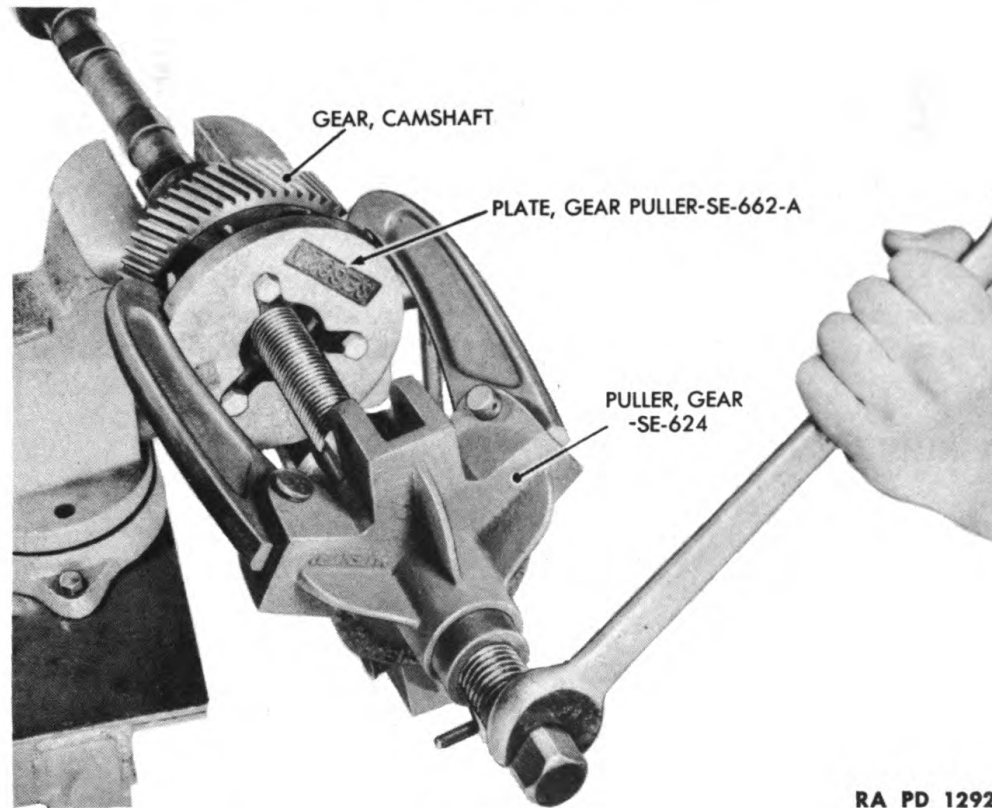
PUNCH

WISE, with copper jaws

WRENCH, open-end, 1 $\frac{1}{2}$ -in.

(a) Place camshaft between copper jaws of vise. Pry back nut lock. Remove nut.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**



RA PD 12920

Figure 123—Pulling Camshaft Gear from Camshaft

(2) PULL GEAR FROM CAMSHAFT (fig. 123).

PLATE, gear puller (IHC
No. SE-662-A or equivalent)

PULLER, gear (IHC No.
SE-624 or equivalent)

WRENCH, open-end, 1 $\frac{1}{16}$ -in.

(a) Place gear puller plate over gear; securing it to gear with three $\frac{3}{8}$ -inch by $2\frac{3}{4}$ -inch cap screws. Install cap screws by hand, leaving sufficient space between plate and gear puller jaws. Then use gear puller to remove gear. Place jaws of puller over puller plate, with puller screw screwed down against end of camshaft. Use wrench on puller screw to pull gear from camshaft.

**128. REMOVED CAMSHAFT, VALVE TAPPET AND TAPPET
GUIDE INSPECTION.**

a. Equipment.

LATHE

MICROMETER

b. Procedure.

(1) CAMSHAFT.

(a) *Inspect Camshaft Journals* (fig. 124). Place micrometer over each journal in camshaft, measuring diameter in one position and then in second position at right angles to first. In each instance, move micrometer across entire width of journal to make complete check for

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

RA PD 12919

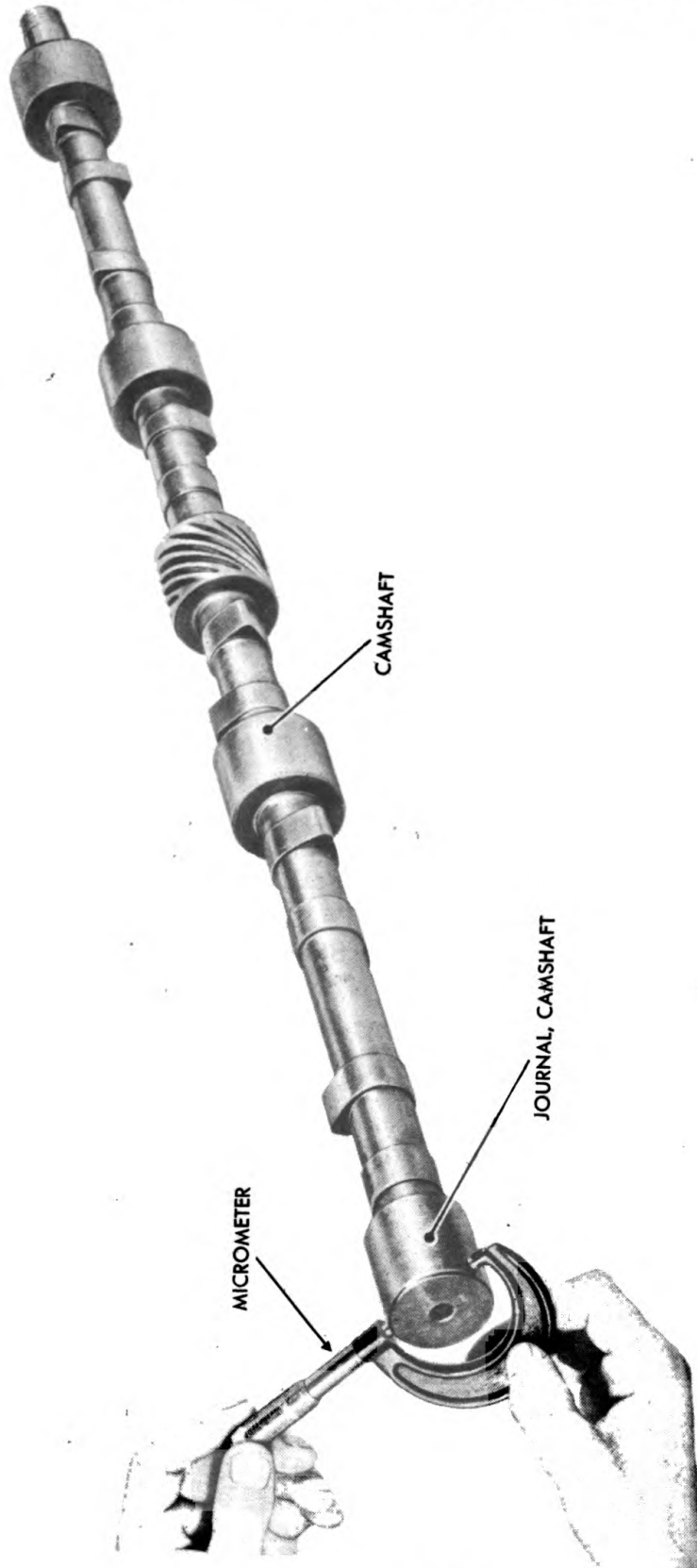


Figure 124—Checking Camshaft Journals for Wear

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

evidence of excessive wear, which necessitates installation of new camshaft.

(b) *Check Camshaft Alinement.* Place camshaft in lathe and check for misalinement at center journals, which would indicate that camshaft is bent. If camshaft is bent, replace with new one.

(c) *Check Camshaft Bearings.* Check camshaft bearings for visible evidence of wear and replace if necessary.

(2) **VALVE TAPPETS AND TAPPET GUIDES.** Inspect faces of valve tappets for evidence of wear. Then insert tappet in guide from which it was removed and check for excessive play. Replace either or both parts, if necessary, to eliminate play.

129. CAMSHAFT, VALVE TAPPET AND TAPPET GUIDE IN- STALLATION.

a. The camshaft must be installed when the engine has been removed from the tractor. Refer to section VIII, Assembly of engine.

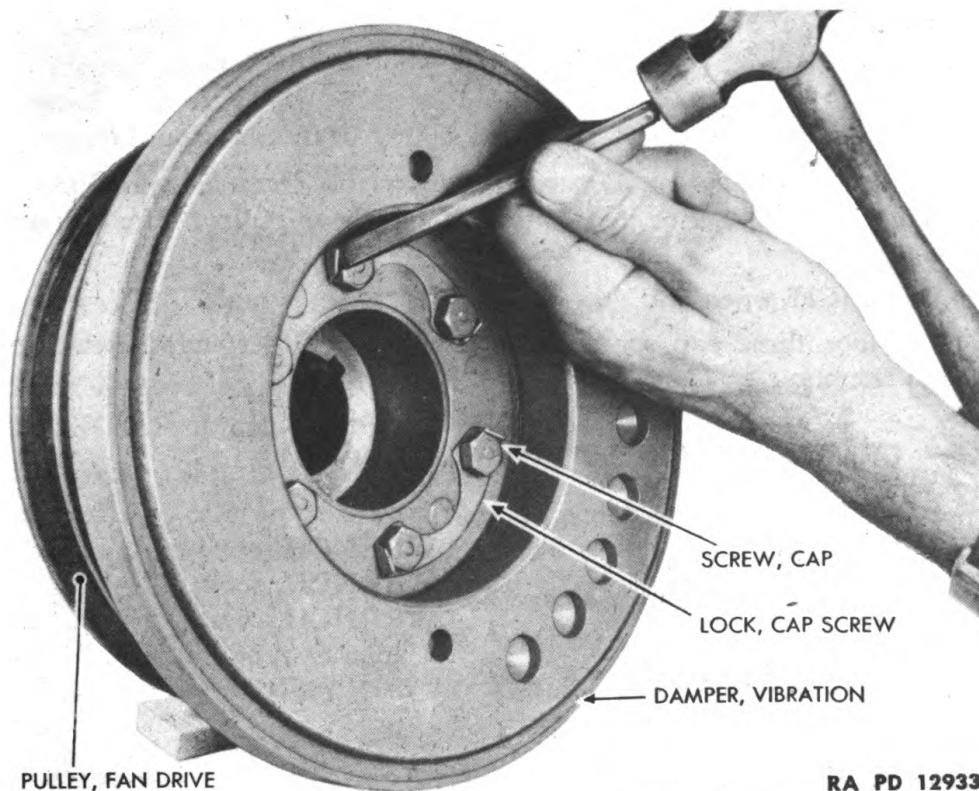


Figure 125—Removal of Vibration Damper from Fan Drive Pulley

130. FAN DRIVE PULLEY AND VIBRATION DAMPER OVER- HAUL.

a. **Equipment.**

SLEEVE, pipe
SOLVENT, dry-cleaning

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

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

b. Procedure. Vibration damper and fan drive pulley are removed as a unit in process of engine disassembly, paragraph 54. Inasmuch as they are not subject to wear, they should not be separated unless either part has become damaged.

(1) CLEAN FAN DRIVE PULLEY AND VIBRATION DAMPER.

• **SOLVENT**, dry-cleaning

(a) Thoroughly wash two assembled parts with **SOLVENT**, dry-cleaning.

(2) INSPECT FAN DRIVE PULLEY AND VIBRATION DAMPER.

(a) Examine both parts for evidence of damage in the event that vehicle has been damaged in general service. If damaged, parts should be replaced by new ones. If necessary to separate two parts, follow procedure outlined in next step (3).

(3) SEPARATE VIBRATION DAMPER FROM FAN DRIVE PULLEY (fig. 125).

SLEEVE, pipe

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

(a) Pry back cap screw locks from cap screws. Then remove six cap screws which secure vibration damper to fan drive pulley. Remove three cap screw locks. Drive fan drive pulley from vibration damper.

(4) PLACE VIBRATION DAMPER IN POSITION OVER DOWEL PINS OF FAN DRIVE PULLEY. For installation of fan drive pulley, refer to paragraph 166.

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

(a) Place three cap screw locks in position, insert cap screws and tighten them.

131. CRANKCASE FRONT COVER REMOVAL.

a. Equipment.

CROWBAR, pinch-point, 3-lb

WRENCH, open-end, $\frac{7}{8}$ -in.

HAMMER

WRENCH, socket, $\frac{3}{4}$ -in.

JACK

WRENCH, socket, $2\frac{1}{8}$ -in., and

SCREWDRIVER

spinner type handle

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

b. Procedure.

(1) REMOVE WINCH. See TM 9-1777D.

(2) REMOVE RADIATOR. See cooling system section, TM 9-1777B.

(3) REMOVE GENERATOR. See electrical system section, TM 9-1777B.

(4) REMOVE FAN ASSEMBLY. See cooling system section, TM 9-1777B.

(5) LIFT OFF FAN BELT.

(6) REMOVE OIL PAN. See paragraph 98.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

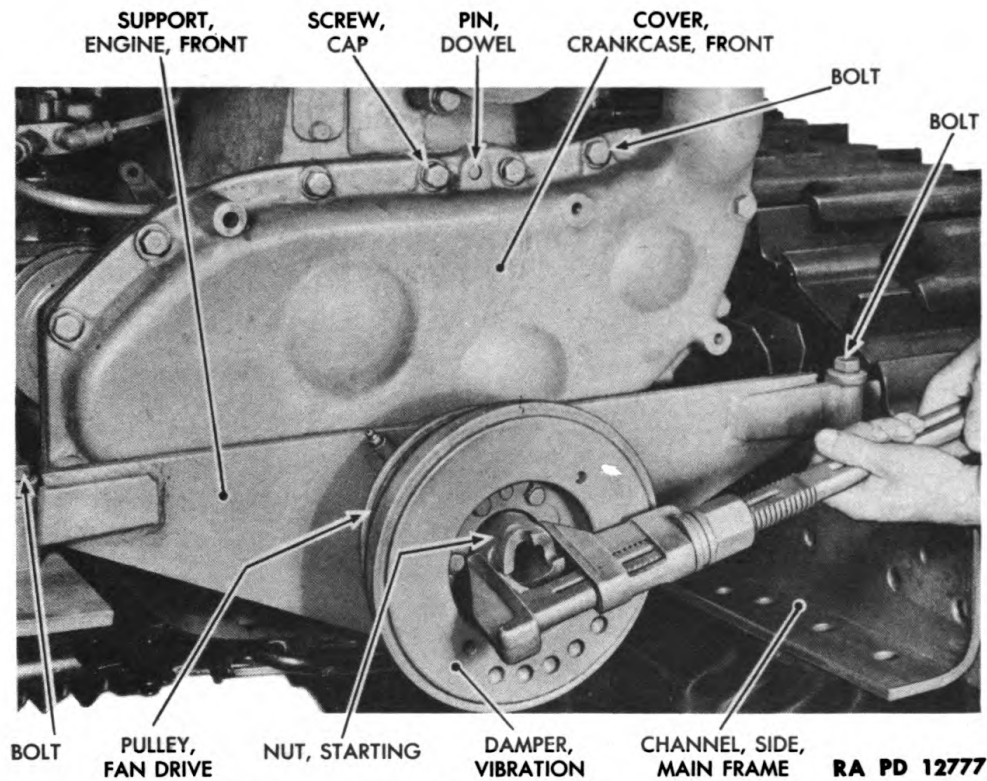


Figure 126—Starting Nut Removal

(7) REMOVE FAN DRIVE PULLEY WITH VIBRATION DAMPER ATTACHED (fig. 126).

BLOCK, wooden, small **WRENCH**, socket, 2 $\frac{1}{8}$ -in., and
CROWBAR, pinch-point, 3-lb spinner type handle

(a) Insert small block of wood between connecting rod bearing journal and side of crankcase in order to keep crankshaft from turning when starting nut is removed.

(b) Use socket wrench or heavy adjustable wrench to remove starting nut. Also remove starting nut lock washer.

(c) Pry fan drive pulley with vibration damper attached loose from crankshaft.

(8) REMOVE FRONT ENGINE SUPPORT (fig. 126).

CROWBAR, pinch-point, 3-lb **WRENCH**, open-end, $\frac{7}{8}$ -in.
JACK

(a) Remove bolt, two shims and nut from each side of support. These two bolts hold support to main frame side channels.

(b) Place jack under front end of crankcase to support weight of engine.

(c) Pry off front engine support.

TM 9-1777A
131-132

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

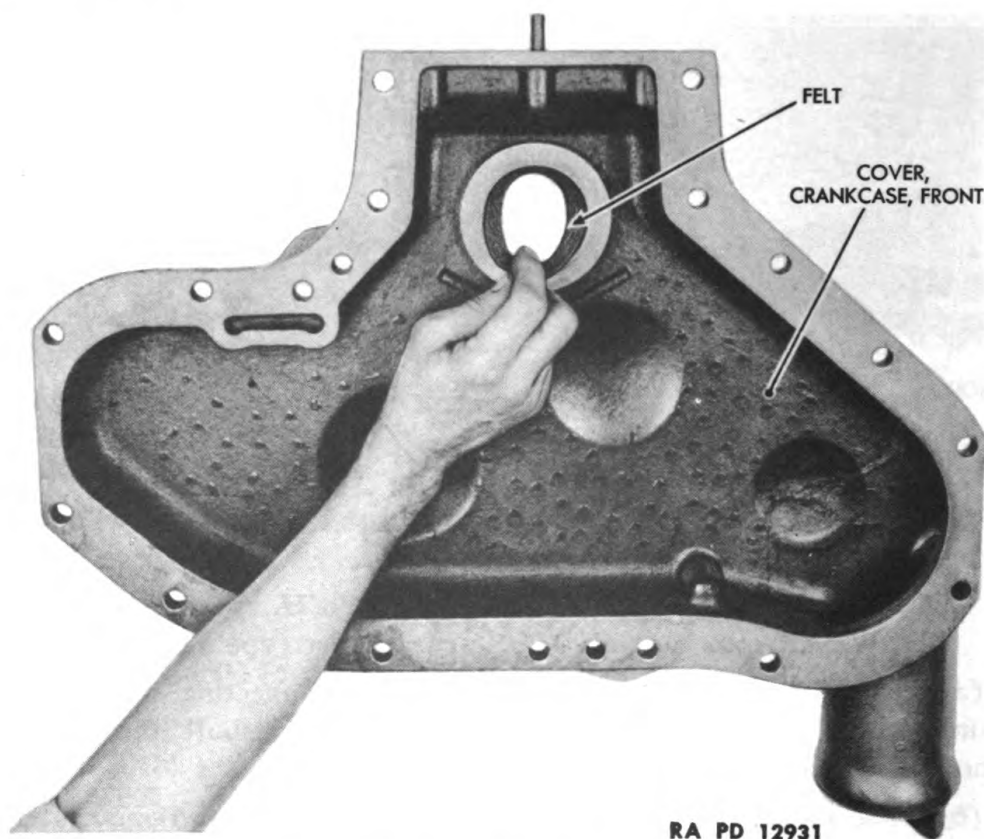
(9) REMOVE CRANKCASE FRONT COVER (fig. 126).

HAMMER
SCREWDRIVER

WRENCH, open-end, $\frac{3}{4}$ -in.
WRENCH, socket, $\frac{3}{4}$ -in.

(a) Use socket wrench to remove seven bolts, nuts and lock washers, which hold front cover in place, holding bolt nuts with open-end wrench. Also remove 11 cap screws and lock washers. Pry cover loose from dowel pins and remove cover. Then remove front cover gaskets.

(10) REMOVE TWO WOODRUFF KEYS AND OIL FLINGER FROM END OF CRANKSHAFT.



RA PD 12931

Figure 127—Removing Felt from Crankcase Front Cover

132. CRANKCASE FRONT COVER OVERHAUL.

a. Equipment.

BAR, steel
HAMMER
PUNCH

SOLVENT, dry-cleaning
WRENCH, offset open-end,
 $\frac{5}{8}$ -in.

b. Procedure.

(1) REMOVE GASKET FROM THE COVER.

(2) REMOVE FELT (fig. 127). Lift out felt from underneath felt retainer in crankcase front cover. This can be done by hand.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

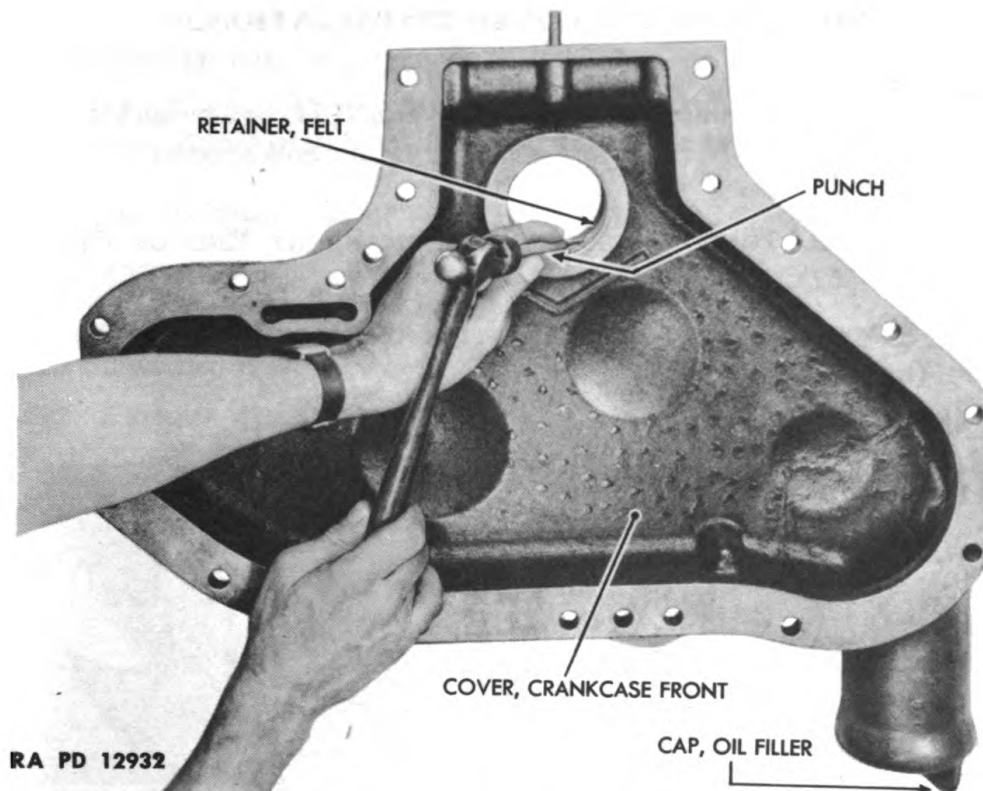


Figure 128—Removing Felt Retainer from Crankcase Front Cover

(3) REMOVE FELT RETAINER (fig. 128).

HAMMER

PUNCH

(a) Drive felt retainer out of cover, entering punch from inside of cover.

(4) REMOVE OIL FILLER CAP (fig. 128).

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

(a) With cap removed examine screen and do not remove unless damaged. If necessary to remove it, remove nut from stud and then lift off screen.

(5) CLEAN ALL PARTS. Thoroughly wash cover and screen in SOLVENT, dry-cleaning.

(6) INSTALL SCREEN.

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

(a) If necessary to install new screen, place screen over stud, secure it in position with nut and tighten nut.

(7) INSTALL TWO NEW FELTS IN COVER (fig. 127).

(8) INSTALL FELT RETAINER.

BAR, steel

(a) Use steel bar of slightly smaller diameter than retainer and drive it into cover, from outside.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

133. CRANKCASE FRONT COVER INSTALLATION.

a. Equipment.

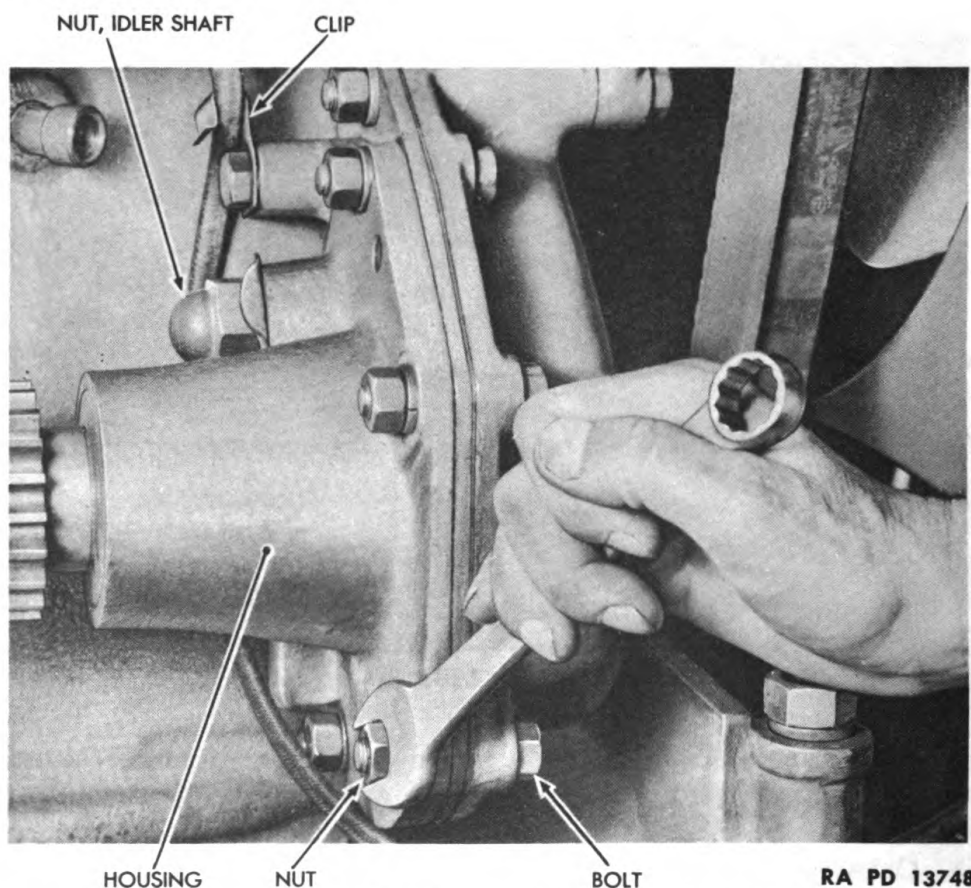
HAMMER, rawhide

WRENCH, box, or socket,
3/4-in., and speeder

b. Procedure.

(1) INSTALL TWO WOODRUFF KEYS IN FRONT END OF CRANK-SHAFT (fig. 162).

(2) PLACE OIL FLINGER IN POSITION ON FRONT END OF CRANK-SHAFT (fig. 162).



RA PD 13748

Figure 129—Air Compressor Drive Removal

(3) INSTALL NEW FRONT COVER GASKET. Place gasket in position on cover.

(4) PLACE COVER IN POSITION (fig. 45).

HAMMER, rawhide

(a) With gasket attached, place cover in position over crankcase front plate, so that it is held in position on two dowel pins. Tap cover firmly against plate.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(5) **INSTALL CAP SCREWS AND BOLTS** (fig. 45).

WRENCH, box, or socket, $\frac{3}{4}$ -in., and speeder

(a) Install and tighten six cap screws and lock washers and eight bolts, nuts and lock washers which hold crankcase cover to crankcase.

134. AIR COMPRESSOR DRIVE REMOVAL.

a. Equipment.

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

b. Procedure.

(1) **REMOVE AIR COMPRESSOR.**

(a) Follow the procedure outlined in TM 9-1777D.

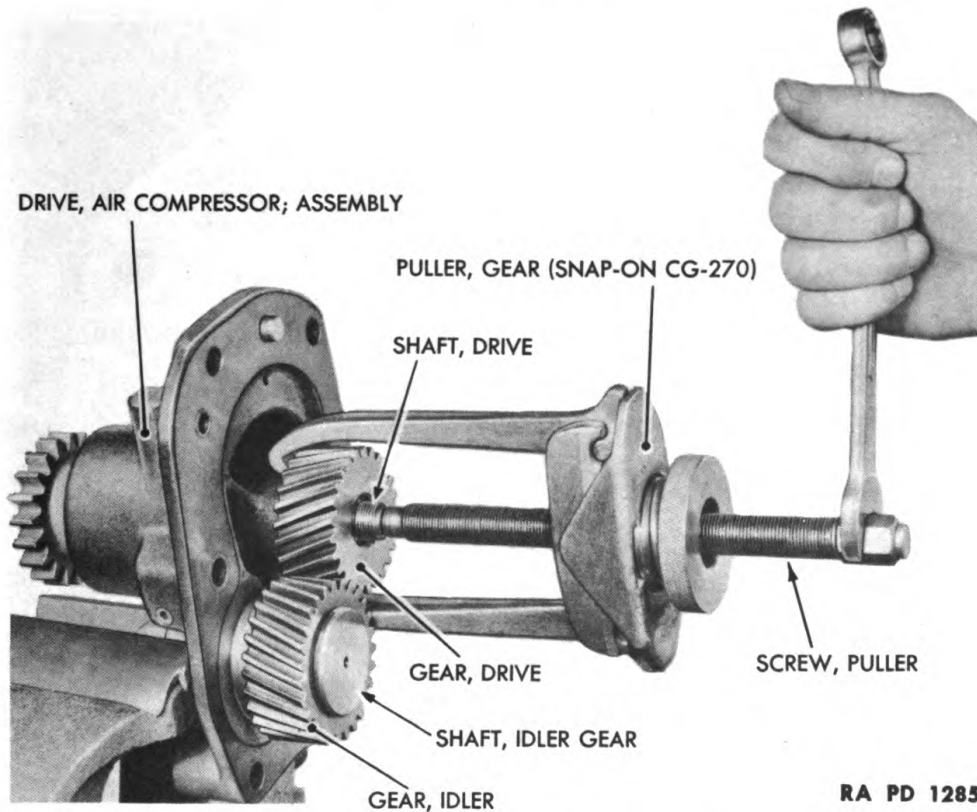


Figure 130—Air Compressor Drive Gear Removal

(2) **REMOVE THE AIR COMPRESSOR DRIVE** (fig. 129).

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

(a) Remove four bolts, cap screws and lock washers and one bolt cap screw and nut which hold housing to crankcase front cover. The bolt also holds a cable clip in place. Then pull air compressor drive from crankcase front cover, toward rear of engine and remove.

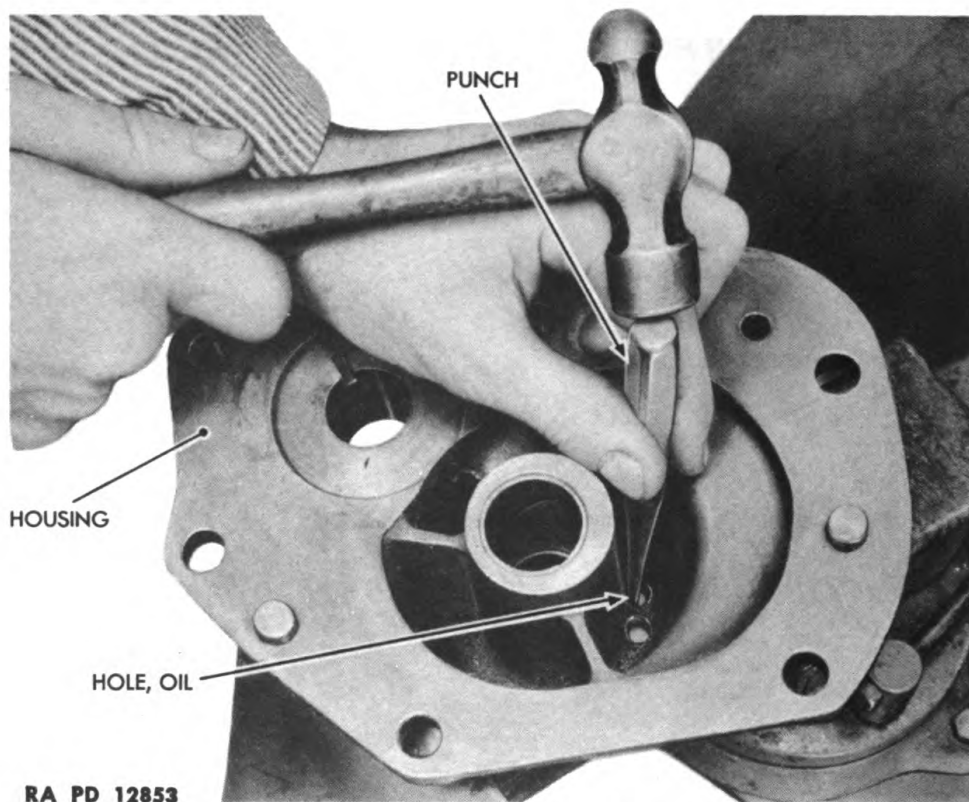
**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

135. AIR COMPRESSOR DRIVE DISASSEMBLY.

a. Equipment.

HAMMER, rawhide
PRESS
PRESS, arbor
PULLER, gears (snap-on blue
point CG-270 or equivalent)
PUNCH
SCREWDRIVER
SLEEVE, pipe

WISE, with copper jaws
WRENCH, open-end, $\frac{5}{16}$ -in.
WRENCH, open-end, $\frac{3}{4}$ -in.
WRENCH, socket, $1\frac{5}{16}$ -in.,
and spinner type handle
WRENCH, socket, $1\frac{1}{2}$ -in.,
and spinner type handle



**Figure 131—Removing Oil Seal, Felt and Felt Retainer
from Compressor Drive Housing**

b. Procedure.

(1) REMOVE AIR COMPRESSOR DRIVE GEAR (fig. 130).

PULLER, gears (snap-on blue
point CG-270 or equivalent)
SCREWDRIVER
WISE, with copper jaws

WRENCH, open-end, $\frac{3}{4}$ -in.
WRENCH, socket, $1\frac{1}{2}$ -in.,
and spinner type handle

(a) Secure air compressor drive assembly between jaws of vise. Pry gear lock free from nut. Remove nuts which hold gear to drive shaft.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(b) Use gear puller, or its equivalent, to pull air compressor drive gear from drive shaft. Place jaws of puller back of gear and use wrench to tighten puller screw until gear is pulled free of drive shaft.

(2) REMOVE DRIVE SHAFT (fig. 130). Remove Woodruff key from end of drive shaft. Then pull drive shaft from housing.

(3) REMOVE IDLER GEAR (fig. 130).

HAMMER, rawhide

WRENCH, socket, $1\frac{5}{16}$ -in.,
and spinner type handle

SCREWDRIVER

WRENCH, open-end, $\frac{5}{16}$ -in.

(a) Pry back lock washer from idler gear shaft nut. Then remove nut from idler gear shaft.

(b) Remove oilhole plug from end of idler gear shaft.

(c) Tap idler gear shaft from housing.

(d) Remove gasket from housing if it has not already been removed.

(e) Remove idler gear shaft from idler gear.

(4) REMOVE OIL SEAL, FELT AND FELT RETAINER FROM HOUSING (fig. 131).

HAMMER

WISE

PUNCH

(a) Place housing in vise and drive out oil seal, felt and felt retainer, using hammer and punch inserted through oilhole in housing.

(5) REMOVE BUSHINGS FROM AIR COMPRESSOR DRIVE HOUSING (fig. 131).

PRESS, arbor

SLEEVE, pipe

(a) Place housing in arbor press, or another suitable press, and use pipe sleeve of approximately same diameter as bushings to press out two bushings. CAUTION: Do not remove bushings from housing, unless inspection procedure outlined in paragraph 137 indicates need of new bushings. When this condition is found, remove bushings.

136. AIR COMPRESSOR DRIVE COUPLING INSPECTION.

a. Equipment.

WRENCH, socket, $\frac{1}{2}$ -in.

b. Procedure.

(1) INSPECT COUPLING COVER. Inspect bolts for tightness.

(2) INSPECT RUBBER COUPLING.

WRENCH, socket, $\frac{1}{2}$ -in.

(a) If necessary, remove bolts and lock washers and remove two sections of housing. Inspect rubber coupling for wear and replace with new part if wear is evident.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

**137. INSPECTION AND OVERHAUL OF AIR COMPRESSOR
DRIVE PARTS.**

a. Equipment.

OIL, engine

SOLVENT, dry-cleaning

b. Procedure.

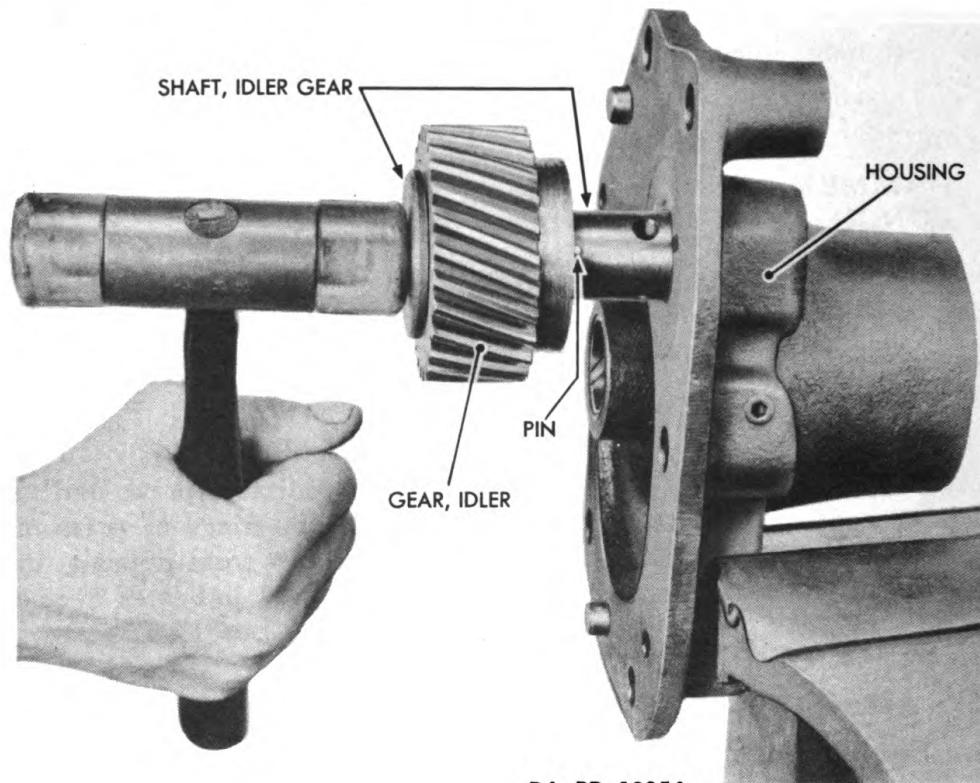
(1) THOROUGHLY WASH AND CLEAN ALL PARTS IN SOLVENT,
DRY-CLEANING.

SOLVENT, dry-cleaning

(2) INSPECT DRIVE SHAFT AND HOUSING.

OIL, engine

(a) Place drop of oil in installed bearings of housing. Then place
drive shaft in position and check for play of drive shaft on bearings.



RA PD 12854

**Figure 132—Air Compressor Drive Idler Gear Shaft
and Idler Gear Installation**

If play is in evidence, remove shaft and examine sections of shaft which are supported by bearings. If wear is noticeable at these points, install new bearings. Make same check after new bearings have been installed and, if play is still noticed, install new shaft.

(3) INSPECT DRIVE SHAFT GEAR. Examine drive shaft gear for

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

worn, chipped or broken teeth. If any of these conditions are found, new drive shaft gear should be installed.

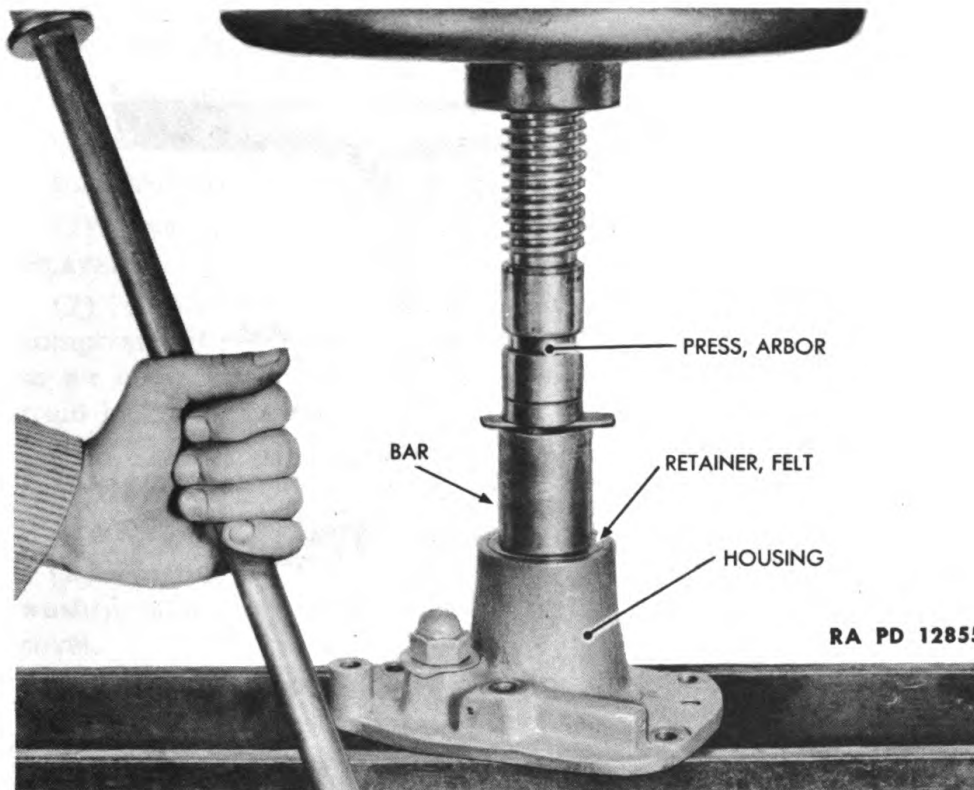
(4) **INSPECT IDLER GEAR.**

OIL, engine

(a) Inspect idler gear for worn, chipped or broken teeth.

(b) Place few drops of engine oil on idler gear shaft and install idler gear on shaft, checking for loose fit and play. When such conditions are encountered, install new gear. If recheck still reveals excessive play, new shaft should be installed.

(5) **NEW OIL SEALS, FELT AND FELT RETAINER SHOULD BE INSTALLED WHENEVER AIR COMPRESSOR IS DISASSEMBLED.**



**Figure 133—Installing Oil Seal, Felt and Felt Retainer
in Air Compressor Drive Housing**

138. ASSEMBLY OF AIR COMPRESSOR DRIVE.

a. Equipment.

PRESS, arbor
SCREWDRIVER
SLEEVE, pipe

WRENCH, socket, 1 $\frac{1}{8}$ -in., and
spinner type handle
WRENCH, socket, 1 $\frac{5}{16}$ -in.,
and spinner type handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) **INSTALL IDLER GEAR AND IDLER GEAR SHAFT (fig. 132).**

PRESS, arbor

SCREWDRIVER

SLEEVE, pipe

WRENCH, socket, 1⁵/₁₆-in.,

and spinner type handle

(a) Install idler gear on shaft with milled hub on gear toward threaded end of shaft.

(b) Insert shaft into housing so that pin on shaft is in alignment with slot in housing. Then tap shaft into housing.

(c) Install lock washer and nut. Tighten nut. Lock the lock washer around nut.

(2) **INSTALL DRIVE SHAFT (fig. 133).**

PRESS, arbor

SLEEVE, pipe

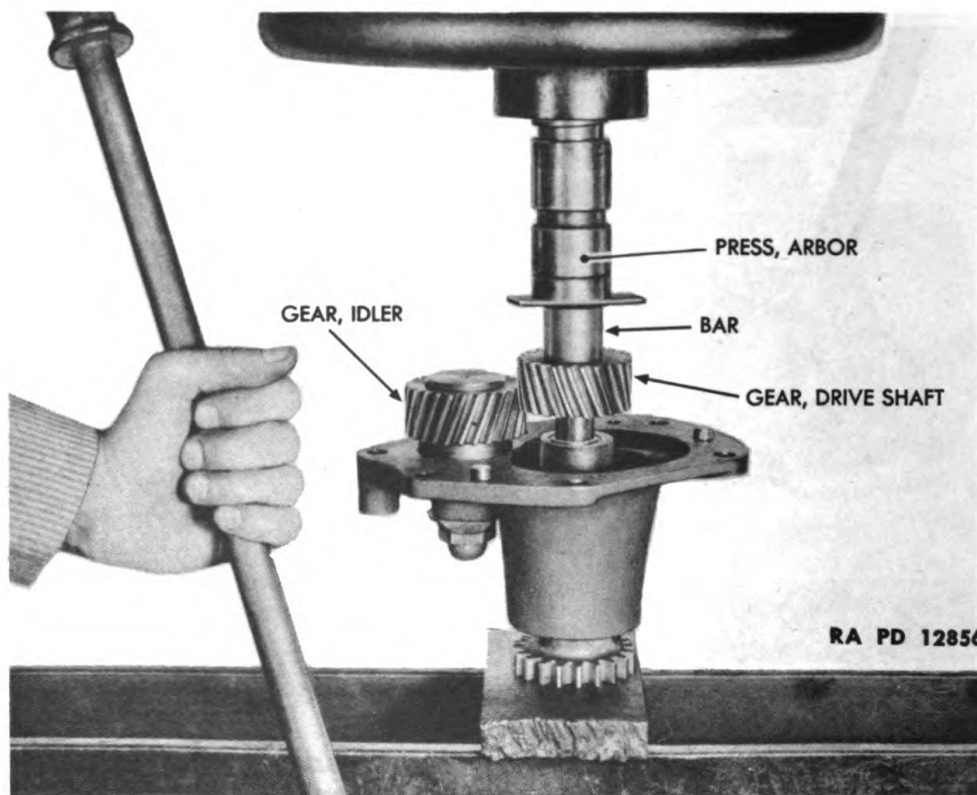


Figure 134—Drive Gear Installation Using Arbor Press

(a) Place new oil seal—with lip toward inside of housing—new felt and new felt retainer in position on housing, in order named. Press three parts into position until felt retainer is flush with housing.

(b) Insert drive shaft into housing.

(c) Install Woodruff key in end of drive shaft.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(3) INSTALL DRIVE SHAFT GEAR (fig. 134).

PRESS, arbor
SLEEVE, pipe

WRENCH, socket, 1 $\frac{1}{8}$ -in., and
spinner type handle

(a) Place gear over end of drive shaft so that it lines up with Woodruff key. Press gear into position on shaft.

(b) Install gear lock so that lip fits into notch in gear. Then install jam nut and tighten nut.

**139. INSPECTION OF AIR COMPRESSOR DRIVE BEFORE
INSTALLATION.**

a. Before installing air compressor drive on engine, inspect idler gear and drive shaft gear for worn, broken or chipped teeth. Also check to see that lock washer locks jam nut in place on end of drive shaft.

140. AIR COMPRESSOR DRIVE INSTALLATION.

a. Equipment.

VARNISH, shellac

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

b. Procedure.

(1) **INSTALL GASKET USING VARNISH TO SECURE IT TO FRONT PLATE.**

(2) **PLACE AIR COMPRESSOR DRIVE IN POSITION (fig. 129).** Lift air compressor drive in position on right side of engine and move it forward so air compressor drive idler gear engages with camshaft gear in gear train in crankcase front cover.

(3) **SECURE AIR COMPRESSOR DRIVE TO CRANKCASE FRONT COVER (fig. 129).**

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

(a) Install the four cap screws and lock washers and the bolt, lock washer, cable clip and nut, which hold the housing to the crankcase front cover.

(4) **INSTALL THE AIR COMPRESSOR.** Refer to TM 9-1777D.

141. FLYWHEEL AND RING GEAR OVERHAUL.

a. Equipment.

BAR, steel

PUNCH

**CARBON TETRA-
CHLORIDE**

SOLVENT, dry-cleaning

HAMMER

TORCH

PULLER, clutch pilot bearing
(IHC No. SE-672-2 or
equivalent)

WRENCH, open-end, $\frac{7}{8}$ -in.

b. Procedure. Flywheel and ring gear are removed in process of engine disassembly, when engine has been removed from tractor. Refer to section VII.



ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(4) REMOVE CLUTCH PILOT BEARING FROM FLYWHEEL (fig. 135).

PULLER, clutch pilot bearing **WRENCH**, open-end, $\frac{7}{8}$ -in.
(IHC No. SE-672-2 or
equivalent)

(a) Brace flywheel with wooden block.

(b) Insert pilot bearing puller into bearing. Then insert puller screw into puller and use wrench to keep puller from turning while using another wrench to enter screw into puller until puller expands firmly against bearing and pulls bearing out.

(5) INSPECT CLUTCH PILOT BEARING.

SOLVENT, dry-cleaning

(a) Wash clutch pilot bearing thoroughly in SOLVENT, dry-cleaning. Spin bearing as a check for flat spots. Examine it for broken bearing balls. Replace with new bearing, if either of these conditions is encountered. In addition, always replace the bearing at each major overhaul.

(6) INSTALL CLUTCH PILOT BEARING.

BAR, steel

(a) Place bearing in position on flywheel and use steel bar of slightly smaller diameter than bearing to drive bearing into position.

142. INTAKE MANIFOLD REMOVAL.

a. The intake manifold must be removed and disassembled before an adequate inspection of its parts can be made. The procedure outlined in this paragraph covers removal from the installed engine.

b. Equipment.

PLIERS	WRENCH , open-end, $\frac{5}{8}$ -in.
SCREWDRIVER	WRENCH , socket, $\frac{13}{16}$ -in., and speeder
WRENCH , open-end, $\frac{3}{8}$ -in.	
WRENCH , open-end, $\frac{9}{16}$ -in.	

c. Procedure.

(1) REMOVE MUFFLERS. See paragraph 28.

(2) REMOVE HOOD SHEET. See paragraph 29.

(3) SHUT OFF GASOLINE SUPPLY. Close valve on gasoline strainer. This is located beneath gasoline tank above left front side of engine.

(4) DISCONNECT AIR VALVE CONTROL ROD (fig. 136).

PLIERS

(a) Remove cotter pin and pin which connects air valve control rod to manifold outer control lever.

(5) DISCONNECT CABLE ASSEMBLY FROM IGNITION CUT-OUT SWITCH IN MANIFOLD HOUSING (fig. 136).

SCREWDRIVER

WRENCH, open-end, $\frac{3}{8}$ -in.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

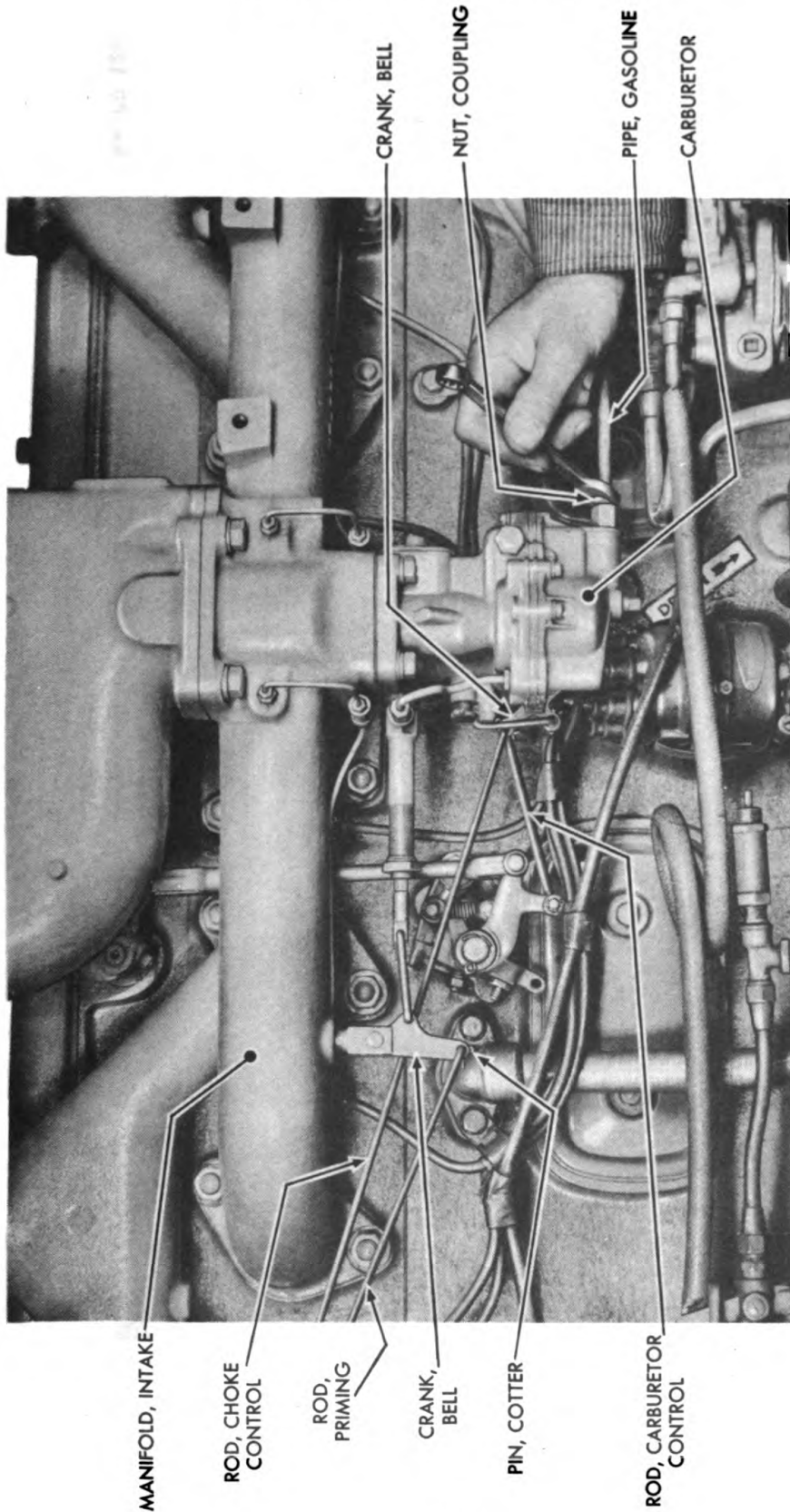


Figure 137 — Intake Manifold and Related Parts (Disconnection of Gasoline Pipe)

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

RA PD 12616

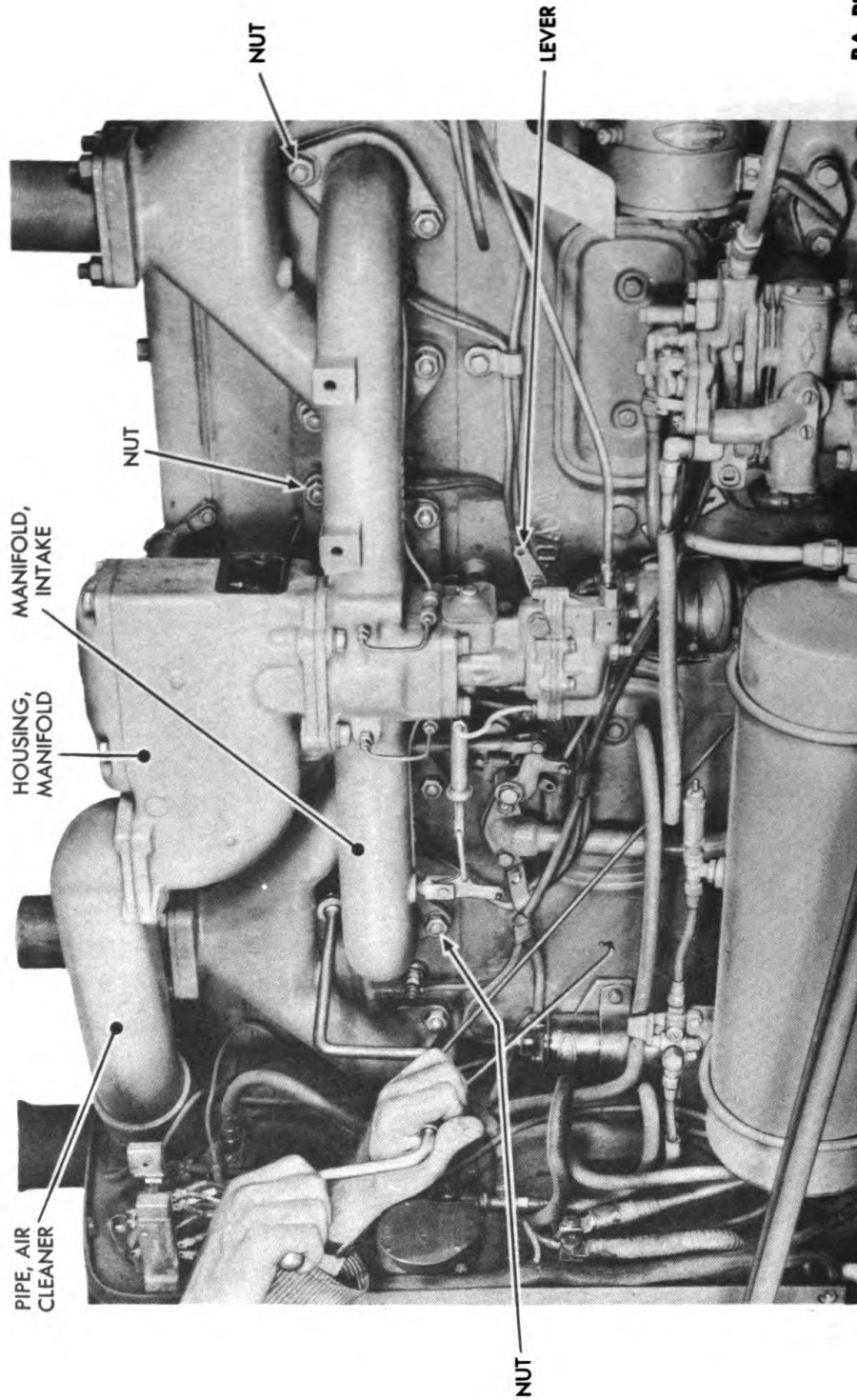


Figure 138 — Intake Manifold Removal

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

RA PD 12857

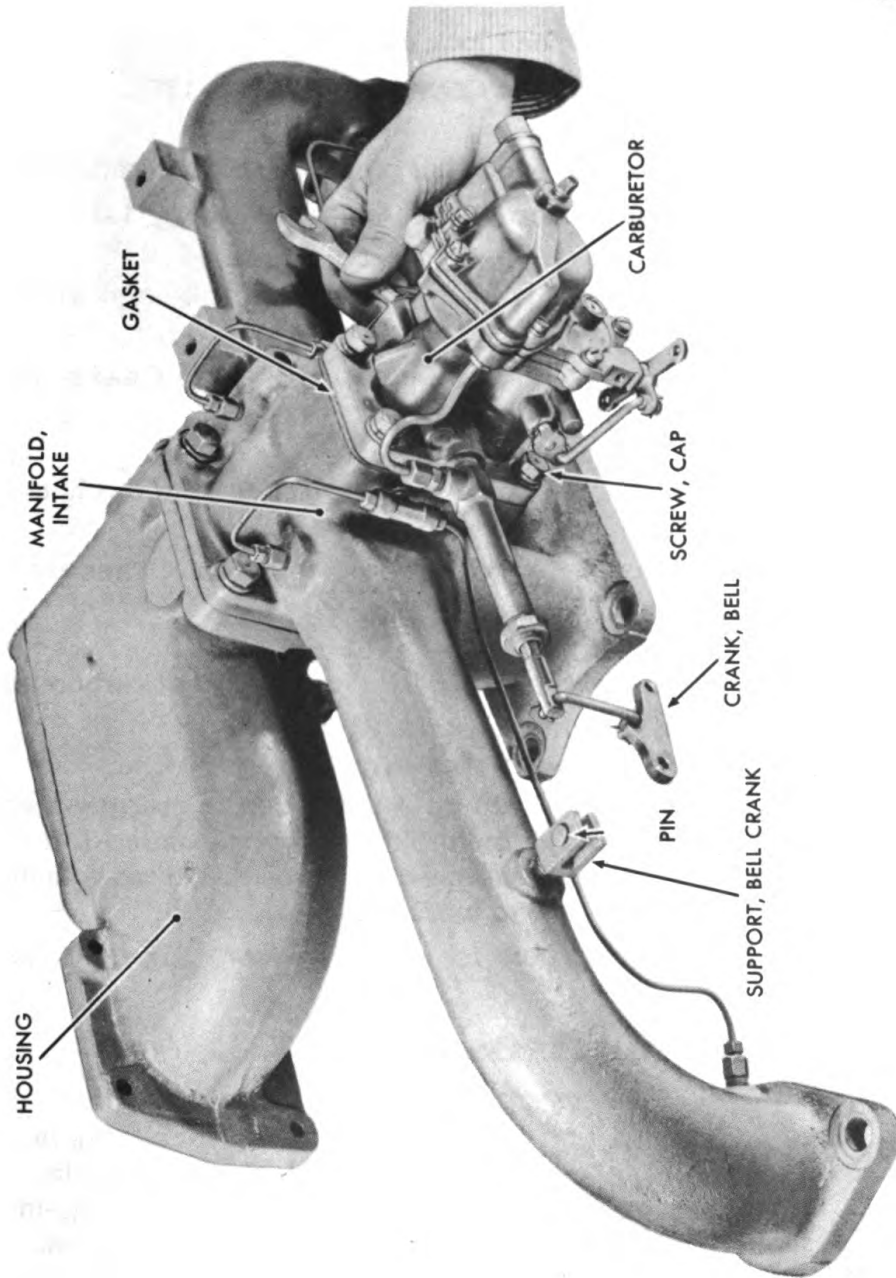


Figure 139 — Removing Carburetor from Intake Manifold

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(a) Remove two slotted screws and lock washers from cover at front side of manifold housing. Remove cover and gasket.

(b) Remove cut-out switch to distributor cable and coil to cut-out switch cable. Remove nut, lock washer and flat washer which secure each cable to its switch terminal within housing. Pull cables out through manifold.

(6) **DISCONNECT AIR CLEANER PIPE FROM MANIFOLD HOUSING** (fig. 136).

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

(a) Remove four cap screws and lock washers.

(7) **DISCONNECT GASOLINE PIPE COUPLING NUT** (fig. 137).

WRENCH, open-end, $\frac{1}{2}$ -in.

(a) Disconnect coupling nut which holds gasoline pipe to carburetor.

(8) **DISCONNECT PRIMING ROD FROM BELL CRANK** (fig. 137).

PLIERS

(a) Remove cotter pin which holds priming rod to bell crank at rear of manifold.

(9) **DISCONNECT CHOKE CONTROL ROD FROM BELL CRANK** (fig. 137).

PLIERS

(a) Remove cotter pin which holds choke control rod to top hole in bell crank at rear of carburetor.

(10) **DISCONNECT CARBURETOR CONTROL ROD FROM CARBURETOR CONTROL LEVER.**

PLIERS

(a) Remove cotter pin which holds control rod to lever at carburetor.

(11) **REMOVE INTAKE MANIFOLD** (fig. 138).

WRENCH, socket, $1\frac{3}{16}$ -in., and speeder

(a) Remove eight nuts which hold intake manifold to cylinder head. There are two nuts at each end of manifold and four at center. Lift off manifold with carburetor attached. Remove three gaskets from cylinder head. Also remove air cleaner pipe to manifold gasket.

(12) **REMOVE CABURETOR FROM INTAKE MANIFOLD** (fig. 139). See paragraph 143 b (1).

143. INTAKE MANIFOLD DISASSEMBLY.

a. Equipment.

BAR, steel

PLIERS

PRESS, arbor

PUNCH, small

SCREWDRIVER

WRENCH, box, $\frac{3}{8}$ -in.

WRENCH, box, $\frac{7}{16}$ -in.

WRENCH, open-end, $\frac{5}{16}$ -in.

WRENCH, open-end, $\frac{3}{8}$ -in.

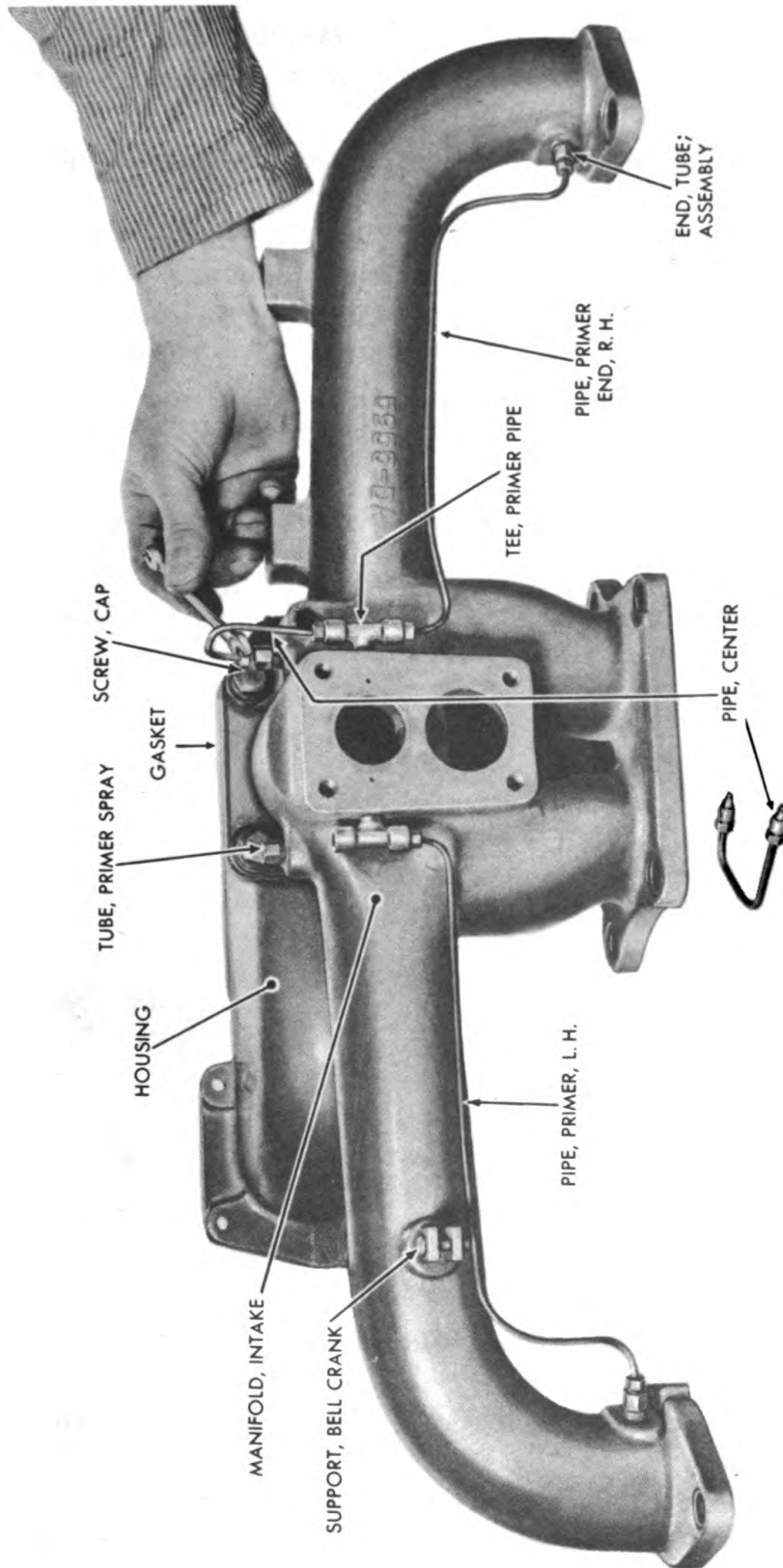
WRENCH, open-end, $1\frac{3}{32}$ -in.

WRENCH, open-end, $\frac{1}{2}$ -in.

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

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

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES



RA PD 12858

Figure 140—Removing Primer Pipes from Intake Manifold

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) REMOVE CARBURETOR FROM INTAKE MANIFOLD (fig. 139).

PLIERS

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

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

NOTE: When engine is disassembled, carburetor and intake manifold are removed together.

(a) Remove cotter pin from pin which secures bell crank to bell crank support at rear of intake manifold. Remove pin and bell crank, replacing pin and cotter pin in bell crank support.

(b) Remove four cap screws, lock washers and flat washers which hold carburetor to intake manifold.

(c) Remove carburetor from intake manifold. Then remove gasket.

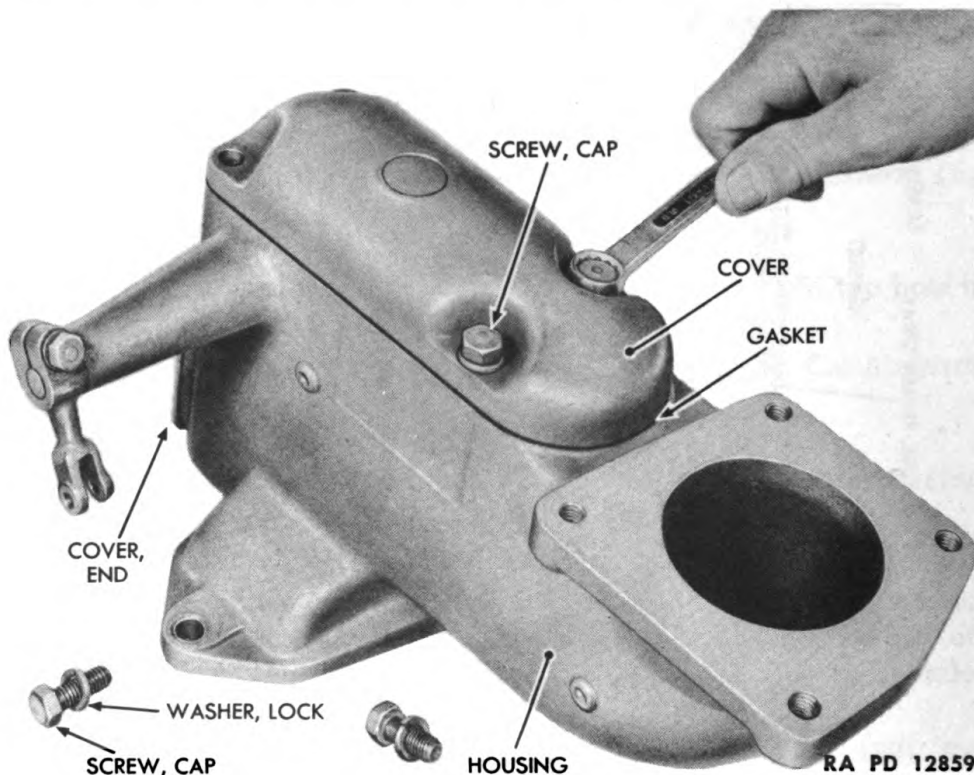


Figure 141—Air Valve Housing Cover Removal

(2) REMOVE CENTER PIPES (fig. 140).

WRENCH, open-end, $\frac{5}{16}$ -in.

(a) Remove connectors at each end of two center pipes. Then remove pipes.

(3) REMOVE PRIMER SPRAY TUBES (fig. 140).

WRENCH, open-end, $1\frac{3}{32}$ -in.

(a) Use wrench to remove two primer spray tubes.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

- (4) REMOVE PRIMER PIPES (fig. 140).

WRENCH, open-end, $\frac{5}{16}$ -in.

(a) Remove nut from tee end of left-hand primer pipe. Remove connector at other end of pipe.

(b) Remove right-hand primer end pipe in similar manner.

- (5) REMOVE TUBE ASSEMBLY ENDS (fig. 140).

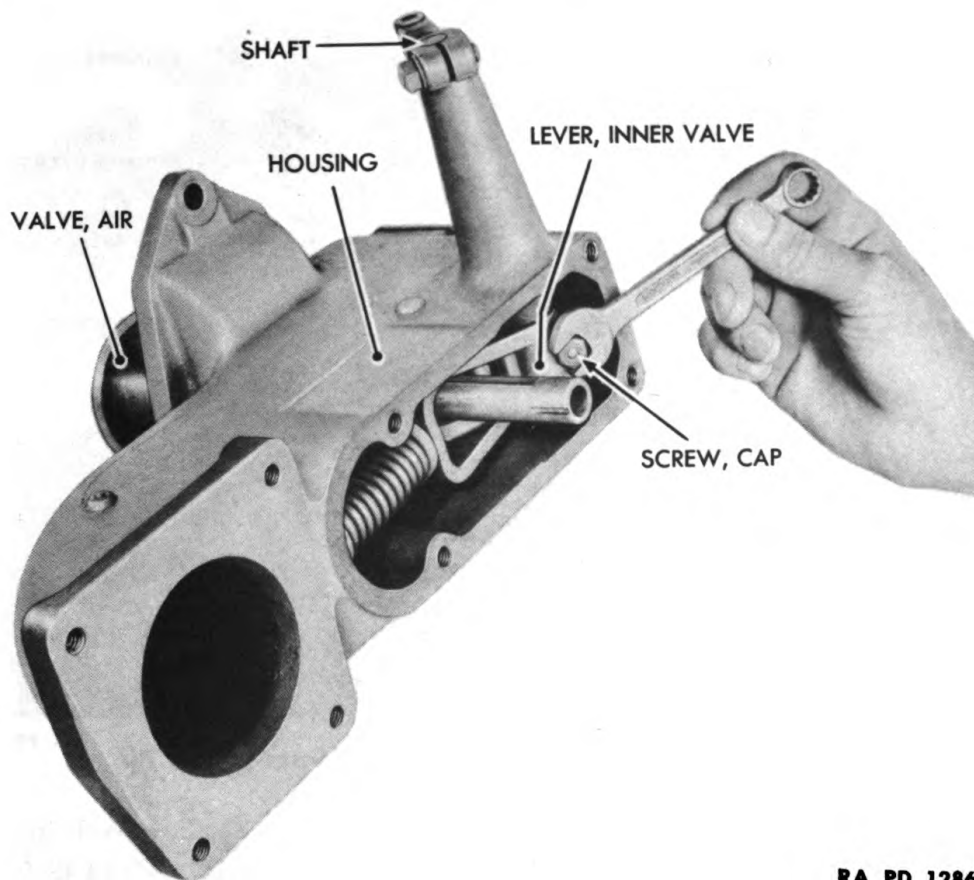
WRENCH, open-end, $1\frac{3}{32}$ -in.

(a) Use wrench to remove two tube assembly ends from manifold.

- (6) REMOVE TWO PRIMER PIPE TEES (fig. 140).

WRENCH, open-end, $\frac{3}{8}$ -in.

(a) Remove two tees from center of manifold.



RA PD 12860

Figure 142—Disconnecting Inner Valve Lever from Shaft

- (7) REMOVE BELL CRANK SUPPORT (fig. 140).

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

(a) Remove bell crank support from rear of intake manifold.

- (8) REMOVE HOUSING FROM INTAKE MANIFOLD (fig. 140).

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Remove three cap screws and lock washers which secure housing to manifold. Remove housing and gasket.

(9) REMOVE HOUSING COVER (fig. 141).

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

(a) Remove four cap screws and lock washers which hold cover to housing. Remove cover and housing gasket.

(10) REMOVE AIR VALVE (figs. 142 and 143).

PUNCH, small

WRENCH, open-end, $\frac{1}{2}$ -in.

SCREWDRIVER

(a) Remove cap screw and lock washer holding inner valve lever to shaft.

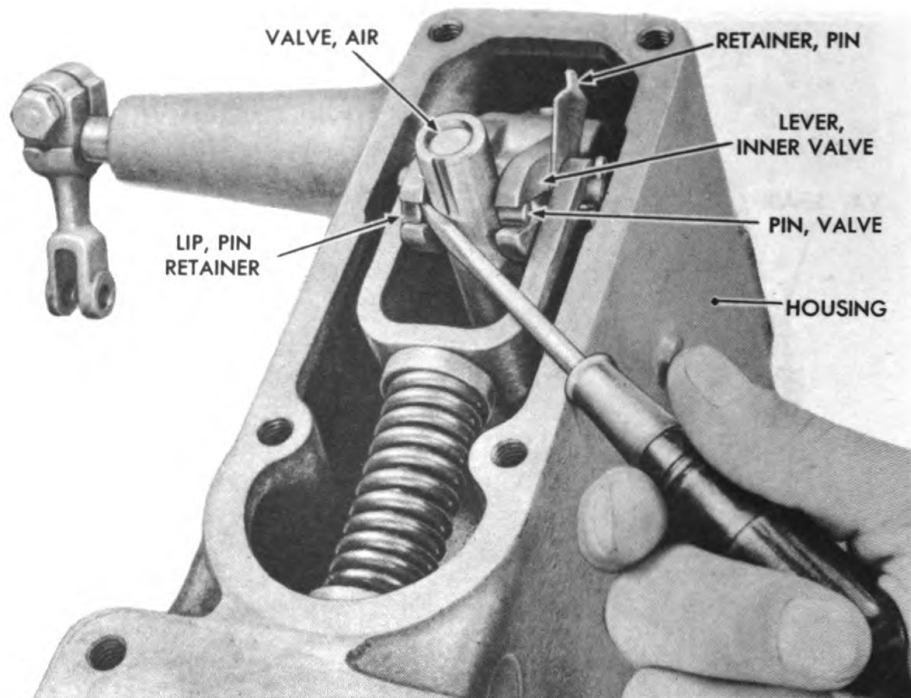


Figure 143—Unlocking Pin Retainer from Valve Pin

RA PD 12861

(b) Unlock pin retainers from valve pin (fig. 143). Pry back lips of two pin retainers from inner valve lever and move retainers away from valve pin.

(c) Drive out valve pin.

(d) Pull out air valve from bottom of housing.

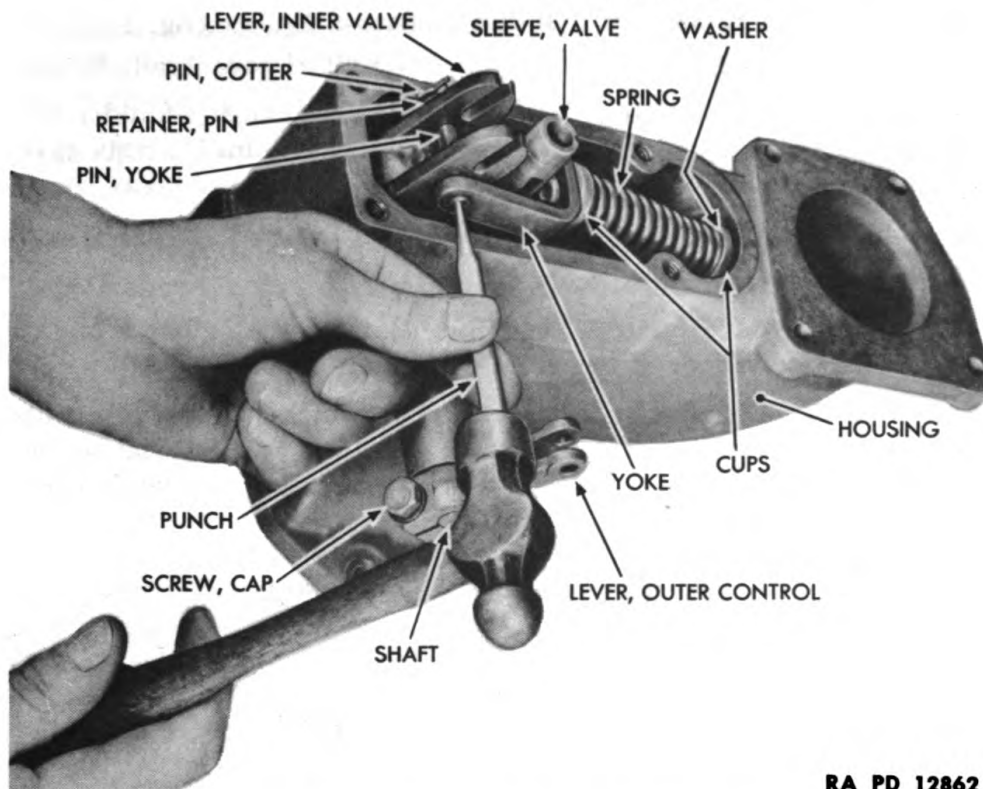
(11) REMOVE YOKE AND SPRING (fig. 144).

PLIERS

(a) Remove cotter pin from one end of yoke pin. Drive out yoke pin.

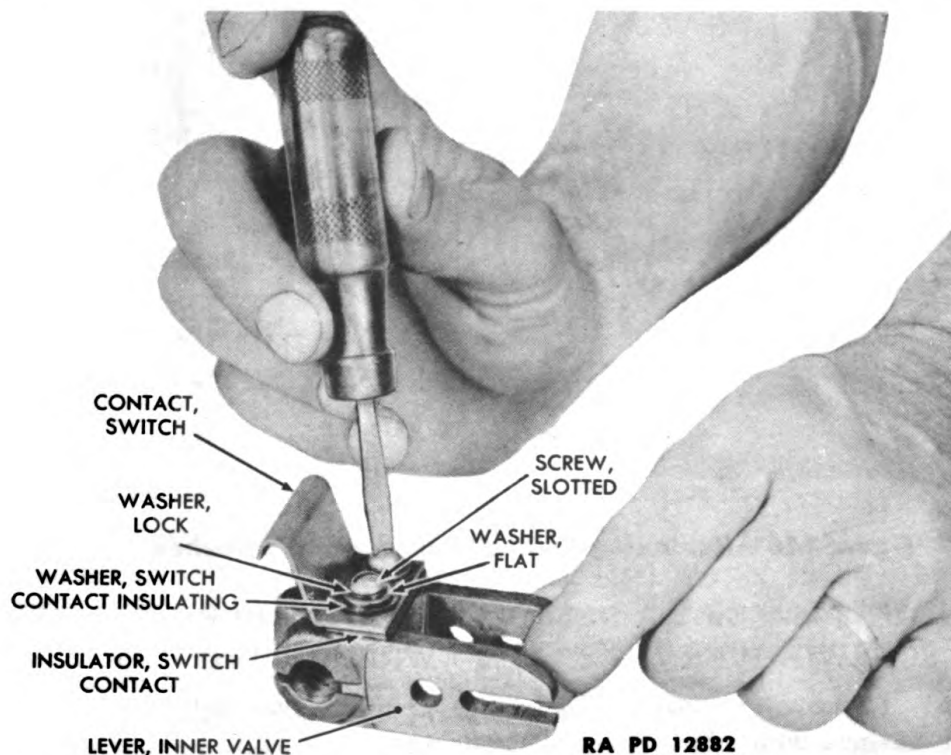
(b) Lift out yoke, spring, cups and washer.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**



RA PD 12862

Figure 144—Removing Yoke Pin from Yoke and Inner Valve Lever



RA PD 12882

Figure 145—Removing Switch Contact from Inner Valve Lever

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(12) REMOVE SHAFT AND OUTER CONTROL LEVER (fig. 142).

SCREWDRIVER

WRENCH, open-end, 1/2-in.

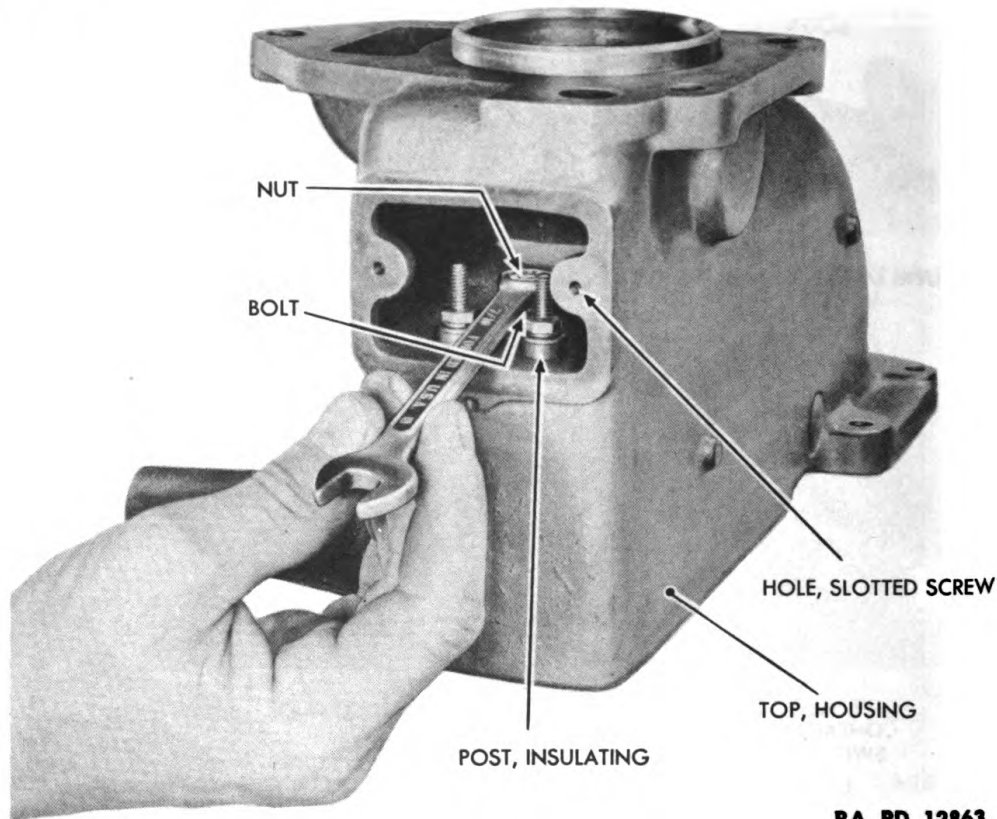
(a) Pull out shaft until Woodruff key rests against shoulder inside housing and pull inner valve lever away from shaft, until it rests against other side of housing. Then remove Woodruff key.

(b) Pull out shaft.

(c) Remove inner valve lever.

(d) Remove outer control lever from shaft, loosening cap screw with wrench. Remove Woodruff key from outer end of shaft.

(e) Remove two switch terminal screws which hold switch contact to inner valve lever (fig. 147). Remove two lock washers, flat washers, switch contact insulating washers, switch contact and switch contact insulator.



RA PD 12863

Figure 146—Removing Switch Insulator and Attached Parts

(13) REMOVE SWITCH INSULATOR AND ATTACHED PARTS (fig. 146).

SCREWDRIVER

WRENCH, box, 7/16-in.

(a) Remove end cover and gasket. Remove two slotted screws and lock washers which hold cover to housing.

(b) Remove nut from bolt which holds switch insulator to housing.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

Then remove lock washer, flat washer, insulating washer and insulating tube from bolt. Next remove switch insulator from top of housing, with two switch springs, insulating posts and two bolts attached.

(14) REMOVE INSULATING POSTS AND SWITCH SPRINGS FROM SWITCH INSULATOR (fig. 147).

WRENCH, box, 3/8-in.

(a) Remove nut, lock washer and flat washer from each bolt which holds each insulating post to switch insulator. Then remove bolts, two switch springs and two insulating posts.

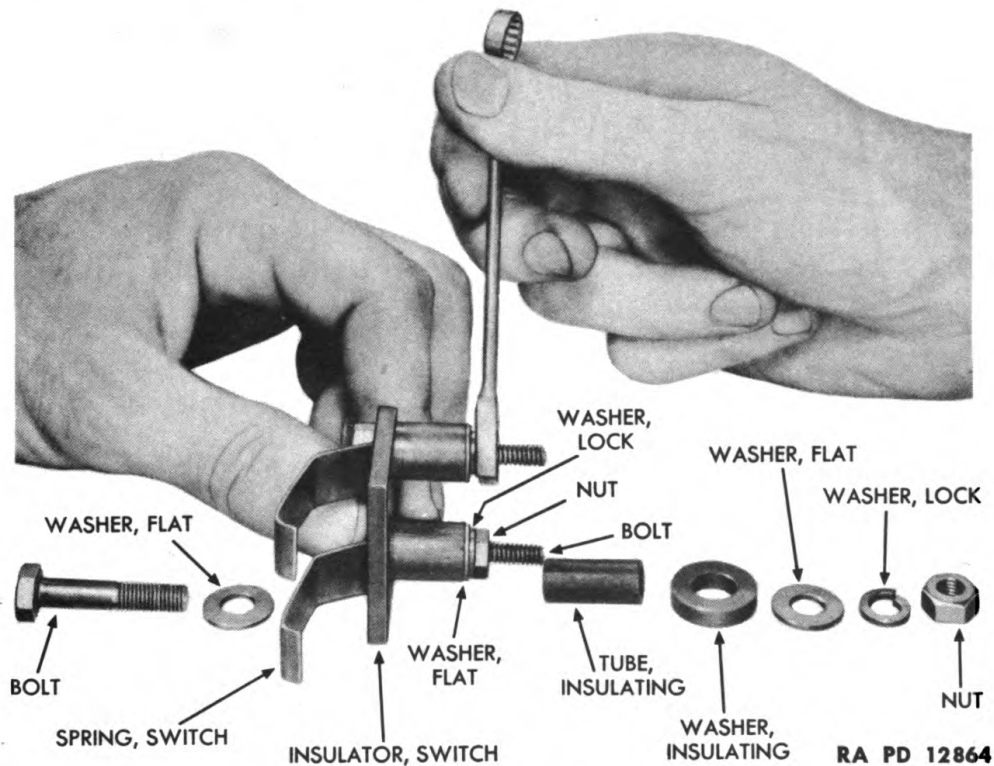


Figure 147—Removing Insulating Tubes and Switch Springs from Switch Insulator

(15) REMOVE VALVE SLEEVE (fig. 148).

BAR, steel

PRESS, arbor

(a) Do not remove the sleeve unless it must be replaced. Place housing top down in arbor press, with steel bar of slightly smaller diameter than sleeve over sleeve. Then press out sleeve. CAUTION: It is important to measure position of sleeve in housing, in order that sleeve may be accurately positioned when reassembled. Distance from end of sleeve to face of top of housing should be measured. This can be done by placing flat piece of steel across housing next to sleeve and then measuring distance from end of sleeve to bottom of steel strip.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(16) REMOVE PIVOT AND HOUSING PLUG (fig. 149).

PUNCH

(a) Place a punch in hole in center of pivot and punch out housing plug. Then remove pivot.

144. CLEANING INTAKE MANIFOLD AND HOUSING PARTS.

a. Before inspecting, all parts of disassembled intake manifold and housing should be thoroughly cleaned in SOLVENT, dry-cleaning. Then, parts should be thoroughly dried with compressed air, if available.

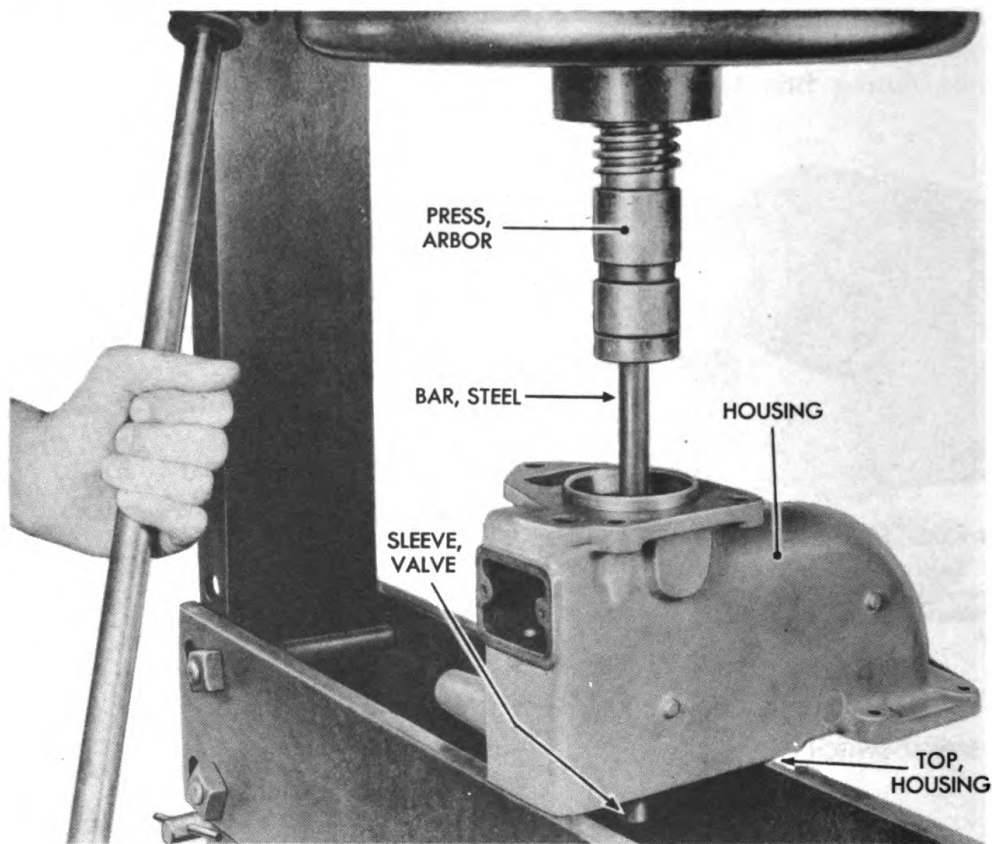


Figure 148—Valve Sleeve Removal

145. INSPECTION AND OVERHAUL OF INTAKE MANIFOLD AND HOUSING PARTS.

a. Inspect housing and intake manifold for cracks, replacing housing if cracks are found.

b. Because of relatively little movement of parts in intake manifold and housing, extended use will not result in appreciable wear on such parts as valve sleeve, yoke, inner valve lever, outer valve lever, spring, spring caps, spring washer and switch contact.

c. Inspect valve and valve seat. While normal service should not

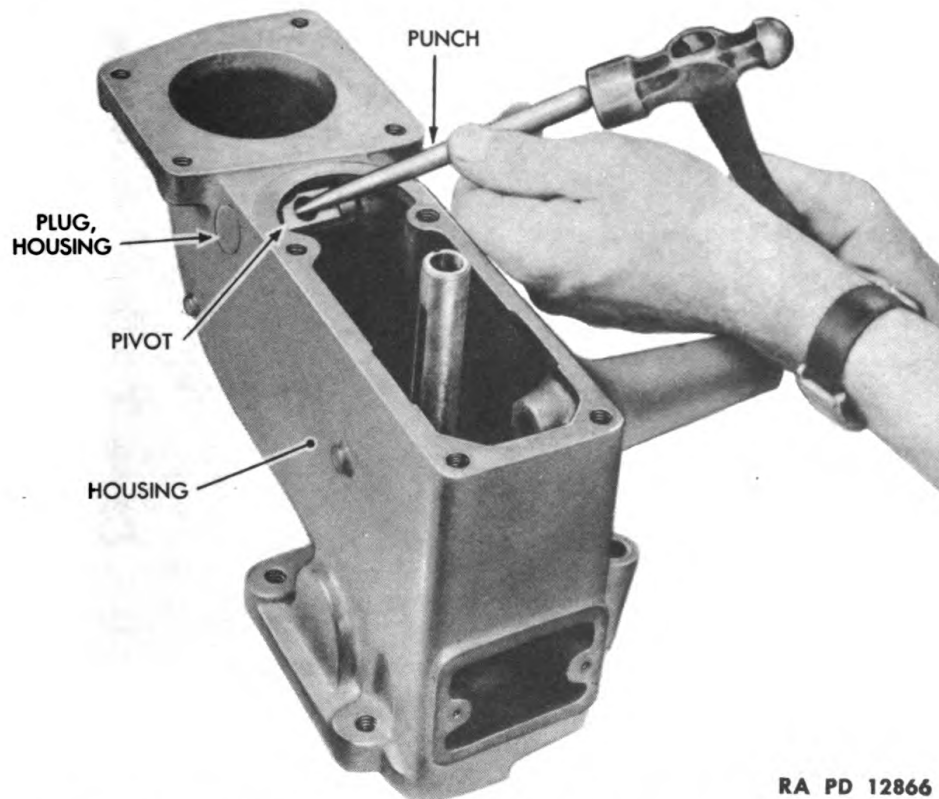
REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

necessitate need for grinding valve and valve seats, in instances where vehicle has been in operation in extremely damp climates or has been in storage for an extended period, valve and valve seat must be inspected for corrosion and thoroughly cleaned, if this condition is found.

d. Check for broken switch springs or for excessive wear on springs, replacing parts found defective. Check switch contact insulator, insulating tube and insulating washer for breakage or chipping, replacing defective parts.

e. Blow out left-hand primer tube, right-hand primer end tube and two center pipes. Inspect nuts on ends of these pipes for damaged threads and heads. Also check for damage to seats at ends of pipes.

f. Inspect two primer spray tubes and two tube assembly ends to see if they are clogged. Replace clogged parts with new parts.



RA PD 12866

Figure 149—Pivot and Compressor Drive Housing Plug Removal

146. ASSEMBLY OF INTAKE MANIFOLD.

a. Equipment.

PRESS, arbor
SCREWDRIVER
VISE, with copper jaws
WRENCH, box, $\frac{7}{16}$ -in.

WRENCH, box, $\frac{1}{2}$ -in.
WRENCH, open-end, $\frac{3}{8}$ -in.
WRENCH, open-end, $1\frac{3}{32}$ -in.

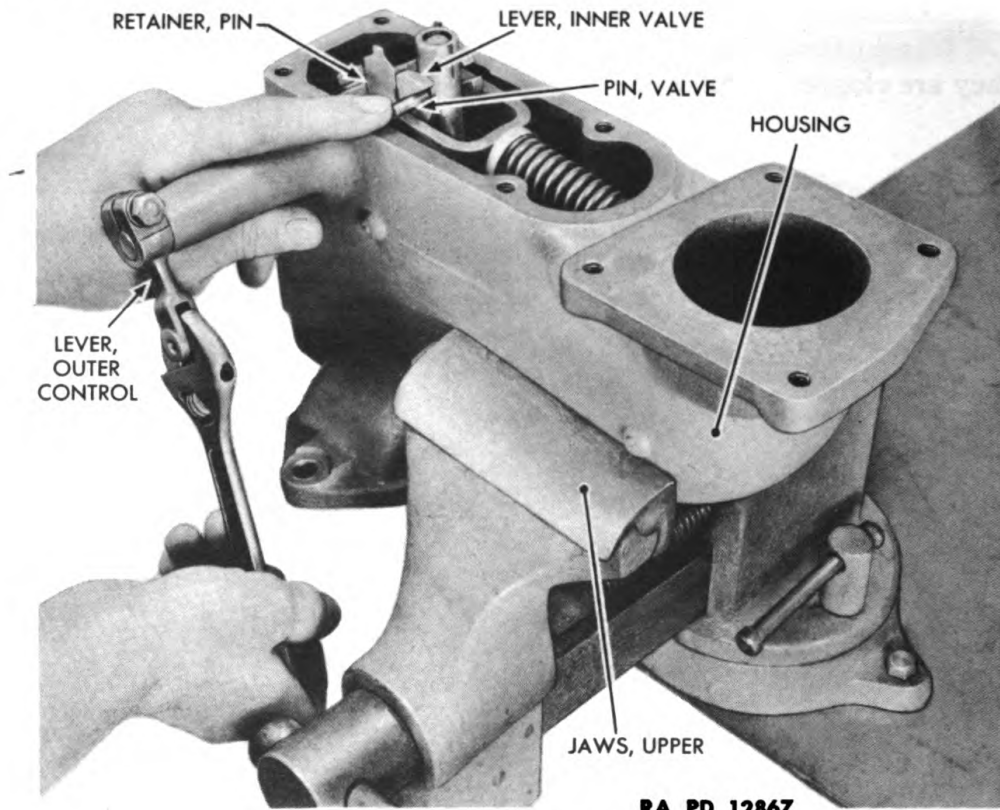
**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) INSTALL VALVE SLEEVE IN HOUSING.

PRESS, arbor

(a) Press sleeve into housing. Sleeve should enter top of housing, the reverse of figure 146. Position of sleeve in housing must measure $1\frac{7}{32}$ inch from end of sleeve to top of housing. This can be measured by placing flat strip of steel across housing and measuring distance from end of sleeve to bottom of flat steel strip. It is imperative that sleeve slot be positioned exactly crosswise in housing.



RA PD 12867

Figure 150—Valve Pin Installation

(2) INSTALL SWITCH INSULATOR (figs. 146 and 147).

WRENCH, box, $\frac{7}{16}$ -in.

WRENCH, open-end, $\frac{3}{8}$ -in.

(a) Assemble two switch springs, switch insulator and two insulating posts. Secure them with two bolts, flat washers, lock washers and nuts. Tighten nuts. Then install parts, placing bolts—nuts first—through holes in top of housing.

(b) Place flat washer and insulating tube on bolt and insert bolt and tube through holes in switch insulator and top of housing. From side of housing, attach insulating washer, flat washer, lock washer and nut. Tighten nut.

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

(3) **INSTALL SWITCH CONTACT TO INNER VALVE LEVER (fig. 145).**

SCREWDRIVER

(a) Assemble on two slotted screws two lock washers, flat washers and switch contact insulating washers, switch contact and switch contact insulator, in order named. Install slotted screws and assembled parts to inner valve lever.

(4) **INSTALL THE SHAFT AND THE INNER VALVE LEVER (fig. 144).**

WRENCH, box, 1/2-in.

(a) Attach outer control lever to shaft by first inserting Woodruff key in end of shaft and placing lever in position on shaft in alignment with Woodruff key. Tighten cap screw and lock washer which secure lever to shaft.

(b) Insert shaft into housing and into inner valve lever. Inner valve lever must be placed in position in top of housing with switch contact down.

(5) **SLIDE INNER VALVE LEVER TO SIDE OF HOUSING AND ADJUST SHAFT SO THAT WOODRUFF KEY CAN BE INSTALLED IN CORRECT VALVE LEVER END OF SHAFT (fig. 144).** Line up Woodruff key with inner valve lever and push shaft all the way into housing. Inner valve lever can be pulled back and placed in position over valve sleeve.

(6) **INSTALL LOCK WASHER AND CAP SCREW WHICH SECURE INNER VALVE LEVER TO SHAFT (fig. 142).**

WRENCH, box, 1/2-in.

(a) Tighten cap screw, with wrench.

(7) **INSTALL PIVOT IN HOUSING (fig. 149).** Place pivot in position in housing and install new housing plug. Place plug in position and tap it in center to secure it in housing.

(8) **INSTALL YOKE AND SPRING (fig. 144).**

(a) Place cup over one end of spring and place spring in position on yoke. Then install washer and cup on other end of spring.

(b) Place yoke and spring in position in housing so that yoke end can be pressed into hole in pivot.

(c) Line up yoke pin holes of yoke with yoke pin holes in inner valve lever. Then place two pin retainers in position so that retainer holes line up with holes in lever and yoke.

(d) Install yoke pin, securing it at each end with cotter pins.

(9) **INSTALL AIR VALVE (figs. 142 and 150).**

(a) Place air valve into sleeve, entering valve from bottom of housing. Valve must be positioned in sleeve so that valve pin hole lines up with slot in valve sleeve.

(b) Place housing between copper jaws in vise. Use wrench or piece

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

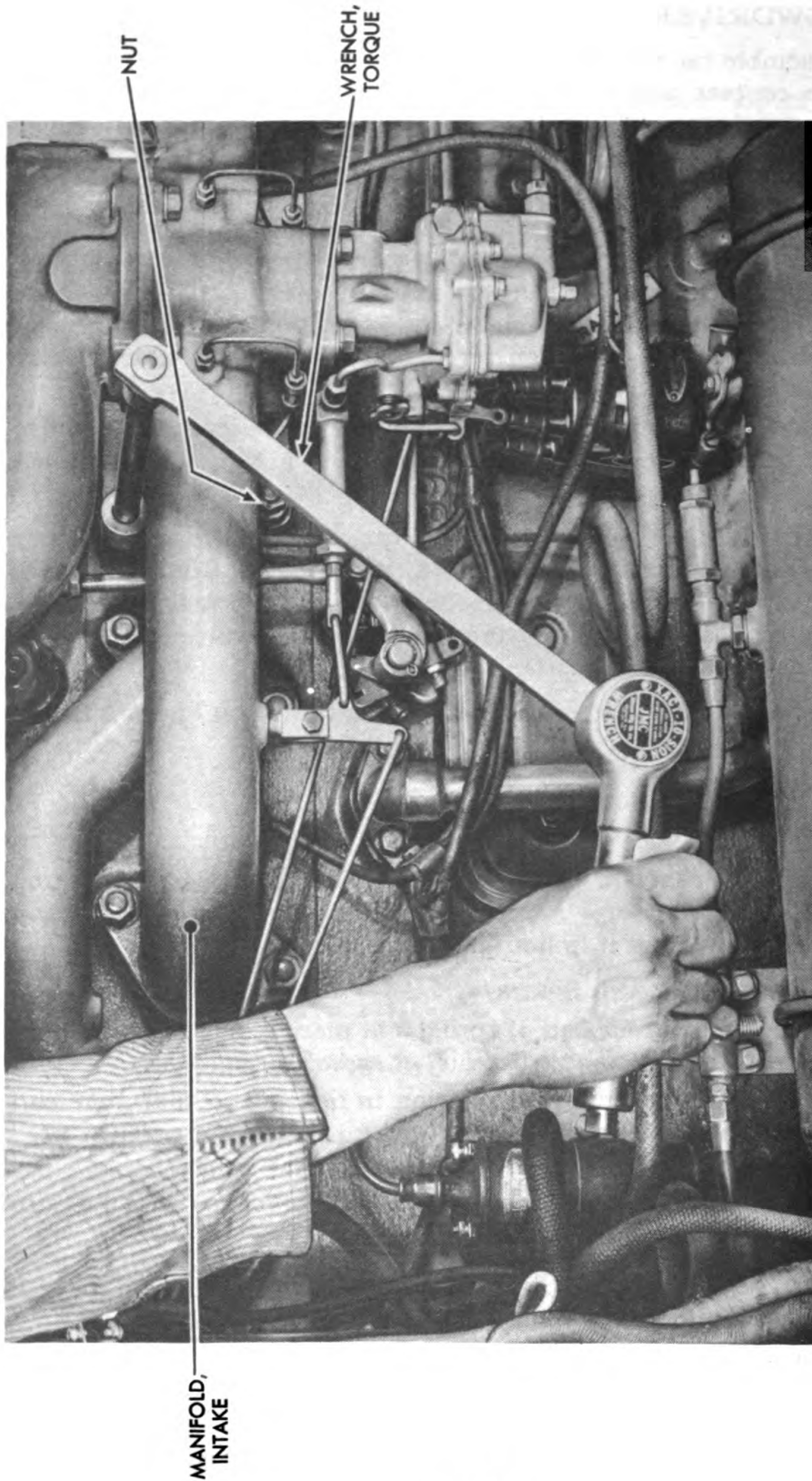


Figure 151—Tightening Intake Manifold Nut with Torque Wrench

REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND REBUILDING OF SUBASSEMBLIES

of pipe on outer control lever, turning lever so that inner valve lever forks are in alinement with pinholes in sleeve and valve.

(c) Tap valve pin in position. Then position pin retainer so that tips of retainer can be bent over ends of pin, locking it in position.

(10) **INSTALL HOUSING COVER** (fig. 141). Install new housing gasket and place cover in position. Insert four cap screws and lock washers and tighten cap screws.

(11) **INSTALL THE SIDE COVER**. Install new gasket and secure cover to housing with two slotted screws. Tighten screws.

(12) **INSTALL HOUSING TO INTAKE MANIFOLD** (fig. 140). Install new gasket and secure housing to intake manifold with three cap screws and lock washers and tighten cap screws.

(13) **INSTALL BELL CRANK SUPPORT** (fig. 140). Use wrench to install bell crank support at rear of intake manifold.

(14) **INSTALL TWO TUBE ASSEMBLY ENDS** (fig. 140). Install two tube assembly ends at each end of intake manifold, tightening them with a $1\frac{3}{32}$ -inch open-end wrench.

(15) **INSTALL PRIMER PIPE TEES** (fig. 140). Install two primer pipe tees on intake manifold and tighten them in position so that two center pipes can be attached.

(16) **INSTALL PRIMER SPRAY TUBES** (fig. 140). Place two primer spray tubes in manifold and tighten them.

(17) **INSTALL CENTER PIPES** (fig. 140). Attach two center pipes to manifold and tighten nut at each end of each pipe.

(18) **INSTALL LEFT-HAND PRIMER PIPE** (fig. 140). Install left-hand primer pipe on left end of manifold, tightening nut at each end of pipe.

(19) **INSTALL RIGHT-HAND PRIMER END PIPE** (fig. 140). Install pipe on right end of manifold, tightening nut at each end of pipe.

147. INTAKE MANIFOLD INSTALLATION.

a. Equipment.

PLIERS	WRENCH, open-end, $\frac{5}{8}$ -in.
SCREWDRIVER	WRENCH, socket, $1\frac{3}{16}$ -in., and speeder
WRENCH, open-end, $\frac{3}{8}$ -in.	WRENCH, torque
WRENCH, open-end, $\frac{1}{2}$ -in.	
WRENCH, open-end, $\frac{9}{16}$ -in.	

b. Procedure.

(1) **ATTACH CARBURETOR TO INTAKE MANIFOLD** (fig. 139).

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Install new gasket and place carburetor in position on intake manifold (carburetor will have been removed from engine with intake manifold). Insert four flat washers, lock washers and cap screws and tighten them.

(b) Attach bell crank support to intake manifold.

(c) Insert pin which holds bell crank to bell crank support and insert and lock cotter pin.

(2) **INSTALL INTAKE MANIFOLD WITH CARBURETOR ATTACHED** (figs. 138 and 151).

WRENCH, socket, $1\frac{3}{16}$ -in., and speeder

WRENCH, torque

(a) Install three new gaskets at cylinder head and new gasket between air cleaner pipe and manifold. Then place intake manifold with carburetor attached in position on engine. Attach two nuts at each end of manifold and four nuts at center which hold intake manifold to cylinder head. Run up nuts and tighten them to 75 foot-pounds.

(3) **CONNECT CARBURETOR CONTROL ROD TO CARBURETOR CONTROL LEVER** (figs. 137 and 138).

PLIERS

(a) Insert cotter pin which holds control rod to carburetor lever and lock cotter pin.

(4) **CONNECT CHOKE CONTROL ROD TO BELL CRANK** (fig. 137).

PLIERS

(a) Attach choke control rod to top hole in bell crank at rear of carburetor, insert cotter pin and lock it.

(5) **CONNECT PRIMING ROD TO BELL CRANK** (fig. 137).

PLIERS

(a) Attach priming rod to bell crank at rear of manifold. Insert cotter pin and lock it.

(6) **ATTACH GASOLINE PIPE COUPLING NUT** (fig. 137).

WRENCH, open-end, $\frac{1}{2}$ -in.

(a) Use wrench to connect coupling nut which holds gasoline pipe to carburetor.

(7) **CONNECT AIR CLEANER PIPE TO MANIFOLD HOUSING** (fig. 136).

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

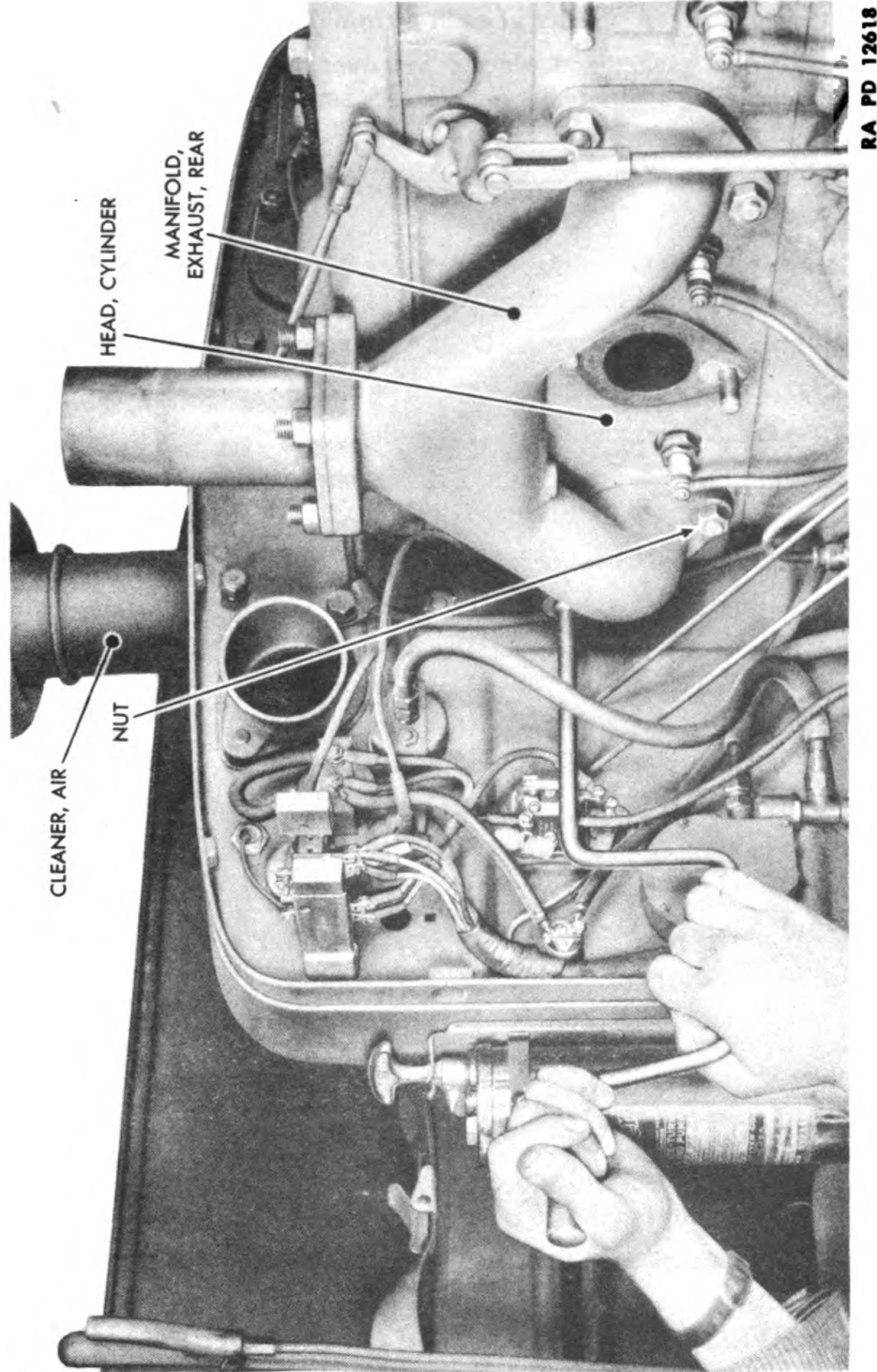
(a) Attach four cap screws and lock washers and tighten.

(8) **CONNECT CABLE ASSEMBLY TO IGNITION CUT-OUT SWITCH IN MANIFOLD HOUSING** (fig. 136).

SCREWDRIVER

WRENCH, open-end, $\frac{3}{8}$ -in.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**



RA PD 12618

Figure 152—Rear Exhaust Manifold Removal

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(a) Insert cut-out switch to distributor cable and coil to cut-out switch cable through hole in bottom of manifold, upward to cut-out switch in manifold housing. Attach each cable to terminal and tighten nut, lock washer and flat washer at each terminal.

(b) Install new gasket and place cover over cut-out switch opening in manifold housing. Tighten two slotted screws and lock washers which hold on cover.

(9) CONNECT AIR VALVE CONTROL ROD (fig. 136).

PLIERS

(a) Connect air valve control rod to manifold outer control lever, insert pin, cotter pin and lock cotter pin.

(10) OPEN GASOLINE SUPPLY. Open end valve on gasoline strainer.

(11) INSTALL HOOD SHEET. See paragraph 204.

(12) INSTALL MUFFLERS. See paragraph 205.

(13) INSTALL AIR COMPRESSOR AIR CLEANER. See paragraph 192.

148. EXHAUST MANIFOLD REMOVAL.

a. Equipment.

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

WRENCH, socket, $\frac{13}{16}$ -in.,
and speeder

b. Procedure.

(1) REMOVE MUFFLERS. See paragraph 28.

(2) REMOVE HOOD SHEET. See paragraph 29.

(3) REMOVE INTAKE MANIFOLD WITH CARBURETOR ATTACHED.
See paragraph 142.

(4) REMOVE AIR CLEANER PIPE (fig. 136).

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

(a) Loosen rear hose clamp and pull pipe and hose from air cleaner.

(5) REMOVE EXHAUST MANIFOLDS (fig. 152).

WRENCH, socket, $\frac{13}{16}$ -in., and speeder

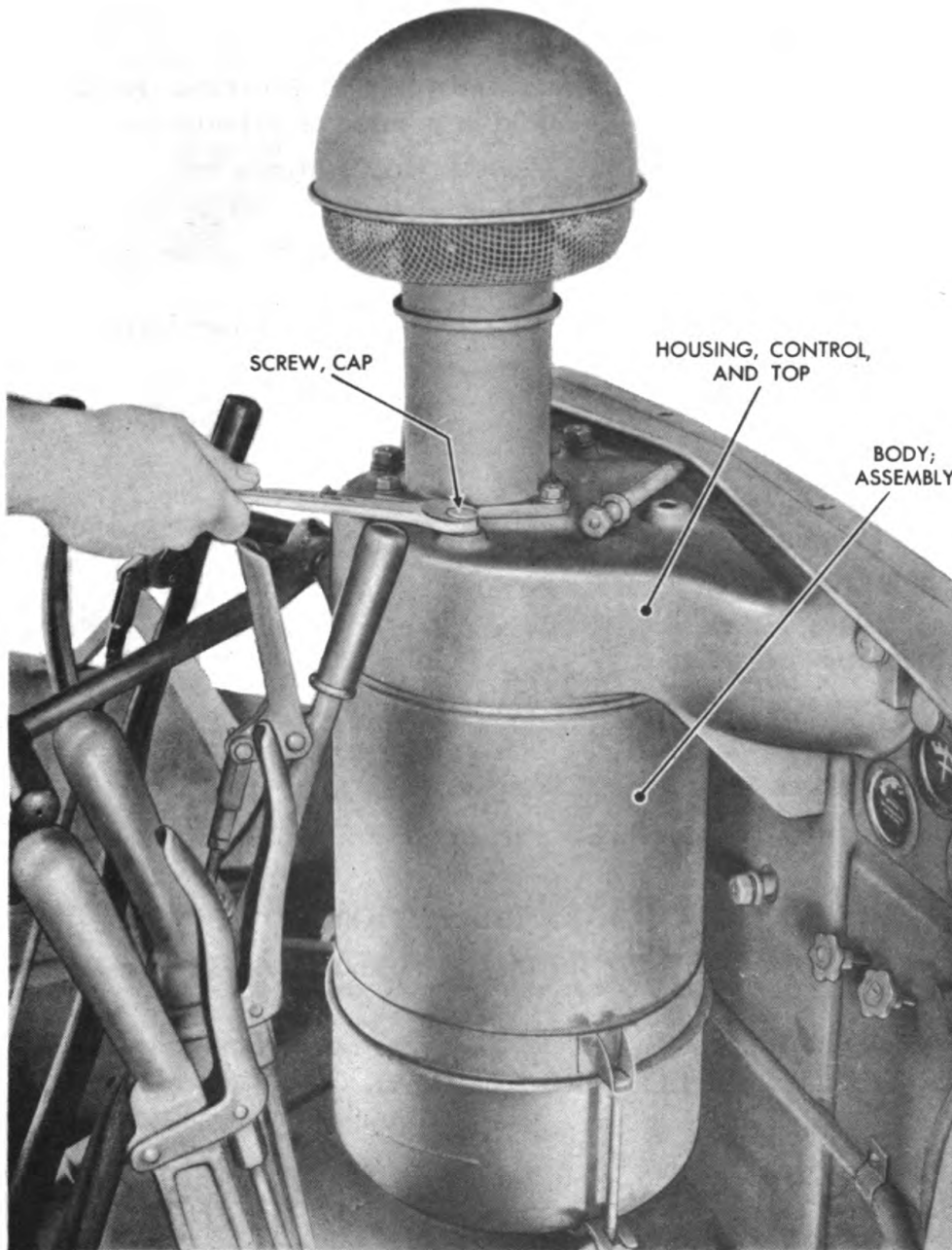
(a) Remove four nuts which secure rear exhaust manifold to cylinder head. Remove manifold and two copper gaskets.

(b) Follow same procedure to remove front exhaust manifold.

149. REMOVED EXHAUST MANIFOLD INSPECTION.

a. Be sure that all traces of old gaskets have been removed. Heat from engine operation prevents inside of exhaust manifolds from becoming dirty.

**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**



RA PD 12703

Figure 153—Air Cleaner Body Assembly Removal

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

150. EXHAUST MANIFOLD INSTALLATION.

a. Equipment.

WRENCH, open-end, $\frac{7}{16}$ -in. **WRENCH**, torque
WRENCH, socket, $\frac{13}{16}$ -in., and speeder

b. Procedure (fig. 152).

(1) **PLACE FRONT EXHAUST MANIFOLD IN POSITION.** Install two new copper gaskets. Place manifold in position on cylinder head.

(2) **INSTALL FOUR NUTS WHICH HOLD MANIFOLD TO CENTER BLOCK STUDS.**

WRENCH, socket, $\frac{13}{16}$ -in., **WRENCH**, torque
and speeder

(a) "Run up" nuts and then tighten them to 75 foot-pounds.

(3) **INSTALL REAR EXHAUST MANIFOLD.**

WRENCH, socket, $\frac{13}{16}$ -in., **WRENCH**, torque
and speeder

(a) Follow same procedure as outlined in steps (1) and (2) above.

(4) **INSTALL AIR CLEANER PIPE (fig. 136).**

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

(a) Place air cleaner pipe and hose in position on air cleaner. Tighten rear hose clamps.

(5) **INSTALL INTAKE MANIFOLD WITH CARBURETOR ATTACHED.** See paragraph 147.

(6) **INSTALL HOOD SHEET.** See paragraph 204.

(7) **INSTALL MUFFLER.** See paragraph 205.

151. ENGINE AIR CLEANER INSPECTION.

(Refer to TM 9-777 for inspection and servicing procedure for engine air cleaner.)

152. ENGINE AIR CLEANER REMOVAL.

a. Equipment.

WRENCH, open-end, $\frac{3}{4}$ -in. **WRENCH**, open-end, 1-in.
WRENCH, open-end, $\frac{13}{16}$ -in.

b. Procedure.

(1) **REMOVE HOOD SHEET.** See paragraph 29.

(2) **REMOVE AIR CLEANER BODY ASSEMBLY FROM CONTROL HOUSING AND TOP (fig. 153).**

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

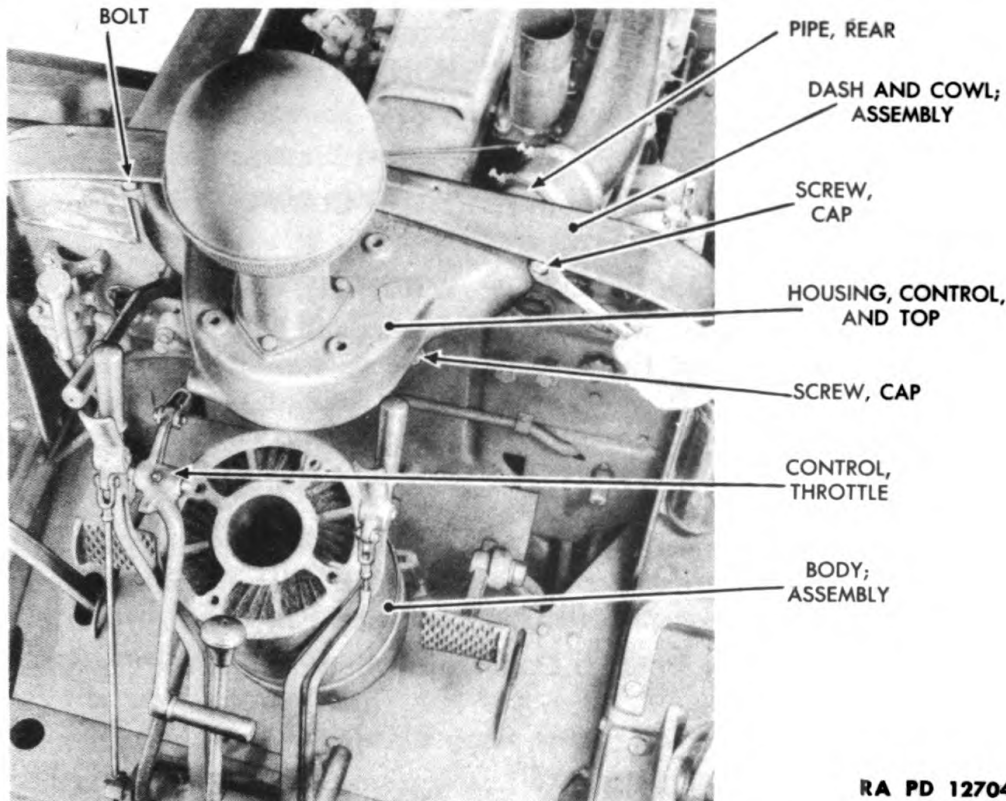
**REMOVAL FROM ENGINE, DISASSEMBLY, REPAIR AND
REBUILDING OF SUBASSEMBLIES**

(a) Remove four cap screws and lock washers which hold body to control housing and top.

(3) DISCONNECT THROTTLE CONTROL FROM CONTROL HOUSING AND AIR CLEANER TOP (fig. 154).

WRENCH, open-end, 1-in.

(a) Remove bolt which holds throttle control to control housing and top.



RA PD 12704

**Figure 154—Removal of Front Air Cleaner Pipe
from Control Housing and Air Cleaner Top**

(4) DISCONNECT REAR PIPE FROM CONTROL HOUSING AND AIR CLEANER TOP (fig. 154).

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

(a) Remove one cap screw and lock washer from driver's side of dash and cowl assembly and remove another cap screw and lock washer from engine side.

(5) DISCONNECT CONTROL HOUSING AND AIR CLEANER TOP FROM DASH AND COWL ASSEMBLY (fig. 154).

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

WRENCH, open-end, $\frac{13}{16}$ -in.

(a) Remove two cap screws and lock washers from driver's side. These cap screws—located at lower part of control housing and air cleaner top—secure it to dash and cowl assembly.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(b) From engine side, remove two cap screws and lock washers which also hold control housing and top to dash and cowl assembly. Then, using wrench from engine side and wrench from driver's side, remove remaining bolt nut and lock washer which holds control housing and air cleaner top to dash and cowl assembly. Balance of air cleaner assembly can then be removed.

153. ENGINE AIR CLEANER INSTALLATION.

a. Equipment.

WRENCH, open-end, $\frac{3}{4}$ -in. WRENCH, open-end, 1-in.
WRENCH, open-end, $\frac{13}{16}$ -in.

b. Procedure.

(1) CONNECT CONTROL HOUSING AND AIR CLEANER TOP TO DASH AND COWL ASSEMBLY (fig. 154).

WRENCH, open-end, $\frac{3}{4}$ -in. WRENCH, open-end, $\frac{13}{16}$ -in.

(a) From engine side install two cap screws and lock washers which hold control housing and top to dash and cowl assembly and tighten cap screws. Then, at left of control housing and at top, install bolt, nut and lock washer which hold control housing and air cleaner top to dash and cowl assembly. Use wrench from engine side and wrench from driver's side.

(b) Install two cap screws and lock washers from driver's side and tighten them. These cap screws—located at lower part of control housing and air cleaner top—secure it to dash and cowl assembly.

(2) CONNECT REAR PIPE TO CONTROL HOUSING AND AIR CLEANER TOP (fig. 154).

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

(a) Install gasket. Install one cap screw and lock washer from driver's side of dash and cowl assembly and install another cap screw and lock washer from engine side. Tighten cap screws.

(3) CONNECT THROTTLE CONTROL TO CONTROL HOUSING AND AIR CLEANER TOP (fig. 154).

WRENCH, open-end, 1-in.

(a) Place throttle control in position on control housing and air cleaner top and tighten bolt which holds throttle control to control housing and top.

(4) INSTALL AIR CLEANER BODY ASSEMBLY TO CONTROL HOUSING AND TOP (fig. 154).

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

(a) Place air cleaner body assembly in position and secure it to top with four cap screws and lock washers and tighten cap screws.

(5) INSTALL HOOD SHEET. See paragraph 204.

Section VIII

ASSEMBLY OF ENGINE

	Paragraph
Facilities needed	154
General precautions	155
Inspection of components	156
Lubrication of components	157
Installing camshaft bearings in crankcase	158
Crankcase front plate installation	159
Camshaft installation	160
Idler gear shaft and gear installation	161
Crankshaft installation	162
Fuel injection pump drive installation	163
Installing air compressor drive assembly	164
Gear train timing	165
Fan drive pulley and vibration damper installation	166
Flywheel installation	167
Valve tappet guide installation	168
Piston and connecting rod installation	169
Lubricating oil pump installation	170
Crankcase oil pan installation	171
Cylinder head installation	172
Hour meter installation	173
Lubricating oil filters and fuel filter installation	174
Fuel injection pump installation	175
Water trap installation	176
Installation of miscellaneous parts on right side of crankcase ..	177
Installation of air compressor and connections	178
Fan and water pump installation	179
Water outlet and thermostat housing installation	180
Generator and heat shield installation	181
Cranking motor installation	182
Cross shaft and governor control installation	183
Valve lever assemblies and housing installation	184
Assembly and installation of starting valve operating cross shaft and related parts	185
Adjustment of starting valve mechanism	186
Spark plug installation	187
Intake and exhaust manifold installation	188
Distributor installation	189
Installation of electrical cables on engine	190
Carburetor installation	191

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

	Paragraph
Air compressor air cleaner installation	192
Checking intake and exhaust valve clearance	193
Valve housing cover installation	194
Assembling clutch to engine	195

154. FACILITIES NEEDED.

a. Tools. Tools required for engine assembly are listed under each paragraph of this section. A hoist is needed to lift the crankcase.

b. Support the Crankcase on Wooden Blocks (fig. 43). Place a rope sling around crankcase so it can be lifted by means of a hoist to a bottom-side-up position. Then rest top of crankcase on two wooden blocks approximately 12-inch by 12-inch by 3-foot.

155. GENERAL PRECAUTIONS.

a. The following precautions should be observed when assembling the engine.

(1) **INSTALL NEW GASKETS.** Wherever a gasket is used, remove all traces of the old gasket and install a new gasket.

(2) **FITTING PARTS.** Use special pilot tools where specified to assure proper alinement of parts. Avoid forcing parts to fit. Double-check the proper location before installing a part.

(3) **CHECK FOR FREE MOVEMENT OF PARTS.** As moving parts are assembled, check frequently to see that they move freely.

(4) **USE OF TORQUE WRENCHES.** Use a torque wrench whenever a torque wrench is specified. In such instances, never substitute another wrench.

156. INSPECTION OF COMPONENTS.

a. Install Only Clean Parts. Examine each part or assembly before it is installed to make sure that it is clean. Use **SOLVENT**, dry-cleaning, or **CARBON TETRACHLORIDE** for cleaning purposes. For special instructions, refer to the procedure outlined in the treatment of the specific component.

b. Install Only New, Rebuilt, Repaired or Inspected Parts. No part or subassembly should be installed unless it is either new or completely rebuilt or repaired for efficient operation, or unless inspection proves that it is in good operating condition. All defective parts should be replaced by new parts.

157. LUBRICATION OF COMPONENTS.

a. Lubricate all moving parts with oil or grease before assembling them into the engine, in accordance with specific instructions given in

ASSEMBLY OF ENGINE

RA PD 12922

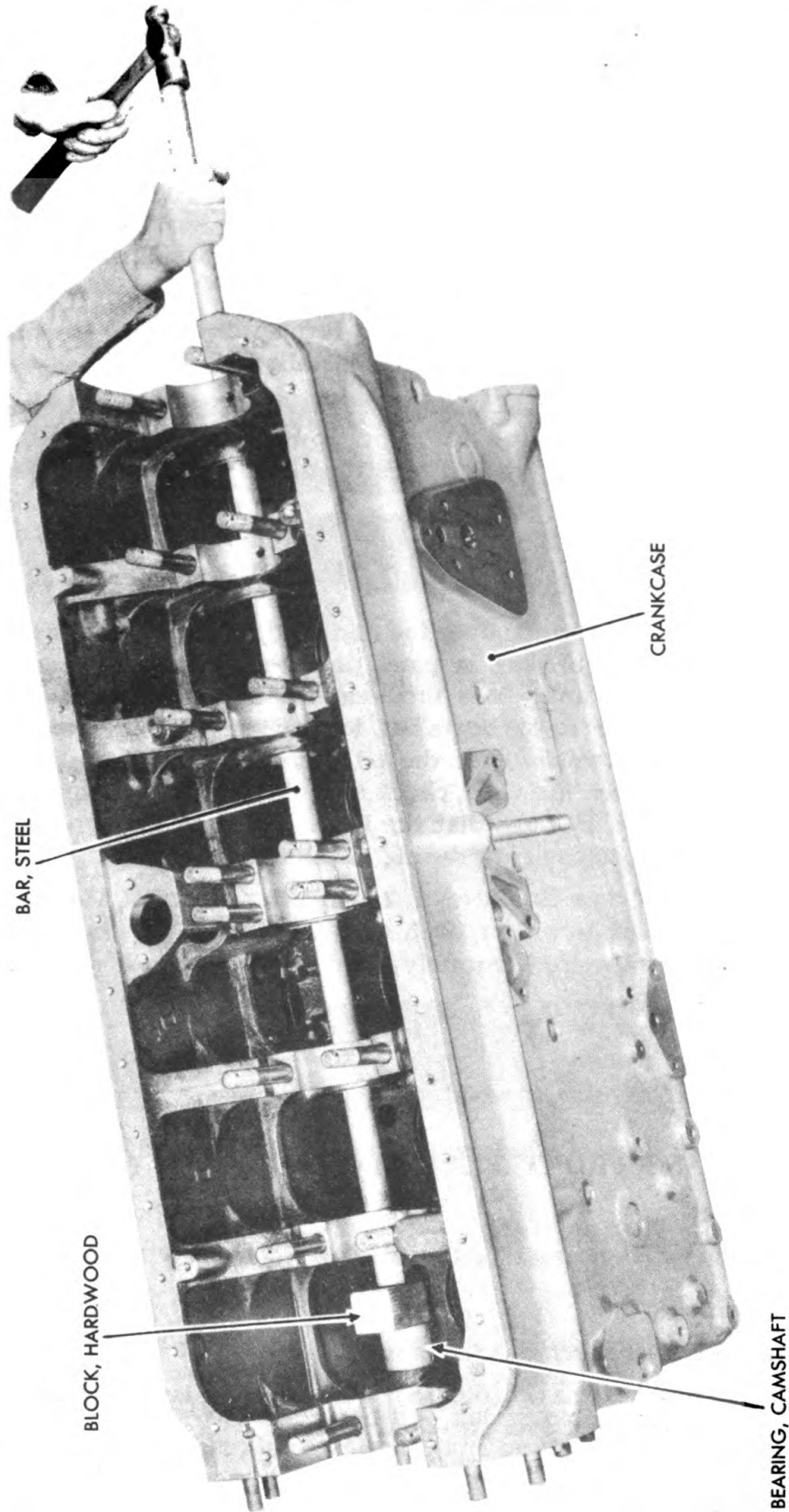


Figure 155—Camshaft Bearing Installation

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

the subsequent paragraphs. This is especially important when installing gears, bushings and bearings.

158. INSTALLING CAMSHAFT BEARINGS IN CRANKCASE (fig. 155).

a. Equipment.

AIR, compressed
BAR, steel, long

BLOCK, hardwood
HAMMER

b. Procedure. Camshaft bearings are furnished reamed to size. Therefore, no line reaming is required after installation.

(1) **POSITION BEARING IN CRANKCASE (fig. 155).** Insert the rear camshaft bearing inside the crankcase and position it so that the oilholes in the camshaft bearing line up with the oilholes in the crankcase.

(2) **DRIVE BEARING INTO POSITION.**

BAR, steel, long
BLOCK, hardwood

HAMMER

(a) Place a hardwood block over the end of the bearing and, using a long steel bar, tap the bearing in place until the end of the bearing toward the rear of the crankcase is three-eighths of an inch inside the crankcase. Extreme care must be taken to have the oilholes in the bearing in accurate alinement with the oil passages in the crankcase. After the bearing has been installed, check to make sure that these holes are in proper alinement. Be sure that the bearing is driven square with the crankcase to avoid damaging it during installation.

(3) **INSTALL CAMSHAFT BEARINGS 1, 2 AND 3 IN A SIMILAR MANNER.** The ends of these bearings will be flush with the boss in the crankcase. Be sure that the oilholes are accurately lined up with the oil passages.

(4) **BLOW OUT BEARINGS AND CRANKCASE WITH COMPRESSED AIR.**

AIR, compressed

(a) Be sure that any dirt or wood splinters are removed.

159. CRANKCASE FRONT PLATE INSTALLATION (fig. 55).

a. Equipment.

SCREWDRIVER

WRENCH, box, $\frac{3}{4}$ -in.

b. Procedure.

(1) **INSTALL NEW FRONT PLATE GASKET (fig. 55).**

(2) **INSTALL FRONT PLATE (fig. 55).** Place front plate in position over front end of crankcase, over two dowel pins.

(3) **INSTALL CAP SCREWS (fig. 55).**

SCREWDRIVER

WRENCH, box, $\frac{3}{4}$ -in.

ASSEMBLY OF ENGINE

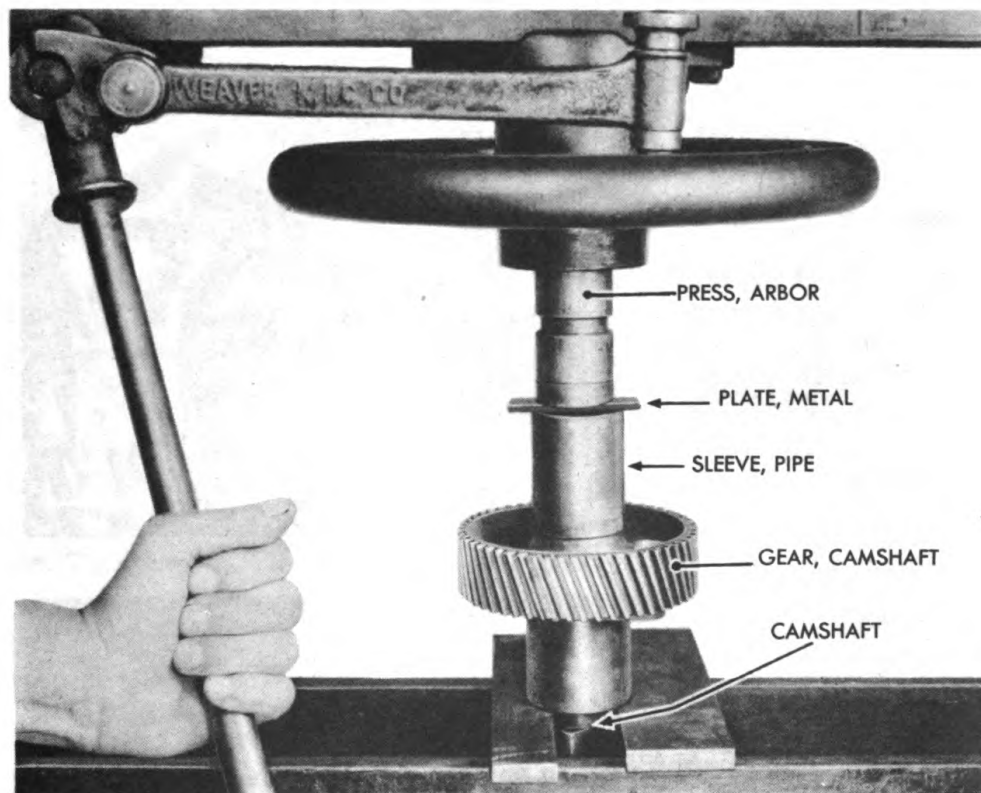
(a) Place four cap screw locks in position and insert five cap screws and lock washers and tighten cap screws. Lock cap screw locks around cap screws.

160. CAMSHAFT INSTALLATION.

a. Equipment.

BAR, steel
COMPOUND, joint and thread
GAGE, feeler
HAMMER
PRESS, arbor

SCREWDRIVER
WRENCH, open-end, 1½-in.
WRENCH, ratchet, with ¾-in.
socket and extension



RA PD 12921

Figure 156—Installing Camshaft Gear on Camshaft

b. Procedure.

(1) PRESS CAMSHAFT GEAR ONTO CAMSHAFT (fig. 156).

PRESS, arbor

(a) Place camshaft plate on gear end of camshaft with milled surfaces around cap screw holes toward the gear.

(b) Insert Woodruff key into slot in end of camshaft. Then make sure gear slot is in alignment with key on shaft.

(c) Press gear onto camshaft until it is resting firmly against shoulder of shaft.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(2) **INSTALL NUT LOCK AND NUT.**

SCREWDRIVER

WRENCH, open-end, 1½-in.

(a) Place nut lock on end of camshaft and attach nut and tighten it. Bend lock around nut.

(3) **CHECK END CLEARANCE.**

GAGE, feeler

(a) Using a feeler gage, check end clearance between camshaft plate and end of camshaft bearing journal. Clearance should be 0.005- to 0.011-inch.

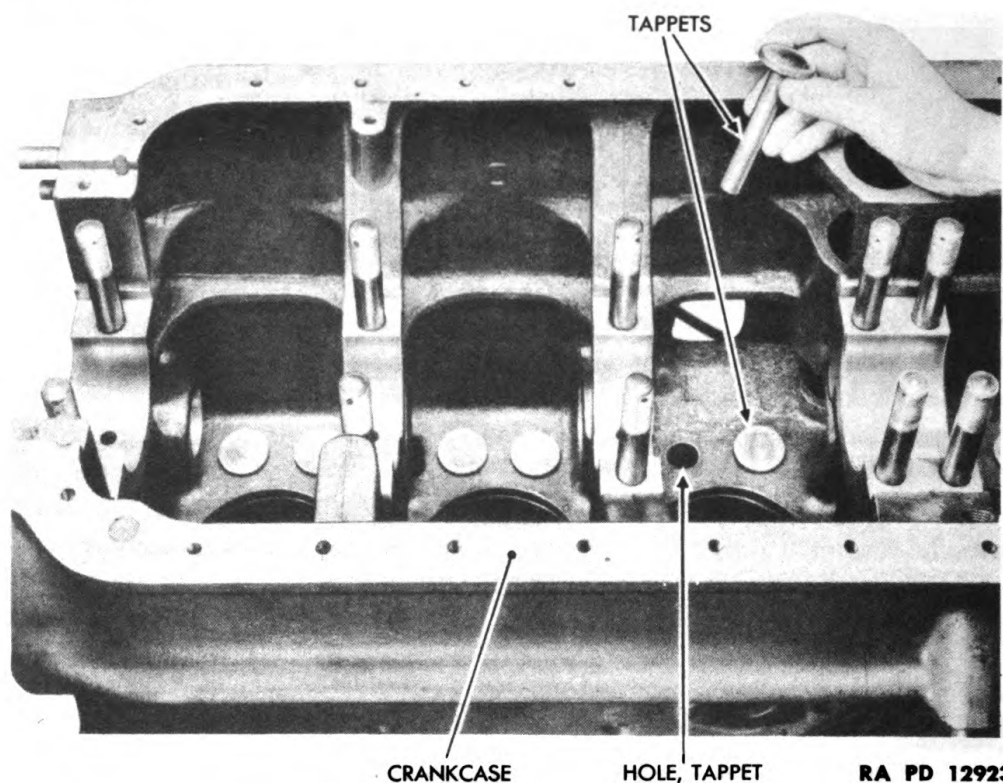


Figure 157—Installing Tappets in Crankcase

(4) **INSTALL TAPPETS** (fig. 157). Place tappets in position, entering them with faces up, from bottom of crankcase.

(5) **INSTALL CAMSHAFT IN CRANKCASE** (fig. 50). Insert camshaft into front end of crankcase.

(6) **SECURE CAMSHAFT PLATE TO CRANKCASE** (fig. 49).

WRENCH, ratchet, with ¾-in. socket and extension

(a) Rotate camshaft gear so that two cap screws and lock washers may be installed through gear holes to hold camshaft plate to crankcase. Tighten cap screws.

ASSEMBLY OF ENGINE

(7) INSTALL CAMSHAFT BEARING PLUG.

BAR, steel
COMPOUND, joint and thread

HAMMER

(a) Place plug in position in crankcase and lock it in position. Place steel bar, slightly smaller than plug, against plug and strike with hammer to set plug. Use joint and thread compound, on edge of plug before installing.

161. IDLER GEAR SHAFT AND GEAR INSTALLATION.

a. Equipment.

HAMMER, rawhide
SCREWDRIVER
WRENCH, open-end, 1/2-in.

WRENCH, socket, 1 1/8-in.,
and spinner type handle

b. Procedure.

(1) DRIVE IDLER GEAR SHAFT INTO CRANKCASE.

HAMMER, rawhide

(a) Enter shaft into front end of crankcase—thread end first and with pin in alignment with slot in crankcase. Then drive the shaft in against shoulder in crankcase.

(2) INSTALL NUT LOCK AND NUT.

SCREWDRIVER
WRENCH, socket, 1 1/8-in.,
and spinner type handle

(a) Place nut lock over threaded end of idler gear shaft and attach nut. Tighten nut. Bend nut lock over nut.

(3) INSTALL IDLER GEAR (fig. 158).

SCREWDRIVER
WRENCH, open-end, 1/2-in.

(a) Place idler gear on idler gear shaft, with gear tooth "C" between two beveled gear teeth, at point marked "C," on camshaft gear. The "C" marks are identified on figure 163.

(b) Install thrust washer (fig. 158). Secure thrust washer to idler shaft with cap screw lock and two cap screws. Tighten cap screws. Pry lock around cap screwheads.

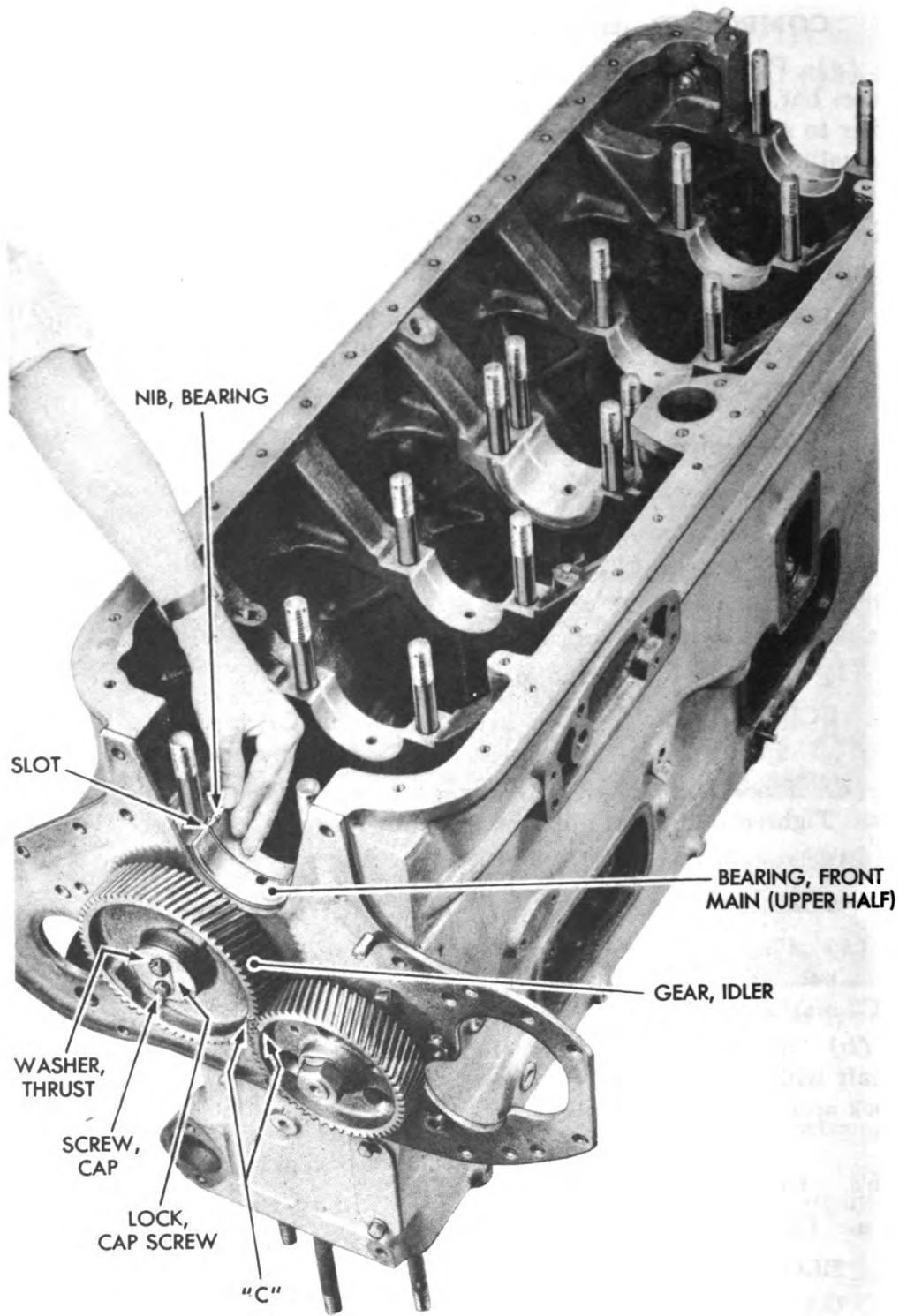
162. CRANKSHAFT INSTALLATION.

a. Equipment.

BLOCK, wooden
GAGE, feeler
HAMMER, rawhide
HOIST
OIL, engine, seasonal grade

PLIERS
SLEEVE, pipe
SLING, rope
WRENCH, torque, with
1 1/8-in. socket

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12927

Figure 158—Main Bearing Installation

ASSEMBLY OF ENGINE

b. Procedure.

(1) INSTALL UPPER HALVES OF MAIN BEARINGS (fig. 158).

OIL, engine, seasonal grade

(a) Install upper half of each main bearing. First start side without nib into support. Then rotate bearing in circular manner and slide bearing into position so nib locks bearing into slot. NOTE: Be sure bearing surfaces in crankcase and the backs of bearings are clean and dry.

(b) Be careful to install bearings in their proper positions. Rear bearing, front bearing and center bearing are not interchangeable with the four intermediate bearings. When intermediate bearings that were originally used are being installed again, they should be installed in their original positions.

(c) Oil each bearing with engine oil.

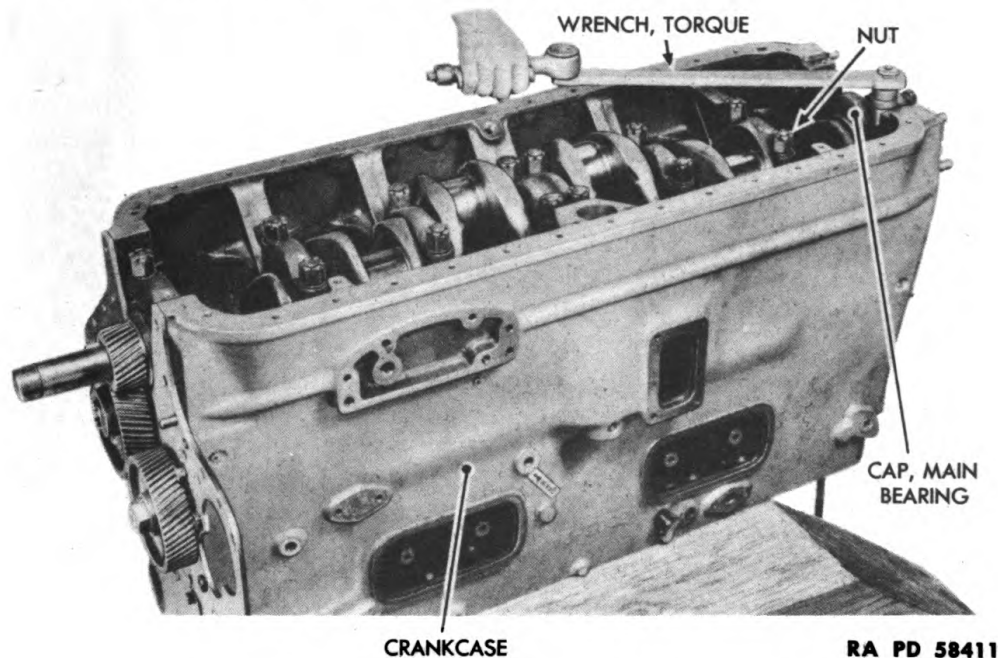


Figure 159—Main Bearing Cap Installation

(2) INSTALL CRANKSHAFT GEAR TO CRANKSHAFT.

SLEEVE, pipe

(a) Install Woodruff key in gear end of crankshaft.

(b) Place gear in position on end of crankshaft with keyways of gear and crankshaft in alignment. Then place pipe sleeve over end of crankshaft and drive gear into position against shoulder of front main bearing journal.

(3) LIFT CRANKSHAFT INTO POSITION IN CRANKCASE (fig. 47).

HOIST

SLING, rope

(a) Place rope sling around two connecting rod journals.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(b) Lower crankshaft into position, so that crankshaft gear meshes with idler gear, with tooth marked "S" between two beveled teeth of idler gear at point marked "S."

(4) **INSTALL LOWER HALVES OF MAIN BEARINGS.**

HAMMER, rawhide

(a) Insert lower halves of main bearings in their respective bearing caps, sliding each bearing in semicircle around crankcase support, moving nib side of bearing toward and into notch in support.

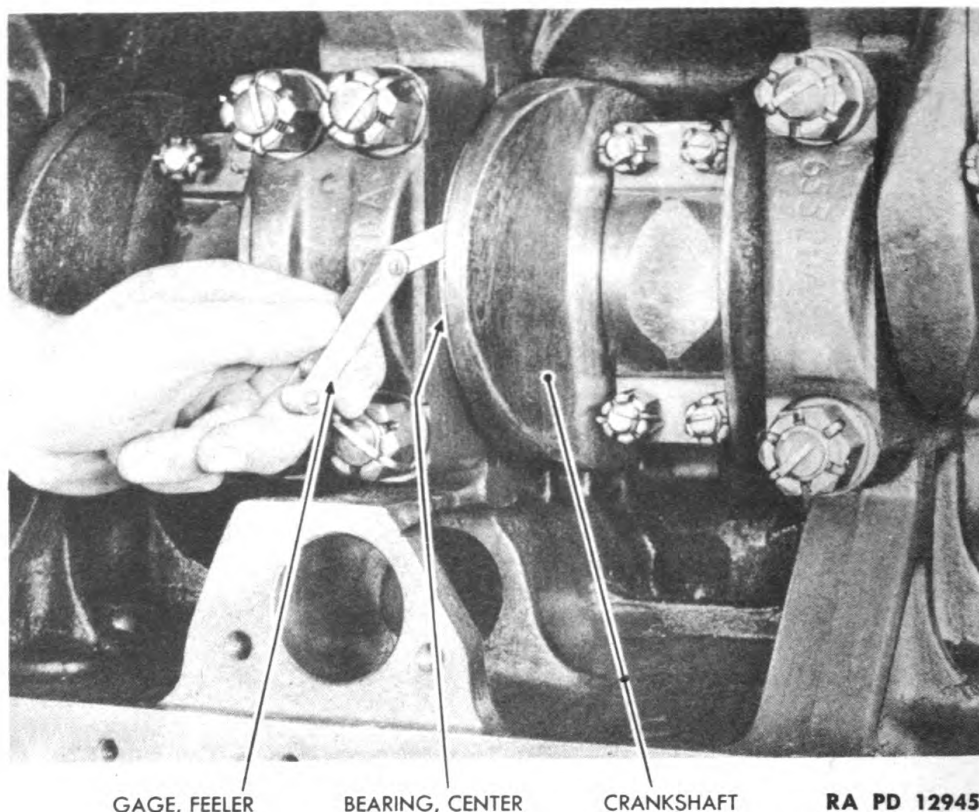


Figure 160—Checking End Clearance of Crankshaft

(5) **INSTALL MAIN BEARING CAPS** (fig. 159).

BLOCK, wooden

PLIERS

GAGE, feeler

WRENCH, torque, with

OIL, engine, seasonal grade

1 $\frac{1}{8}$ -in. socket

(a) With upper half of each main bearing installed in its proper bearing cap, add a few drops of engine oil over surface of each bearing. Then install each bearing cap in its proper position over crankcase studs, so that identifying number stamped on one end of bearing cap is next to same number stamped in proper position on edge of crankcase. Tap each cap securely into position.

(b) At each cap install flat washer and two nuts and tighten nuts

ASSEMBLY OF ENGINE

to 150 foot-pounds. Install cotter pins in nuts and lock pins. **CAUTION:** If cotter pin holes in nuts and studs do not line up when nut has been tightened to 150 foot-pounds, tighten nut still further to line up holes. **NOTE:** Center main bearing cap is secured to crankcase studs by means of four flat washers and nuts.

(c) *Check End Clearance of Crankshaft.* Drive wood wedge between flywheel flange on crankshaft and crankcase to force crankshaft to the rear. Place feeler gage between center main bearing flange and journal on crankshaft at rear of center main bearing. The clearance is 0.006- to 0.014-inch for new bearings and crankshaft.

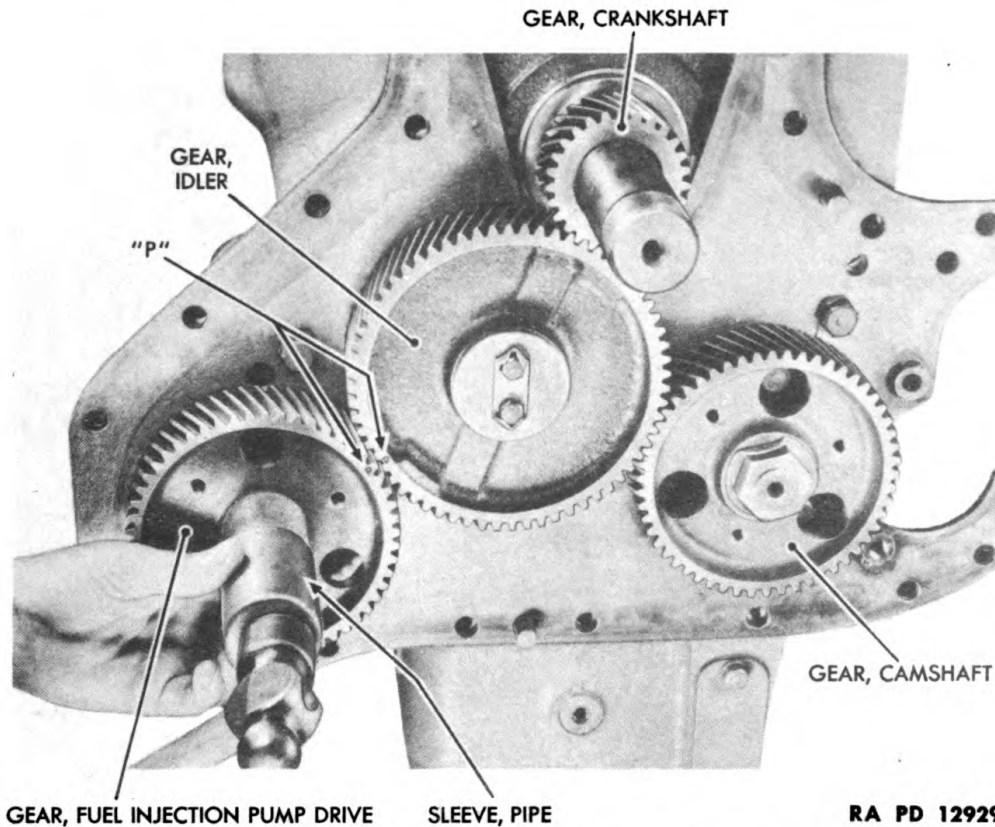


Figure 161—Fuel Injection Pump Drive Gear Installation

163. FUEL INJECTION PUMP DRIVE INSTALLATION.

a. Equipment.

SCREWDRIVER

WRENCH, box, 3/4-in.

b. Procedure.

(1) **INSTALL NEW HOUSING GASKET.** Place new gasket in position between housing and crankcase front plate.

(2) **SECURE FUEL INJECTION PUMP DRIVE HOUSING TO CRANKCASE FRONT PLATE** (fig. 53).

SCREWDRIVER

WRENCH, box, 3/4-in.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Hold housing—with gasket in position—against plate and install cap screw lock and two cap screws and tighten cap screws. Bend lock of each cap screw.

(3) **INSTALL FUEL INJECTION PUMP DRIVE GEAR** (fig. 161).

(a) Install Woodruff key in end of drive shaft.

(b) Install gear with keyway in alignment with Woodruff key. Beveled tooth marked "P" on gear goes between two beveled teeth marked "P" on idler gear.

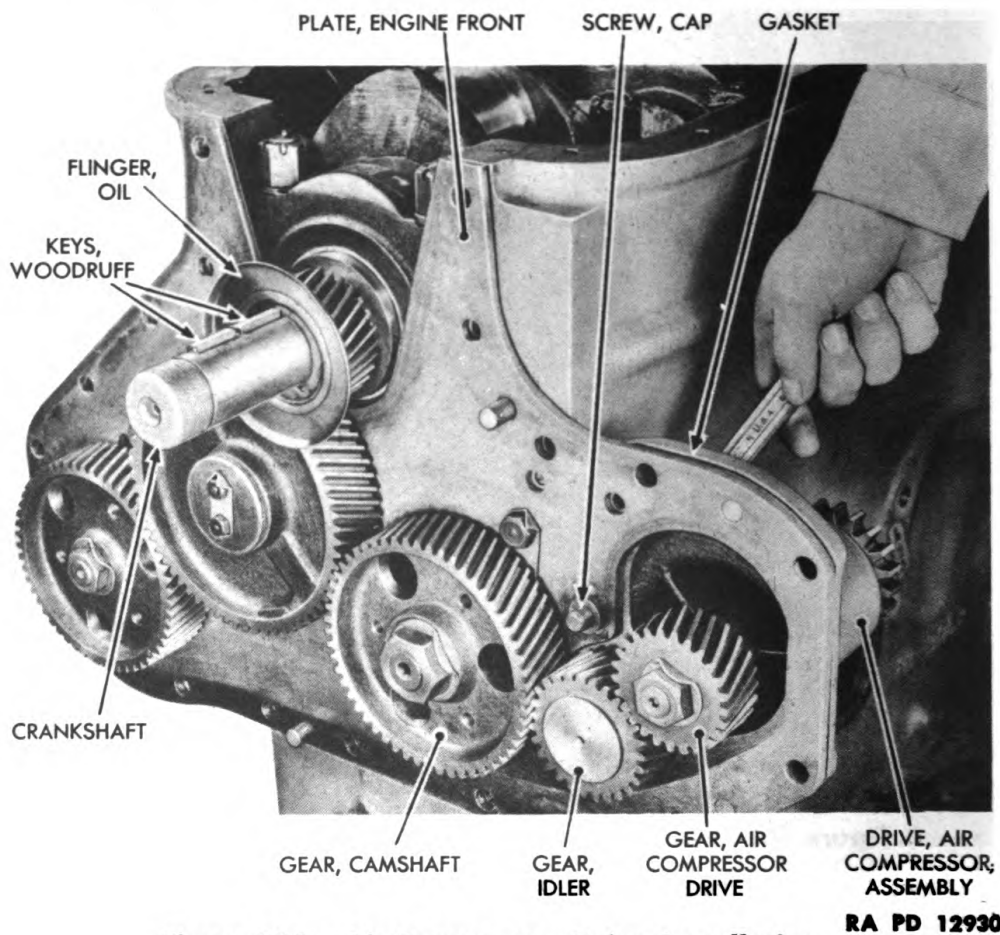


Figure 162—Air Compressor Drive Installation

164. INSTALLING AIR COMPRESSOR DRIVE ASSEMBLY.

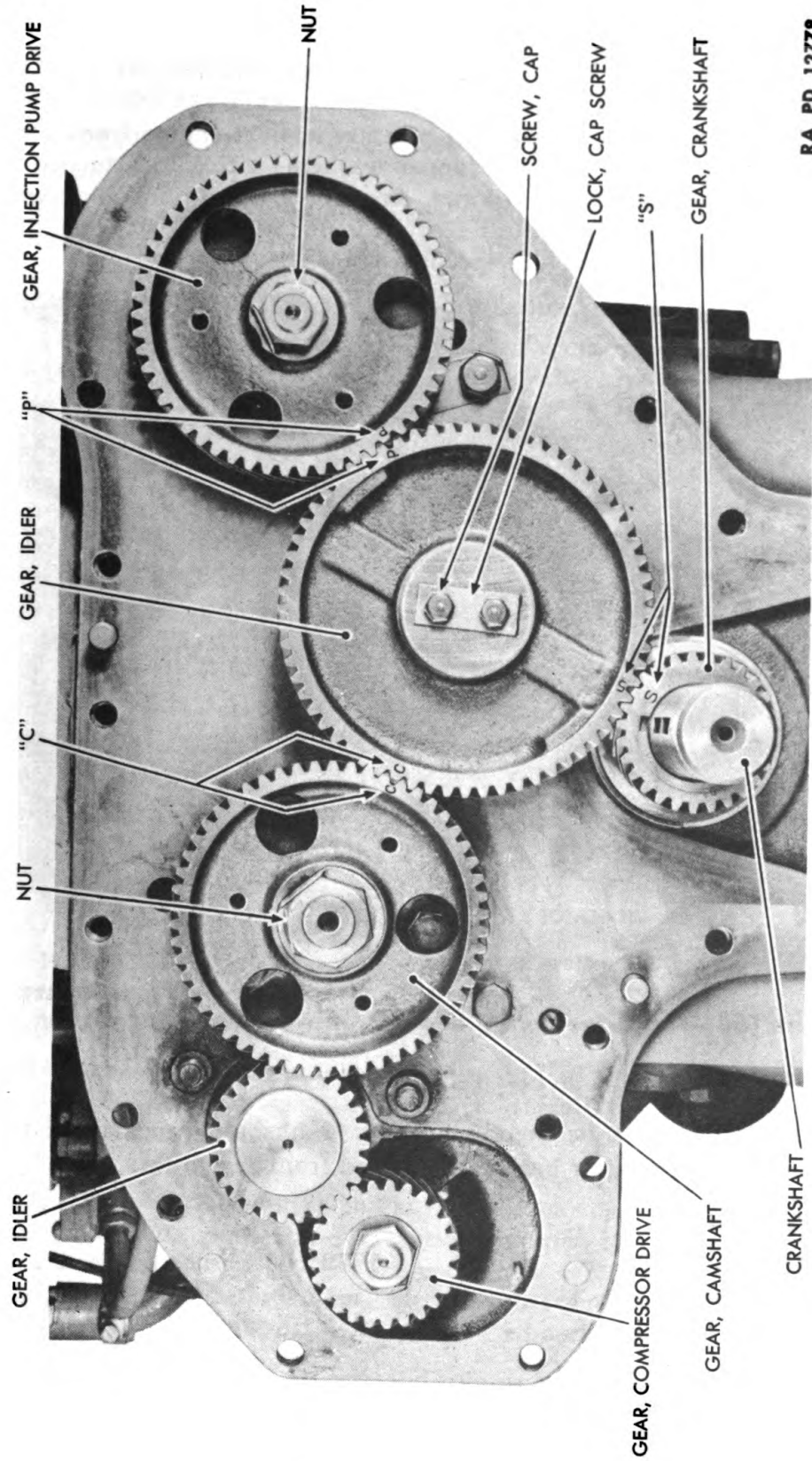
a. Equipment.

WRENCH, box, $\frac{3}{4}$ -in.

b. Procedure.

(1) **INSTALL NEW GASKET** (fig. 162). Position new gasket between engine front plate and air compressor drive housing.

ASSEMBLY OF ENGINE



RA PD 12778

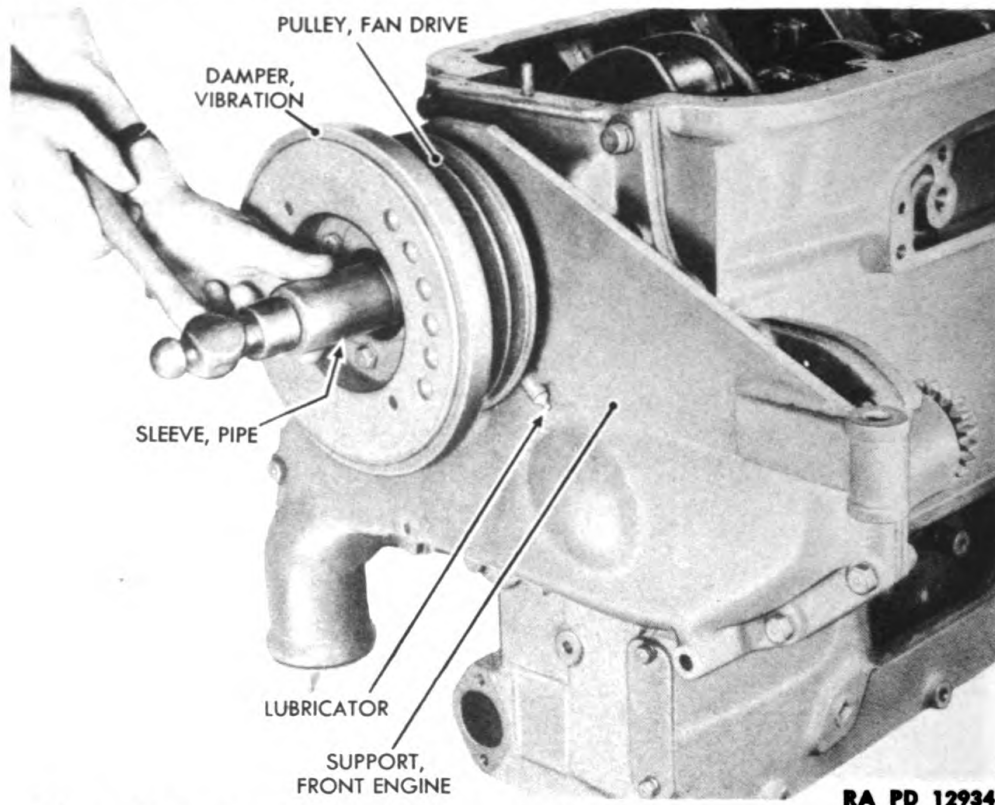
Figure 163—Timing the Gear Train

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(2) ATTACH AIR COMPRESSOR DRIVE ASSEMBLY TO ENGINE FRONT PLATE (fig. 162).

WRENCH, box, $\frac{3}{4}$ -in.

(a) Hold housing and gasket in position against engine front plate and install two cap screws and copper washers—with clip attached to lower cap screw. Tighten cap screws. Assembly must be installed with idler gear engaged with camshaft gear. It is not necessary to aline idler gear with camshaft gear at any specified point.



RA PD 12934

Figure 164—Fan Drive Pulley and Vibration Damper Installation

165. GEAR TRAIN TIMING (fig. 163).

a. Gear train must be timed whenever crankshaft, camshaft or fuel injection pump drive gear has been removed from gear train.

b. Equipment.

WRENCH, open-end, $\frac{1}{2}$ -in.

WRENCH, socket, $1\frac{1}{8}$ -in.,
and spinner type handle

WRENCH, socket, $1\frac{1}{2}$ -in.,
and spinner type handle

c. Procedure.

(1) REMOVE IDLER GEAR IF IT HAS NOT ALREADY BEEN REMOVED.

WRENCH, open-end, $\frac{1}{2}$ -in.

ASSEMBLY OF ENGINE

(a) Remove two cap screws and cap screw lock. Then pull out idler gear.

(2) POSITION CAMSHAFT GEAR, INJECTION FUEL PUMP DRIVE GEAR AND CRANKSHAFT GEAR FOR PROPER TIMING WITH IDLER GEAR.

WRENCH, socket, 1½-in.,
and spinner type handle

WRENCH, socket, 1½-in.,
and spinner type handle

(a) Turn camshaft so that camshaft gear timing mark "C" will be opposite "C" on idler gear. Beveled idler gear tooth fits between two beveled teeth of camshaft gear.

(b) Turn fuel injection pump drive gear so that timing mark "P" will be opposite "P" on idler gear. Beveled tooth of fuel injection pump drive gear fits between two beveled teeth of idler gear.

(c) Install starting nut on end of crankshaft. Then use engine crank to turn crankshaft gear until timing mark "S" is opposite "S" on idler gear. Beveled tooth of crankshaft gear fits between two beveled teeth on idler gear.

(d) Install idler gear so that timing marks line up, as outlined in steps (a), (b), and (c) above.

(3) INSTALL CRANKCASE FRONT COVER. See paragraph 133.

166. FAN DRIVE PULLEY AND VIBRATION DAMPER INSTALLATION.

a. Equipment.

HAMMER, brass
SLEEVE, pipe
WRENCH, open-end, 7/16-in.

WRENCH, socket, 2½-in.,
and spinner type handle

b. Procedure.

(1) INSTALL FRONT ENGINE SUPPORT.

HAMMER, brass
WRENCH, open-end, 7/16-in.

(a) Install lubricator to support. Make sure that lubricator is clean before installing it.

(b) Install support in position over end of crankshaft. Drive it in position against crankcase front cover. Install the support with the lubricator fitting toward end of crankshaft and pointing toward top of crankcase.

(2) INSTALL FAN DRIVE PULLEY AND VIBRATION DAMPER (fig. 164). Place fan drive pulley and vibration damper in position on end of crankshaft, with keyway in alignment with Woodruff keys on end of crankshaft. Drive fan drive pulley and vibration damper into position.

(3) INSTALL STARTING NUT.

WRENCH, socket, 2½-in., and spinner type handle or
heavy adjustable

(a) Place washer over end of crankshaft and attach starting nut and tighten it.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

167. FLYWHEEL INSTALLATION.

a. Equipment.

HAMMER

HOIST

SLING, rope

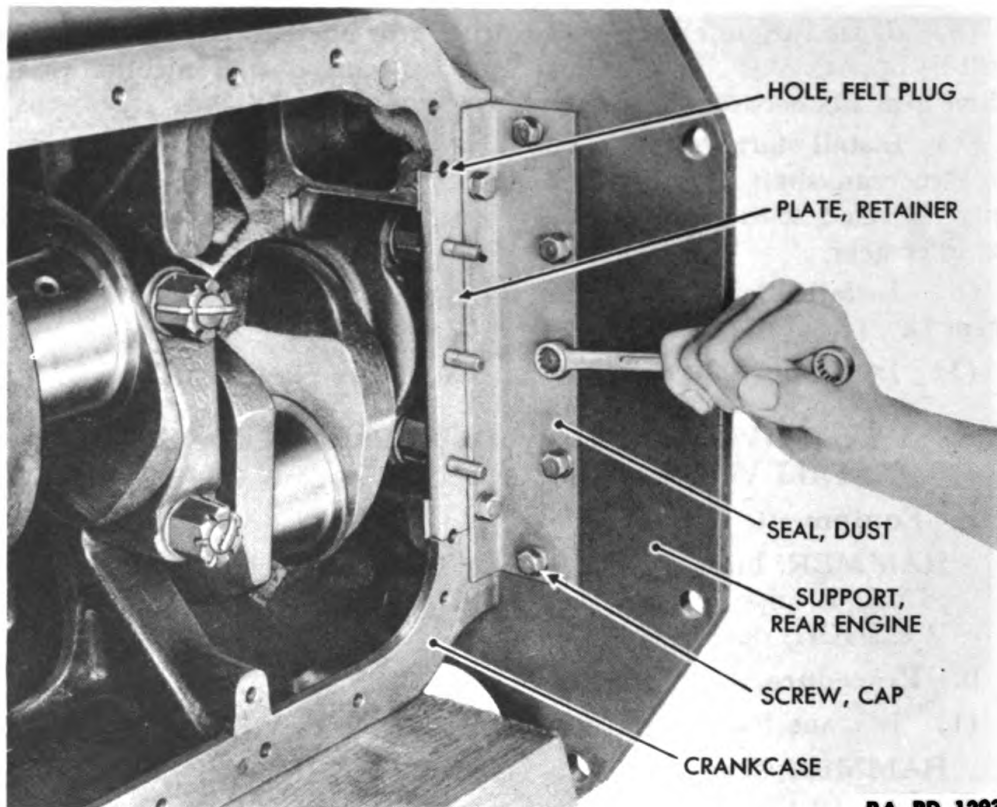
WRENCH, box, $\frac{9}{16}$ -in.

WRENCH, socket, $\frac{9}{16}$ -in.,
and speeder handle

WRENCH, socket, $\frac{9}{16}$ -in.,
and spinner type handle

WRENCH, socket, 1-in., and
spinner type handle

WRENCH, torque



RA PD 12935

Figure 165—Crankcase Dust Seal Installation

b. Procedure.

(1) **INSTALL OIL SEAL RETAINER (fig. 44).**

WRENCH, box, $\frac{9}{16}$ -in.

WRENCH, socket, $\frac{9}{16}$ -in.,
and speeder handle

WRENCH, socket, $\frac{9}{16}$ -in.,
and spinner type handle

- (a) Place new oil seal gasket in position on end of crankcase.
- (b) Install crankcase rear oil seal upper retainer, attaching four flat washers, lock washers and cap screws. Tighten cap screws.
- (c) Install oil seal felt.
- (d) Place two new retainer gaskets between upper and lower retainers.
- (e) Install oil seal felt in lower retainer.

ASSEMBLY OF ENGINE

(f) Install crankshaft rear oil seal lower retainer, attaching two flat washers, lock washers and cap screws. Tighten cap screws.

(g) Secure upper retainer and lower retainer, inserting two flat washers, lock washers and cap screws. Tighten cap screws.

(2) INSTALL CRANKSHAFT OIL SEAL RETAINER PLATE WITH STUDS (fig. 44).

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Install new plate gasket.

(b) Place plate in position over bottom of crankcase and lower retainer. Attach four lock washers and cap screws and tighten them.

(3) INSTALL REAR ENGINE SUPPORT (fig. 43).

HAMMER

WRENCH, socket, 1-in., and
spinner type handle

(a) Place rear engine support in position over crankcase dowel pins and studs. Opening for starting motor is on same side of crankcase as air compressor drive housing. Tap plate snugly in position against crankcase. Install nine lock washers and nuts and tighten nuts.

(4) INSTALL DUST SEAL (fig. 165).

WRENCH, box, $\frac{9}{16}$ -in.

(a) Place new dust seal gasket in position against dust seal and place two parts in position at bottom rear of crankcase next to rear engine support.

(b) Install seven cap screws and lock washers which hold dust seal to rear engine support and to crankcase. Tighten cap screws.

(c) Install two felt plugs into crankcase at end of retainer plate.

(5) INSTALL FLYWHEEL WITH RING GEAR (fig. 30).

HOIST

WRENCH, socket, 1-in., and
spinner type handle

SLING, rope

WRENCH, torque

(a) Place crankcase on its side with fuel injection pump drive up. Place rope sling around crankcase and lift crankcase from its support blocks and lower it again on its side, with fuel injection pump drive in upward position.

(b) Flywheel can be installed in only one position, as one of the cap screw holes is off center. Determine correct position before starting flywheel on crankshaft. Lift flywheel into position. Because of weight of flywheel, hoist should be used to lift it in position. Otherwise, extreme care should be taken in lifting it by hand. Install two dowel pins, three cap screw locks and six cap screws which secure flywheel to crankcase. Tighten cap screws to 150 foot-pounds with torque wrench. Bend cap screw locks around heads of cap screws.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

168. VALVE TAPPET GUIDE INSTALLATION (fig. 58).

a. Push each guide into position from top of crankcase, with holes in guides pointing toward front of crankcase and over its corresponding tappet. If necessary, reach through cylinder in crankcase to fit tappet into valve tappet guide.

169. PISTON AND CONNECTING ROD INSTALLATION.

a. Equipment.

COMPRESSOR, piston ring	SCREW, slotted,
HAMMER, rawhide	1 $\frac{3}{4}$ -in. by $\frac{1}{4}$ -in.
METAL, sheet, 2 pieces,	SCREWDRIVER
2-in. by $\frac{1}{2}$ -in.	SHEARS, tinner's, hand
METAL, sheet, 2 pieces,	SOLUTION, soap
$\frac{45}{8}$ -in. by $8\frac{1}{4}$ -in.	WISE
OIL, engine, seasonal grade	WRENCH, torque, with
PLIERS	$\frac{3}{4}$ -in. socket
ROD, $\frac{1}{4}$ -in.	

b. Procedure.

(1) INSTALLATION OF CYLINDER SLEEVES.

HAMMER, rawhide SOLUTION, soap

(a) Before installing new cylinder sleeves, check each sleeve in the crankcase without the seal ring being installed. This is to make sure that the sleeves will slip into the crankcase without binding. If some of the new sleeves are not fitting properly, interchange them until you find the crankcase bore into which each sleeve fits best. This procedure is used only when installing a set of new sleeves.

(b) Install cylinder sleeve rings (fig. 42). First clean out the ring grooves in the crankcase and then coat packing rings with soapsuds and install them in the grooves in the crankcase. Make a soap solution, using a pint of water, $\frac{1}{2}$ ounce of glycerine and one tablespoonful of soap flakes.

(c) Coat the outside tapered end of the cylinder sleeve where it enters into the crankcase holding the seal ring. Tap the sleeve into position and wipe off any surplus soap solution. Be sure rings remain in the grooves when installing sleeves.

(d) If the same sleeves originally used are being installed, look for the identifying marks which should have been made when sleeves were removed, so that sleeves may be reinstalled in the same cylinder and in the same position in the crankcase. **NOTE:** When installing a new set of sleeves, identify them so that the new pistons which come fitted to the sleeves are not interchanged in any of the sleeves. Be sure the pistons are installed on the correct connecting rod so that when the assembly is installed in the engine, the connecting rod will be in its correct position.

ASSEMBLY OF ENGINE

RA PD 12941

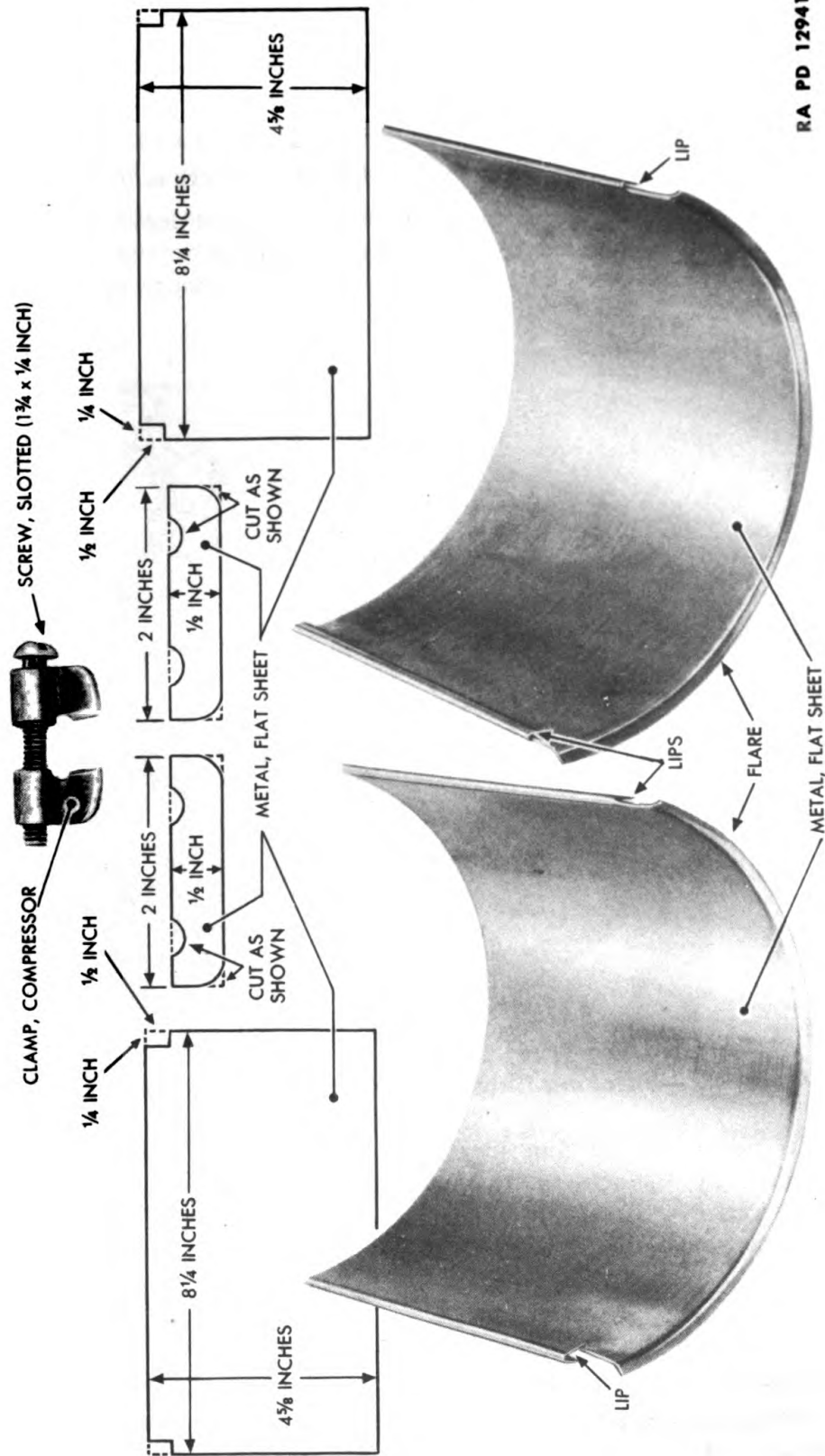


Figure 166—Components of Piston Ring Compressor

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(2) MAKE PISTON RING COMPRESSOR (fig. 166).

METAL, sheet, 2 pieces,
2-in. by $\frac{1}{2}$ -in.

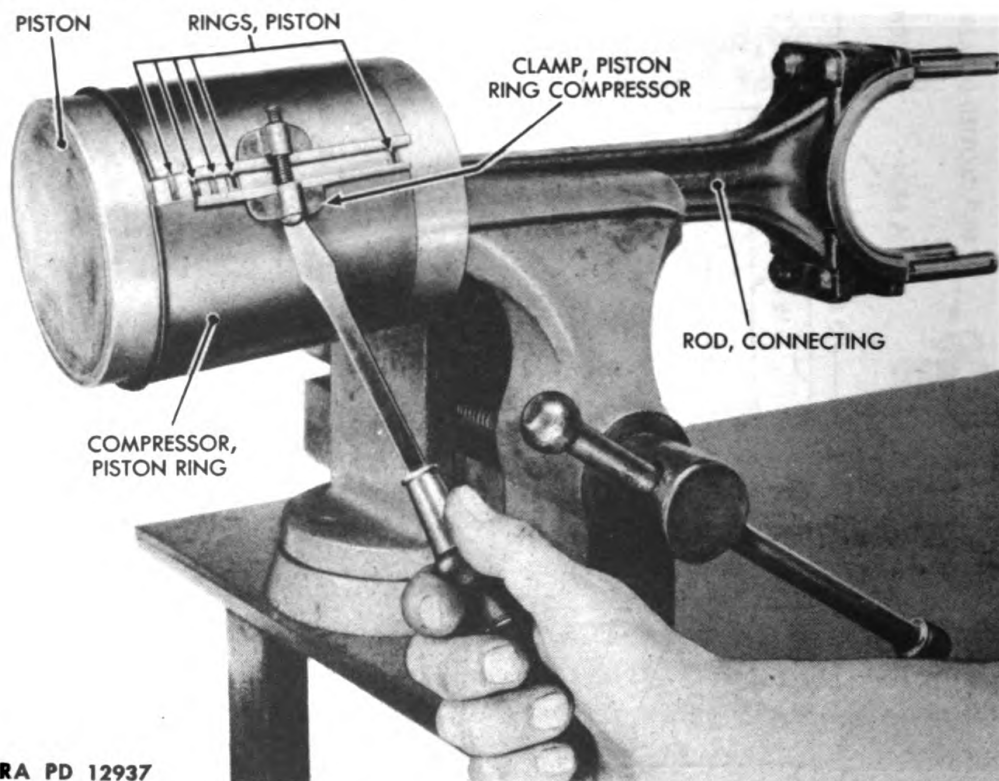
METAL, sheet, 2 pieces,
 $4\frac{5}{8}$ -in. by $8\frac{1}{4}$ -in.

ROD, $\frac{1}{4}$ -in.

SCREW, slotted, $1\frac{3}{4}$ -in.
by $\frac{1}{4}$ -in.

SHEARS, tinner's, hand

(a) Most standard piston ring compressors do not leave sufficient space when installed on piston to provide for installation of piston in cylinder sleeve. However, an efficient piston ring compressor can be made easily.



RA PD 12937

Figure 167—Installing Piston Ring Compressor on Piston

(b) Cut two pieces of thin sheet metal, $4\frac{5}{8}$ -inch by $8\frac{1}{4}$ -inch. Cut notch, $\frac{1}{4}$ -inch by $\frac{1}{2}$ -inch, in upper right corner of one piece and in upper left corner of other piece, making $\frac{1}{4}$ -inch cut parallel with $8\frac{1}{4}$ -inch dimension, and $\frac{1}{2}$ -inch cut parallel with $4\frac{5}{8}$ -inch dimension.

(c) Bend back each piece of each $4\frac{5}{8}$ -inch side to form lip. On one piece, lips should face upward, and on other piece, left lip should face downward and right lip should face upward.

(d) Looking at two pieces as described in (c), flare top $8\frac{1}{4}$ -inch side of each piece upward.

(e) Bend each section into semicircle to fit circumference of piston, with the flare across top of each piece outward.

ASSEMBLY OF ENGINE

(f) Make compressor clamp. Cut two pieces of heavier sheet metal, 2-inch by 1/2-inch, and then cut curved corners on one side of each piece. Bend each piece around a 1/4-inch rod into shape shown in figure 166. Thread each piece for 1/4-inch screw. File flat side of each piece to form sharp flat edge at bottom. Join two pieces with 1 3/4-inch by 1/4-inch slotted screw. The screw and these two pieces thus form clamp which can be used to draw two halves of compressor together, for use as described in step (3) below.

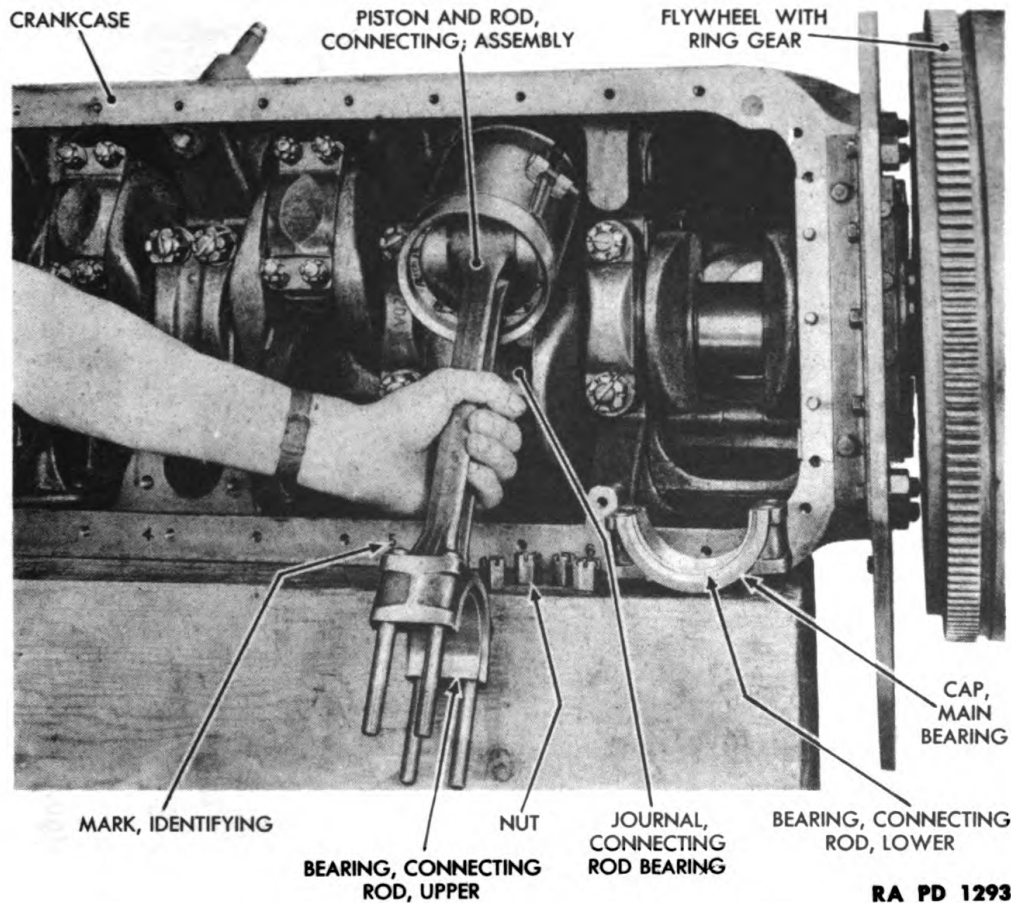


Figure 168—Piston and Connecting Rod Assembly Installation

(3) INSTALL PISTON RING COMPRESSOR ON NO. 1 PISTON (fig. 167).

COMPRESSOR, piston ring SCREWDRIVER
OIL, engine, seasonal grade VISE

(a) Coat piston and rings as well as upper connecting rod bearing, with engine oil. Then place connecting rod in vise and install piston ring compressor, first staggering the piston ring gaps evenly around the piston. Place two sections of compressor around rings and tighten clamp screw until rings are tightly compressed on piston.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

RA PD 12940

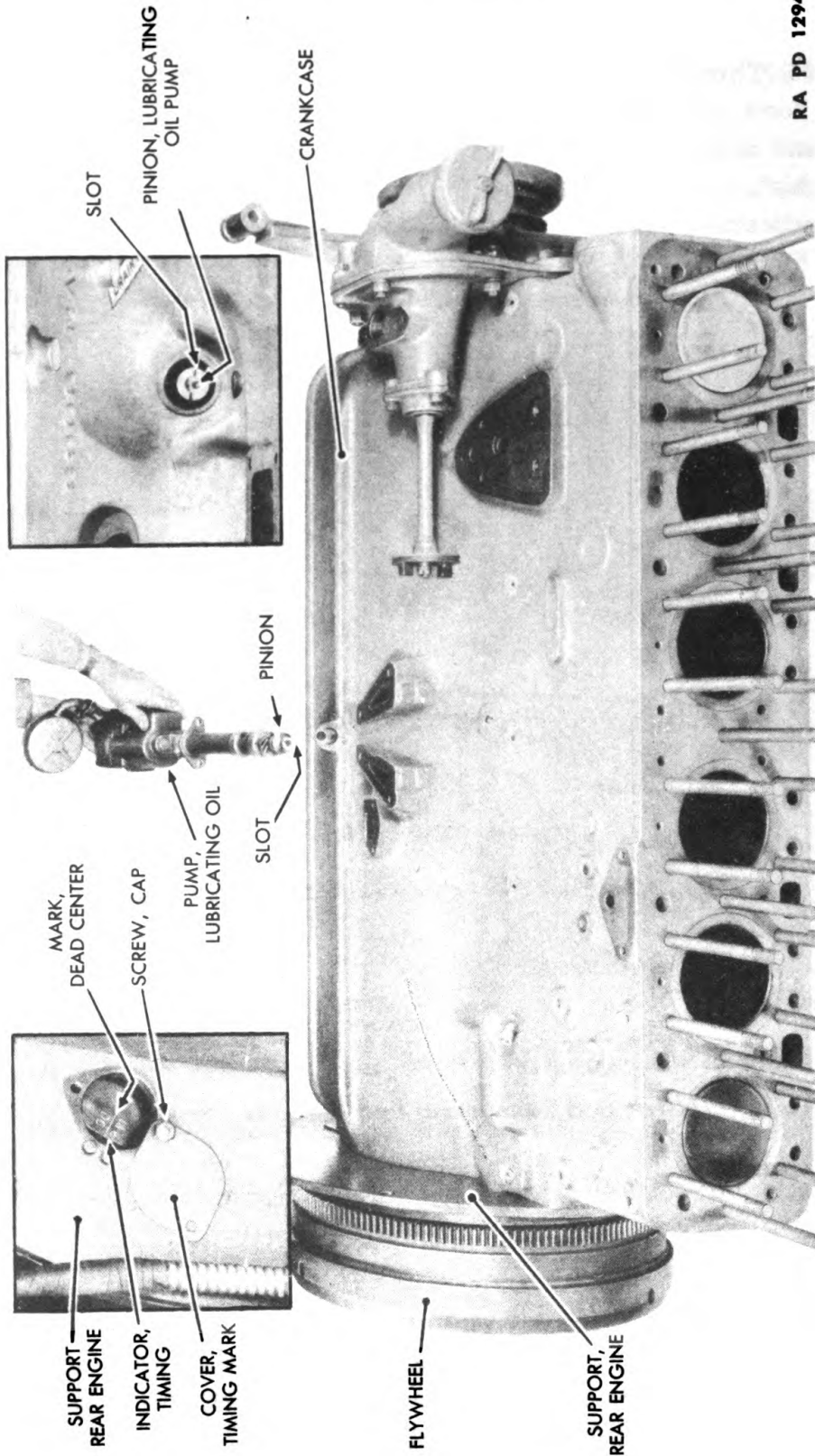


Figure 169 — Lubricating Oil Pump Installation

ASSEMBLY OF ENGINE

(4) INSTALL NO. 1 PISTON AND CONNECTING ROD ASSEMBLY (fig. 168).

HAMMER, rawhide
OIL, engine, seasonal grade
PLIERS

WRENCH, torque, with
 $\frac{3}{4}$ -in. socket

(a) Turn flywheel so that No. 1 connecting rod bearing journal on crankshaft provides space to enter piston into bottom of No. 1 cylinder sleeve. Position connecting rod so that identifying mark "I" is on camshaft side of crankcase. Push piston into sleeve until all rings are inserted and ring compressor slides off bottom of piston. While doing this, adjust position of crankshaft as is necessary so that piston may be entered into sleeve to uppermost position of its stroke. Then remove piston ring compressor and pull the connecting rod back, so that upper connecting rod bearing rests snugly against journal on crankshaft.

(b) Coat lower connecting rod bearing with engine oil and attach bearing and cap to studs of No. 1 connecting rod, with "I" which is stamped on connecting rod bearing cap toward camshaft side of crankcase. Tap cap into position.

(c) Attach four stud nuts, tightening them securely to 70 foot-pounds tension. Tighten the nuts in diagonal order, to maintain uniform tension on bearings. Lock the nuts to studs with cotter pins. If cotter pin holes and nuts do not line up with holes in connecting rod studs, tighten nuts still further until holes are in alignment. Never back up nuts. Lock cotter pin.

170. LUBRICATING OIL PUMP INSTALLATION.

a. Equipment.

PLIERS
WIRE
WRENCH, open-end, $\frac{1}{2}$ -in.

WRENCH, open-end, $\frac{9}{16}$ -in.
WRENCH, open-end, $\frac{3}{4}$ -in.
WRENCH, pipe, adjustable

b. Procedure.

(1) INSTALL OIL FILTER RETURN PIPE (fig. 96).

WRENCH, pipe, adjustable

(a) Install oil filter return pipe into bottom of crankcase.

(2) INSTALL PUMP (fig. 169).

PLIERS
WIRE

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

(a) Place pump in position on bottom of crankcase and turn flywheel until No. 1 piston is on top dead center compression stroke. No. 1 piston will be on top dead center compression stroke when the pointer in the rear engine support has lined up with dead center marks No. 1 and No. 6, and when two cams which operate intake and exhaust valves on No. 1 piston are pointing up as viewed, or toward the bottom of the crankcase. This is a very important point because if the cams are

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

pointing in the opposite direction and the piston is on top dead center, it will be on the exhaust stroke and the timing would be incorrect in this position (fig. 169). When holding pump in position for installing, position the slot in the pinion so it will be toward the rear of the crankcase (slot off center) and in a nearly vertical position so that when it engages the gear on the camshaft it will turn in a clockwise direction and be almost parallel with the crankcase and toward the camshaft. Check slot position by looking into distributor opening from top of crankcase (fig. 169).

(b) Attach two cap screws and lock washers, tightening cap screws. Insert wire through holes in two cap screws and lock ends of wire together.

(3) INSTALL FRONT OIL RETURN PIPE.

WRENCH, open-end, 1/2-in. WRENCH, open-end, 9/16-in.

(a) Install new gasket on pump cover and attach front oil return pipe. Install two cap screws and lock washers and tighten them.

(b) Install cap screws and lock washers which secure bracket to crankcase.

(4) INSTALL REAR OIL RETURN PIPE (fig. 96).

WRENCH, open-end, 1/2-in. WRENCH, open-end, 9/16-in.

(a) Place new gasket in position on upper housing, placing rear oil return pipe in position and attach two cap screws and lock washers. Tighten cap screws.

(b) Tighten cap screws and lock washers which secure bracket to crankcase.

171. CRANKCASE OIL PAN INSTALLATION.

a. Equipment.

DRIFT, brass
VARNISH, shellac

WRENCH, socket, 9/16-in.,
and speeder, with extension

b. Procedure.

(1) INSTALL NEW GASKET.

VARNISH, shellac

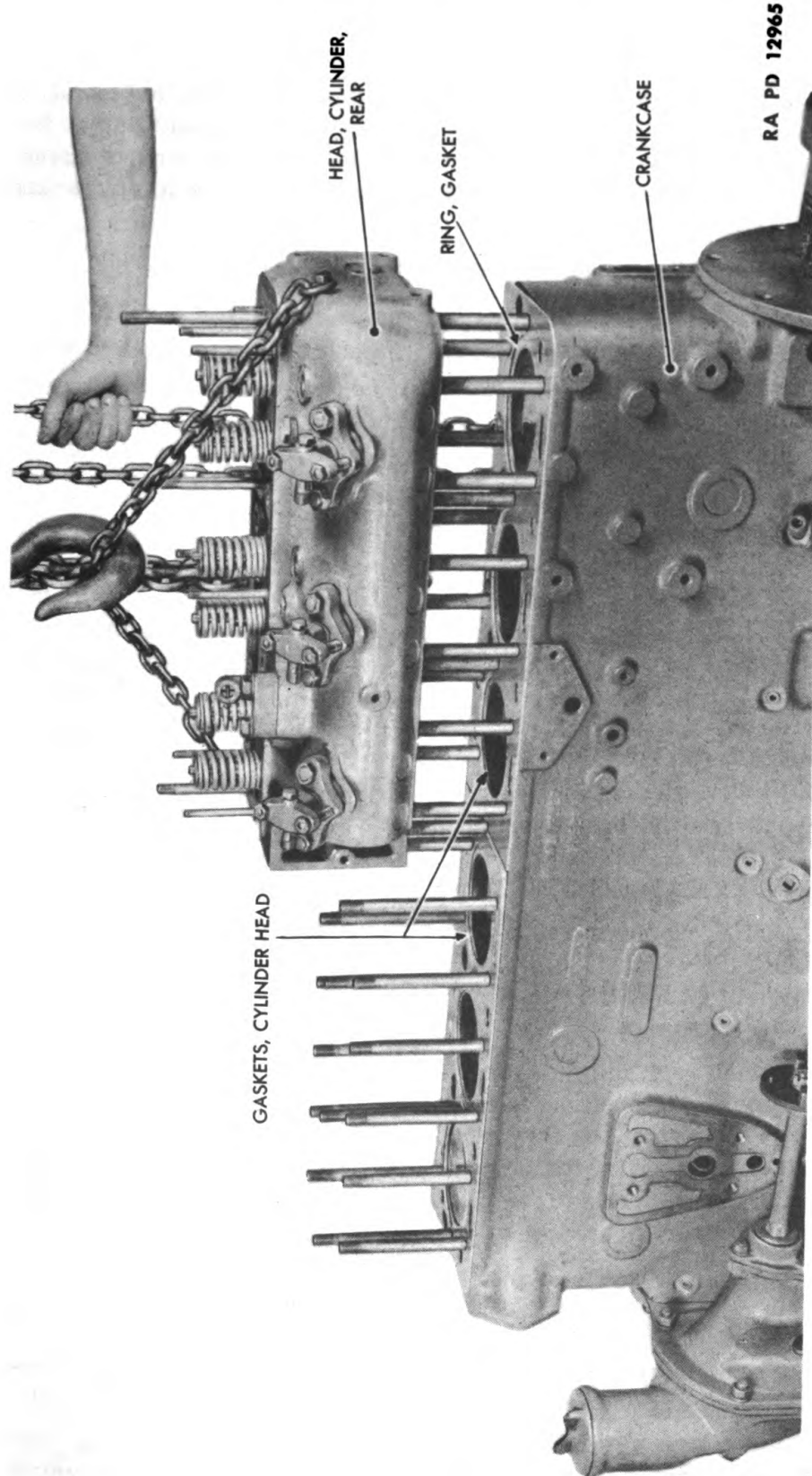
(a) Make sure that all traces of old gasket have been removed from crankcase. Then coat gasket mounting surface of crankcase with varnish. When varnish becomes "tacky," but not quite dry, place gasket in position on crankcase.

(2) INSTALL OIL PAN (fig. 95).

WRENCH, socket, 9/16-in., and speeder, with extension

(NOTE: Figure 95 illustrates oil pan in position when engine is installed. Parts can be identified on this illustration for installation of

ASSEMBLY OF ENGINE



RA PD 12965

Figure 170—Rear Cylinder Head Installation

GASKETS, CYLINDER HEAD

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

oil pan during process of engine assembly.) Two men should lift crankcase, with gasket attached, into position on crankcase. Then install 32 cap screws and lock washers and four stud nuts and lock washers. Three studs are located at rear of crankcase and one at front. Also, one cap screw on right-hand side of crankcase secures breather pipe clip to crankcase, while cap screw on left-hand side of crankcase also holds engine pump overflow pipe clip in place.

(3) INSTALL OIL LEVEL GAGE SLEEVE (fig. 95).

DRIFT, brass

(a) Place oil level gage sleeve in position in lower left side of crankcase and drive it into place.

(4) INSTALL OIL LEVEL GAGE IN OIL LEVEL GAGE SLEEVE (fig. 95).

172. CYLINDER HEAD INSTALLATION.

a. Equipment.

BLOCKS, wooden, small
BLOCKS, wooden, approxi-
mately 12-in. by 12-in. by
3-ft (2)

CHAIN

FLAME (or fire)

HOIST

SLING, rope
TWO-BY-FOUR, short
WRENCH, socket, $\frac{9}{16}$ -in.,
and spinner type handle
WRENCH, socket, 1-in.,
and spinner type handle
WRENCH, torque

b. Procedure.

(1) PLACE CRANKCASE IN VERTICAL POSITION (fig. 21).

BLOCKS, wooden, small
BLOCKS, wooden, approxi-
mately 12-in. by 12-in. by
3-ft (2)

SLING, rope
TWO-BY-FOUR, short

(a) Attach rope sling to crankcase and lift crankcase from its wooden block supports. Reposition two wooden blocks, approximately 12-inch by 12-inch by 3-feet, so they support the engine at the rear mounting and at the front end of the oil pan. Also place short two-by-four on top of front block, underneath oil pan, and use small wooden blocks under outer front flange of oil pan to keep crankcase in lifted position.

(2) INSTALL NEW CYLINDER HEAD GASKETS (fig. 170).

FLAME (or fire)

(a) Check to see that top of crankcase is clean and that all traces of old gaskets and deposits underneath gasket rings are removed.

(b) Place new cylinder head gaskets in position, exercising caution to position gaskets correctly, with gasket openings in alinement with corresponding openings in crankcase.

ASSEMBLY OF ENGINE

(c) Install gasket rings, with ridges toward the cylinder head. Gasket rings originally used may be used again, providing the ridge at top of each ring has not been worn away. However, before installing used rings they should be annealed. This can be done by placing each gasket ring, in turn, in flame or in fire until ring is red hot, and then immersing ring in water while red hot. Otherwise, a new gasket ring should be installed in position over each cylinder sleeve, with ridge surface at top.

(3) LIFT REAR CYLINDER HEAD INTO POSITION (fig. 170).

CHAIN

HOIST

(a) Lift rear cylinder head into position over crankcase studs, lowering it evenly on top of crankcase and rear cylinder head gasket. Before lifting cylinder head, attach stud nut or cap screw to diagonally located points and attach chain to which hoist can be hooked.

(4) LIFT FRONT CYLINDER HEAD INTO POSITION (fig. 170).

Follow same procedure outlined in step (3) above. Be sure the heads are in line. Place the edge of a steel rule across the finished surfaces around the intake parts and the center of the engine. Cylinder heads can be shifted a little to bring them into line.

(5) INSTALL NUTS WHICH HOLD CYLINDER HEAD TO CRANKCASE (fig. 88).

WRENCH, socket, 1-in., and
spinner type handle

WRENCH, torque

(a) Cylinder heads are secured to crankcase by nuts on 31 crankcase studs. There is one row of studs on each side of cylinder head, in addition to center row. Stud between two cylinder heads has flat washer beneath nut. After running up nuts, tighten nuts to 100 foot-pounds, exercising care to tighten nuts in numerical sequence. Then repeat same procedure, tightening to 150 foot-pounds; finally, repeat procedure again, tightening nuts to 170 foot-pounds.

(6) INSTALL PUSH RODS (fig. 67). Insert push rods into position in cylinder heads.

(7) INSTALL WATER MANIFOLD.

WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle

(a) Install new water manifold gasket and place water manifold in position between front and rear cylinder heads on left side. Install and tighten six cap screws and lock washers. Location of water manifold is identified on figure 62.

173. HOUR METER INSTALLATION.

a. Equipment.

PLIERS

WRENCH, open-end, $\frac{1}{2}$ -in.

SEAL, wire

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) **INSTALL HOUR METER DRIVE GEAR ASSEMBLY.** Place hour meter drive gear assembly in position in fuel injection pump drive housing, with oil slot up.

(2) **INSTALL HOUR METER** (fig. 171).

PLIERS
SEAL, wire

WRENCH, open-end, 1/2-in.

(a) Be sure all traces of old gasket are removed. Then install new hour meter gasket and hour meter, securing it to housing with two cap screws and lock washers.

(b) Install wire seal which locks two cap screws together.

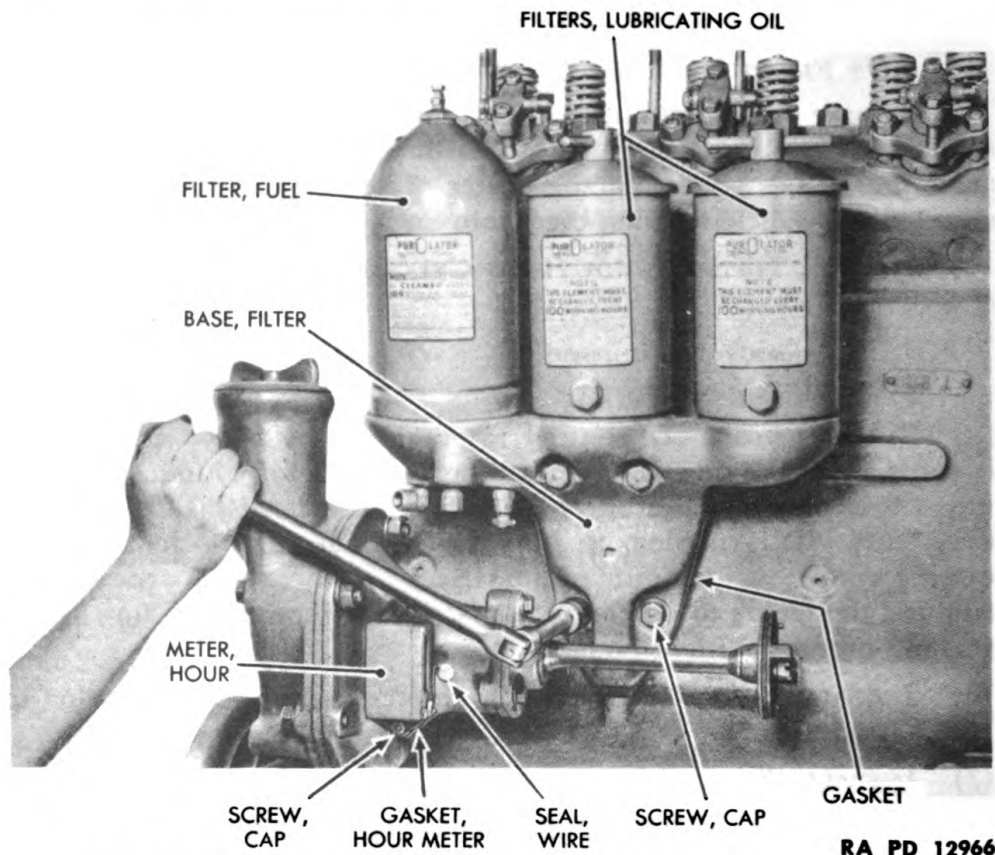


Figure 171—Installing Fuel Filter and Lubricating Oil Filters

174. LUBRICATING OIL FILTERS AND FUEL FILTER INSTALLATION (fig. 171).

a. Equipment.

WRENCH, socket, 3/4-in., and spinner type handle

b. Procedure.

(1) **INSTALL NEW GASKET.** Be sure all traces of old gasket are removed from crankcase and filter base. Then install new gasket.

ASSEMBLY OF ENGINE

(2) INSTALL FILTER BASE WITH FILTERS ATTACHED.

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle

(a) Place filter base with filters attached in position on crankcase, securing it with four cap screws and lock washers.

175. FUEL INJECTION PUMP INSTALLATION.

a. Equipment.

SCREWDRIVER

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

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

WRENCH, socket, $\frac{3}{4}$ -in.,

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

and spinner type handle

b. Procedure.

(1) **INSTALL SPACER ON FUEL INJECTION PUMP DRIVE SHAFT FLANGE.** Place spacer in position on flange.

(2) **PLACE FUEL INJECTION PUMP IN POSITION ON CRANKCASE** (fig. 172).

SCREWDRIVER

WRENCH, socket, $\frac{3}{4}$ -in.,
and spinner type handle

(a) Time injection pump to engine as outlined in fuel system section, TM 9-1777B. Place pump in position so that pin on drive shaft flange fits into hole in adjuster. Install four cap screws and lock washers which hold fuel injection pump bracket to crankcase.

(b) Place boot over flange, spacer and adjuster.

(3) **INSTALL FUEL PIPE (FUEL FILTER TO INJECTION PUMP)** (fig. 172).

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

(a) Tighten connector at each end of pipe to fuel filter and to injection pump.

(4) **INSTALL FUEL PIPE (FUEL SUPPLY PUMP TO FUEL FILTER)** (fig. 172).

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

(a) Tighten connector at each end of pipe to fuel supply pump and to fuel filter.

(5) **INSTALL FUEL PIPE (WATER TRAP TO FUEL SUPPLY PUMP)** (fig. 172).

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

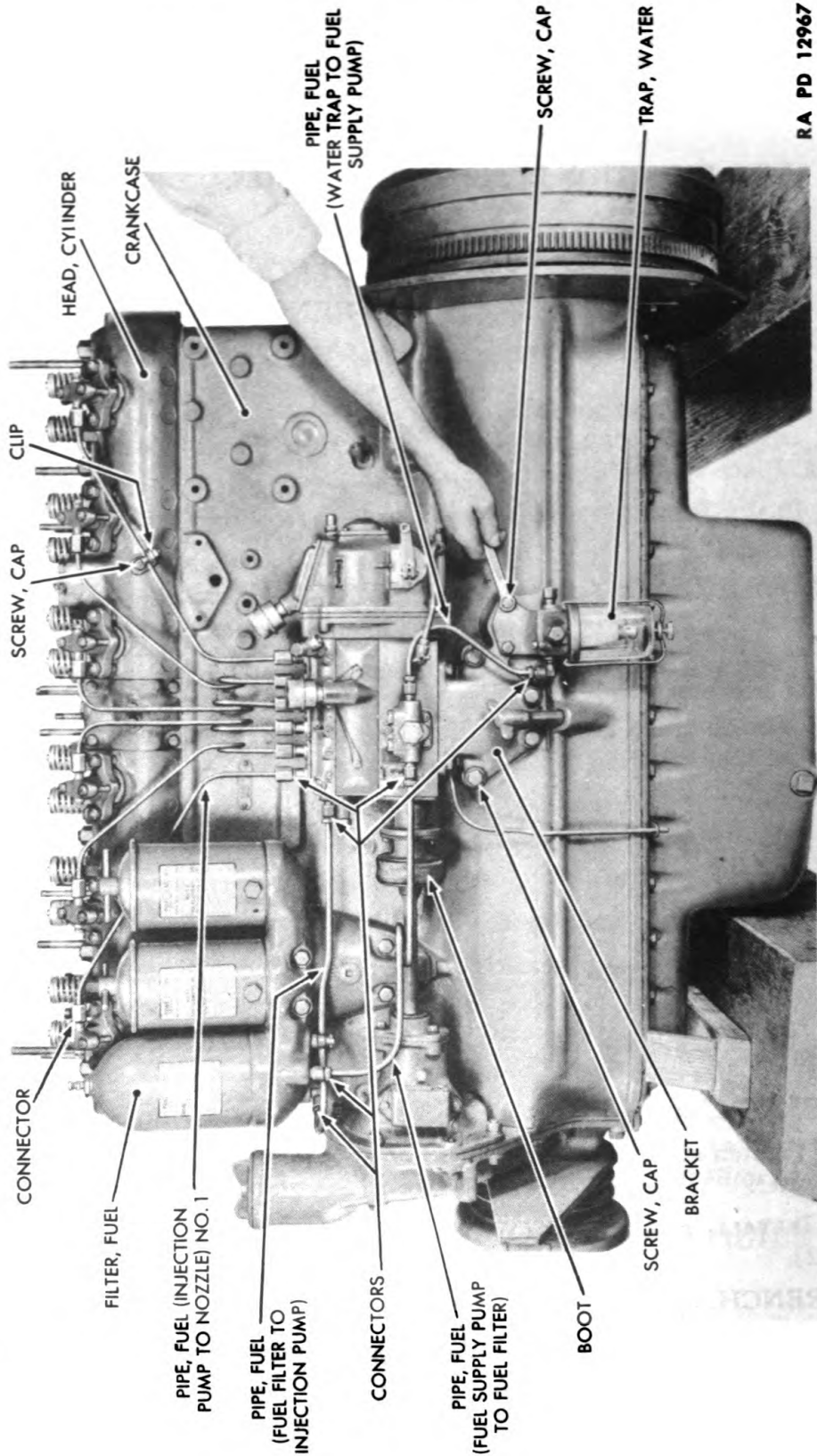
(a) Install connector at one end of pipe to fuel supply pump.

(6) **INSTALL SIX FUEL PIPES (INJECTION PUMP TO NOZZLES)** (fig. 172).

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

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

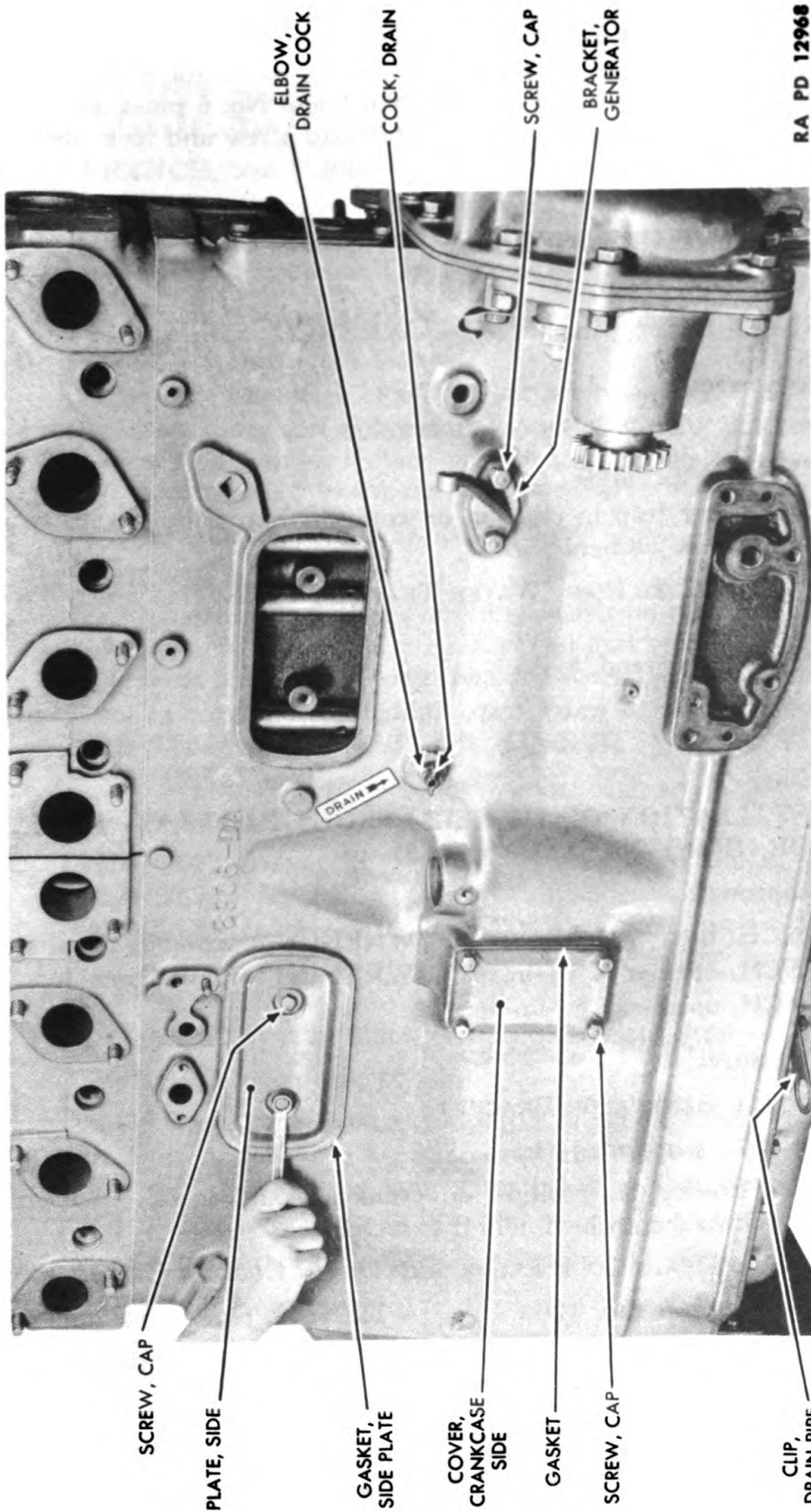
**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 12967

Figure 172—Installed Fuel Injection Pump and Installing Water Trap

ASSEMBLY OF ENGINE



RA PD 12968

Figure 173—Installing Miscellaneous Parts on Right Side of Crankcase

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(a) Before installing each pipe, remove protective cap from delivery valve holder. Then install each pipe, tightening connector at each end to delivery valve holder and to nozzle. No. 1 and No. 6 pipes are held to cylinder heads by means of clips. Install cap screw and lock washer which hold each of these pipes to cylinder head.

176. WATER TRAP INSTALLATION (fig. 172).

a. Equipment.

WRENCH, box, $\frac{9}{16}$ -in.

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

b. Procedure.

(1) INSTALL WATER TRAP ON CRANKCASE.

WRENCH, box, $\frac{9}{16}$ -in.

(a) Place water trap in position on crankcase, securing it with two cap screws and lock washers.

(2) CONNECT FUEL PIPE (WATER TRAP TO FUEL SUPPLY PUMP) TO WATER TRAP.

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

(a) Connect pipe to water trap, tightening connector at lower end of pipe.

177. INSTALLATION OF MISCELLANEOUS PARTS ON RIGHT SIDE OF CRANKCASE (fig. 173).

a. Equipment.

WRENCH, box, $\frac{9}{16}$ -in.

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

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

WRENCH, pipe, adjustable

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

b. Procedure.

(1) INSTALL GENERATOR BRACKET.

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

(a) Place bracket in position on crankcase and install two cap screws and lock washers which hold it to crankcase.

(2) INSTALL DRAIN COCK ELBOW AND DRAIN COCK IN CRANKCASE.

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

WRENCH, pipe, adjustable

(a) Install elbow in right side of crankcase. Then install drain cock in elbow.

(3) INSTALL CRANKCASE SIDE COVER.

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

(a) Be sure all traces of old gasket are removed and then install new

ASSEMBLY OF ENGINE

gasket and side cover, securing cover to crankcase with four cap screws and lock washers.

(4) INSTALL TWO CRANKCASE SIDE PLATES.

WRENCH, box, $\frac{9}{16}$ -in.

(a) Be sure all traces of old gaskets are removed. Then install new side plate gaskets and side plate covers, securing each cover to crankcase with two cap screws and lock washers.

(5) INSTALL BREATHER PIPE.

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

(a) Be sure all traces of old gasket are removed. Then install new gasket. Insert lower end of breather pipe through clip at outer top edge of crankcase oil pan and place pipe in position on side of crankcase. Secure breather pipe to crankcase with two cap screws and lock washers.

(6) INSTALL IGNITION COIL AND BRACKET (fig. 24).

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

(a) First remove all traces of old gasket from rear of crankcase and install new gasket. Then place ignition coil and bracket in position and secure bracket to crankcase with two cap screws and lock washers.

178. INSTALLATION OF AIR COMPRESSOR AND CONNECTIONS.

a. Equipment.

WRENCH, box, $\frac{1}{2}$ -in.

WRENCH, open-end, $1\frac{1}{16}$ -in.

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

**WRENCH, socket, $\frac{1}{2}$ -in.,
and speeder**

**WRENCH, socket, $\frac{3}{4}$ -in.,
and speeder**

b. Procedure.

(1) INSTALL WATER TUBE ELBOW IN RIGHT SIDE OF CRANKCASE.

WRENCH, open-end, $1\frac{1}{16}$ -in.

(2) INSTALL NEW BRACKET GASKET (fig. 26). Check to see that all traces of old gasket have been removed from gasket mounting surfaces of both crankcase and air compressor bracket. Then install new gasket in position over dowel pins on bracket.

(3) SECURE AIR COMPRESSOR TO CRANKCASE (fig. 26).

WRENCH, socket, $\frac{3}{4}$ -in., and speeder

(a) Lift air compressor into position with bracket and gasket against right side of crankcase. Install and tighten four cap screws and lock washers which hold bracket to crankcase.

(4) INSTALL AIR COMPRESSOR COUPLING (fig. 26).

WRENCH, box, $\frac{1}{2}$ -in.

**WRENCH, socket, $\frac{1}{2}$ -in.,
and speeder**

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(a) Line up gear of coupling flange with gear of drive shaft. Then install two coupling sections around two gears. Place two coupling covers in position around coupling sections and install two bolts and flat washers and two lock washers and nuts. Hold bolt heads with wrench while tightening nuts with wrench.

(5) **CONNECT AIR COMPRESSOR INLET TUBE TO WATER TUBE ELBOW (fig. 26).**

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

(a) Attach tube connector to elbow and tighten connectors at each end of tube.

(6) **INSTALL AIR COMPRESSOR OUTLET TUBE (fig. 26).**

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

(a) Connect water outlet tube to air compressor, tightening connector at air compressor end of tube.

179. FAN AND WATER PUMP INSTALLATION.

a. Equipment.

VARNISH, shellac

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

b. Procedure.

(1) **INSTALL NEW WATER PUMP BODY GASKET.**

VARNISH, shellac

(a) Check to see that all traces of old gasket have been removed from gasket mounting surface on front of crankcase. Then coat surface with varnish and when varnish is "tacky," but not completely dry, place new gasket in position.

(2) **INSTALL FAN AND WATER PUMP.**

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

(a) Lift assembled fan and water pump into position on front end of crankcase, securing it with four cap screws and lock washers. Two pump body spacers (gasket material) must be in place before any of the cap screws are tightened. Do not tighten upper right cap screw, since it also holds generator shield, to be installed in later step. Parts may be identified in figure 28.

(3) **CONNECT AIR COMPRESSOR OUTLET TUBE TO ELBOW AT WATER PUMP BODY (fig. 26).**

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

(a) Tighten connector at each end of outlet tube.

(4) **PLACE FAN BELTS IN POSITION (fig. 174).** Lift fan belts over fans onto water pump pulley and then place lower ends of fan belts in position on fan drive pulley.

ASSEMBLY OF ENGINE

180. WATER OUTLET AND THERMOSTAT HOUSING INSTALLATION.

a. Equipment.

SCREWDRIVER
VARNISH, shellac

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

b. Procedure.

(1) **INSTALL NEW WATER OUTLET GASKET (fig. 28).**

VARNISH, shellac

(a) Be sure that gasket surfaces of front cylinder head and water outlet are clean, with all traces of old gasket removed. Then coat crankcase surface with varnish and when varnish is "tacky," but not completely dry, place new gasket in position.

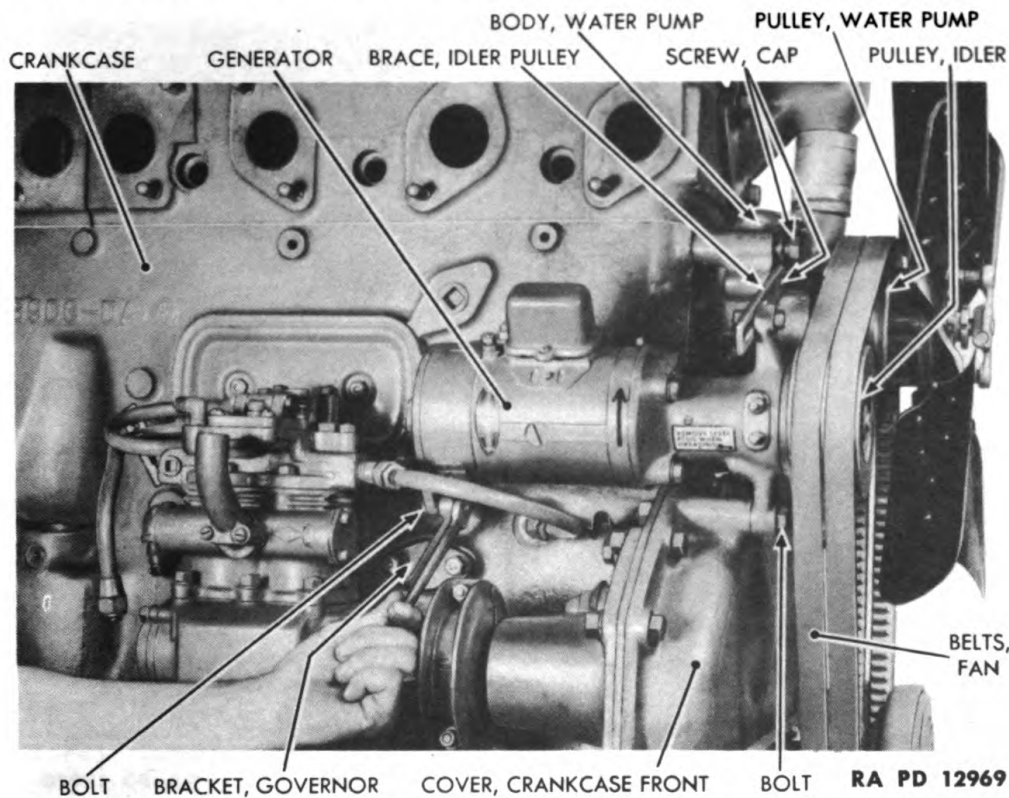


Figure 174—Generator Installation

(2) **INSTALL WATER OUTLET WITH THERMOSTAT HOUSING ATTACHED (fig. 28).**

SCREWDRIVER

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

(a) Place water outlet in position over gasket on front end of front cylinder head. Install and tighten three cap screws and lock washers which hold water outlet to front cylinder head. Then tighten hose clamps on hose which joins water outlet to water pump.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

181. GENERATOR AND HEAT SHIELD INSTALLATION

(fig. 174).

a. Equipment.

WRENCHES, open-end, two,
 $\frac{1}{2}$ -in.
WRENCH, open-end, $\frac{9}{16}$ -in.

WRENCHES, open-end, two,
 $\frac{3}{4}$ -in.

b. Procedure.

(1) INSTALL GENERATOR WITH IDLER PULLEY ATTACHED.

WRENCHES, open-end, two,
 $\frac{1}{2}$ -in.

WRENCHES, open-end, two,
 $\frac{3}{4}$ -in.

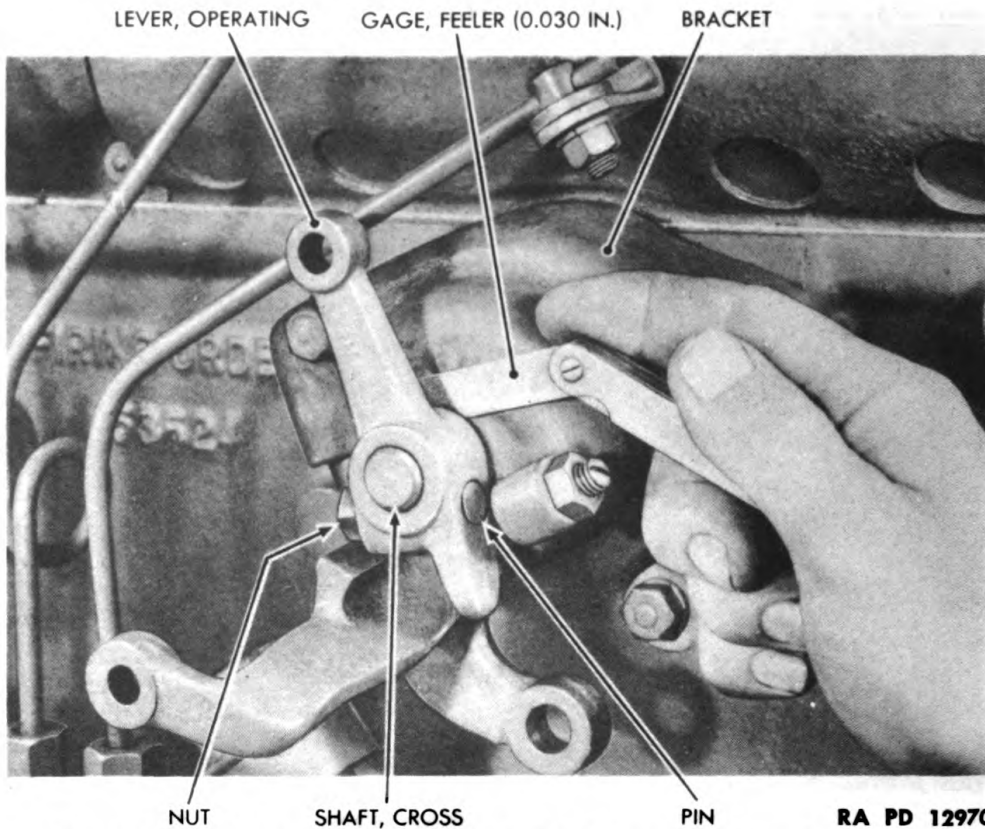


Figure 175—Checking Cross Shaft End Play at Operating Lever

(a) Lift generator into position, with fan belts over idler pulley and use two bolts, lock washers and nuts to secure it to generator bracket and crankcase front cover.

(2) INSTALL HEAT SHIELD.

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

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

(a) Place heat shield in position, removing upper right cap screw and lock washer from water pump body, and reposition and tighten

ASSEMBLY OF ENGINE

cap screw so that it holds heat shield to water pump body and body to crankcase. Install second cap screw and lock washer which hold idler pulley brace to water pump body. NOTE: Fan belt tension should be adjusted at later point, because generator must be moved, for installation of cables, in second engine assembly step.

182. CRANKING MOTOR INSTALLATION (fig. 23).

a. Equipment.

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

b. Procedure. Lift cranking motor into position against rear engine support and secure it in position with three cap screws and lock washers.

183. CROSS SHAFT AND GOVERNOR CONTROL INSTALLATION.

a. Equipment.

DRIFT, brass

GAGE, feeler, 0.030-in.

WRENCH, open-end, $\frac{1}{2}$ -in.

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

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

WRENCH, socket, $\frac{9}{16}$ -in., and speeder

b. Procedure.

(1) INSTALL LATCH AND LATCH BRACKET (fig. 35).

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

(a) On right side of crankcase, place latch bracket in position on stud. Attach and tighten lock washer and nut.

(2) INSTALL LATCH (fig. 35).

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

(a) Place latch in position on latch bracket and install and tighten pin.

(3) INSTALL STARTING VALVE CROSS SHAFT (fig. 35). From right side of crankcase, insert cross shaft with operating rod and connecting parts attached.

(4) INSTALL BRACKET AND CONTROL LEVER WITH ASSEMBLED PARTS (fig. 34).

DRIFT, brass

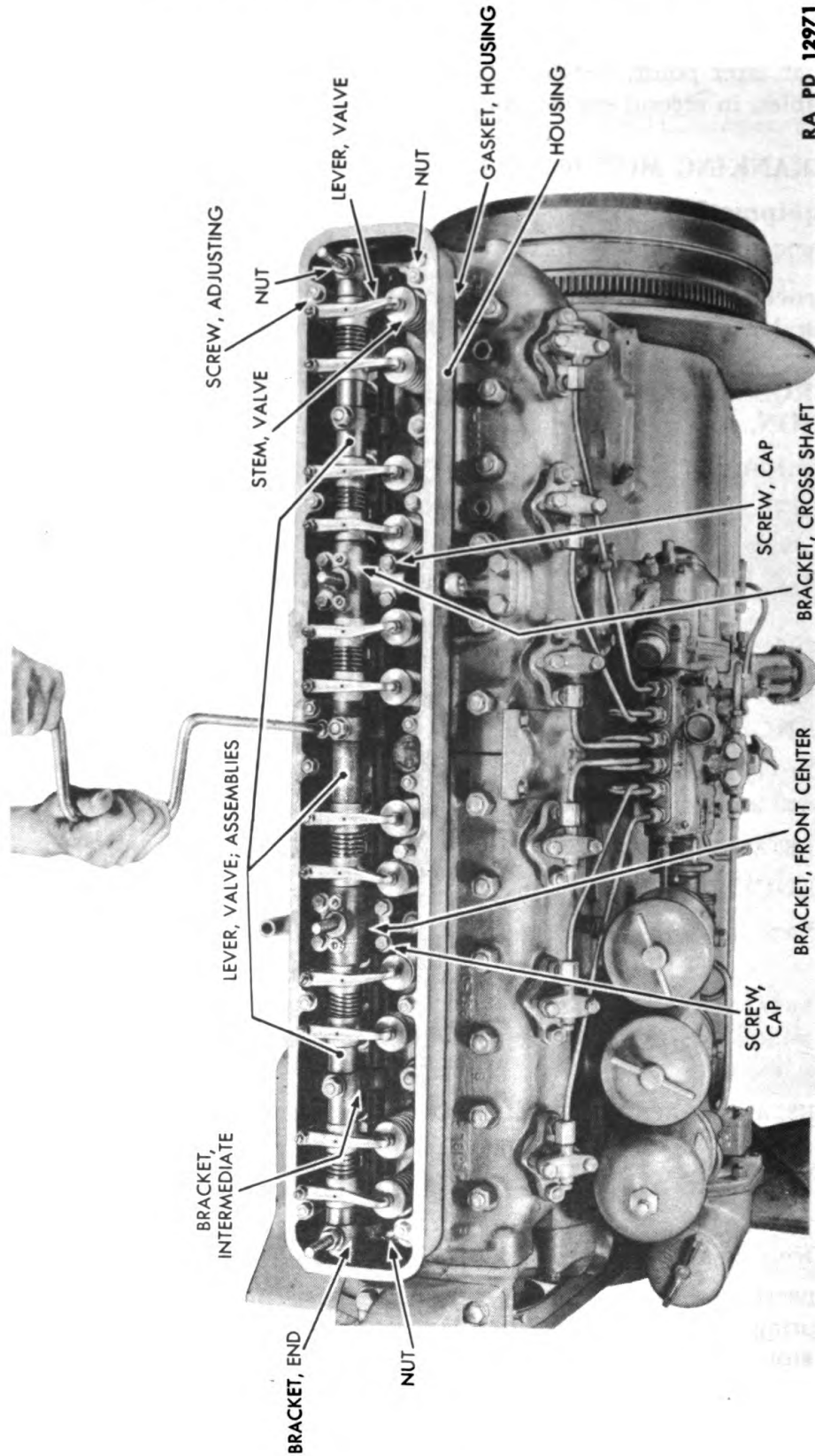
WRENCH, socket, $\frac{9}{16}$ -in., and speeder

(a) Drive control disk pin into left side of crankcase.

(b) Insert control lever and attached parts into bracket. Place poppet spring and stop in bracket. Move lug on stationary disk, compressing stop so that hole in lug on stationary disk will engage with control disk pin when assembled parts are placed on cross shaft.

(c) Install three cap screws and lock washers which hold bracket to crankcase.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE



RA PD 12971

Figure 176—Valve Lever Assemblies and Housing Installation

ASSEMBLY OF ENGINE

(5) **INSTALL CROSS SHAFT OPERATING LEVER (fig. 175).**

GAGE, feeler, 0.030-in. WRENCH, open-end, 1/2-in.

(a) Place cross shaft operating lever on end of cross shaft, next to bracket. Then insert tapered pin which holds lever to cross shaft.

(b) Insert 0.030-inch feeler gage between bracket and operating lever, until it touches shaft. Pull cross shaft snugly toward left side of crankcase and, with feeler gage in position, attach lock washer and nut to pin and tighten nut.

184. VALVE LEVER ASSEMBLIES AND HOUSING INSTALLATION (fig. 176).

a. Equipment.

VARNISH, shellac WRENCH, socket, 9/16-in., and
WRENCH, open-end, 3/4-in. speeder

b. Procedure.

(1) **INSTALL NEW HOUSING GASKET.**

VARNISH, shellac

(a) Make sure that gasket mounting surface on cylinder heads is clean. Then coat surface with varnish and install new gasket in position when varnish is "tacky," but not completely dry.

(2) **INSTALL HOUSING.**

WRENCH, socket, 9/16-in., and speeder

(a) Place housing in position on two cylinder heads and install 12 nuts to studs on top of housing and five nuts to studs inside and at bottom of housing.

(3) **INSTALL VALVE LEVER ASSEMBLIES.**

WRENCH, open-end, 3/4-in. WRENCH, socket, 9/16-in., and
speeder

(a) Place valve lever assemblies into position inside housing. Valve lever adjusting screws in one end of valve levers should rest on ends of push rods and other ends of levers should rest over end of valve stems. Then install five nuts on bracket studs, five nuts on studs at bottom of intermediate and end brackets, four cap screws which hold cross shaft bracket in position and four cap screws which hold front center bracket in position.

185. ASSEMBLY AND INSTALLATION OF STARTING VALVE OPERATING CROSS SHAFT AND RELATED PARTS (fig. 177).

a. Equipment.

PLIERS WRENCH, box, 1/2-in.

b. Procedure.

(1) **ATTACH CROSS SHAFT LEVER TO STARTING VALVE OPERATING CROSS SHAFT.**

WRENCH, box, 1/2-in.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

- (a) Place cross shaft lever in position on cross shaft and insert pin. Attach and tighten lock washer and nut to pin.
- (2) **INSERT STARTING VALVE OPERATING CROSS SHAFT INTO CROSS SHAFT BRACKET.**

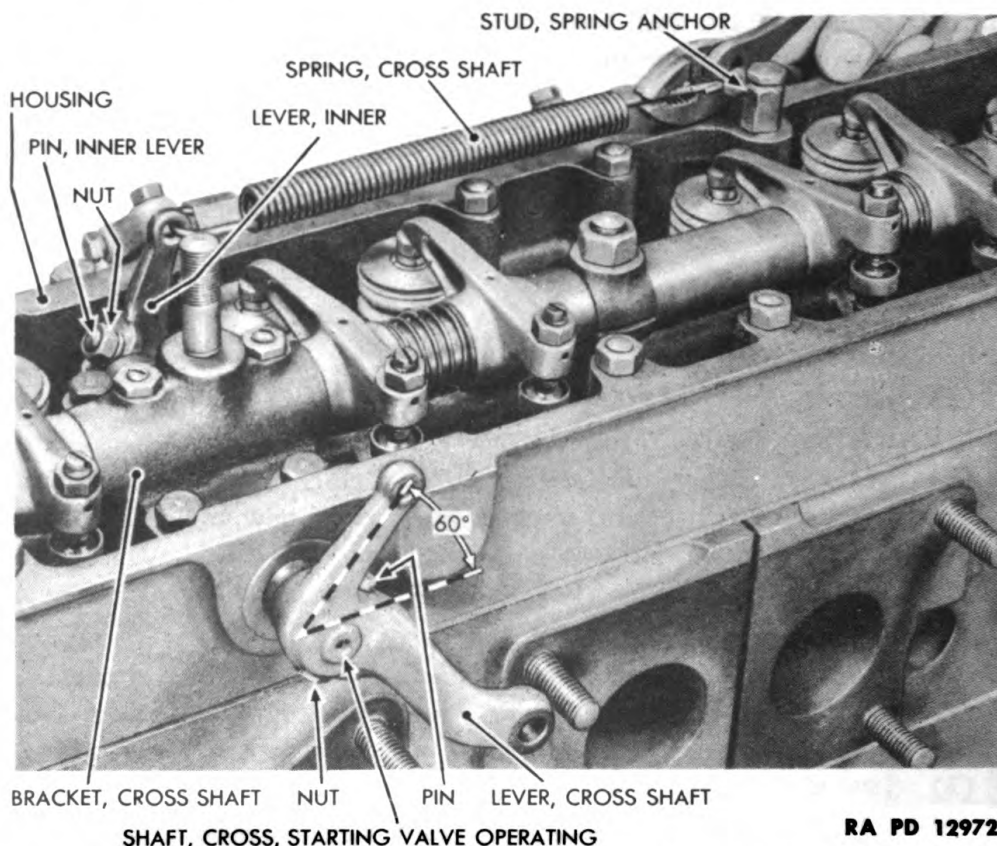


Figure 177—Installation of Starting Valve Operating Cross Shaft and Related Parts

(a) As cross shaft is inserted into bracket, its spiral gear will engage with gear in cross shaft bracket. Cross shaft should be inserted so that it will neither depress starting valves nor permit starting valve shaft rollers to point up when cross shaft lever is positioned toward front of engine at angle of approximately 60 degrees from horizontal position.

(b) As cross shaft is inserted through cross shaft bracket, install inner lever between bracket and side of housing. Position inner lever with milled side up. Then turn cross shaft so that inner lever pin can be installed. Next, turn cross shaft back and attach lock washer and nut to pin. Do not tighten this nut at this point, since subsequent adjustment must be made. **CAUTION:** When inserting end of cross shaft through oil seal in left side of housing, be careful to avoid damage to seal.

- (3) **INSTALL CROSS SHAFT SPRING.**
PLIERS

ASSEMBLY OF ENGINE

(a) Attach cross shaft spring to inner lever and to spring anchor stud, with long end of spring attached to stud.

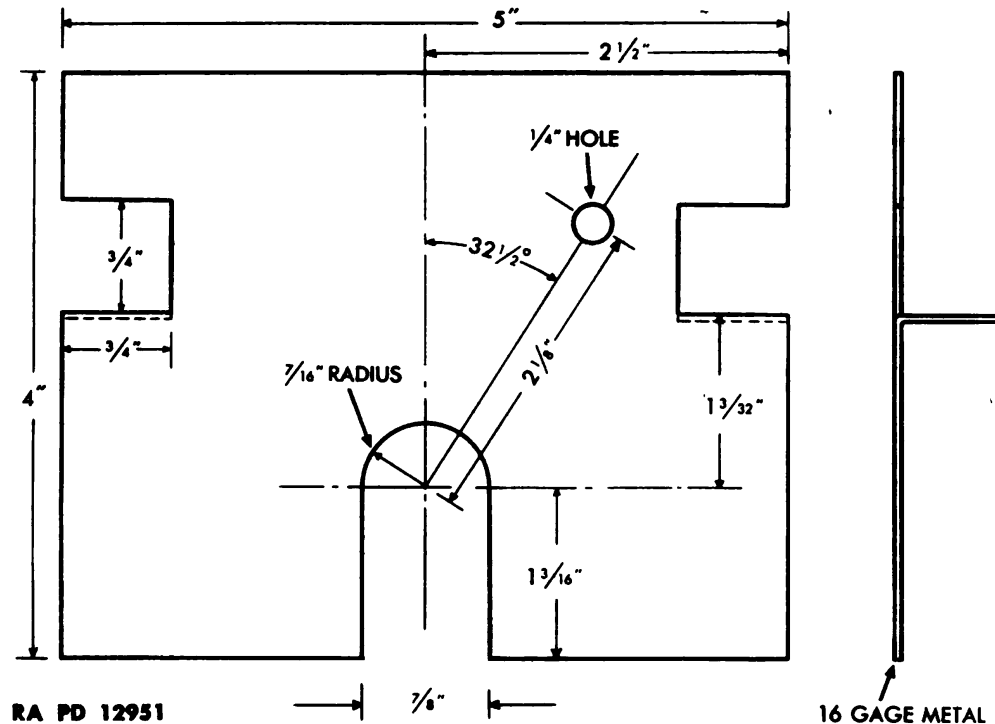


Figure 178—Template for Setting Starting Valves

186. ADJUSTMENT OF STARTING VALVE MECHANISM.

a. Equipment.

CHISEL, hard, cold
GAGE, feeler, long
METAL, sheet, 16-gage
PIN, 1/4-in.
SCREWDRIVER
SHEARS, tinner's, hand

TEMPLATE
WRENCH, box, 9/16-in.
WRENCH, box, 5/8-in.
WRENCH, open-end, 1/2-in.
WRENCH, open-end, 9/16-in.
WRENCH, open-end, 5/8-in.

b. Procedure.

(1) CUT TEMPLATE FOR ACCURATE POSITIONING OF CROSS SHAFT LEVER (fig. 178).

CHISEL, hard, cold
METAL, sheet, 16-gage

SHEARS, tinner's, hand

(a) Prepare piece of sheet metal to form template to be used as outlined in this paragraph.

(2) INSTALL TEMPLATE OVER OPERATING CROSS SHAFT (fig. 179).

PIN, 1/4-in.

TEMPLATE

(a) Place template in position over starting valve operating cross shaft. Place template over cross shaft next to outside of housing on right side of engine, with right angle edges of template resting on top

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

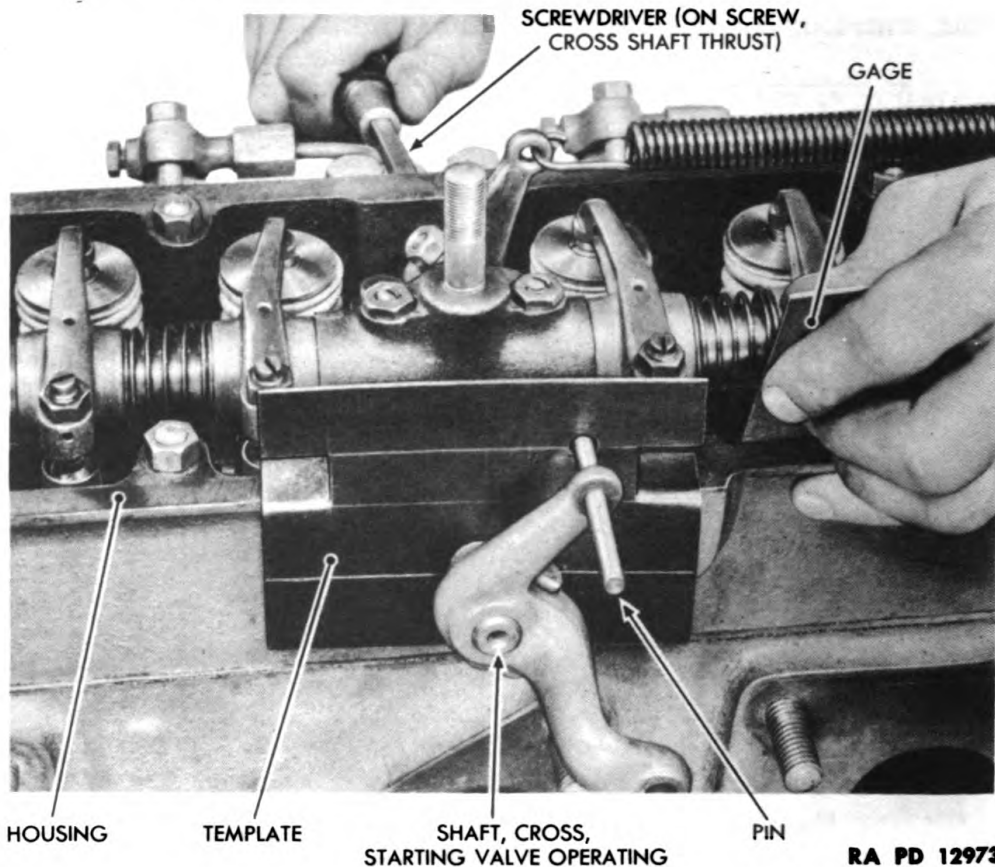


Figure 179—Adjusting Starting Valve Clearance

of housing. Then install pin through cross shaft lever and through hole in template.

(3) CHECK CLEARANCE BETWEEN EACH STARTING VALVE SHAFT ROLLER AND STARTING VALVE (fig. 179).

GAGE, feeler, long

(a) Use long feeler gage to locate valve and roller which have least clearance between them.

(4) ADJUST VALVE CLEARANCE (fig. 179).

GAGE, feeler, long

SCREWDRIVER

(a) Tighten or loosen cross shaft thrust screw until roller and valve with least clearance between them adjusts to not less than 0.185-inch clearance.

(5) CHECK CLEARANCE BETWEEN REMAINING ROLLERS AND VALVES (fig. 179).

GAGE, feeler, long

(a) Clearance between remaining rollers and valves should be checked and should not exceed 0.205-inch. Be sure valve retainers are screwed entirely down on the valves. If clearance exceeds this limit, it

ASSEMBLY OF ENGINE

is an indication that rollers and pins on starting valve shafts are worn and should therefore be replaced by new parts. Lock cross shaft thrust bracket screw in position in cross shaft bracket by installing cotter pin.

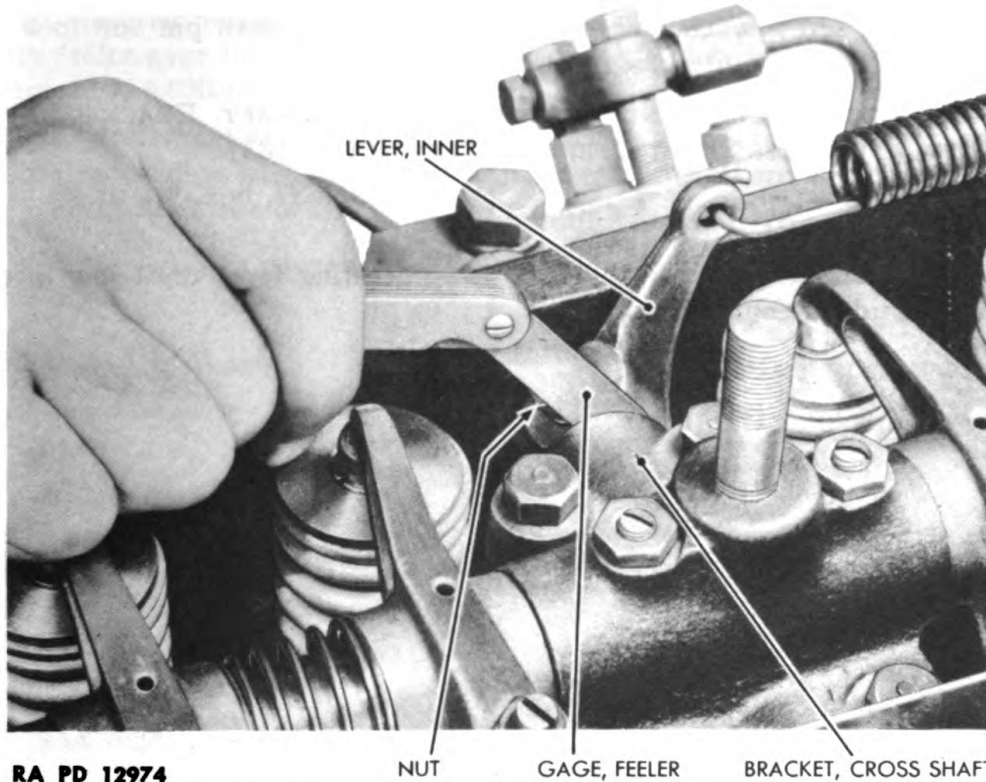


Figure 180—Checking Clearance of Inner Lever and Cross Shaft Bracket

(6) CHECK CLEARANCE BETWEEN INNER LEVER AND CROSS SHAFT BRACKET (fig. 180).

PLIERS

WRENCH, open-end, 1/2-in.

(a) Place feeler gage between inner lever and cross shaft bracket. This clearance should be 0.010-inch. If not, readjust inner lever until that clearance is attained. Then tighten nut on inner lever pin.

(7) CHECK CLEARANCE BETWEEN STARTING VALVE CROSS SHAFT LATCH AND JAW (fig. 181).

GAGE, feeler, long
SCREWDRIVER

WRENCH, box, 5/8-in.

(a) Loosen nut on flat point headless set screw in jaw. Then back up screw.

(b) Insert feeler gage between latch and jaw and tighten set screw until 0.060-inch clearance is attained when jaw is held against set screw. Then tighten nut on set screw.

(8) CONNECT OPERATING LEVER TO CROSS SHAFT LEVER (fig. 182).

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

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) With template and pin still in position, loosen lock nut which holds yoke in position on end of operating rod. Then turn yoke until it lines up with cross shaft lever, so that pin can be inserted. Hold jaw against set screw when making this adjustment. Install pin and lock it with cotter pin. Tighten lock nut on yoke.

(9) ADJUST CLEARANCE BETWEEN CROSS SHAFT BRACKET SET SCREW AND CROSS SHAFT OPERATING LEVER (fig. 183).

GAGE, feeler
SCREWDRIVER

WRENCH, box, $\frac{9}{16}$ -in.

(a) From left side of engine, move operating lever until jaw lever on right side of engine contacts jaw.

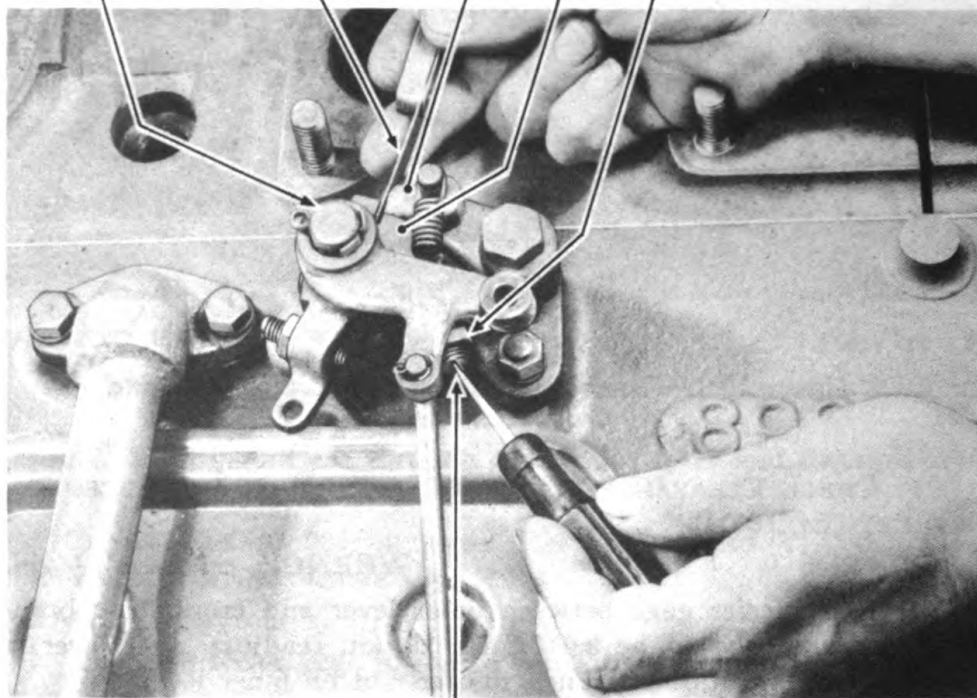
SHAFT, CROSS, STARTING VALVE

GAGE, FEELER (0.060 IN.)

LATCH

JAW

NUT



SCREW, SET, FLAT POINT HEADLESS

RA PD 12975

Figure 181—Checking Clearance between Starting Valve Cross Shaft Latch and Jaw

(b) On left side of engine, loosen jam nut on oval point headless set screw in cross shaft bracket. Then place feeler gage between cross shaft operating lever and set screw, adjusting screw until clearance is 0.100-inch. Then tighten jam nut.

(10) ADJUSTING CLEARANCE BETWEEN STARTING VALVE CROSS SHAFT JAW AND LATCH BRACKET (fig. 184).

GAGE, feeler, long
SCREWDRIVER

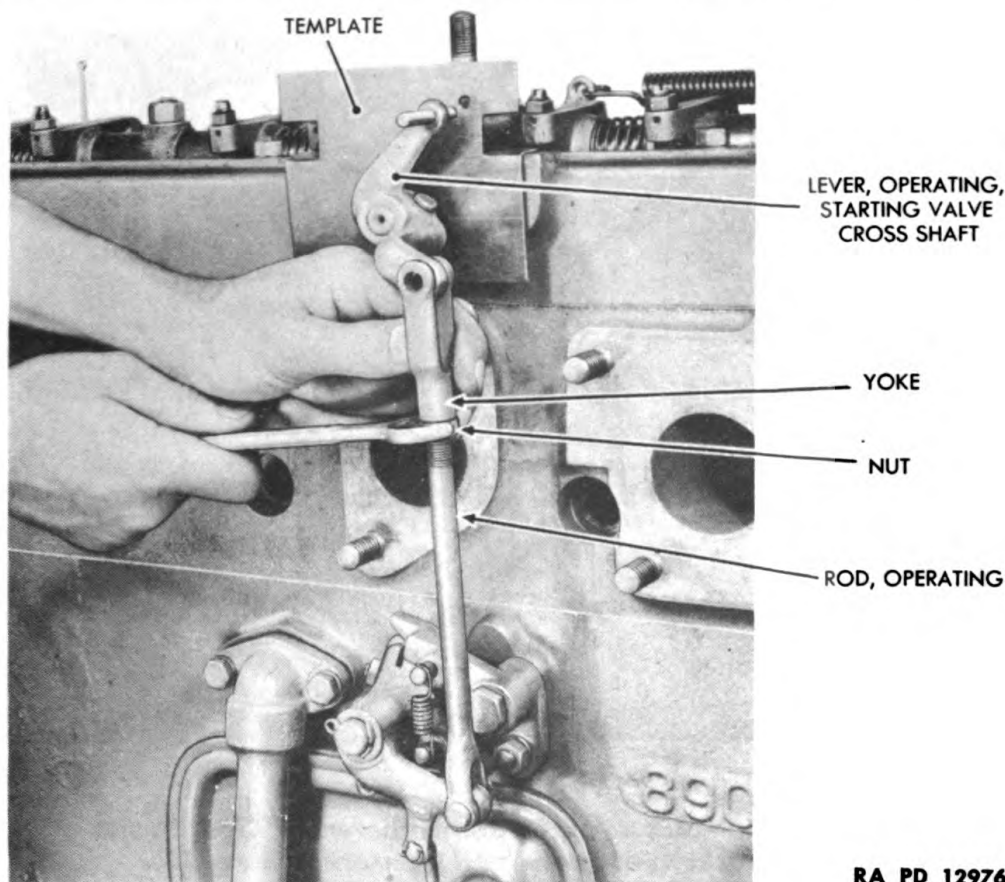
WRENCH, open-end, $\frac{9}{16}$ -in.

ASSEMBLY OF ENGINE

(a) Move starting valve cross shaft operating lever, which is located at left side of engine, to "low compression" position, which will engage latch on right side of engine in front notch in top of jaw.

(b) Loosen jam nut on slotted screw in jaw and then back up screw. Place feeler gage between jaw and latch bracket and tighten screw until clearance is 0.030-inch. Tighten jam nut.

(11) **INSTALL SPARK PLUGS AND INTAKE AND EXHAUST MANIFOLDS.** Before proceeding with additional adjustments, install spark plugs (par. 187), and install intake and exhaust manifolds (par. 188).



RA PD 12976

Figure 182—Adjusting Starting Valve Cross Shaft Operating Lever

(12) **INSTALLING AND ADJUSTING AIR VALVE CONTROL ROD** (fig. 185).

(a) On left side of engine, pull starting valve cross shaft operating lever back (gasoline cycle position).

(b) Install air valve control rod yoke.

(c) Pull outer control lever on intake manifold housing back (gasoline cycle position). Loosen nut which locks yoke in position on air valve control rod, so rod may be turned in yoke to desired position. When slot in end of rod is positioned in manifold outer control lever—

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

ready for installation of pin—slot should project slightly beyond pin at end rod. Then install pin and secure it in position with cotter pin.

(d) On left side of engine, push starting valve cross shaft operating lever forward (Diesel cycle position). In this position, there should be a similar amount of play between pin and rear end of slot in air valve control rod. Pin should not strike end of slot in either gasoline or Diesel cycle positions. If accurate positioning is not attained at this point,

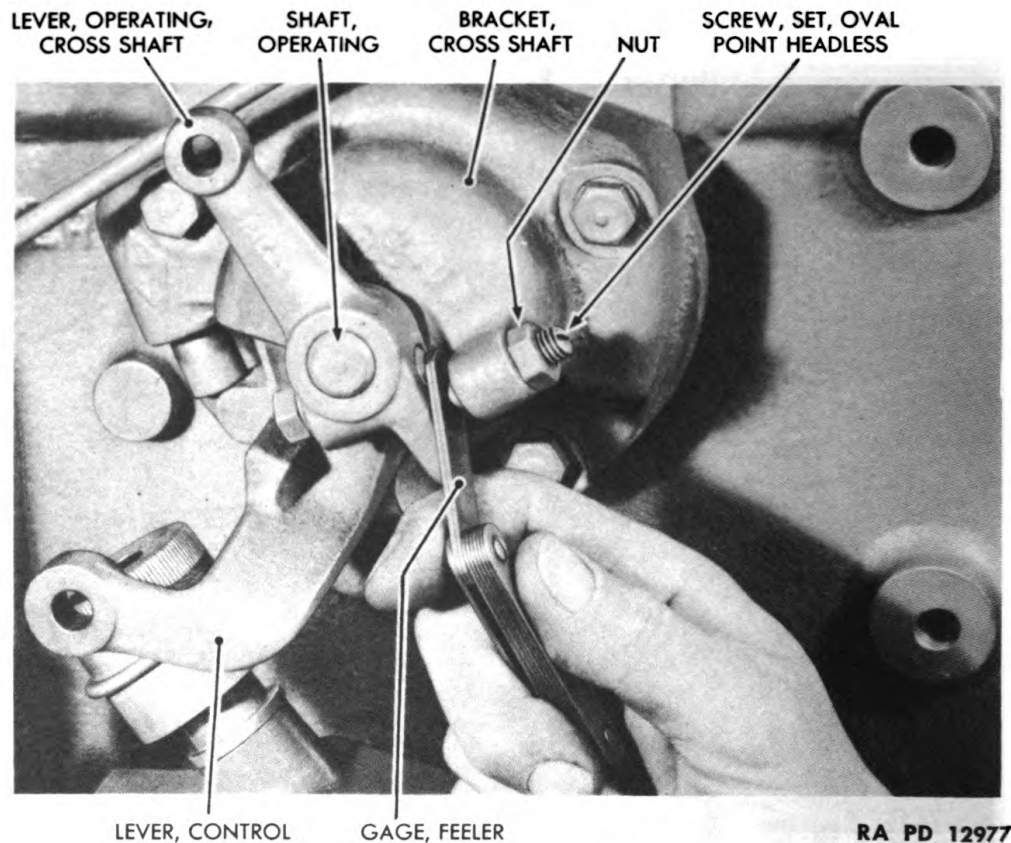


Figure 183—Adjusting Clearance between Cross Shaft Bracket Set Screw and Operating Lever

remove pin from slot and reposition rod in yoke, rechecking position of pin in slot in both gasoline and Diesel cycle positions, until proper position is located.

(e) Lock yoke in rod by tightening nut.

187. SPARK PLUG INSTALLATION.

a. Equipment.

WRENCH, spark plug (IHC No. 32941-D or equivalent)

b. Procedure (fig. 186). Install six spark plugs in right side of cylinder heads.

ASSEMBLY OF ENGINE

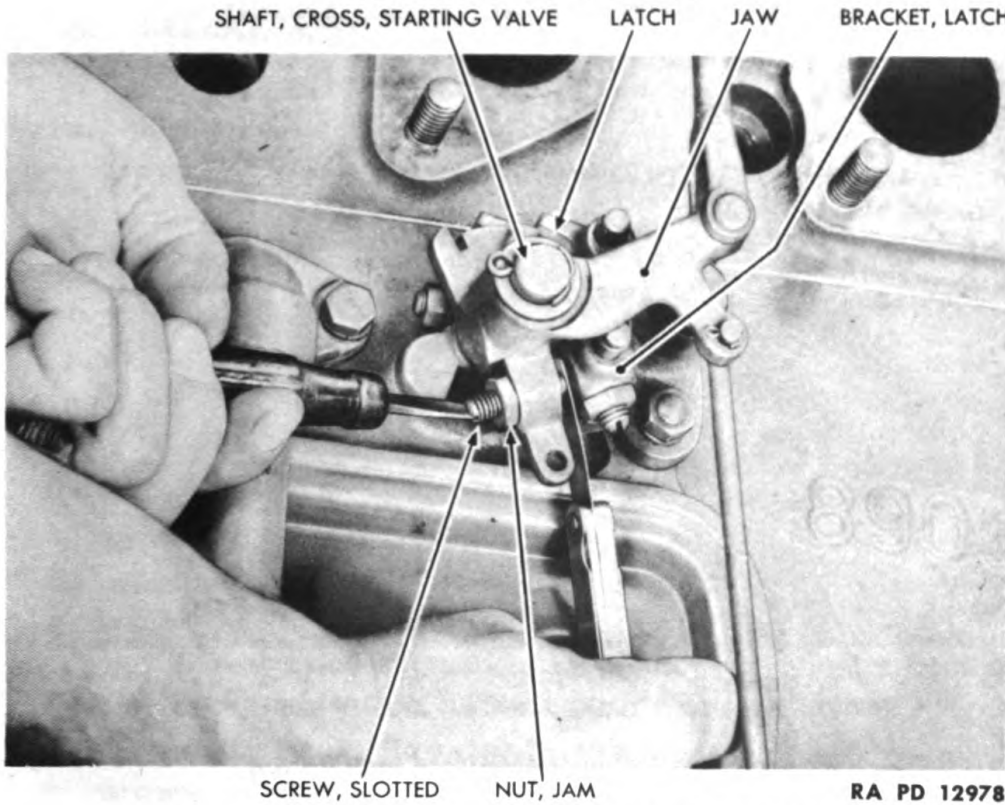


Figure 184—Adjusting Clearance between Starting Valve Cross Shaft Jaw and Latch Bracket

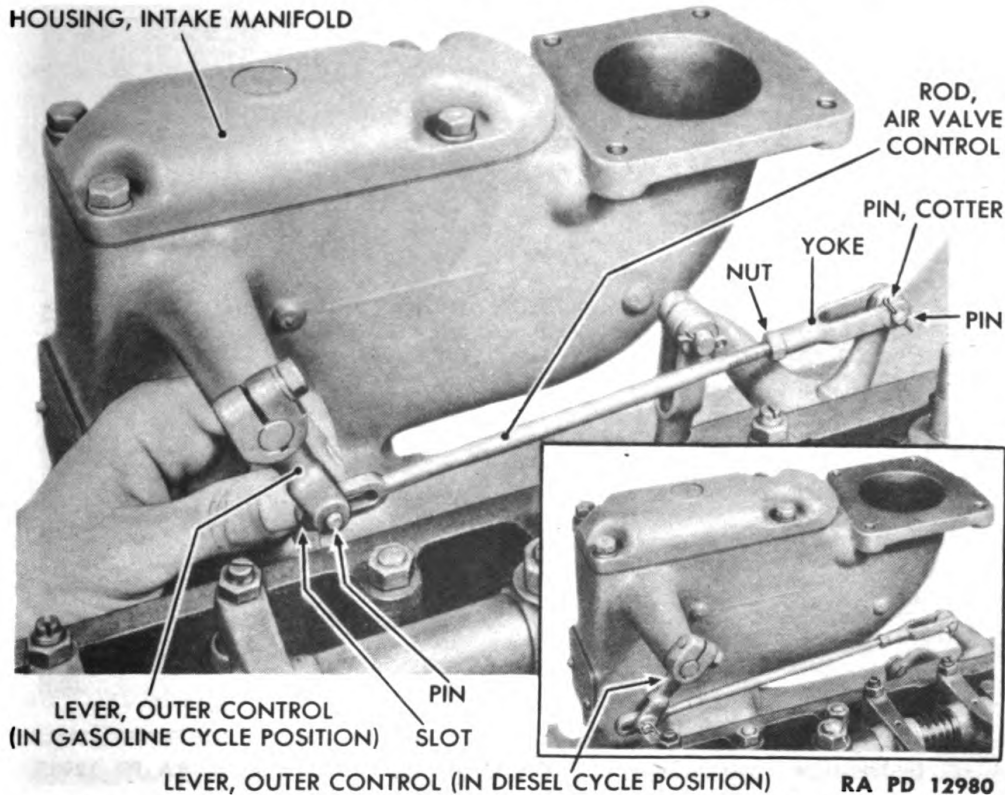


Figure 185—Air Valve Control Rod Installation and Adjustment

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HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

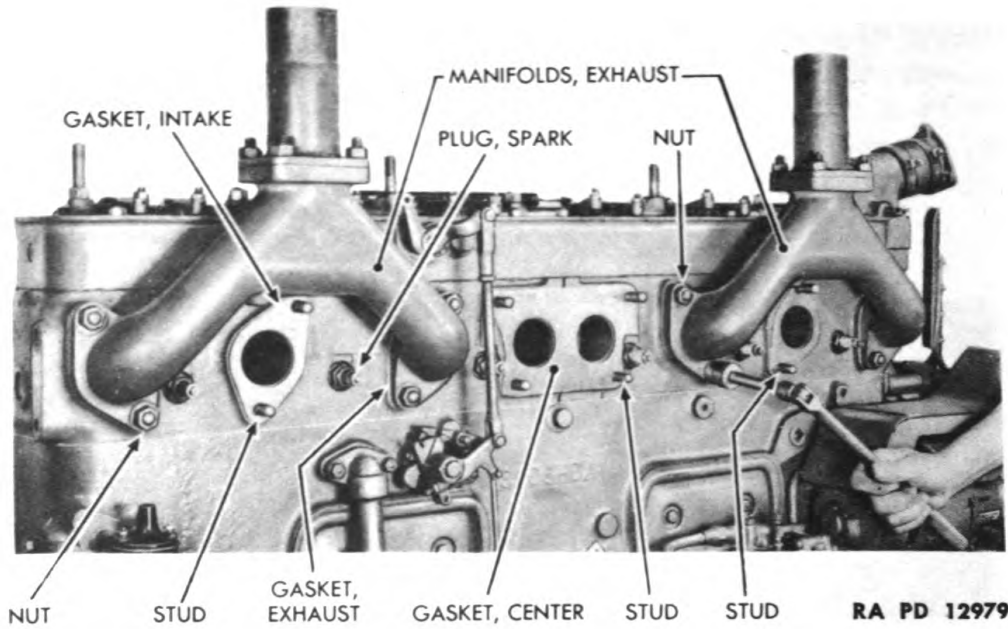


Figure 186—Exhaust Manifold Installation

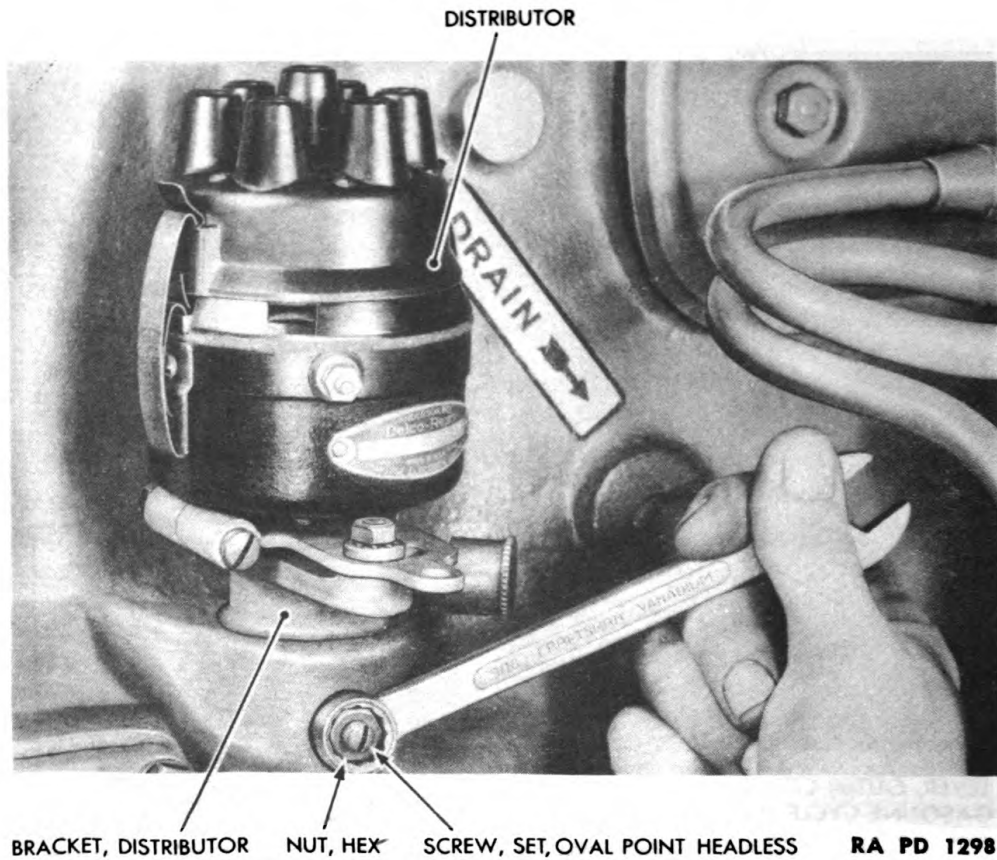


Figure 187—Distributor Installation

ASSEMBLY OF ENGINE

188. INTAKE AND EXHAUST MANIFOLD INSTALLATION (fig. 186).

a. Equipment.

WRENCH, socket, $1\frac{3}{16}$ -in., WRENCH, torque
with spinner type handle
and extension

b. Procedure.

(1) **INSTALL NEW GASKETS.** Place new cylinder gasket, four new exhaust gaskets and two new intake gaskets in position over studs on cylinder heads.

(2) **INSTALL REAR EXHAUST MANIFOLD.**

WRENCH, socket, $1\frac{3}{16}$ -in., WRENCH, torque
with spinner type handle
and extension

(a) Lift rear exhaust manifold in position on cylinder head studs and attach and tighten four nuts. Tighten to 75 foot-pounds.

(3) **INSTALL FRONT EXHAUST MANIFOLD.**

WRENCH, socket, $1\frac{3}{16}$ -in., WRENCH, torque
with spinner type handle
and extension

(a) Place front exhaust manifold in position on cylinder head studs and install and tighten four nuts. Tighten to 75 foot-pounds.

(4) **INSTALL INTAKE MANIFOLD AND HOUSING.**

WRENCH, socket, $1\frac{3}{16}$ -in., WRENCH, torque
with spinner type handle
and extension

(a) Lift intake manifold and housing in position over studs and cylinder gasket. Attach and tighten four nuts. Tighten to 75 foot-pounds.

(5) **INSTALL AND ADJUST AIR VALVE CONTROL ROD.** See paragraph 186 b (12).

189. DISTRIBUTOR INSTALLATION.

a. Equipment.

SCREWDRIVER WRENCH, box, $\frac{9}{16}$ -in.

b. Procedure (fig. 187). Place distributor in position in crankcase so that shaft fits into slot in oil pump pinion. Countersunk hole on distributor shaft should also be positioned opposite oval point headless set screw and hexagon nut. Tighten set screw and lock it in position with hexagon nut.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

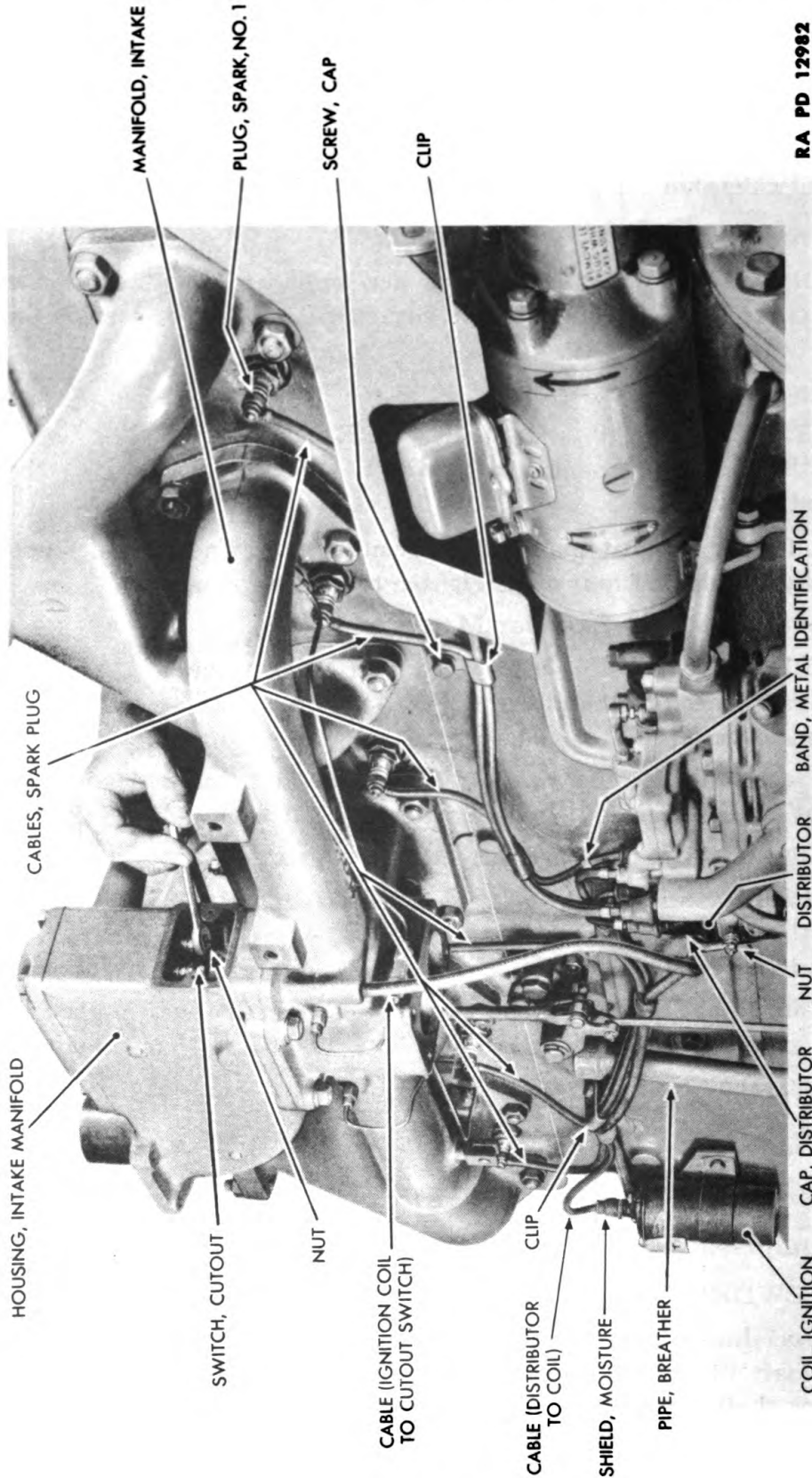


Figure 188 — Electrical Cable Installation

ASSEMBLY OF ENGINE**190. INSTALLATION OF ELECTRICAL CABLES ON ENGINE**
(fig. 188).**a. Equipment.**

WRENCH, open-end, $1\frac{1}{32}$ -in. WRENCH, open-end, $\frac{9}{16}$ -in.
WRENCH, open-end, $\frac{3}{8}$ -in.

b. Procedure.**(1) ATTACH CABLES TO RIGHT SIDE OF ENGINE.**

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

(a) Assembled cables are held to right side of engine by two cable clips. Rear clip is held by one of cap screws and lock washers which also hold breather pipe to crankcase. Front clip is held to crankcase by cap screw and lock washer.

(2) ATTACH SPARK PLUG CABLES TO SPARK PLUGS. A metal band on distributor end of each cable identifies spark plug to which each cable should be attached, beginning with No. 1 spark plug in front of engine. Attach each cable by hand. Do not use pliers. Position end of cable in extreme counterclockwise position until screw is tightened securely with fingers. Then turn both cable and screw to tighten cable under screw still more.

(3) ATTACH SPARK PLUG CABLES AND CABLE (DISTRIBUTOR TO COIL) TO DISTRIBUTOR CAP. Turn engine to "T.D.C." compression stroke. Remove distributor cover and hold it over distributor in same relative position as when installed. Then note position of metal strip on rotor arm, which will be directly under terminal to which No. 1 spark plug cable is attached. Replace distributor cover and attach No. 1 spark plug cable. Then, in counterclockwise manner, attach remaining cables in their proper firing order, which is 1-5-3-6-2-4. NOTE: Distributor should be timed when engine has been fully assembled and installed in tractor.

(4) CONNECT CABLE (COIL TO DISTRIBUTOR). This cable has moisture shield at each end. Connect one end to center of distributor and other end to center of ignition coil.

(5) CONNECT CABLE (IGNITION COIL TO CUT-OUT SWITCH).

WRENCH, open-end, $1\frac{1}{32}$ -in. WRENCH, open-end, $\frac{3}{8}$ -in.

(a) In process of engine disassembly, recommended procedure is to attach tag labelled + to ignition coil end of this cable. Attach this cable to + terminal at coil. Secure cable to coil with nut and lock washer. Then connect one lead to terminal at side of distributor, securing it with nut and lock washer and finally insert ignition coil to cut-out switch and distributor to cut-out switch cables through opening in intake manifold and into manifold housing. Connect these two cables to cut-out switch terminals, securing them with two lock washers and nuts. Either cable may be connected to either terminal at this point.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

191. CARBURETOR INSTALLATION (fig. 189).

a. Equipment.

WRENCH, box, $\frac{9}{16}$ -in.

b. Procedure.

(1) ATTACH CARBURETOR TO INTAKE MANIFOLD.

WRENCH, box, $\frac{9}{16}$ -in.

(a) Check to see that all traces of old gasket have been removed from carburetor and intake manifold. Then place new gasket in position on carburetor.

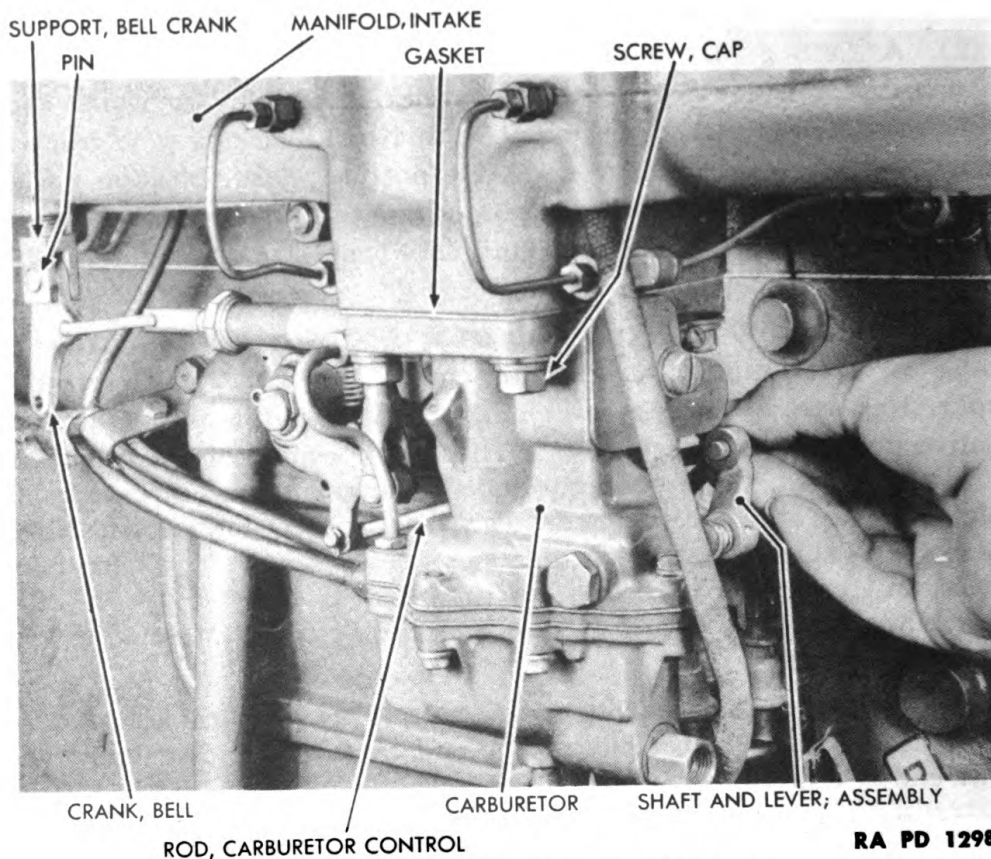


Figure 189—Carburetor Installation

(b) Lift carburetor into position on intake manifold and secure it with four flat washers, lock washers and cap screws.

(2) CONNECT BELL CRANK TO REAR OF MANIFOLD. Attach bell crank to bell crank support which is located at rear of intake manifold, installing pin and locking pin with cotter pin.

(3) ATTACH CARBURETOR CONTROL ROD TO CARBURETOR SHAFT AND LEVER ASSEMBLY. Place rod in lever and lock it with cotter pin.

ASSEMBLY OF ENGINE

192. AIR COMPRESSOR AIR CLEANER INSTALLATION.

a. Equipment.

SCREWDRIVER

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

b. Procedure.

(1) LIFT AIR COMPRESSOR AIR CLEANER INTO POSITION ON RIGHT SIDE OF ENGINE (fig. 22). Position air cleaner so that compressor inlet pipe hose slips onto air compressor. Air cleaner bracket should be in position on intake manifold.

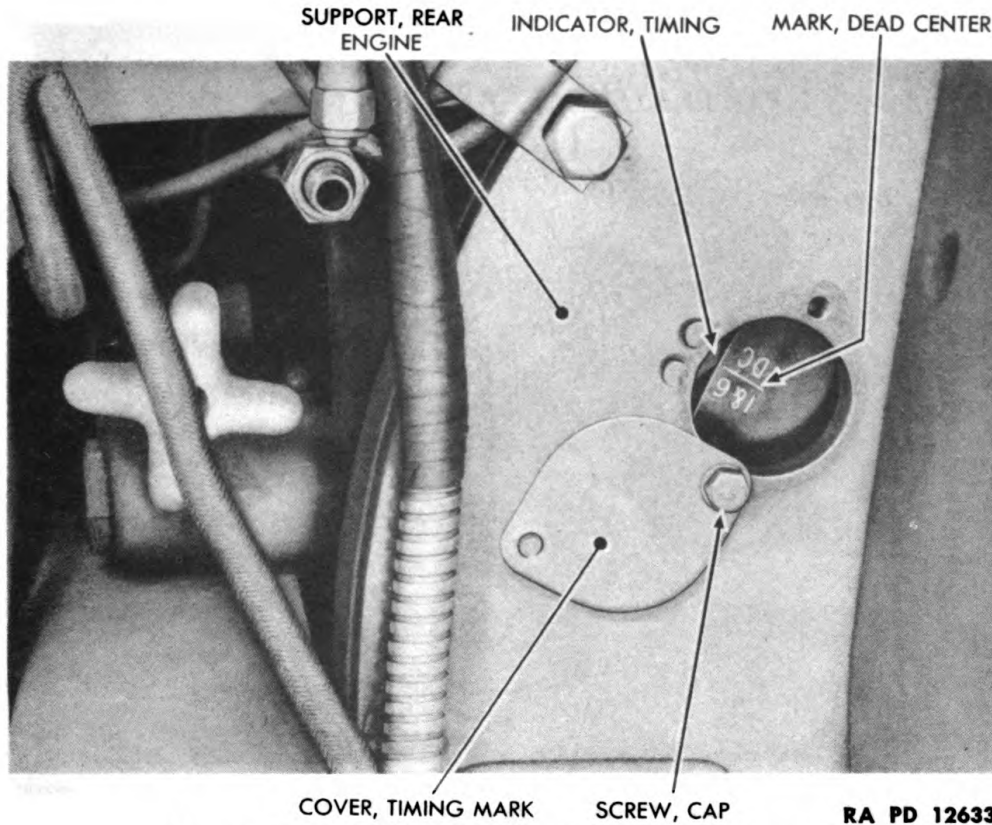


Figure 190—Checking Dead Center on Flywheel

(2) INSTALL TWO CAP SCREWS AND LOCK WASHERS WHICH HOLD AIR CLEANER TO INTAKE MANIFOLD (fig. 22).

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

(3) TIGHTEN AIR COMPRESSOR INLET PIPE HOSE CLAMP (fig. 22).

SCREWDRIVER

193. CHECKING INTAKE AND EXHAUST VALVE CLEARANCE.

a. Equipment.

BAR, steel
GAGE, feeler

SCREWDRIVER

WRENCH, box, $\frac{1}{2}$ -in.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

b. Procedure.

(1) POSITION NO. 1 CYLINDER ON TOP DEAD CENTER COMPRESSION STROKE (fig. 190).

BAR, steel

(a) Install steel bar in one of holes in flywheel and turn flywheel until flywheel marks—visible through hole in rear engine support—indicate that No. 1 cylinder is in top dead center position. No. 1 cylinder must be on compression stroke.

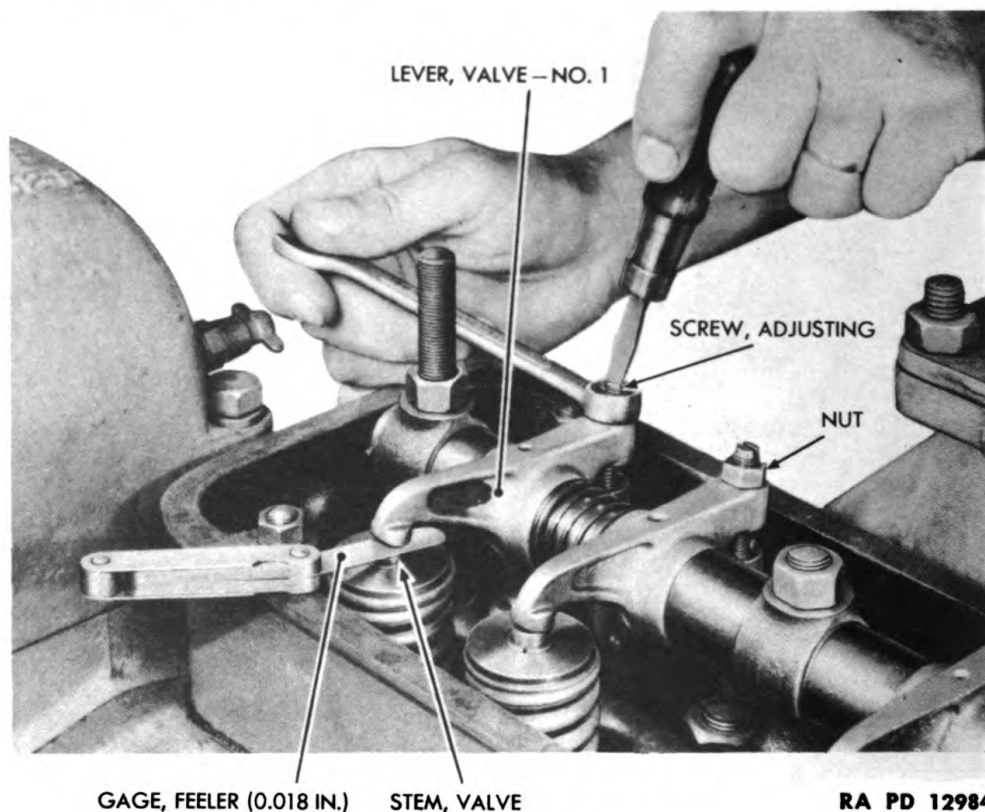


Figure 191—Checking Valve Clearance

(2) CHECK CLEARANCE BETWEEN NO. 1 VALVE LEVERS AND STEMS (fig. 191).

GAGE, feeler
SCREWDRIVER

WRENCH, box, 1/2-in.

(a) On both No. 1 intake and exhaust valve levers, loosen nut on adjusting screws. Then, in turn, place feeler gage between valve lever and valve stem of No. 1 intake and exhaust valves, adjusting screws until 0.018-inch clearance is attained. Then lock the nut on adjusting screw. To avoid deviation from proper adjustment, leave wrench on nut while adjusting the screw, so that nut can be tightened while screw is being held in position for proper valve clearance.

ASSEMBLY OF ENGINE

(3) TURN THE FLYWHEEL OVER SLOWLY UNTIL "DC 2 & 5" APPEAR IN THE OPENING IN REAR ENGINE SUPPORT. At this point No. 5 piston is on top dead center compression stroke for the purpose of checking valve clearance. Again turn the flywheel over slowly until the marks "DC 3 & 4" appear in the opening. This will indicate that the No. 3 piston is on top dead center in preparation for checking valve clearance. Turn the flywheel over further until marks "DC 1 & 6" appear again and this will indicate that the No. 6 piston is on top dead center compression stroke. Continue to turn the flywheel until "DC 2 & 5" appear again which will indicate that the No. 2 piston is on top dead center. Turn flywheel until "DC 3 & 4" appear again. No. 4 cylinder is now top dead center for checking.

194. VALVE HOUSING COVER INSTALLATION.

a. Equipment.

VARNISH, shellac

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

b. Procedure.

(1) INSTALL FELT IN POSITION OVER VALVE LEVER ASSEMBLIES.

(2) INSTALL NEW GASKET.

VARNISH, shellac

(a) Check to see that all traces of old gasket are removed from housing and cover. Then coat top edge of housing with varnish and install new gasket when varnish becomes "tacky," but not completely dry.

(3) INSTALL COVER (fig. 63).

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

(a) Lift valve housing cover in position and secure it in position with four copper washers and nuts.

195. ASSEMBLING CLUTCH TO ENGINE.

a. Equipment.

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle

b. Procedure.

(1) LIFT CLUTCH IN POSITION ON FLYWHEEL WITH CLUTCH SHAFT ENTERING PILOT BEARING (fig. 29).

(2) CONNECT CLUTCH BACK PLATE TO FLYWHEEL.

WRENCH, socket, $\frac{3}{4}$ -in., and spinner type handle.

(a) Install and tighten nine cap screws and lock washers which hold clutch back plate to flywheel.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Section IX

INSTALLATION OF ENGINE IN VEHICLE

	Paragraph
Check engine before installation	196
Facilities	197
Precautions	198
Placing engine in position in vehicle	199
Attaching engine supports to frame	200
Connection of miscellaneous parts to right side of engine	201
Connection of miscellaneous parts to left side of engine	202
Installation of radiator and connecting parts at front of engine...	203
Hood sheet installation	204
Muffler installation	205
Crankcase guard installation	206
Winch installation	207
Check after installation	208

196. CHECK ENGINE BEFORE INSTALLATION.

- a. Inspect all subassemblies on engine to make sure that all nuts and cap screws are tightly connected.
- b. Check engine to see that all subassemblies and connections required before installation are installed.
- c. Check all parts of engine to see that they are thoroughly clean and that no extraneous material or equipment is left on engine.

197. FACILITIES.

- a. In addition to tools listed in various paragraphs of this section, following equipment should be available to install engine in tractor:
 - (1) A hoist capable of lifting engine and swinging it into position in tractor.
 - (2) Twenty-five feet of 1½-inch rope. This rope is used to form sling around engine, so that hoist can be attached.

198. PRECAUTIONS.

- a. No attempt to install engine in tractor should be made unless facilities outlined in paragraph 197 are available.
- b. To assure dependable service and to minimize possible future repairs, all necessary service and repairs needed on engine should be made before engine is installed in tractor.

INSTALLATION OF ENGINE IN VEHICLE

c. Examine tractor to see that clutch compartment in main frame is clean. Check to see that cables and connections in dash and cowl assembly are out of way so that engine will be unobstructed when lifted into place on main frame side channels.

199. PLACING ENGINE IN POSITION IN VEHICLE.

a. Equipment.

HOIST SLING, rope

b. Procedure.

(1) PLACE ROPE SLING ON ENGINE (figs. 18 and 19). Follow same procedure to form rope sling as used in removing engine from vehicle (par. 35 b (1)).

(2) ATTACH HOIST TO ROPE SLING.

HOIST SLING, rope

(a) Position hoist hook on rope sling so that weight of engine will be properly balanced when engine is lifted.

(3) LIFT ENGINE FROM ITS SUPPORTS INTO VEHICLE (fig. 20). Lift engine off its wooden block supports. Then push it into position in tractor between main frame side channels, toward rear of tractor, until rear engine support is flush with main frame and engine front support positioned as near as possible to boltholes in frame side channels.

200. ATTACHING ENGINE SUPPORTS TO FRAME.

a. Equipment.

PUNCH WRENCH, socket, $\frac{7}{8}$ -in., and
WRENCH, open-end, $\frac{3}{4}$ -in. spinner type handle
WRENCH, open-end, $\frac{15}{16}$ -in.

b. Procedure.

(1) CONNECT REAR ENGINE SUPPORT TO MAIN FRAME (fig. 16).

PUNCH

(a) Line up cap screw and dowel boltholes in rear engine support and main frame. Then install two dowel bolts which line up engine and clutch with transmission. From driver's side of dash and cowl assembly, install two nuts and lock washers to two dowel bolts. One bolt is at left and other at right of dash and cowl assembly. Cable clip is also installed on engine side with right dowel bolt.

(b) Install six cap screws and lock washers from engine side and two cap screws and lock washers from driver's side of dash and cowl assembly. These cap screws secure engine support to main frame.

(2) CONNECT FRONT ENGINE SUPPORT TO MAIN FRAME SIDE CHANNELS (fig. 126).

WRENCH, open-end, $\frac{15}{16}$ -in. WRENCH, socket, $\frac{7}{8}$ -in., and
spinner type handle

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

(a) Insert shims, if any, in same quantity used at original installation, under front engine support. Then install bolts from underneath side of each main frame side channel through each end of front engine support. Install two nuts and lock washers. To tighten bolts adequately, it may be necessary to hold bolt heads with one wrench while tightening nuts with the other.

(3) REMOVE ROPE SLING FROM ENGINE.

(4) SECURE DASH AND COWL ASSEMBLY TO REAR CYLINDER HEAD.
WRENCH, open-end, $\frac{3}{4}$ -in.

(a) Install two cap screws, spacers and lock washers which hold rear cylinder head to dash and cowl assembly.

201. CONNECTION OF MISCELLANEOUS PARTS TO RIGHT SIDE OF ENGINE.

a. Equipment.

PLIERS	WRENCH, open-end, $\frac{5}{8}$ -in.
SCREWDRIVER	WRENCH, socket, $\frac{9}{16}$ -in.
WRENCH, box, $\frac{7}{16}$ -in.	WRENCH, ratchet, with $\frac{3}{4}$ -in. socket
WRENCH, open-end, $\frac{3}{8}$ -in.	WRENCH, socket, $\frac{9}{16}$ -in., and spinner type handle
WRENCH, open-end, $\frac{7}{16}$ -in.	
WRENCH, open-end, $\frac{1}{2}$ -in.	
WRENCH, open-end, $\frac{9}{16}$ -in.	

b. Procedure.

(1) ATTACH CABLE (STARTING SWITCH TO STARTING MOTOR) (fig. 13).

WRENCH, open-end, $\frac{5}{8}$ -in.	WRENCH, ratchet, with $\frac{3}{4}$ -in. socket
--------------------------------------	--

(a) Remove top outside cap screw which holds cranking motor to rear engine support. Then insert cap screw through cable clip and install cap screw in place.

(b) Install cable to terminal on top of cranking motor, securing it with lock washer and nut.

(2) CONNECT CHOKE CONTROL ROD TO BELL CRANK IN CARBURETOR (fig. 13).

PLIERS

(a) Pull rod from dash toward engine. Then place rod in top hole of carburetor bell crank. Secure rod in bell crank with cotter pin.

(3) CONNECT PRIMING ROD TO BELL CRANK IN REAR OF INTAKE MANIFOLD (fig. 13).

PLIERS

(a) Pull rod from dash toward engine and install rod in bell crank, locking it in position with cotter pin.

INSTALLATION OF ENGINE IN VEHICLE

(4) INSTALL FRONT AIR CLEANER PIPE (fig. 13).

WRENCH, open-end, $\frac{7}{16}$ -in. WRENCH, socket, $\frac{9}{16}$ -in., and
spinner type handle

(a) Install new air pipe gasket, first checking to see that gasket mounting surfaces on intake manifold housing and on air cleaner pipe are clean.

(b) Place front air cleaner pipe in position. Slip rear hose and clip over tubular end of pipe. Line up holes in other end of the air cleaner pipe with matching holes in intake manifold housing. Install four cap screws and lock washers which secure pipe to intake manifold housing. Tighten nut on rear hose clip.

(5) INSTALL AIR TUBE (AIR COMPRESSOR TO GOVERNOR) TO THE GOVERNOR (fig. 13).

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

(a) Place tube in position and connect one connector to governor and other connector to air compressor.

(6) CONNECT CABLE (COIL TO IGNITION SWITCH) TO IGNITION COIL (fig. 13).

WRENCH, open-end, $\frac{3}{8}$ -in.

(a) Secure cable to coil with lock washer and nut.

(7) INSTALL AIR RESERVOIR. Follow procedure outlined in TM 9-1777D.

(8) CONNECT CABLE (SERVICE SWITCH TO GENERATOR) TO GENERATOR (fig. 14).

SCREWDRIVER

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

WRENCH, box, $\frac{7}{16}$ -in.

(a) Loosen nut on idler pulley brace. Then push generator toward engine to relieve fan belt tension. Remove fan belts from idler pulley. Generator can then be pulled away from engine to provide access to generator without removing heat shield.

(b) Install nut holding cable (service switch to generator) (black tracer) to generator terminal. Also secure cable (ammeter to voltage regulator) to voltage regulator (black and red tracer) by installing screw.

(c) Insert cable in clip which is attached to air compressor drive housing.

(d) Adjust fan belt tension as outlined in cooling system section, TM 9-1777B.

(9) CONNECT GASOLINE PIPE TO CARBURETOR (fig. 13).

WRENCH, open-end, $\frac{1}{2}$ -in.

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

(a) Attach connector to carburetor and secure clip to crankcase with cap screw and lock washer which also holds heat shield to crankcase.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

202. CONNECTION OF MISCELLANEOUS PARTS TO LEFT SIDE OF ENGINE.

a. Equipment.

PLIERS

WRENCH, open-end, 1/2-in.

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

WRENCH, open-end, 1 1/16-in.

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

b. Procedure.

(1) INSTALL FUEL SUPPLY PIPE (fig. 14).

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

(a) Attach connectors at each end of pipe to water trap and fuel pipe (extension).

(2) INSTALL FUEL RETURN PIPE (fig. 15).

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

(a) Attach connector at each end of pipe to check valve and fuel pipe (extension).

(3) CONNECT LUBRICATING OIL INDICATOR PIPE (fig. 15).

WRENCH, open-end, 1/2-in.

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

(a) Secure pipe clip to crankcase by installing cap screw and lock washer. Then connect connectors at each end of pipe to crankcase and to lubricating oil indicator on dash and cowl assembly.

(4) INSTALL GOVERNOR CONTROL ROD (fig. 15).

PLIERS

(a) Place rod in position, connecting adjusting yoke to operator's governor control lever. Install cotter pin in rod at governor control lever and secure rod to adjusting yoke by installing pin and cotter pin.

(5) CONNECT COMPRESSION RELEASE ROD TO CROSS SHAFT OPERATING LEVER (fig. 15).

PLIERS

(a) Place rod in position in cross shaft operating lever and lock it in position with cotter pin.

(6) INSTALL HEAT INDICATOR PLUG IN REAR CYLINDER HEAD (fig. 15).

WRENCH, open-end, 1 1/16-in.

(a) Install plug in cylinder head and secure it in position by tightening connector.

203. INSTALLATION OF RADIATOR AND CONNECTING PARTS AT FRONT OF ENGINE.

a. Follow the procedure outlined in cooling system section, TM 9-1777B.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

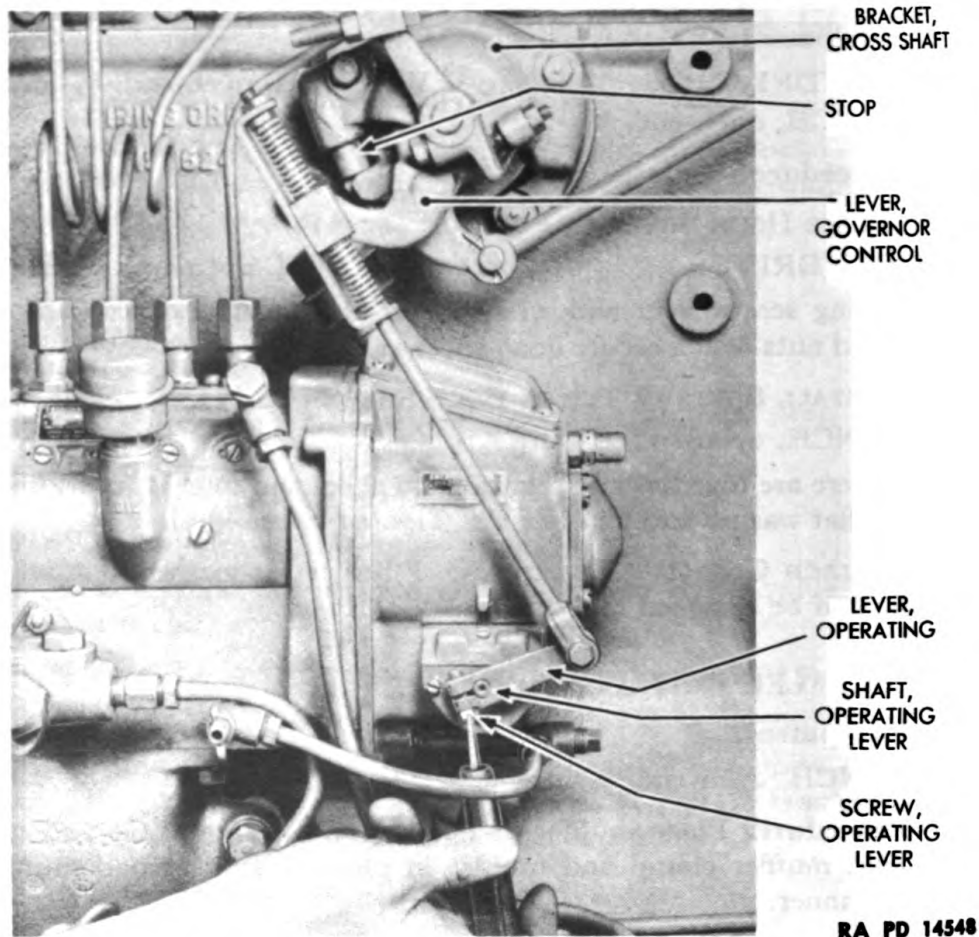


Figure 192—Adjusting Operating Lever for Idling Position

208. CHECK AFTER INSTALLATION.

a. Equipment.

SCREWDRIVER, 6-in.

WRENCH, open-end, 1/2-in.

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

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

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

b. Procedure.

(1) START ENGINE AND OPERATE IT ON DIESEL CYCLE.

(2) SET THROTTLE CONTROL TO IDLING SPEED (fig. 192). At idling speed—425 revolutions per minute—finger on governor control lever should just contact stop in cross shaft bracket.

(3) ADJUST OPERATING LEVER (fig. 192).

SCREWDRIVER, 6-in.

(a) If engine does not operate at idling speed when step (2) above is performed, loosen operating screw, remove operating lever from shaft and shift it on serrations so that engine will idle, with controls in proper position.

INSTALLATION OF ENGINE IN VEHICLE

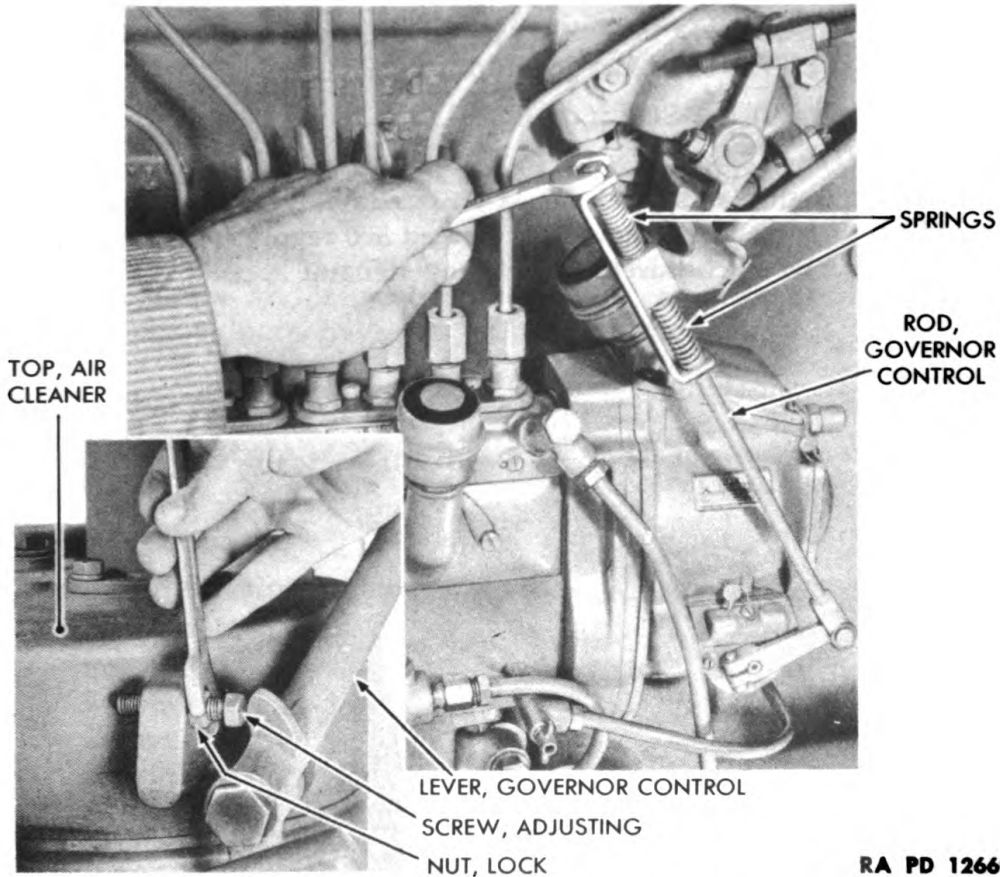


Figure 193—Adjusting Governor Control Rod Springs and Stop Screw

(4) PLACE THROTTLE LEVER IN STOP POSITION (fig. 193).

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

(a) With throttle in stop position, the stop in bracket should be depressed until it extends $\frac{3}{32}$ inch from bracket. Adjust yoke governor control lever on dash to adjust distance the stop extends from bracket. Turn yoke to left to shorten and to right to extend distance the stop extends from bracket.

(5) ADJUST GOVERNOR CONTROL ROD SPRINGS (fig. 193).

WRENCH, open-end, $\frac{1}{2}$ -in.

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

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

(a) With throttle in stop position, upper spring should be slightly compressed but not compressed solid. If compressed solid, loosen nut on end of control rod, turn nut under end of trunnion guide to the right and tighten nut on end of rod.

(b) Place throttle in full open position. Lower spring on control rod should be slightly compressed but not compressed solid. If spring is compressed solid, loosen lock nut on air cleaner top and turn adjusting screw until spring is slightly compressed.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(6) **ADJUST GOVERNOR.** Follow procedure outlined in fuel system section, TM 9-1777B, to adjust governor.

(7) **ADJUST ENGINE SPEED ON GASOLINE CYCLE.**

SCREWDRIVER

(a) Start engine and check speed on gasoline cycle after engine has warmed up. Engine speed should not exceed 800 revolutions per minute. Adjust stop screw on carburetor to set proper engine speed.

Section X
FITS AND TOLERANCES

	Paragraph
Fits and tolerances	209
Specifications of parts	210

209. FITS AND TOLERANCES.

a. Specifications given in this section should be used as a guide in inspecting new and repaired parts before assembly and installation. Wear limits on parts have not yet been established.

210. SPECIFICATIONS OF PARTS.

a. Specifications of major parts of the engine and accessories are as follows:

(1) **CRANKSHAFT.**

Main bearing journal diameter	3.4980- to 3.4985-in.
Bearings, total length:	
Front	17/8-in.
Intermediate (2-3-5-6)	15/8-in.
Center (thrust)	3.118- to 3.120-in.
Rear	2 1/16-in.
End clearance	0.006- to 0.014-in.
Running clearance	0.003- to 0.004-in.

(2) **CONNECTING ROD.**

Length, center to center	13 3/4-in.
Crankpin, diameter	3.2480- to 3.2485-in.
Bearing, total length	2 1/16-in.
Bearings, running clearance	0.003- to 0.004-in.
Side clearance	0.005- to 0.012-in.

(3) **CAMSHAFT.**

Bearings, number	4
Bearing, material	Babbitt (steel back)
Bearing journal, diameter:	
Front	2.618- to 2.619-in.
2nd	2.4305- to 2.4315-in.
3rd	2.368- to 2.369-in.
Rear	1.9305- to 1.9315-in.
Bearing, length:	
Front	2 5/16-in.
2nd and 3rd	2-in.
Rear	1 5/16-in.
Running clearance	0.0015- to 0.0035-in.
End clearance	0.005- to 0.011-in.

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

(4) PISTON.

Material	A-132 aluminum alloy
Fit in sleeve	Pistons and sleeves are selected to give 0.0085- to 0.0095-inch normal measured clearance, checked with ribbon gage ½ inch wide used at 90 degrees from the piston pinhole. Use a 0.006-inch ribbon gage as "GO" gage, with light pull of two to four pounds, and a 0.008-inch ribbon as "NO-GO" gage, with a tight pull of 11 to 14 pounds.
Piston pin length	4.105-in.
Piston pin diameter	1.6250- to 1.6253-in.
Clearance of pin in piston	0.0001- to 0.0003-in.
Clearance of pin in rod	0.0003- to 0.0004-in.

(5) PISTON RINGS.

Ring width:

Compression	0.123- to 0.124-in.
Oil control	0.2485- to 0.2490-in.

Ring gap:

Top compression	0.010- to 0.018-in.
All other rings	0.010- to 0.020-in.

Clearance in groove:

Top compression	0.004- to 0.005-in.
2nd compression	0.003- to 0.004-in.
3rd and 4th rings	0.0025- to 0.0035-in.
Oil control rings	0.0025- to 0.0035-in.

(6) VALVE LEVER SHAFT.

Diameter	0.9660- to 0.9665-in.
Clearance in bushing	0.0015- to 0.002-in.

(7) VALVES.

Exhaust:

Stem diameter	0.4315-in.
Stem clearance in guide	0.003- to 0.005-in.
Head diameter	1¾-in.
Port diameter	1.530-in.

Intake:

Stem diameter	0.4325-in.
Stem clearance in guide	0.002- to 0.004-in.
Head diameter	2-in.
Port diameter	1.780-in.
Valve seat angle	45°
Valve seat width in head	⅜-in.

FITS AND TOLERANCES

Starting:

Stem diameter	0.371- to 0.372-in.
Stem clearance in guide	0.0015- to 0.0035-in.
Head diameter	1.276- to 1.286-in.
Valve seat angle	45°
Valve seat width in head	$\frac{3}{64}$ -in.

(8) VALVE TAPPET.

Outside diameter	0.623- to 0.624-in.
Valve tappet guide clearance	0.0015- to 0.003-in.

(9) LUBRICATING OIL PUMP.

Oil pump body gear to oil pump body clearance.....	0.006- to 0.007-in.
Oil pump body gear, length	3.4995- to 3.5005-in.
Oil pump body bore, depth	3.499- to 3.501-in.
Gasket, pump body to auxiliary gear upper housing, thickness.	0.006-in.
Idler gear shaft, diameter.....	0.8635- to 0.8640-in.
Idler gear to idler gear shaft, clearance.....	0.0015- to 0.0030-in.
Pump drive shaft, diameter	0.8665- to 0.8675-in.
Pump drive shaft to pump body, clearance.....	0.004- to 0.006-in.
Regulating valve, diameter	0.900- to 0.901-in.
Regulating valve, clearance in body.....	0.004- to 0.006-in.

(10) IDLER GEAR (TIMING).

Idler gear shaft, diameter.....	1.4985- to 1.4990-in.
Idler gear shaft to idler gear, clearance.....	0.001- to 0.0025-in.

(11) COMPRESSOR DRIVE.

Compressor drive shaft, diameter	1.186- to 1.187-in.
Compressor drive shaft to compressor drive shaft bushing, clearance	0.001- to 0.003-in.
Idler gear shaft, diameter	1.4985- to 1.4990-in.
Idler gear shaft to idler gear, clearance	0.001- to 0.0025-in.

(12) SPRING TESTING DATA.

Spring	Free Length	Test Lb.	Test Length
Governor control rod.....	$1\frac{7}{8}$ -in.	28	$1\frac{3}{16}$ -in.
Starting valve	$1\frac{45}{64}$ -in.	$26\frac{3}{4}$	$1\frac{1}{4}$ -in.
Intake and exhaust valve.....	$2\frac{7}{8}$ -in.	50-56	$2\frac{1}{2}$ -in.
Intake and exhaust valve*.....	$3\frac{1}{16}$ -in.	62-68	$2\frac{1}{2}$ -in.
Regulating valve	$3\frac{3}{32}$ -in.	47.6	$2\frac{3}{32}$ -in.

*Two different types of valve springs have been used in the tractors. Determine by free length which test to apply.

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

Section XI

SPECIAL TOOLS AND EQUIPMENT

	Paragraph
Special tools	211
Standard tools	212
Equipment	213
Torque wrench table	214

211. SPECIAL TOOLS.

a. The following special tools are prescribed by the manufacturer for this engine. If they are not available, use similar tools of other manufacturers:

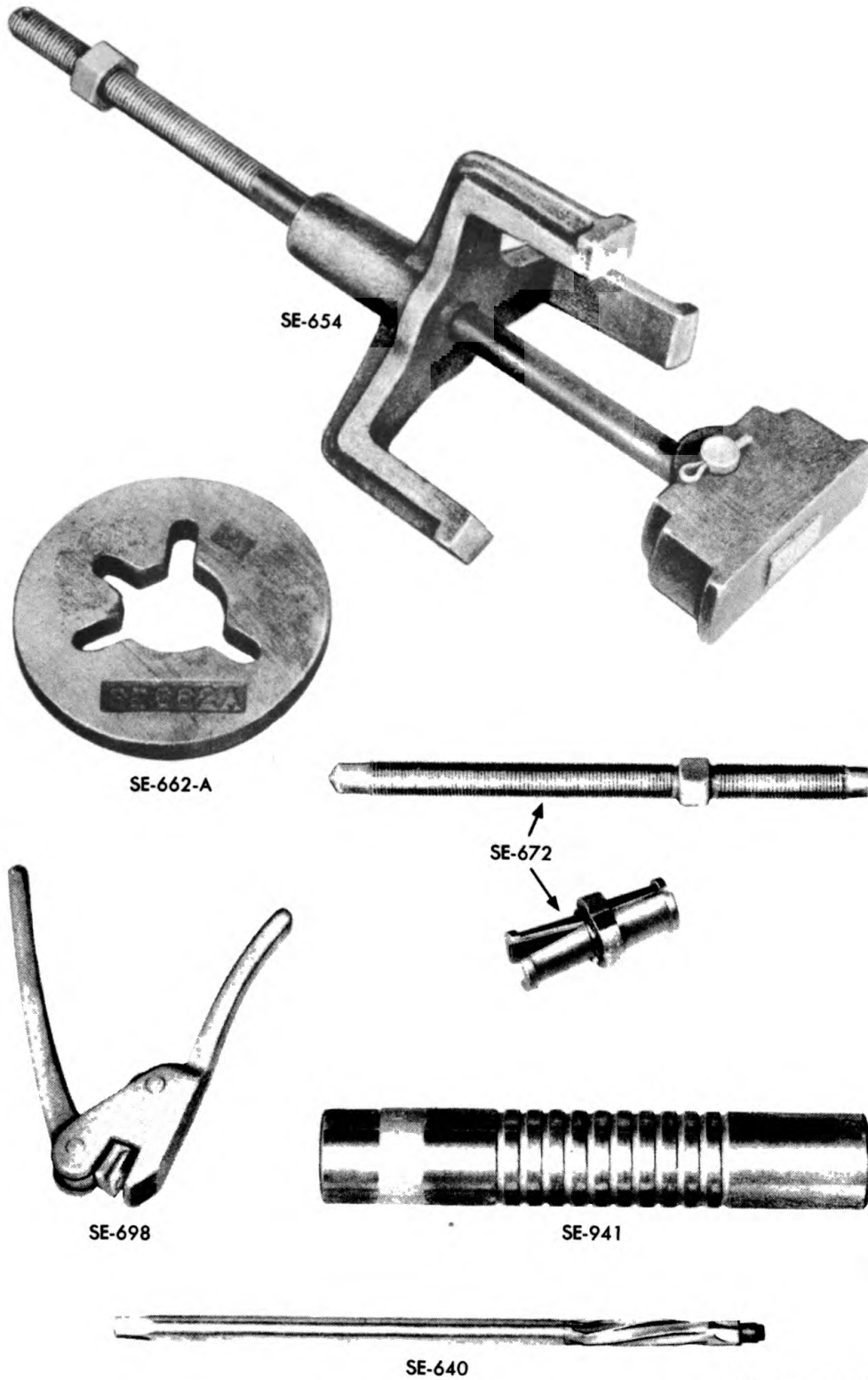
PLATE, puller	SE-622-A
PRESS, governor seal	SE-698
PULLER, cylinder sleeve	SE-654
PULLER, engine clutch pilot bearing	SE-672
REAMER, valve guide	SE-640
TOOL, connecting rod bushing burnishing	SE-941

212. STANDARD TOOLS.

a. The following standard tools are provided with each tractor:

GAGE, breaker point and spark plug	45578-DA
HAMMER (1½ lb.)	2583-T
HANDLE, spark plug wrench	25466-D
HANDLE, stem handled socket wrench	25463-D
LUBRICATOR, bucket (with hose), complete	60012-D
LUBRICATOR, hand (9 oz.)	Q-3794
OILCAN	H-156
PLIERS, combination slip joint, 8-in.	2587-T
SCREWDRIVER, 5-in. (wood handle)	2588-T
TOOL, steering clutch compressor angle	58920-DAX
WRENCH, end, ¾-in.—7/8-in.	1326-E
WRENCH, spark plug, 31/32-in.	32941-D
WRENCH, steering clutch pilot bearing retainer bolt	50092-D
WRENCH, stem handled socket, 11/32-in.	25462-DA
WRENCH, water pump	11858-DA
WRENCHES, socket—complete set (in carrying case)	19329-D

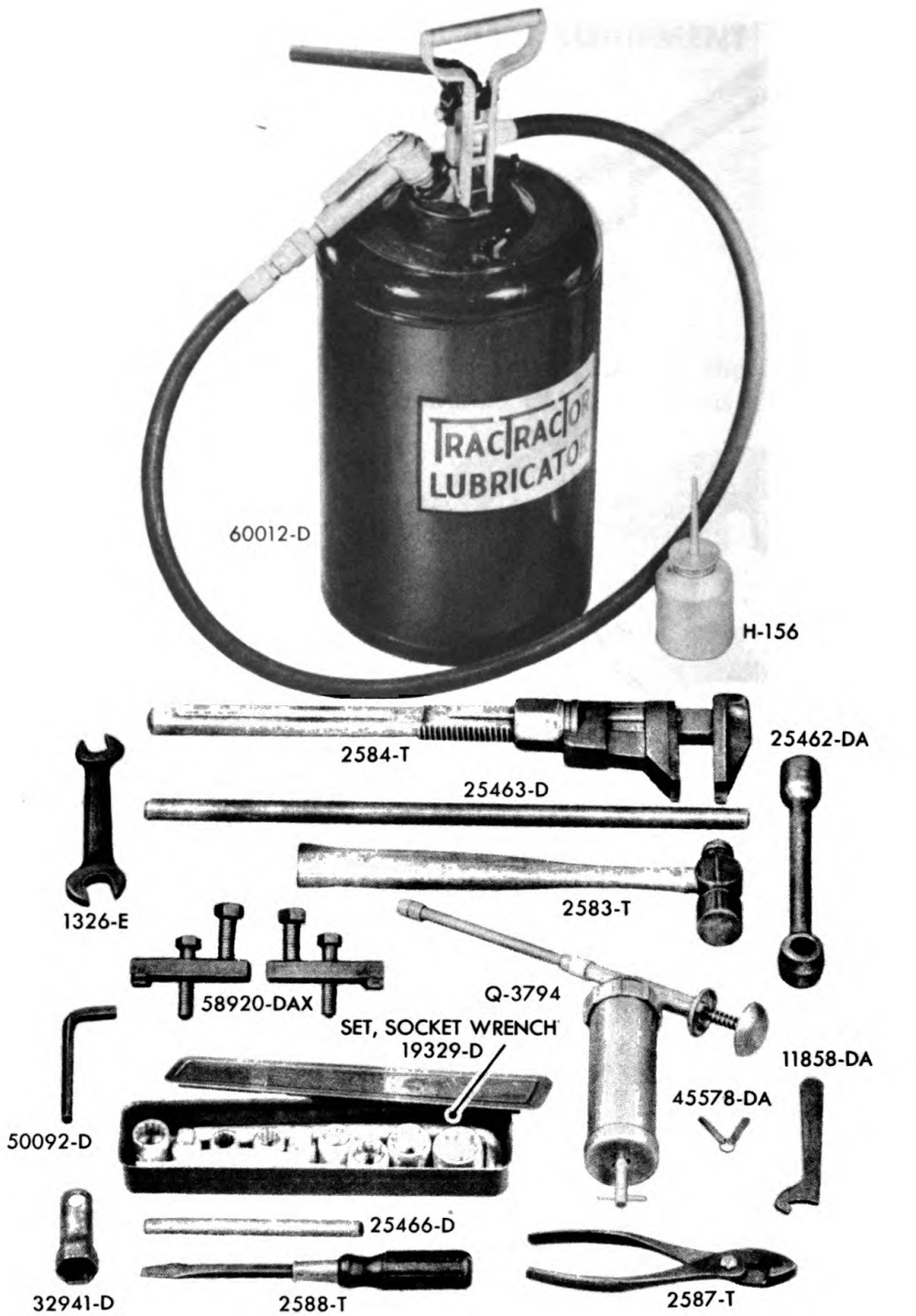
SPECIAL TOOLS AND EQUIPMENT



RA PD 13743

Figure 194—Special Tools for Heavy Tractor M1

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**



RA PD 58335

Figure 195—Standard Tools for Heavy Tractor M1

SPECIAL TOOLS AND EQUIPMENT

- 60012-D LUBRICATOR, BUCKET; WITH HOSE; COMPLETE
- H-156 CAN, OIL
- 2584-T WRENCH, ADJUSTABLE
- 25462-DA WRENCH, SOCKET; SQ. DRAIN PLUG; 1¹/₃₂ IN.
- 25463-D HANDLE, STEM HANDLED SOCKET WRENCH
- 2583-T HAMMER (1¹/₂ LB.)
- 1326-E WRENCH, OPEN-END; ³/₄-IN.—⁷/₈-IN.
- 58920-DAX TOOL, STEERING CLUTCH COMPRESSOR ANGLE
- Q-3794 LUBRICATOR, HAND (9 OZ.)
- 45578-DA GAGE, BREAKER POINT AND SPARK PLUG
- 11858-DA WRENCH, WATER PUMP
- 50092-D WRENCH, STEERING CLUTCH PILOT BEARING
RETAINER BOLT
- 19329-D SET, SOCKET WRENCH; SOCKETS ⁹/₁₆-IN.,
⁵/₈-IN., ³/₄-IN., ¹³/₁₆-IN., ⁷/₈-IN., 1-IN., 1¹/₈-IN.;
SQ. PLUGS ¹/₂-IN., ¹¹/₁₆-IN.; WITH HANDLE
AND "T" HANDLE ATTACHMENT
- 25466-D HANDLE, SPARK PLUG WRENCH
- 32941-D WRENCH, SPARK PLUG; ³¹/₃₂-IN.
- 2588-T SCREWDRIVER, 5 IN. (WOOD HANDLE)
- 2587-T PLIERS, COMBINATION SLIP JOINT; 8 IN.

RA PD 58336

ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE

213. EQUIPMENT.

a. Each tractor is provided with the following equipment:

BLOCK, snatch

CABLE, winch

CHAIN, tow

HOOK, winch cable

214. TORQUE WRENCH TABLE.

a. In several instances, steps in the process of assembly, or in the installation of parts or subassemblies require the use of torque wrenches. The table below should be referred to in such instances:

Part	Foot-pound Torque Recommended
NUT, nozzle body stud	45 ft-lb
NUTS, connecting rod	70 ft-lb
NUTS, cylinder head stud	170 ft-lb
NUTS, main bearing stud	150 ft-lb
NUTS, manifold stud	75 ft-lb
SCREWS, flywheel cap	150 ft-lb

Section XII

REFERENCES

	Paragraph
Standard nomenclature lists	215
Explanatory publications	216

215. STANDARD NOMENCLATURE LISTS.

- a. Cleaning, preserving and lubricating materials.... SNL K-1
 - b. Heavy tractor M1 (IHC TD-18) SNL G-101
- Current standard nomenclature lists are as tabulated here. An up-to-date list of SNL's is maintained as the "Ordnance Publications for Supply Index"..... OPSI

216. EXPLANATORY PUBLICATIONS.

a. Automotive Materiel.

- Heavy tractor M1 (IHC TD-18) TM 9-777
- Military motor vehicles AR 850-15
- Motor transport FM 25-10
- Ordnance maintenance: Heavy tractor M1 (IHC TD-18)
engine accessories TM 9-1777B
- Ordnance maintenance: Heavy tractor M1 (IHC TD-18)
equipment TM 9-1777D
- Ordnance maintenance: Heavy tractor M1 (IHC TD-18)
power train, track frame assembly, and seats..... TM 9-1777C

b. Care and Preservation.

- Cleaning, preserving, lubricating, and welding materials. TM 9-850
- Decontamination, 1941 TC No. 38
- Defense against chemical attack FM 21-40
- Detailed lubrication instructions for ordnance materiel.. OFSB 6-Series

c. Inspection and Maintenance.

- Echelon system of maintenance TM 10-525
- Fire prevention, safety precautions, accidents..... TM 10-360
- Motor transport inspections TM 10-545
- Ordnance maintenance procedure: Materiel inspection
and repair TM 9-1100

**ORDNANCE MAINTENANCE
HEAVY TRACTOR M1 (IHC TD-18) ENGINE**

d. Miscellaneous.

Automotive electricity	TM 10-580
Diesel engines and fuels	TM 10-575
Electrical fundamentals	TM 1-455
List of training publications	FM 21-6
The internal combustion engine	TM 10-570

e. Shipment and Storage.

Loading of mechanized and motorized army equipment on open top railroad equipment	Association of American Railroads
Storage of motor vehicle equipment	AR 850-18

f. Training Films and Film Strips.

Diesel engines	TF 9-159
Diesel engines and fuels	FS 10-37
Engine of the Diesel tractor	TF 9-171
Lubrication	FS 10-39
Power train of the Diesel tractor	TF 9-172
The electrical system of the Diesel tractor	TF 9-169
The fuel system of the Diesel tractor	TF 9-170
The track and suspension system of the Diesel tractor	TF 9-173

**ORDNANCE MAINTENANCE—HEAVY TRACTOR M1
(IHC TD-18) ENGINE**

C—Cont'd	Page No.		Page No.
Clutch		Crankshaft	
assembly to engine	285	description	12
removal	67-68	end clearance	241
preparation for with engine	41-43	fits and tolerances	295
Compression, lack of	32	inspection of removed	188
Compression ratio, data on	20	installation	188, 237-241
Compression drive, fits and tolerances	297	removal	186-187
Condenser and ignition	34	of gear from	186
Connecting rod/		Crankshaft and main bearing, inspection	102
description	14	Cross shaft and governor control	
fits and tolerances	295	installation	267-269
Connecting rod bearing		removal	73-75
checking	31	Cut-out relay, inspection	103
inspection	179	Cylinder heads	
installation	179-181	assembly	125-126
removal	179	cleaning and inspection of disassembled parts	123-127
Construction		construction	107
cylinder head	107	description	7-12
valve lever assemblies and housing	141	disassembly	120-123
Contact points, burned	29	inspection	100
Cooling system		installation	137-141, 256-257
clean and adjust	35	removal	69-73, 107-119
description	7	Cylinder sleeves	
insufficient water in and clogged	32	description	12
maintenance duties by echelons	21	inspection	102
Crankcase		installation	185-186
description	12	removal	79-82, 184-185
inspection	102		
installation of parts	262-263	D	
Crankcase and main bearing, removal	84-87	Data, engine	20
Crankcase front cover		Dead center compression stroke	253-254
installation	196-197	Description: (See also Description of vehicle systems)	
overhaul	194-195	electrical system parts	17
removal	192-194	governor	16
Crankcase front plate		supply pump	16
installation	234-235	Description of vehicle systems	
removal	93	air cleaner	16
Crankcase guard, removal	41	air compressor drive	16-17
Crankcase oil pan		camshaft	14
cleaning and inspection	153	cooling system	7
inspection of installed	153	crankcase	12
installation	155, 254-256	crankshaft	12
removal	75-76, 153	cylinder heads	7-12
Crankcase stud, removal	97-99	cylinder sleeves	12
Cranking motor		Diesel fuel system	15
inspection	103	electrical system	17
installation	267	engine lubricating system	17-20
removal	57	flywheel	12

INDEX

D—Cont'd	Page No.		Page No.
Description of vehicle systems—Cont'd			
fuel injection pump.....	15-16	fuel injection pump.....	63-64
gear train and gear train timing..	14	fuel injection pump drive.....	90-92
governor.....	16	heat shield and generator.....	61-63
main bearing.....	12	hour meter.....	65
pistons and connecting rods... 12-14		idler gear shaft.....	92
starting system.....	14-15	ignition coil.....	58-60
Diesel engine, converting to gasoline		intake manifold with carburetor	
cycle.....	14-15	attached.....	56
Diesel fuel oil, improper.....	32	lubricating oil filters, and fuel	
Diesel fuel system.....	15	filter.....	64-65
Diesel principle.....	7	lubricating oil pump.....	77-78
Diesel throttle control, checking		miscellaneous parts from sides of	
operation of.....	34	crankcase.....	93-95
Differences from gasoline engine... 7		piston and connecting rod.....	78-79
Disassembly:		rear engine support.....	83-84
air compressor drive.....	198-199	spark plug cable and spark plug..	60
camshaft.....	188-189	thermostat housing and water out-	
cylinder head.....	120-123	let.....	66
intake manifold.....	210-218	valve tappet guide.....	95-97
lubricating oil pump.....	156-159	water trap.....	64
piston and connecting rod... 167-168		Distributor	
valve lever assemblies and hous-		inspection.....	103
ing.....	143-147	installation.....	279-280
Disassembly of engine		moisture in.....	30
facilities.....	54	removal.....	60
general precautions.....	54	Distributor cap, moisture inside and	
removal:		out.....	29
air compressor.....	63	Distributor points, cleaning and ad-	
air compressor air cleaner... 54-56		justing.....	34
air compressor drive assembly 87-88		Drive shaft broken.....	30
camshaft.....	88-90		
camshaft bearing.....	97		
clutch, complete.....	67-68		
crankcase			
front plate.....	93		
oil pan.....	75-76		
stud.....	97-99		
cranking motor.....	57		
crankshaft and main bearing. 84-87			
cross shaft and governor con-			
trol.....	73-75		
cylinder head.....	69-73		
cylinder sleeve.....	79-82		
distributor.....	60		
engine flywheel.....	68-69		
exhaust manifold.....	57-58		
fan and water pump.....	66		
fan drive pulley with vibration			
damper attached.....	66-67		
front engine support.....	67		

E

Echelons defined.....	20-21
<i>(See also Maintenance duties by echelons)</i>	
Electrical and starting systems,	
inspection.....	103
Electrical cables, installation on	
engine.....	281
Electrical connections.....	34
Electrical system	
description of parts.....	17
maintenance duties by echelons..	22
Engine	
assembly.....	231-235
<i>(See Assembly of engine for names of components)</i>	
firing irregular.....	33
installation of in vehicle... 286-294	
<i>(See engine in vehicle under Installation for detailed information)</i>	

INDEX

F—Cont'd	Page No.	H	Page No.
Float level too high.....	29	Heat shield (See Generator and heat shield)	
Flooding carburetor.....	29	High tension circuits and wiring, defective.....	29
Flywheel		Hoot sheet.....	39-41
description.....	12	Hour meter	
installation.....	246-247	installation.....	257-258
Flywheel and ring gear, overhaul	203-206	removal.....	65
Fuel filter			
installation.....	258-259	I	
removal.....	64-65	Idler gear shaft (and gear)	
Fuel injection pump		installation.....	237
description and function.....	15-16	removal.....	92
inspection.....	101	Idler gear (timing), fits and tolerances.....	297
installation.....	259-262	Ignition coil	
removal.....	63-64	defective.....	30
Fuel injection pump drive		removal.....	58-60
inspection.....	104	Ignition switch, defective.....	29
installation.....	241-242	Ignition system, data on.....	20
removal.....	90-92	Injection nozzles	
Fuel oil filter, inspection.....	103	checking for leaks.....	34
Fuel supply lines, damaged or leaking.....	30	inspection.....	37
Fuel supply system, air bound.....	30	not functioning.....	32
Fuel system		Injection pump	
maintenance duties by echelons	24-25	air lock in.....	30
trouble shooting.....	28-30	does not deliver fuel.....	30
		timing	
G		checking.....	34
Gages, maintenance duties by echelons.....	25-26	incorrect.....	32
Gasoline		Injection pump control rod stop plate.....	32
does not reach carburetor.....	29	Injection pump housing.....	16
supply.....	28	Inspection:	
Gasoline cycle		air cleaner.....	100
converting.....	14-15	air compressor drive... 103, 200-201	
starting troubles.....	28	air compressor drive coupling... 199	
Gear train		bearings and pistons.....	36
description.....	14	breather pipe.....	37
inspection.....	36, 102	camshaft and bearings.....	102
maintenance duties by echelons... 25		carburetor.....	101
timing.....	14, 244-245	connecting rod bearing.....	179
Generator and heat shield		crankcase.....	102
installation.....	266-267	crankcase oil pan.....	153
removal.....	61-63	cranking motor.....	103
Generator inspection.....	36, 37	crankshaft, removed.....	188
Governor		crankshaft and main bearing... 102	
description and purpose of.....	16	cut-out relay.....	103
inspection.....	102	cylinder heads.....	100
Governor control inspection.....	37	parts.....	123-127
Grinding valve seat.....	130-134	cylinder sleeves.....	102

**ORDNANCE MAINTENANCE—HEAVY TRACTOR M1
(IHC TD-18) ENGINE**

I—Cont'd	Page No.		Page No.
Inspection—Cont'd		carburetor	282
distributor	103	connecting rod bearing	179–181
electrical and starting systems	103	crankcase	
engine		front cover	196–197
components	232	front plate	234–235
disassembled (subassem- blies)	100–104	oil pan	155, 254–256
in vehicle		parts	262–263
after installation	36–37	cranking motor	267
periodic	36	crankshaft	188, 237–241
engine air cleaner	228	cross shaft and governor con- trol	267–269
engine speeds	37	cylinder head	256–257
exhaust manifold	100	cylinder sleeve	185–186
removed	226	distributor	279–280
fan and water pump	102	electrical cables on engine	281
fuel injection pump	101	engine air cleaner	230
fuel oil filter	103	engine in vehicle	
gear train	36, 102	attaching engine supports to frame	287–288
generator	36, 37	checking engine before installa- tion	286
governor	102	connection	
governor control	37	parts to left of engine	290
fuel injection pump drive	104	parts to right of engine	288–289
injection nozzles	37	facilities	286
instruments and controls	104	installation of:	
intake manifold	100, 218, 219	check after	292–294
lights	37	crankcase guard	291
lubricating oil pump	104, 159–161	hood sheet	291
main bearing	183	muffler	291
oil pressure	36	radiator	290
piston and connecting rods	102, 168–169	winch	291
piston and connecting rods	102, 168–169	placing engine in position in vehicle	287
piston pins	36	precautions	286–287
radiator	103	exhaust manifold	228, 279
service lighting switch	103	fan and water pump	264
starting valve mechanism	101	fan drive pulley	245
thermostat housing	102	flywheel	246–247
valve lever assemblies and hous- ing	148	fuel filter	258–259
installed	141–142	fuel injection pump	259–262
valve operating mechanism	100	fuel injection pump drive	241–242
valves	37	generator and heat shield	266–267
water trap	103	hour meter	257–258
Installation:		idler gear shaft and gear	237
air compressor air cleaner	283	intake manifold	223–226, 279
air compressor and connec- tions	263–264	lubricating oil filters	258–259
air compressor drive	203	lubricating oil	
air compressor drive as- sembly	242–244	pump	164–166, 253–254
camshaft	191, 235–237	main bearing	183–184
camshaft bearings in crankcase	234	piston and connecting rod	177, 248–253

INDEX

I—Cont'd	Page No.	M	Page No.
Installation—Cont'd		Main bearings	
spark plug	276-278	checking for wear	31
starting valve operating cross shaft and related parts	269-271	description	12
valve housing cover	285	inspection	183
valve lever assemblies and hous- ing	151-153, 269	installation	183-184
valve tappet guide	191, 248	lubrication	17
vibration damper	245	removal	181-182
water outlet and thermostat hous- ing	265	Main frame assembly, maintenance	
water trap	262	duties by echelons	25
Instruments, maintenance duties by echelons	25-26	Maintenance duties by echelons	
Instruments and controls, inspection	104	auxiliary equipment	
Intake manifold		air brake control	26
air leaks around	30	electric brake control	27
assembly	219-223	cooling system	21
cleaning	218	definitions of terms	20-21
disassembly	210-218	electric brake control	27
inspection	100	electrical system	22
inspection and overhaul	218-219	engine	22-23
installation	223-226, 279	exhaust system	23
removal	206-210	final drive assemblies	21
with carburetor attached	56	fire extinguisher	24
Intake valve clearance, checking	283-285	fuel system	24-25
		gear train and main frame as- sembly	25
		instruments and gages	25-26
		master clutch assembly	21
		sheet metal group	26
		truck frame	24
		vehicle assembly	26
		winch assembly	27
		Manifold ignition switch	29
		Master clutch assembly	21
		Missing and backfiring (gasoline cycle)	30
		Model of engine	20
		Muffler	39
		N	
		Numbers, serial, of engine	7
		O	
		Oil consumption, high	33
		Oil leaks, checking for	33
		Oil level, checking	31
		Oil pressure	
		inspection	36
		loss of	31-32
		Oil pressure gage	
		checking	31
		mounted on dash	17
		Oil pump, worn	31
		Oilholes, alinement of	234

INDEX

S—Cont'd	Page No.	V	Page No.
Specifications of parts:		Valve clearance, checking	32
camshaft	295	Valve housing cover, installation ...	285
compressor drive	297	Valve lever assemblies and housing	
connecting rod	295	assembly	149-151
crankshaft	295	cleaning and inspection	148
idler gear (timing)	297	construction	141
lubricating oil pump	297	inspection of installed	141-142
piston	296	installation	269
piston rings	296	of parts	151-153
spring testing data	297	overhaul	148-149
valve lever shaft	296	removal	143
valve tappet	297	Valve lever shaft, fits and tolerances	296
valves	296-297	Valve operating mechanism	
Spring testing data, fits and tolerances	297	description	14
Standard tools, list of	298-301	inspection	100
Starting control mechanism, not functioning	30-31	Valve seat	
Starting system	14-15	grinding	130-134
Starting the engine, troubles	28	lapping	135
Starting valve mechanism		refacing	134-135
adjustment	271-276	Valve tappet, fits and tolerances ...	297
inspection	101	Valve tappet guide	
Starting valve operating cross shaft and related parts	269-271	installation	248
Starting valves, warped	32	removal	95-97
Supply pump, description	16	Valve(s)	
		clearance	34
		fits and tolerances	296-297
		inspection	37
		replacing	32
		sticking	32
		Vehicle assembly, maintenance	
		duties by echelons	26
		Vibration damper, installation	245
		W	
		Water	
		in Diesel fuel	30
		in gasoline	29, 30
		insufficient in cooling system	32
		Water outlet, removal	66
		Water outlet and thermostat housing, installation	265
		Water temperature	33
		Water trap	
		cleaning	34
		inspection	103
		installation	262
		removal	64
		Winch, removal	38
		Winch assembly, maintenance duties	
		by echelons	27
		Wiring, defective	29
T			
"Tacky" varnish	254		
"T.D.C." compression stroke	281		
Thermostat housing			
inspection	102		
removal	66		
Thermostats, inoperative	32		
Throttle linkage, broken	30		
Timing gear train	14		
Timing gears, lubrication of	20		
Tools for engine assembly	232		
Torque wrench, use of	232		
Torque wrench table	302		
Trouble shooting (See Engine trouble shooting)			
Truck frame, maintenance duties by echelons	24		
Tune-up, engine	34-35		
		U	
Uneven operation of engine	31		

TM 9-1777A

**ORDNANCE MAINTENANCE—HEAVY TRACTOR M1
(IHC TD-18) ENGINE**

[A.G. 062.11 (12-12-42)
O.O. 461/29521 O.O. (2-15-43)]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

Official:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION: R 9(2); IBn 9(1); IC 9(4)

(For explanation of symbols, see FM 21-6)

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