HALL POWER SCOTT

HANDBOOK OVERHAUL INSTRUCTIONS

DEFENDER
MARINE ENGINE
MODELS 2268 & 2269

HALL-SCOTT MOTOR DIVISION

HALL-SCOTT DEFENDER
MODEL 2268 & 2269

FOREWORD

Hall-Scott engines are designed and built with the idea of obtaining long life and low maintenance cost. Necessary adjustments have been minimized by increasing strength and wearing quality of parts through the careful selection of materials.

No piece of machinery, however, can perform well without proper care, and the operator must do his share in maintaining the equipment in the best possible manner. Lubrication of the proper type, and properly applied, will add greatly to the life of the engine. Periodic and systematic inspections will do much to insure uninterrupted service.

The "Unit" principle of design as used in Hall-Scott engines, with inter-changeable sub-assemblies, permits making convenient routine servicing operations on any unit. The engine meanwhile, fitted with a spare unit, is kept in service. This includes such items as cylinder heads, water pumps, oil filters, oil pumps, etc.

It is hoped that all service personnel will acquaint themselves with this handbook and use it at every opportunity.

Any desired information relative to maintenance not contained in this book may be had on request to our service department.

WARRANTY

Seller warrants every new engine manufactured and every engine rebuilt by it to be free from defects in material and workmanship under normal use and service. Seller's obligation under this warranty is limited to making good at its factory any part or parts thereof which shall within ninety (90) days after delivery of such engine to the original purchaser, or prior to the time when such engine has been operated one hundred (100) hours, whichever event shall first occur, be returned to it with transportation charges prepaid and which at Seller's examination shall disclose to its satisfaction to have been thus defective; this warranty being expressly in lieu of all other warranties expressed or implied and of all other obligations or liabilities on Seller's part, and Seller neither assumes nor authorizes any other person to assume for it any such liability in connection with the sale of its engines or spare parts therefore.

This warranty shall not apply to any engine which shall have been repaired or altered outside of Seller's factory, in any way so as, in Seller's judgement, to affect its stability or reliability or which has been subject to misuse, negligence, or accident. Seller makes no warranty whatever in respect to trade accessories inasmuch as they are usually warranted separately by their respective manufacturers.

INSTRUCTIONS FOR ORDERING PARTS

In ordering parts for engines, always give the following information:

1. The model number and serial number of the engine.
2. The correct part number and name as listed in the parts catalog.
3. The exact quantity of each part required.
4. The exact shipping instructions.
5. If in doubt as to parts needed send in old parts, transportation charges prepaid, for duplication.

Parts will be shipped out C.O.D. by express or parcel post, and sight draft against bill of lading, if by freight, unless other terms have been previously established. Terms and discount status for spare parts are fixed by the credit department. Prices, terms and discount status are subject to change without notice.

INSTRUCTIONS FOR RETURNING PARTS

Parts returned to the factory for credit or replacement must be clearly identified by a tag bearing the following information:

1. Name and address of the operator.
2. The date of failure and total hours the particular part has run.
3. The model and serial number of the engine.
4. Reference to any correspondence regarding failure.
5. Always confirm telegrams or telephone messages with a letter giving full details.
6. Adjustments can only be considered upon parts purchased through this organization; therefore, always give our invoice number and your order number on parts in question.

Parts arriving at the factory upon which the carrying charges have not been prepaid will not be received.

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MATERIAL SPECIFICATIONS

Most of the lubricants and gasket cements called for in this handbook are identified by Government Specification numbers. For the benefit of those who do not have ready access to Government publications, the following list has been prepared to aid in the selection of proper materials.

Where a commercial trade name is mentioned it is not intended as a recommendation, but only as a typical example of the material under consideration. For specific recommendations it is suggested that this list along with your request be submitted to your supplier's specification expert.

GOVERNMENT SPECIFICATION NO.	SYMBOL	PRODUCT	USE
Army Specification 62-5		Cement - Gasket liquid for automotive application. Similar to "Permatex" No. 3	Seal for gaskets and threaded fittings
Army Stock 052-C-685-2PX		Cement - Gasket viscous non-hardening. Similar to "Permatex" No. 2	Seal for gaskets and tubing fittings
Army Stock 052-C-675-1PX		Cement - Gasket viscous hardening. Similar to "Permatex" No. 1	Cement for rope type packing between reverse gear upper housing and adapter
JAN-A-669	CAS	Compound - Anti-seize. Contains white lead, graphite, petrolatum, lubricating oil and asphalt	General purpose lubricant for studs and press fit parts. Do not use on spark plugs or oil circulation fittings
Navy Specification 52-C-18		Compound - Rust preventive thin film polar type. To be removable from metal surfaces with a kerosene saturated wiping cloth. Shall be sprayable in a household spray gun at temperatures of 40°F and above. Flash point not less than 100°F. Shall contain no abrasive substances	Grade I - For use on the exterior of the engine Grade II - For use on the interior of the engine
Army Specification 2-104B	OE	Oil - Engine. For general characteristics see paragraph 3-35 in the Service Handbook or paragraph 10-16 in the Overhaul Handbook	Lubrication of the interior of the engine and reverse gear. Viscosity to conform to paragraph 3-36 in the Service Handbook or paragraph 10-17 in the Overhaul Handbook
Navy Specification 14-0-13 Series 9000		Oil - Engine. For general characteristics see paragraph 3-35 in the Service Handbook or paragraph 10-16 in the Overhaul Handbook	Lubrication of the interior of the engine and reverse gear. Viscosity to conform to paragraph 3-36 in the Service Handbook or paragraph 10-17 in the Overhaul Handbook
AN-4062-1		Capsule - Moisture absorbing	Use in spark plug holes of stored engine to control humidity in engine cylinders
JAN-D-169 and AN-D-6		Bag - Moisture absorbing silica gel	Use in exhaust manifolds, intake manifolds and engine shipping case to control humidity around a stored engine
VV-L-761	GO	Lubricant - Gear universal. Viscosity to conform to paragraphs 6-11 and 6-16 in the Service Handbook or paragraphs 11-41 and 11-44 in the Overhaul Handbook	Use on the water pump pilot gears and starter drive gears
AN-O-6	OGP	Oil - General purpose low temperature lubricating. A low viscosity petroleum fraction containing oxidation and rust inhibitors intended for general squirt can use	Use in the bilge pump, starter, throttle controls, generator drive bearings and Bendix drive helix
AN-G-25	CLT	Grease - Low temperature containing a special synthetic oil having extreme low volatility. Generally suited for ball bearings and lightly loaded gear drives	Use for distributor and generator ball bearing lubrication as well as the distributor drive gears
AN-G-14	GRG	Grease - Gasoline and oil resistant	Use as a gasket paste to make a tight joint and facilitate separation of the joint at disassembly

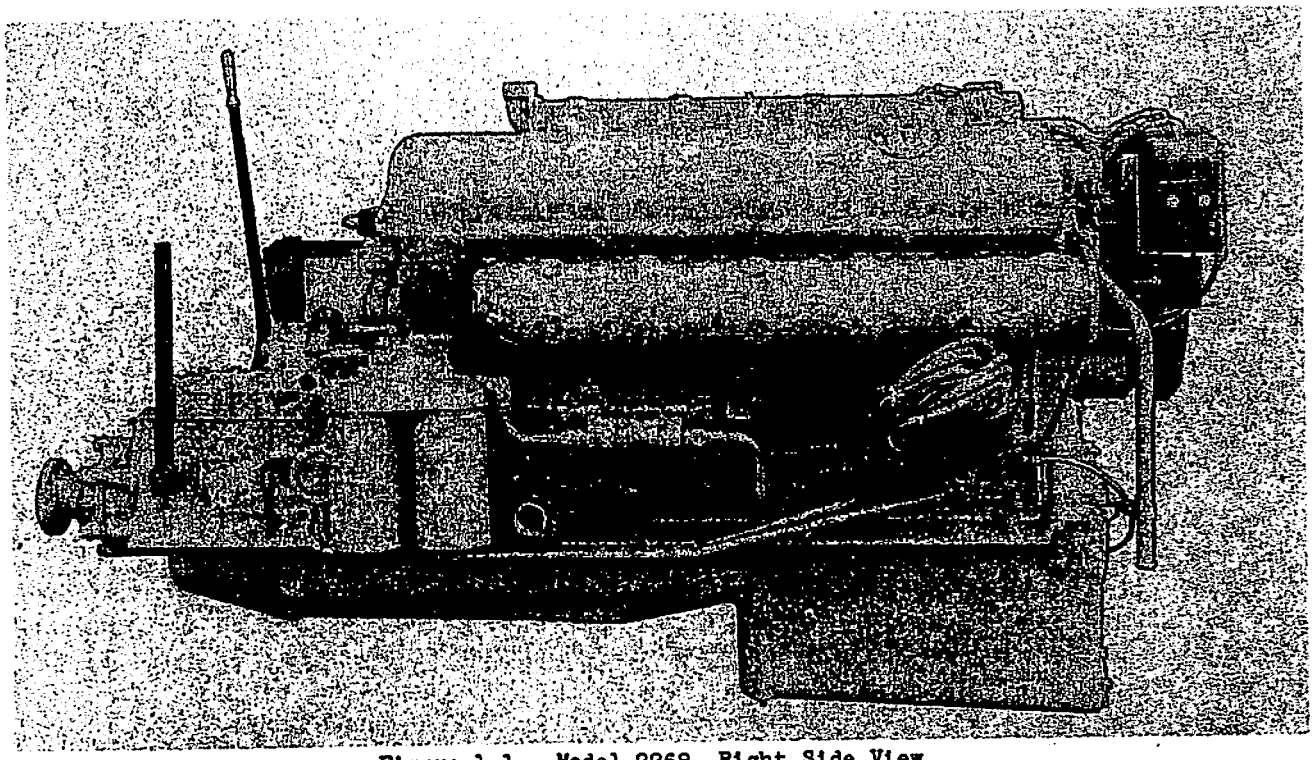


Figure 1-1. Model 2268 Right Side View

INTRODUCTION

1-1 SCOPE.

1-2 This publication comprises the Overhaul Instructions for RH Engine No. 2268 Stock List No. 1906AAF200 000 (henceforth referred to as Model 2268), for LH Engine No. 2269 Stock List No. 1906AAF200 100 (henceforth referred to as Model 2269) and associated models, if any, manufactured by the HALL-SCOTT MOTOR DIVISION of ACF-BRILL MOTORS CO., 2850 7th Street, Berkeley 10, California, U.S.A.

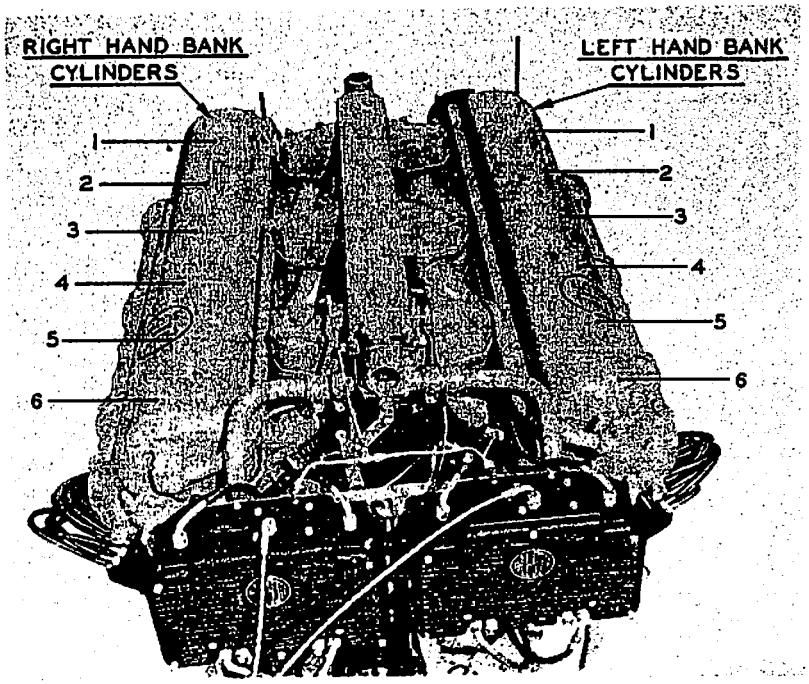


Figure 1-2. Cylinder Numbers

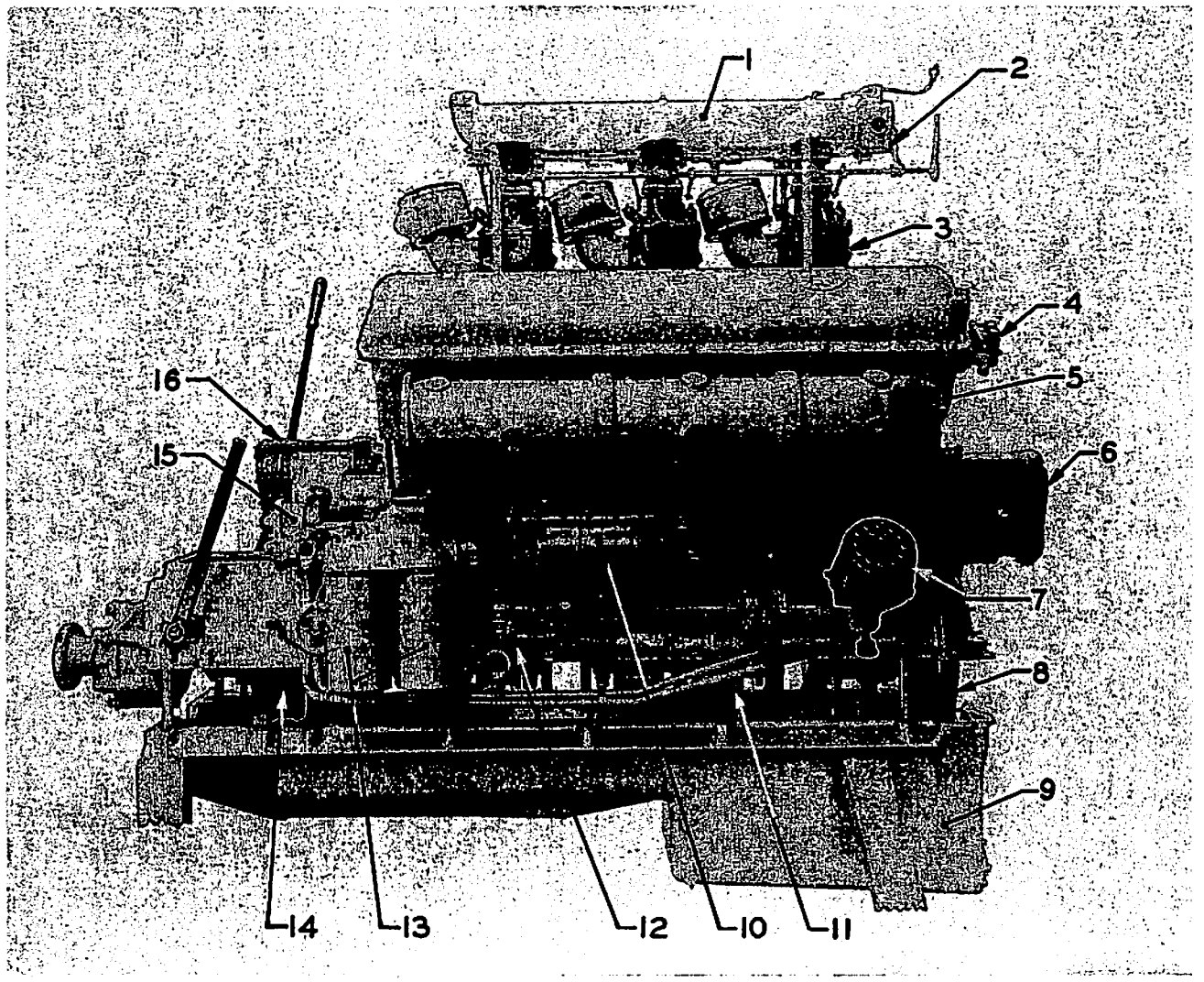


Figure 1-3. Exploded Side View of the Engine

Ref No.	Name	Ref No.	Name
1	Intake Manifold	9	Lower Crankcase
2	Thermostat	10	Oil Cooler
3	Carburetor	11	Crankshaft
4	Fuel Pump, Mechanical	12	Water Pump
5	Exhaust Manifold	13	Oil Filters
6	Starter	14	Reverse Gear
7	Distributor	15	Bilge Pump
8	Flywheel	16	Generator

1-3 TABLE OF LIMITS. Frequent reference is made to the Table of Limits, section XII. Use this table for all operations involving measurements or use of gages.

1-4 UNIT CONSTRUCTION. The Hall-Scott principle of "unit" construction makes for easy and rapid servicing operations. Major units can be pulled off the engine quickly, and serviced conveniently at the bench. The manner of removal of parts such as the rockerarm cover, are obvious. There are other more complex parts where a few "pointers" will simplify the job considerably. In this section of the service manual every effort is made to be helpful without dwelling on obvious points.

1-5 CLEANLINESS. Cleanliness must be practiced in all work on the engine. This applies to tear-down as well as assembly. A very small quantity of dirt can quickly ruin a fine piece of equipment. Tools, benches, working space and clothing must be kept clean at all times.

1-6 SEQUENCE OF OPERATIONS. The order of operations to remove any one particular unit should be very closely followed. However, the order in which the various units are removed from the engine is somewhat flexible and can be varied to best meet the problem at hand. For example, it is not necessary to remove the bilge pump before the oil pressure regulating valve is removed although the details

for removing the bilge pump may be explained before the removal of the oil pressure regulating valve.

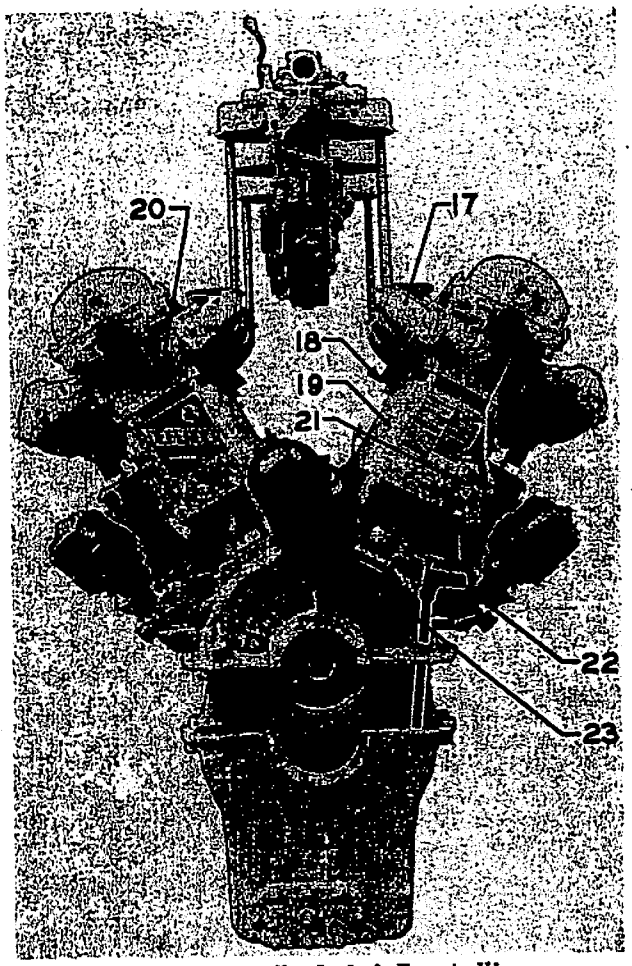


Figure 1-4. Exploded Front View

Ref No.	Name
17	Elbow, Intake
18	Spark Plugs
19	Cylinder Block
20	Cylinder Head
21	Fuel Pressure Regulating Valve
22	Oil Gage and Hand Scavenge Pump
23	Timing Inspection Cover

1-7 DEFINITIONS.

1-8 In this publication the following definitions will be used.

1-9 FRONT END. The front or bow end of the engine is at the flywheel end. That is, the end opposite the propeller drive flange.

1-10 REAR END. The rear end or stern end of the engine is at the propeller drive flange end. That is, the end opposite the flywheel end.

1-11 RIGHT SIDE. The right or starboard side of the engine is on the right hand side as one stands at the propeller drive flange and faces forward.

1-12 LEFT SIDE. The left or port side of the engine is on the left hand side as one stands at the propeller drive flange and faces forward.

1-13 CYLINDER DESIGNATION. The engine cylinders are numbered starting with number one cylinder at the rear of the cylinder block and terminating with number six at the front of the cylinder block. The two cylinder blocks are designated as right hand and left hand. For example, cylinder number "5L" is the fifth cylinder from the rear of the cylinder block in the left hand bank of cylinders.

1-14 SIDES OF THE CYLINDER. The cylinders are designed according to their two sides. The "exhaust side" refers to the side of the cylinder on which the exhaust valve occurs. The "intake side", of course, refers to the side on which the intake valve occurs. For example: "4R EX" is the exhaust side of the fourth cylinder from the rear in the right hand bank of cylinders.

1-15 DIRECTION OF ROTATION. The rotation of the engine is determined by standing at the propeller drive flange and facing forward. When running in a normal manner, the propeller drive flange of a right hand engine rotates clockwise. (Model 2268 is a right hand engine.) When running in a normal manner, the propeller drive flange of a left hand engine rotates counterclockwise. (Model 2269 is a left hand engine.) In a direct drive engine, such as these are, the crankshaft rotation is the same as the propeller drive flange rotation.

1-16 ACCESSORY ROTATION. Direction of rotation of all accessories is understood to mean their rotation as viewed from the rear of the engine facing forward. The ignition distributors, which are mounted in a vertical plane, rotate in a counterclockwise direction when viewed from the drive end of the distributor.

1-17 TOP CENTER. "Top Center" is the angular position of the crankshaft when the piston is at the top of its stroke in the cylinder. For example: "T.C. 1 & 6 R.H. Bank" is the angular position of the crankshaft when number one and number six in the right hand bank are at the top of their stroke. Refer to markings on the flywheel rim. This definition is not to be confused with the piston position when its crank is on the vertical centerline of the engine.

1-18 BOTTOM CENTER. "Bottom Center", (BC) is the angular position of the crankshaft when the piston is at the bottom of its stroke in the cylinder. This is a position 180 degrees from the "top center" position explained in paragraph 1-17.

1-19 INTAKE OPENS. "Intake Opens" is the angular position of the crankshaft at which the intake valve just begins to open. Refer to marks on the rim of the flywheel as seen thru the timing inspection hole in the flywheel housing. These flywheel marks pertain to the number one cylinders, no others. On the right hand engine (Model 2268) the "INT. OPENS" mark for number one cylinder in the left hand bank comes into view first as the engine is rotated. On the left hand engine (Model 2269) the "INT. OPENS" mark for number one cylinder in the right hand bank comes into view first as the engine

is rotated.

1-20 EXHAUST CLOSES. "Exhaust Closes" is the angular position of the crankshaft at which the exhaust valve is just closed. Refer to marks on the rim of the flywheel as seen thru the timing inspection hole in the flywheel housing. These flywheel marks pertain to the number one cylinders, no others. On the right hand engine (Model 2268) the "EXH. CLOSES" mark for number one cylinder in the left hand bank comes into view first as the engine is rotated. On the left hand engine (Model 2269) the "EXH. CLOSES" mark for number one cylinder in the right bank comes into view first as the engine is rotated.

1-21 ROTATION DEFINITIONS. "C.W." means clockwise rotation. "C.C.W." means counterclockwise rotation. "rpm" means revolutions per minute.

1-22 LEADING AND TRAILING BANKS. The direction of rotation of the crankshaft determines the leading and trailing cyl. banks. The leading cylinder bank is the bank approached first by the engine cranks in the upper half their normal rotation. The trailing cylinder bank is the bank approached last by the engine cranks in the upper half of their normal rotation. For example, on a right hand engine the left hand bank is the leading bank and the right hand bank is the trailing bank. On a left hand engine the opposite is true, that is, the right hand bank is the leading bank and the left hand bank is the trailing bank.

1-23 LIQUID MEASURE DEFINITIONS. "U.S. gal" means United States standard gallon of 231 cubic inches. "Imp. gal" means British Imperial gallon of 277.42 cubic inches.

1-24 STANDARDS DEFINITION. "AN 0000" means Army-Navy standard. "SAE" means Society of Automotive Engineers. "JAN 00000" means Joint Army-Navy standard. "AGMA" means American Gear Manufacturers Association standard. "AWG" means Standard American Wire Gage. "ASA" means American Standards Association.

1-25 THERMAL DEFINITIONS. "F" means Fahrenheit thermometer scale. "C" means Centigrade thermometer scale. "BTU" means British Thermal Units of heat.

1-26 WIRING DIAGRAM DEFINITIONS.
"Arm." means armature.
"Adj." means adjustable.
"Bat." means battery.
"Dist." means distributor.
"Fix." means fixed.
"Grd." means grounded.
"Loc." means locating.
"S." means radio shielded wire.
"Start." means starter.

1-27 MISCELLANEOUS DEFINITIONS.
"in." means United States standard inch.
"ft" means United States standard foot.
"lb" means United States pound, commercial or avoirdupois.
"oz" means United States ounce, commercial or avoirdupois.
"CL" means the centerline of an object.
"cg" means the center of gravity.
"in. of Hg" means inches of mercury as measured in a manometer filled with mercury.
"in. of water" means inches of water as measured in a manometer filled with water.
"rms" means root mean square.

GENERAL DESCRIPTION

2-1 MODEL 2268 DEFENDER. The Model 2268 Defender is a direct drive gasoline marine engine turning a right hand propeller. The engine propeller shaft flange, on this model, rotates clockwise as one views it from a position at the rear of the engine and faces forward. Refer to name plate on front of cylinder block for model identification.

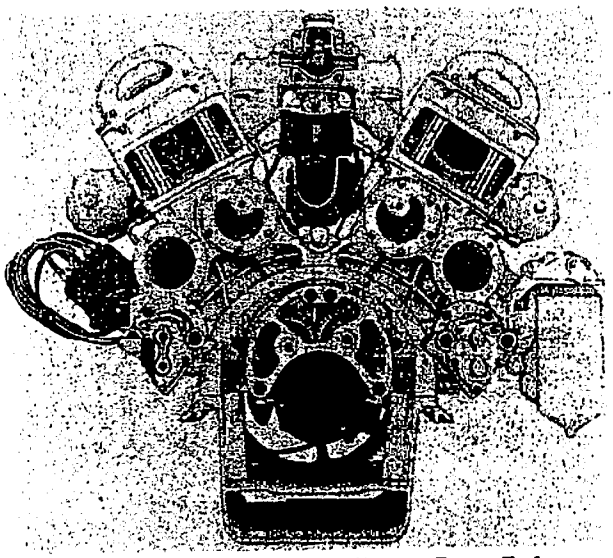


Figure 2-1. Cutaway View, Rear End

2-2 MODEL 2269 DEFENDER. The Model 2269 Defender is a direct drive gasoline marine engine turning a left hand propeller. The engine propeller shaft flange, on this model, rotates counterclockwise as one views it from a position at the rear of the engine and faces forward. Refer to name plate on front of cylinder block for model identification.

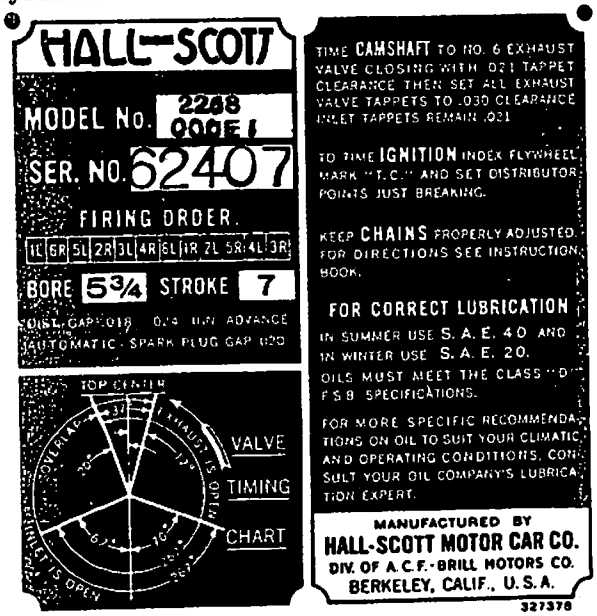


Figure 2-2. Engine Nameplate

2-3 CRANKSHAFT. The crankshafts in these engines are forged molybdenum steel heat treated to desired physical properties. They are counterweighted for good running balance. Crank journals and webs are drilled for full pressure lubrication to connecting rod bearings. Shafts are rigidly supported in seven main bearings. The accessory drive is taken from the reverse

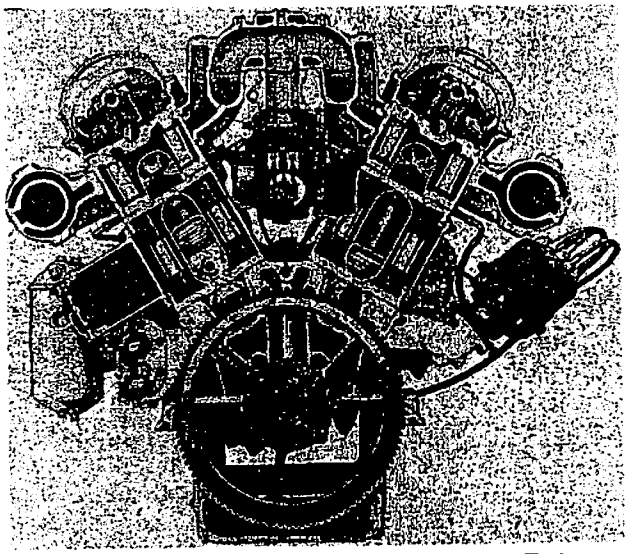


Figure 2-3. Cutaway View, Front End

gear end of the crankshaft where torsional vibration is negligible.

2-4 MAIN BEARINGS. The main journals in this engine are carried in precision type "snap-in" shells. The shells are copper-lead on a steel backing. A surface coating of indium over lead is used to provide a "break-in" surface on the shells. The shells are grooved to distribute the pressure lubricating oil. The center shells are flanged to take the crankshaft end thrust.

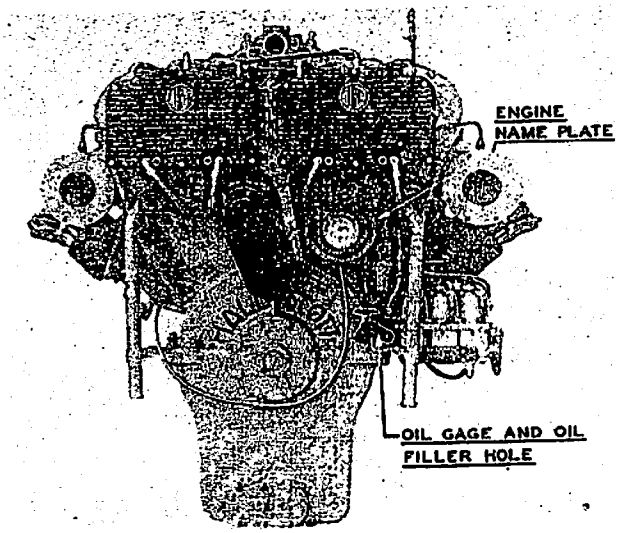


Figure 2-4. Front View of Engine

The replacement main bearing shells, because of the precision finish, may be snapped into their saddles and run without being "line-reamed".

2-5 FLYWHEEL AND VIBRATION DAMPER. The flywheel is mounted on the front end of the crankshaft. The starter ring gear is mounted on the flywheel. The valve timing marks are carried on the front face of the flywheel where they can be viewed through the timing inspection hole in the flywheel housing. A vibration damper is incorporated into the rim of the flywheel. This damper is simply an inertia rim surrounded by a quite viscous fluid. Its purpose is to absorb torsional vibrations.

2-6 GEAR CARRIER. The accessory drive is driven from the crankshaft by gears mounted in a carrier. By selectively positioning the gear carrier on the crankcase, at assembly, a uniform direction of rotation can be obtained for all accessories on both sides of the engine regardless of the direction of crankshaft rotation thereby simplifying the engine considerably.

2-7 CONNECTING RODS. The connecting rods are "I" section forgings of nickel chromium steel. They are of "yoke" and "blade" design for symmetrical location on the crank journal. Finished weights are held to close tolerance for smoothness of engine operation. A wide bearing shell is used in the "yoke" rod and it rides directly on the crankshaft. The "blade"

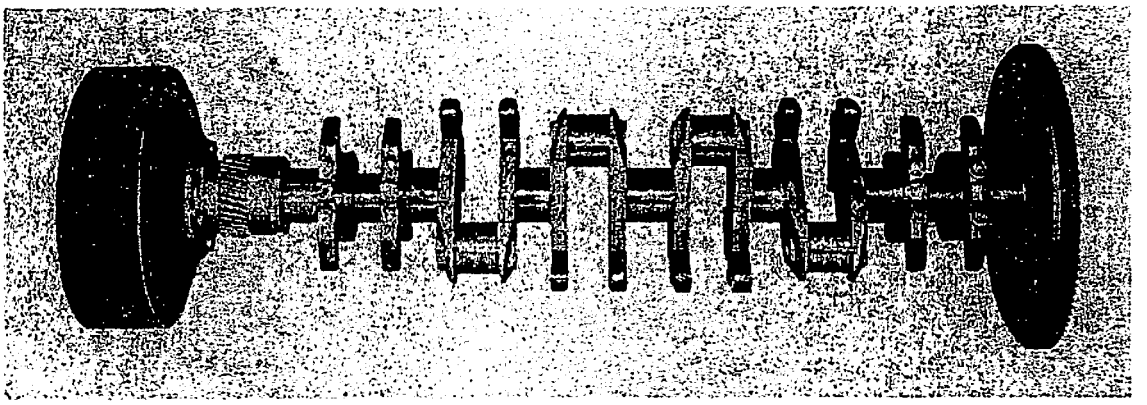


Figure 2-5. Crankshaft, Flywheel and Clutch Drum

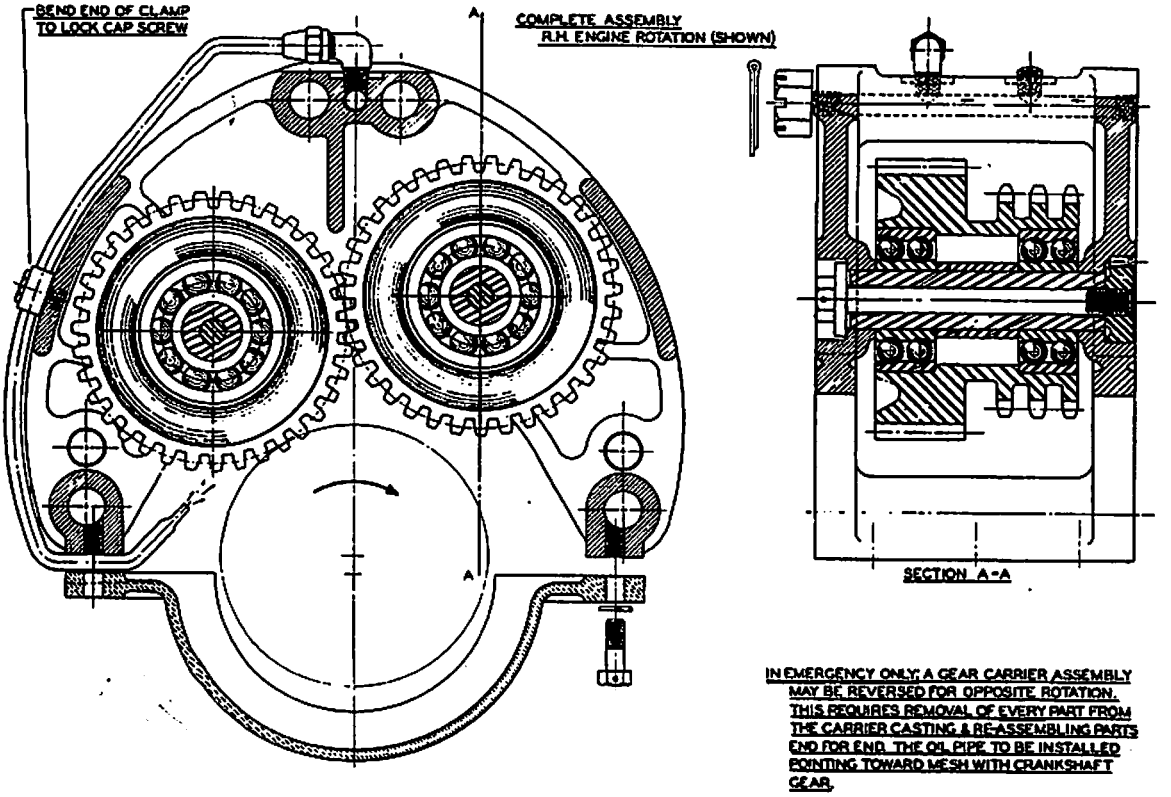


Figure 2-6. Gear Carrier

rod uses a narrow bearing shell and it bears on the outside diameter of the "yoke" rod shell. Shells are precision "snap-in" type copper-lead on the inside diameter and with a steel back on the outside diameter. A surface coating of indium over lead is used to provide a "break-in" surface on the shells. Alloy steel bolts are used to secure the connecting rod caps to the connecting rods.

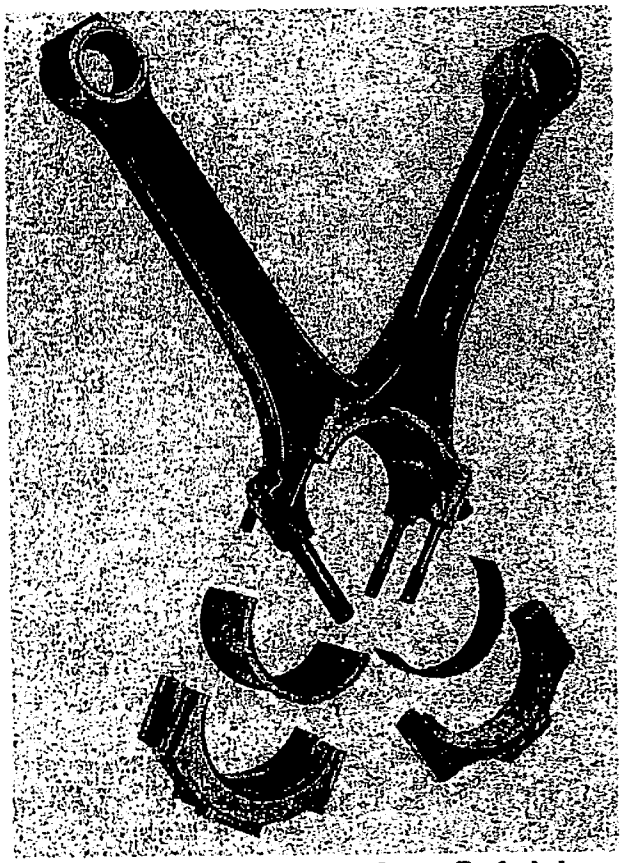


Figure 2-9. Connecting Rods, Exploded

2-8 PISTON PINS. The piston pins are made of nickel chromium molybdenum steel. The surface is case hardened for maximum wear quality. The piston pin floats in both the piston and the bronze bushing in the connecting rod. It is retained in the piston through the use of soft metal plugs fitted to each side of the piston. Magnetic inspection is employed on the piston pins to assure their being free of cracks.

2-9 PISTONS. The pistons used in these engines are of cast aluminum alloy. They are generously ribbed for greater strength and are designed to distribute the mechanical and heat load in the best manner. They are cam ground to permit close fitting to the cylinder bores. Piston ring grooves are located in the piston to provide maximum compression and a minimum of oil consumption. The compression ratio is such that high octane fuel can be used to advantage.

2-10 PISTON RINGS. Piston rings are held to close tolerances on radial tension so that compression pressures can be maintained and oil consumption controlled. The surface finish of the rings are selected to give rapid seating and long wearing qualities after seating.

2-11 UPPER CRANKCASE. The upper crankcase is made of alloy cast iron. It is provided with ribbed webs to rigidly support the crankshaft. Internally drilled oil passages supply oil to the main and connecting rod bearings. Accessories are fastened to the upper crankcase so the cylinder blocks may be removed without disturbing the accessories. For maximum rigidity the cylinder head hold down studs pass through the cylinder block and screw directly into the upper crankcase webs over the main journal bearings. In this manner the driving force of the combustion is transmitted directly to the crankshaft.

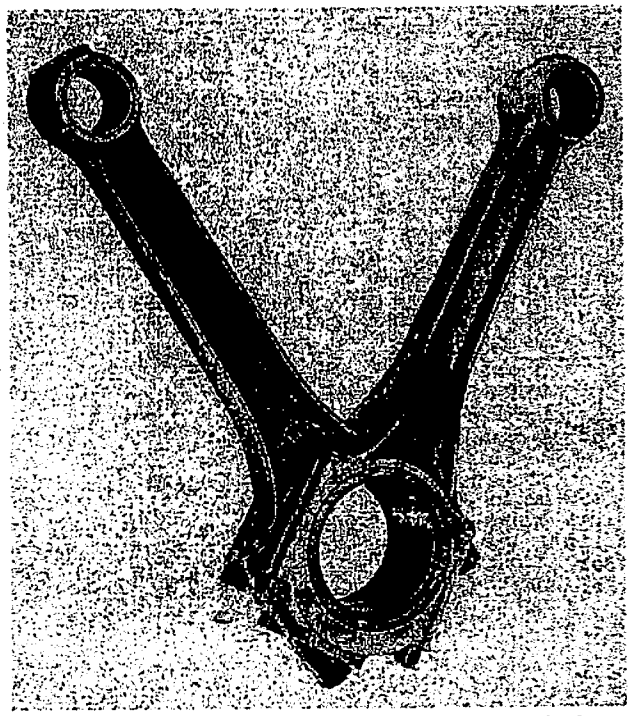


Figure 2-10. Connecting Rods, Assembled

2-12 CYLINDER BLOCKS. Cylinder blocks are cast of high alloy cast iron, six cylinders enbloc. The cylinders are completely water jacketed for uniform cooling. Large cover plates are used to permit cleaning the jacket space. The cylinder wall hardness is such that very good wearing qualities are obtained.

2-13 CYLINDER HEAD. The cylinder heads are cast of alloy iron with six heads in a casting. The entire valve mechanism is self-contained in the head. This includes valves, rockerarms and camshafts. This type construction permits replacement of cylinder heads and valves as a unit. One exhaust valve and one intake valve are used per cylinder. The exhaust valve has a hard metal face and closes against a hard metal replaceable seat. Intake passages are short and direct. Lubricating oil is directed against the camshaft and rockerarm contact. Two spark plugs are used per cylinder. Water jacket space is provided around the entire combustion

chamber, valve seats, valve guides and spark plugs. A zinc plug is used in the water jacket space in the head to reduce the electrolytic action of salt water on the structural elements of the engine.

2-14 VALVE MECHANISM. The valves are operated from the cams thru rockerarms. No push rods are used. The cams are proportioned to give maximum engine performance and long valve life. Two springs per valve are used to prevent damage due to spring breakage.

2-15 SPROCKET HOUSING. The sprocket housing is fastened to the rear of the upper crankcase. It is an aluminum casting designed to suppress mechanical noise to a minimum. Its primary purpose, as its name implies, is to support and protect the accessory drive chains and sprockets. Triple width roller chain running within the housing carry the drive from the gear carrier to the various accessories such as oil pump, water pump, distributor, generator, bilge pump, tachometer drive, and fuel pump. Two manual type chain take-ups are also provided in this housing.

2-16 INTAKE MANIFOLD. The intake manifold is a gallery type fed by three carburetors. The mixture, in turn, is distributed to the individual cylinders through six pairs of intake elbows. All of this intake manifold assembly is water jacketed in order to condition the mixture. Priming nozzles are placed in the intake manifold to aid cold starting. A by-pass thermostat is provided to control the water outlet temperature. Ventilation for the distributor and multiple shield box is made thru the intake manifold.

2-17 EXHAUST MANIFOLD. Water jacketed exhaust manifolds are used with individual ports to each cylinder. The outlets may be changed from the rear of the engine to the front merely by changing the right exhaust manifold for the left, etc. Two expansion joints are provided in the outer jacket wall.

2-18 LOWER CRANKCASE. The lower case is an aluminum casting. It is of a deep section with internal baffles and channels in order to reduce the engine oil consumption. The front section of the case provides an integral oil sump tank as this engine uses a dry sump type of lubrication. A large hand hole is provided to aid in cleaning the sump tank. The lower crankcase is constructed with mounting flanges, each side, upon which the engine rests. A hand sump pump and oil gauge are provided at the front end of the lower crankcase.

2-19 OIL PUMPS. Two oil pumps, which are identical in every respect, are used on each engine. The two being used to improve the dependability of the engine. Each oil pump is divided into different sections. The rear section is the scavenging side and it picks up any surplus oil from the rear end of the lower crankcase and delivers it to the oil sump. The front section of the two pumps are the pressure sides.

2-20 OIL PRESSURE REGULATING VALVE. The oil pressure regulating valve is located between the cylinder banks at the front of the engine. The oil pressure supplied to the engine is controlled by adjusting this valve. When the oil pressure becomes excessive, oil is by-passed back to the oil sump tank thru passages drilled in the upper crankcase. Refer to figure 12-10.

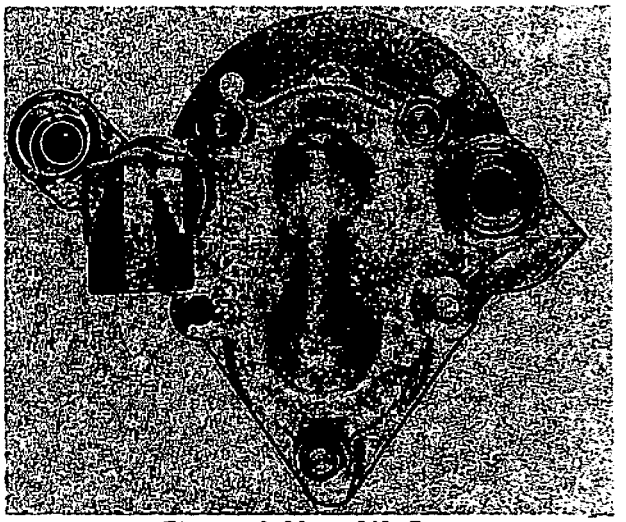


Figure 2-11. Oil Pump

2-21 OIL COOLERS. Two oil coolers are used on these engines, one is mounted on the outside of each cylinder block. Oil is pumped thru small tubes which are surrounded by cold water. Heat is thereby transferred from the oil to the water. The coolers are identical, each receiving its oil and water from independent oil and water pumps. A by-pass valve is provided in the oil cooler cover to insure oil reaching the engine should the cooler become stopped up for any reason. Thermometer bulb adapters are provided in the oil lines suitable for receiving thermometers. Refer to figure 12-10.

2-22 OIL FILTERS. Two pairs of absorption type replaceable element oil filters are used to condition the lubricating oil. Each pair of filters operates independently from the other pair and is in the oil circuit with the oil pump and oil cooler on its particular side of the engine. The oil filter body is provided with two by-pass valves. One by-pass valve protects the engine in the event that the filters become stopped up. The other valve is put in to protect the oil system in the event of extreme high pressure as might be encountered when the oil is cold. Refer to figure 12-10.

2-23 WATER PUMPS. Two gear type water pumps are used, one on either side of the engine. The pumps operate independently of one another and supply water to the oil cooler, exhaust manifold, cylinder block and cylinder head on its particular side of the engine. The pumps are of the pilot gear type which design permits them to handle considerable sand in the sea water without damage to the pump gears.

2-24 FUEL PUMPS. Two mechanical vane type fuel pumps are used per engine. The fuel pumps are part of a continuous circuit that assures adequate fuel supply to the carburetors while reducing the chances of vapor lock to a minimum. The circuit is so arranged that a hand or electric fuel pump may be used to fill the system before the engine is cranked. A pressure regulating valve is part of the circuit which

make it all quite dependable as well as adaptable to accessory equipment. Refer to figure 9-54.

2-25 CARBURETORS. Three marine type 2-1/2 in. multiple venturi updraft carburetors are fitted to the intake manifold. The carburetors are located in the "V" between the cylinder blocks. These carburetors are of balanced design so that any exterior restrictions in the air inlet will not alter the mixture ratio. A drain pickup tube is fitted to each carburetor to draw off any gasoline that might run down into the carburetor air intake. These carburetors are not fitted with a choke valve. Cold starting is made thru the use of a hand priming pump. Wire mesh air filters and back fire traps are fitted to the carburetor air intakes. The three carburetor throttle valves are connected to a common control shaft. Crankcase ventilation is provided through shrouds fitted to the carburetor air intakes.

2-26 REVERSE GEAR. The reverse gear is designed to give direct drive in reverse as well as ahead. The gear is equipped with anti-friction bearings for long trouble free life. Large thrust bearings are provided within the engine assembly to take the full thrust load from the propeller in both forward and reverse. A convenient cover is provided over the reverse gear to permit adjustment when necessary. A 36 in. long hand lever is provided as well as a 16-1/2 in. lever for remote control. Levers may be mounted on either side of the engine. Lubrication is supplied from the engine crankcase system.

2-27 IGNITION DISTRIBUTOR. The two ignition distributors are heavy duty units designed especially for this type of service. These distributors are radio shielded and vacuum ventilated. Two sets of breaker points are fitted to each distributor, thus each distributor fires twelve spark plugs. For maximum dependability the distributors are wired so that each distributor fires six spark plugs in each bank of cylinders. In this way, should there be a failure in either distributor, the engine will continue to develop almost full power as all cylinders will still have one spark plug in operation. The two distributors are identical and thus interchangeable, one with the other. The only difference in application being the sequence of attaching the secondary wires to the distributor cap. The distributors are provided with numerous adjustable features to make accurate ignition timing a simple operation.

2-28 GENERATOR. A single 24 volt belt driven generator is used on these engines. The same generator is used on both the Model 2268 and 2269 engine. It is a four pole, four brush type generator for a positive ground system. It is regulated for 25 amperes at 1250 generator rpm at twenty-six volts. It is radio shielded.

2-29 APPARATUS BOX. The generator output is controlled thru the use of an apparatus box which permits the generator output to vary according to the needs of the battery. It is radio shielded to match the rest of the electrical system of the engine.

2-30 STARTER. The electric starting motor is mounted on the flywheel housing and engages the flywheel ring gear thru the use of an inertia shifting pinion. A gear reduction is provided between the starter armature and the cranking pinion. This gives the starter tremendous torque to crank this large engine. The starter is energized thru the use of an instrument panel push button switch. This push button circuit, in turn, closes a magnetic switch which impresses the full battery voltage across the starter motor. The cranking pinion is shifted into engagement with the flywheel ring gear by being mounted on a helical thread. The inertia of the pinion causes it to shift endwise and engage the ring gear. A slipping clutch is provided to absorb the initial shock of engagement. After the engine starts the high velocity of the ring gear kicks the pinion out of engagement.

2-31 SPARK PLUGS. Spark plugs are of the ceramic type with a metal jacket for radio shield system. The single gap type of plug is used. Two spark plugs per cylinder are employed and they are connected in such a way that each spark plug in any particular cylinder draws its energy from separate distributors. This assures maximum freedom from ignition failure.

2-32 BILGE PUMP. Gear type bilge pumps are fitted to Model 2268 engines only. These pumps are mounted on the sprocket housing and are driven through a cone clutch. The pumps are normally stationary and are only engaged when it is necessary to drain the bilge.

2-33 RADIO SHIELDING. The engines are fitted with all necessary equipment to suppress disturbing impulses that interfere with the sending or receiving of radio signals. This is primarily concerned with the electrical equipment, but includes all elements of the engine that might give rise to electrical disturbances. Electrical noise suppression is accomplished by the use of resistor-suppressors, capacitor, filters, metallic shielding, electrical bonding or grounding. The suppression is effective regardless of the amount of engine equipment in use.

2-34 ELECTRIC FUEL PUMP. A six unit electric fuel pump is fitted to the engine to aid in filling the fuel system before starting the engine and to act as an auxiliary pump to the mechanical pumps. The fuel pressure regulating valve is designed so that either the mechanical or electrical pumps can work separately or together. The electrical fuel pump is radio shielded.

2-35 OVERSPEED GOVERNOR. To prevent damage to the engine because of excess speed, a governor is used. This is a mechanical device that controls the ignition circuit. When the engine reaches a predetermined speed the ignition circuit is interrupted. Just as soon as the engine speed drops to a safe rpm then the ignition circuit is restored and the engine will continue to run, hence there is no danger of the engine stopping. The overspeed governor is mounted on the front of the engine with a tachometer dial included so the attendant in the engine room can tell directly at what speed the engine is running.

2-36 TACHOMETER SENDING UNIT. An electric tachometer unit is used on these engines to avoid long tachometer cables to the Bridge.

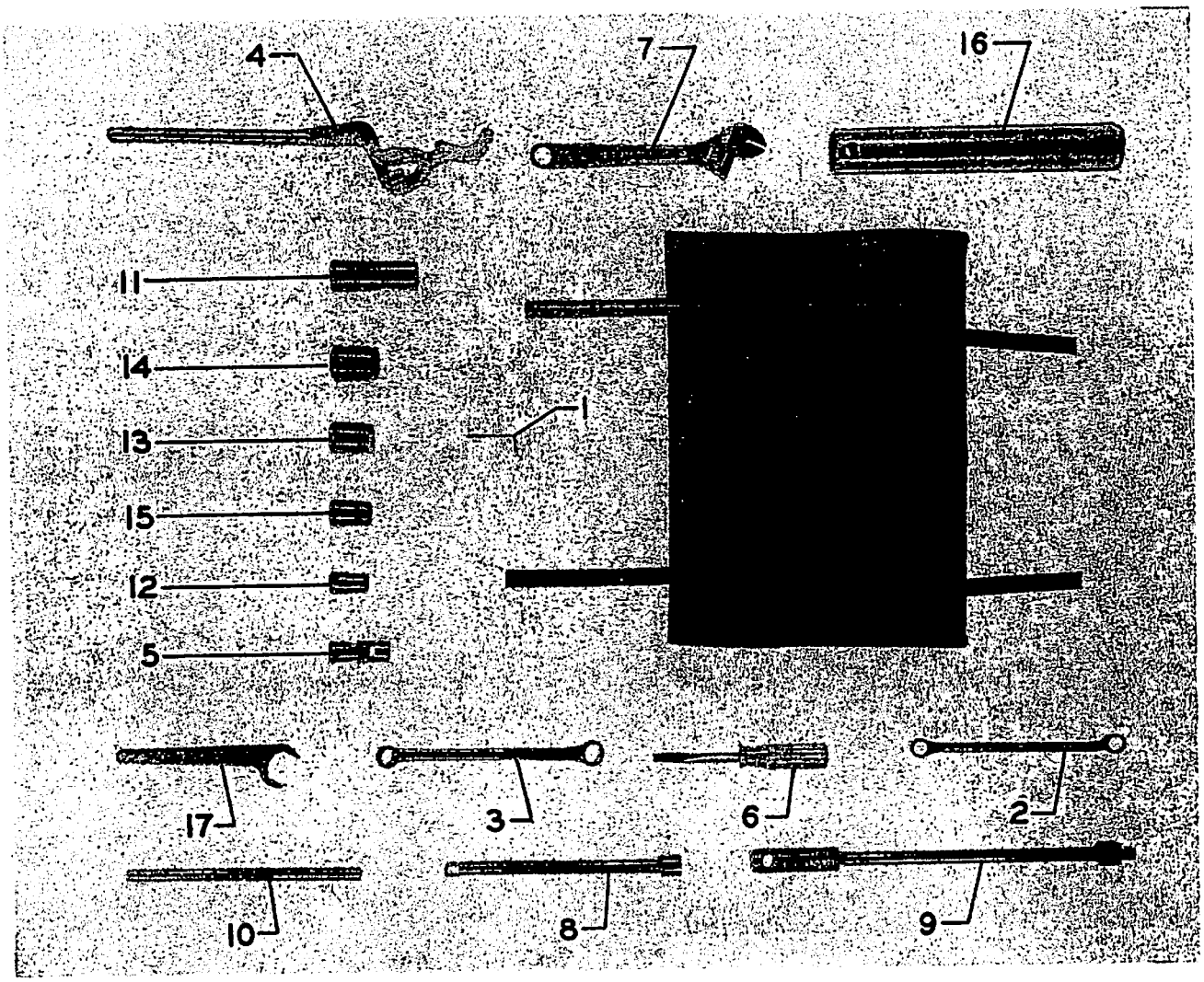


Figure 3-1. Tools

OVERHAUL TOOLS

3-1 GENERAL. Listed and illustrated in this section will be found all the Government approved overhaul tools used on the subject engines. The tools listed are of a general purpose nature hence they are used for both right and left hand engines as well as for dismantling, disassembly, repair and replacement. For this reason no segregation is made in the following list to indicate special applications. General applications are noted below and reference is made to appropriate illustrations of the tools in use.

3-2 TYPICAL TOOLS. Tools that are shown in use, elsewhere in this handbook, but not found listed here are not necessarily Government approved and are thus designated as "typical" to distinguish them from the tools listed in this section.

FIG. AND INDEX NO.	TOOL NO.	NOMENCLATURE	APPLICATION
3-1-1	161002	Wrench - Allen 3/32 in.	Distributor rotor set screw refer to figure 9-45.
-2	306551	Wrench - Cylinder head and manifold nut double hexagon	Nuts and cap screws on rockerarm cover, water pump, distributor drive housing, flywheel housing, oil cooler, sprocket housing, intake manifold, yoke connecting rod and reverse gear cover.
-3	308587	Wrench - Double hex nut 5/8 and 3/4 in. openings	Nuts and cap screws on exhaust manifold; intake manifold elbows; flywheel housing; upper and lower crankcase flange; valve tappet lock; reverse gear thrust bearing container, retainer, packing gland and adapter.

FIG. AND INDEX NO.	TOOL NO.	NOMENCLATURE	APPLICATION
-4	309526	Tool - Valve spring compressor	Used to install and remove valve springs.
-5	317805	Flexocket - 5/8 in. double hexagon	Nuts and cap screws on the exhaust manifold; intake manifold elbows; flywheel housing; upper and lower crankcase flange and reverse gear thrust bearing container.
-6	318282	Screw driver	Distributor cam locking screw.
-7	318283	Wrench - 10 in. single end superadjustable 1-1/8 in. capacity	Adjustable for general purpose application.
-8	318284	Extension - 10 in.	Use with socket to reach cap screws in rear interior wall of reverse gear housing.
-9	318285	Handle - Flexible 17 in.	Use with sockets and extension.
-10	318286	Bar - Cross	Use with flexible handle and with chain take-up socket wrench.
-11	318287	Socket - Double hex 1 hex 1/2 in. square drive	Use on spark plugs.
-12	318288	Socket - Double hex 9/16 hex 1/2 in. square drive	Nuts and cap screws on rockerarm cover, water pump, distributor drive housing, intake manifold, oil cooler, sprocket housing, carburetor flange and reverse gear cover.
-13	318289	Socket - Double hex 15/16 hex 1/2 in. square drive	Nuts and cap screws on the reverse gear thrust bearing retainer and generator bracket.
-14	318290	Socket - Double hex 1-1/16 hex 1/2 in. square drive	Nuts and cap screws on the cylinder head, and main bearing studs; generator and bilge pump drive sprocket shafts and camshaft drive sprocket.
-15	318442	Socket - Double hex 3/4 hex 1/2 in. square drive	Nuts on the valve tappets, reverse gear housing adapter and reverse gear packing nuts.
-16	326894	Wrench - Chain adjustment sprocket	Hex on chain take-up support. Refer to figure 9-36.
-17	326978	Wrench - Water pump packing nut	Water pump packing nuts.

DISMANTLING AND DISASSEMBLY

4-1 PREPARATION FOR DISMANTLING. When the engine to be overhauled is contained in a re-useable shipping case it must be removed as follows. Place the shipping case under a one ton hoist capable of lifting to 12 foot height from the floor. Remove 38 - 1/2 in. cap screws, nuts and washers from the lower flange of the shipping case. Carefully lift the cover from the shipping case by the use of lifting hooks provided. Set the cover aside. Remove the bag from over the engine if one is used.

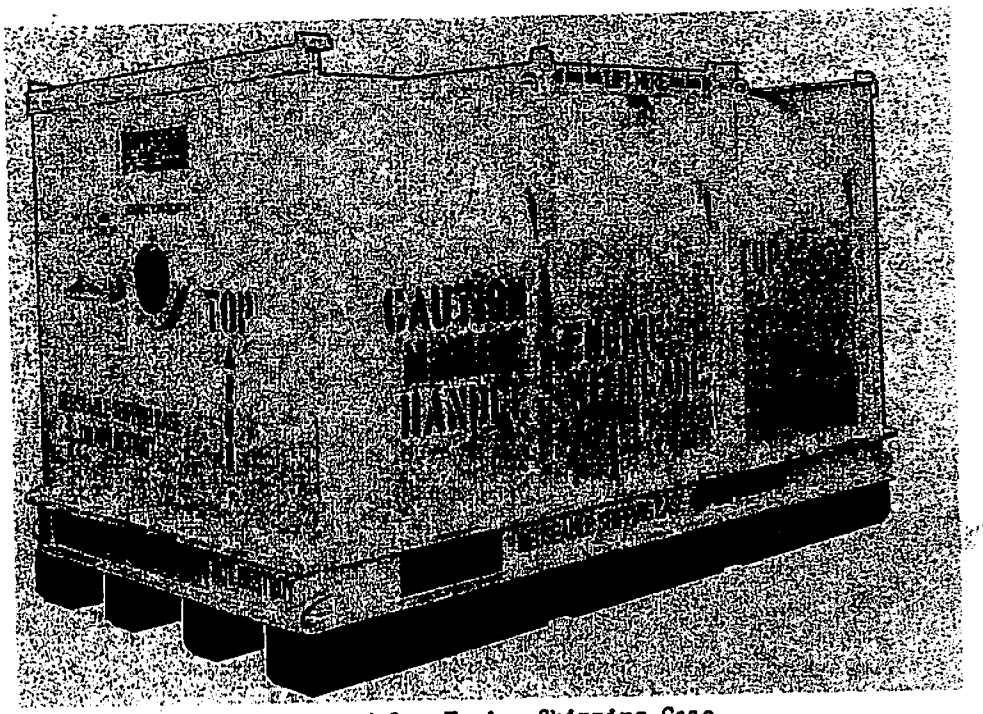


Figure 4-1. Engine Shipping Case

4-2 DISMANTLING INTO MAJOR ASSEMBLIES. This operation can best be performed while the engine is still sitting in the base of the shipping case.

4-3 DISASSEMBLY EXAMINATION. During each stage of disassembly, examine all parts and assemblies for scoring or burning. Look for indications of work incorrectly performed during any previous overhauls. Report any such indications in accordance with current practice.

4-4 MULTIPLE SHIELD REMOVAL. Remove and carefully mark each wire from the multiple shield, electric fuel pump filter and starting motor filter to make sure the wire can be returned to its proper place. Remove the ventilating pipes. Remove three 1/4 in. nuts and lockwashers from the back of the multiple shield box and take it from the engine along with the radio shield filter assembly located directly beneath it. This operation is repeated for the opposite assembly. The multiple shield assembly supporting bracket may now be removed. This is done by removing four 3/8 in. cap screws and washers from the multiple shield supports at the front of each cylinder head. Also remove two 5/16 nuts and washers from the lower end of the multiple shield supporting leg and then remove the entire bracket from the engine.

4-5 DISTRIBUTOR CAP AND SPARK PLUG WIRE REMOVAL. These units may be removed as an assembly without taking the wires out of the distributor cap. Unscrew the elbow connectors from all the spark plugs. Release all the ignition wire clamps. Remove the distributor caps as follows. Unscrew the four high hex hd cap screws that project down from the base of the distributor. Do not disturb the two fillister head screws that are conspicuous on the top flange of the cap. Now pull the distributor cap and wire assembly from the engine. See figure 4-3.

4-6 INTAKE MANIFOLD REMOVAL. Remove all water connections from the intake manifold. Remove the fuel line connections from the carburetors and the priming pump connection to the manifold. Remove the distributor and multiple shield ventilating pipes from the intake manifold as well as the vacuum gage connection. Remove the crankcase ventilating pipes from the air filter shrouds. Remove the throttle control linkage from the front end of the throttle control shaft. Now remove 24 - 7/16 in. cap screws from the top of the intake manifold. Slide the intake manifold and carburetor assembly off the engine until it can be lifted straight up. Be careful so as not to damage any spark plugs, wires, pipes or controls. It is best to drain all the gasoline from the carburetor bowls into a closed container. See figure 4-5.

4-7 CYLINDER HEAD REMOVAL. Remove both rocker-arm covers. Loosen up the 3/4 in. cap screws

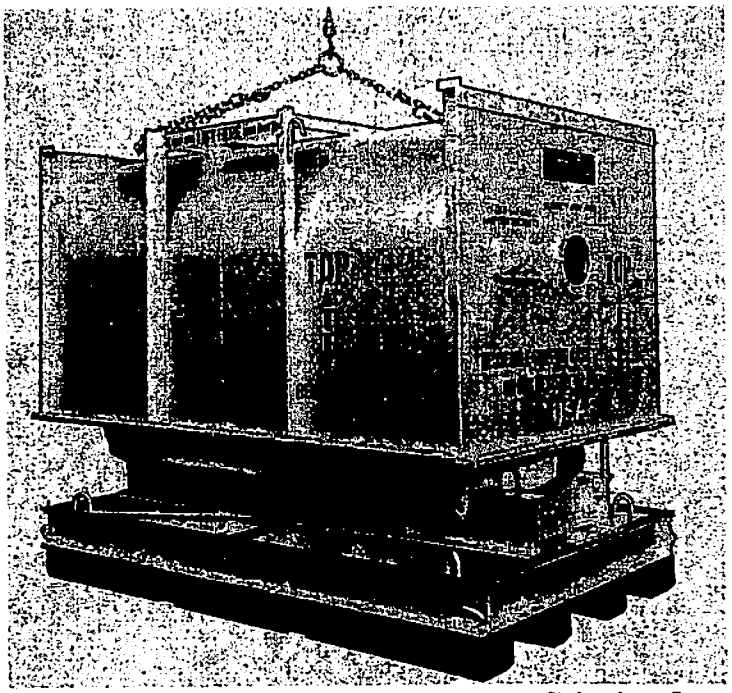


Figure 4-2. Lifting Cover from Engine Shipping Case

that hold the camshaft sprocket in place. With a soft brass drift carefully knock the camshaft sprockets from the driving taper. Now remove 14 3/4 in. hex nuts from the cylinder head. Also remove two 1/2 in. hex nuts from the rear of the cylinder head. Remove oil drain pipe from front end of cylinder head. Remove oil supply pipes from rear of cylinder head. Remove water connection to the oil cooler body. With a rope sling under the rocker arm shaft carefully lift the cylinder heads from the engine and set them aside. Now fit spacers in place on the center cylinder head studs with nut to retain the cylinder blocks when the engine is turned over.

CAUTION

It is most important that these spacers be installed as otherwise someone will quite likely be hurt when the engine is turned over.

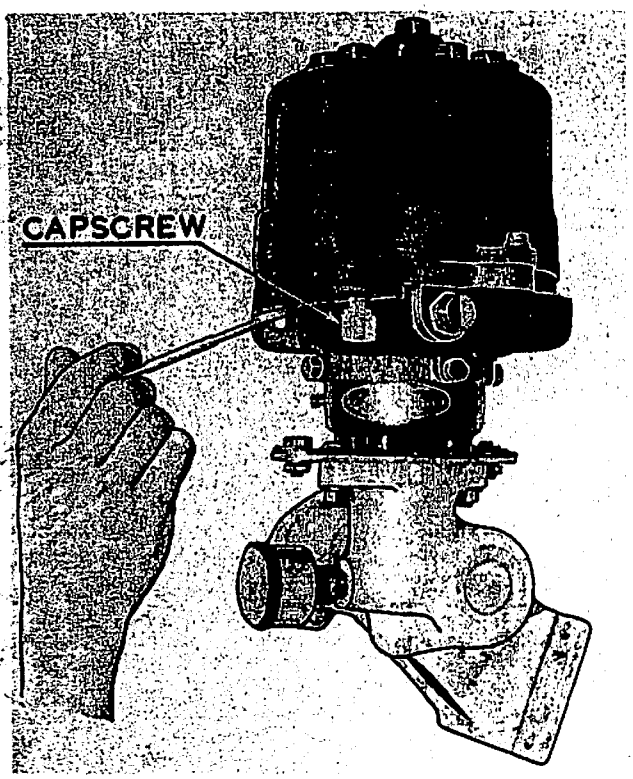


Figure 4-3. Removing Distributor Cap

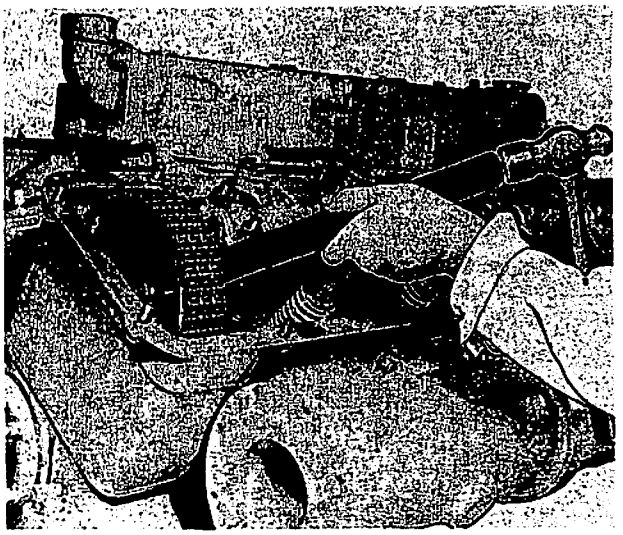


Figure 4-4. Removing Camshaft Sprocket

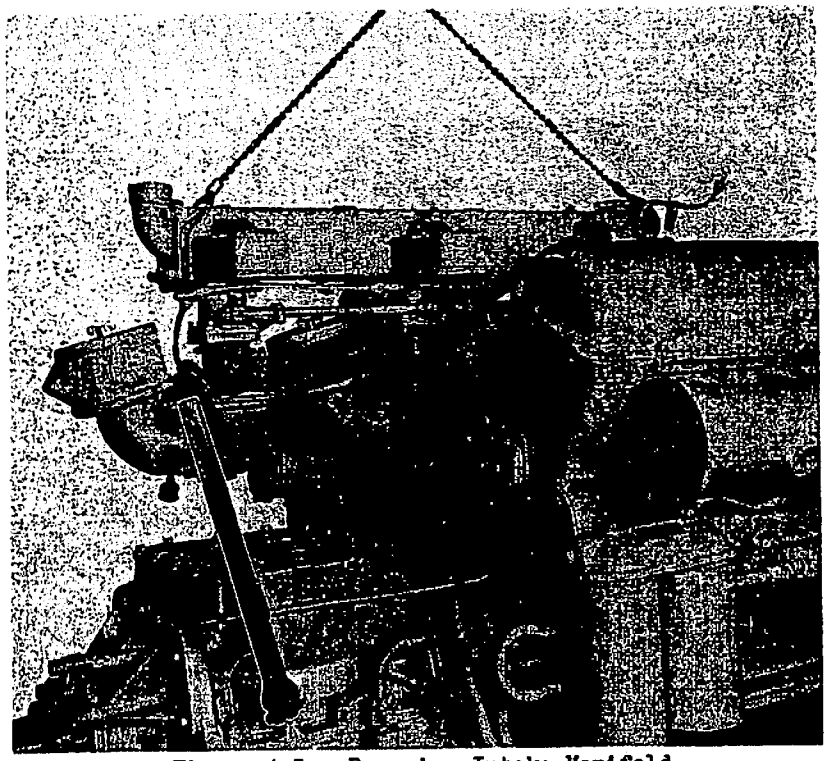


Figure 4-5. Removing Intake Manifold

4-8 Place support under camshaft sprockets as shown in figure 4-7.

4-9 GENERATOR REMOVAL. Carefully tag and mark all wire connections to the generator so they can be returned to their proper places. Remove the shielding connections and wires. Loosen the two 5/8 in. clamp bolts on the generator mounting bracket and swing the generator around to loosen up the two V-belts. Now remove the four 3/8 in. cap screws from the generator mounting bracket and after removing the V-belts from the generator pulley, lift the generator from the engine.

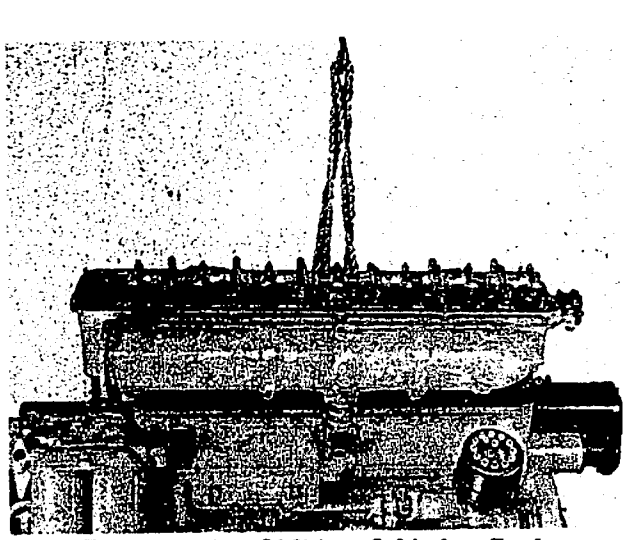


Figure 4-6. Lifting Cylinder Head

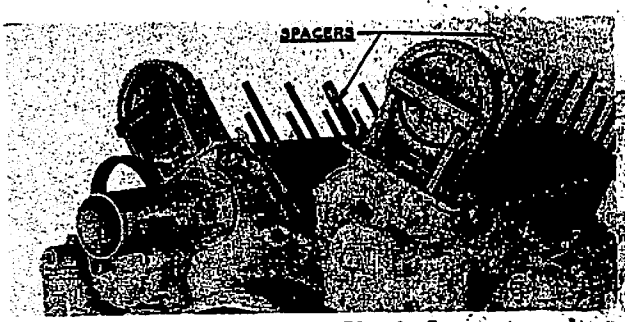


Figure 4-7. Cylinder Block Spacers and Camshaft Sprocket Supports

4-10 GENERATOR AND IDLER SUPPORT RING REMOVAL. Remove six 3/8 in. hex nuts and washers.

4-11 REVERSE GEAR REMOVAL. Remove the flat cover from over the reverse gear. See that the reverse gear lever is in the "Ahead" position so that all the clutch plates will be locked together. This makes reassemble to the engine easier. See that the engine is rotated so that the three levers are in the position shown. Remove oil pressure pipe to rear thrust bearing. Remove any remote control linkage attached to the short reverse gear lever. Remove nut "14" and anchor strap "16". Remove lock wire and two cap screws "17" from anchor strap. Pull link pin "18" out of the assembly. Remove eight 1/2 in. cap screws from the outside flange of the reverse gear housing. Also remove two cap screws from the inside rear wall of the reverse gear housing. Remove seven 7/16 in. cap screws from the rear flange of the thrust bearing container. Now carefully lift the reverse gear housing from the engine. Be sure that all

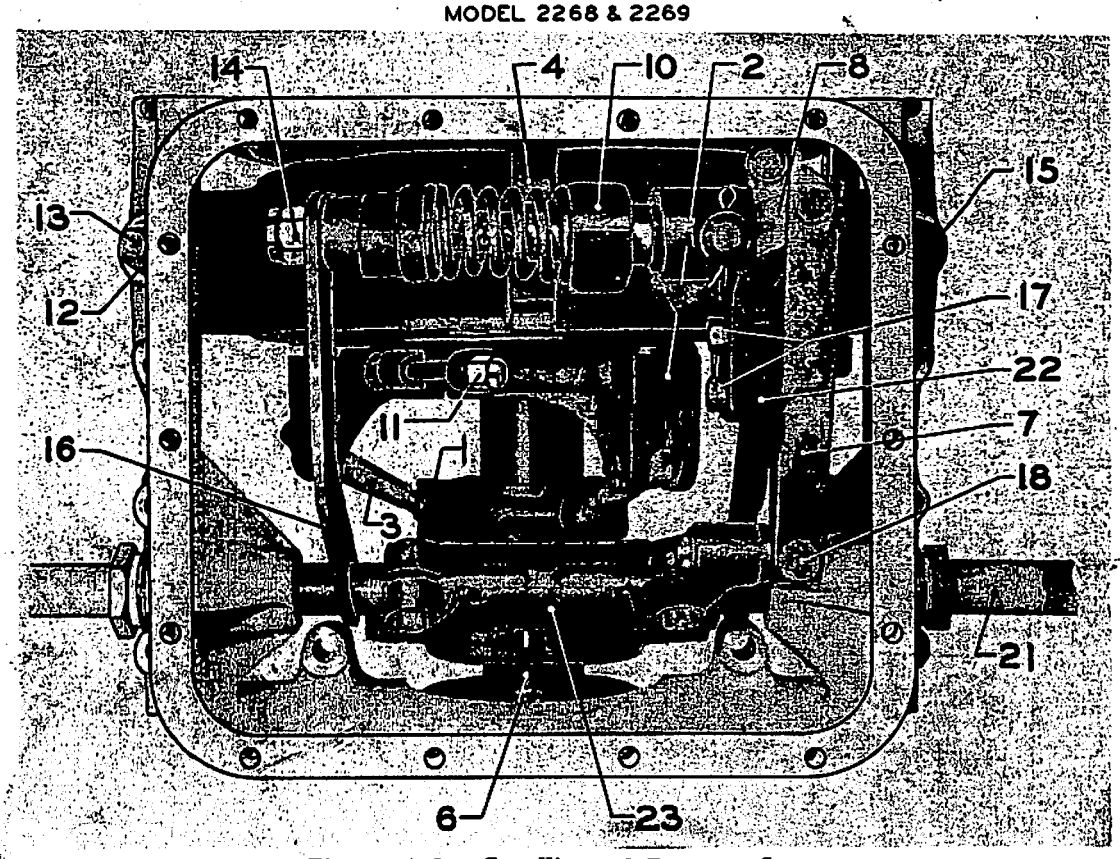


Figure 4-8. Top View of Reverse Gear

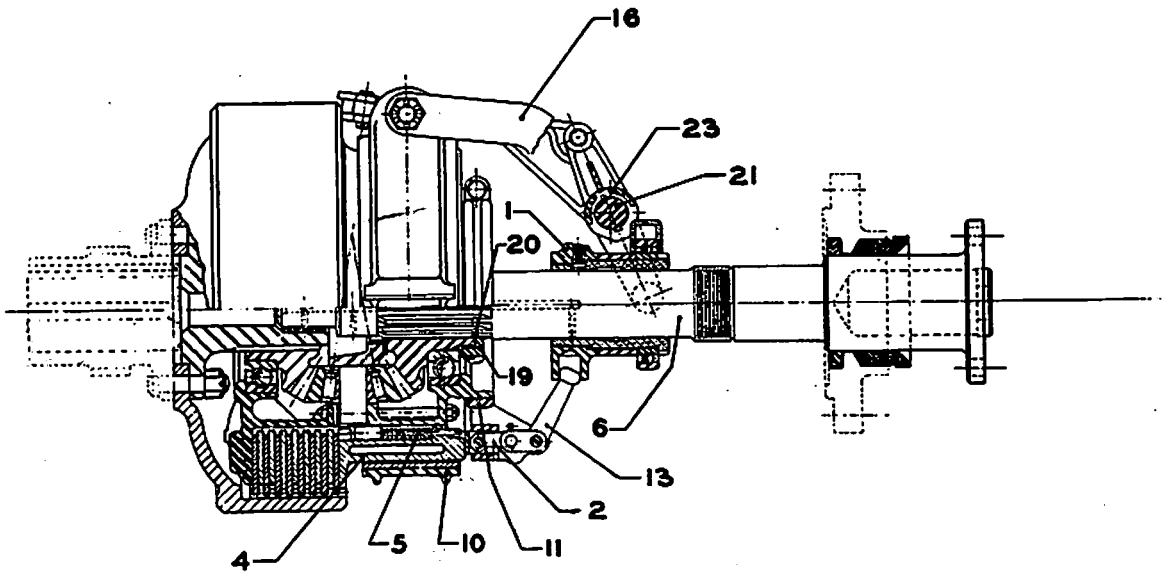


Figure 4-9. Sectional View of Reverse Gear

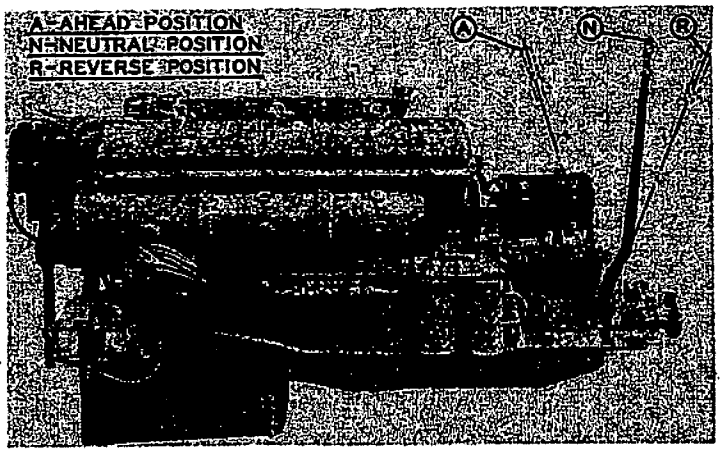


Figure 4-10. Reverse Gear Operating Lever in Various Positions

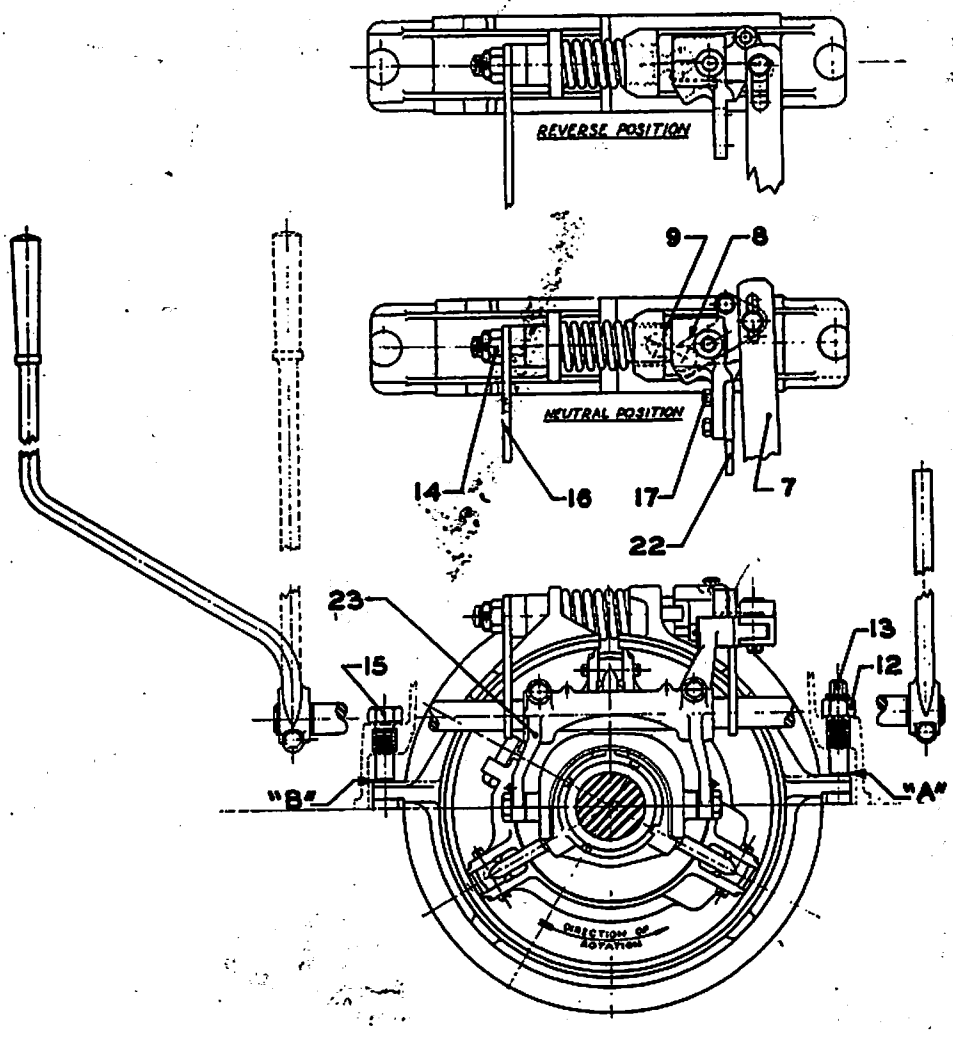


Figure 4-11. End and Top View of Reverse Gear

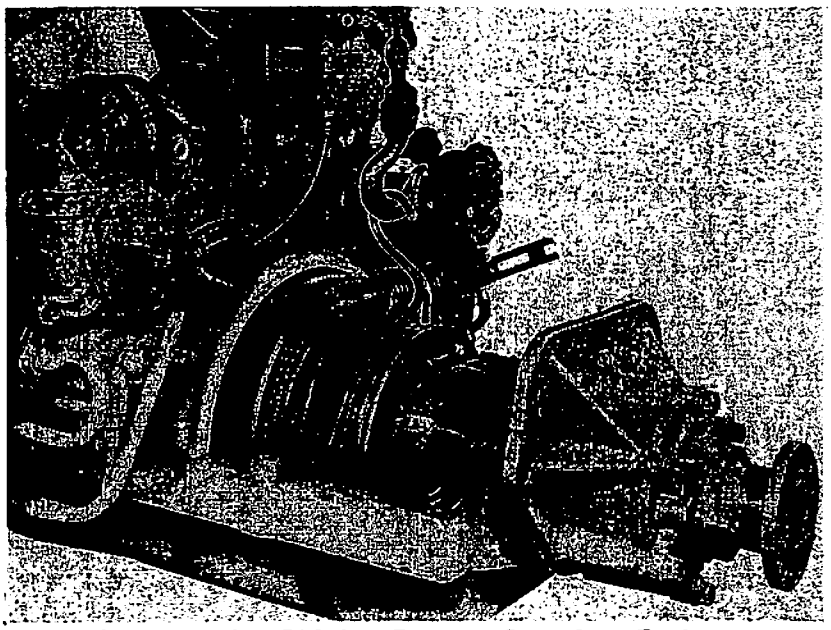


Figure 4-12. Lifting Reverse Gear from Engine

fastenings have been removed as mentioned above. The gaskets may stick together so some force may be required to break the housing loose. Be careful in prying that none of the gasket flanges is damaged. Loosen lock nut "19" while still in the engine. Replace nut "14" and tighten so the reverse band grips the drum "4". Now place a hook or sling under the brake toggle adjusting stud as shown in figure 4-12 and take a light strain on the hoist. Reach in under the reverse gear shaft and pull the lock wires from the four 7/16 in. studs. Remove the four nuts. The whole reverse gear assembly is now free to be moved back. The toothed clutch driving discs will come out of the clutch driving drum. Adjust the hoist so the reverse gear assembly can be moved back and lifted clear of the engine. Set the assembly aside on a clean work surface. Refer to paragraph 4-56 for disassembly of the reverse gear.

4-12 THROWOUT CAM PLATE REMOVAL. Remove eight 3/8 in. hex nuts from the front of the engine and then remove the hand starting lever hole plug and the hand starting lever throwout cam.

4-13 OIL PIPE REMOVAL. Remove the oil circulation pipes that connect the oil pump to the lower crankcase. One pipe is on either side of the engine. Lift the oil level gage and hand scavenge pump from the flywheel housing and set the gage aside.

4-14 UPPER CRANKCASE REMOVAL. Remove 20 - 1/2 in. nuts and washers from the upper crankcase flange. Remove six 1/2 in. cap screws from the upper crankcase flange. The upper crankcase is now free from the lower crankcase and may be lifted. Place suitable sling in the lifting "U" bolts provided in the upper crankcase between

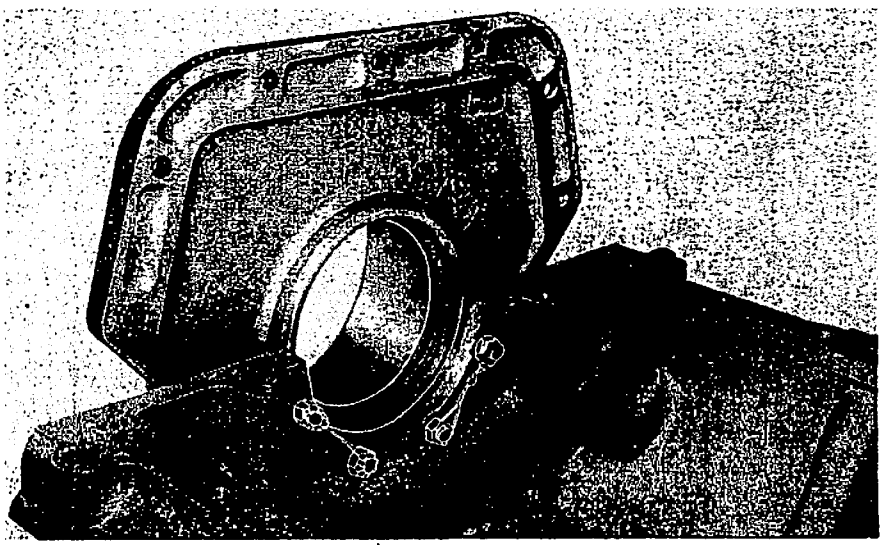


Figure 4-13. Lower Fastenings of Reverse Gear Thrust Bearing Container

the cylinder blocks and lift the upper crankcase and place it on a clean work surface or on a roll over fixture. Both the upper crankcase and lower crankcase must be marked so they can be reassembled properly to assure alignment of the dowel holes.

NOTE

Before rotating the engine crankshaft be sure the camshaft sprockets are both supported as shown in figure 4-7 so as not to bind and break the chains.

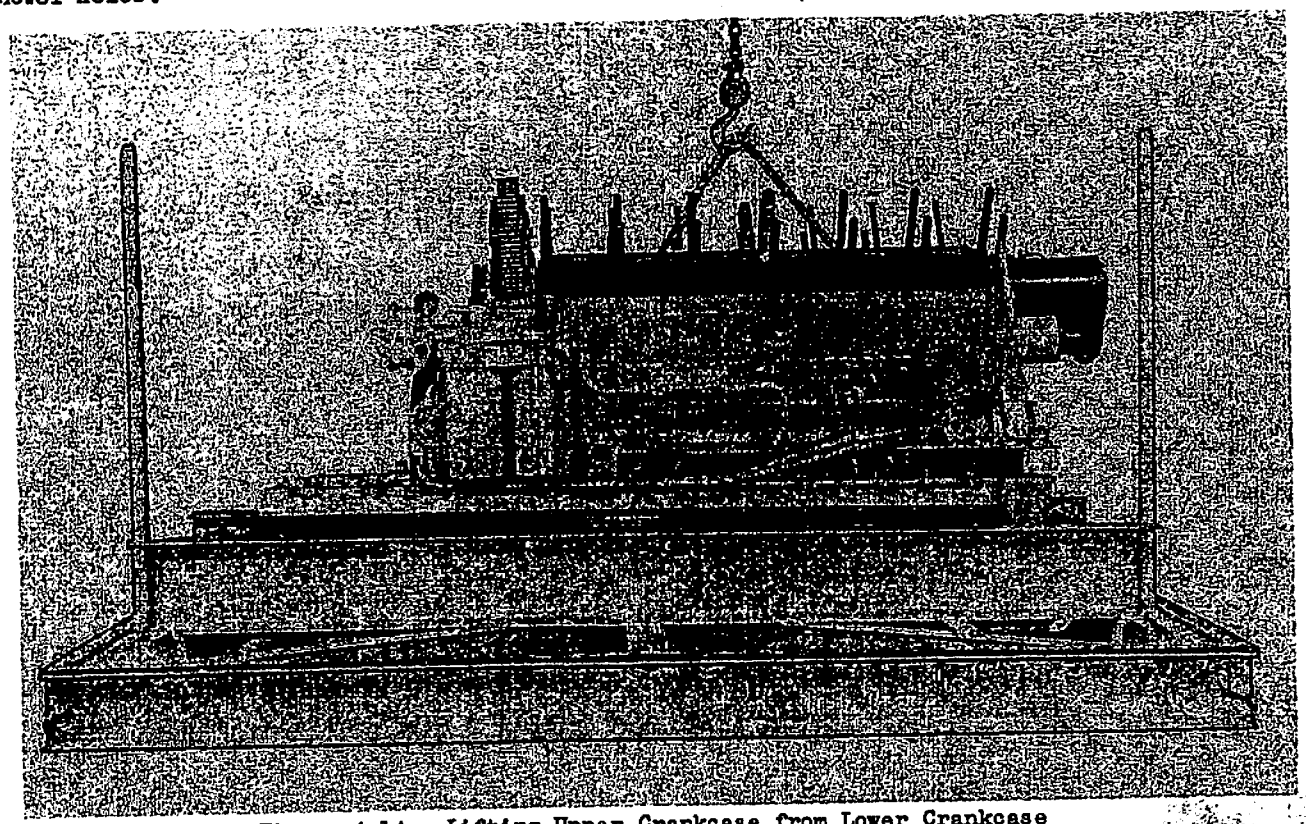


Figure 4-14. Lifting Upper Crankcase from Lower Crankcase

4-15 TURN ENGINE UPSIDE DOWN. At this point in the disassembly operation it is necessary to turn the engine over so the crankshaft is on the top side.

CAUTION

Spacers must be in place on top of each cylinder block to keep the blocks from falling off when the engine is turned over. Refer to figure 4-7.

This may be done with a block and tackle and the engine placed on a sawhorse in the "V" between the cylinder banks. This arrangement will permit the piston and connecting rods to be withdrawn from the engine. If a roll over fixture is available the engine is readily turned over. If the engine is turned over with a block and tackle be careful not to damage any studs, oil pipes or other parts of the engine.

4-16 PISTON AND CONNECTING ROD REMOVAL. With the engine upside down, as noted above, turn the crankshaft until the number one crank is in a convenient position such as at the bottom of its stroke.

Pull all the cotter pins from the connecting rod bolts. Loosen and remove the nuts from one blade connecting rod at a time. The connecting rod bolts are a snug fit in the cap so the cap cannot be merely lifted off. It is necessary to force the rod loose from the cap. This is safely done thru the use of a forked bar, as shown in figure 4-15, with the fork of the tool against the piston pin bosses of the connecting rod, never against the piston. A typical tool is illustrated in figure 4-16. After the connecting rod cap has been pulled off the bolts place a protecting tube over the bolt threads. This is most important so the threads do not scratch the yoke rod bearing shells as the blade rod is pushed out of the engine. Now push the blade rod and its piston out of the engine. Be careful not to mar, scratch or otherwise damage the cylinder bore. It is necessary to catch the piston so it does not drop to the floor and get damaged. As soon as the piston and connecting rod are out of the engine replace the cap and shell to the rod along with its nuts. This is important so the parts will not become mixed as they must be returned to their proper place on reassembly. Do not pull down tight as this only causes difficulty in removal. Now proceed to remove

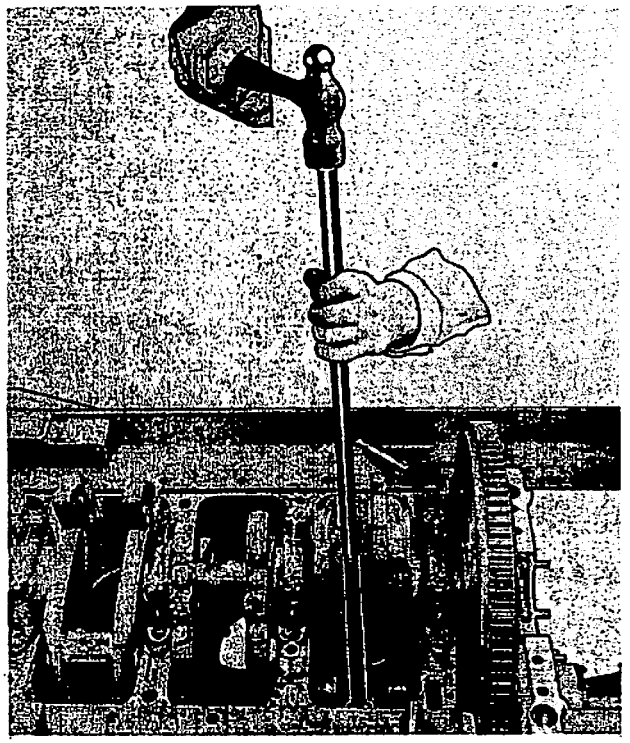


Figure 4-15. Driving Piston and Connecting Rod Assembly from Connecting Rod Cap

the yoked rod in the same manner being careful not to damage the caps, shells, rods or pistons. Continue this work until all the connecting rods and pistons are out of the engine. It is a good idea to mark the rods with a solvent proof tag to show the engine number from which they were removed.

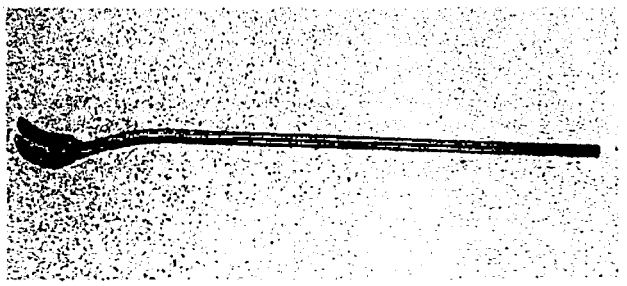


Figure 4-16. Typical Tool for Driving Connecting Rod Assembly from Connecting Rod Cap

4-17 CRANKSHAFT REMOVAL. With the engine still in the upside down position, cut the lock wires from all the main bearing nuts and remove the 14 hex nuts. With a light bar under each end of the main bearing cap, carefully lift the cap from the engine. All the caps are marked on the side to agree with the number stamped on the main bearing web. They are also stamped with a common identifying number to agree with a number stamped on the top of the upper crankcase near the oil pressure regulating valve pad. Remove the gear carrier oil tray. Place protecting tubing over the four main bearing studs at the extreme ends of the crankcase as shown. This is most important to avoid damaging the finely finished main journals as the crankshaft is lifted from the upper crankcase. Place a rope sling around the center cranks and with a hoist carefully lift the shaft from the crankcase. It is necessary to place the lifting device in such a way that the crankshaft is balanced fore and aft. If the shaft is teetered carefully as it is lifted it will not bind in the center thrust bearing. Mark the crankshaft with a durable tag showing the engine number so it can be reassembled to the proper engine. The finely finished journals should all be wrapped with cloth or heavy paper



Figure 4-17. Typical Protectors on Blade Connecting Rod Bolts

to protect them against damage while the crankshaft is out of the engine.

4-18 CYLINDER BLOCK REMOVAL. Turn the upper crankcase so that one of the cylinder blocks is in a horizontal position. See that all

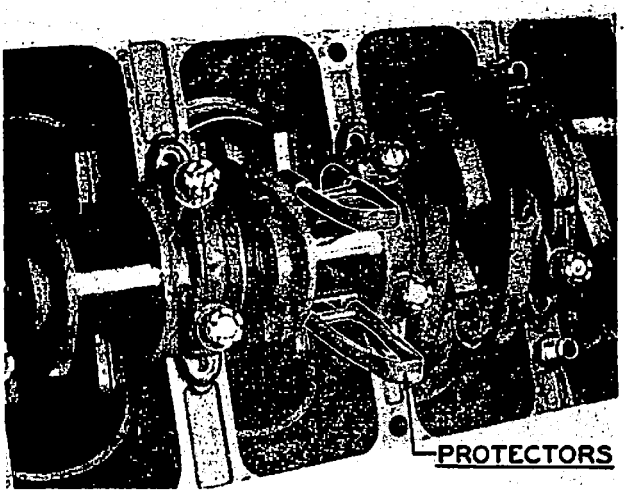


Figure 4-18. Typical Protectors on Yoke Connecting Rod Bolts



Figure 4-19. Lifting Main Bearing Caps

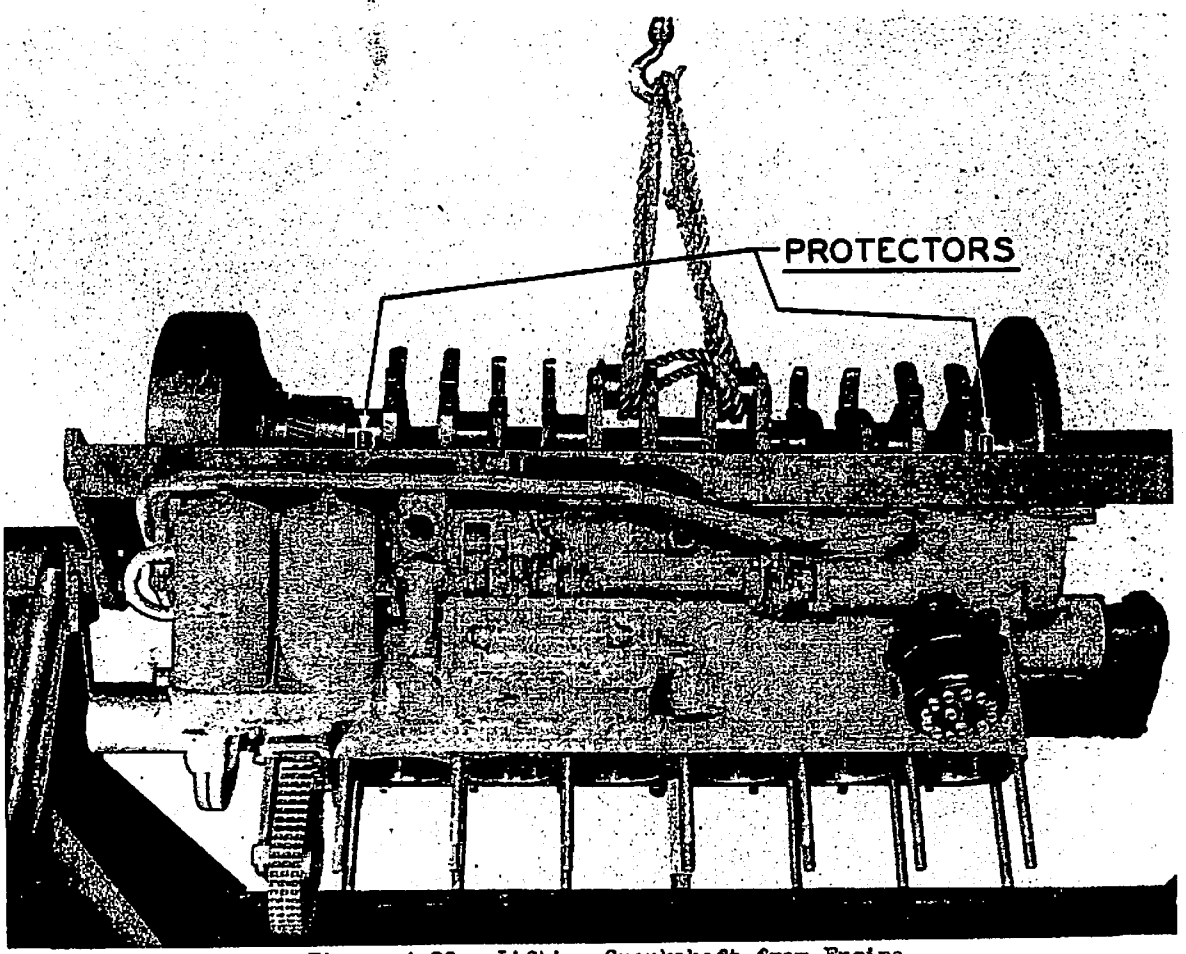


Figure 4-20. Lifting Crankshaft from Engine

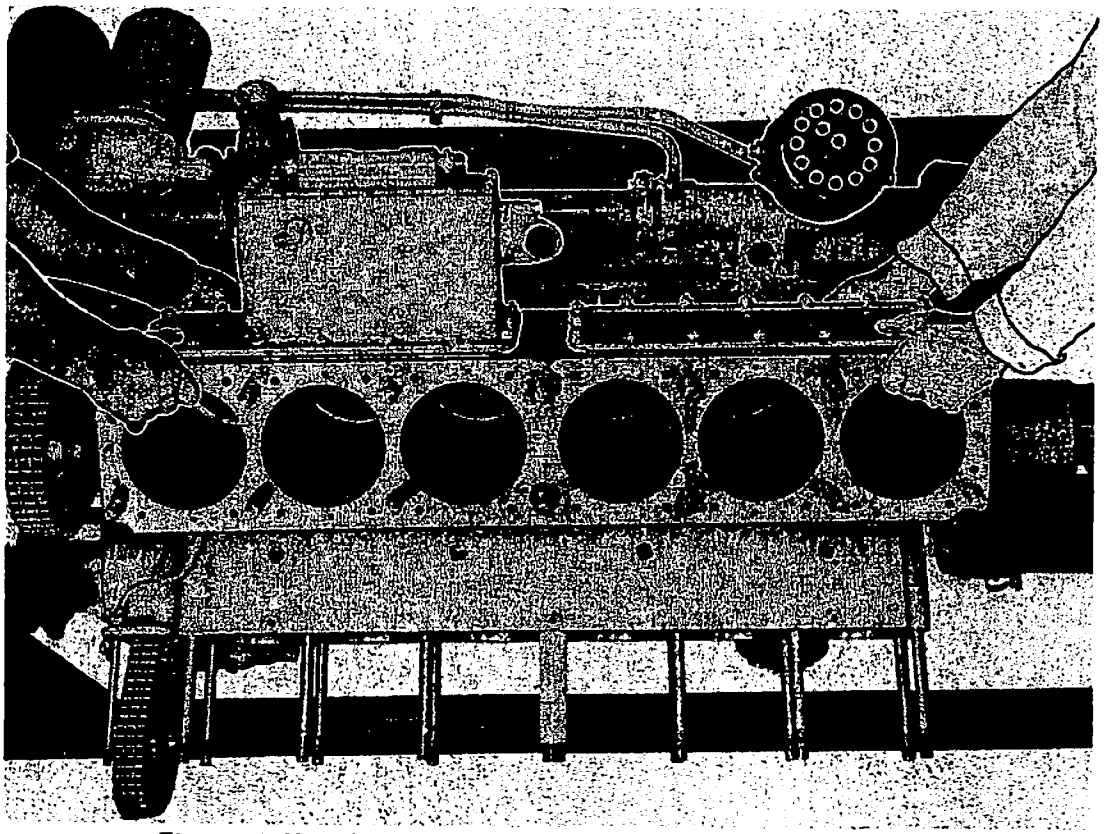


Figure 4-21. Sliding Cylinder Block from Upper Crankcase

water and oil connections to the oil cooler are unfastened. Now remove the nut and spacer previously installed on top of the cylinder block to keep it in place. Slide the cylinder block off its studs onto a suitable support. If the above procedure is impractical for one reason or another then the block may be lifted from the engine by hoisting it temporarily until a rope sling can be passed completely around it. In lifting the cylinder block from the studs it is necessary to teeter it from end to end to prevent its binding on the long studs.

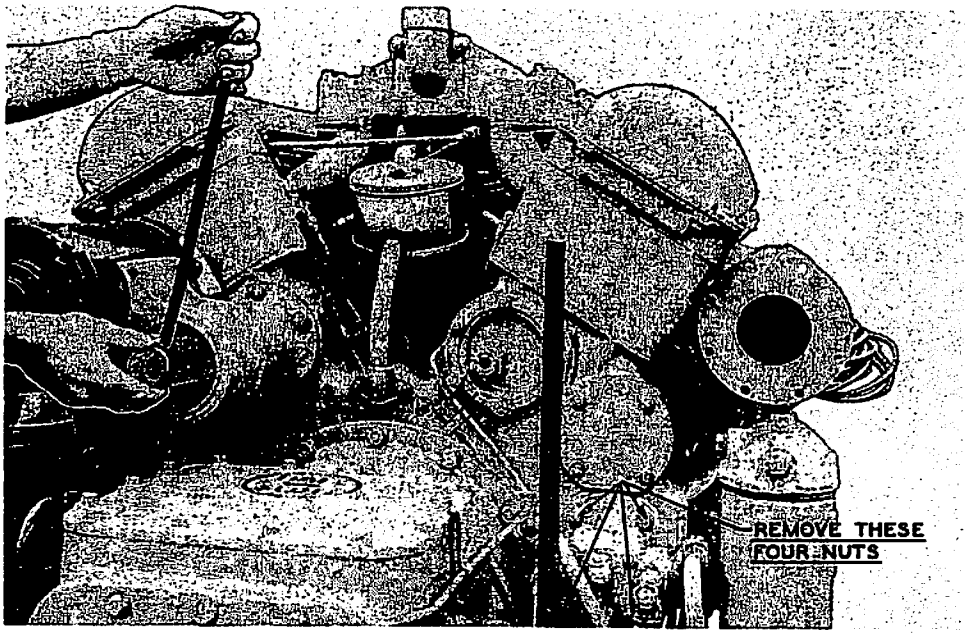


Figure 4-22. Oil Pump Removal

4-19 STARTER REMOVAL. Remove eight 5/16 in. hex nuts and washers from the starter flange that holds the assembly to the flywheel housing. Pull the starter assembly from the engine.

4-20 FLYWHEEL HOUSING REMOVAL. Remove eight 3/8 in. cap screws from the vertical flange of the flywheel housing. Four of these cap screws are on the outside and four are on the inside of the flywheel housing. Lift the housing from the engine and set it aside.

4-21 OIL PUMP REMOVAL. The first step in removal of the oil pump is to disconnect all the oil line connections to the pump housing. Then remove four nuts and washers from the back of the pump as indicated in figure 4-22. The pump may be pulled straight back away from the sprocket housing. It may be necessary to break the body loose from the gasket. This should be done carefully so as not to damage either the pump or its mounting face.

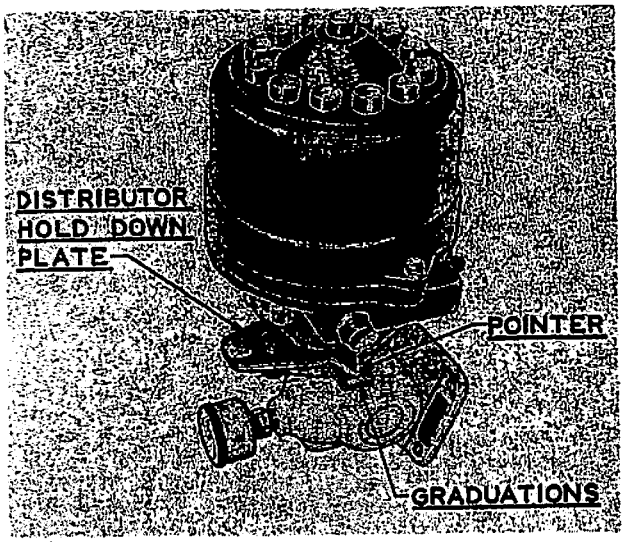


Figure 4-23. Removing Distributor

4-22 REVERSE GEAR UPPER HOUSING ADAPTER REMOVAL. Remove seven 1/2 in. hex nuts and lock washers from the vertical flange face and pull the reverse gear upper housing adapter from the engine.

4-23 OIL FILTER REMOVAL. Remove the oil circulation pipes from the filter. Remove four 3/8 in. hex nuts and washers from the oil filter base and pull the oil filter assembly from the engine.

4-24 BILGE PUMP REMOVAL. The bilge pump is removed by first removing the inlet and outlet flange connections. Then remove the four 3/8 in. nuts and lockwashers from the pump mounting flange. Pull the pump straight back off its mounting studs. If it becomes necessary to pry on the pump in order to separate it from the sprocket housing be careful not to mar the mounting flange so an oil leak will develop.

4-25 CHAIN TAKEUP REMOVAL. Remove six 3/8 in. hex nuts and washers from the chain takeup clamp ring. Remove the clamp ring from the engine. Then reach in thru the top of the sprocket housing with a long slender bar and hold the timing chain away from the idler sprocket so the chain takeup assembly may be removed.

4-26 DISTRIBUTOR REMOVAL. The distributor is removed from the engine as follows. Remove two 1/4 in. cap screws from each end of the distributor hold down plate and then pull the distributor from its drive housing.

4-27 DISTRIBUTOR DRIVE HOUSING REMOVAL. The first step in this procedure is to remove the distributor as explained in paragraph 4-26. Then loosen and remove two 3/8 in. cap screws that hold the flexible coupling to the drive flange on the distributor drive shaft. Now remove the four nuts and washers that fasten the distributor drive housing to the upper crankcase and lift the housing off the studs at the same time flexing the two flexible couplings. With a screw driver carefully pry the flexible coupling spools from the drive dog.

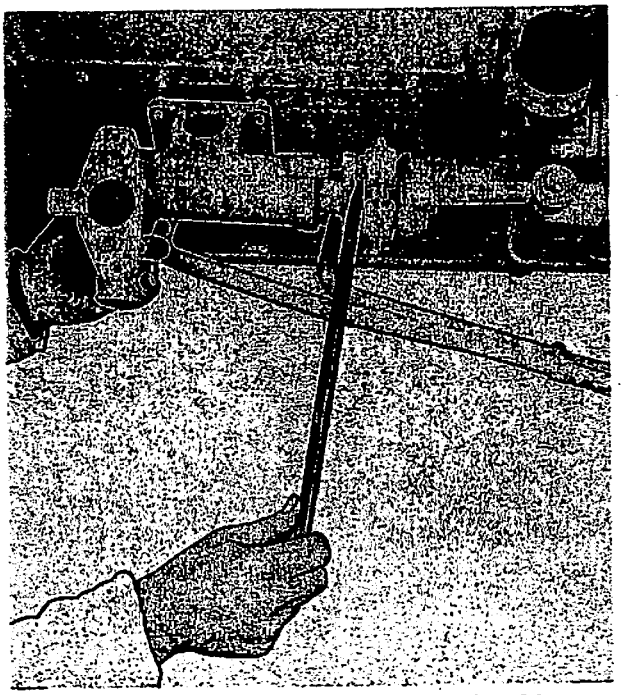


Figure 4-24. Removing Flexible Coupling

4-28 OIL COOLER REMOVAL. Remove 16 - 3/8 in. hex nuts and copper washers. Remove the oil cooler assembly as a unit from the engine. Be careful not to damage the studs or mounting flanges.

4-29 WATER PUMP REMOVAL. Remove two of the 3/8 in. bolts from the flexible coupling and pry the spools loose from the water pump driving dog similar to the idea shown in figure 4-24. Remove the water connections from the water pump. Next remove the four 3/8 in. cap screws from the water pump base where it fastens onto the upper crankcase. One of these cap screws has to be removed by working in back of the water pump pilot gear housing with an open end wrench. After these four screws are loose pull the water pump straight forward. It is not necessary to remove the bearing retainer plate from the side of the sprocket housing in order

to remove the water pump.

4-30 ACCESSORY DRIVE CHAIN REMOVAL. Plug the openings around the chain with cloth as shown in figure 4-25 and grind two pin ends off the chain. Select two pin ends that pass thru a common side bar. Then carefully push the chain pins out of the chain. See that the camshaft sprocket is supported securely in the bracket shown and lift the parted chain from the sprocket. Allow the chain to feed out through the bottom of the sprocket housing. Do not drop the chain abruptly as it may get jammed in the sprockets and be hard to get out. Remove both chains in this manner.



Figure 4-25. Removing Accessory Drive Chain

4-31 GEAR CARRIER REMOVAL. Carefully note the position of the gear carrier housing on the upper crankcase. Punch mark the gear carrier housing and crankcase so they can be reassembled exactly as they came apart. The same side of the gear carrier housing must be in contact with the upper crankcase as it was originally assembled, otherwise the rotation of the accessories will be wrong. Remove the lock wires from the four gear carrier studs and then remove the four 5/8 in. hex nuts. Carefully lift the gear carrier housing from the upper crankcase. The gear carrier housing is located by dowels in the upper crankcase so do not cock the housing so these dowels are damaged. It is wise to mark the gear carrier assembly with the engine serial number so it can be returned to the proper engine on reassembly.

4-32 SPROCKET HOUSING REMOVAL. Remove eight 1/2 in. hex head cap screws from the front vertical face of the sprocket housing. These cap screws are located inside the housing. Now pull the housing off the upper crankcase and set it aside for complete disassembly as discussed later.

4-33 MAJOR ASSEMBLIES. After all the fore mentioned items have been removed, the engine is separated in a number of major assemblies. These, in turn, are now further taken apart into their component parts as described below.

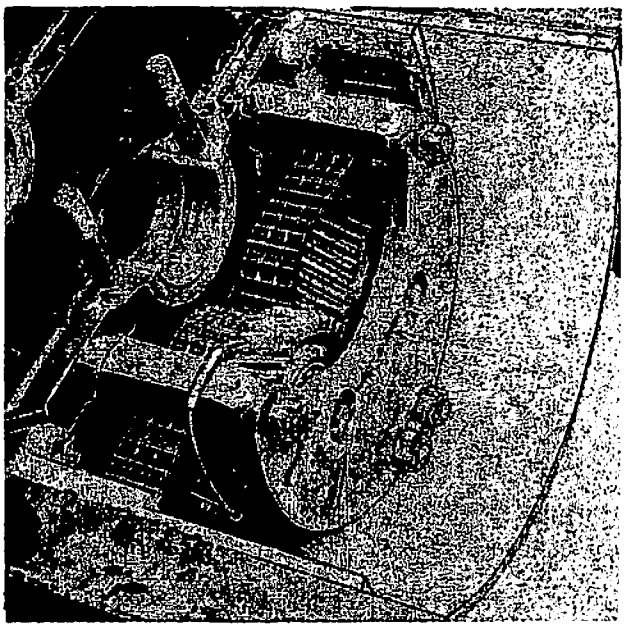


Figure 4-26. Gear Carrier

4-34 CRANKSHAFT DISASSEMBLY. Carefully tag and mark, with durable ink, the flywheel and hand starting ratchet with the engine model number and serial number so they can be reassembled to the proper engine. Now remove the drive flange, reverse gear drum and the flywheel from the crankshaft. Do not remove the crankshaft counterweights unless necessary for regrinding the crankshaft or replacement of the counterweights. The running balance of the engine is dependent on the matched counterweights. If they are disturbed it is necessary to rebalance the crankshaft. Push the crank pin hole seals out of the crankshaft. This must be done with a typical tool as shown in figure 4-27. It is necessary to push the seals

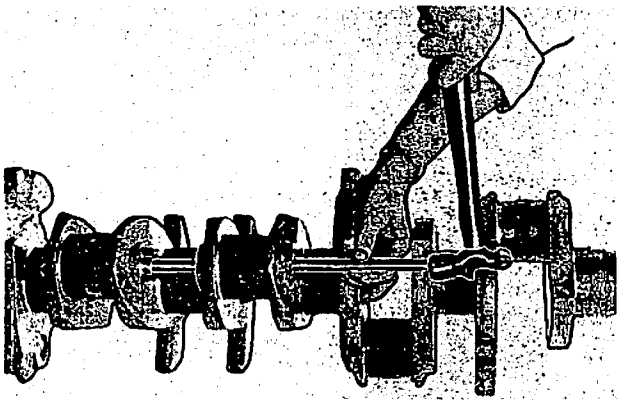


Figure 4-27. Typical Drift used to Remove Crankshaft Pin Seals

out of number three and four throws as shown otherwise they will not clear the adjacent crank webs. Normally it is unnecessary to remove the reverse gear drive flange. This part is considered as a semi-permanent assembly to the crankshaft. It may, however, be removed if necessary to replace the gear. Care must be used to prevent damage to the crankshaft. As this disassembly must be made with tremendous pressure it is best to locally heat the flange to from 177 to 232°C (350 to 450°F) before attempting to remove it. The lockwasher and nut may be removed from the flange after it is taken from the crankshaft assembly.

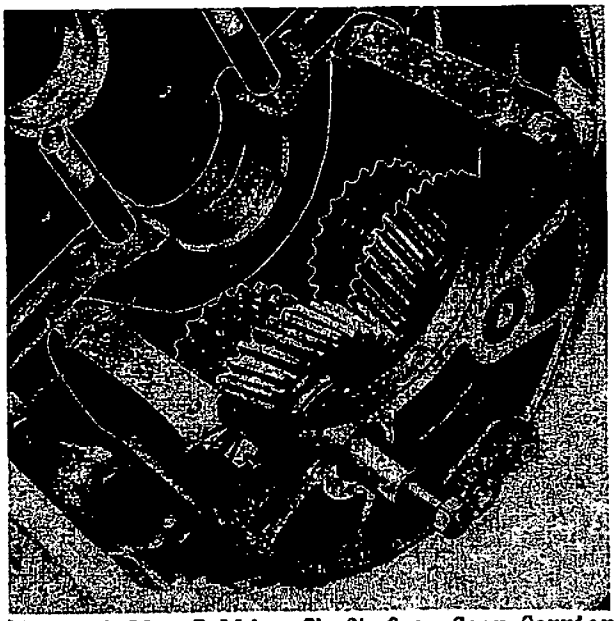


Figure 4-28. Pulling Shaft from Gear Carrier

4-35 GEAR CARRIER DISASSEMBLY.

a. Remove the individual parts from the gear carrier as follows. Remove the 1/4 in. copper tubing from the gear carrier. Cut the lock wire from the two 7/16 in. cap screws and remove the screws from the assembly. Now screw a 1/2 - 20 cap screw into the shaft end and thus pull the shaft out while holding the accessory drive gear and sprocket by hand to keep it from falling out. After the shaft is removed then lift the gear and sprocket from the gear carrier housing. Remove both gears in this manner. Remove all pipe plugs from the gear carrier housing.

b. The anti-friction bearings may be pulled from the accessory drive gear and sprocket assembly. This is done by using a slender drift against the bearing. Place the gear end of the unit on a couple of one in. high spacers and then place a drift thru the bore of the top bearing and allow the drift to rest against the lower bearing. Push the interior spacer aside. Strike the drift lightly and work all around the bearing while knocking it out to keep it from binding in the bore. Be sure the spacers are far enough apart so the bearing will clear them as it comes out. After the first bearing has been removed, turn the accessory drive gear and sprocket over and knock out the remaining bearing. This removal operation will quite likely damage the anti-friction bearings beyond further use. Be careful so as not to mar the counterbore in the accessory drive gear and sprocket.

4-36 FLYWHEEL HOUSING DISASSEMBLY. This is rather a simple assembly and the primary disassembly operation is to press the starter drive bushing out of the flywheel housing.

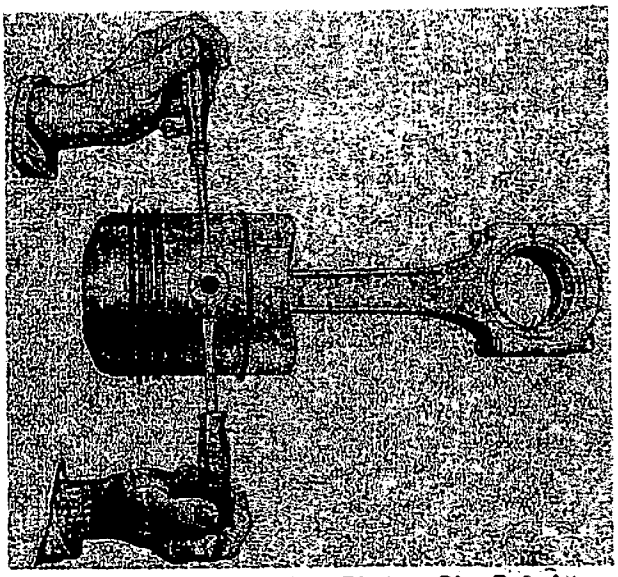


Figure 4-29. Lifting Piston Pin Retainer

4-37 CYLINDER BLOCK DISASSEMBLY. The cylinder block has been intentionally kept simple to make it easy to change. No special instruction of any sort are necessary for its disassembly.

4-38 PISTON AND CONNECTING ROD DISASSEMBLY. The first step in disassembly is to lift the piston pin retainers from the piston. Place the piston on a clean surface and with a couple of screw drivers lift one of the retainers out. Turn the piston and connecting rod assembly over and push the remaining piston pin retainer out. Now push the piston pin carefully from the assembly. This may be done using a special soft drift. Handle the piston, piston pin and connecting rod carefully as they are most important parts of the engine and must not be damaged by careless handling.

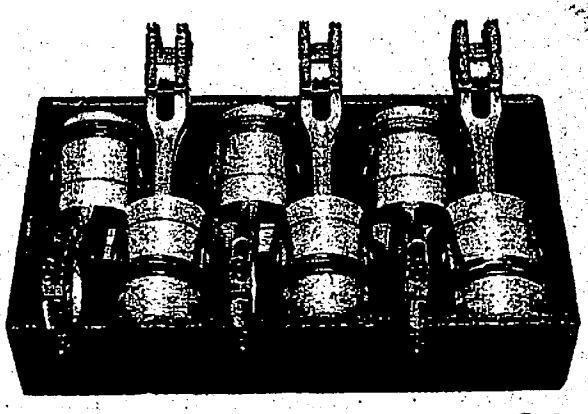


Figure 4-30. Piston and Connecting Rod Assemblies in a Protective Box

4-39 CONNECTING ROD DISASSEMBLY. Remove the nuts from the connecting rod cap. Pull the cap from the rod as well as the bearing shells. The caps and bearing shells must be placed in racks so they can be kept in order and protected until such time as they can be reassembled to the engine. Press the piston pin bushing from all the connecting rods.

4-40 PISTON DISASSEMBLY. In an overhaul, such as outlined in this handbook, the pistons and piston rings are always discarded so there is no purpose served in disassembling them.

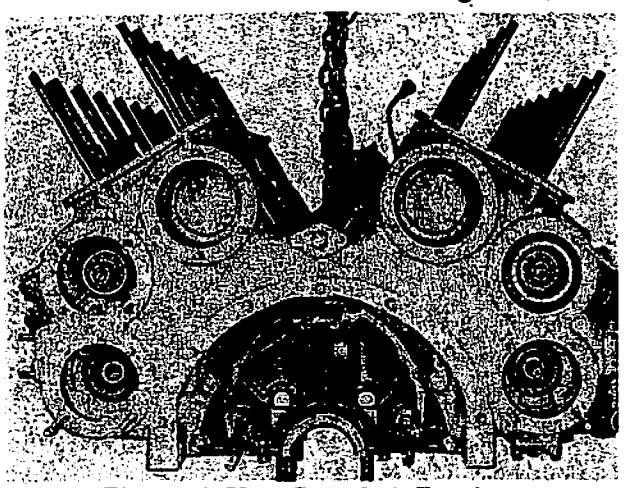


Figure 4-31. Sprocket Housing

4-41 SPROCKET HOUSING AND GENERATOR DRIVE DISASSEMBLY.

4-42 GENERATOR DRIVE DISASSEMBLY. After the generator has been removed, as outlined in paragraph 4-9, then the generator drive may be removed as follows: Disconnect the tachometer drive and set it aside. Remove four 3/8 in. cap screws and lockwashers from both the generator belt guard and tachometer adapter plate assembly and the engine. Remove the two V-belts. Now remove eight 1/4 in. cap screws from the tachometer drive flange. Remove the drive flange from the engine, being careful not to bend or otherwise damage the tachometer drive spindle. Remove the cotter pin from the end of the generator drive shaft and then unscrew the 3/4 in. nut. Remove the generator drive pulley. Now remove four 3/8 in. nuts and lockwashers from the generator drive shaft bearing retainer and pull the retainer from the engine. Cut the lockwire and remove four 3/8 in. cap screws from the generator drive shaft flange and pull the shaft free. The generator and idler sprocket support clamp ring assembly nuts and washers are then removed from the assembly.

4-43 SPROCKET HOUSING DISASSEMBLY. Remove the cotter pins and hex nuts from the bilge pump and generator drive sprocket shafts. Pull the drive sprockets from the shafts. Press the bilge pump and generator drive sprocket shafts from the sprocket housing. Carefully support the housing directly beneath the shaft bosses so it will not be over-stressed or cracked when the shafts are pressed out. Remove the accessory drive sprocket bearing retainers from both sides of the sprocket housing. Remove the idler sprocket support assembly from both sides of the sprocket housing.

4-44 IDLER SPROCKET SUPPORT DISASSEMBLY. Release the locking tang from the retainer nut and unscrew the nut with a spanner wrench. Press the idler sprocket assembly from the shaft. Knock the anti-friction bearings out of the idler sprocket. The bearings are held in place by retainer rings so the interior spacer must be pushed aside and a soft brass drift used to knock the bearings out by working thru the center hole of the bearing bore. Press the shaft from the idler sprocket support.

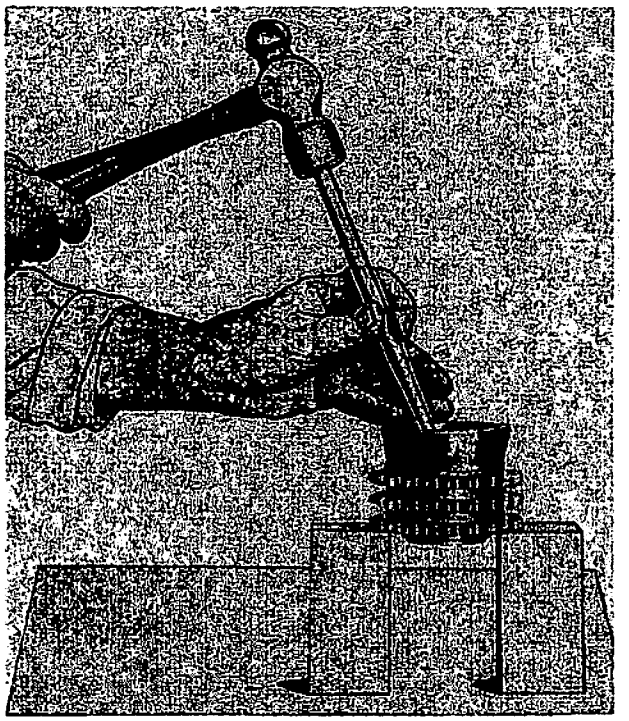


Figure 4-32. Removing Ball Bearings

4-45 CYLINDER HEAD AND MANIFOLD DISASSEMBLY. Remove all the 7/16 in. hex nuts and washers from the intake manifold elbows and remove the elbows from the cylinder head. Then remove all the 7/16 in. hex nuts and washers from the exhaust manifold. Frequently the manifold is difficult to remove from the cylinder head and care must be used so the manifold is not damaged. It may be struck with a soft lead hammer or wooden mallet. The manifold has unsupported walls in some areas and these points must not be struck as the wall will give way. Strike alternately from end to end and top side then bottom side to carefully work the manifold loose. Some of the brass dowels may be left sticking in the cylinder head. These must be removed by twisting with pliers. This will probably damage them beyond repair.

4-46 CYLINDER HEAD DISASSEMBLY. Remove 14 - 1/2 in. nuts and washers that hold the rockerarm shaft caps in place. Now lift the rockerarm shaft assemblies, one at a time, from the engine. Slide the rockerarms and spacing springs off one end of the rockerarm shaft. Now place an auxiliary bar 1-1/8 in. in diameter in the rockerarm shaft brackets and secure in

several places with caps and nuts. Install a valve support piece in the combustion chambers to hold the valves closed.

NOTE

Do not fit this valve support piece until after the rockerarms have been removed otherwise the valves may be bent.

If a valve support piece is not available a 5/8 diameter soft brass bar or wooden dowel may be poked thru the spark plug hole to support the valve while its keys are being removed. With a special tool 309526 depress the valve collar and remove the valve keys. A small screw driver is handy in this operation. After all the valve keys are removed lift all the collars out as well as the valve springs. Remove the auxiliary 1-1/8 in. dia bar and then lift all the camshaft brackets from the cylinder head. Now lift the camshaft from the engine and carefully tag it with the engine model and serial number as well as to whether it was taken

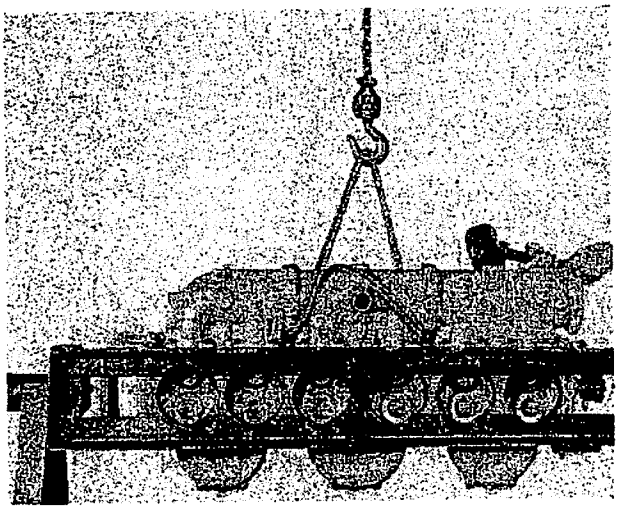


Figure 4-33. Striking Exhaust Manifold

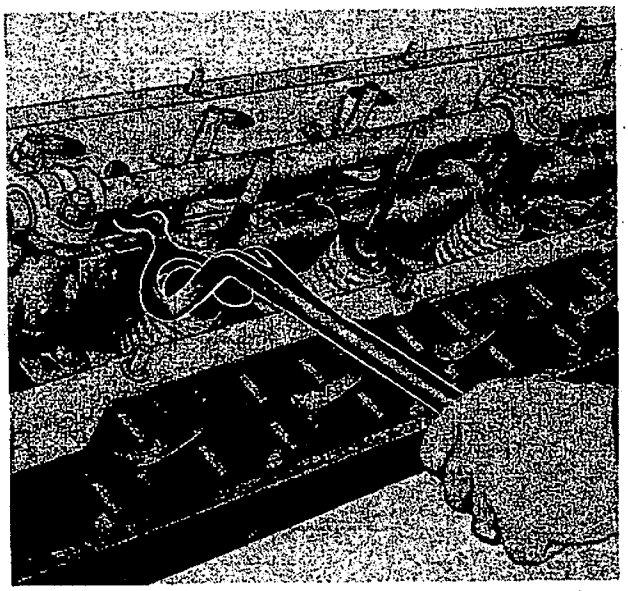


Figure 4-35. Removing Valve Springs

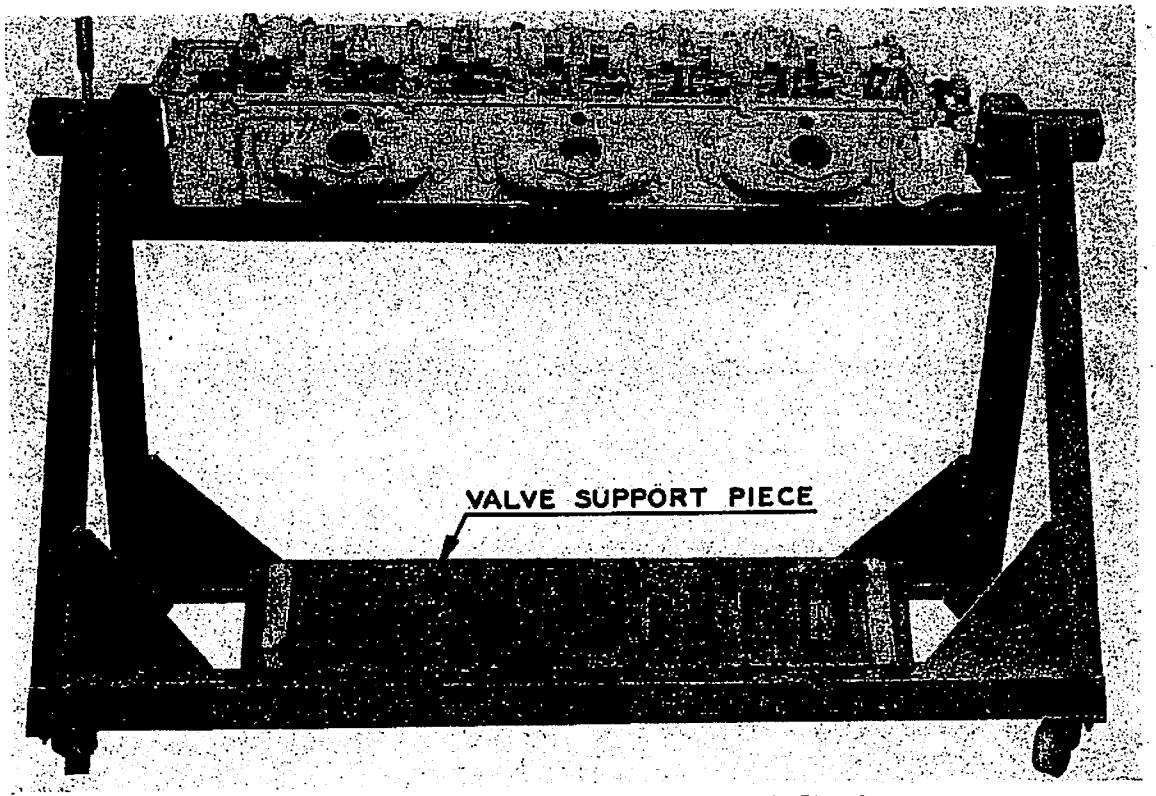


Figure 4-34. Cylinder Head in Typical Stand

from the right hand head or the left hand head. Pull the small oil supply pipe from the cylinder head being careful not to bend it. Turn the cylinder head over and remove the valve support piece. Lift all the valves from the head. Remove the 1 in. square head pipe plug from the front of the cylinder head. Remove the rocker-arm cover base. Remove all dowels from the exhaust side of the cylinder head. Drive all the valve guides out of the head from the combustion chamber end as shown in figure 4-47.

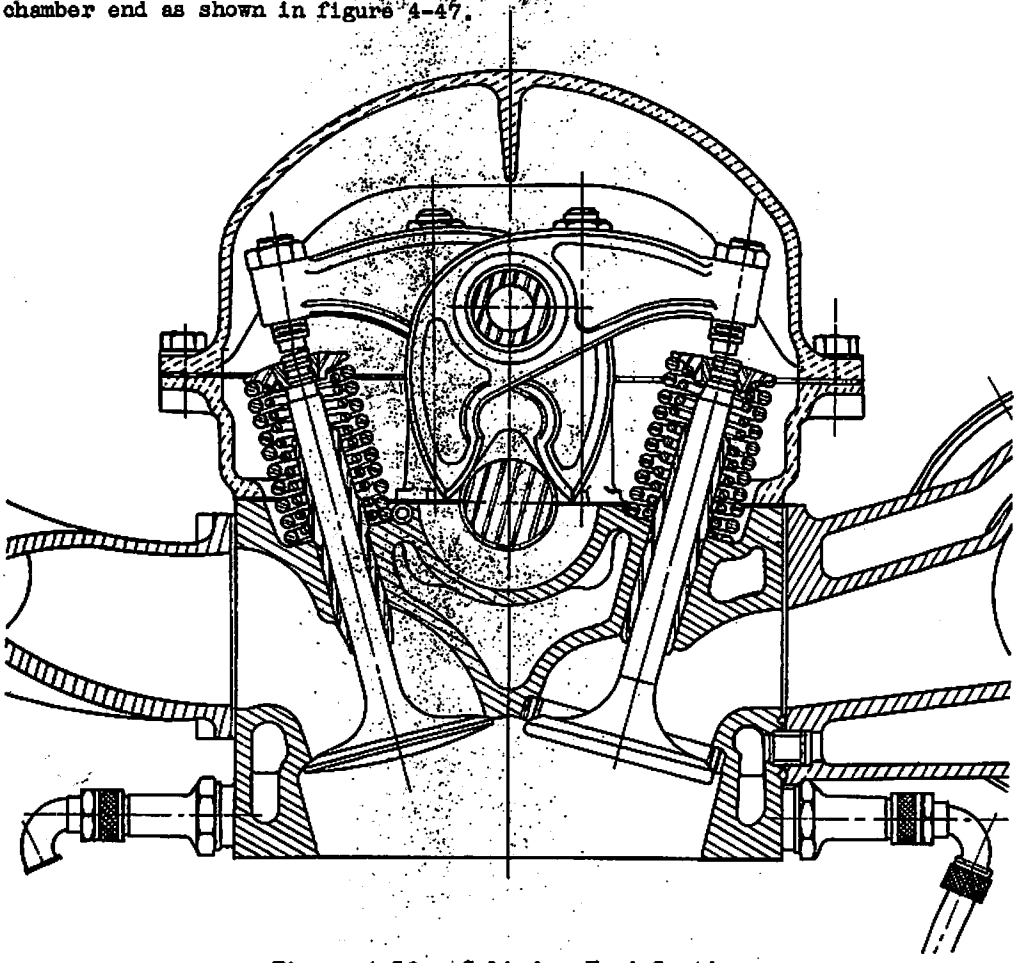


Figure 4-36. Cylinder Head Section

4-47 LOWER CRANKCASE DISASSEMBLY. Remove the lower cover plate from the front end of the oil sump. Remove all pipe plugs.

4-48 OIL FILTER DISASSEMBLY. Remove two 1/2 in. cap screws from the top of the oil filter bracket and then remove the two oil filter shells and elements. Discard the oil filter elements. Remove all pipe plugs and tubing fittings from the assembly. Pull the by-pass valve and valve spring from the back of the bracket. With a wide blade screw driver reach thru the bottom hole in the filter bracket and unscrew the oil pressure relief valve plug. Pull the valve and spring from the bracket.

4-49 OIL PUMP DISASSEMBLY. Pull the oil pump drive shaft from the pump. This should slide out easily. Remove three 3/8 in. hex nuts and washers from the rear face of the pump. Now carefully knock the pump apart at the center. Use a brass or plastic hammer and gently hit the pump all around the body. Do not use a steel hammer or the aluminum housing may be damaged. Under no circumstances must a wedge be driven into the joint of the pump as this will damage it and result in an oil leak. Also separate the pump diaphram from the body by carefully striking its edge. Do not mar the ground face. The oil pump gears may now be lifted out. Press the idler shaft from the oil pump scavenge body. Pull the roller bearing cup from the oil pump pressure body with a typical tool such as illustrated.

4-50 WATER PUMP DISASSEMBLY. Clamp the splined end of the pump drive shaft in a soft jawed vise. If a soft jawed vise is not available an accessory drive sprocket may be placed over the splined shaft so it can be held from rotating while the 5/8 in. nut is removed from the end of the drive shaft. Pull the flexible coupling flange from the pump drive shaft. If it is necessary to use a gear puller it must be hooked behind the ears of the coupling flange. Remove the key from the pump shaft. Remove six 5/16 in. nuts from the water pump pilot gear cover and loosen the cover by tapping it lightly with a rawhide hammer. Remove the pilot gear cover from the pump and wash all the oil off the pilot gears with solvent. Pull the pilot drive gear

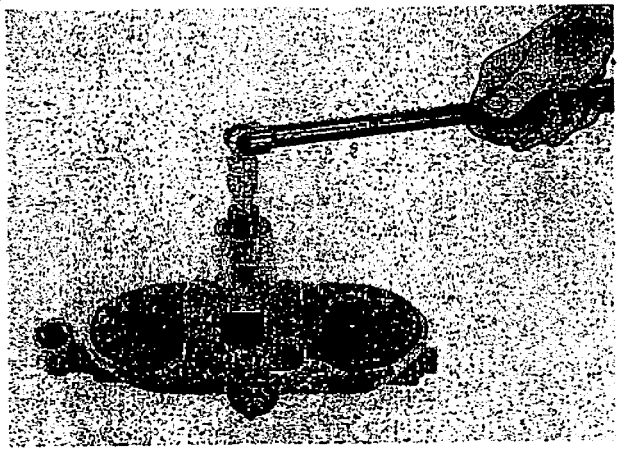


Figure 4-37. Removing Slotted Plug from Oil Filter Base

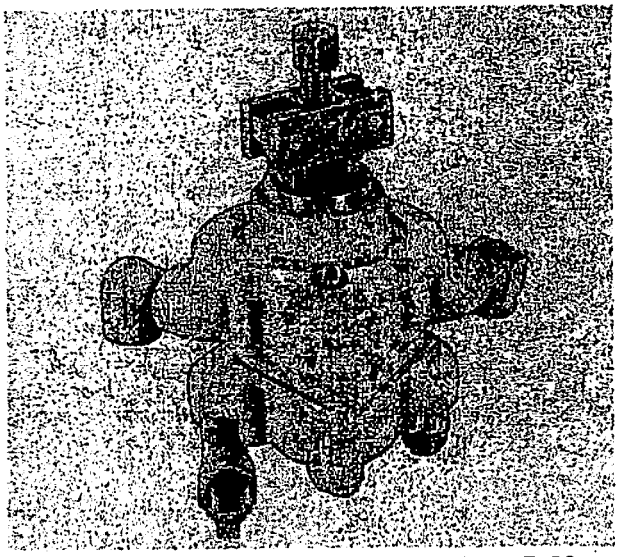


Figure 4-38. Typical Tool used to Pull Bearing Cup from Oil Pump

and the sleeve off the pump drive shaft. It may be necessary to place a couple of wedges under the pilot drive gear and then hit the drive shaft end sharply with a soft nosed hammer to start the gear off the shaft. The sleeve is hardened and may be split with a chisel if necessary to remove it. Support the shaft before striking the sleeve. Again hold the pump drive shaft from rotating and remove the 1/2 in. hex nut from the water pump driven shaft. Use a 2 in. long piece of mild steel 3/4 in. wide x 3/8 in. thick drill a couple of 9/32 in. diameter holes in it on 1-1/2 in. centers so they register with the tapped holes in the pilot driven gear. Fit a couple of 1/4 - 28 cap screws to the steel piece and then screw them into the pilot driven gear thereby pulling the gear off the pilot driven gear hub. Pull the hub off the shaft and remove all the keys from both the water pump drive and driven shafts. Remove the spring locks from the packing nuts both ends of the pump. Back off all

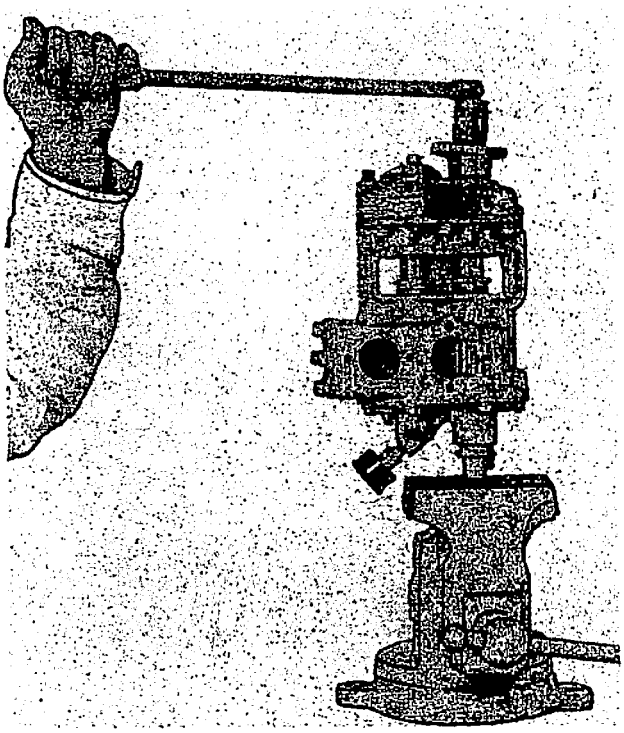


Figure 4-39. Removing Nut from Pump Drive Shaft

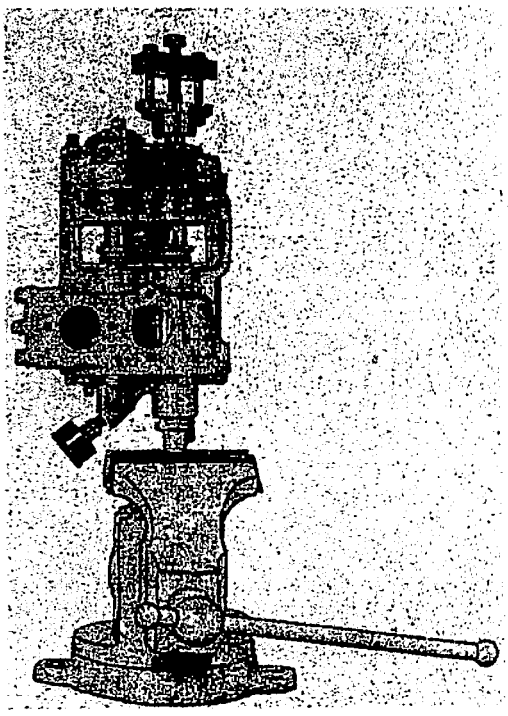


Figure 4-40. Pulling Coupling Flange from Pump Shaft

packing nuts. They are all right hand threads. Now remove six 5/16 in. hex nuts from the water pump cover and carefully remove the cover from the pump. Use no wedge or screw driver to open up the gasket joint as this will spoil the gasket faces and thus cause the joint to leak on reassembly. Pull both the water pump drive

and driven shafts from the pump body. The gears may now be pressed off the shafts if they are to be replaced. With a screw driver carefully work the bearing retainer rings from their recesses over the anti-friction bearings. In some case it may be best to drill two small holes in the ring ends and then use a typical tool as shown in the figure 4-43. After the retainer rings are removed knock the bearings out using a soft brass drift. Tap the bearing all around its circumference to avoid binding in the bore. Now pull the oil retainer from the water pump body.

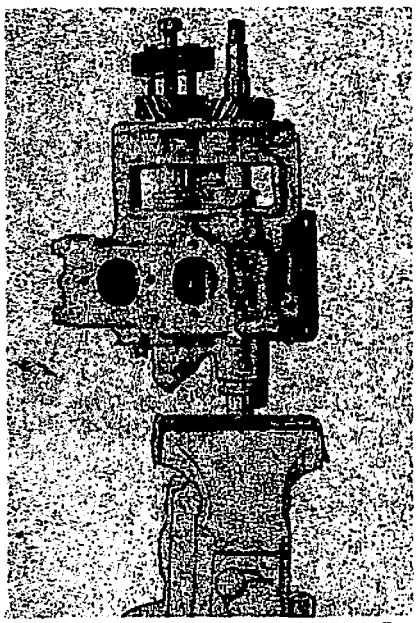


Figure 4-41. Removing Water Pump Pilot Driven Gear

4-51 DISTRIBUTOR DRIVE HOUSING DISASSEMBLY. Remove two 3/8 in. hex nuts from the distributor drive housing cover. Pull the cover from the assembly and then withdraw the distributor drive shaft assembly. Clamp the distributor drive gear in a soft jawed vise and then remove the 1/2 in. hex nut. Press the gear and both bearings from the shaft. Press the oil retainer from the distributor drive housing cover.

4-52 INTAKE MANIFOLD DISASSEMBLY. Remove the throttle control shaft from the carburetor extension pieces. This is done by loosening all the four control levers and then pulling the shaft out. Remove the fuel pipes and priming pipes. Remove the three carburetors and carburetor extensions. Remove the throttle shaft bracket and thermostat. Remove both end covers from the manifold.

4-53 EXHAUST MANIFOLD DISASSEMBLY. Remove the bands from the two expansion joints and pull the rubber rings from the joint. Examine the flange faces and remove any hollow brass dowels that may have stuck to the manifold.

4-54 OIL COOLER DISASSEMBLY. Remove the hex nuts from the oil cooler cover and then carefully pull the cover and the core from the cooler. Use care so as not to damage the cover, or the gasket faces of the cover and core. Do not drive a wedge into the gasket joint. Tap the

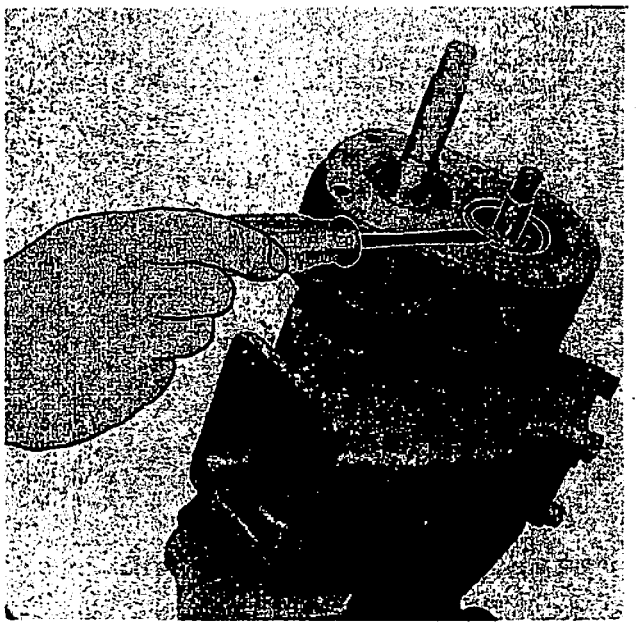


Figure 4-42. Removing Ball Bearing Retainer Ring with a Screw Driver

joint from side to side with a soft nosed hammer until the parts can be separated. Set the core aside where the small tubes will not be damaged. Remove the tubing fittings from the cover and pull the by-pass valve and spring from the cover.

4-55 STARTER DISASSEMBLY. Remove six 1/4 in. cap screws and five 1/4 in. bolts from the starter drive housing cover flange. Pull the cover from the assembly. Lift the starter gear idler from the idler gear shaft. Pull the starter drive gear from the starting motor shaft. Remove the key from the motor shaft. With a screw driver, take out the two counter sunk head screws that are on either side of the

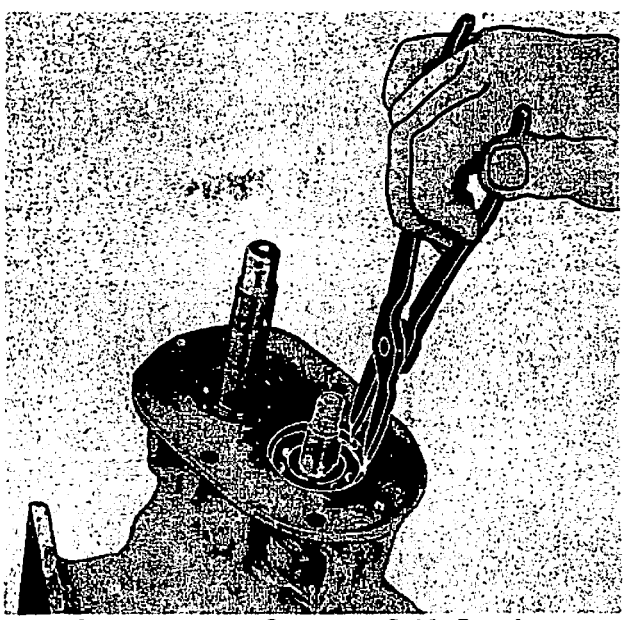


Figure 4-43. Removing Ball Bearing Retainer Ring with Typical Pliers

idler gear shaft. This will permit the starter drive housing to be removed from the starting motor. On the Bendix drive there are six coil pressure springs arranged parallel to the shaft. Between a couple of these springs there is a slotted head screw of 3/8 in. diameter. With a screw driver, slide the lock wire out of the screw head and remove this screw. This will permit the Bendix drive shaft and starter driven gear to be separated from the starter drive housing. Press the gear from the shaft. Press the idler gear shaft from the starter drive housing. Press the needle bearings from the idler gear and from the starter drive housing. Press the bushing from the starter drive housing.

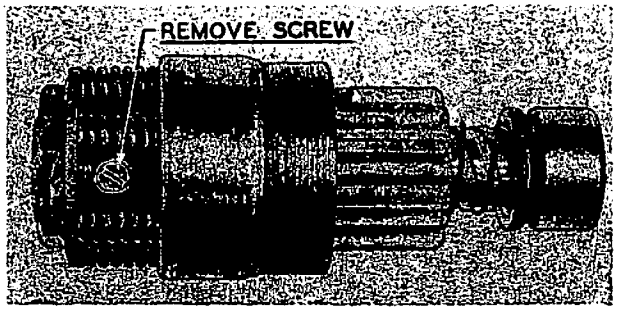


Figure 4-44. Bendix Drive

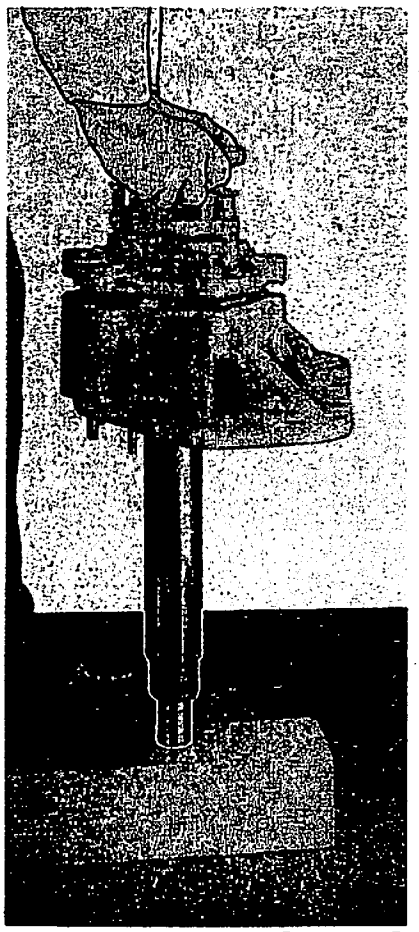


Figure 4-45. Removing Reverse Gear Thrust Bearing Container

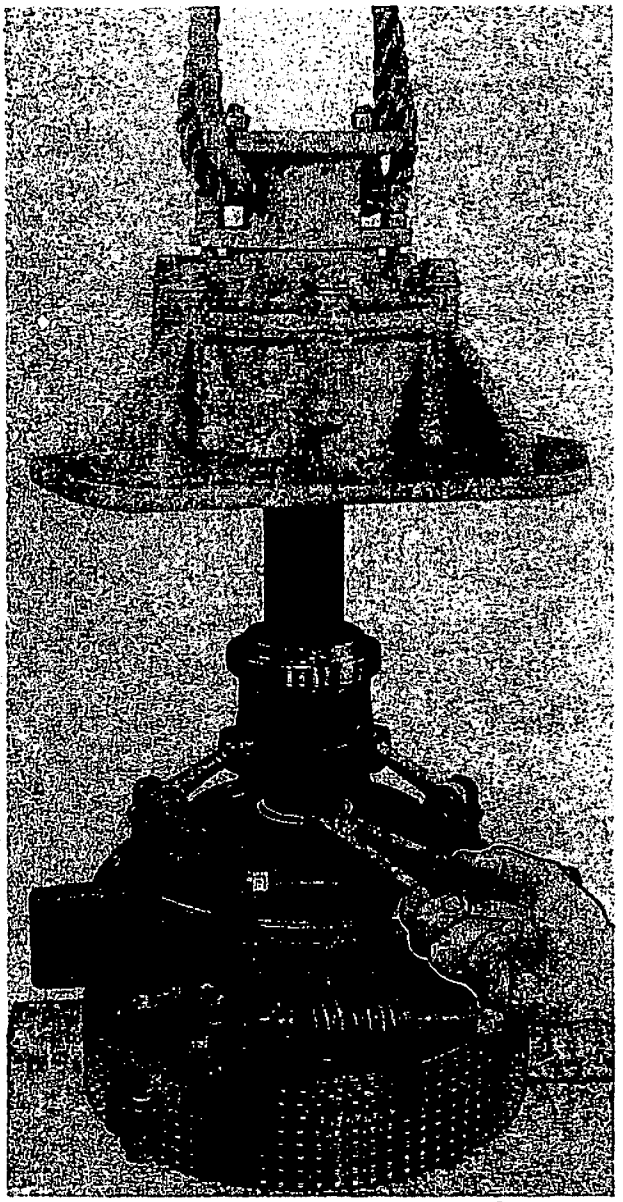


Figure 4-46. Removing Reverse Gear Shaft Lock Ring

4-56 REVERSE GEAR DISASSEMBLY.

a. The reverse gear shaft is removed from the assembly by unscrewing reverse gear bevel driven gear lock nut "19" and then opening reverse gear bevel driven gear lock ring thus releasing the reverse gear shaft so it can be pulled from the assembly. The reverse gear thrust bearing retainer assembly will come out along with the shaft. Refer to figures 4-8 and 4-9. The reverse gear thrust bearing container is removed from the thrust bearing by removing six 5/8 in. cap screws from the reverse gear thrust bearing container. Now if the assembly is raised up and dropped on the end of the reverse gear shaft the container will slide off the bearings as it is not very tight on the outside diameter of the ball thrust bearings. Drop the shaft onto a wooden block never on a concrete floor or other hard surface. Release the lock washer from the ball bearing lock nuts and unscrew them from the reverse gear shaft with a spanner wrench. Press

the ball thrust bearings from the shaft. The retainer assembly must be pushed back against the propeller flange so that bars can be fitted each side of the shaft to bear against the thrust bearing inner race. After the ball bearings are removed the retainer assembly will slide off the shaft.

b. For disassembly of the remainder of the reverse gear refer to applicable Air Force and Navy handbooks.

4-57 CARBURETOR DISASSEMBLY. Refer to War Department Technical Manual TM9-1826C Ordnance Maintenance Carburetors (Zenith).

4-58 ACCESSORY DISASSEMBLY. The details for disassembly of the following enumerated accessories refer to applicable Air Force and Navy handbooks.

a. Ignition Timing Distributor
b. Generator
c. Apparatus Box
d. Radio Shielding
e. Starting Motor
f. Bendix Drive (Starter)
g. Fuel Pump (Mechanical)
h. Fuel Pump (Electrical)
j. Tachometer Sending Unit

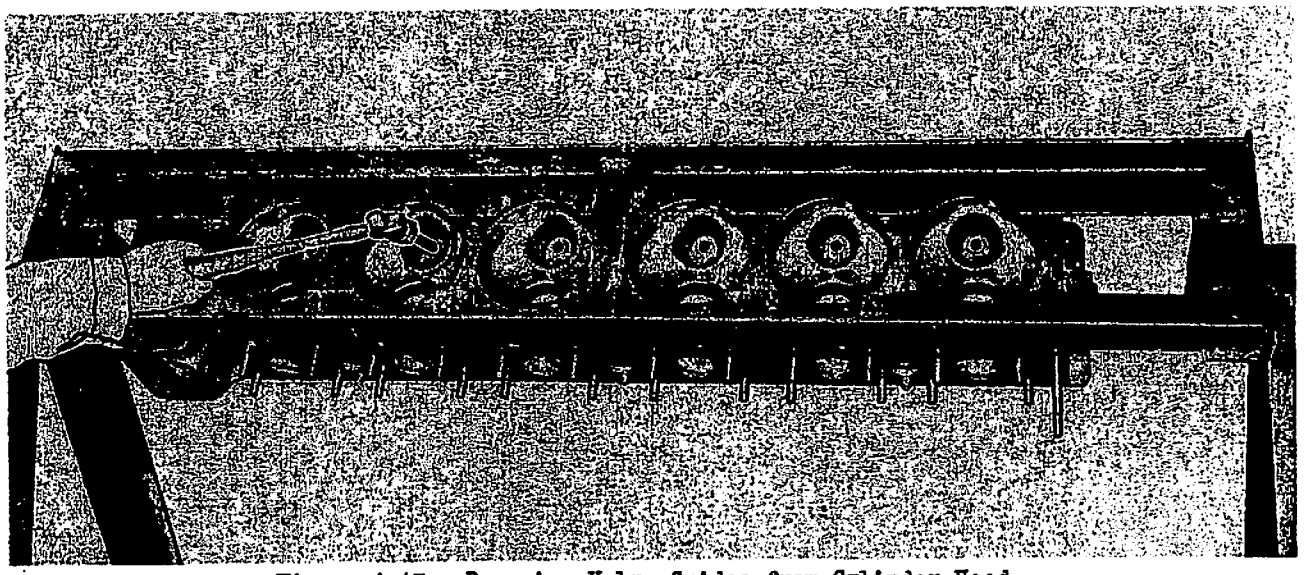


Figure 4-47. Removing Valve Guides from Cylinder Head

CLEANING

5-1 GENERAL. After all the engine parts have been disassembled as described in section IV they must be prepared for degreasing and cleaning.

5-2 GASKET FACES. All gasket faces must be scraped to clear them of gasket cement and old gasket material. Do not scrape in such a manner as to cut any metal from these faces. A fine wire brush may be used around the studs to clean up the gasket face.

5-3 IDENTIFYING MARKS. See that all tags and other identifying marks are secure and are of such a nature that they will not be destroyed by the cleaning solution.

5-4 OIL PASSAGES. Remove plugs from all oil and water passages so they may be cleaned and blown out with cleaning solution.

5-5 ELECTRICAL EQUIPMENT. Be careful in cleaning electrical parts so as to avoid destroying the insulation. Follow the appropriate instruction publication for cleaning the various accessories.

5-6 ARRANGEMENT OF PARTS. Lay all the parts out so that all surfaces can be reached with the cleaning solution. Finely finished parts must not be stacked in such a way that any of the finished surfaces will be damaged. Stacking of any sort should be avoided otherwise dirt and grit from the top parts will run down onto the lower parts. Allow sufficient space between parts so they can be turned over during the cleaning operation without striking adjacent parts. Do not subject rubber parts to prolonged immersion in cleaning solutions. This pertains to the flexible couplings that drive the water pump and distributor.

5-7 CLEANING AND DEGREASING PROCESSES. Two methods of degreasing are in general use for preparing the parts of a disassembled engine for inspection.

5-8 WASHING. The removal of grease and soft carbon compounds may be accomplished by spraying the parts with a petroleum solvent such as kerosene, cleaner's naphtha or a white furnace oil. Gasoline containing tetraethyl lead should never be used.

CAUTION

When using any inflammable cleaning solution take all possible precautions against explosion or fire. Keep a serviceable fire extinguisher near by and do the work out of door or in a well ventilated building. Do not allow appreciable quantities of the vapor or solution to collect in open containers.

It is advisable to use a high grade white furnace oil of 38 to 40 specific gravity. The parts may be immersed in the oil or be sprayed in a protected hood with the oil and clean dry compressed air. In case perspiration is to be removed a second solvent cleaning with methyl alcohol will be effective.

5-9 VAPOR CONDENSATE. For bearing shells and other parts where a more thorough cleaning is desired, the vapor condensate method is preferred. Equipment for this procedure consists of a closed vessel containing the solvent with heating coils in the bottom, a space directly above this for suspending the parts being cleaned in the vapor and condensing equipment for reliquefying the solvent. Because of the fire hazard involved in this process, non-inflammable solvents containing chlorine are frequently used. Trichlorethylene is a wholly satisfactory solvent to use. Care should be observed that corrosion does not occur, due to the action of these solvents particularly when contaminated with water. Carbon tetrchloride is particularly unsuitable due to this possibility. In all cases where a chlorinated solvent is used it should be checked frequently for presence of free acid. If acid is found it should either be neutralized before proceeding or the solvent discarded.

5-10 CLEANING PROCEDURE. After the external surfaces of the parts are cleaned, a particular effort should be made to insure all the internal passages of the engine being thoroughly cleaned and blown out with compressed air. Particular attention should be paid to the oil passages of the crankshaft, crankcase, reverse gear, and oil manifold. A sufficient number of oil passage plugs should be removed to facilitate the cleaning and inspection of the oil passages. Then the degreasing fluid should be forced, under pressure, through each of the passages, and the system blown out with compressed air. The crankshaft is to be cleaned prior to inspection and again after, wiping crankshaft dry with clean lintless cloth just before installing into crankcase. The inside of the cylinder head should be thoroughly cleaned to remove the carbon and permit thorough inspection of this surface. Carbon may be removed with hand scrapers, or with special carbon cleaning brushes driven by an electric motor. Any hard carbon remaining on the heads of the valve after removal from cleaning solution may be removed with a fine wire brush.

5-11 CLEANING ANTI-FRICTION BEARINGS. Ball and roller bearings, except sealed types, should be cleaned with a neutral cleaning solution. Most bearing trouble is caused by the entry of dirt into the bearings. The cleaning of a bearing is particular, painstaking work, and should be done with thoroughness and caution. The bearings should be washed and blown out with compressed air. While doing this, hold both races to prevent turning of the bearing.

CAUTION

Do not allow bearing to spin. Spinning in a dry condition will cause scoring of the races.

The cleaning of the bearing should be continued until bearing runs smoothly when well oiled. A dry bearing will often appear loose and defective. When it has been cleaned, it should be oiled, wrapped in wax paper, and put in a

box to prevent entry of dirt. A clean bearing should never be exposed on the work bench.

5-12 OIL PIPES. All oil pipes must be thoroughly washed and blown out before inspection.

5-13 CLEANING OIL COOLER CORE. The oil cooler core passages must be cleaned by blowing high pressure air thru each individual tube. Pressures as high as 2000 pounds per square inch may be used to blow the sludge and dirt from the tubes. A small nozzle with a rubber sealing tip on it will do the job. It aids in the cleaning operation if the core is soaked in solvent for some time prior to cleaning it. The outside of the core must be cleaned in an inhibited solution of muriatic acid. Cover the top of the core to keep the acid out of the cooler tubes. After cleaning in acid, flush thoroughly with a neutralizing solution of baking soda or sodium carbonate. Flush with clean water and blow dry. Care should be taken in handling the core to prevent dropping, bumping or scraping which will result in closing certain tubes or removing the protective tin coating.

5-14 WATER PIPES. All water pipes and small water lines are to be examined carefully for any deposits, then thoroughly cleaned. If the lines show an excessive amount of sediment, it may be necessary to replace them.

5-15 DRYING. Regardless of what cleaning procedure is used, all parts should be thoroughly dried either by clean, dry compressed air or by careful wiping with clean dry lintless cloths. They should be kept at temperatures above the dew point of the atmosphere until protected with a rust preservative. They should not be touched by the hands after cleaning but should be handled with tongs or gloves since rusting is liable to occur even after coating with rust preventive material at spots where finger prints of perspiration are left.

5-16 RUST PREVENTION. Any effective cleaning process will leave the bare metal exposed to oxidation and protective steps must be taken immediately after cleaning in order to prevent rust formation on the steel parts. All steel parts must be sprayed, all over or otherwise completely covered, with Type A Compound, Rust Preventive, Thick Film per Navy Department specification 52C17 dated October 15, 1945.

INSPECTION

6-1 DEFINITIONS. Various types of failures will be mentioned in this section. So that there will be no misunderstanding, the more common types of surface failures are described and illustrated. These are all in accordance with a standard "AGMA 110.01" established by the American Gear Manufacturers Association. The illustrations show gear tooth surfaces, but whether the failure occurs in a tooth surface or a shaft journal the general characteristics are the same.

6-2 NORMAL WEAR. This condition refers to the gradual smoothing and polishing of the working surfaces resulting from the sliding and rolling action of the teeth. It is frequently spoken of as "running in". With proper design, manufacture and operation, a condition is reached after which wear practically ceases.

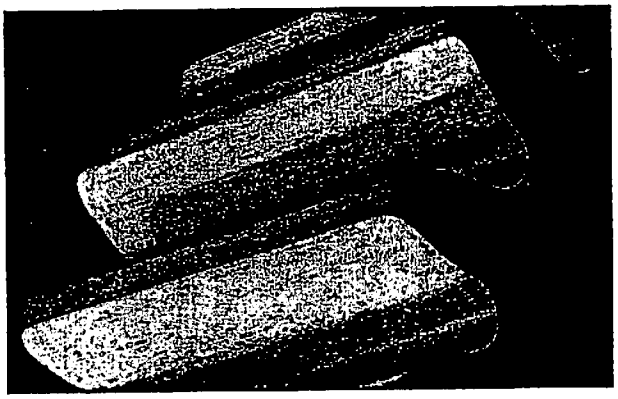


Figure 6-1. Normal Wear

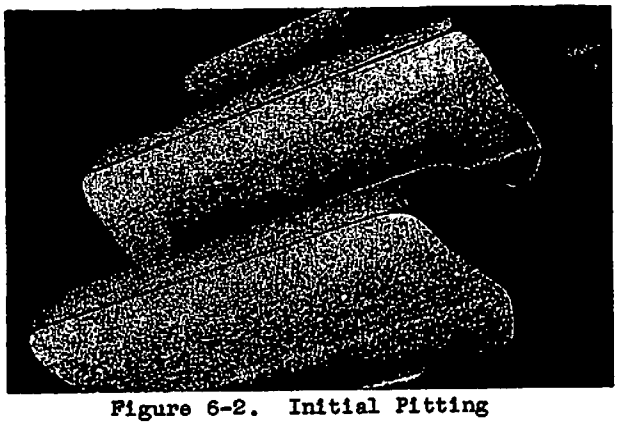


Figure 6-2. Initial Pitting

6-3 INITIAL PITTING. This term applies to the formation of small pits in the tooth surfaces as large as the head of a pin or smaller, usually starting in the vicinity of the pitch line, and frequently occurring during the initial period of gear operation. Pitting should not be considered as detrimental, unless it advances beyond the initial stage. If pits occur gradually, and do not increase rapidly, they indicate a temporary condition and may disappear entirely in the course of normal wear.

6-4 PROGRESSIVE PITTING. This type of failure is indicated when the formation of pits continues at an increasing rate, both as to number and size. A point may be reached when the unpitted areas of the tooth surfaces are insufficient to carry the load, and complete destruction of the tooth shape may occur, especially after continued operation at relatively high load, and over loading.

6-5 ABRASION. This condition may be described as a general wearing away of the tooth surface at a comparatively rapid rate. It generally results from the presence of foreign matter such as dirt, grit, or metallic particles in the lubricant. It may also be caused by a breaking down of the material on the wearing surface. Abrasion appears as fine scratch marks parallel to the direction of rubbing.

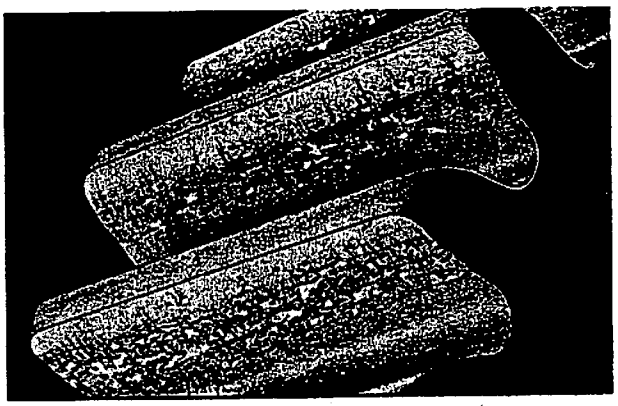


Figure 6-3. Progressive Pitting

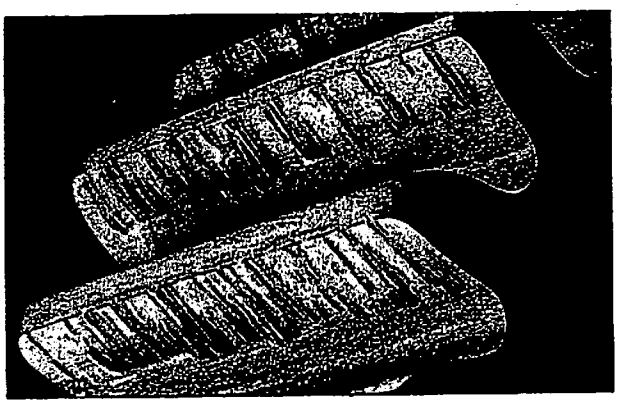


Figure 6-4. Abrasion

This type of failure is encountered in gear teeth, bearing shells and camshaft bearings.

6-6 SCORING. This condition results from excessive loading or inadequate lubrication. Scoring may occur in parts which are properly designed, manufactured and installed, when conditions of operation are such as to cause metal-to-metal contact. The tooth surfaces may be roughened only on small areas and on the same position on all teeth. This may be followed by

a general disintegration of the surfaces, if abnormal conditions of operation are continued. Scoring in its initial stages may sometimes be eliminated by applying more effective lubrication.

6-7 GALLING. Galling is an aggravated condition of scoring caused by particles of metal torn out of the surface of the mating parts in a manner that is sometimes referred to as seizing and welding.

6-8 BURNING. This condition is indicated by discoloration of the type associated with high temperatures. Such discoloration indicates that excessively high temperature has actually occurred, and may be caused by overspeed, overload or faulty lubrication. Burning may result in a reduction in the hardness of hardened steel gear teeth and worn threads, making them unsuited for carrying the specified load.

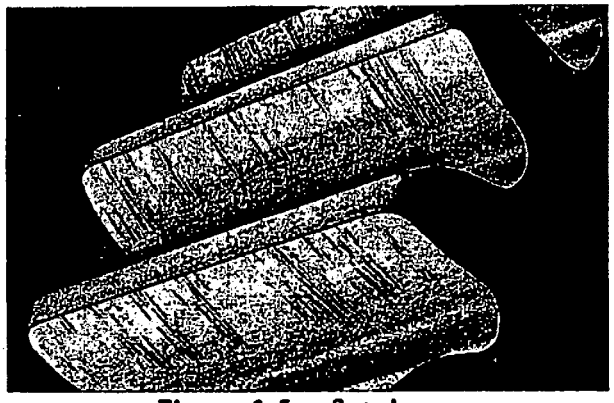


Figure 6-5. Scoring

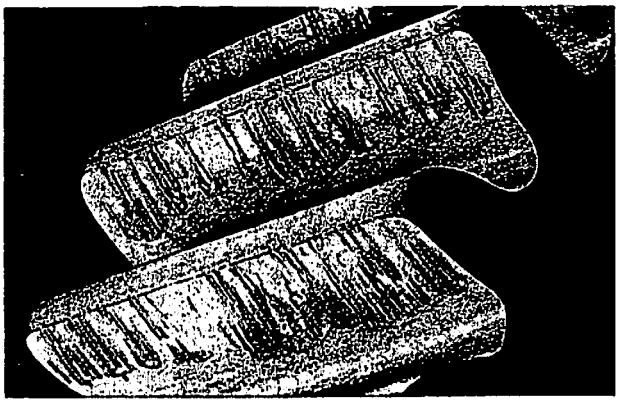


Figure 6-6. Galling

6-9 ROLLING AND PEENING. These terms refer to plastic flow of the mating surface or surfaces, which may occur when the material is ductile in compression. Scoring may not be present. One effect of rolling is the formation of slight "fins" at the top edges and ends of the teeth. Rolling refers to that condition where plastic flow takes place due to heavy continuous loading. Peening where the load is intermittent resulting in a plastic flow of the material due to "hammer blows".

6-10 CRACKING AND CHECKING. Cracking refers to the occurrence of single or scattered cracks in the tooth surface which do not necessarily result in failure. Checking refers to the formation of numerous and closely grouped cracks in the surface. Cracking may result from loading and lubrication conditions causing excessive temperature fluctuations; and also from excessive hardness. Checking may result from several causes. The direction and arrangement of the cracks and checks usually indicate the probable causes. Frequently, cracks and checks can only be detected by etching or by the magnetic inspection.

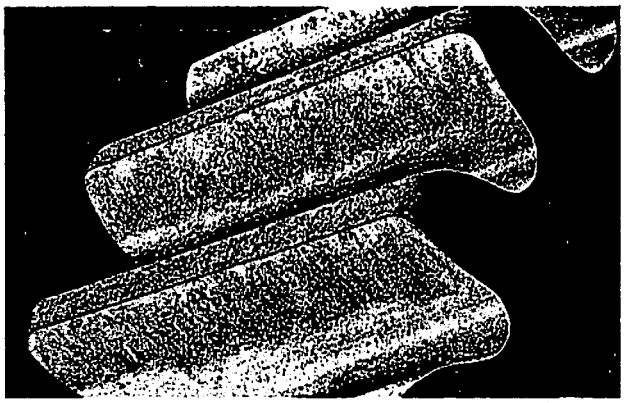


Figure 6-7. Burning

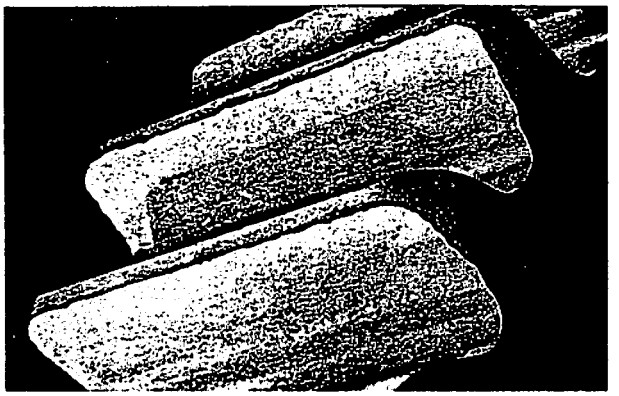


Figure 6-8. Rolling and Peening

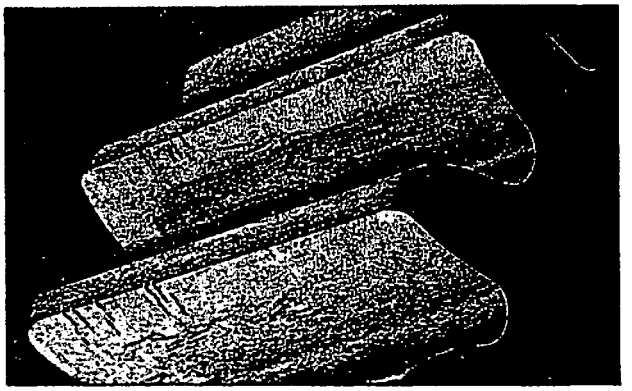


Figure 6-9. Cracking and Checking

6-11 CHIPPING OR SPALLING. These terms refer to the breaking off of portions of material at the edges or boundaries of the teeth.

6-12 GOUGING. This may occur in unhardened gears when there is interference between the flank of the driving pinion and the tip of the driven gear. The top edges of the gear teeth may gouge the material near the roots of the pinion teeth.

6-13 GENERAL. This section shall outline all inspection procedures that are peculiar to this engine. The methods of inspection shall be described and illustrated where necessary for clarity. Too much importance cannot be placed on the need for careful examination of parts and the use of sound judgment, based upon operating conditions and past performance of similar units, when rendering decisions as to the further usability of parts. No instructions could possibly cover all conditions that may be found in engines disassembled or overhauled. The section of the building devoted to inspection should have the best possible illumination. Sufficient space should be provided to permit laying out of all engine parts for inspection at one time. Then the relative wear on component parts may be readily compared, and it is often possible to determine at once the cause of abnormal wear, as well as to compare the condition of the engine as a whole with other engines. Unacceptable parts must be conspicuously marked and the details listed.

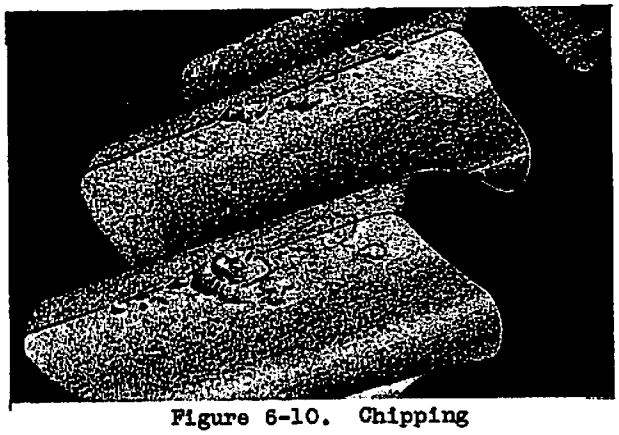


Figure 6-10. Chipping

6-14 INSPECTION TOOLS. It is assumed that the inspector will be skilled in the use of micrometers, feelers, dial indicator gages, plug gages and other measuring devices generally used to determine dimensions, fits and clearances, and no detailed instruction for their use will be given here. Where unusual application of standard measuring devices is required it will be described and illustrated.

6-15 INSPECTION PROCEDURE. The initial step in the inspection process is to see that the parts are thoroughly clean so that no grease, oil or rust preventive compound hides a defect or interferes with the inspection process. Rust preventive coating must be reapplied at the completion of the inspection. Refer to paragraph 5-16. All parts should first be given a visual inspection as an obviously damaged part need not have any more time spent on it. All the remaining parts should be given a physical check which includes determining dimensions, clearances and checking them against the standards given in the Table of Limits, figure 12-1. Also, parts should be given a close visual inspection for cracks, scratches, scoring or other signs of non-standard condition. Certain engine parts should, in addition, be subjected to magnetic inspection for detection of fatigue crack which cannot be seen in the usual course of inspection. Inspection details for each subassembly and its component parts are given under the appropriate heading. A number of inspection methods or procedures are common to a number of similar parts used throughout the engine. In order not to complicate the detailed inspection instructions, these inspection operations will be covered in the adjacent paragraphs and will not be repeated. These operations should be performed where indicated in conjunction with the other detailed inspection, whether or not they are specifically mentioned.

6-16 GEAR BACK LASH. Back lash of all gears should be checked against the specification. The indicator should be located so that the button will contact the gear tooth. At points where end play may affect the back lash, end play should always be taken up by holding the gear up in driving position while readings are being taken.

6-17 STUDS. Check all studs for looseness, cross-threading, nicks or other damage to threads.

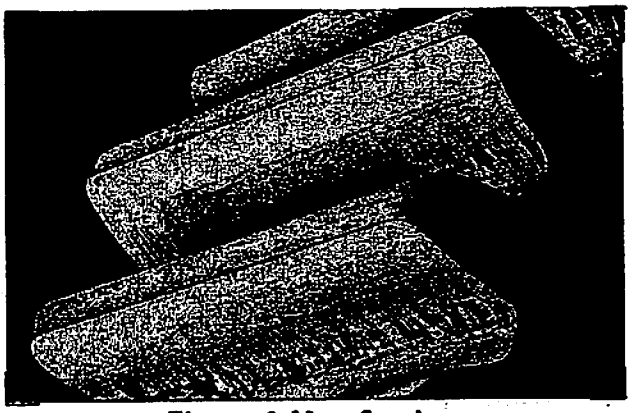


Figure 6-11. Gouging

6-18 SHAFTS. Check for wear and fatigue cracks. Inspect bearing journals for dimensions and smoothness. Splines and threads should be checked for wear, nicks, scores, or other mutilation.

6-19 GEARS. Inspect for signs of improper tooth contact, corrosion, pitting, scoring, burrs, sharp edges, and excessive wear.

6-20 PIPES. Inspect pipes for dents, cracks, corrosion, nicks and condition of flanges. Oil pipes that fit in a mating bracket, or hole, in another piece, should be carefully checked for abrasion that might result in an oil leak.

6-21 BALL AND ROLLER BEARINGS. With those types of ball and roller bearings which can be separated they should be carefully inspected for pitting, scoring, flaking, corrosion and wear. Bearings which cannot be separated should be visually inspected so far as possible. Thoroughly clean bearings, except sealed types, prior to inspection as outlined in paragraph 5-11. Never spin an unlubricated bearing by hand or com-

pressed air. Relubricate with light oil and try for smoothness. Check mounting diameters, both inside and out, for signs of excessive working. Excess movement at either of these points will destroy the fit of the bearing in its mounting.

6-22 TABLE OF LIMITS. Refer to paragraphs 12-5 to 12-9 inclusive for an explanation of the Table of Limits found in section XII. This Table must be used for the proper evaluation of the inspection data.

6-23 MAGNETIC INSPECTION. Some of the more highly stressed parts must be magnetically inspected in order to detect possible cracks that are otherwise difficult to see. This type inspection must be done on a device especially made to do this type of work. It is best done by an experienced operator. The part in question is magnetized in one of two patterns or both as indicated in figure 6-19. Also the current to be used is specified in this table. The wet method of inspection is used. The part to be inspected is first cleaned thoroughly as explained in section V. Then it is wet with a magnetic material such as iron or steel ground to a fineness such that the particles will pass thru a .0002 in. mesh. The magnetic material is suspended in a fluid such as kerosene in the ratio of from 0.8 to 1.0 part solids to 100 parts liquid by volume. A red colored solid is used as it is conspicuous. The inspection is made by placing the part in question on the machine and wetting it all over with the inspection fluid. Employ a rate of fluid flow such that the jet can be projected vertically from 1-1/2 to 2 inches high. Excessive rates of flow will destroy feeble indications. After the part is fully wet, turn on the current and flow the inspection fluid over the entire part. Where ever there is a break in the surface, the magnetic material will collect, thus revealing a break in the surface. Of course, because of the nature of the process, all junctions will show. For example, if a connecting rod and cap assembly is being tested a strong indication will form around the joint between the rod and cap. If a possible defect is found in the body of the part, wipe off the indication and give it a second "shot" to confirm the first indication. The seriousness of cracks is dependent on their location and size. This is further discussed under each item so inspected. Parts must be demagnetized after this inspection. This is done by giving the part successive "shots" of diminishing current until the minimum current is used.

6-24 FLUORESCENT INSPECTION. The fluorescent penetrant method of inspection is useful in detecting flaws in aluminum pistons. Since new aluminum pistons are always inspected by this process after manufacture and since pistons are always replaced with new ones in the overhaul of this engine it is not necessary to dwell on this inspection process as it is not used in the overhaul of the engine.

6-25 DETAILED INSPECTION.

6-26 UPPER CRANKCASE INSPECTION.

a. Check all the walls for cracks, rust or thin spots.

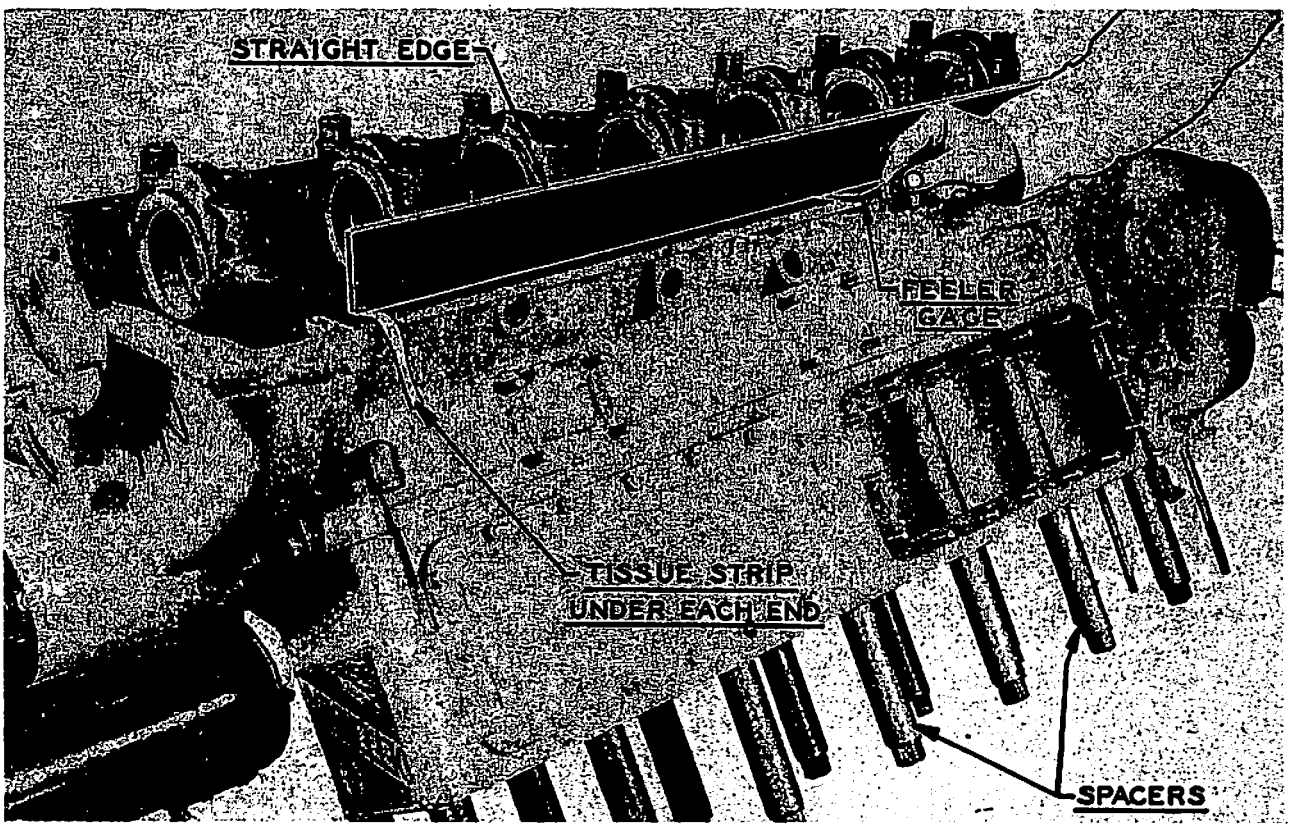


Figure 6-12. Straight Edge on Bottom Surface of Upper Crankcase

b. Check the bottom and two top faces with a straight edge to see that there is no distortion in the upper crankcase. The upper faces are checked along each edge. Use a 43 in. long straight edge and place a piece of tissue under each end (.0015 thick). Now try a .003 in. thick feeler gage under the straight edge in three or four places along the length of the surface. Check the lower surface in much the same manner. Refer to items 24, 25 and 26, Table of Limits, figure 12-1.

c. Check all the main bearing shells for general condition. Examine them for signs of errosion, corrosion and abrasion. See that there are no indications of broken bond between the copper lead coating and the steel backing. Check shells for "crush". Crush is readily checked by installing a perfectly flat plate in the joint between the upper crankcase and the main bearing cap with both shells in place. Draw the nuts down to from 10 to 15 lb feet torque and try a feeler gage between the case and the plate. Also between the cap and the plate. Refer to item 3, Table of Limits, figure 12-1. If the shells are otherwise acceptable install them in the upper crankcase paying attention to the numbers stamped on the upper case webs, the caps and the shells. The numbers are to assemble on a common side of the engine. Refer to figure 7-4. After the shells are installed, fit the cap nuts and draw them down to the specified torque as shown in figure 12-9. In order to duplicate the stress of an assembled engine it is necessary to fit both cylinder blocks and spacers on all studs. Draw down with hex nuts to the torque mentioned in figure 12-9. Place a rigid straight edge thru the bores and try a .0015 feeler under the straight edge at each bearing. See figure 6-31. Check the diameter of each main bearing. Be careful not to measure at a point of relief in the shells. If inside micrometers are used be careful that the soft metal in the shell does not lead to an inaccurate reading. See reference number 1, figure 12-1. Check the length over the flange of the center main bearing shells.



Figure 6-14. Checking Crush of Main Bearing Shell

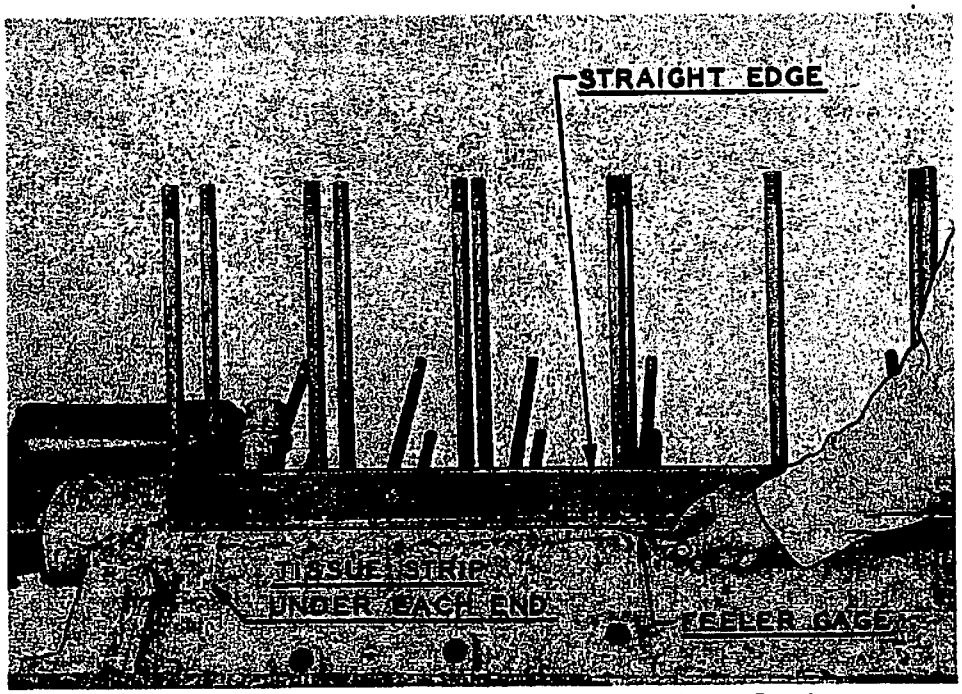


Figure 6-13. Straight Edge on Top Face of Upper Crankcase

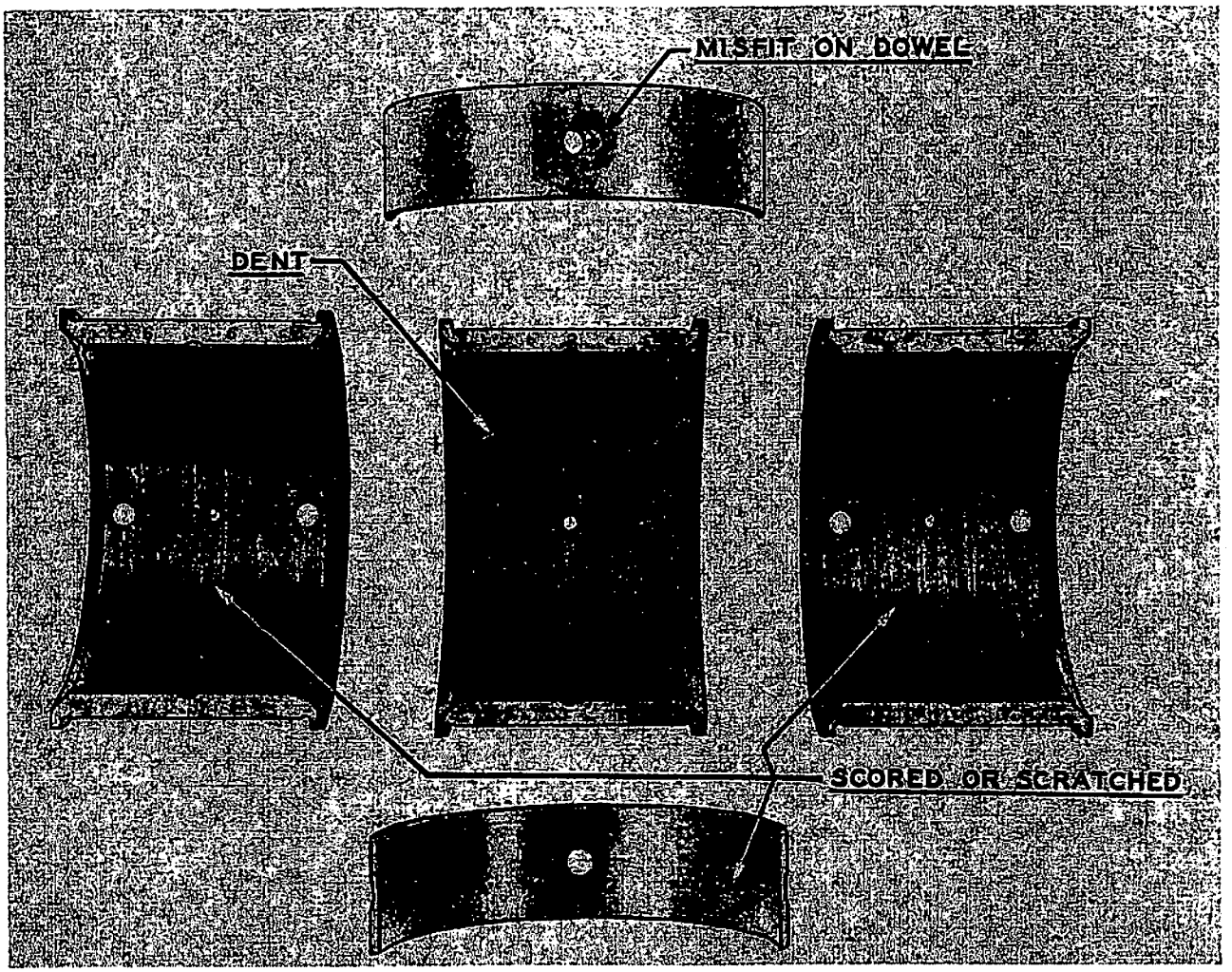


Figure 6-15. Defective Bearing Shells

d. Check the condition of the machined faces on the front and rear of the case as well as the pads on the sides where the water pumps and distributors mount. These faces must be flat and true.

e. Examine the bushings pressed into either side of the upper crankcase where the oil lines attach. These brass bushings must be tight and smooth so an oil tight contact can be made with the flared end of the tubing.

f. Check the condition of all studs, dowels and pipe threads.

g. The detailed inspection of the gear carrier is described in paragraph 6-33.

h. See that all drill oil passages are clear.

6-27 CRANKSHAFT AND FLYWHEEL INSPECTION.

a. Support the crankshaft on "V" blocks under each end main bearing journal. With a dial gage check the run out of each main bearing journal. Straighten the shaft if necessary. Refer to item 4 , Table of Limits, figure 12-1.

b. Check the condition of the crankshaft gear and reverse gear drive flange. The back lash of the crankshaft gear is checked after the crankshaft is set back in the upper crankcase and meshes with the accessory drive gear.

c. Measure the diameter of all the main bearing journals. Each journal must be measured at several points in order to get the minimum reading. Refer to item 8 , Table of Limits, figure 12-1. Check the distance between the thrust faces of the center main journal.

d. Measure the diameter of all the crank journals. Each journal must be measured at several points in order to get the minimum reading.

e. Magnetically inspect the crankshaft as outlined in paragraph 6-23, figure 6-18 and the Magnetic Inspection Table. For convenience of identifying angular positions on the crankshaft main journals the following "o'clock" positions shall be established , by placing the shaft in a horizontal position with the number one and six crank journals at their top most position. Then the top point of each main journal shall be considered 12 o'clock and the bottom point six o'clock as the shaft is viewed from the front or flywheel end. For the purpose of identifying the angular positions of the crank journals the following "o'clock" positions shall be established , by placing the crankshaft in a horizontal position with the crank under consideration at its top most position. The top point of this crank journal shall then be considered as 12 o'clock and its

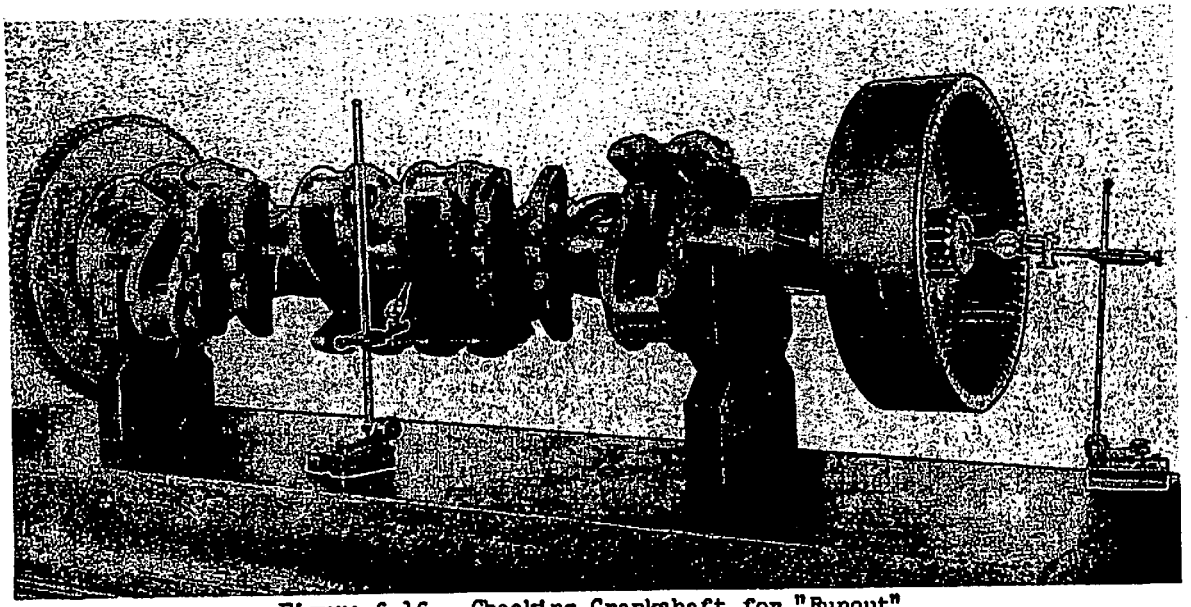


Figure 6-16. Checking Crankshaft for "Runout"

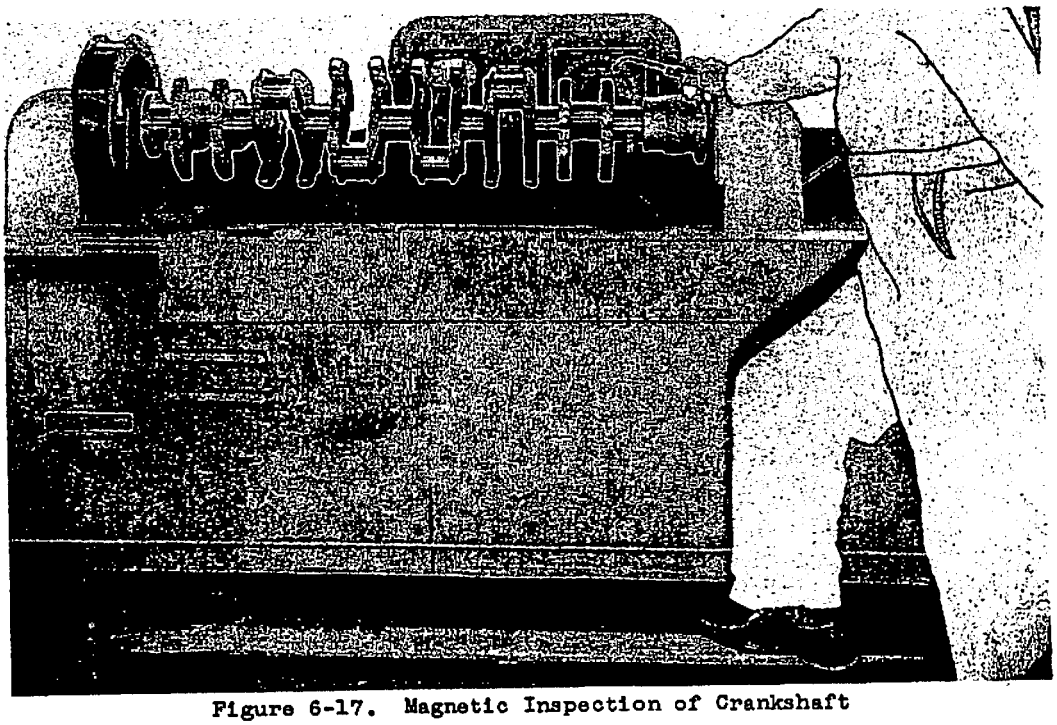


Figure 6-17. Magnetic Inspection of Crankshaft

bottom point as six o'clock as the shaft is viewed from the front or flywheel end. When considering the fillets where the webs join the journals the same o'clock positions shall be used as outlined above for the crank journals. The following standards of rejection are to be used in judging magnetic inspection of the crankshaft:

All circumferential or diagonal indications are cause for rejection.

All indications in or around oil holes are cause for rejection.

All open indications in the main journal over 5/8 in. long are cause for rejection.

All open indications in the crank journals over 3/4 in. long are cause for rejection.

Any open indication longer than 3/8 in. falling between 10 and 2 o'clock in the crank journal fillet or between 4 and 8 o'clock in the adjacent main journal fillets is cause for rejection.

Any open indication in the crank journal fillet between 2 and 10 o'clock or between 8 and 4 o'clock in the adjacent main journal fillet is cause for rejection.

Any indication that is perceptibly open is cause for rejection.

Any indication that extends to the edge of the cheek shall be cause for rejection.

Any indication about which there is doubt shall be cause for rejection.

Magnetic indication, although acceptable, may require protective measures as mentioned in paragraph 7-6e.

f. See that all drilled oil passages are clear of sludge and dirt.

g. All the main and crank journals are to be lapped as explained in paragraph 7-6f.

h. Inspect the condition of the starter ring gear. The ring gear must be tight on the flywheel. None of the gear teeth must be chipped or broken. The ring gear chamfer must be arranged so as to allow the starter pinion to engage easily.

j. Examine the crankshaft hand starting ratchet.

6-28 FLYWHEEL HOUSING INSPECTION.

a. Inspect the flywheel housing for general condition such as distortion or cracks.

b. Check the internal diameter of the Bendix drive housing bushing. Refer to item 68, Table of Limits, figure 12-1.

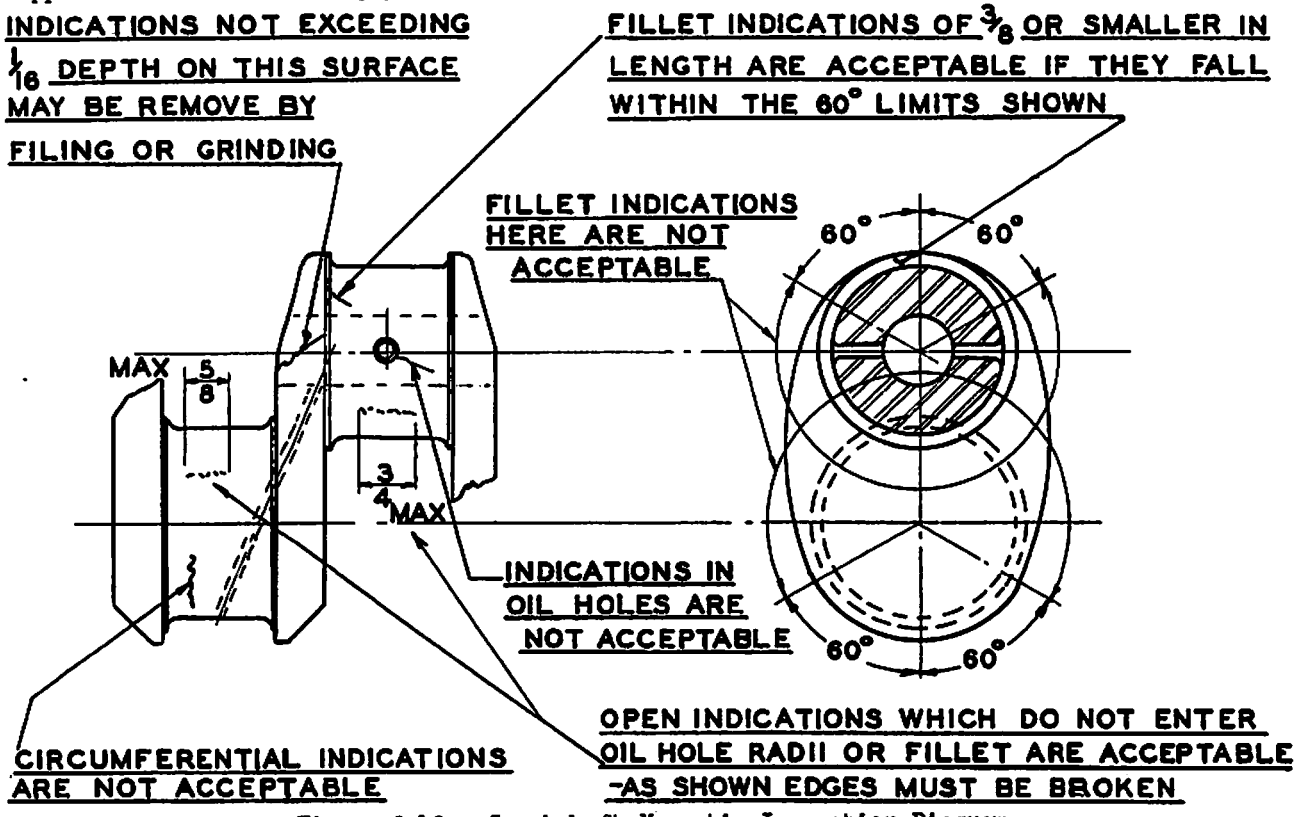


Figure 6-18. Crankshaft Magnetic Inspection Diagram

MAGNETIC INSPECTION TABLE
WET METHOD

PART	METHOD OF MAGNETIZATION AND RECOMMEND AMPERAGE	POINTS OF SPECIAL CONCERN
Crankshaft	3000 Amperes lengthwise (End contacts only).	Crack in the web between the rear main bearing and the No. 1 pin. Refer to figure 6-17 and 6-18 and paragraph 6-27e.
Connecting rod with cap bolted on (blade)	1500 Amperes lengthwise (End contacts) inspect. 1500 Amperes crosswise (Encircling coil) inspect.	Any transverse cracks refer to figure 6-24 and 6-26 and paragraph 6-30c.
Connecting rod with caps bolted on (yoke)	1500 Amperes lengthwise (End contacts) inspect. 1500 Amperes crosswise (Encircling coil) inspect.	Watch inside of crotch at junction of yoke to main body. Refer to figure 6-24 and 6-26 and paragraph 6-30c.

Figure 6-19. Magnetic Inspection Table

6-29 CYLINDER BLOCK INSPECTION.

a. Check block for cracks in any of the walls or flanges. Check for distortion of top and bottom faces similar to the idea mentioned in paragraph 6-26b.

b. Check the diameter of each cylinder bore in several places in order to determine the maximum diameter. Refer to item 27, Table of Limits, figure 12-1.

c. Inspect cover plate for rust penetration. Inspect top face around water passage holes for corrosion. Examine flange face of water jacket opening for corrosion.

d. Inspect all studs and dowels.

e. Bolt on auxiliary cover plates and subject the water jacket space to 20 lb per square in. water pressure and examine for leaks.

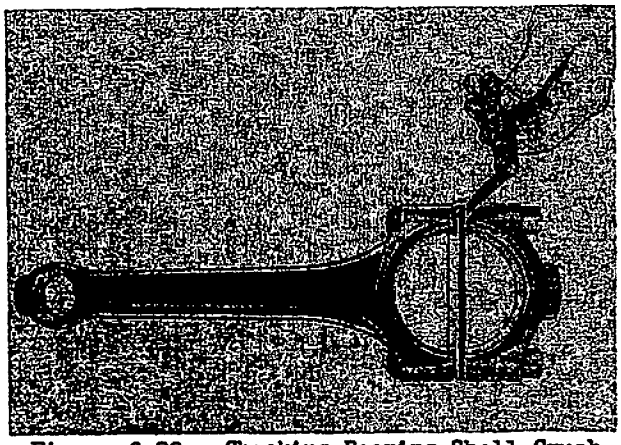


Figure 6-20. Checking Bearing Shell Crush in Blade Connecting Rod

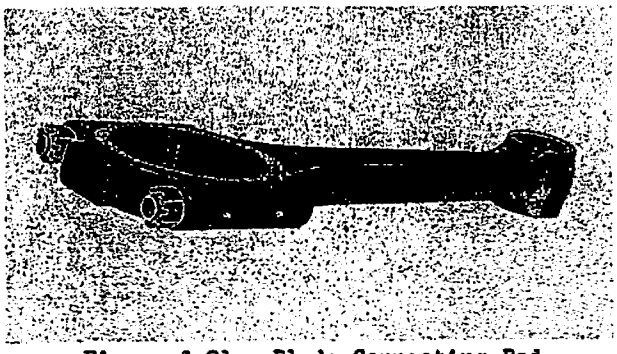


Figure 6-21. Blade Connecting Rod Showing Stamped Numbers

6-30 CONNECTING ROD INSPECTION.

a. Check general condition of connecting rod for nicks or dents. Examine the big end and small end for defects of any sort. Examine the bearing shell locating dowels.

b. Check all the connecting rod bearing shells for general condition. Examine them for signs of abrasion, errosion and corrosion. See that there are no signs of broken bond between the copper lead coat and the steel backing. Check shells for "crush". Refer to figure 6-15. The crush is readily checked by installing a flat plate in the joint between the connecting rod and cap. Draw the nuts down to about 10 lb ft torque to seat the shells securely without crushing them down. Now try a feeler gage between the test plate and cap. Also between the test plate and connecting rod. If the shells are otherwise acceptable assemble them to the connecting rods and caps. Paying particular attention to the number markings on the rods, caps and shells. Also see that the 3/8 in. nuts on the forked rods are assembled to the bolts so all the stamped numbers are in agreement. Pull the nuts down to the correct torque rating as mentioned in figure 12-9. Check the diameter of each large end bearing at several points. Be careful not to measure at a point where there is a relief in the shell. If inside micrometers are used be careful that the soft metal in the shell does not lead to an inaccurate reading. Refer to items 11, 14 and 18, Table of Limits, figure 12-1. Check the width thru the large end connecting rod bores and compare it with its mating part to determine

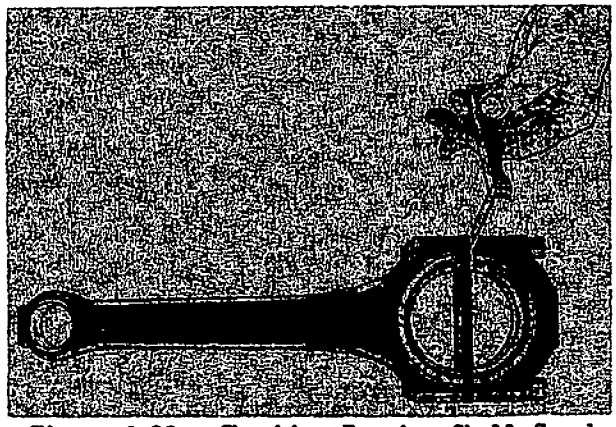


Figure 6-22. Checking Bearing Shell Crush in Yoke Connecting Rod



Figure 6-23. Yoke Connecting Rod Showing Stamped Numbers

the end clearance. Refer to items 12 and 15, Table of Limits, figure 12-1. Pull the bearing caps off the connecting rods carefully so as not to damage either the bearing shells or the connecting rods. Do not hit the connecting rod, connecting rod cap or shells so as to damage or mar them in any respect. It is best to use a typical separator as shown. See figure 6-25.

c. Magnetically inspect the connecting rod as outlined in paragraph 6-23, figure 6-24 and the Magnetic Inspection Table. The following standards of rejection are to be used in judging magnetic inspection of both blade and yoke connecting rods.

Any transverse or diagonal indication in the connecting rod is cause for rejection.

Any indication in the connecting rod that extends to the edge of the flange is cause for

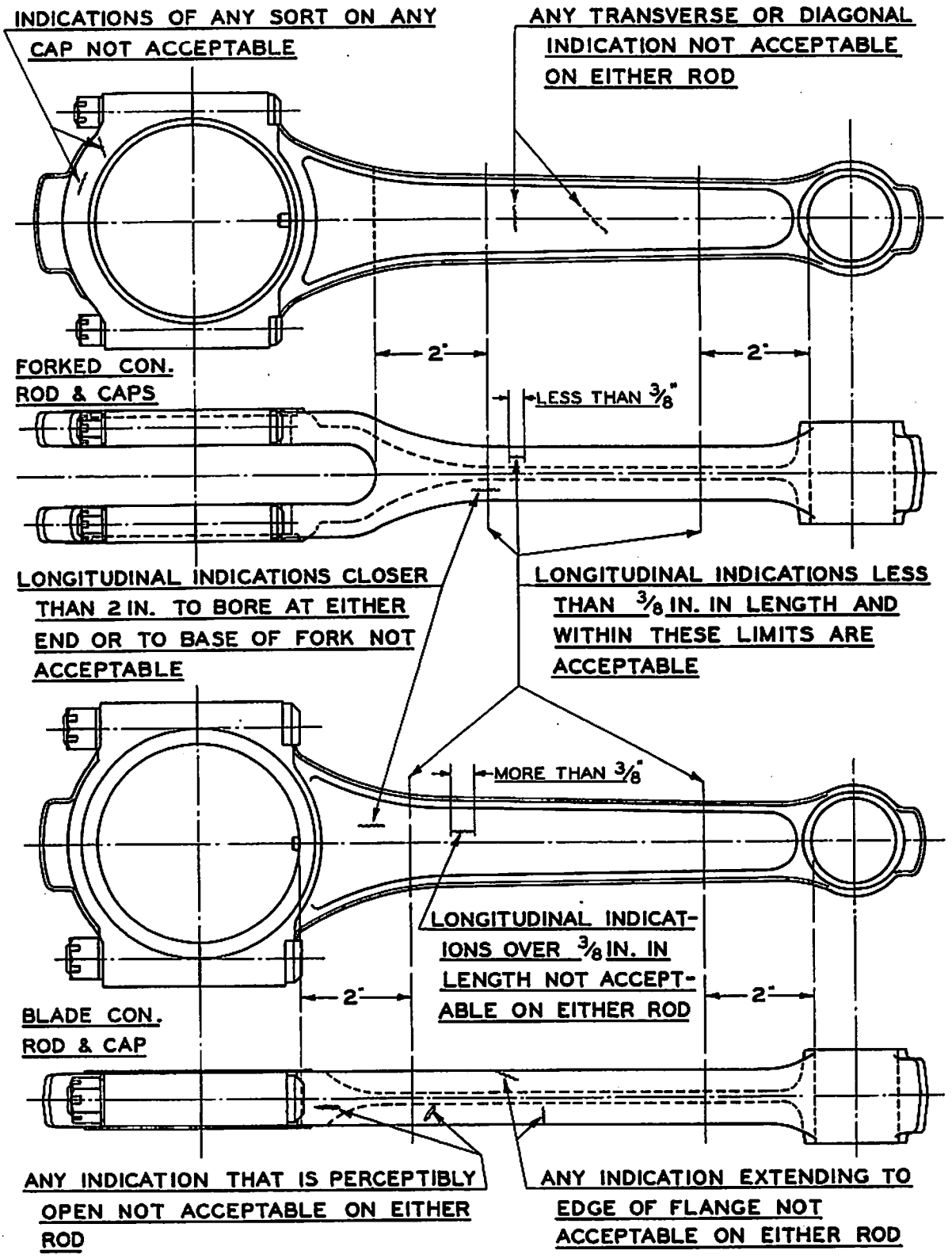


Figure 6-24. Connecting Rod Magnetic Inspection Diagram

rejection.
Any longitudinal indication in the connecting rod that is over 3/8 in. in length is cause for rejection.
Any indication in the connecting rod that is perceptibly open is cause for rejection.
Any longitudinal indication in the connecting rod that is closer than 2 in. to the bore at either end is cause for rejection.
Any indication of any sort in the caps are cause for rejection.
Any indication about which there is doubt shall be cause for rejection.

d. The connecting rods are to be inspected for alignment and twist after installation of the piston pin bushings as explained in paragraph 7-9d.

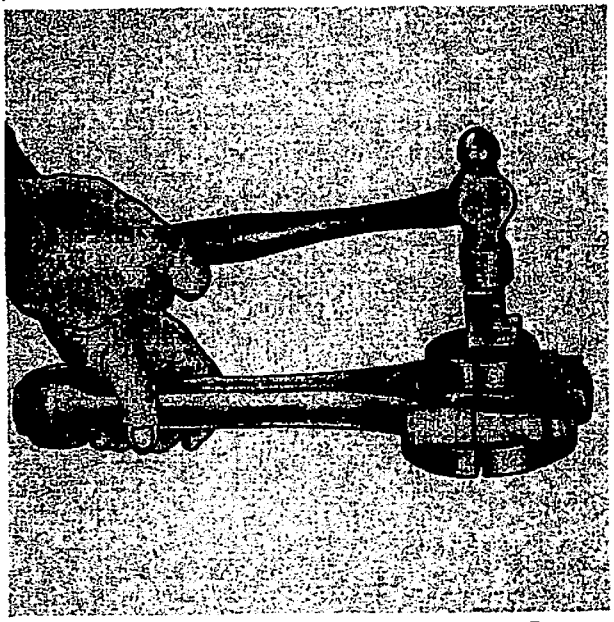


Figure 6-25. Separating Connecting Rod from Cap with Typical Tool

6-31 PISTON AND PISTON RING INSPECTION. The pistons, piston pins and piston rings are always replaced with new parts at the overhaul period so no inspection of these parts is required.

6-32 SPROCKET AND SPROCKET HOUSING INSPECTION.

a. Make a general overall visual inspection watching for cracks or distortion. Lay a straight edge across machined faces to check for distortion.

b. Examine sprocket for wear in the teeth and in the bores. One method of checking a sprocket for wear is to roll it along a new piece of chain. If it binds in the chain the sprocket is worn excessively and must be discarded. See that the toothless idler sprocket is not burred over on the edges where the chain runs.

c. Inspect all ball and roller bearings as explained in paragraph 6-21.

6-33 GEAR CARRIER INSPECTION.

a. Check the accessory drive gear and sprocket for wear. It is necessary to assemble the gear and sprocket into the carrier housing in order to check the back lash with the crankshaft gear. Roll the sprockets on a new piece of roller chain. If they do not roll freely they must be replaced with new accessory drive gears and sprockets. See reference number 21, figure 12-1.

b. Inspect the gear carrier housing to see that it is not cracked or otherwise damaged.

c. Check the accessory drive gear and sprocket drive shaft. Also examine the ball bearings. It is quite likely the ball bearings were damaged in removing them from the accessory drive gear and sprocket.

6-34 CYLINDER HEAD INSPECTION.

a. Visually inspect the main cylinder head casting for cracks, thin walls and gasket faces damaged by rust or dents. Watch for thin walls and scored camshaft bearings. There are counter-bored water holes in the exhaust side face of the head. See that the shoulder in these water



Figure 6-26. Magnetic Inspection of Connecting Rod

holes is intact and has not been destroyed by rust. Examine the area around all water holes to make certain the gasket face has not been destroyed by rust so that a water leak will be encountered on reassembly. Check all the exhaust valve seat rings to determine their general condition and to see if they are tight in the head. Loose seats may be detected by signs of working at the boundary between the seat rings and the cylinder head. Loose seats may also be detected by striking them lightly. A loose seat will give out a dull hollow sound whereas a tight seat will give forth a sharp metallic ring or tone. Seats that are deeply pitted or burnt must be replaced with new seats. Refer to paragraph 7-12 for details on cylinder head repairs. See that all drilled oil passages are clean.

b. Examine the camshaft for wear on the cams or at the bearing journals. Any signs of wear on the cams are cause for rejection of the shaft. Do not mistake the high polish on the cams for wear. See reference numbers 37 and 38, figure 12-1. Examine the condition of the driving taper on the camshaft. Inspect the fuel pump driving dog at the front end of the camshaft. It must be tight in the camshaft. Check the crush of the bearing shell at the rear of the

head.

c. Inspect all the camshaft bearing brackets and caps. See that they are not scored or otherwise damaged.

d. Examine all the rockerarms and rockerarm shafts for wear. Any rockerarm shoe that is worn must be discarded. Do not mistake a high polish for wear. Wear will be evident if the area where the cam rubs is depressed below the rest of the shoe surface. See reference number 41, figure 12-1 for allowable wear of rockerarm bushings and rockerarm shafts. See that oil holes in rockerarm shafts are open.

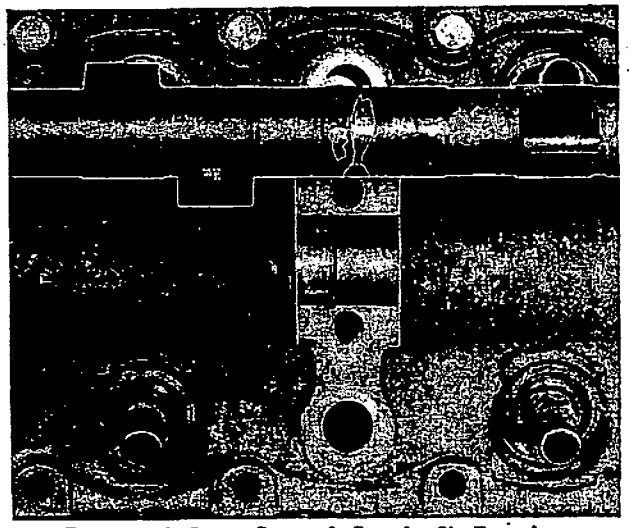


Figure 6-27. Scored Camshaft Bearing

e. Inspect the valves and valve guides. See reference numbers 46 and 49, figure 12-1 for allowable clearance. Examine the general condition of the valve heads and stems. See what type of pattern the tappet screw has made on the end of the valve stem. The tappet screw normally makes a straight line rubbing pattern on the tip of the valve stem. If this rubbing pattern fans out over the entire tip, it indicates that the valve has been rotating and must be discarded. Experience has shown that a rotating valve is quite apt to break, with serious results.

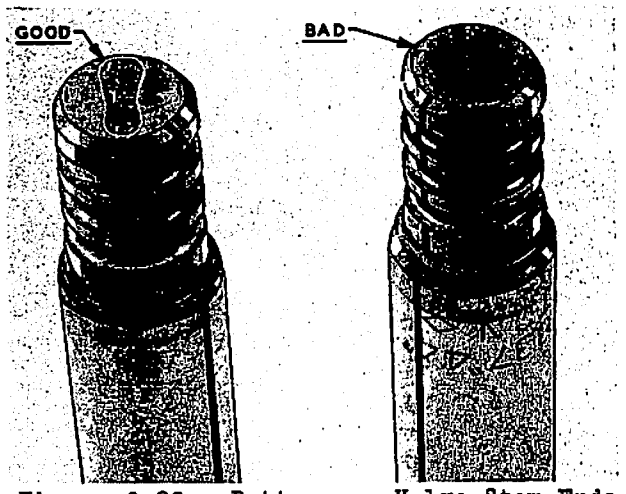


Figure 6-28. Pattern on Valve Stem Ends

Examine the valves for cracks and warpage. Discard any valves that show such defects. Do not be led into false economy by reusing defective parts. When in doubt, use new parts. Watch out for valves that have been ground off until they become thin on the edges. Such a valve is likely to warp, and also develop hot spots that cause preignition. All valves that pass the above mentioned examinations may now be refaced as outlined in paragraph 7-12f.

f. Check all the valve springs for general condition and tension. See reference numbers 100 and 101, figure 12-9.

g. Water test head at 20 lb per square in.

6-35 LOWER CRANKCASE INSPECTION. Make a visual inspection for cracks, dents, thin walls or corrosion. See that all gasket faces are true and smooth. Dowel holes must be in good condition. See that the interior surface of the sump tank is clean. Check the condition of studs and pipe threads.

6-36 EXHAUST MANIFOLD INSPECTION. Inspect the manifold for cracks, distortion, damage by rust on the gasket face and enlarged dowel holes. See that the water passages are clear. Refit packing strips and subject to 20 lb per square in. water pressure.

6-37 INTAKE MANIFOLD INSPECTION.

a. Inspect the intake manifold and intake elbows for cracks and distortion. Lay a straight edge across the machined faces to check for distortion. Examine the gasket faces around water passages to determine if the faces have been destroyed by corrosion. See that all drilled and tapped holes are clear and undamaged. See that all intake passages are free and unobstructed. Cover water passages in the intake manifold and intake elbows and subject to water pressure of 20 lb per square in.

b. Inspect the thermostat housing for cracks and rust. See that all gasket faces are smooth and true. Check the condition of all pipe threads and filler cap threads.

c. Examine the condition of the thermostat. Check it in hot water to see that it closes and opens fully. See reference number 100, Miscellaneous Table, figure 12-9.

6-38 RUST PREVENTION. At the completion of the various inspection operations all steel parts must be adequately protected from rust as outlined in paragraph 5-16.

6-39 ACCESSORY INSPECTION. Refer to section XI for details of accessory inspection, repair and reassembly.

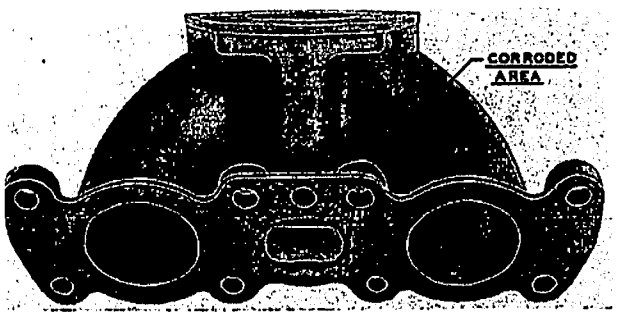


Figure 6-29. Intake Manifold Elbow

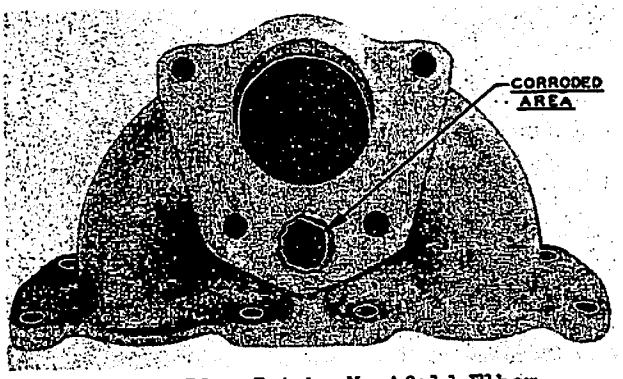


Figure 6-30. Intake Manifold Elbow

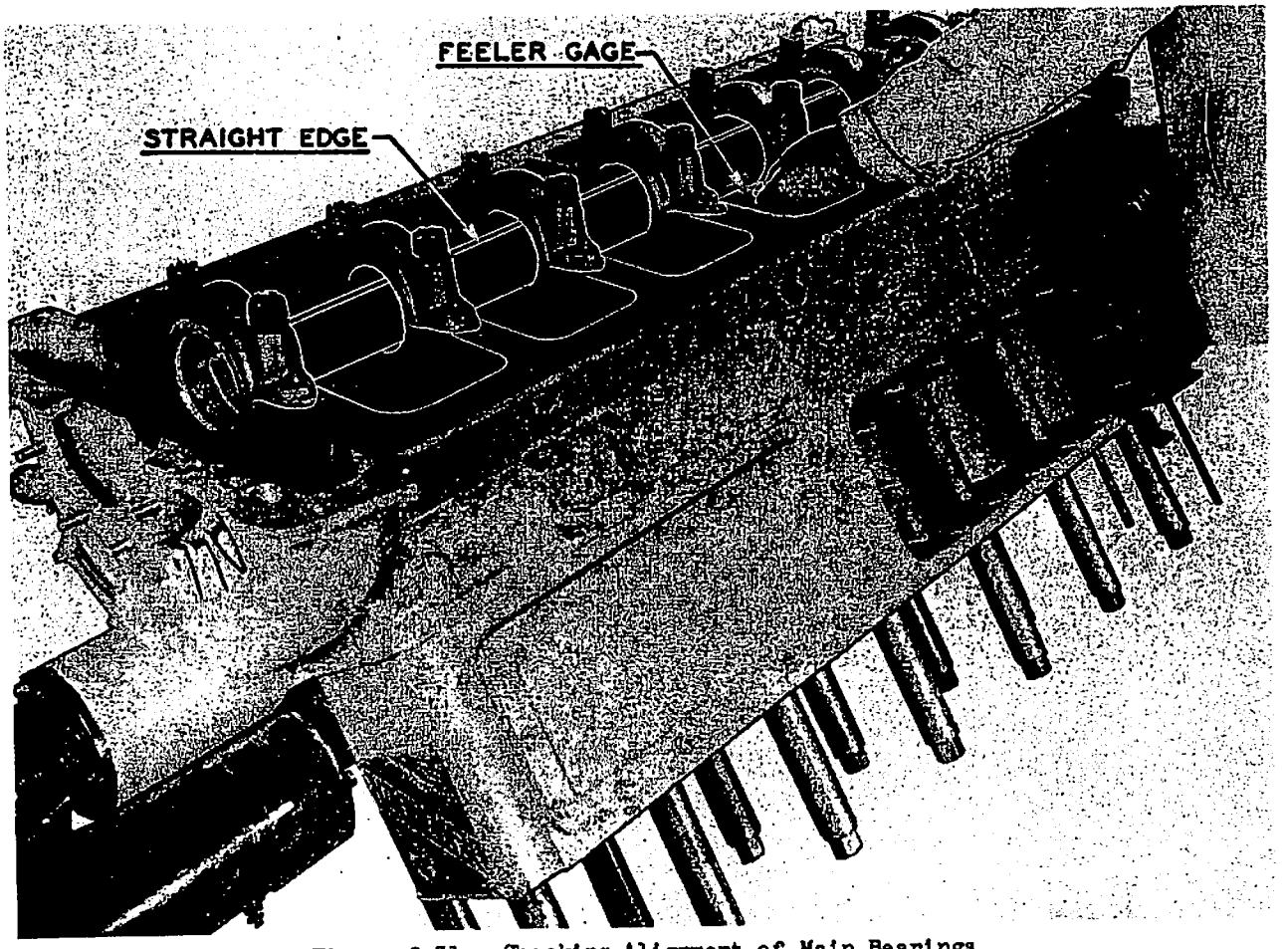


Figure 6-31. Checking Alignment of Main Bearings

HALL-SCOTT DEFENDER
MODEL 2268 & 2269

REPAIR AND REPLACEMENT

7-1 GENERAL. In this section detailed instructions are given for repair and replacement of parts found unacceptable in the inspection procedure. All possibilities of reclaimation are explained.

7-2 RUST PREVENTION. At the completion of the various repair and replacement operations all steel parts must be adequately protected from rust as outlined in paragraph 5-16.

7-3 TABLE OF LIMITS. Refer to paragraphs 12-5 to 12-9 inclusive for an explanation of the Table of Limits found in section XII. This table must be used frequently in the repair and replacement of the engine parts.

7-4 INSPECTION AFTER REPAIR OR REPLACEMENT. All parts, before being considered useable, must be inspected as outlined in section VI and be acceptable according to these standards.

7-5 UPPER CRANKCASE REPAIR AND REPLACEMENT. If the upper crankcase has been found unacceptable as inspected in paragraph 6-26 it must be repaired or discarded.

a. Loose or damaged studs must be replaced. Loose or damaged dowels must be replaced providing the dowel holes are not enlarged.

b. The brass oil line bushings in either side of the case must be pulled out if they are defective and new ones fitted. The old bushings can be pulled out by screwing a standard 5/8 - 18 standard tap into them. When the tap is firmly embedded, draw the tap out along with the bushing. Install a new bushing using the typical driving tool shown. Be sure to use a new gasket behind the new bushing.

c. Main bearing shell "crush" is corrected either by using new shells or modifying the old shells. Shells that exhibit too much crush may be carefully rubbed down on abrasive cloth "backed up" by a perfectly flat surface. All abrasive particles must be removed from the shell before it is put into the engine. When necessary to install new main bearing shells always do so in pairs. For example, do not replace the case half of the shell without also replacing the cap half of the corresponding shell. The bearing metal will frequently become "smeared" over into the relief at the parting line of the shells. This smeared metal must

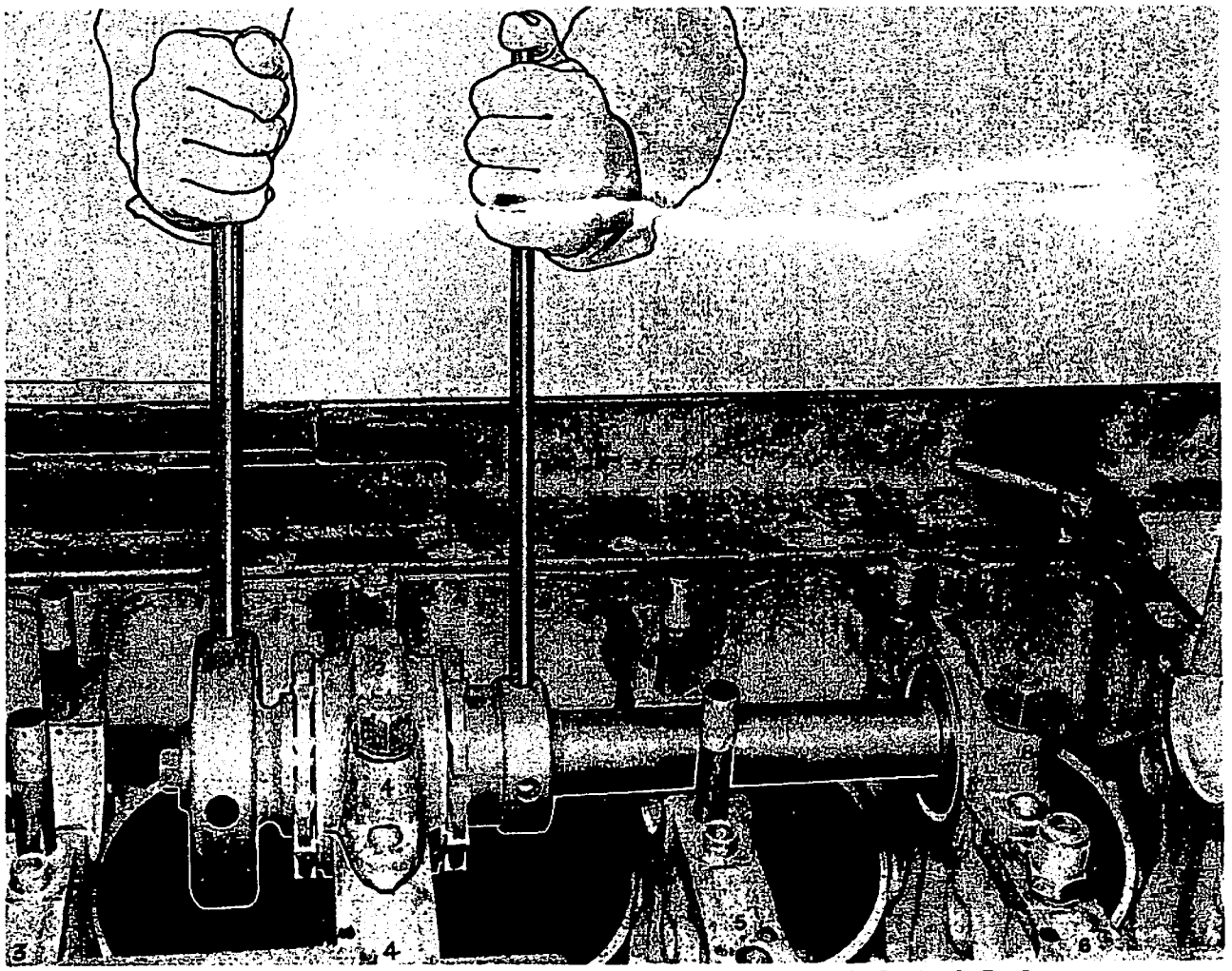


Figure 7-1. Facing Center Main Bearing Shell with Typical Tool

be scraped off to restore the original shape of the relief. New center main bearing shells have excess metal on the flange faces and must be reworked to obtain the proper clearance. These thrust faces may be faced off with a typical tool as shown, on a lathe or by careful use of a fine cut hand file. Use micrometers, and check to see that wall thickness at thrust face does not vary between the two flanges. If a file is used, be careful to see that the faces are kept flat and parallel to obtain maximum bearing area.

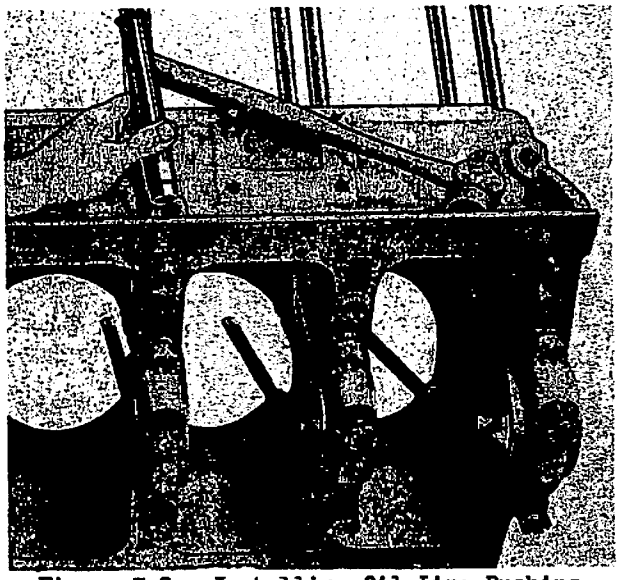


Figure 7-2. Installing Oil Line Bushing with Typical Tool

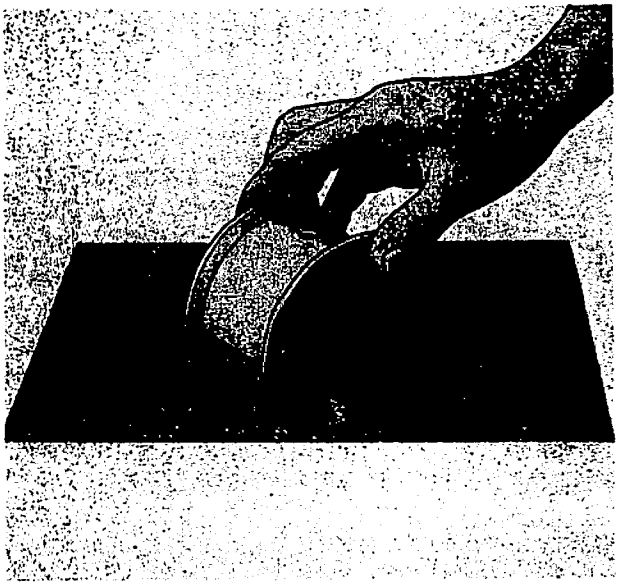


Figure 7-3. Facing Bearing Shell on Abrasive Cloth

d. Do not attempt to repair cracks in an upper crankcase as any welding operation will result in distortion of the part.

7-6 CRANKSHAFT AND FLYWHEEL REPAIR AND REPLACEMENT.

a. Straighten the crankshaft if necessary. Use suitable pads on the journals so as not to dent or mar them in any way. A 75 ton press must be used in straightening the crankshaft as it is very stiff.

b. The reverse gear drive flange and crankshaft gear assembly may be removed from the crankshaft if necessary. This assembly is a heavy press fit on the crankshaft and it is necessary to heat it to from 177° to 232° C (350° to 450°F) before attempting to remove it. As common soft solder (50% tin, 50% lead) melts at 204°C (400°F) it is simple to determine when the assembly is at the correct temperature by holding a piece of solder against it. The heating may be done by using an oxy-acetylene torch. The parts must be heated rapidly to prevent the crankshaft from expanding also. In refitting new parts it is necessary to heat them also to avoid damage to the crankshaft. Do not heat the parts above the temperatures mentioned.

c. The counterweights are normally never removed from the crankshaft, however, should this ever be necessary it is of upmost importance that they be returned to exactly the same location from which they were removed. If one or more new weights are fitted it is necessary to statically and dynamically balance the assembly to within 1-1/4 oz in.

d. Crankshafts that have journals damaged or worn beyond the allowances shown in the Table of Limits, figure 12-1 may be reclaimed by regrinding. Regrinding must be done by a skilled operator on a suitable machine. The surface must be lapped to eight micro-inches rms as outlined in paragraph 7-6f. It is of vital importance that the radius of fillet between the journals and webs be maintained from 5/32 to 11/64 in. The main and crank journals must be ground to standard undersizes as shells are available for these standard sizes. The main bearing journals are originally ground to 3.24725 - 3.24675 in. diameter. Regrind main journals to .010, .020 or .030 in. diameter under the original size. The crank journals are originally ground to 2.99725 - 2.99675 in. diameter. Regrind the crank journals to .010, .020, .030, .040, or .060 in. diameter under the original size. Only remove sufficient material to remove the imperfection. If this can be done at .030 in. undersize, for example, do not go to .040 in. undersize. All main journals must be of the same size and all crank journals must be the same size. After the crankshaft has been reground, carefully remove all sharp edges around the oil holes.

e. Minor magnetic indications that do not call for rejection of the crankshaft, as mentioned in paragraph 6-27e, require protective measures as outlined below. With a fine abrasive hand stone cut all otherwise acceptable indications to a maximum depth of .004 in. Any indication on the cheek in the area adjacent the section between a pin and main journal may be removed by stoning to a depth no greater than 1/16 in. deep. Indications in this area which cannot be cleaned up at 1/16 in. depth are cause for rejecting the crankshaft.

f. Lap the journals of the crankshaft to a surface smoothness of eight micro-inches rms.



Figure 7-4. Checking Crankshaft End Play

Refer to American Standards Association standard B46.1. It is best to mount the crankshaft on centers and spin it while lapping. This will aid in preventing flat spots. Use an abrasive cloth. Fold it over to give it an abrasive edge so the journal fillets may be polished. The abrasive cloth must not be over 3/4 in. wide. Use number 240 grit or mesh abrasive cloth. The crankshaft must be cleaned thoroughly as mentioned in paragraphs 5-8, 5-9 and 5-10. None of the abrasive material can be left on the crankshaft or oil holes. In lapping the journals be careful not to polish more in the center than on the sides so the surface becomes concave.

g. When it is necessary to replace the ring gear the defective ring may be removed from the flywheel as follows. Lay the flywheel on a flat surface and with a cold chisel cut the weld beads loose from the flywheel. Then with a drift drive the ring gear from the flywheel. Work the gear off a little at a time working all around the circumference, otherwise the gear may bind. The ring gear may also be removed after the welding beads are cut loose by placing the assembly on three supports with the weld bead side down. The supports must be against the ring gear, not against the flywheel. Now quickly and uniformly heat the ring gear to 204°C (400°F) and the flywheel will drop thru the ring gear with a little help. Do not heat the parts beyond the temperatures mentioned as the viscous dampening fluid within the flywheel may be damaged. After the old ring gear has been removed, prepare the flywheel to receive the new gear. With a file, carefully dress off rough spots on the flywheel flange and diameter so that a new ring gear can be fitted properly. Be careful that the new ring gear is the correct

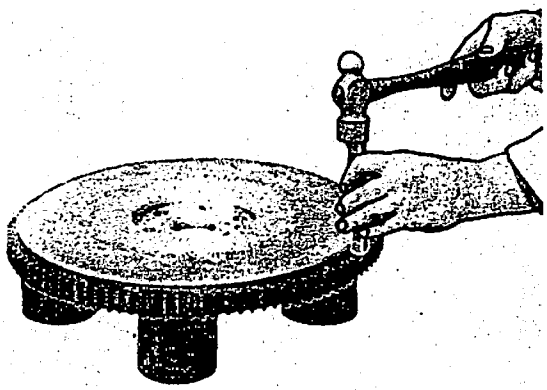


Figure 7-5. Flywheel Assembly set up so Ring Gear can be Knocked off with Drift

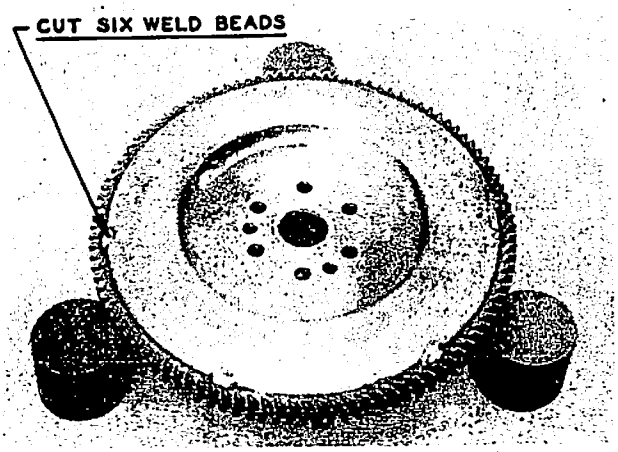


Figure 7-6. Flywheel Assembly set up so Ring Gear can be Removed by Heating

size. See reference number 22, Table of Limits, figure 12-1. Make certain that the proper hand of ring gear is used. The tooth chamfer on the ring gear for a right hand engine is different than that used for a left hand engine. Comparison with the old ring gear will assist in selecting the correct new gear. The new ring gear will go onto the flywheel easily if it is heated to from 204° to 218°C (400° to 425°F). Be sure that the ring gear is placed on the flywheel with the tooth chamfer away from the flywheel flange. The ring gear can be worked evenly onto the flywheel by striking the gear with a soft faced mallet. The ring gear may be heated in a furnace, or with an oxy-acetylene torch, but it must be heated uniformly. The flywheel must be uniformly supported on a flat surface while this new ring is being fitted. After the new ring gear is firmly seated it is necessary to weld it in place. The flywheel and ring gear assembly must be preheated before welding to from 204° to 218°C (400° to 425°F). It is most important that the flywheel be supported on a flat surface during this heating operation. After the assembly is heated to the proper temperature, electric arc weld the flywheel on the flange side to the ring gear in six equally spaced places around the circumference of the flywheel. The weld metal is to be deposited at diametrically opposite spots consecutively thus equallizing the heat stresses. Weld beads are to be 1/8 in. wide by 3/4 in. long. Use 1/8 in. diameter flux coated stainless welding rod of 18% chromium and 8% nickel composition. Use a direct current welding machine set at 125 amperes for this job with a positive electrode. Of course, the work must be done by a competent operator. After the new ring gear has been welded into place, set the flywheel and ring gear assembly on a close fitting mandrel and against a true running flange. Check the run out of the flywheel and ring gear. See reference number 23, Table of Limits, figure 12-1.

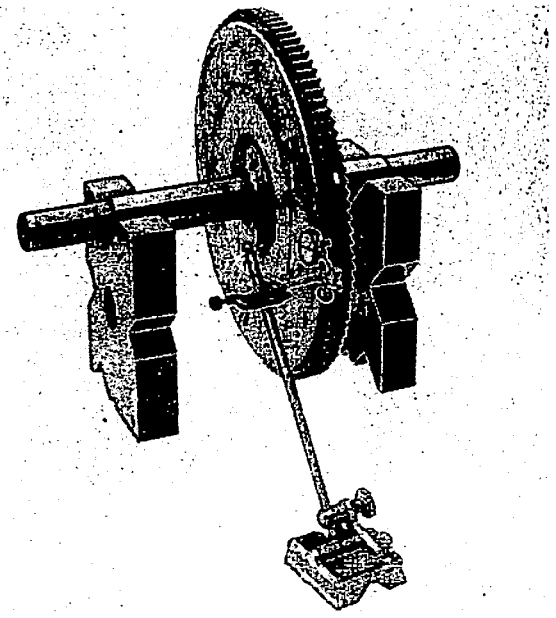


Figure 7-7. Checking Flywheel and Ring Gear Run Out

7-7 FLYWHEEL HOUSING REPAIR AND REPLACEMENT.

a. Replace any damaged or loose studs.

b. Fit a new Bendix drive housing bushing if necessary. Line ream this bushing to (1.6880-1.6885) in. diameter with a fixture to make certain it is square with the pilot diameter of the starter drive housing flange.

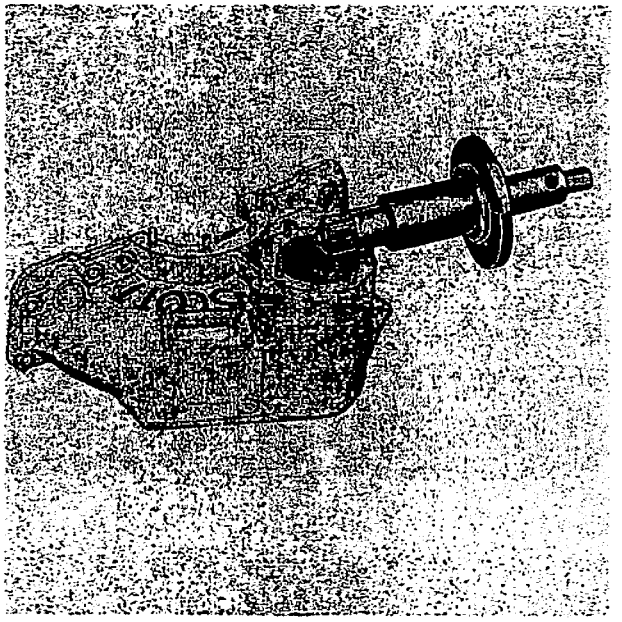


Figure 7-8. Reaming Bendix Drive Housing Bushing with a Typical Tool

7-8 CYLINDER BLOCK REPAIR AND REPLACEMENT.

a. Replace any damaged or loose studs. Replace any damaged or loose dowels so long as the dowel holes are not enlarged.

b. If the cylinder bores are worn or damaged so they will not pass inspection as mentioned in paragraph 6-29 they may be rebored. Cylinder reboring is a particular job and must be done on a suitable machine by an experienced operator. Rebore to a standard oversize as piston and piston rings are available to suit these standard oversizes. The original cylinder bores are (5.7492 - 5.7505) in. diameter. Reboring must be .010, .020, .030, .040 or .060 in. diameter over the original size. All the bores must be the same size in both blocks. Bore the cylinder with the most wear or deepest score and machine the others to match. Take out just sufficient material to "clean up" to the minimum oversize. For example, if .020 in. oversize will do the job do not go to .030 in. oversize. The surface finish must equal 8 to 16 micro-inches rms. Refer to standard B46.1 of The American Standards Association. This is a most important condition, as any finish different than this, either smoother or rougher, may cause piston scuffing. Care must be exercised to make sure the cylinder bore centers are held as originally machined. The bores must be perpendicular to the lower mounting face of the block. If the bores are not sufficiently worn or damaged to require reboring then the surface glaze must be removed before new pistons and rings are fitted. This may be done with a "Glaze Buster", a cylinder hone or a piece of sand paper used in the hand. Any of these three methods must be used carefully, so as not to remove anything more than the glaze. Do not remove any metal from the cylinder

walls. Use kerosene as a cutting fluid while removing the glaze. In using sand paper manually, work around the circumference of the bore not lengthwise. After the glaze is removed wash the cylinder bores with warm water and soap to clear out all the dirt and grit. Dry thoroughly and apply rust preventive compound as mentioned in paragraph 5-16.

c. Clear all water circulation holes in the top of the cylinder block.

7-9 CONNECTING ROD REPAIR AND REPLACEMENT.

a. Press the 3/8 in. diameter connecting rod bolts out of the yoked connecting rods and press in new bolts using white lead as a lubricant per specification JAN-A-669 (Symbol CAS).

b. Correct any connecting rod bearing shells that show too much "crush". This may be done by rubbing the shell on abrasive cloth. The cloth must be "backed up" with a flat surface so the edge of the shell is kept true. Refer to figure 7-3. If the shells do not have enough crush new shells must be used. Do not attempt to file off the cap or rod to obtain the correct crush. Any bearing metal that is smeared into the shell reliefs must be scraped out. In replacing bearing shells always do so in pairs. For example, do not replace the cap half shell without also replacing the connecting rod half shell. Replace any damaged or loose dowels.

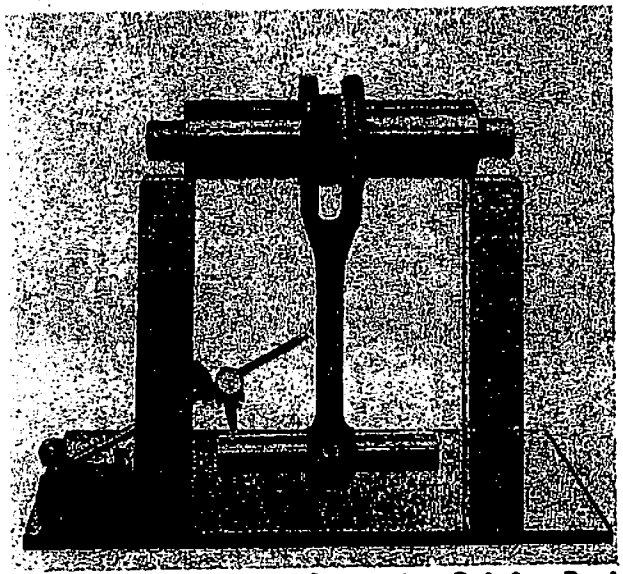


Figure 7-9. Checking Connecting Rod for Bend

c. Replace the piston pin bushing and ream to size in a fixture so that the center distance and proper alignment with the big end of the rod will be maintained. Use light engine oil as a lubricant when pressing the bushing in. Do not use white lead. The hole in the piston pin bushing need not come opposite the oil hole in the top of the connecting rod as a groove in the bushing assures oil getting to the piston pin. The center distance from the piston pin end of the connecting rod to the crank pin end must be held at from (11.998 to 12.002) in. and the piston pin bushing is reamed to from (1.3753 to 1.3755) in. diameter.

d. The connecting rods must be checked for alignment and twist before they may be considered ready to go back into the engine. This is done as follows. Place a close fitting 12 in. long mandrel to the crank end of the rod. Place a close fitting eight in. long mandrel to the piston pin end of the rod. The mandrels are to project equal distance on either side of the connecting rod. Of course, when making this check the piston pin bushing is to be finish reamed and the bearing shells, caps and nuts are to be fitted to the connecting rod. Draw the connecting rod nuts down to the proper torque as mentioned in Miscellaneous Table, figure 12-9. Now on a surface plate place two blocks of exactly equal height (about 16-1/2 in. long). Hang the rod from these blocks, piston pin end down. Now with a dial indicator mounted on the surface plate, check the height of the mandrel at both ends. Any difference in height between the two ends of the mandrel in the lower end of the rod indicate a bent rod. Do not use a bent rod. See reference number 32, Table of Limits, figure 12-1. A bent rod may be straightened if it is otherwise in good condition. This straightening operation may be done by supporting the rod at either end and pulling down in the center between supports with a clamp. The supports must be of relative soft material such as mild steel, brass or lead so that the connecting rod surface is not marred. The supporting surfaces must be good size to

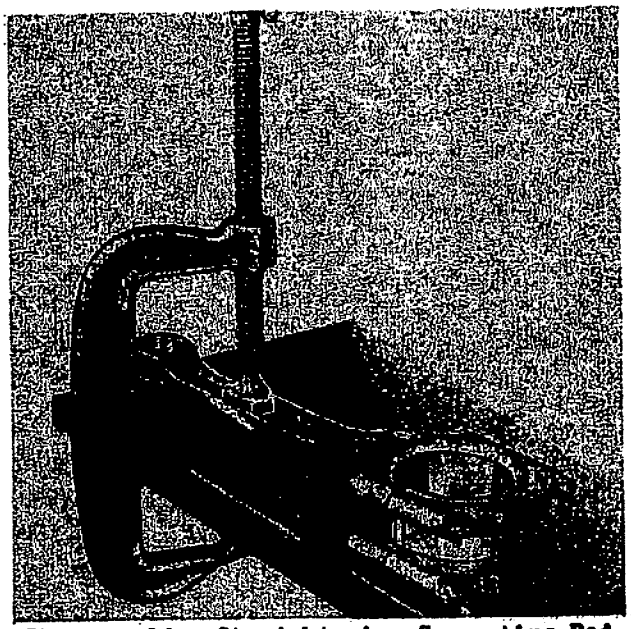


Figure 7-10. Straightening Connecting Rod

assure plenty of bearing area. Do not use anything like a knife edge. Be careful not to bend the yoke end of the yoke rod. Exert just enough pressure to take the bend out of the rod. After the connecting rod has been inspected for bend and corrected then it must be checked for twist. This is done by using the same tight fitting mandrel as before. Lay the connecting rod down horizontally on a surface plate with exactly equal height blocks under the mandrels at one end. Again check the height of the unsupported mandrel at equal distance either side of the connecting rod. Any difference in height between the ends of the mandrel is an indication of a twisted rod. Do not use a twisted rod in the engine. See reference number

31, Table of Limits, figure 12-1. A twisted rod may be corrected as follows if it is otherwise acceptable. Clamp the large end of the connecting rod in a soft jawed vise. Be careful so as not to collapse the yoke end of the yoke rod. Put a piston pin or a close fitting mandrel in the piston pin end. The rod may now be twisted to bring it back into alignment. A 9/16 in. diameter bar may be used in the piston pin hole for additional leverage.

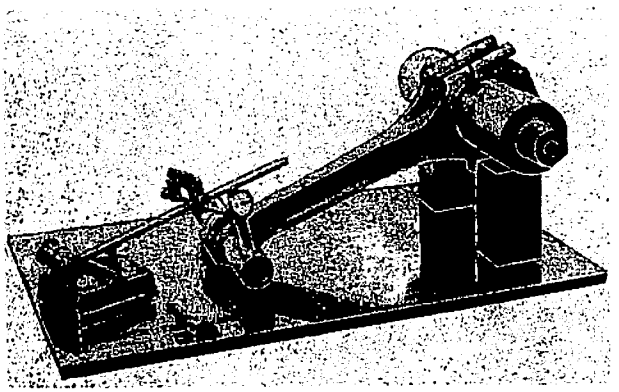


Figure 7-11. Checking Connecting Rod for Twist

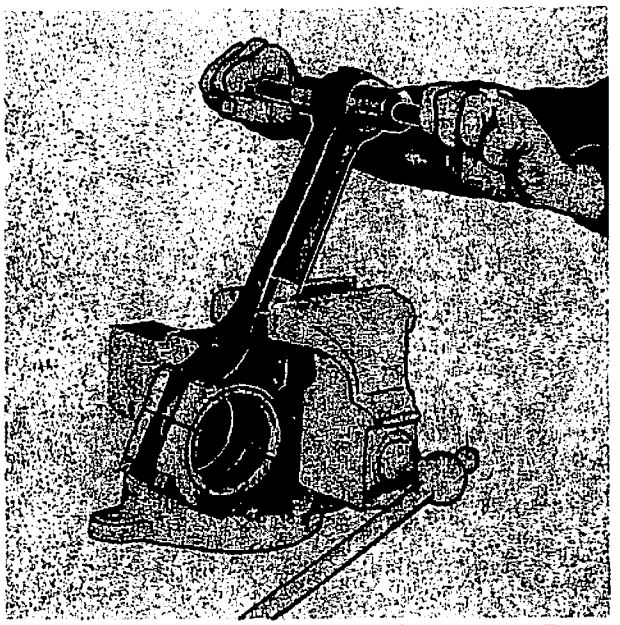


Figure 7-12. Straightening Connecting Rod

7-10 SPROCKET HOUSING REPAIR AND REPLACEMENT.

a. Replace damaged or loose studs. Replace damaged or loose dowels provided the dowel holes are not enlarged.

b. Do not attempt to repair a cracked or broken sprocket housing as any welding is certain to distort the machined faces and thus render the housing useless.

c. Replace all oil seals. Use care in handling these seals as the sealing lip is very delicate and is easily damaged. Do not distort the seals in pressing them into place.

7-11 GEAR CARRIER REPAIR AND REPLACEMENT.

a. The gear carrier housing is only replaced if it is cracked or otherwise damaged. It is not normally subject to wear and rarely needs replacing. Do not attempt to repair a crack by welding.

b. Replace gears, shafts and bearings as may be judged from the information gathered in paragraph 6-33.

7-12 CYLINDER HEAD REPAIR AND REPLACEMENT. If the cylinder head has been found unacceptable as inspected in paragraph 6-34 it must be discarded or repaired as explained here.

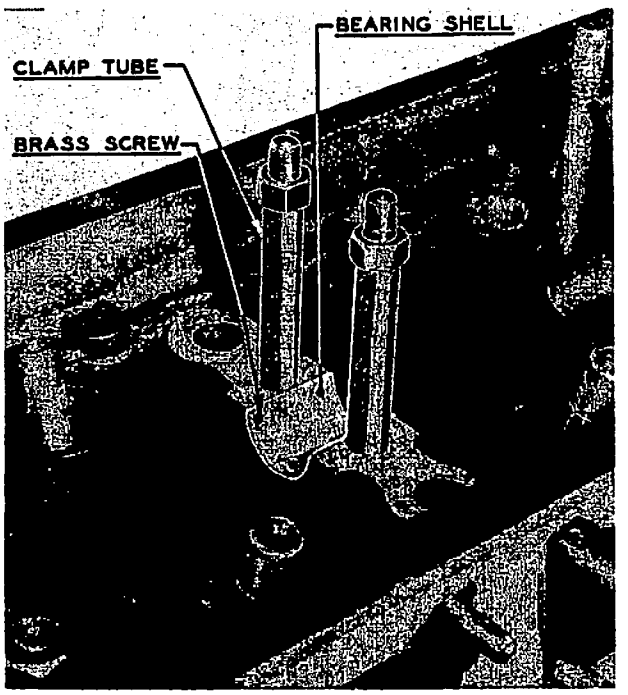


Figure 7-13. Camshaft Bearing Repair

a. A scored camshaft bearing is repaired as follows. Bore out the damaged bearing to (1.561 - 1.563 in.) diameter suitable for receiving camshaft bearing shell part 311540. (This is the same shell used at the sprocket end of the head.) Cut the shell to suit the length of bearing saddle being repaired. Fit shell to cylinder head, and with 1/2 in. inside diameter tubing over studs, clamp shell in position. Then drill, at four corners, with No. 29 drill 5/16 deep into both shell and cylinder head. Keep drilled holes close (about 3/16) to end of saddle. This precaution is necessary to keep from breaking thru into the water jacket space. No clearance hole in shell screw hole is required. Tap four holes, standard 8-32 threads, full depth of drilled hole. Screw in 1/2 in. long brass screws until they hit bottom. Cut off screws about 1/32 in. above surface of bearing and peen over ends of screw. Now remove tubing clamps and with hand scraper, scrape off screw ends and "blue in" bearing until a nice fit is obtained with the camshaft journal. File off top edges of shell until it is just flush with the cast iron head. The bearing shell has two 5/16 diameter holes in it. These holes may be filled with lead, but this is not essential.

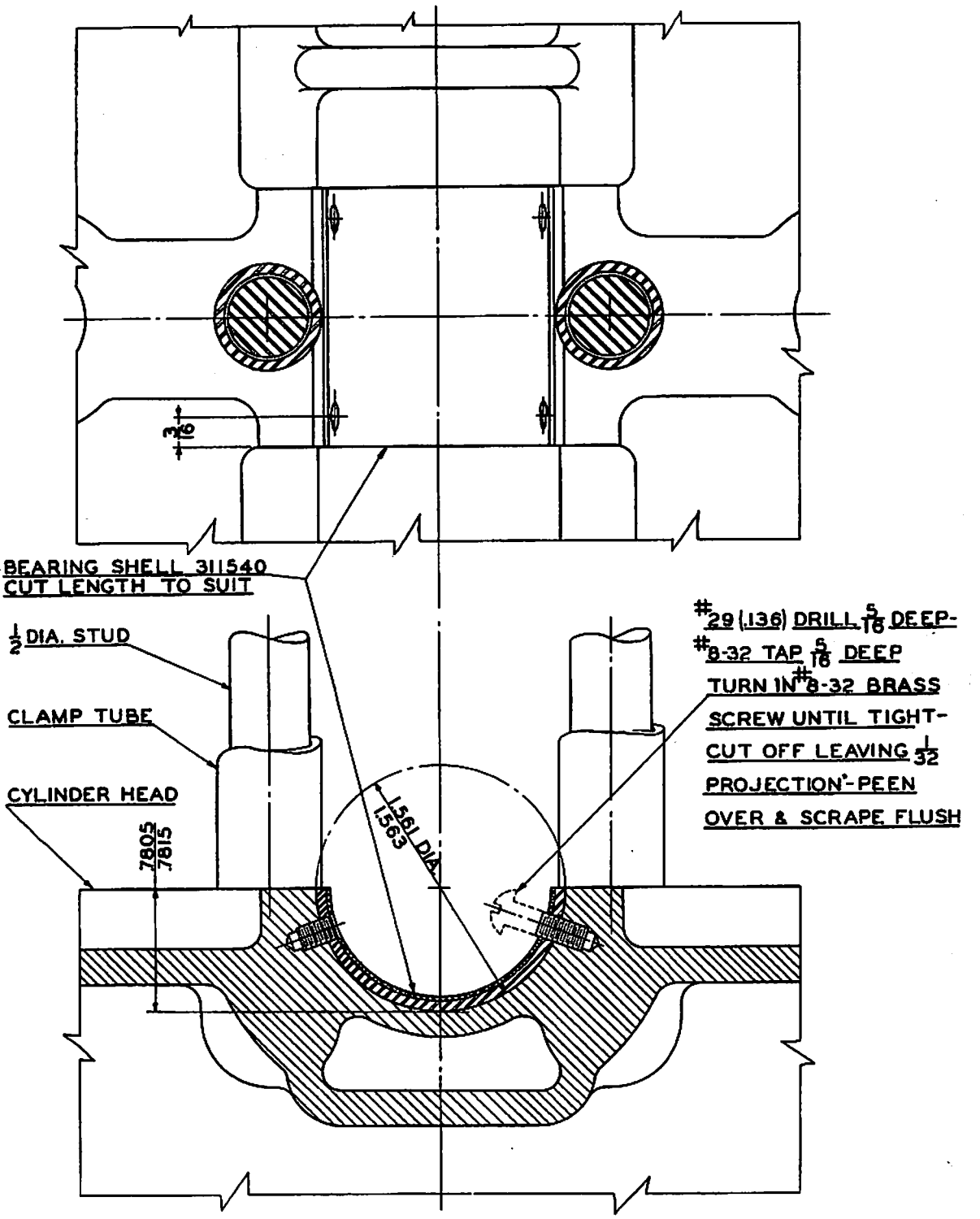


Figure 7-14. Camshaft Bearing Repair

b. Replace all loose or damaged studs. Use white lead per specification JAN-A-669 (Symbol CAS) as a lubricant. Replace all loose or damaged dowels in case the dowel holes are not enlarged.

c. Replace all valve guides driving them into place from the top side of the head, not from the combustion chamber end. Be sure to get the intake and exhaust guides in the proper place. The exhaust guides have the large bore. Use a tool similar to that shown in the illustration to avoid damaging the guides. Use white lead as a lubricant when installing new guides. The guides must be driven down until

the guide shoulder stands clear of the head per item 53, figure 12-1. Do not drive this shoulder down tight against the head as this will distort the guide bore. Exhaust valve guides must be reamed from (.5310 to .5300 in.) diameter. The intake guides are reamed from (.4990 to .4985 in.) diameter. These guides are available either finished reamed, or rough bored. The rough bored guides must be finished reamed after they are installed in the head. Finish reaming, after installation makes the best job, but in the event reamers are not available, the already reamed guides are acceptable, but they should be checked for distortion and clearance after they are in place in the cylinder head. The reaming operation, when done on the job, must be made in two stages. First rough ream, and then finish ream to the diameters given above. Always use valve guide reamer bushing to maintain alignment of guide bores.

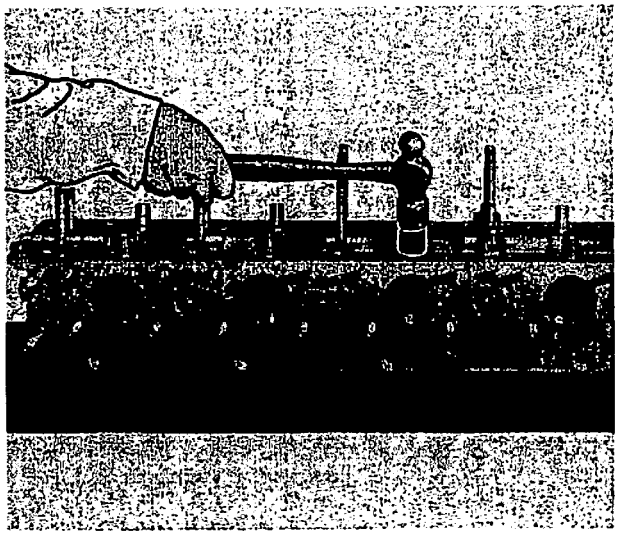


Figure 7-15. Installing Valve Guide with a Typical Tool

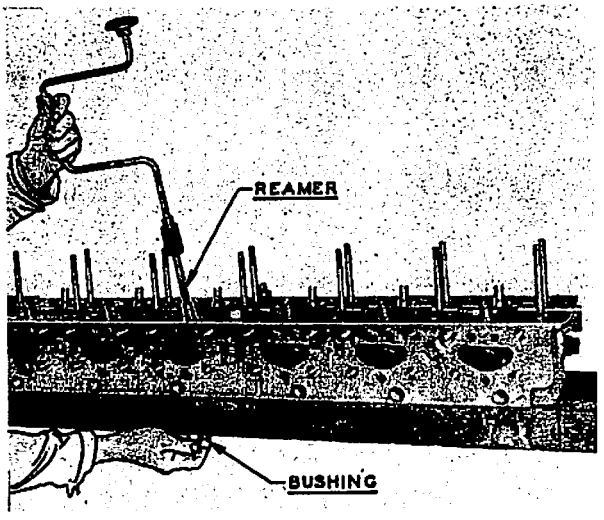


Figure 7-16. Reaming Valve Guide with a Typical Tool

d. Loose or damaged exhaust valve seat rings must be replaced, otherwise they may be refaced. Always reface seats if new guides have been installed, as that is the only way the alignment between the valve guides and the valve seats can be assured. Exhaust valve seat rings can be removed from the cylinder head by using valve seat ring tool kit 327079. This same tool kit is also used for reworking the counterbore in the cylinder head to take oversize valve seat rings. The reamers for this tool are of such a diameter that they will give the correct press fit for the replacement exhaust valve seat rings. The valve seat rings must be a press fit in the cylinder head as shown in the Table of Limits, reference number 51, figure 12-1. If the counterbore in the head has become enlarged so that the minimum fit cannot be obtained, then the next closest oversize ring must be used.

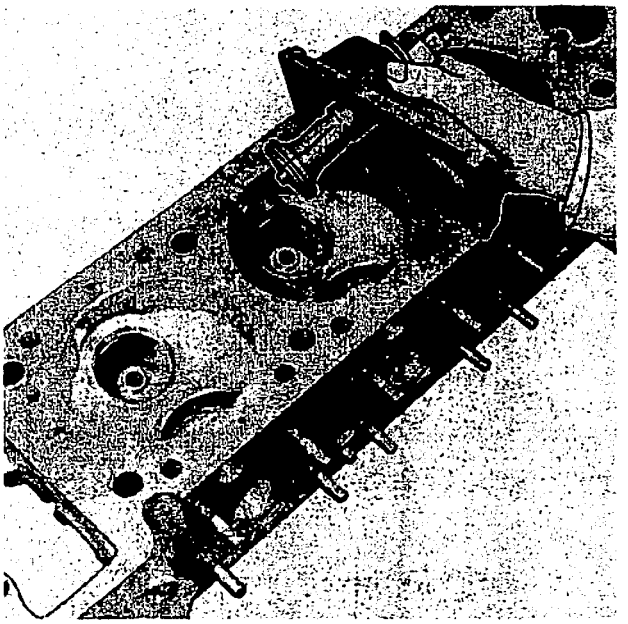


Figure 7-17. Typical Tool for Removing Valve Seat Ring

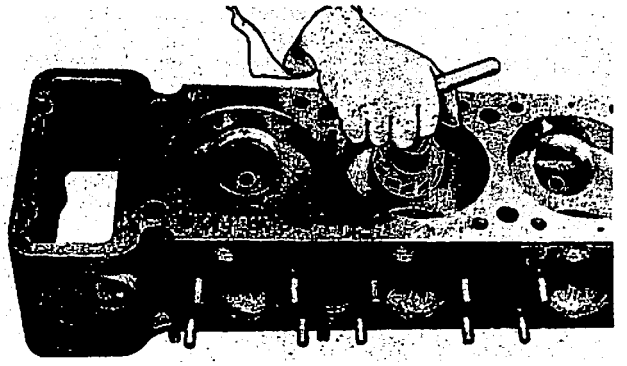


Figure 7-18. Typical Tool for Reaming Bore for Oversize Valve Seat Ring

The outside diameter of the standard size ring is from (2.8090 to 2.8085 in.) diameter. Oversizes of .020 and .040 in. are available. Do not use a larger oversize than is necessary. For example, if the proper fit can be obtained with a .020 in. oversize ring, do not go to a .040 in. oversize. The use of inside and outside micrometers is necessary to accurately determine the fit of the valve seat rings. Check the "run

ASSEMBLY OF SUBASSEMBLIES

8-1 GENERAL. In this section instructions are given for the assembly of separate parts into their various subassemblies. All parts must have been subjected to the inspection procedure outlined in section VI and accepted as satisfactory before they may be used in the engine. Shop practices and general instructions applying to a number of similar parts are covered in the following paragraphs of this section. It is expected that these instructions will be followed where ever applicable, and are therefore not repeated. All necessary inspection procedures to be made in these operations are explained.

8-2 GASKETS. The reuse of old gaskets and seals is not recommended. It is assumed that all gasket, seals and packing will be installed where required, using new material to replace that removed during disassembly. It is general practice to stick one side of a gasket to the gasket flange with shellac or similar tacky compound. The opposite gasket face is then coated with grease similar to specification AN-G-14 (Symbol GRG). Such practice allows the assembly to be easily separated at the gasket face. If grease is used against the face carrying the studs it will make "clean up" of the gasket face considerably easier at the next overhaul.

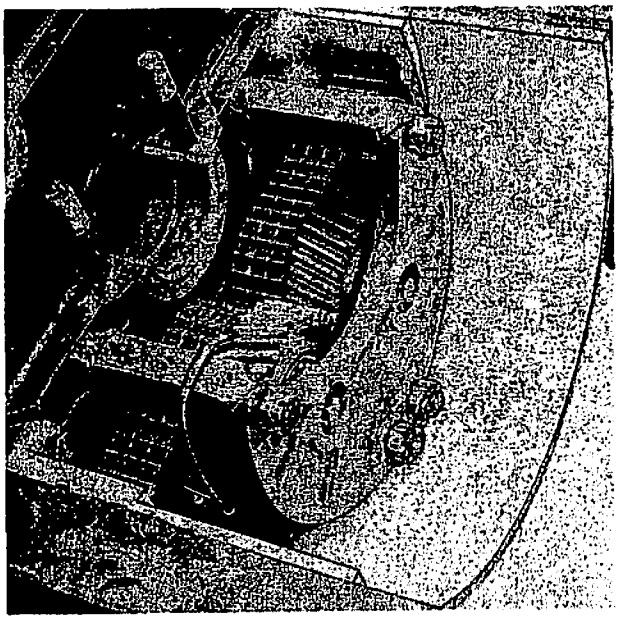


Figure 8-1. Gear Carrier Assembly Showing Lock Wires

8-3 LOCKING DEVICES. It is assumed that all means used to lock nuts, bolts, screws, etc., to prevent their loosening in service, will be replaced with new material in the same manner as originally applied by the manufacturer and as shown in the illustrations. Cotter pins are usually damaged or destroyed when removed and should not be used a second time. The new pins should be tapped securely in place and the tangs split, one side bent back over end of nut, and the other down along the side. Dowel pins, both tapered and straight, may be used again if they have not been damaged, or if the bore from which they were removed has not enlarged beyond the point where the pins are a tight fit. Safety wiring should be done carefully, following the same grouping as the original installation. Wire should be drawn snugly and then be twisted between each nut, to prevent loosening. Thread the wire thru the nut slots in such a way that it tends to tighten the screw elements as illustrated. Use fully annealed wire for securing parts. Lock washers of the spring type should never bear directly on aluminum. Plain steel washers should always be used under the lock washers to prevent damage to the aluminum part.

8-4 CLEANING AND OILING. Of all parts at assembly is of utmost importance. First, wipe all parts clean and dry. Clean all oil passages and vents and make sure they are open. All splines, gears and bearing surfaces should be liberally coated with oil when assembling, to supply lubrication until the engine oiling system has established circulation.

8-5 GEAR CARRIER ASSEMBLY. Press the ball bearings into the accessory drive gear and sprocket. Press against the outside race only. Do not forget to place the spacer in between the two bearings. This spacer should be centered in the bearing bores so the shaft will slide thru easily. Now lubricate the ball bearings and fit the gear and sprocket assemblies to the gear carrier housing. The gear that meshes with the crankshaft is to be fitted last. See that the helix angle of the gears are correct so they will mesh properly with one another and the crankshaft gear. Push the gear carrier shaft into place and secure with the long 7/16 in.

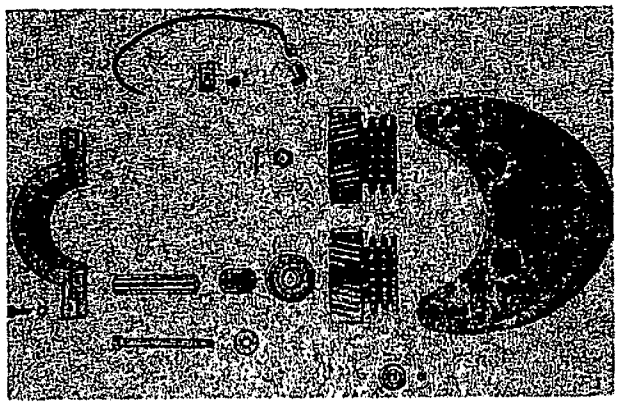


Figure 8-2. Exploded View of Gear Carrier

diameter cap screw. The cap screws must be assembled to the gear carrier in such a way that they come on the outside face so they can be removed while the gear carrier assembly is on the upper crankcase. Refer to paragraph 9-7. Be sure to use the heavy washer under the head of the cap screw. After both shafts and cap screws are fitted they must be secured with lockwires passed thru the drilled holes in the heads of the cap screws as shown. Fit the oil supply pipe and lock the oil pipe clip by bending an ear of the clip against the head of the cap screw. The oil pipe is placed on the assembly

so it will spray oil onto the entering side of the crankshaft gear. Refer to figure 2-6. See that all pipe plugs are returned to the oil passages so the oil pressure will come from the main oil line drilled in the upper crankcase and be directed onto the gears thru the tubing provided.

8-6 CRANKSHAFT AND FLYWHEEL ASSEMBLY.

a. Press crankshaft connecting rod pin seals into place. These parts may be driven in using the same tool with which they were removed. After the seals are in place put a slight dimple in one spot each end to retain the seal in the crankshaft. Check each pin seal for leaks by putting the oil hole under slight air pressure with each end of the pin seal coated with light oil, watch for air bubbles. If the pin seal leaks it may be spun tight by using the typical spinning tool as illustrated.

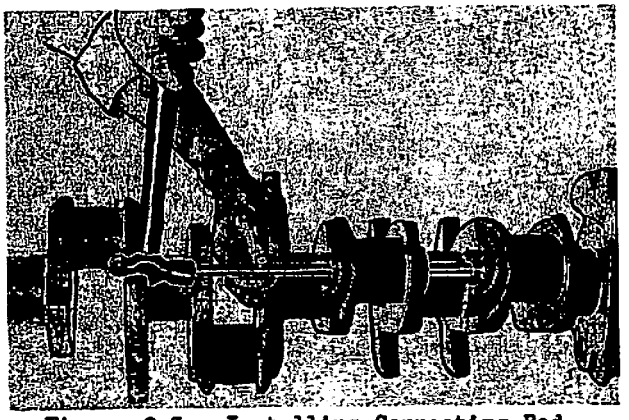


Figure 8-3. Installing Connecting Rod Pin Seal with Typical Tool

b. See that the flange face and diameter at the front of the crankshaft are clean and smooth. See that the flywheel pilot diameter and mounting face are also clean and smooth. Fit the flywheel to the crankshaft. Be sure the flywheel, ring gear and crankshaft are properly matched so they can be assembled into the engine for the intended rotation. If these parts have been properly marked, as mentioned in paragraphs 4-17 and 4-34, there will be no question on this point. The dowel locates the flywheel on the crankshaft flange. See that this dowel is properly entered into the flywheel. Fit the hand starting ratchet and carefully draw the flywheel onto the crankshaft flange.

WARNING

Fit the proper hand ratchet, otherwise an accident may occur when the hand starting lever is used.

If the cap screws are drawn up evenly the flywheel will go on without difficulty. Finally draw the cap screws down to the torque mentioned in figure 12-9. Secure the cap screws with lock wires. Also fit the reverse gear clutch driving drum and drive flange. Make certain that the mounting flanges and pilot diameters are clean and free of burrs. Draw the parts together with the bolts and nuts. Secure the nuts with wire.

c. Now set the crankshaft up on "V" blocks under the front and rear main bearing. Rotate the crankshaft and check the runout of the reverse gear clutch driving drum and the drive flange bushing. Also check the runout of the face of the starter ring gear. See reference number 6, Table of Limits, figure 12-1. Refer to figure 6-16.

d. If the crankshaft assembly is not to be placed into an engine immediately then all the finely finished journals must be protected with rust preventive compound and heavy paper or cloth wrapped around the journals.

8-7 PISTON AND CONNECTING ROD ASSEMBLY.

a. Lubricate the piston pin and fit it to the piston and connecting rod. The piston pin can normally be pushed into place with the fingers. If any force must be used be careful to use a soft brass drift against the piston pin end. Center the piston pin in the assembly and fit the piston pin retainers. These retainers should fit just tight enough to keep them from falling out. They may be filed slightly if too tight or spread just a bit by hammering on them if they are too loose. Be sure that the retainers

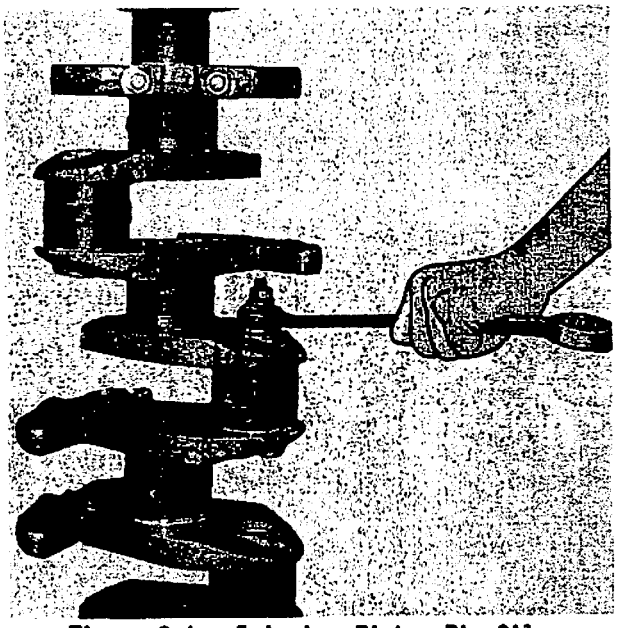


Figure 8-4. Spinning Piston Pin Oil Seal with Typical Tool

go in far enough so they will not rub against the cylinder walls.

b. The next step in the assembly of the piston and connecting rod is to check the end clearance of all piston rings. This is done by sliding the ring into the cylinder bore at its minimum diameter and then try a feeler gage in the gap. See reference number 61, Table of Limits, section XII. The piston ring must be square in the bore when this gap measurement is made. This is easily accomplished by pushing the ring down with a piston thus assuring its being square. The rings should be checked in the bore in which they are to run. Ring gap may be enlarged with a fine cut file if necessary. The file can best be used by holding it in a vise and by grasping one end of the ring in each hand, rub one end of the ring against each side of the file. Be careful not to remove too much metal and see that the gap is kept square and true. Remove any burrs on the ring faces or outside diameter raised by the file.

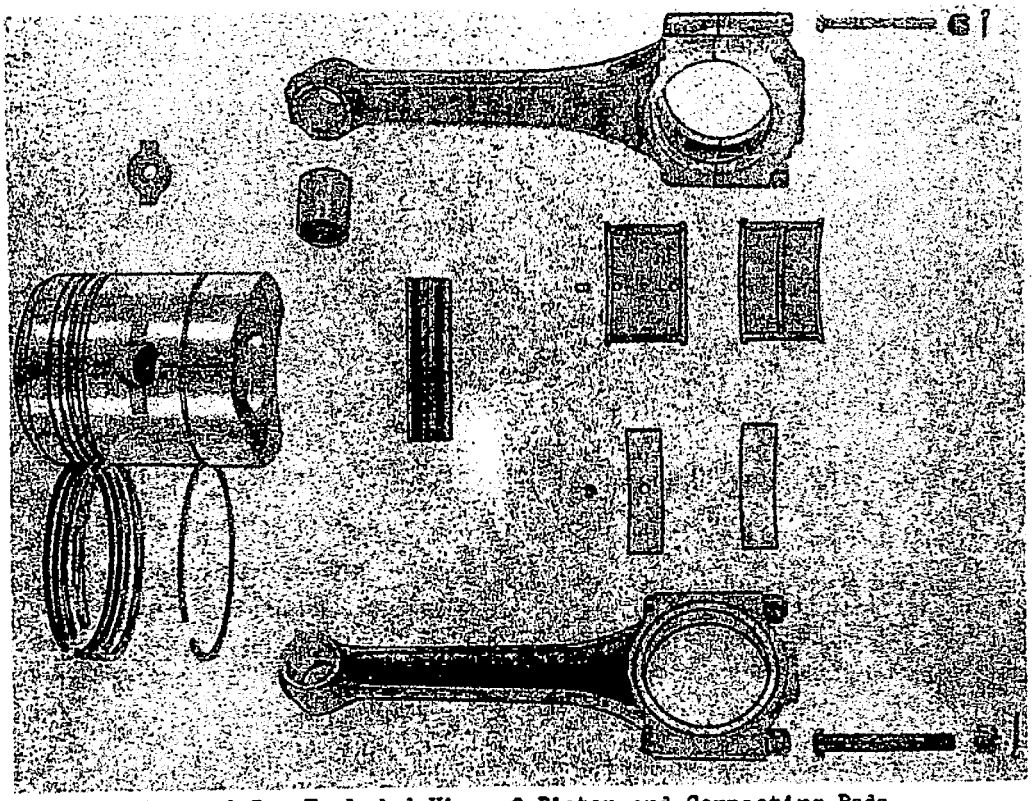


Figure 8-5. Exploded View of Piston and Connecting Rods

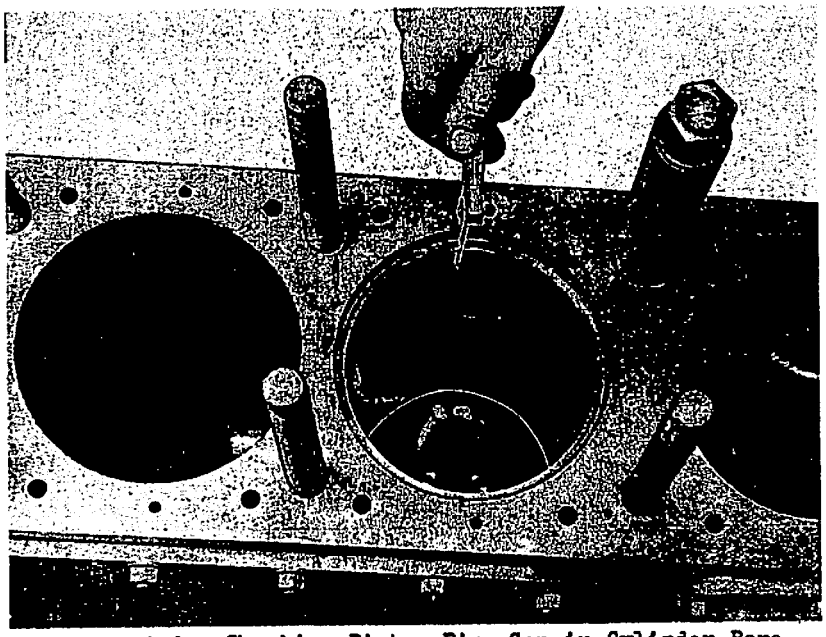


Figure 8-6. Checking Piston Ring Gap in Cylinder Bore

As the rings are fitted for each cylinder keep them grouped so they can be correctly fitted to the piston to run in the bore for which the rings were fitted. Connecting rods are stamped with the cylinder numbers. Refer to paragraph 9-12a for location of blade and yoked rods.

c. Clamp the connecting rod and piston assembly lightly in a soft jawed vise and fit the piston rings to the piston. Use a piston ring expanding tool so as not to distort the rings. Of course, the lowest ring on the piston must be fitted first. See that the rings are installed right side up as on some rings it makes a difference. The ring grooves are numbered from the top down. That is, the groove nearest the piston head is number one and the groove in the skirt is number five. The ring for number three groove must be installed with the relief on the bottom side as illustrated. Unless the pistons and connecting rod assemblies are to be assembled to the engine immediately they should be carefully coated with rust preventive coating as mentioned in paragraph 5-16, placed in a box and covered to keep the dust out. See figure 8-17.

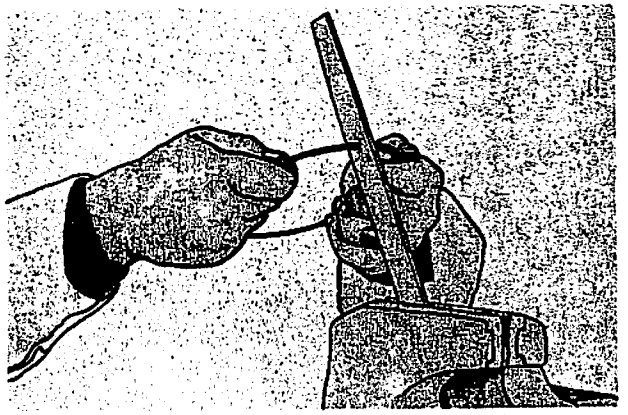


Figure 8-7. Filing Piston Ring Ends

8-8 SPROCKET HOUSING ASSEMBLY. Press the two bilge pump drive sprocket shafts into the sprocket housing. See that the shaft flange is free of dirt and burrs so it can seat accurately. Be sure to support the sprocket housing close to the shafts as they are pressed in so as not to distort or crack the housing. Use a little white lead per specification JAN-A-669

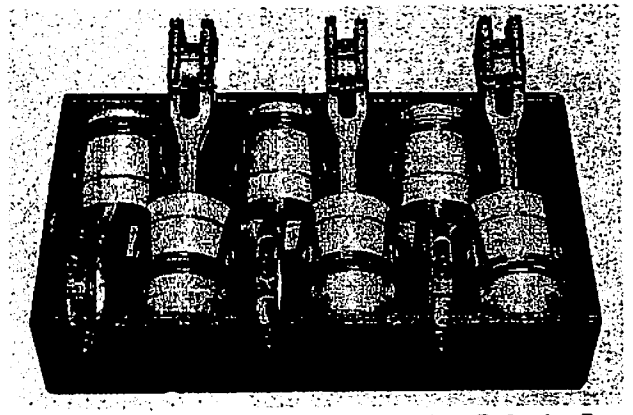


Figure 8-8. Pistons and Connecting Rods in Box

(Symbol CAS) as a lubricant while the shafts are being pressed into place. Press a new ball bearing into the generator drive sprocket, the bilge pump drive sprocket and the accessory drive idler sprockets. Press on the outer race of the ball bearings only. Be sure the spacer is in place in between the ball bearings of the bilge pump drive sprocket and the accessory drive idler sprocket. If the spacer is centered up in the assembly it will make fitting to the shafts easier. The bilge pump drive sprocket, of course, is used only on the right hand engine. The left hand engine uses a toothless idler sprocket instead. Place the assembled sprockets on the shafts in the sprocket housing, secure with washers, nuts and cotter pins. Now see that the mounting face and pilot diameter in

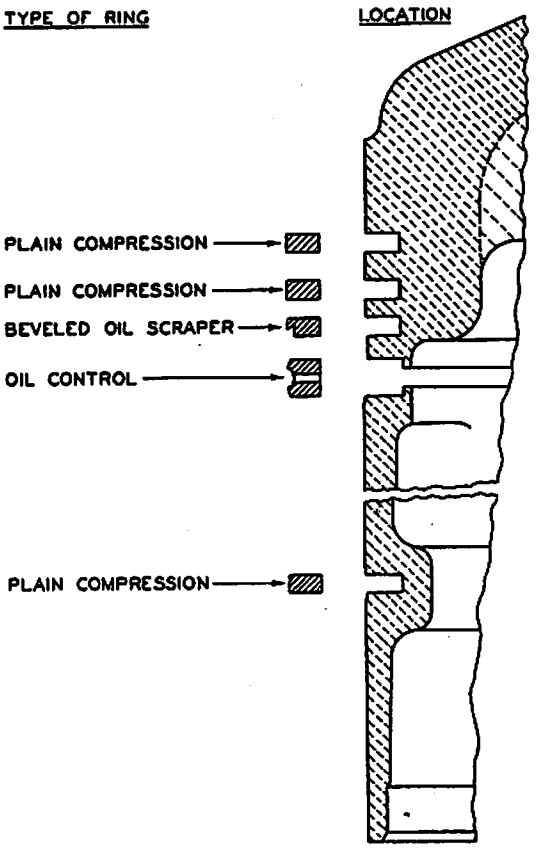


Figure 8-9. Piston Ring Location

the sprocket housing is clean, smooth and flat. See that the generator drive sprocket face and pilot diameter is in good condition and clean. After the generator drive shaft flange is smooth and clean fit it to the drive sprocket. Secure with four 3/8 in. cap screws. Pull the shaft into place evenly so it does not bind. Secure the cap screws with a lock wire. Clean the bearing mounting diameter on the generator drive shaft carefully and add a drop or two of oil per specification AN-O-6 (Symbol OGP) to this diameter. Clean the mounting face of the generator drive shaft bearing retainer and see that it is flat and smooth. Coat the mounting face lightly with gasket cement. A tacky gasket

cement, such as Army specification 62-5. Place a new gasket on this face. Coat the mounting face of the sprocket housing with light cup grease specification AN-G-14 (Symbol GRG). See that the ball bearing and oil seal are placed in the generator drive shaft bearing retainer. Fit the retainer to the engine and secure with nuts and lockwashers. Draw it into place evenly so as not to bind or distort the bearing retainer. Now fit the generator drive pulley to the generator drive shaft. Enter the pulley carefully into the oil seal so as not to damage the lip of the oil seal. Secure the pulley with nut and washer. Lock it in place with a cotter pin.

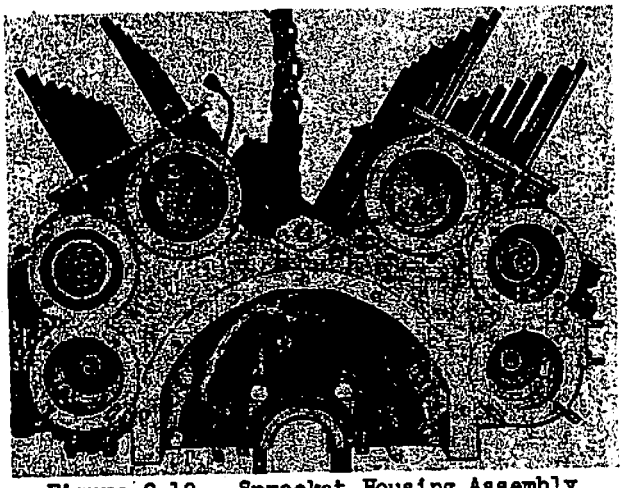


Figure 8-10. Sprocket Housing Assembly

8-9 CYLINDER HEAD ASSEMBLY. After the cylinder head parts have been repaired and passed inspection, as mentioned in paragraphs 6-34 and 7-12, the parts may be assembled as follows:

a. See that the flange faces of the cylinder head and rockerarm cover base are smooth and clean. Coat the bottom face of the rockerarm cover base with a tacky gasket cement similar to Army specification 62-5 and stick the new gasket in place. Now coat the top flange of the cylinder head with light cup grease per specification AN-G-14 (Symbol GRG). Fit the rockerarm cover base to the cylinder head and secure with washers and cap screws. It is well to place a close fitting plug in the fuel pump mounting hole to assure the bore being round after assembly. A fuel pump may be used for this purpose.

b. Now lubricate the valve stems with engine oil and slide them into place. Be sure that the valves are placed on the seats for which they were fitted. It is most convenient to place a valve support piece over the valves now to hold them in place while the valve springs and keys are fitted. See figure 4-34. On the top side of the cylinder head fit the chain and rockerarm shoe oil pipe. There are two different pipes. Be sure the pipe is selected so the oil squirt holes are exposed opposite each cam. Lubricate and place the camshaft bearing shell in the rear camshaft bearing saddle. Lubricate and place the camshaft in the cylinder head. Be careful at this point to get the correct camshaft in the cylinder head. The part number is etched on the camshaft flange. If the camshaft has been properly marked, as mentioned in paragraph 4-46, there will be no trouble on this point, otherwise the parts catalog must be consulted (AN 19-85BHB-4) to determine the proper camshaft to use. Place the center and both end camshaft brackets in place over the camshaft. Place an auxiliary 1-1/8 in. diameter shaft or bar on the camshaft brackets and fasten it down by using camshaft bracket caps. Now install the valve springs and collars. All valve springs are the same for both exhaust and intake valves as well as collars and keys. Be sure to place both inner and outer springs on all valves. With the special tool depress the valve collars and fit keys to all valves. See that all parts are clean and that the keys seat properly around the valve stems. Remove the auxiliary 1-1/8 diameter shaft and set the remainder of the camshaft brackets in place over the camshaft. Be sure to remove valve support piece.

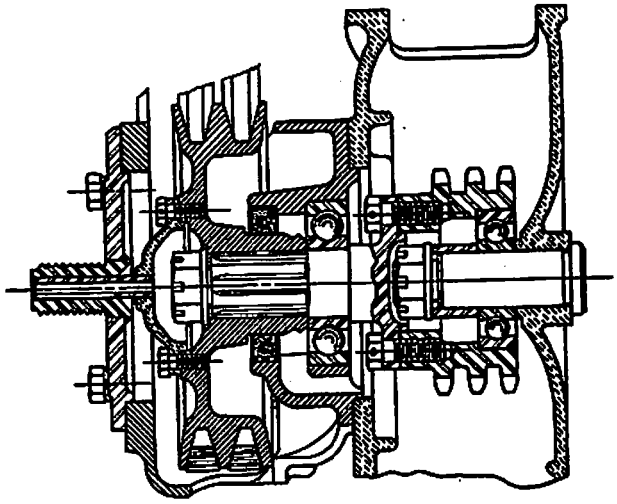


Figure 8-11. Generator Drive Mounting on Sprocket Housing

c. Lubricate and assemble the rockerarms and spacer springs onto the rockerarm shafts. There are two types of shafts. The center shaft is open at both ends whereas the shafts that assemble to the ends of the cylinder head are plugged at the outside end. The rockerarms, spacer springs and rockerarm bearing caps are assembled to the head as illustrated. The studs that pass thru the camshaft brackets are long so that the caps can be pulled down into place with the nuts. All the caps must be pulled down evenly. Be sure to use lock washers under those rockerarm bearing cap nuts. See that cap dowels properly enter the holes in the rockerarm shafts.

d. To aid in setting the valve timing in final assembly it is a good idea at this point to rotate the camshafts to the positions mentioned below. Determine first which head is for the leading cylinder bank and which is for the trailing cylinder bank as explained in paragraph 1-22. Set all the valve tappet clearances to the figure mentioned in Ref. No. 42, Table of Limits, figure 12-1. Rotate the camshaft in its normal running direction of rotation while watching the number six exhaust valve in the cylinder head intended for the leading bank. When number six exhaust valve in the leading bank is just seated the camshaft is properly set for assembly of the cylinder head to the engine. Now attend to the camshaft in the cylinder head

intended for the trailing cylinder bank. Rotate this camshaft in its normal direction until the number one exhaust valve is just closed. The camshaft for the trailing cylinder bank is now properly set for assembly of the cylinder head to the engine. The camshaft is rotated for this operation by installing the 3/4 in. cap screw in the camshaft end with a 11/16 in. long collar on it to keep it from "bottoming". Standard 3/4 in. pipe may be used for the collar. The camshaft is then easily rotated with a wrench applied to the 3/4 in. cap screw. After the camshaft is properly positioned do not forget to remove the collar from the camshaft cap screw. To determine exactly when the exhaust valve is just seated do this. The valve collar can be oscillated by hand so long as the valve is off its seat but locks up tight just as soon as the valve comes against its seat. With this in mind, oscillate the exhaust valve collar while turning the camshaft in its normal running direction. When the valve is open the collar can be oscillated, but just as soon as it closes it is impossible to oscillate and that is the position we want and so do not rotate the camshaft any farther. Figure 9-2 shows the normal rotation of the camshafts. This camshaft rotation is same regardless of the crankshaft rotation.

e. Assemble the exhaust manifold to the cylinder head. Make sure that all dowels enter the holes in the manifold properly. Coat the manifold gasket face and the cylinder head gasket face with a viscous non-hardening cement similar to Army Stock No. 052-C-685-2PX. Always use new gaskets for the exhaust manifolds. Draw the manifolds up tight against the cylinder head. Fit the mechanical fuel pump to the cylinder head. Use a new gasket and use a tacky gasket cement similar to Army specification 62-5 on the pump flange. Be careful not to obstruct the oil hole in the pump flange or in the cylinder head. Make sure the gasket is properly punched to admit oil from the head to the pump. Coat the cylinder head flange with soft cup grease similar to specification AN-G-14 (Symbol GRG). Set the pump in place and see that the fuel pump driving tongue properly enters the

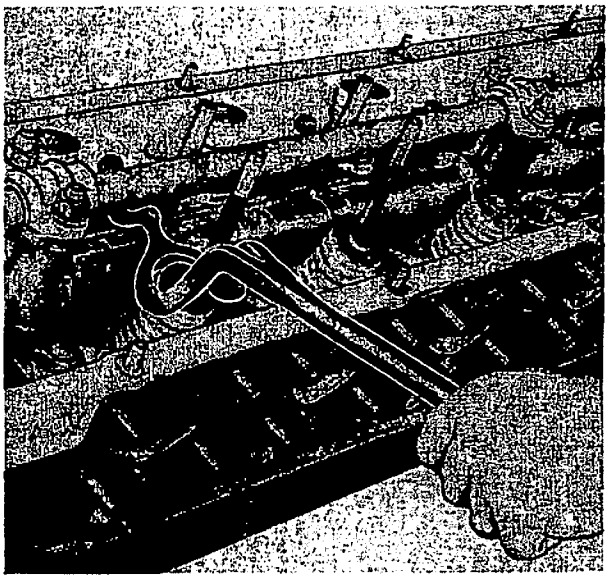


Figure 8-12. Fitting Valve Springs, Collars and Keys

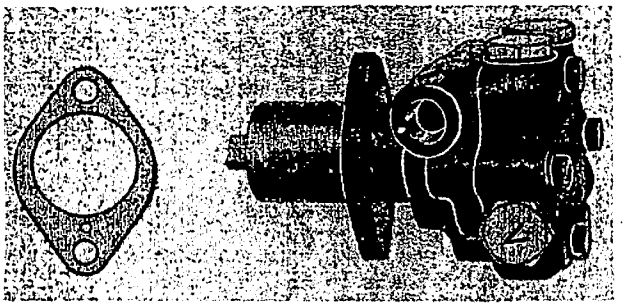


Figure 8-14. Mechanical Fuel Pump

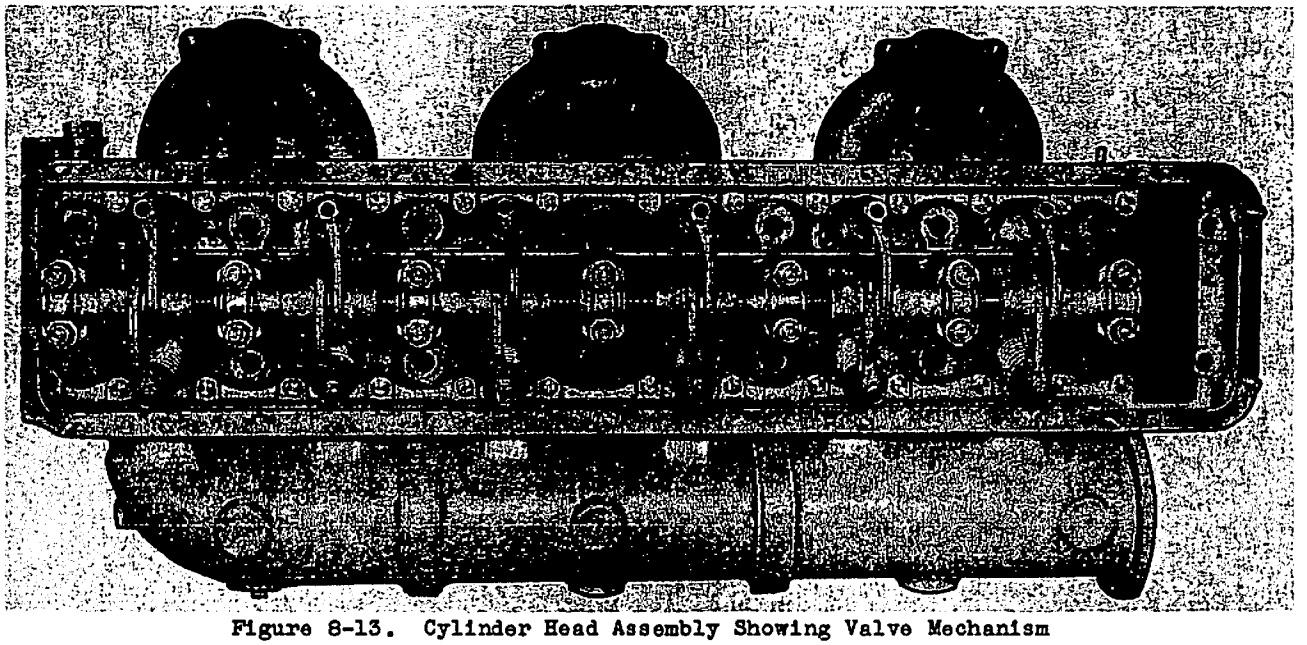


Figure 8-13. Cylinder Head Assembly Showing Valve Mechanism

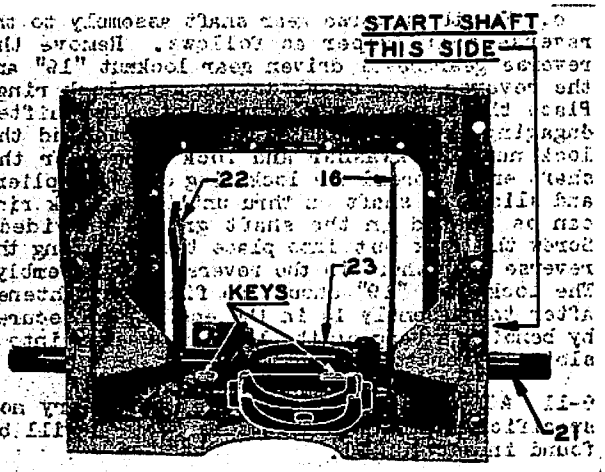


Figure 8-15. Assembly of Reverse Gear Upper Housing

slot in the end of the camshaft. It is important that the fuel pump valves be arranged so the one marked with a "V" is on the intake side of the cylinder head. Set the rockerarm cover temporarily in place on the assembled cylinder head to keep dust and dirt out of the valve mechanism.

8-10 REVERSE GEAR ASSEMBLY. The reverse gear is assembled as mentioned in paragraph 11-48. In order to prepare the reverse gear for final assembly to the engine the following additional steps are necessary.

a. Assemble the reverse gear control mechanism to the reverse gear upper housing as illustrated. Place a reverse gear upper housing upside down on a bench. The clutch shifter shaft "21" is not quite symmetrical. One keyway is closer to the shaft end than the other. Start the end of the shaft with the closest keyway into the right hand side of the housing. Thread the reverse gear brake toggle bracket anchor "22", reverse gear clutch shifter fork assembly "23" and the reverse gear brake bank anchor strap "16" onto the shaft as the shaft is pushed into place. The arm of the shifter fork assembly must come on the same side as illustrated. When the shaft keyways are in the position shown, fit the two keys, line the keys up with the keyways and push the shaft into place so the key just comes flush with the end of the shifter fork. Now tighten the clamp cap screws in the shifter fork and secure with wires as shown in figure 4-8. Fit packing and packing nuts over each shaft end and into the upper housing. All the parts are fitted as shown regardless of the rotation of the engine.

b. The reverse gear thrust bearing retainer assembly and thrust bearing container must be fitted to the reverse gear shaft. A new oil seal must be fitted to the thrust bearing retainer. The sealing lip of the oil seal must point in toward the flange of the retainer so as to retain oil in the reverse gear housing. Press the seal into place evenly. Do not let it get cocked in the bore. Press on the outside diameter of the seal only, otherwise it may be damaged. Use white lead per specification JAN-A-669 (Symbol CAS). Fit the steel baffle plate to retainer and peen in place at four spots. The baffle plate has reliefs in four places on its outside diameter to accommodate the peening. The reliefs are to be on the outside, exposed face of the baffle. It may be

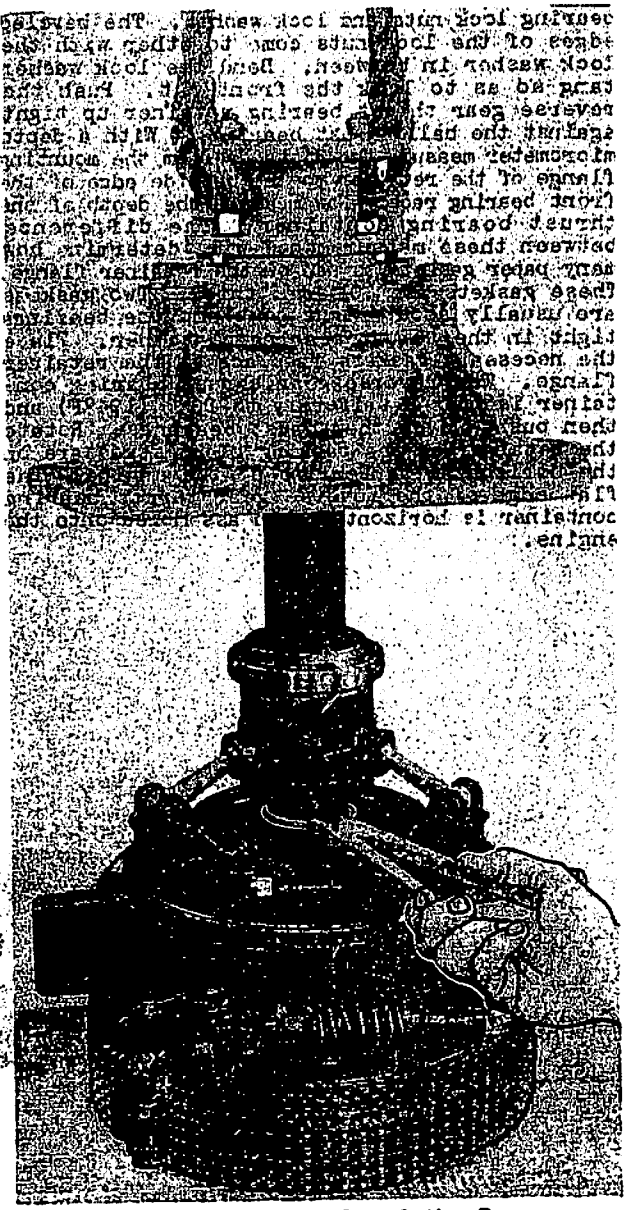


Figure 8-16. Assembly of the Reverse Gear Shaft to the Reverse Gear

necessary to push the baffle down in the center as they sometimes buckle after the peening operation. Fit three pieces of propeller shaft packing to the thrust bearing retainer. Set the propeller shaft packing gland in place and draw down with nuts on the two 1/2 in. diameter studs. Do not draw down so tight as to close the packing in. Smooth the inside diameter of the packing, lubricate with engine oil and place on the reverse gear shaft with the packing gland against the shaft flange. Lubricate the mounting diameter of the ball thrust bearings with white lead per specification JAN-A-669 (Symbol CAS) and place them on the shaft. It is important that the "thrust" faces of the two bearings be against one another. These thrust faces are quite distinctly marked. With the bearings arranged in this manner the engine will take thrust in either direction. Press the bearings down firmly in place against the shaft shoulder. Press against the inner race only. Install the

bearing lock nuts and lock washer. The beveled edges of the lock nuts come together with the lock washer in between. Bend the lock washer tang so as to lock the front nut. Push the reverse gear thrust bearing retainer up tight against the ball thrust bearings. With a depth micrometer measure the distance from the mounting flange of the retainer to the outside edge of the front bearing race. Now measure the depth of the thrust bearing container. The difference between these measurements will determine how many paper gaskets to use on the retainer flange. These gaskets are .012 in. thick. Two gaskets are usually about right to clamp the bearings tight in the thrust bearing container. Place the necessary gaskets in place on the retainer flange. The reverse gear thrust bearing container is heated uniformly to 90°C (194°F) and then pushed over the thrust bearings. Rotate the retainer so the packing gland studs are on the horizontal centerline of the engine. The flat edge of the reverse gear thrust bearing container is horizontal when assembled onto the engine.

c. Fit the reverse gear shaft assembly to the reverse gear proper as follows. Remove the reverse gear bevel driven gear locknut "19" and the reverse gear bevel driven gear lock ring. Place the reverse gear shaft into the shifter engaging spider assembly and then thread the lock nut, lockwasher and lock ring over the shaft end. Spread the lock ring out with pliers and slide the shaft on thru until the lock ring can be seated in the shaft groove provided. Screw the lock nut into place thus locating the reverse gear shaft in the reverse gear assembly. The lock nut "19" should be finally tightened after the assembly is in the engine and secured by bending a tang of the lock nut washer into a slot. Refer to figure 9-33.

8-11 ACCESSORY ASSEMBLY. Any accessory not specifically mentioned in this section will be found in section XI.

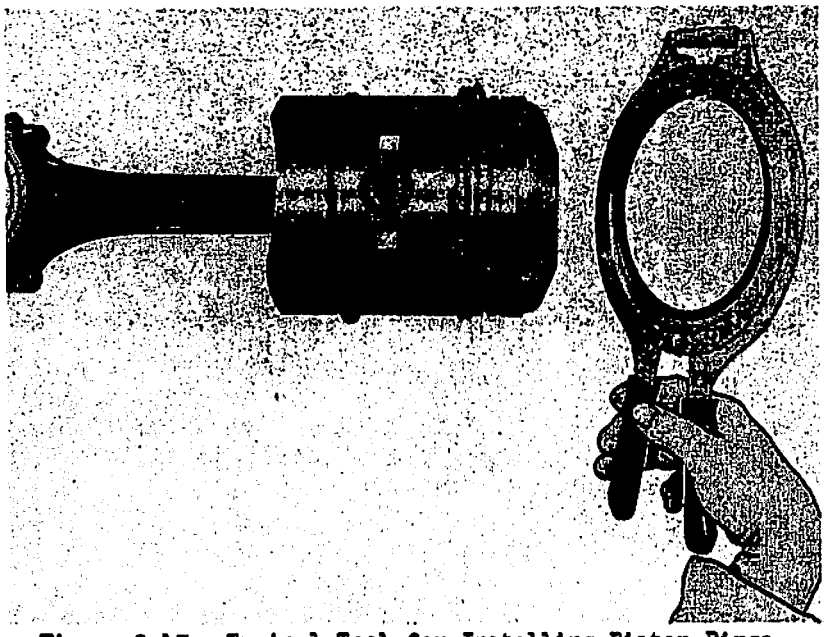


Figure 8-17. Typical Tool for Installing Piston Rings

FINAL ASSEMBLY

9-1 GENERAL. In this section instructions are given for the final assembly of the separate subassemblies into a complete engine. The instructions for making the various subassemblies are covered in sections VIII and XI. Inspections to be made in the final assembly are described and illustrated. Shop practices and general instructions applying to a number of similar parts are covered in the following paragraphs of this section. It is expected that these instructions will be followed where ever applicable, and are therefore not repeated.

9-2 GASKETS. The reuse of old gaskets and seals is not recommended. It is assumed that all gasket, seals and packing will be installed where required, using new material to replace that removed during disassembly. It is general practice to stick one side of a gasket to the gasket flange with cement such as Army specification 62-5 or similar tacky compound. The opposite gasket face is then coated with grease similar to specification AN-G-14 (Symbol GRG). Such practice allows the assembly to be easily separated at the gasket face. If grease is used against the face carrying the studs it will make "clean up" of the gasket face considerably easier at the next overhaul.

9-3 LOCKING DEVICES. It is assumed that all means used to lock nuts, bolts, screws, etc., to prevent their loosening in service, will be replaced with new material in the same manner as originally applied by the manufacturer and as shown in the illustrations. Cotter pins are usually damaged or destroyed when removed and should not be used a second time. The new pins should be tapped securely in place and the tangs split, one side bent back over end of nut, and the other down along the side. Dowel pins, both tapered and straight, may be used again if they have not been damaged, or if the bore from which they were removed has not enlarged beyond the point where the pins are a tight fit. Safety wiring should be done carefully, following the same grouping as the original installation. Wire should be drawn snugly and then be twisted between nuts, to prevent loosening. Thread the wire thru the nut slots in such a way that it tends to tighten the screw elements as illustrated. Use fully annealed wire for securing parts. Lock washers of the spring type should never bear directly on aluminum. Plain steel washers should always be used under the lock washers to prevent damage to the aluminum part.

9-4 CLEANING AND OILING. Of all parts at assembly is of utmost importance. First, wipe all parts clean and dry. Clean all oil passages and vents to make sure they are open. All splines, gears and bearing surfaces should be liberally coated with oil when assembling, to supply lubrication until the engine oiling system has established circulation.

9-5 CLEANLINESS. Cleanliness must be practiced in all work on the engine. This applies to tear-down as well as assembly. A very small quantity of dirt can quickly ruin a fine piece of equipment. Tools, benches, working space and clothing must be kept clean at all times.

9-6 SPROCKET HOUSING TO UPPER CRANKCASE ASSEMBLY. See that the mounting faces of both the sprocket housing and upper crankcase are clean and free

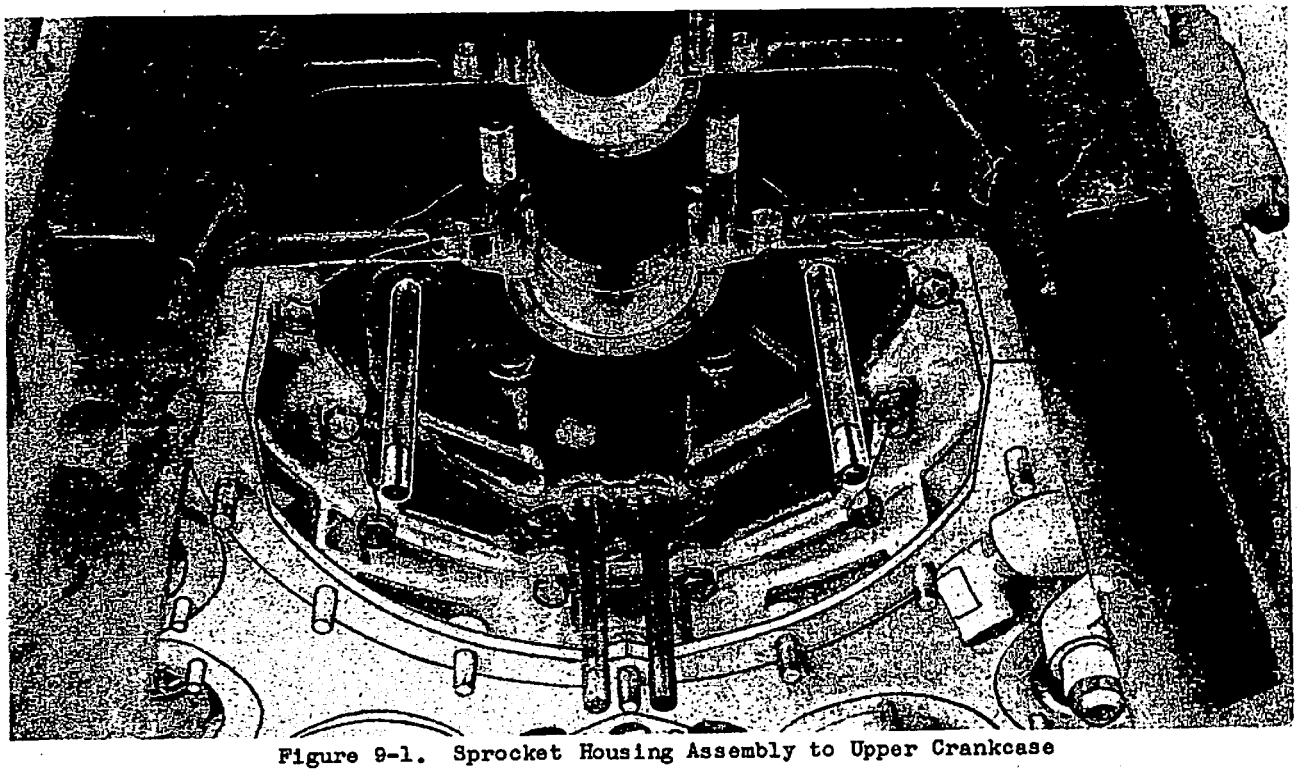


Figure 9-1. Sprocket Housing Assembly to Upper Crankcase

of burrs. See that the dowel and dowel holes are clean. Coat one side of the sprocket housing to upper crankcase gasket with a tacky gasket cement such as Army specification 62-5 and stick it to the flange face of the upper crankcase. Coat the other face of the gasket with soft cup grease per specification AN-G-14 (Symbol GRG). Fit the sprocket housing to the upper crankcase and fasten with cap screws. Secure the cap screws with lock wires.

9-8 REVERSE GEAR UPPER HOUSING ADAPTER TO SPROCKET HOUSING ASSEMBLY. Coat the vertical flange face of the reverse gear upper housing adapter with a tacky gasket cement per Army Spec. 62-5 and stick a gasket in place on this flange. Coat the rear flange face of the sprocket housing with soft cup grease per specification AN-G-14 (Symbol GRG). Fit the adapter to the sprocket housing and secure with plain washers, lock washers and nuts. See that the horizontal

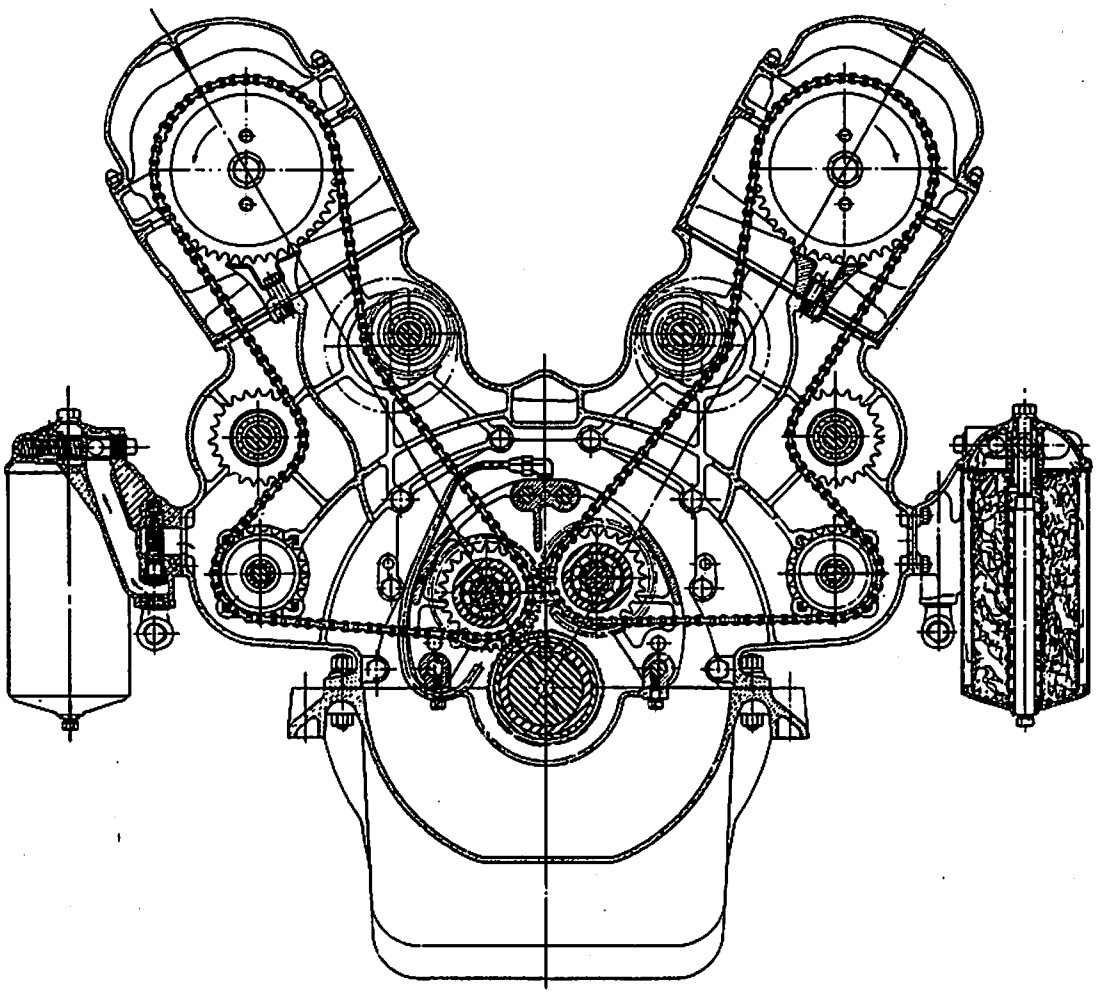


Figure 9-2. Chain Pattern in Sprocket Housing

9-7 GEAR CARRIER TO UPPER CRANKCASE ASSEMBLY. The gear carrier must be assembled to the upper crankcase to suit the direction of crankshaft rotation. The arrow cast on the side of the gear carrier housing is to agree with the crankshaft rotation. The first step is to determine whether a right hand or a left hand engine is to be assembled. Then assemble the gear carrier to the upper crankcase so the cast arrow on the rear face of the gear carrier agrees with the crankshaft rotation. The gear carrier must have been assembled properly so the hex head cap screws are in the rear wall of the gear carrier when all other conditions are satisfied. Refer to paragraph 8-5. After the gear carrier assembly has been properly assembled to the upper crankcase draw it down into place on the dowels. Secure the nuts with lock wire as illustrated, figure 8-1.

flanges of the upper crankcase and the upper reverse gear housing adapter are in line so an oil tight joint will result when the assembly is made with the lower crankcase.

9-9 OIL PUMP TO SPROCKET HOUSING ASSEMBLY. Before the oil pumps are fitted to the sprocket housing the tubing fittings must all be in place in the oil pump as shown in figure 11-14. Also one cap screw on each side of the engine must be fitted to the horizontal flange of the reverse gear adapter housing. These cap screws and their washers must be fitted at this point as they are impossible to fit after the oil pumps are in place. Coat the oil pump to sprocket housing gasket, one side, with tacky gasket cement per Army Spec. 62-5. Stick the gasket to the oil pump mounting flange. Coat the other side of the gasket with soft cup grease such as

AN-G-14 (Symbol GRG). Set the oil pump in place on the sprocket housing and draw tightly into place with the four hex nuts. Use plain washers and lock washers under the nuts. Now lubricate the accessory drive sprocket assembly and slide it over the oil pump drive shaft. Fit the accessory drive sprocket bearing retainer to the sprocket housing with several shims. Install the four nuts and washers temporarily and draw down snug. Check sprocket for end play through the hole in the sprocket housing where the oil filter bolts on. See reference number 73, Table of Limits, figure 12-1. Install or remove shims until the desired end clearance is obtained. Then coat the selected shims with soft cup



Figure 9-3. Camshaft Sprocket Supports in Place on Sprocket Housing

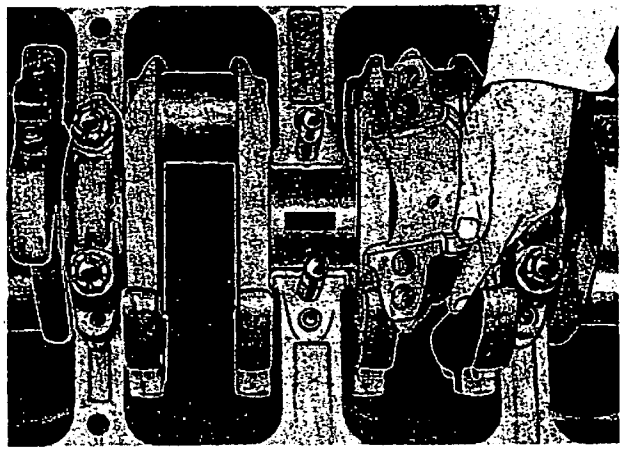


Figure 9-5. Fitting Shim in Place on a Main Bearing

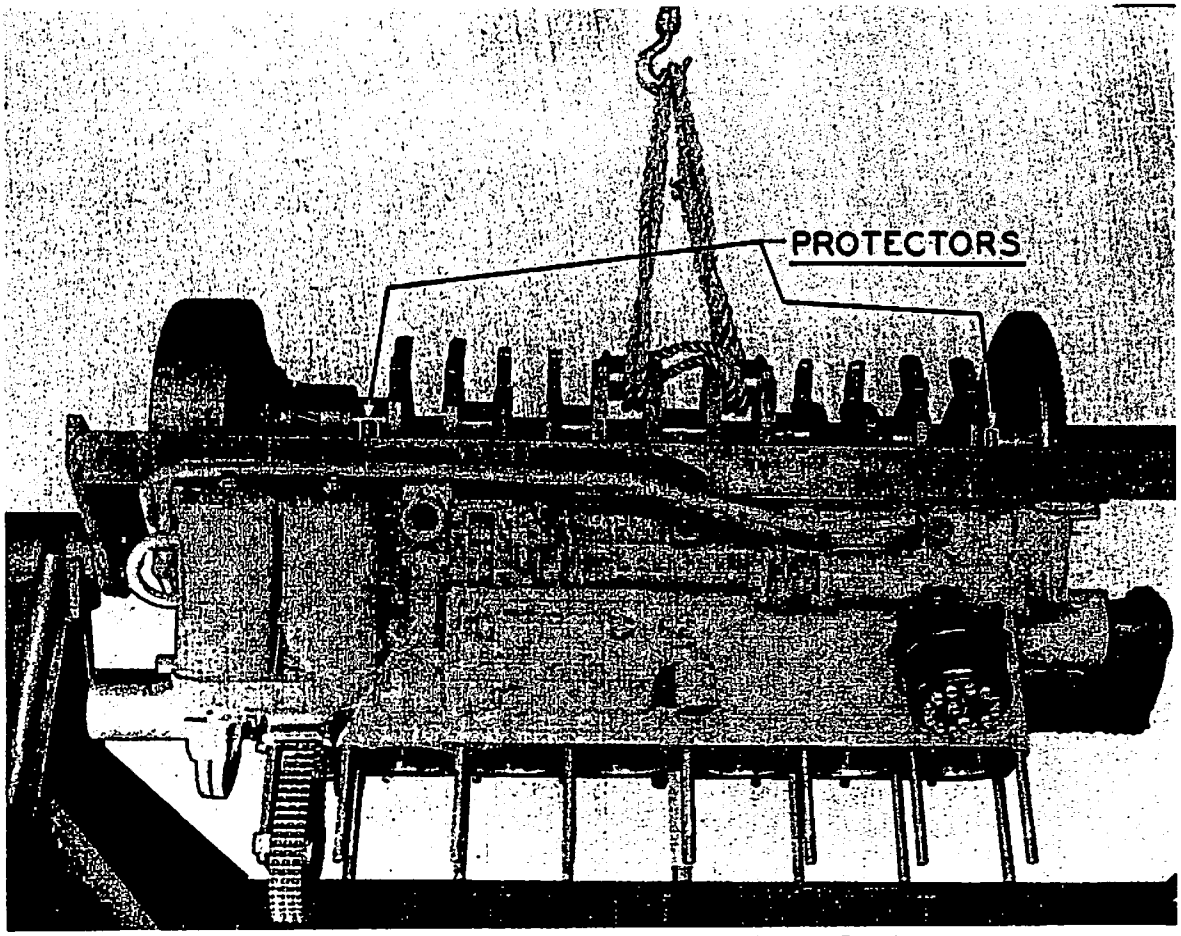


Figure 9-4. Lowering Crankshaft into Upper Crankcase

grease, both sides, and fit to the sprocket housing. Secure with lock washers and nuts. The assembly of the oil pump is covered in paragraph 11-39.

9-10 ACCESSORY DRIVE CHAIN TO SPROCKET HOUSING ASSEMBLY. With the engine upside down thread the chain over the accessory drive sprocket in the gear carrier and out thru the lower end of the sprocket housing. Thread the chain over the sprockets as illustrated. When both ends of the chain come forth from the lower end of the sprocket housing, join the ends temporarily with a connecting link. Be sure to install a side bar near the center of the chain to keep the connector pins from spreading. Set the camshaft sprocket into the loop of chain and affix the camshaft sprocket support. Fit the other accessory drive chain and camshaft sprocket in a similar manner. Of course, it is necessary to rotate the sprockets as the chain is fed into place. Sometimes it is convenient to attach a piece of soft wire to the entering end of the chain to aid in threading it thru the sprockets. The manual chain take ups may now be temporarily installed.

9-11 UPPER CRANKCASE AND CRANKSHAFT ASSEMBLY. This is one of the most critical jobs in assembling the engine and every care must be used to assure its being done correctly.

a. Carefully clean off all the main bearing saddles and caps of the upper crankcase. Set the bearing shells into their proper places according to the stamped numbers on the shells and on the main bearing webs of the upper crankcase. It is assumed that the shells have all been fitted and checked according to paragraph 7-5c. Carefully clean and lubricate all the main bearing journals with engine oil. Place protective tubing over the front and rear main bearing studs so the crankshaft journals will not be marred when the crankshaft is lowered into place. Put a rope sling around the crankshaft so that it hangs level. Now carefully lower the crankshaft into the upper crankcase. If the crankshaft is teetered from end to end slightly it will not be so apt to hang up on the center main bearing flanges.

b. Although the main bearing shells are of the precision "snap-in" type it is a wise precaution to check them for clearance on final assembly with the use of a fitting shim. This is done as follows. After the crankshaft is in place in the upper crankcase fit all except one cap and draw the main bearing stud nuts down to the proper torque as mentioned in the torque wrench table, figure 12-9. On the main journal, to which the cap has not been fitted, place a greased fitting shim .004 in. thick, 1/2 in. wide and 1-1/2 in. long. Arrange the fitting shim lengthwise of the engine. Put the shell and cap into place over the fitting shim and draw the stud nuts down to the proper torque. Now rotate the crankshaft by hand. It should show no signs of binding. If there is any binding it must be corrected. If everything is correct there will

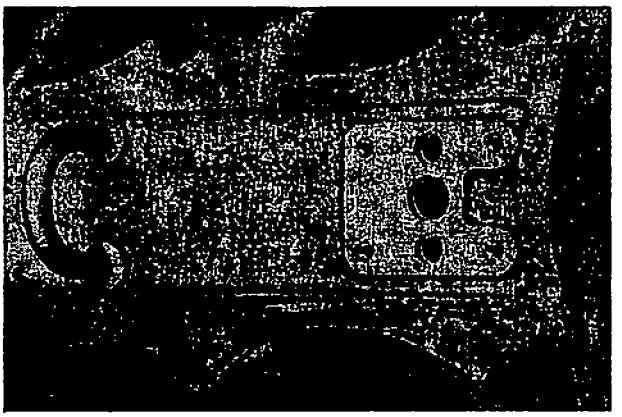


Figure 9-7. Identifying Number on Top of Upper Crankcase

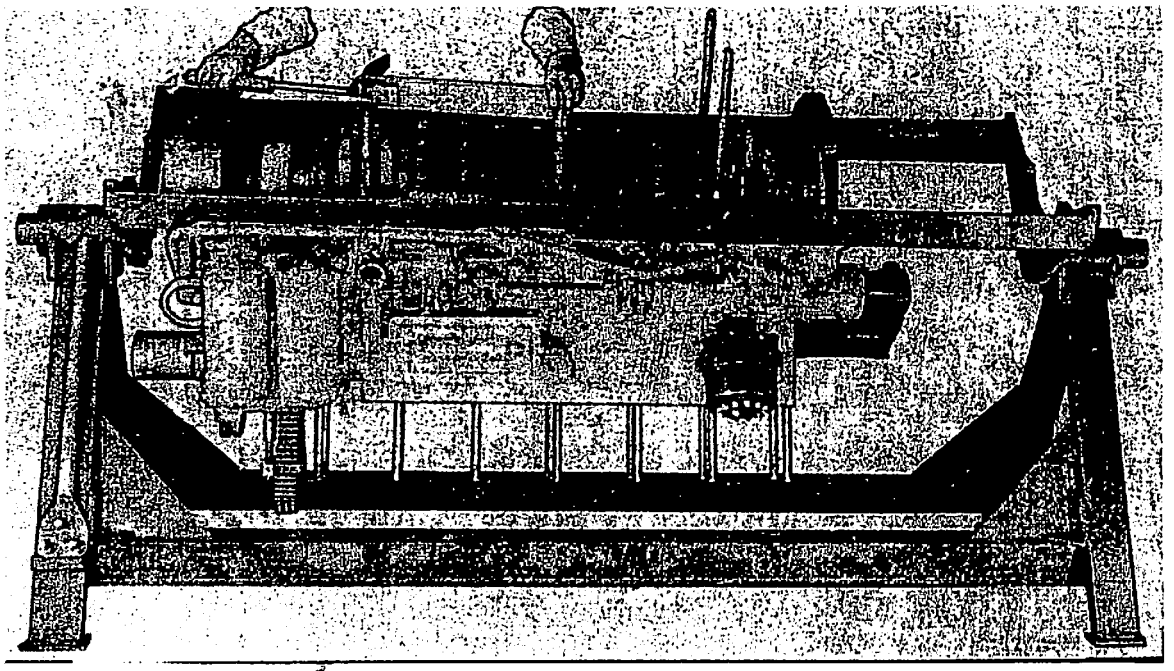


Figure 9-6. Tightening Main Bearing Cap Nuts with Torque Wrench



Figure 9-8. Checking Crankshaft End Clearance

be just a little "drag" to the rotation of the crankshaft under the influence of the fitting shim. If there is binding look for dirt under the shells, excessive "crush" or improper alignment of the dowels in the bearing shells. The fitting shim must be moved from journal to journal until they have all been checked in this fashion. Do not forget to thoroughly lubricate each main bearing journal nor to remove the fitting shim after the last journal has been checked. The bearing shells must be clean and dry on their outside diameter so they can

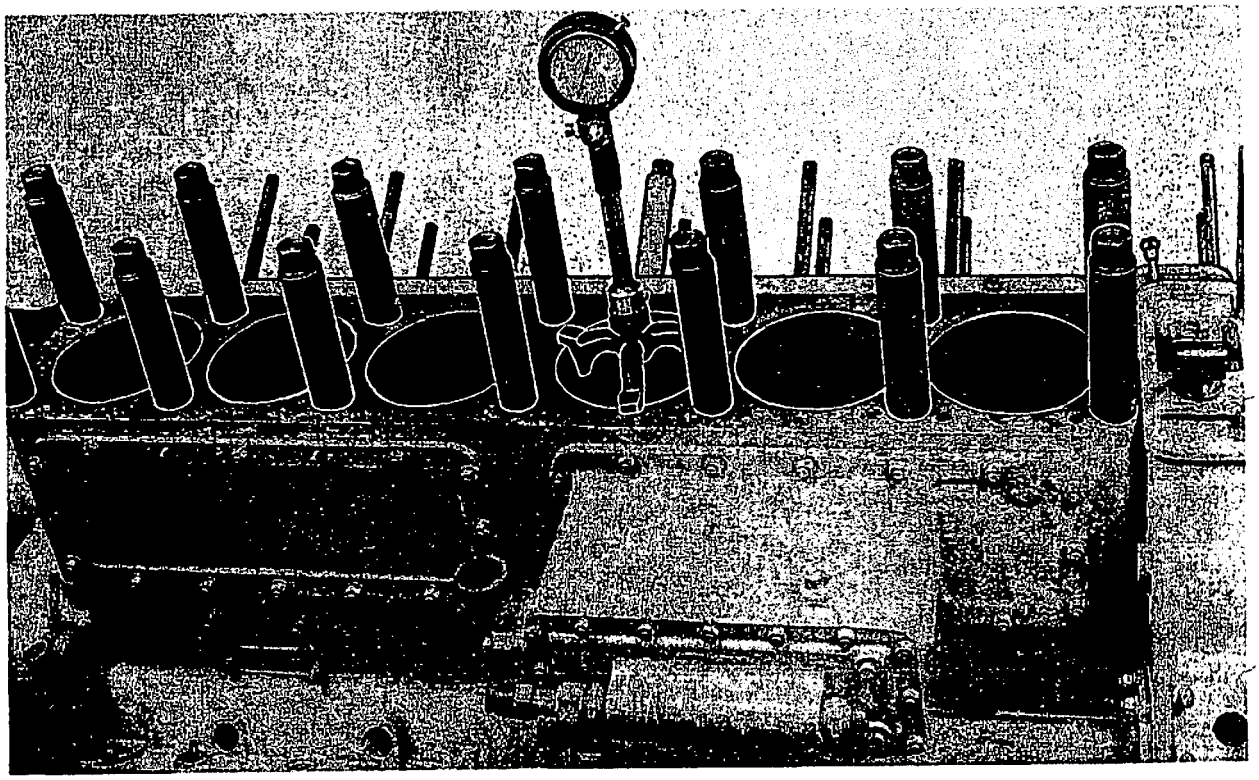


Figure 9-9. Checking Cylinder Bores with Typical Gage

conduct heat away from the shells rapidly. Make sure that all the main bearing shells and caps are in their proper place as indicated by the stamped number on the edge of the shells and on the side of the caps. The numbered side of the shells and caps are to be assembled to the engine so they come on the same side of the

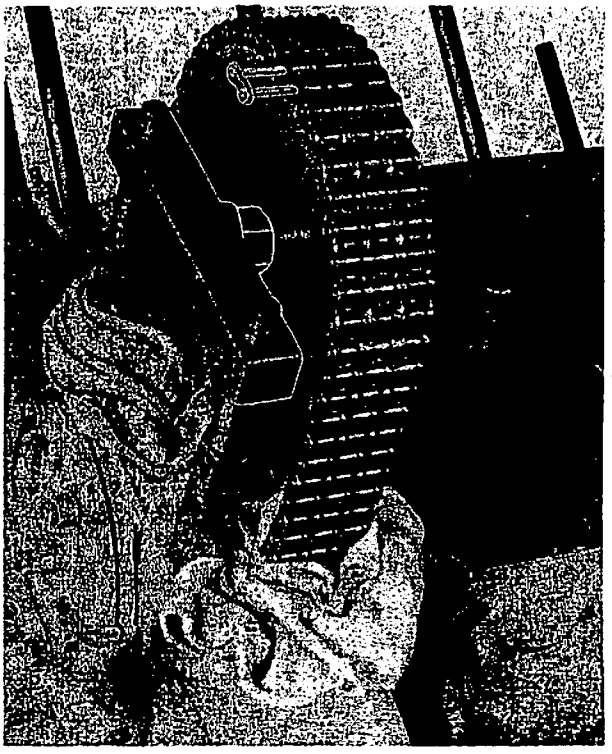


Figure 9-10. Installing Chain Connecting Link

engine as the numbers stamped on the main bearing webs. In the event it becomes necessary to install new main bearing shells they must be stamped with numbers at the time of replacement in the identical location as those on the parts being replaced. Support the shells carefully so they will not be damaged in stamping. Use a sharp stamp so a light blow will leave a visible mark. Stone off any up turned edges left by the stamp so they will not effect the crush of the bearing shells. The common number found stamped on the top of the main bearing cap is to agree with the upper crankcase identifying number stamped on the top side of the upper crankcase at the front end right near the oil pressure regulating valve pad. Refer to figure 9-7. After all the main bearing caps are secure, lock them with wire. Check again to see that the crankshaft can be rotated by hand. Check the end clearance of the crankshaft. See reference number 2 , Table of Limits, figure 12-1. Check the back lash of the gears. See reference number 21, Table of Limits, figure 12-1. Install gear carrier oil circulation pipe and oil tray.

9-12 UPPER CRANKCASE AND CYLINDER BLOCK ASSEMBLY. Turn the upper crankcase and crankshaft assembly on its side. Coat an upper crankcase to cylinder block gasket with a tacky gasket cement such as Army specification 62-5 and stick it to the base of the cylinder block. Coat the top face of the cylinder block with soft cup grease per specification AN-G-14 (Symbol GRG). Now slide the cylinder block over the upper crankcase studs and down into place. Refer to figure 4-21. Place spacers on all of the studs and secure with nuts. This is most important otherwise the cylinder block may fall off when the piston and connecting rods are being fitted. Check bores after the cylinder block is pulled down tight to make certain there is no distortion. Refer to figure 9-3. Assemble



Figure 9-11. Riveting Chain Connecting Link

the opposite cylinder block in a similar manner. Of course, the blocks are placed on the engine so the water jacket openings come on the outside of the "V". The right hand bank cylinder block is identical with the left hand bank cylinder block. They are merely turned end for end to make them suitable for either bank.

9-13 RIVET CHAIN. After the engine assembly is turned right side up, rotate the crankshaft until the temporarily placed connecting link of one chain appears on the top side of the camshaft sprocket. Carefully withdraw the connecting link until two chain side bars can be fitted between each strand of chain. Thread the connecting link pin on thru the chain so these side bars are fitted into place. After the ends of the connecting link emerge from the chain fit the final outside side bar and then rivet over the ends of the pins. Use a back up bar in the riveting operation as illustrated. It is not necessary to upset a heavy bead on the pins as this may bind the chain. Rivet the pins over just sufficient to retain the side bar. The cloth is placed around the assembly to catch any parts that may be dropped so they do not get into the sprocket housing. After one chain is secure remove the cloth and rotate the engine until the other accessory drive chain can be

similarly connected and riveted.

9-14 PISTON AND CONNECTING ROD ASSEMBLY TO THE ENGINE. This operation too, is quite critical and the success or failure of the job depends on everything being done with care.

a. The yoked connecting rod is fitted to the engine first. The side of the engine to which the yoked rod is fitted depends on the rotation of the engine. For example, the yoked connecting rod is fitted to right hand bank of a right hand rotating engine. For a left hand rotating engine the yoked connecting rod is fitted to the left hand bank of cylinders. Do not forget that the "hand" of the cylinder banks is determined as one stands at the back of the engine and faces forward. The sides of the connecting rods are numbered to indicate the cylinder into which they are to be fitted. The numbered side of the connecting rod and cap is to be assembled to the engine so that the numbers come on the right hand side of a right hand rotating engine and on the left hand side of a left hand rotating engine. Numbers stamped on the yoke connecting rod bolts and nuts are not to be confused with numbers stamped on the side of the connecting

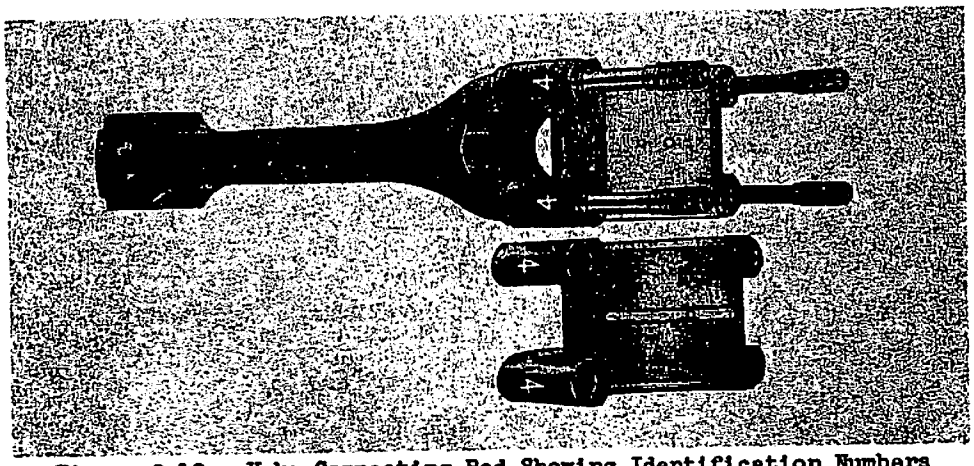


Figure 9-12. Yoke Connecting Rod Showing Identification Numbers



Figure 9-13. Yoke Connecting Rod Showing Weight Group Letter

BLADE CONNECTING ROD

GROUP LETTER	TOTAL WEIGHT
T	5 lb 14-1/2 oz
U	6 lb 1-1/2 oz
S	6 lb 3-1/2 oz
A	6 lb 4-3/4 oz
C	6 lb 5-1/4 oz
B	6 lb 7-1/4 oz
Z	6 lb 8-1/4 oz
E	6 lb 8-3/4 oz
D	6 lb 11-1/4 oz
I	6 lb 13-3/4 oz

Figure 9-14. Table of Blade Connecting Rod Weight Groups

YOKE CONNECTING ROD

GROUP LETTER	TOTAL WEIGHT
A	6 lb 7-7/8 oz
U	6 lb 11-1/8 oz
B	6 lb 14-3/8 oz
D	6 lb 15-7/8 oz
C	7 lb 2-3/8 oz
E	7 lb 4-7/8 oz
N	7 lb 6-7/8 oz
Y	7 lb 8-3/8 oz
P	7 lb 8-7/8 oz
Z	7 lb 11-7/8 oz

Figure 9-15. Table of Yoke Connecting Rod Weight Groups

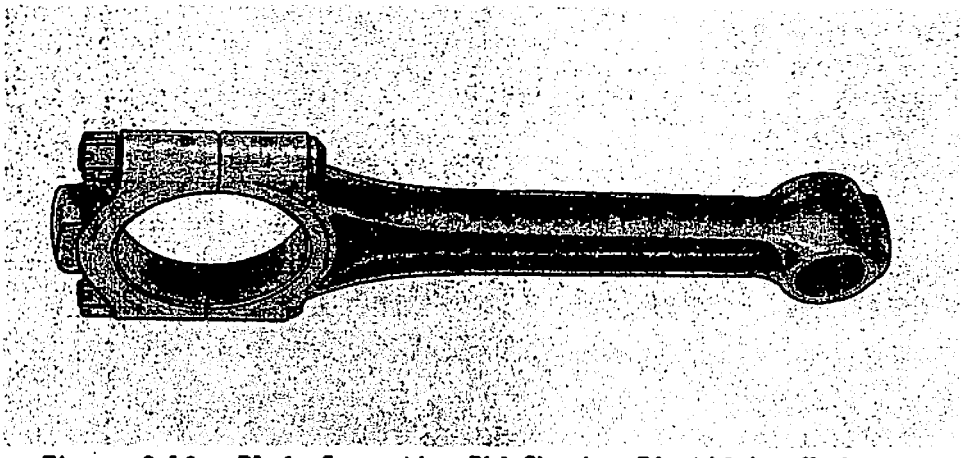


Figure 9-16. Blade Connecting Rod Showing Identifying Numbers

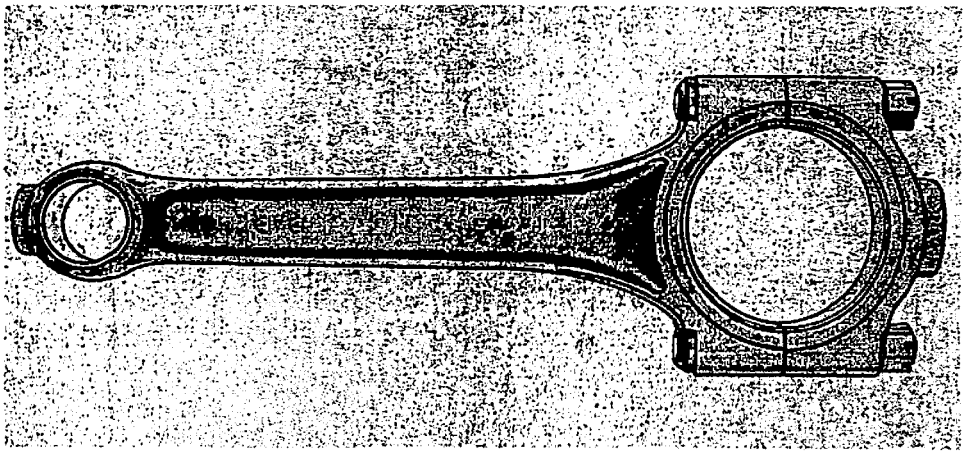


Figure 9-17. Blade Connecting Rod Showing Identifying Marks on the Edge of the Bearing Shells

rods and connecting rod caps. In the event it becomes necessary to install a new connecting rod bearing shell or connecting rod the service parts will not be marked with the cylinder number. It is extremely important that such parts be marked at the time of replacement with the identical mark and in the identical location as those on the part being replaced. The blade rod shells are marked with slight score marks on the edges as there is no space available for

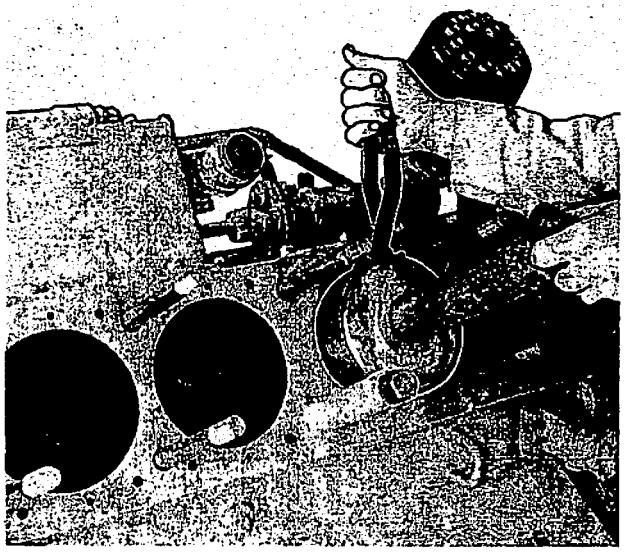


Figure 9-18. Installing Piston and Connecting Rod Assembly with Typical Tools

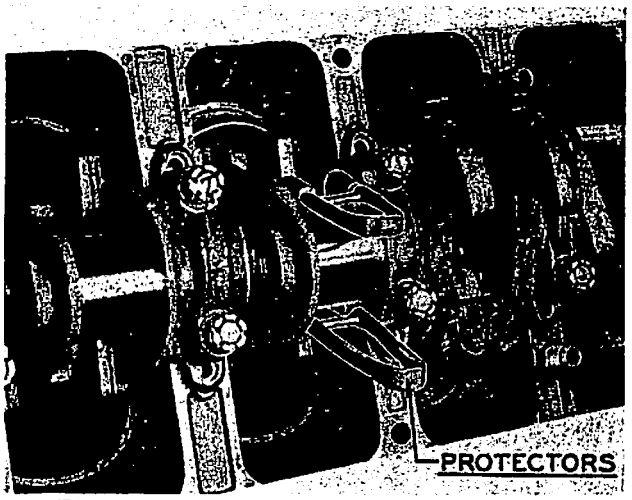


Figure 9-19. Protectors on Connecting Rod Bolts

stamped numbers on these shells. Where stamps are used, they must be sharp so a light blow will be sufficient to leave a good impression. Be careful to support the part well so it will not be marred or bent when it is stamped. Stone off any burrs raised by the stamp on the edge of the yoke rod shell so as not to effect the shell "crush".

b. In assemblying the connecting rods and pistons to the engine, attention must also be paid to the weights of the connecting rods. On the side of each connecting rod and connecting rod cap will be found a stamped letter. This letter is a weight classification of the connecting rod assembly. All the blade connecting rods in an engine must be of a common weight classification. Similarly, all the yoke connecting rods in an engine must be of a common weight classification. However, it is not necessary that the weight classification letter of the blade rods agree with the letter of the yoke rods. If it becomes necessary to replace any of the connecting rods, they must be of the same weight group as the ones they are to run with. In the event it is impossible to have all the blade rods of a common weight group or all the yoke rods of a common weight group then new rods must be as near the same weight as possible to the old rods and must be replaced in groups of three. For example, if one connecting rod is defective and it is impossible to replace it with a connecting rod of the same weight classification, then three similar new connecting rods of a common weight group must be used and they must be installed in cylinders one, two and three or cylinders four, five and six. No other combinations must be used. The preceding tabulation in paragraph 14a will aid in selecting new connecting rods of as near the same weight as possible to those in the engine.

c. The yoke connecting rod must be fitted to the engine first. Rotate the engine crankshaft until number one and number six crank journals are at bottom center. Wipe the journals off carefully and blow free of lint. Lubricate the crank journals with engine oil. See that the outside diameter of the connecting rod shells are clean and free of dirt. Also the connecting rod and cap. Fit the bearing shell to the connecting rod so that the stamped number on the shells, rod and rod caps all agree with one another and with the cylinder into which they are being installed. The number on the shells and caps must be on the same side as the stamped number on the side of the connecting rod. Stagger the gaps in the piston rings so they do not come directly beneath one another. Lubricate the piston pin, connecting rod bearing shell and the piston with engine oil. See that the cylinder is clean and free of moisture. Slip tubing protectors over the connecting rod bolts. Start

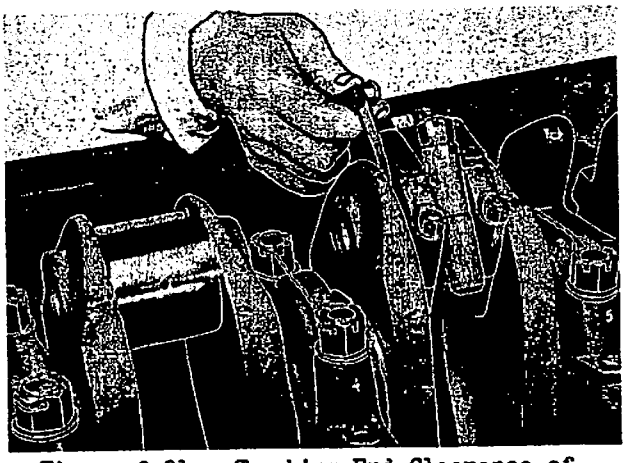


Figure 9-21. Checking End Clearance of Yoke Connecting Rod

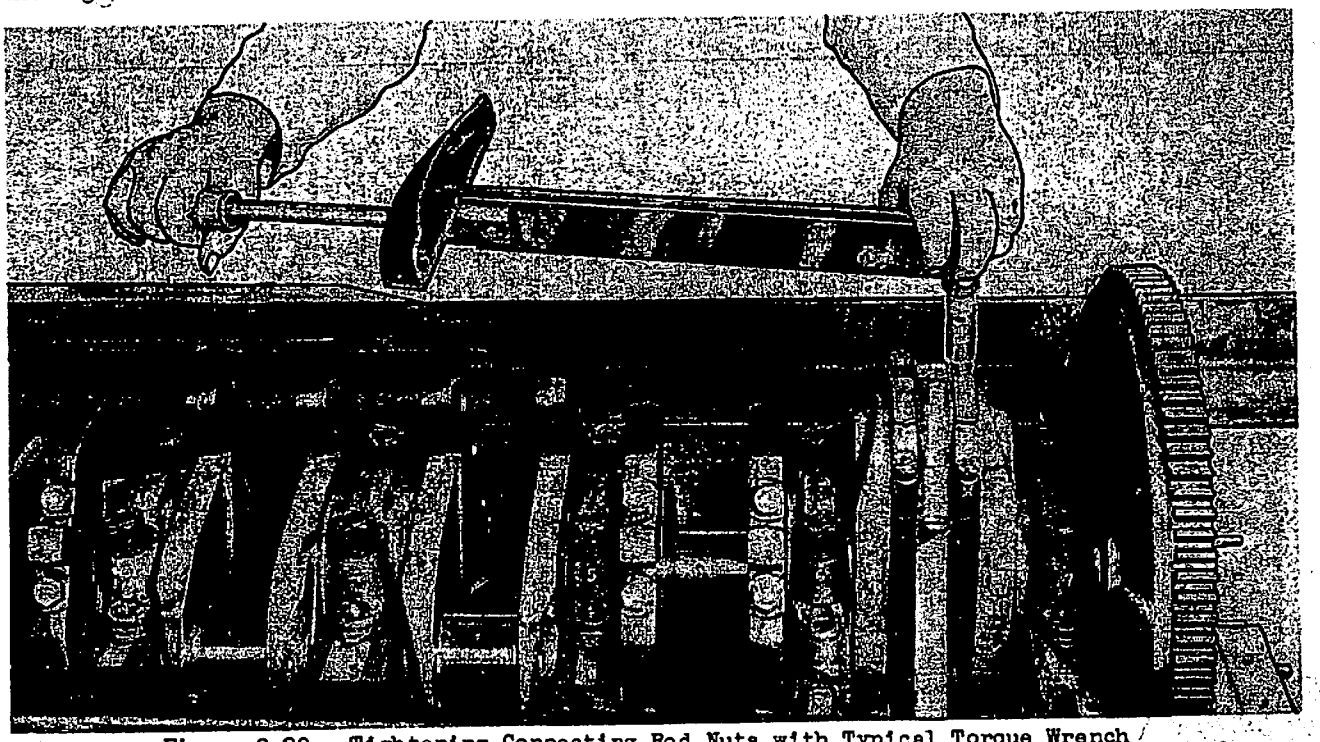


Figure 9-20. Tightening Connecting Rod Nuts with Typical Torque Wrench

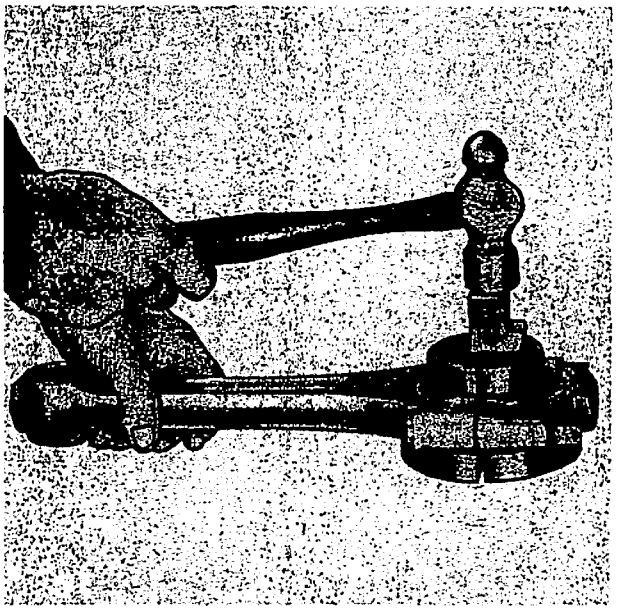


Figure 9-22. Typical Tool for Removing Cap from Connecting Rod

the big end of the connecting rod into the cylinder bore with the numbered side of the connecting rod arranged as instructed in paragraph 9-14a. Place a piston ring compressor on the rings and push the piston into the bore with a wooden block. It is best to have a man guide the big end of the connecting rod onto the crank journal. When the connecting rod is firmly seated against the crankshaft place a greased fitting shim on the crank journal. This shim to be .0035 in. thick and approximately 3/8 in. wide and 1 in. long. Arrange the shim lengthwise of the engine as illustrated in

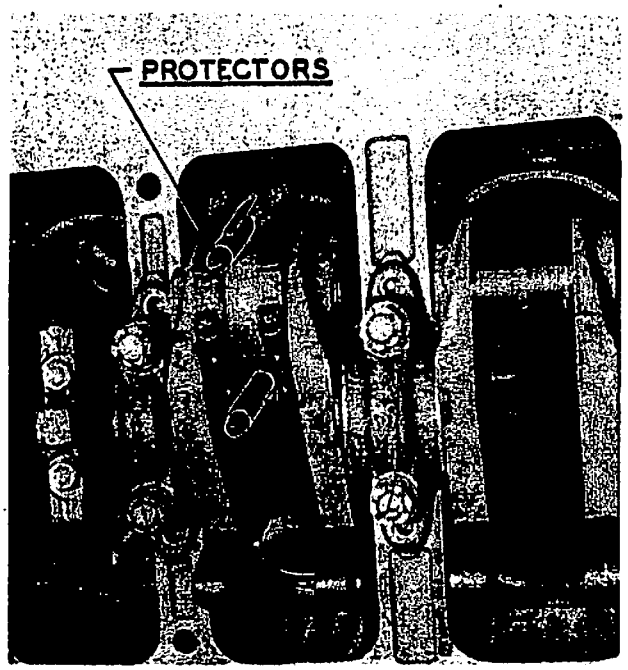


Figure 9-23. Protectors on Blade Connecting Rod Bolts

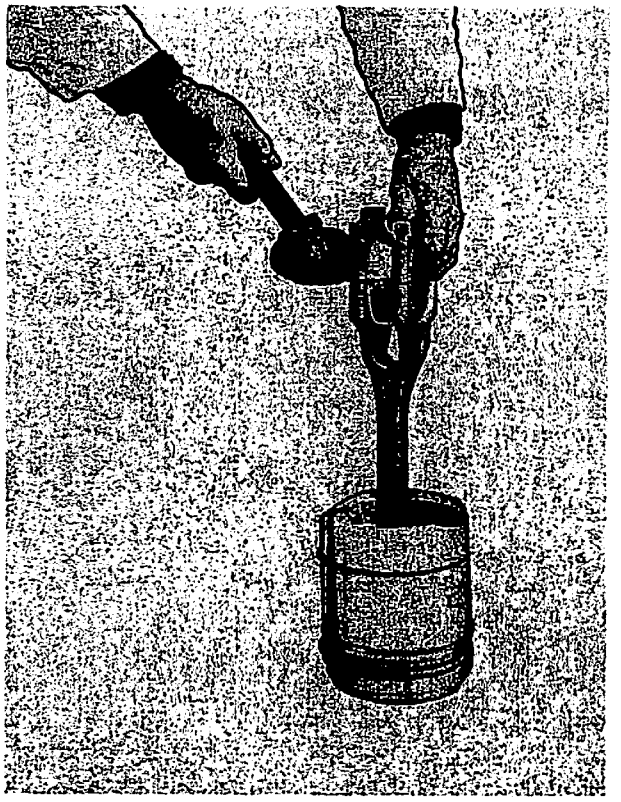


Figure 9-24. Striking Connecting Rod Cap to Remove Cap

figure 9-26. Now lubricate the cap bearing shell and fit it along with the caps to the connecting rod. Of course, the numbered side of the shell and caps must come on the same side of the engine as the number stamped on the side of the connecting rod. Install the 3/8 in. hex nuts so their numbers agree with the numbers stamped on the ends of the bolts. Draw the nuts down to their proper torque value as indicated in figure 12-9. Now push the connecting rod from side to side on the crank journal. Just a slight "drag" should be felt. If the connecting rod is tight on the crank journal look for dirt under the shell, excess crush or improper fit of the bearing shell on the dowel. Always use a tool similar to that shown in figure 4-16 in order to remove the connecting rod caps. Never hammer on the ends of the connecting rod bolts. Do not forget to remove the fitting shim when the shell is properly set. Check the end clearance of the yoke connecting rod as illustrated. When everything is in order draw the connecting rod nuts down to the proper torque as called for in figure 12-9. Install cotter pins and proceed to fit all the yoke connecting rods similarly.

d. The blade connecting rods are next fitted to the engine as follows. Remove the nuts from the connecting rod bolts and pull the connecting rod cap off. This may be done with a spreading tool or if the assembly is suspended by the connecting rod cap and rapped lightly first one side and then the other with a soft brass hammer, the cap will come off. Strike the rod cap along side the bolt bosses, no place else. Do not attempt to pry the connecting rod cap off as this is certain to damage the finely finished surfaces. Rotate the engine crankshaft until

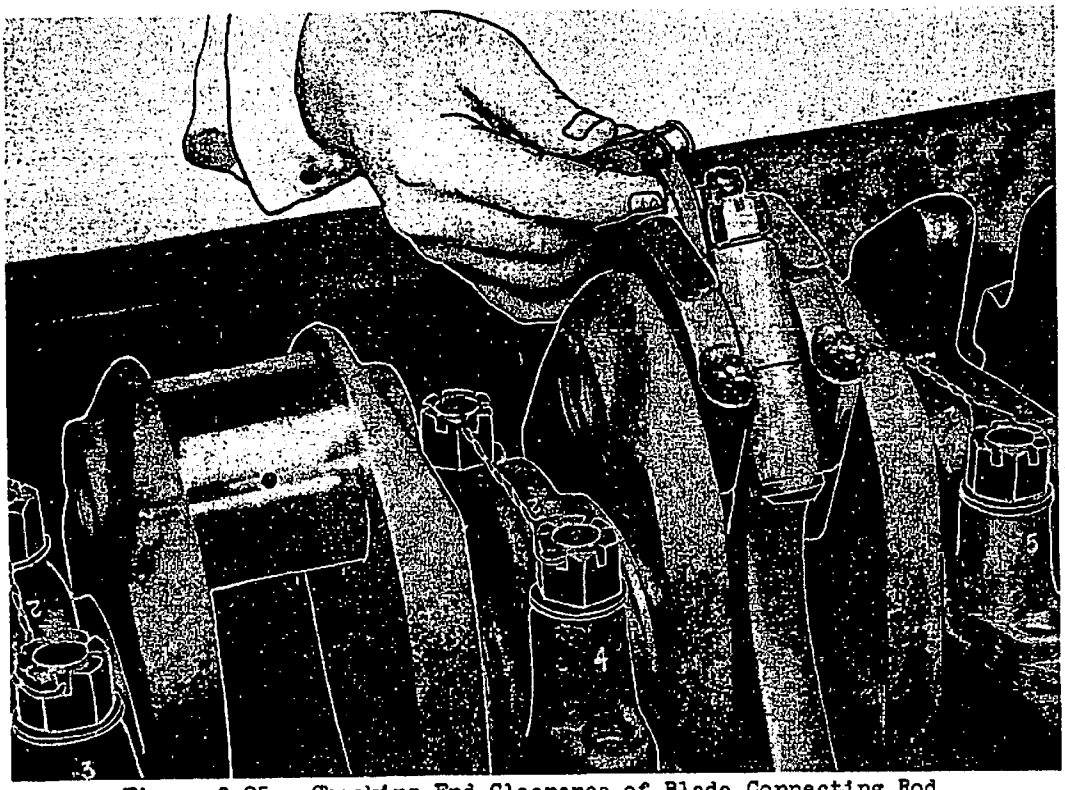


Figure 9-25. Checking End Clearance of Blade Connecting Rod

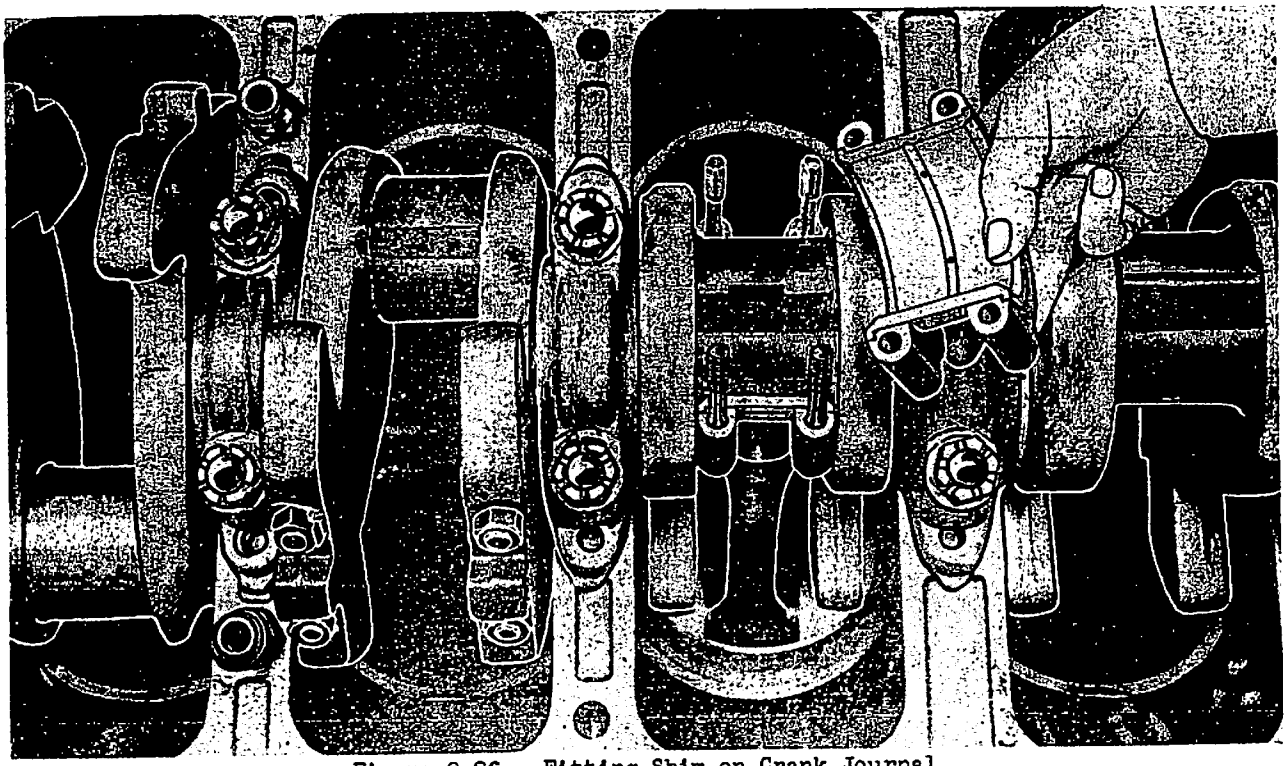


Figure 9-26. Fitting Shim on Crank Journal

the crank journal for cylinders number one and six are at bottom center. Lubricate the piston, piston pin and piston rings. Rotate the piston rings so the ring gaps are staggered with respect to one another. Place soft protective tubes on the connecting rod bolts and lubricate the bearing shell on the inside diameter only. Place the big end of the connecting rod in the number one cylinder bore. Be sure that the number stamped on the side of the connecting rod agrees with the cylinder to which it is being fitted. Also the numbered side of the rod must be arranged as explained in paragraph 9-14a. Start the piston into the cylinder bore and compress the piston rings with a suitable tool such as illustrated in figure 9-18. Push the piston into the bore by striking it lightly with a wooden block or mallet. Do not dent or mar the top of the piston and do not strike the cylinder walls. It is best to have another man guide the big end of the connecting rod onto the yoke rod shell as the piston is pushed down. Lubricate the connecting rod bearing shell on the inside diameter only and assemble the cap to the connecting rod. The marks on the shell and cap must register with the marks on the connecting rod and connecting rod shell. Draw the nuts down to the proper torque as mentioned in figure 12-9, section XII. Rap the blade connecting rod from side to side to center the bearing shells in the rod. Hit the rod on the balance pad only with a soft brass or lead hammer. Check the blade rod for end clearance. See reference number 15, figure 12-1. If everything is in order the blade connecting rod must be free to slide from side to side with a slight pressure by hand. It must not lock up tight or drag. If it is too tight look for dirt under the bearing shell, excessive "crush" or improper fit on the dowel. After the proper fit is obtained, lubricate the parts thoroughly with engine oil and draw the connecting rod nuts down to the proper torque. Secure the nuts with cotter pins. Proceed to assemble all the other blade connecting rods in a similar manner.

9-15 UPPER CRANKCASE TO LOWER CRANKCASE ASSEMBLY.

a. The lower crankcase must be placed on a stable support. The shipping skid may be used for this purpose if nothing better is available. See that the flange face is clean and smooth. Coat the gasket flange face with gasket cement per Army Spec. 62-5. Fit the long paper gasket to both sides of the case. Do not tear the gasket or allow it to wrinkle up. Fit both dowels to the lower crankcase. In the event that a new lower crankcase is being used, it will be necessary to ream the rear dowel hole in assembly as explained in paragraph 9-15b. Now clean off the mounting flange of the upper crankcase and coat it with a tacky gasket cement per Army Spec. 62-5. Care must be used to see that the assembly is made up of parts that were originally assembled as that is the only way one can be assured that the reverse gear driving flange will be concentric with the thrust bearing support in the lower crankcase. When the gaskets are all in place carefully let the upper crankcase down

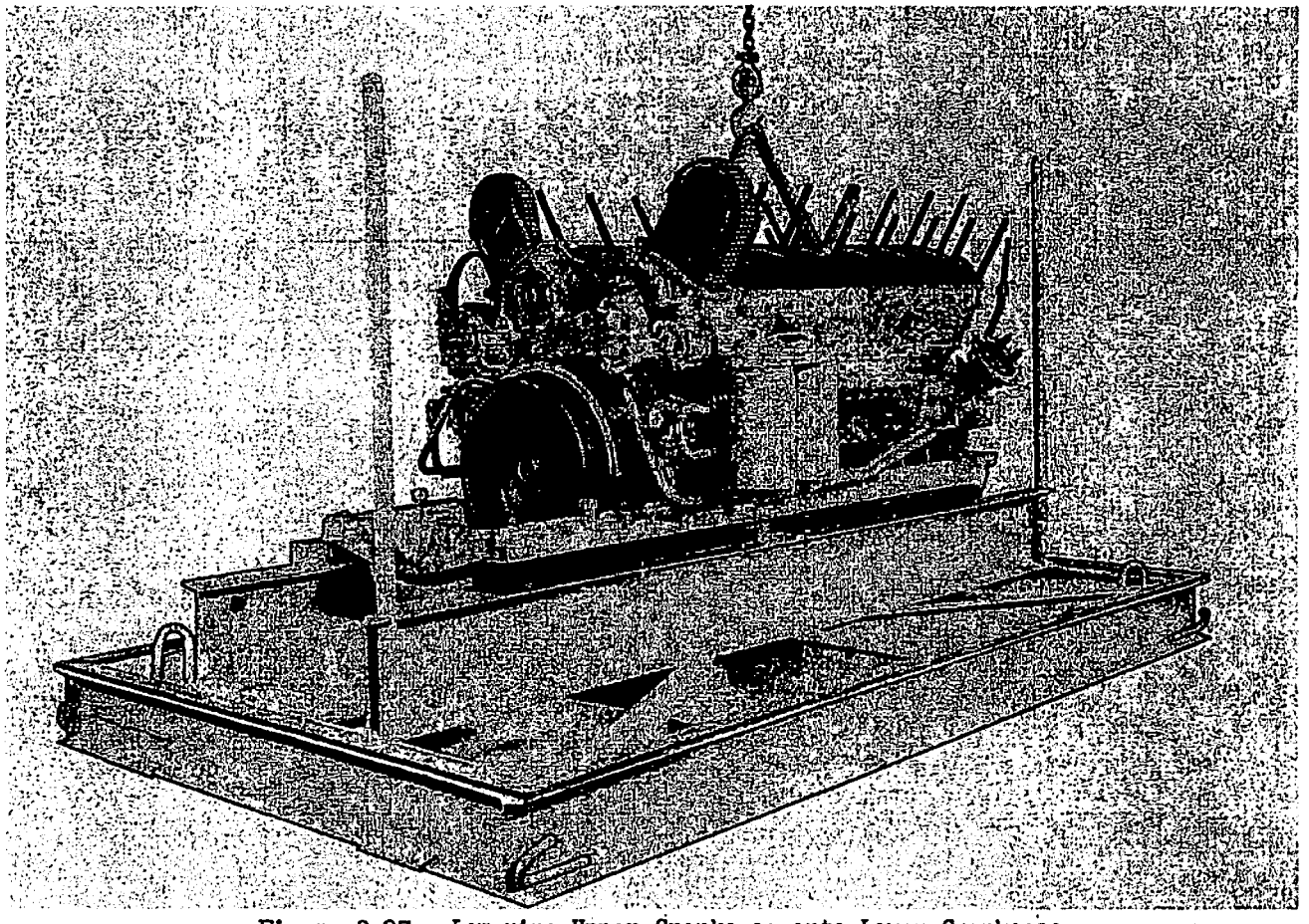


Figure 9-27. Lowering Upper Crankcase onto Lower Crankcase

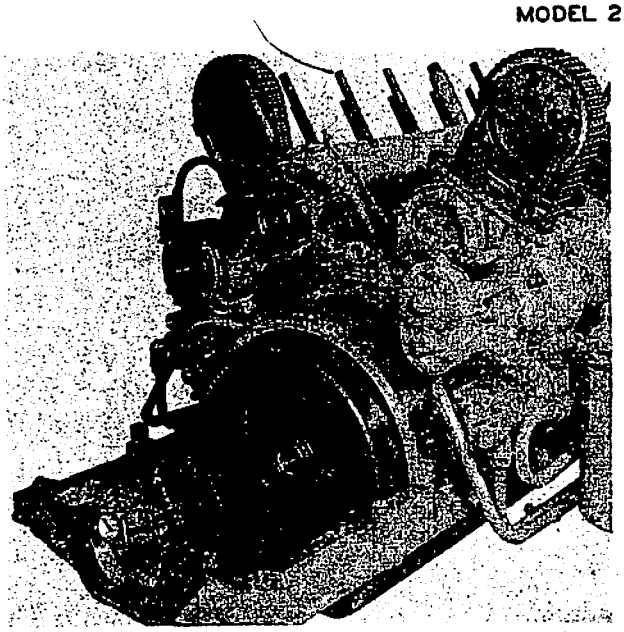


Figure 9-28. Dial Gage in use to Adjust Crankcase Assembly

onto the lower crankcase flange. Secure with plain washers, lock washers and hex nuts. Tighten the cap screws in the reverse gear upper housing adapter. Tighten the hex nuts in the vertical flange of the reverse gear upper housing adapter. The reverse gear driving flange must be checked with respect to the thrust bearing support at the rear of the lower crankcase. Use a fixture to clamp on the reverse gear driving flange and a dial gage as illustrated. See reference number 6, figure 12-1.

b. When the lower crankcase is "new" the rear dowel hole is intentionally left undersize for reaming to size at assembly. Bring the upper and lower crankcase together as mentioned above except, of course, the rear dowel must be left out for the time being. Fit the checking fixture to the reverse gear driving flange along with the dial indicator. Shift the upper crankcase on the lower until the dial gage indicates that the drive flange is concentric with the

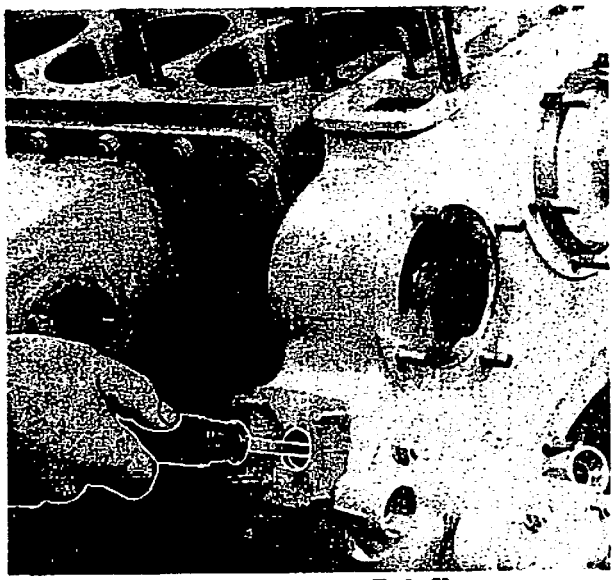


Figure 9-29. Checking End Clearance of Accessory Drive Sprocket

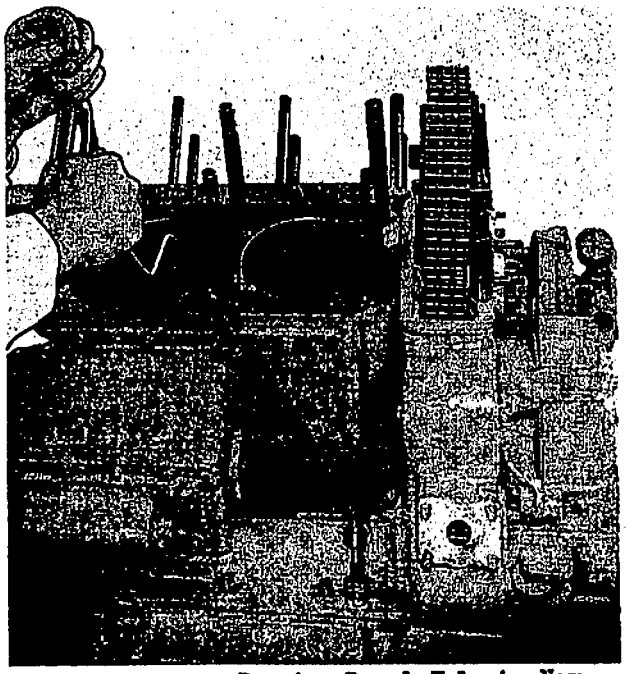


Figure 9-30. Reaming Dowel Hole in New Upper Crankcase with Typical Tools

thrust bearing support of the lower crankcase. Clamp the crankcases together with the flange nuts. Fit a reamer bushing in place in the dowel hole at the left hand rear corner of the upper crankcase. Run a reamer of .499 - .500 in. diameter down into the lower crankcase 1/2 in. deep. Withdraw the reamer and bushing. Blow the chips out of the hole. Fit the dowel and drive it into place. Tighten up all the flange nuts. Be sure to use plain washers under the lock washers. Tighten the cap screws in the reverse gear upper housing adapter.

9-16 FLYWHEEL HOUSING TO UPPER CRANKCASE ASSEMBLY. See that the flange faces of both the upper crankcase and the flywheel housing are clean and smooth. Coat the flywheel housing flanges, both vertical and horizontal, with a tacky gasket cement per Army Spec. 62-5. Stick a gasket to the vertical face. Coat the vertical flange face of upper crankcase with light cup grease per specification AN-G-14 (Symbol GRG). Set the flywheel housing in place on the engine and draw it up uniformly so that both the vertical and horizontal flanges are made oil tight. The oil gage and hand scavenge pump may now be set in place in the engine. The hand starting lever throw out cam may now be fitted to the front of the engine. Also fit the hand starting lever hole cover.

9-17 REVERSE GEAR ASSEMBLY TO THE ENGINE.

a. The brake toggle adjusting nut "14" must be tightened to clamp the brake band "10" onto drum "4". This is necessary to keep the band from slipping when the unit is lifted. The band must be arranged before clamping, so the clutch engaging levers are in a position such that one points directly down away from the lifting hook as illustrated in figure 4-12. Coat the flange face of the reverse gear thrust bearing container with a tacky gasket cement per Army Spec. 62-5 and stick a gasket to this flange. Do not let any tacky cement get on the exposed face of this gasket. Coat the exposed face of the reverse

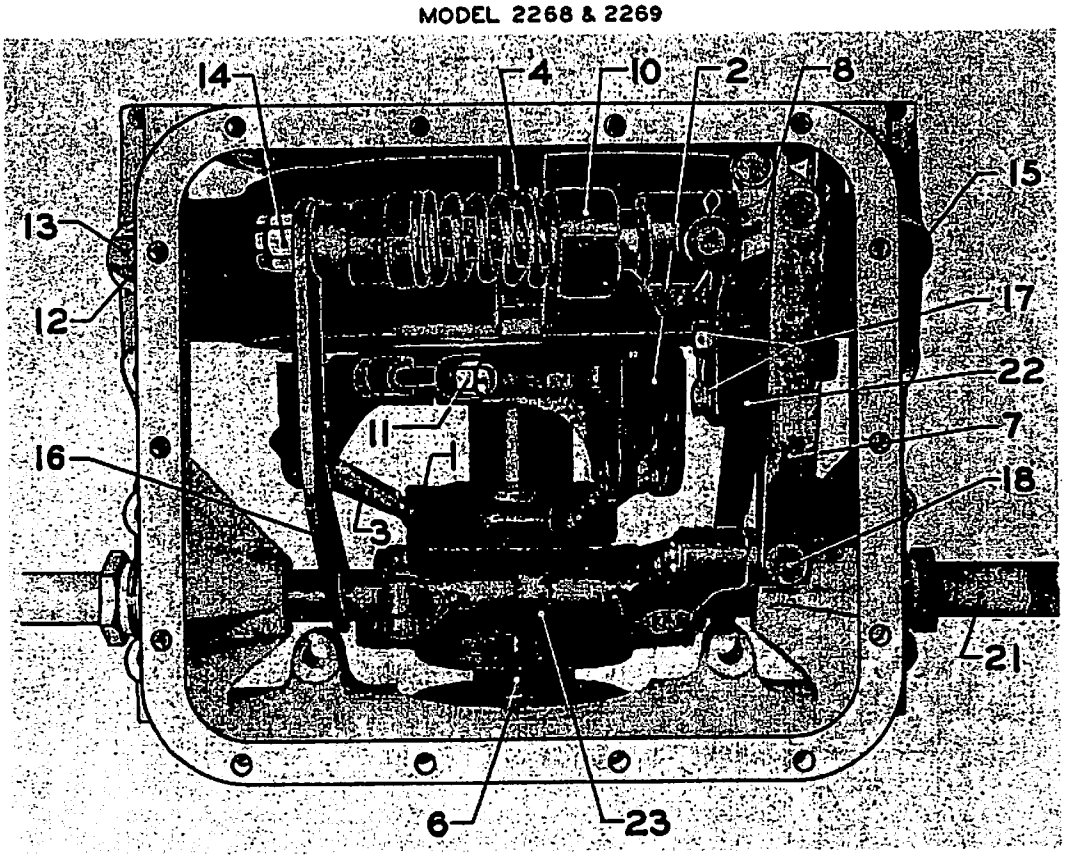


Figure 9-31. Top View of Reverse Gear

gear thrust bearing container gasket with soft cup grease per specification AN-G-14 (Symbol GRG). Lift the reverse gear and set it into the lower crankcase. Suspend the assembly at a level so that the clutch driving discs can be entered into the clutch drum. It may be necessary to move the clutch driving discs so they will enter the drum. This may be done by using a screw driver on either side of the assembly and by prying against the flange of the lower crankcase. If one pushes against the reverse gear shaft flange all the while, the gear will slide forward as clearance is obtained. It is also necessary to rotate the reverse gear shaft to align the splines of the reverse gear bevel driving gear with the reverse gear drive flange. See that the ears of the brake drum are not "hung up" on the steel pads on the lower crankcase flange. Also see that the four studs in the thrust bearing container enter the holes in the lower crankcase. See figure 4-13. When the reverse gear assembly is in place remove the hoist and add the plain washers and hex nuts to the four studs in the rear face of the lower crankcase. Secure these nuts with lock wire. Be careful not to drop any parts into the lower crankcase. Finally tighten locknut "19" and secure by bending one ear of the washer into a slot in the lock nut. See figure 4-9.

b. The reverse gear upper housing is fitted to the engine at this point of the assembly operation. Coat a piece of rope type packing with gasket cement per Army Stock No. 052-C-675-1PX and place it on the circumference of the reverse gear upper housing adapter. Let either end of the packing hang down several inches beyond the end of the adapter. Centralize the clutch shifter assembly in the upper reverse gear housing. See that all the flange faces of the housing are clean and smooth. Coat the exposed flange face of the lower crankcase gasket with a tacky gasket cement per Army Spec. 62-5. Cut a piece of thin sheet metal in the general shape of the rear flange of the reverse gear housing. See that this sheet metal piece is smooth. Coat it with soft cup grease both sides per specification AN-G-14 (Symbol GRG). Set this sheet metal piece against the rear flange gasket and lower the upper reverse gear housing assembly into place. See that the shifter mechanism properly engages the ball bearing on the clutch shifter spider. Push the housing assembly down as far as it will go. Pull the thin sheet metal piece out from between the housing and thrust bearing container flange. Do not damage the flange gasket. Remove nut "14" and fit link "16" in place and refit nut "14". Connect link "22" and secure with two cap screws "17". This link is engaged with the serrations such that the brake band "10" is centered up on brake drum "4". Fit pin "18" and secure with a cotter pin. Fit cap screws, plain washers and lock washers to all the flanges. Do not overlook the two cap screws on the inside rear face of the upper housing. The brake band locating cap screw "15" is next fitted to the boss on the outside of the upper housing. This cap screw is fitted to the right hand side of a right hand rotating engine and the left hand side of a left hand rotating engine. Next fit the brake band balance adjusting stud "13" and brake band balance adjusting stud nut "12" to the boss on the outside of the upper housing.

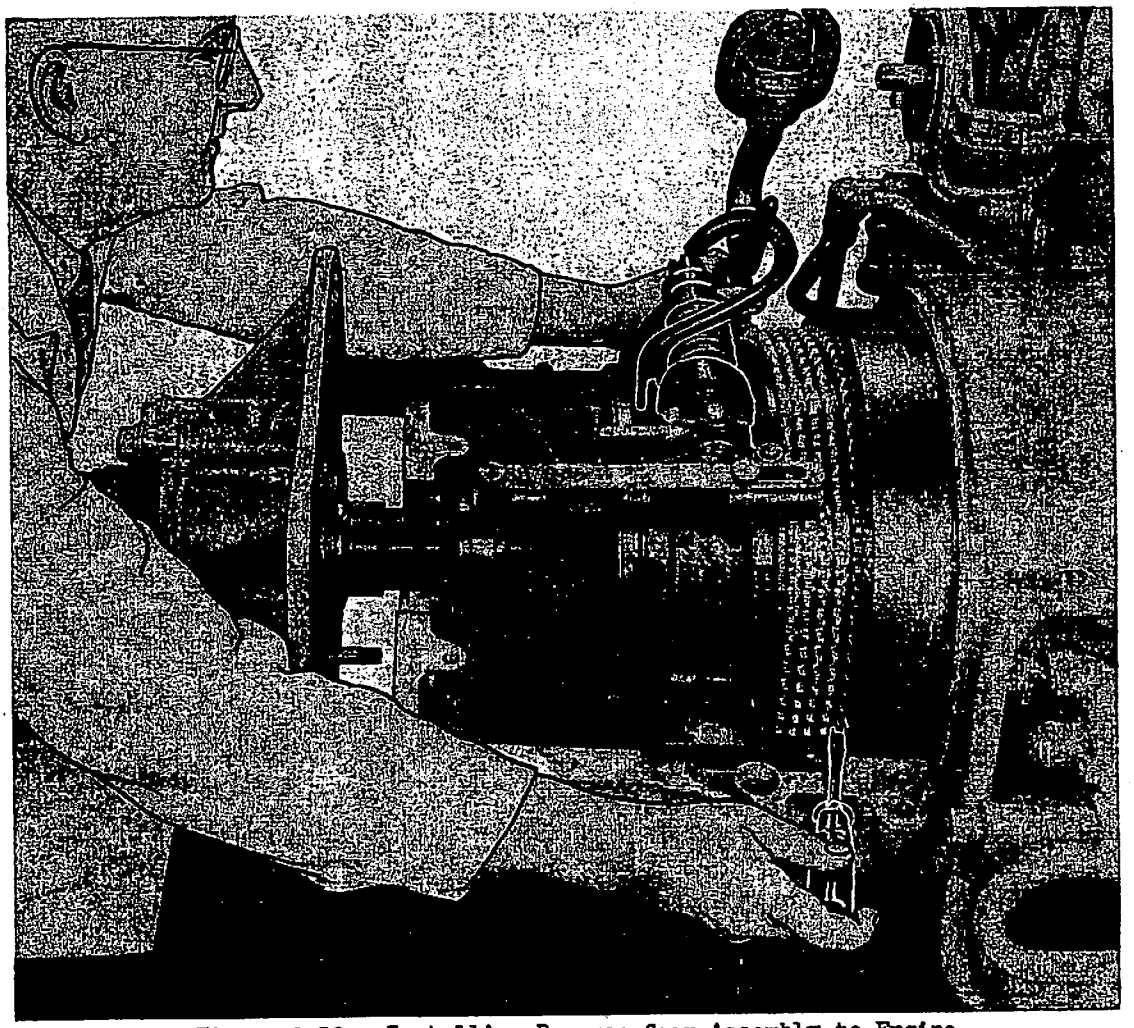


Figure 9-32. Installing Reverse Gear Assembly to Engine

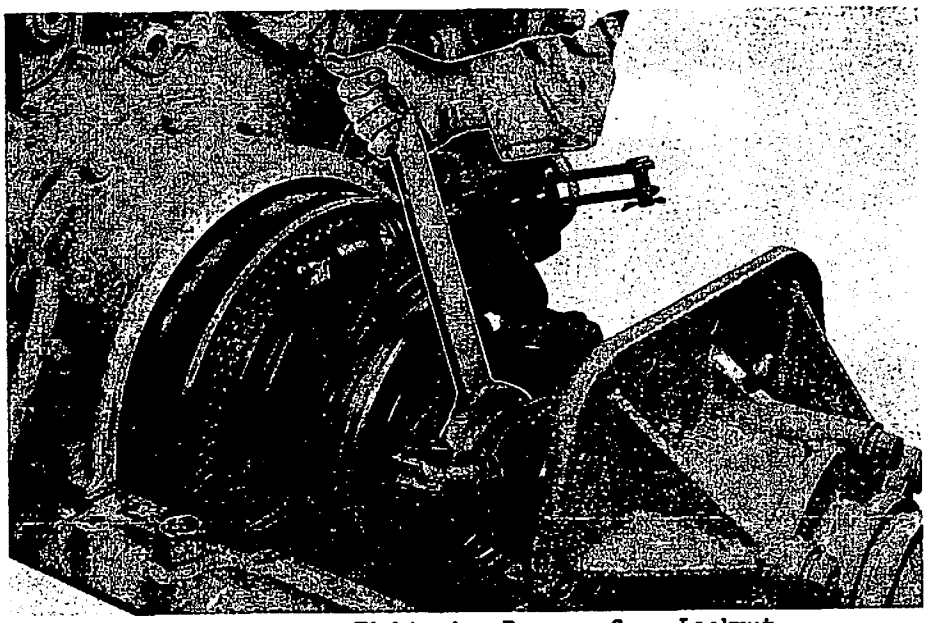


Figure 9-33. Tightening Reverse Gear Locknut

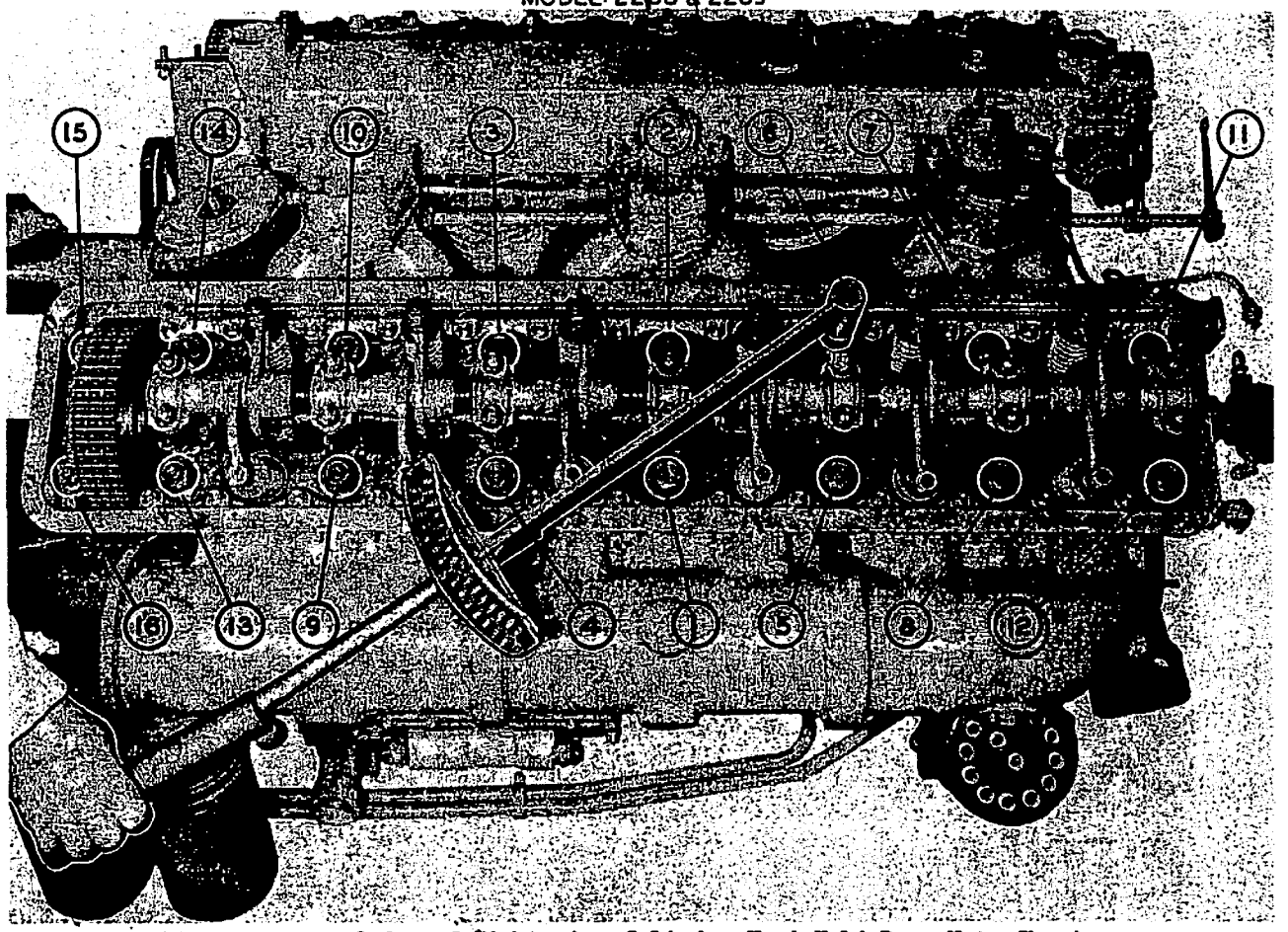


Figure 9-34. Order of Tightening Cylinder Head Hold Down Nuts Showing Typical Torque Wrench

NOTE

These two above mentioned balancing and adjusting screws are the only parts effected by the rotation of the engine. All other parts of the reverse gear assemble to the engine in the same manner regardless of rotation of the engine.

Assemble the reverse gear operating levers to the engine. The hand lever normally goes on the left hand side and the short lever on the right hand side of the engine although they are interchangeable to suit the particular installation. Refer to figures 4-9 and 4-11.

9-18 REVERSE GEAR ADJUSTMENT.

a. To tighten forward clutch, loosen clamp bolt nut on "11" clutch adjusting ring, then screw this ring (together with its three bellcranks, links and shifter spider) in for tightness or out for looseness. Test lever force and tighten clamp bolt nut and then try lever again. One hundred and sixty pounds at the end of a 36 inch lever is quite sufficient force to hold the clutch, with a considerable safety factor. It is unnecessary to set this clutch up any tighter than mentioned above as it will carry the load without excessive clutch pressure. Once properly adjusted, the clutch will function a long time without further attention.

NOTE

As soon as clutch slippage is noticeable make above adjustment at once. Do not continue to operate a slipping clutch, as it will cause rapid wear, heating and warping of clutch discs.

b. To tighten the reverse band "10", first loosen nut "12" and unscrew the balance adjusting stud "13" three or four turns. With lever in neutral, tighten brake and toggle nut "14", then try lever from neutral to reverse and get the "feel" of this adjustment. Repeat until the band firmly grips the drum "4". Due to the powerful action of this mechanism, ample reversing capacity is possible without excessive hand lever load. In "forward" position a clearance of not less than 1/64 in. should exist completely around the drum and brake band.

c. Torque reaction screw adjustment is made as follows. Turn the engine 1/4 turn in its running direction to gather all the slack on the trailing side of the reverse band. After the brake band has been properly tightened, and with the hand lever in "reverse" position, very carefully turn the balance adjusting screw "13" so it barely touches the brake band lug at "A".

CAUTION

Do not screw this stud down so far that it moves the lug or affects the radial

CAUTION

position of the brake band on the drum. If this adjusting stud is down too far, the purpose of the torque-reaction stud will be destroyed, and only the top half of the brake band will bear down on the drum.

After the above adjustment has been effected, tighten locknut "12" without disturbing the position of the stud "13". This adjustment is important in that it causes the reverse reaction load to be assumed by the "13" screw instead of causing the "reaction" to spring the entire unit out of line. Carefully work the hand lever forward, neutral and reverse a few times and the reason for this provision will be readily appreciated. There should be approximately 1/16 in. clearance at "B" between "15" and brake band lug. Install or remove 1/16 thick washers until the adjustment is correct. This 1/16 in. clearance is measured by turning the screw down tight and then backing it off 1/16 in. Measure the clearance under the screw head and fit washers to fill this space. Refer to figure 4-9 and 4-11.

9-19 CYLINDER HEAD ASSEMBLY TO THE ENGINE. Remove the auxiliary supports from the camshaft drive sprockets and allow the sprockets to rest on the pedestals on the top face of the sprocket housing. Fit the 3/4 in. diameter cap screws and lock washers into the sprocket bores. See that both the top face of the cylinder block and the bottom face of the cylinder head are smooth and clean. Coat a cylinder head gasket, both faces, with a tacky gasket cement per Army Spec. 62-5. Place the smooth side of the cylinder head gasket against the cylinder block. This means the flanged edges of the grommet holes go against the cylinder head. Put a teaspoonful of engine oil in each cylinder bore. Set the cylinder head carefully on the engine. See that it goes down smoothly over the studs and camshaft sprocket. As soon as the head is down in place set the camshaft sprocket onto the camshaft and start the 3/4 in. diameter cap screw into place in the end of the camshaft, but do not draw it down tight. Install all the 3/4 in. and 1/2 in. hex nuts and washers on the head studs. Draw the nuts down evenly in the order indicated. After they are all uniformly snug apply the torque wrench and tighten them down to the correct torque value. Refer to figure 12-9. Assemble the head onto the opposite cylinder bank in a similar manner. Use care to see that the cylinder head camshafts are correct for the model engine being assembled. The driving flange of the camshaft shows the part number of the camshaft. If the parts are properly tagged at disassembly no trouble will be encountered on this point. Otherwise it may be necessary to consult the parts catalog AN 19-85BHB-4 in order to determine the proper camshaft to use in each head. Camshafts must be set per paragraph 8-9d.

9-20 VALVE TIMING, RH Engine No. 2268 Stock List No. 19O6AAF200 000.

9-21 TAPPET ADJUSTMENT FOR TIMING. For valve timing it is necessary to set all exhaust and intake tappet clearances to the figures shown in figure 12-1, reference No. 42.

9-22 ADJUST TIMING CHAIN. Set the two accessory drive chains to the proper tension as explained in paragraph 9-29.

9-23 POSITION CRANKSHAFT. Turn the engine in its normal running direction until the flywheel mark "T.C. 1 & 6" leading bank shows in the timing inspection hole and then continue to rotate until the flywheel mark "EXH. CLOSES" comes directly opposite the notch in the timing inspection hole. Refer to paragraph 1-22.

NOTE

There are two "EXH. CLOSES" marks on the flywheel. Only by carefully following the procedure outlined can one be certain of timing to the correct mark.

Now grasp the camshaft sprocket of the leading bank and rotate it in the opposite direction from its normal rotation. This takes all the slack out of the chain on the driving side. Then draw the sprocket on to its driving taper with the 3/4 in. cap screw. Again rotate the engine 60° until the flywheel mark "T.C. 1 & 6" trailing bank comes into view in the timing inspection hole. Continue to rotate until the flywheel mark "EXH. CLOSES" comes directly opposite the notch in the timing inspection hole. Now grasp the camshaft sprocket of the trailing bank and rotate it as far as it will go in a direction opposite to its normal rotation and then draw it on to the camshaft taper with the 3/4 in. cap screw. Camshafts must have been previously set per paragraph 8-9d.

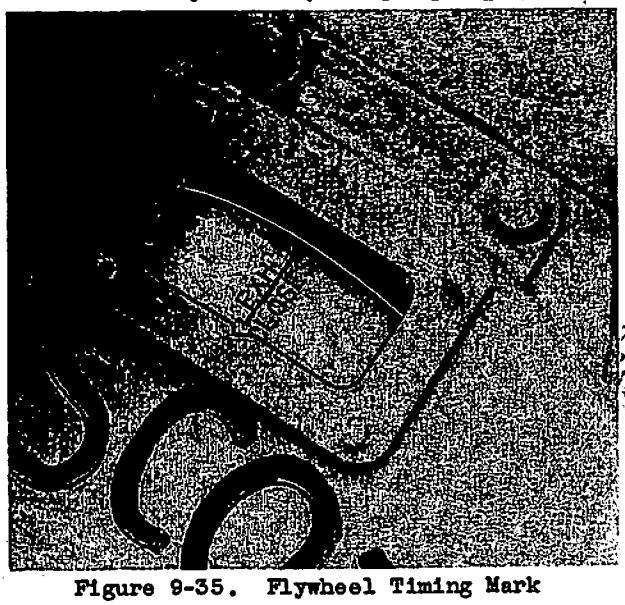


Figure 9-35. Flywheel Timing Mark

9-24 BALANCE VALVE TIMING. After the above routine has been followed, paragraph 9-20 through 9-23, it is necessary to check the exhaust valve timing of number 1 cylinder in the leading bank and number 6 cylinder in the leading bank against the flywheel timing marks. A difference will sometimes appear here because of wear in the camshaft, rockerarm shoe or rockerarm bushing. If a difference in valve timing appears between the two end cylinders of a bank it is necessary to split the difference in timing with relation to the flywheel. For example, if it is found that number 1 cylinder in the right hand bank is

timed correctly on the flywheel mark, but number 6 cylinder in the right hand bank falls 1/2 in. late with respect to the flywheel mark, then it is necessary to retime until the number 1 cylinder is 1/4 in. early and number 6 cylinder is 1/4 in. late with respect to the flywheel timing mark. Of course, it is necessary to check both the camshafts in both heads in this respect.

9-25 TRUE UP SPROCKETS. After the proper valve timing has been made it is necessary to see that the camshaft sprockets are running true. If there is found to be a "wobble" in the sprocket it can be corrected by striking the rim of the sprocket with a soft nosed mallet. Do not damage the chain or sprocket teeth. When the sprocket is adjusted on the camshaft so it runs true, tighten up the 3/4 in. cap screw until it is heard to "give" as it grips the camshaft.

9-26 ADJUST VALVE TAPPETS. After the valves are timed it is necessary to open up the exhaust valve tappets to the clearance shown in reference No. 44 , figure 12-1.

9-27 VALVE TIMING, LH Engine No. 2269 Stock List No. 1906AAF200 100.

9-28 The valve timing for LH Engine No. 2269 Stock List No. 1906AAF200 100 is made in exactly the manner outlined in paragraphs 9-20 through 9-26. The reference to leading and trailing cylinder banks takes care of the difference in crankshaft rotation between the right hand and left hand engine. Refer to paragraph 1-22 for definition of leading and trailing cylinder bank.

9-29 ADJUST TIMING CHAIN. This is done by loosening six 3/8 in. nuts in the chain take-up clamp ring. Rotate the chain take-up in the direction indicated by the arrow cast into the sprocket housing until the chain is taut. Scribe a mark on the clamp ring and support. Now back off the take-up 3/8 in. as measured by the distance between the scribe marks. This gives the chain operating slack. It is necessary to look behind the generator support tube in order to see the arrow cast into the sprocket housing on the left hand side.

9-30 INSTALLING OIL PRESSURE REGULATING VALVE. Clean off the gasket faces of both the upper crankcase and the regulating valve. Coat the upper crankcase mounting face with a tacky gasket cement such as Army specification 62-5. Coat the regulating valve body with soft cup grease per specification AN-G-14 (Symbol GRG). Use a new gasket and set the valve assembly in place. Draw it down evenly and tight with four 5/16 in. cap screws. Make sure the dowels have properly entered the reamed holes. See that the pad on the regulating valve matches that on the upper crankcase. Do not put the valve on backwards.

9-31 INSTALLING INTAKE MANIFOLD. The first step in this operation is to fit the intake manifold elbows to the cylinder head. Coat the cylinder head gasket face and the intake manifold elbow gasket face with a tacky gasket cement per Army specification 62-5 similar to shellac. Coat only the elbow face that goes against the cylinder head at this time. Set the elbows in place on the cylinder head using new gaskets. Install the nuts and washers, but do not draw them up tight. Now set a bare intake manifold on top of the elbows and fit at least two cap screws into each flange and draw them up fairly snug. This brings all six intake elbow flanges into alignment. Proceed to tighten all the 7/16 in. nuts that hold the elbows to the cylinder heads. Now remove the bare intake manifold from the engine. See that all spark plugs and ignition wires are in place in the "V" between the cylinder banks. The carburetors must be fitted to the intake manifold before the manifold is finally fitted to the engine. This is done as follows: Clean off the carburetor mounting flanges, as well as the carburetor extension and manifold flanges. Use new gaskets and assemble the carburetors to the carburetor extension and to the intake manifold. The extension piece is put on as illustrated in figure 9-37. Install

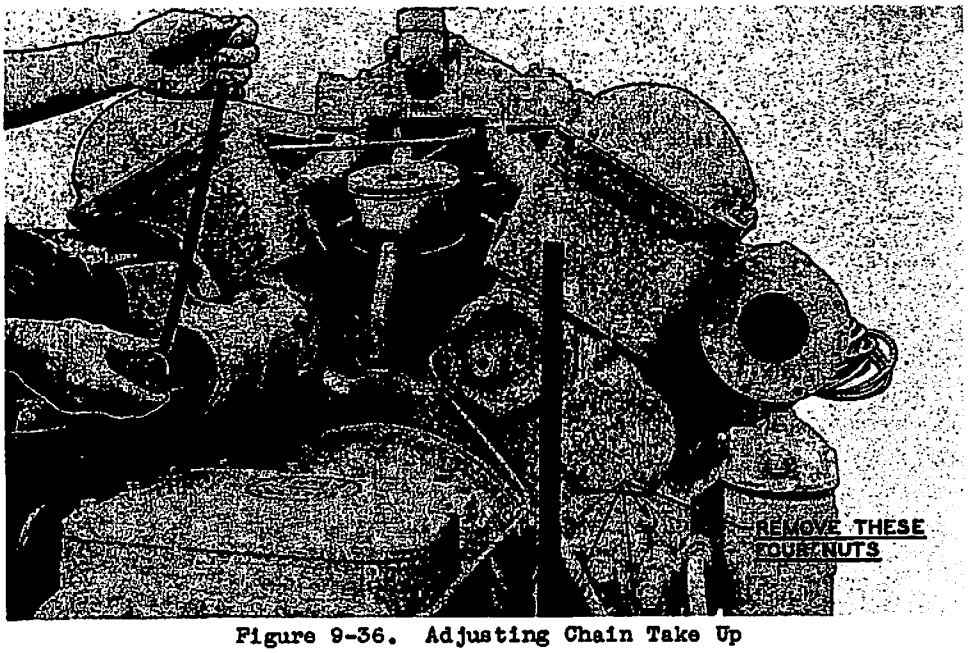


Figure 9-36. Adjusting Chain Take Up

the long carburetor control shaft and connect up the linkage to each carburetor. Lubricate the control linkage with oil per specification AN-O-6 (Symbol OGP). Slide the carburetor and manifold assembly into place from the rear of the engine. Be careful not to damage any spark plugs, pipes, wires or control linkage. Coat the gasket faces of both the intake manifold and intake manifold elbows with a tacky gasket cement per Army specification 62-5 similar to shellac. Use new gaskets and fasten the manifold to the intake elbows with 7/16 in. cap screws and lockwashers. Connect all fuel pipes to the carburetors. Install ventilating pipes to the distributors, multiple shield boxes and to the rockerarm covers as well as the sprocket housing.

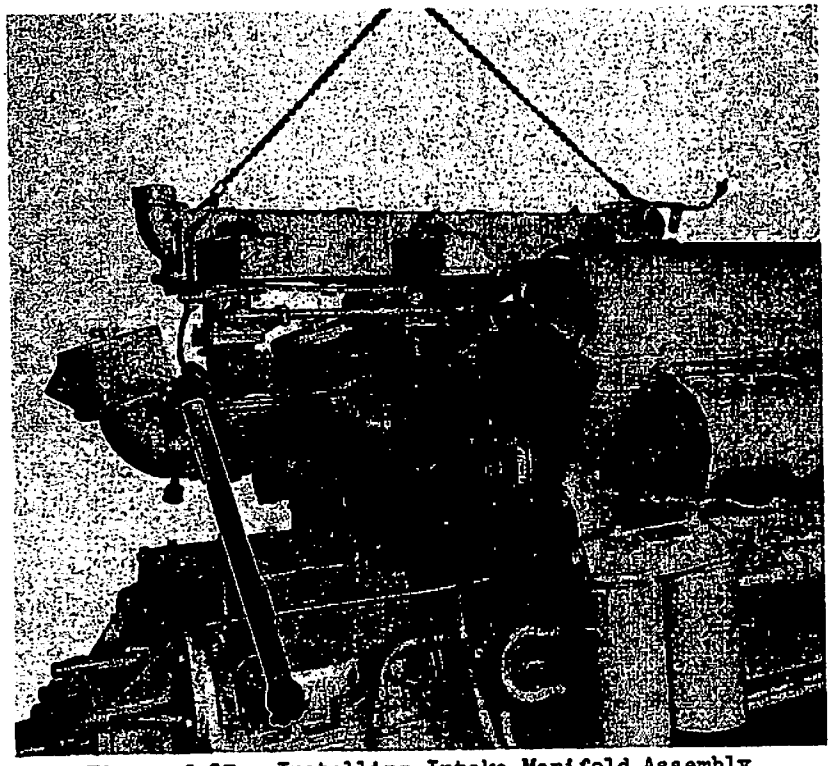


Figure 9-37. Installing Intake Manifold Assembly

9-32 INSTALLING MULTIPLE SHIELD. The multiple shield support is assembled to the engine and secured with cap screws, nuts and washers. The multiple shield assemblies, electric fuel pump filter and starting motor filter are next secured to the support. The exterior wire connections are made to the multiple shield assembly, electric fuel pump filter and starting motor filter, paying careful attention to the wiring diagram figure 9-39. Fit the ventilating pipes to the multiple shield assembly. Secure the wires and pipes with clips and tape so they cannot vibrate excessively.

9-33 INSTALLING STARTER. The starter flange mounting face and the flywheel housing face must be clean and smooth. Use a new starter flange gasket and coat one side with gasket cement per Army Spec. 62-5. Stick this coated side against the starter flange. Coat the other side of the gasket with light cup grease per specification AN-G-14 (Symbol GRG). See that the starter drive bushing is clean and smooth. The starter drive sleeve on the end of the starter drive shaft must be clean and free from nicks and burrs so it will freely enter the flywheel housing bushing. Fit the starter to the flywheel housing and secure with nuts and washers. Draw the nuts up evenly so as not to bind or distort the parts. Reconnect the electric wires. Lubricate the starter by putting two drops of oil per specification AN-O-6 (Symbol OGP) in the oil cup at the rear end of the starter and on the Bendix drive helix.

9-34 INSTALLING THE GENERATOR DRIVE. Refer to paragraph 8-8 for preliminary assembly of the generator drive to the sprocket housing. Then fit the tachometer drive flange to the generator drive pulley after the mounting faces and pilot diameters have been inspected and found to be in good condition. Draw down the eight 1/4 in. cap screws evenly so as not to bind or distort the tachometer drive flange. Secure with a lock wire. Fit the V-belts to the generator drive pulley. Clean off the mounting faces, dowels and dowel holes and then fit the generator belt guard assembly to the engine. Fasten it with four 3/8 in. cap screws. Clean off the mounting faces and pilot diameter and then fit the tachometer adapter plate to the generator drive assembly. This adapter plate is fitted to the engine with the 17/64 in. diameter hole and the flat edge of the flange on the under side.

9-35 INSTALLING GENERATOR. See that the base of the generator is clean, smooth and free from paint or grease. Set the generator in place, fitting the V-belts over the generator drive pulley. Secure the generator with cap screws and lock washers.

CAUTION

Do not use cap screws longer than 3/4 in. and be sure to use lockwashers. If a longer screw is used the field windings of the generator are quite likely to be damaged.

Now rotate the generator bracket on its support so as to bring the V-belts up to operating tension. Make sure the drive and driven pulleys are aligned with one another. Tighten the two 5/8 in. clamp cap screws in the generator bracket. Carefully connect wires to the generator according to the wiring diagram figure 9-39. The generator must be polarized before it is run on the engine. Refer to applicable Air Force and Navy Handbooks.

9-36 INSTALLING BILGE PUMP. The first step in installing a bilge pump is to see that the pump mounting flange and pilot diameter as well as that of the sprocket housing are clean, smooth and flat. Stick a new gasket to the bilge pump mounting flange with a gasket cement per Army Spec. 62-5. Fit the pump to the engine and secure it with four 3/8 in. nuts and lockwashers. Refit the inlet and outlet pipe flanges using new gaskets. See that the pipes are installed so that no strain is thrown on the pump. Lubricate the pump by filling the grease cup with grease of soda or soda-alumina base and water repellant, but not necessarily water proof. Must be of 177°C (350°F) minimum melting point.

9-37 INSTALLING WATER PUMP. See that the mounting face of both the water pump and upper crankcase are clean and smooth. Carefully enter the splined end of the water pump drive shaft into the bearing retainer plate on the sprocket housing so as not to damage the oil retainer. It may be necessary to rotate the shaft slightly to make the mating splines register. Push the water pump into position and secure with four 3/8 in. cap screws and washers. Next fit the distributor floating shaft assembly and the flexible couplings. Carefully enter the flexible coupling driving spools into place in the flexible coupling flanges and draw them into place with their bolts and nuts. Remake the water connections being sure all the gasket faces are clean and smooth. Use new gaskets on all flanges. Put gasket cement on the gaskets both sides. Fill the grease cups with grease of soda or soda-alumina base and water repellant, but not necessarily water proof. The grease must be of 177°C (350°F) minimum melting point. Fill oil cup on the water pump pilot gear case with oil that meets specification VV-L-781 (Symbol GO) SAE 90 viscosity.

9-38 INSTALLING THE DISTRIBUTOR DRIVE HOUSING. See that the mounting face of the distributor drive housing is smooth and clean. Also the mounting face on the upper crankcase must be smooth and clean. Fit the flexible coupling driving spools into the driving flange on the distributor drive shaft while fitting the housing into place on its mounting studs. Fit the four nuts and washers. Draw the flexible coupling spools into place with the coupling bolts and nuts. Be careful to see that they enter the counterbore squarely. Pull them down until they seat firmly against the shoulder provided. See that the distributor drive is lubricated with grease per specification AN-G-25 (Symbol CLT). Fit the overspeed governor drive to the right hand distributor drive housing.

9-39 INSTALLING THE DISTRIBUTOR. The distributor is fitted to the engine by lowering it into the distributor drive housing so that the pointer on the distributor steel mounting plate comes on top of the graduation on the drive housing plate. Be sure to see that the drive housing is clean and is packed with grease as mentioned in paragraph 9-38. Locate the pointer in the center of the graduation and secure with 1/4 in. cap screws. The wires are connected as shown in figure 9-51 and 9-52. See that the distributor is lubricated. Refer to applicable Air Force and Navy handbooks.

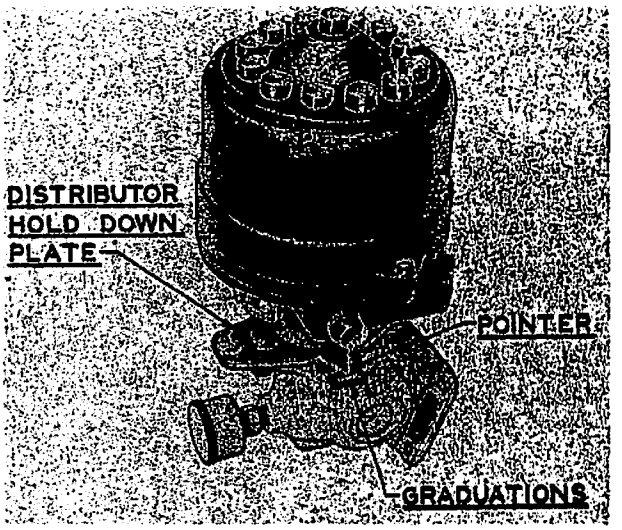


Figure 9-38. Distributor Hold Down Plate and Graduations

9-40 IGNITION TIMING. Ignition timing can only be done after the valve timing has first been set as explained in paragraphs 9-20 through 9-28.

9-41 IGNITION TIMING, RH Engine No. 2268 Stock List 1906AAF200 000.

9-42 POSITION THE CRANKSHAFT. Remove the timing inspection cover plate from the front of the flywheel housing. Remove the exhaust side spark plug from the number one cylinder in the left hand bank. Do not forget the "hand" of the cylinder banks are determined as one stands at the rear of the engine and faces forward. Turn the engine over by hand in its normal running direction until the number one piston in the left hand bank starts to come up on its compression stroke. This can be determined by blocking the spark plug hole with the thumb and if air is forced out as the piston comes up then it is on its compression stroke. Of course, it is necessary to set the valve timing before the ignition timing is made. Refer to paragraphs 9-20 through 9-28. When number one left hand piston is on its compression stroke continue rotating the engine in its normal running direction until the flywheel mark "T.C. 1 & 6 L.H. BANK" is directly in line with the notch in the housing inspection hole. See figure 9-43.

9-43 POSITION DISTRIBUTOR. Now loosen the two 1/4 in. cap screws in the distributor hold down

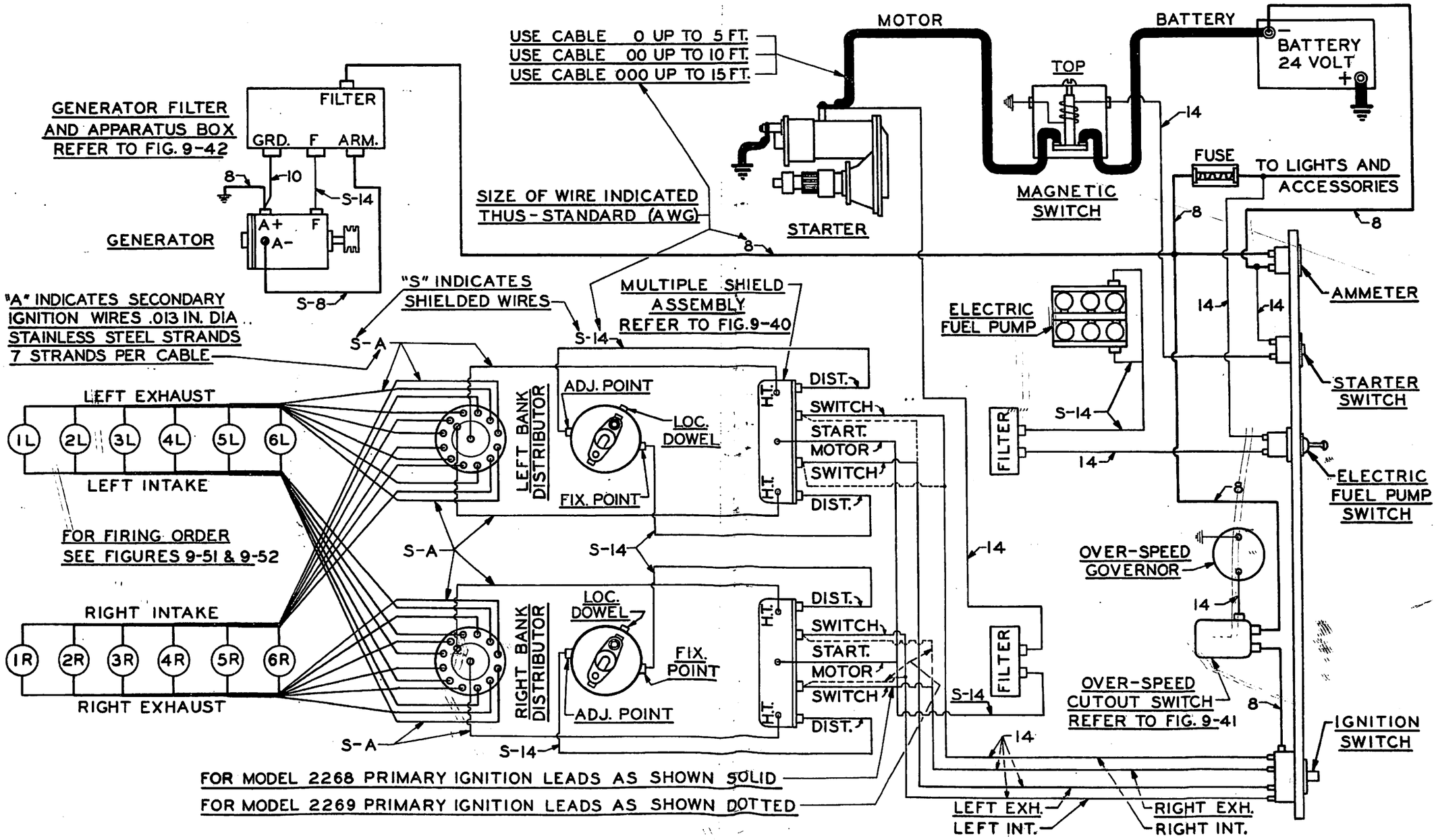


Figure 9-39. Engine Wiring Diagram

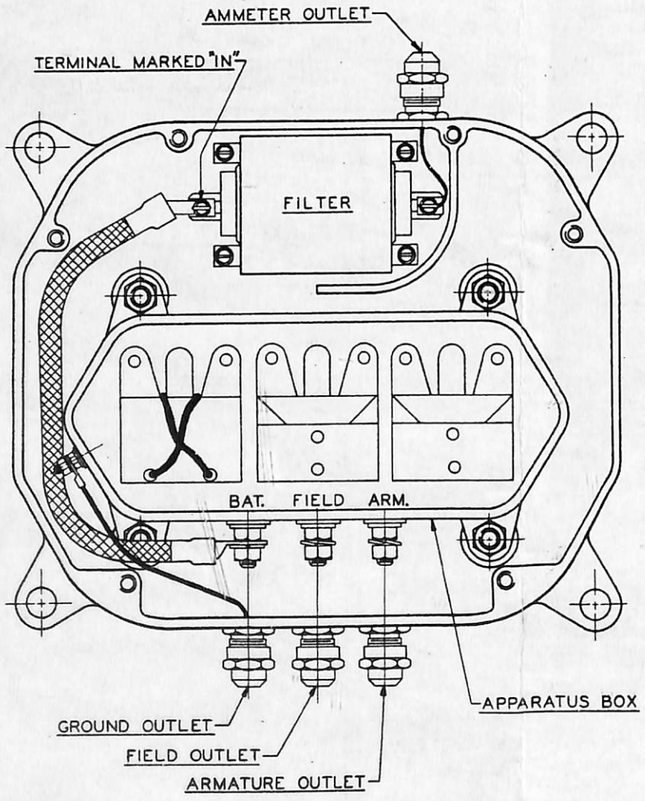


Figure 9-42. Internal Wiring Diagram of Apparatus Box

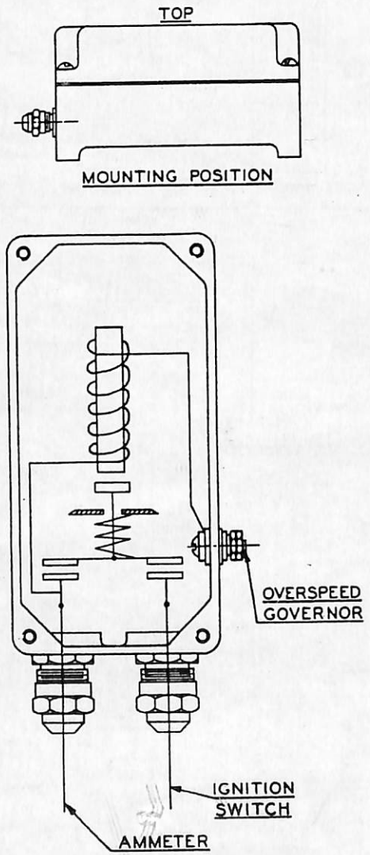


Figure 9-41. Internal Wiring Diagram of Overspeed Governor Switch

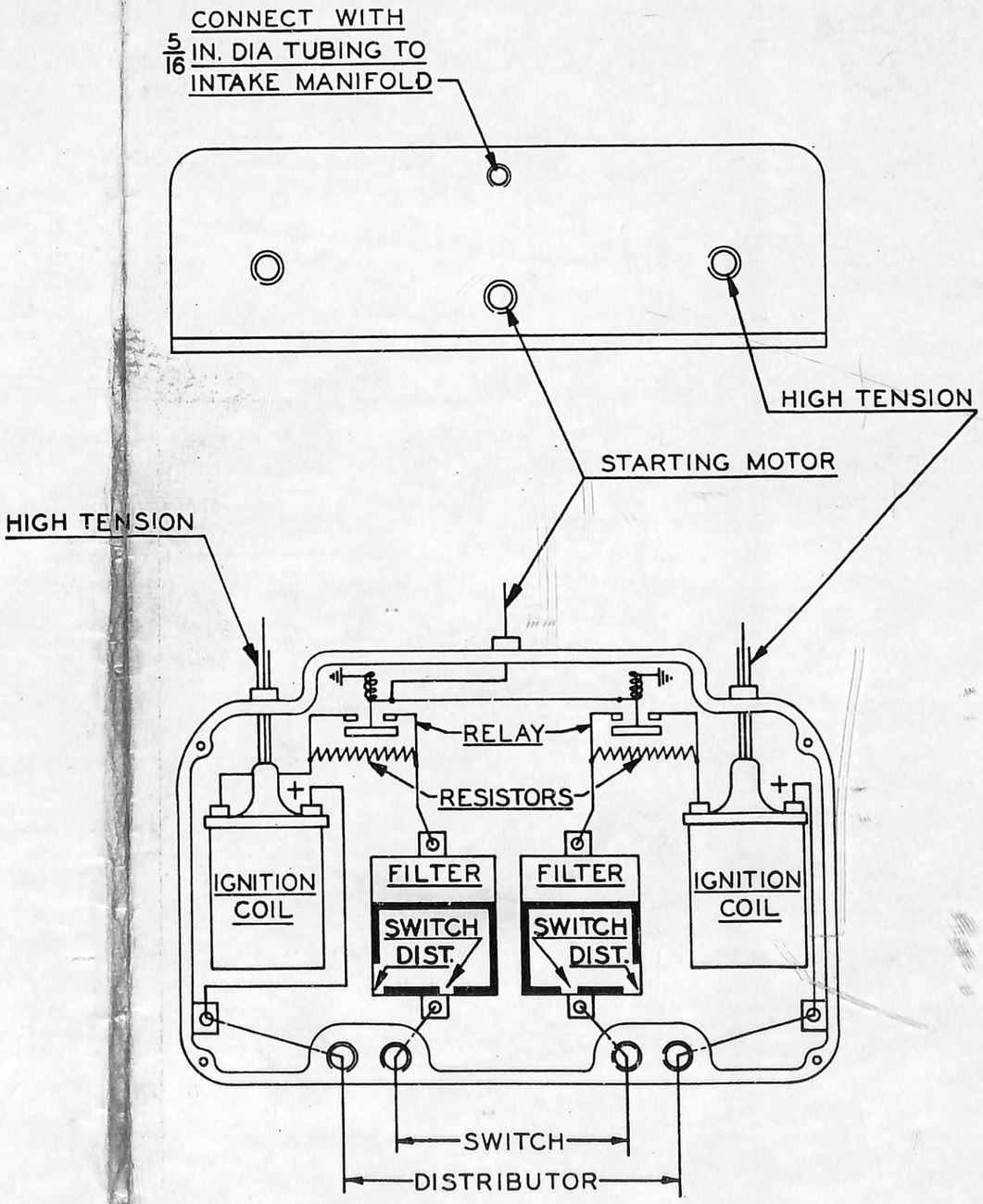


Figure 9-40. Internal Wiring Diagram of Multiple Shield Box

plate and rotate both distributors until the pointer is located in the center of the graduation as shown in figure 9-38.

9-44 OPEN DISTRIBUTOR. Remove the caps from both distributors as explained in paragraph 4-5. Lift the lock wire from around the rotor base carefully so as not to bend or break it. Unscrew the hollow head set screw from the base of the rotor by three turns. Do not take this screw completely out as it may be lost. Now carefully lift the rotor from the distributor cam. In some cases it may be necessary to pry the rotor up off the cam, but do so carefully so as not to damage either the rotor or the distributor cam. Loosen the cam by backing out the lock-screw from the center of the cam. This screw is made in such a way that it will pull the cam from the shaft if it is backed out. After the cam is drawn out far enough so it can be freely rotated on its shaft, turn the lock screw down until the cam just starts to drag on the shaft, but still can be turned. This is done to both distributors.

9-45 BREAKER POINTS. These distributors are each fitted with two sets of breaker points. One is known as the "fixed" points as they are



Figure 9-43. Flywheel Timing Mark

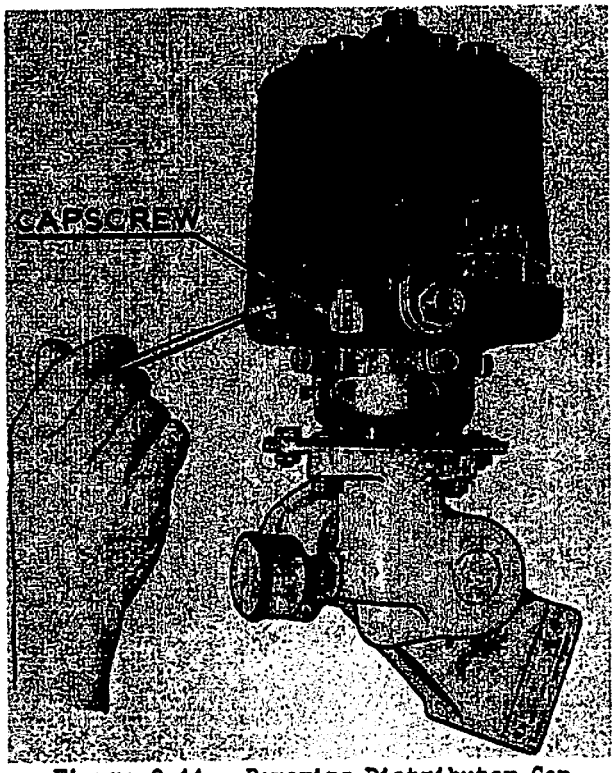


Figure 9-44. Removing Distributor Cap

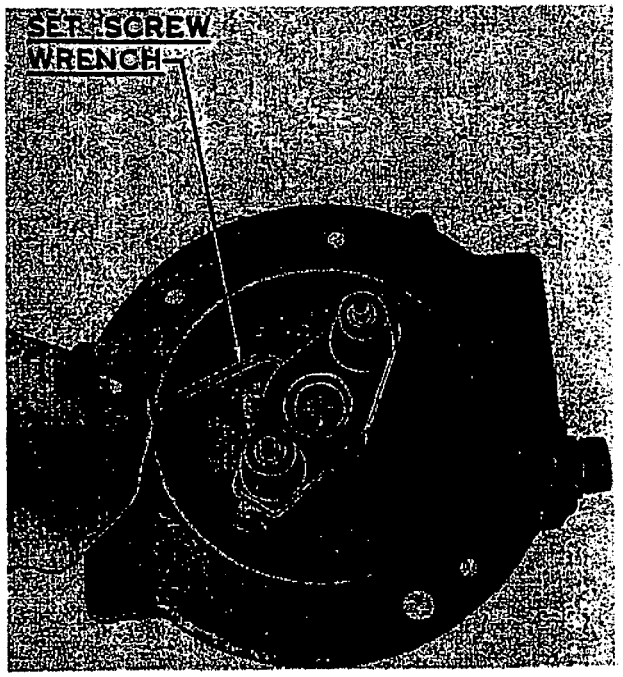


Figure 9-45. Loosening Rotor Set Screw

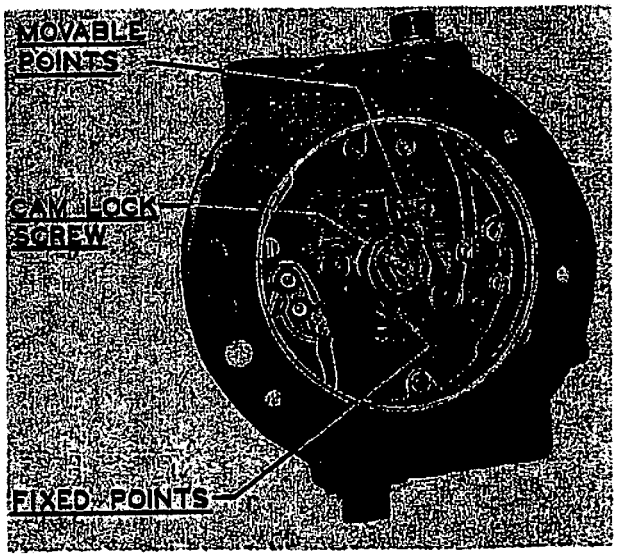


Figure 9-46. Interior of Distributor

not adjustable in angular position with respect to the distributor base. The other set is known as the "moveable" points as they are adjustable in angular position with respect to the distributor base.

9-46 BREAKER POINT GAP. Adjust all the distributor breaker points to the gap per Refer. No. 70, figure 12-1. This gap is measured when the breaker arm brush is resting on a high point of the cam. For best results all four distributor point sets (both distributors) must be adjusted to as near the same gap as possible.

9-47 POSITION ROTOR. Place the distributor rotor back on the distributor cam so that it properly engages the flat on the side of the cam. Do not push the rotor clear down as it has to be withdrawn presently. Now turn the rotor opposite to its normal running direction, that is, turn it counterclockwise as you look down on it, until the rotor is positioned with respect to the cap locator dowel as shown in figure 9-48. Note the relative position of the metal strip in the rotor that extends under one of the brush towers and out to the end of the rotor. This is of vital importance as one of the rotor brushes is "alive" and one is a "dummy" for balancing purposes only. The embedded metal strip that extends from the center of the rotor to the tip of the rotor passes beneath the dummy brush tower. With the rotor in the relative position shown in figure 9-48 continue to turn the rotor counterclockwise as you look down on it, until the fixed distributor points just close. Make this same adjustment to both distributors. Bear in mind that this is the position where the points would be just opening were the distributor to be turned in its normal running direction. This point of just opening or closing, as the case may be, can be determined thru the use of an electric light as explained in paragraph 9-51. This same treatment applies to both the left hand as well as the right hand distributor. They are both turned counterclockwise for the timing operation. They are turned opposite to their normal running direction so as to take all the backlash out of the drive. This is important. Now carefully pull the rotor from the cam without altering the cam position and tighten down the lock screw in the center of the cam, both distributors. Be careful to see that points in both distributors are synchronized so they open at the same instant.

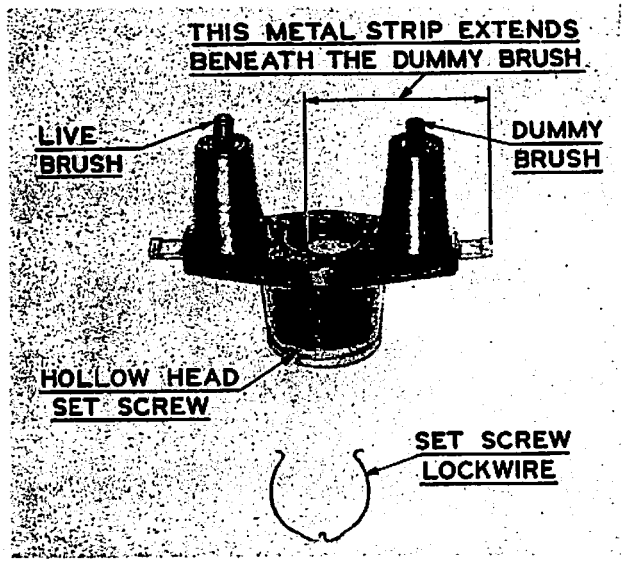


Figure 9-47. Distributor Rotor

CAUTION

Be sure the cam is down as far as it will

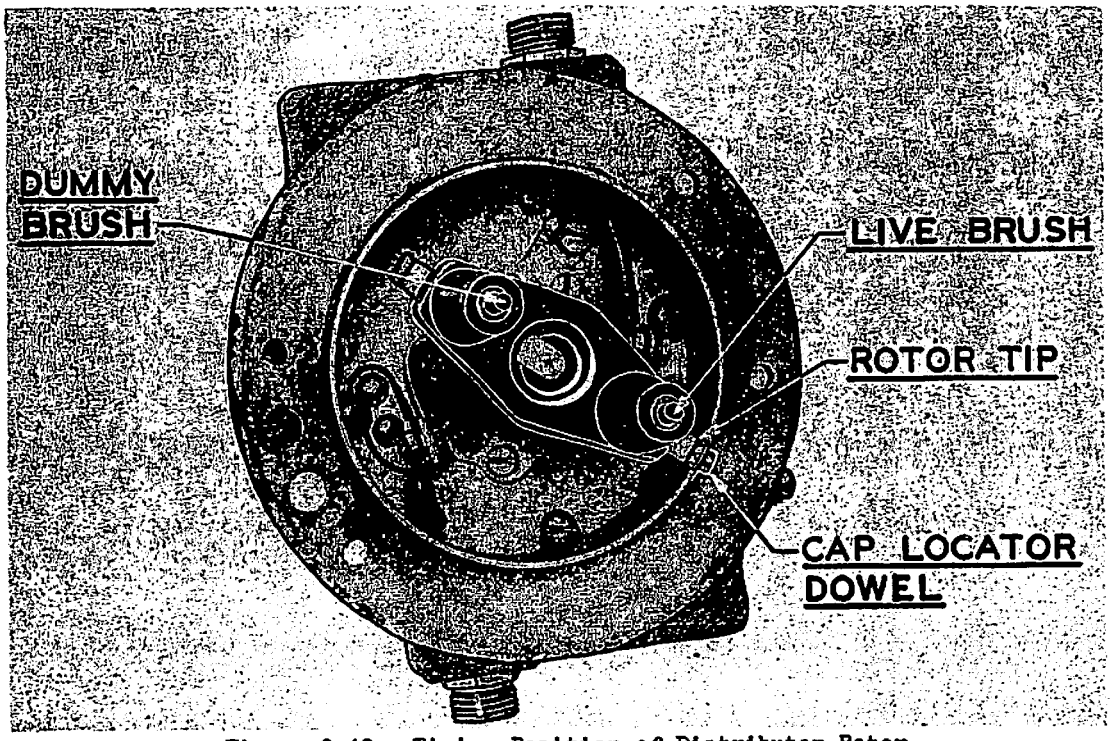


Figure 9-48. Timing Position of Distributor Rotor

go on the shaft, otherwise the rotor may be raised so high as to damage the distributor cap when the engine is started.

9-48 ADJUSTING MOVEABLE BREAKER POINTS. Rotate the crankshaft in its normal running direction 60 degrees until the mark "T.C. 1 & 6 R.H. BANK" is directly in line with the notch in the flywheel housing. This 60 degree location is most important so be careful to see that the flywheel marks come exactly opposite the timing notch in the flywheel housing inspection hole. The moveable breaker points in the distributors are now swung around by use of the eccentric screw until they are just beginning to open, backlash having been removed. Securely lock the moveable points in this position, both distributors.

9-49 REASSEMBLE. Coat the distributor cam with a light coat of petrolatum and one drop of oil on hinge pins as mentioned in paragraph 11-48 . Set the rotor back in place and see that it is firmly seated. Tighten hollow head set screw and fit spring lock wire.

9-50 COIL CONNECTION. The ignition timing cannot be considered complete until a check is made to see that the distributor points are properly connected to the ignition coils. As shown in figure 9-39, the fixed distributor points must be connected to the ignition coil so that they fire through the "live" brush of the distributor rotor and through the off center connection in the distributor cap. The moveable distributor points must fire through the center contact of the distributor rotor and cap. These connections can be verified by tracing the connecting wires. The ignition coils are located in the multiple shield boxes directly under the secondary connections to the boxes.

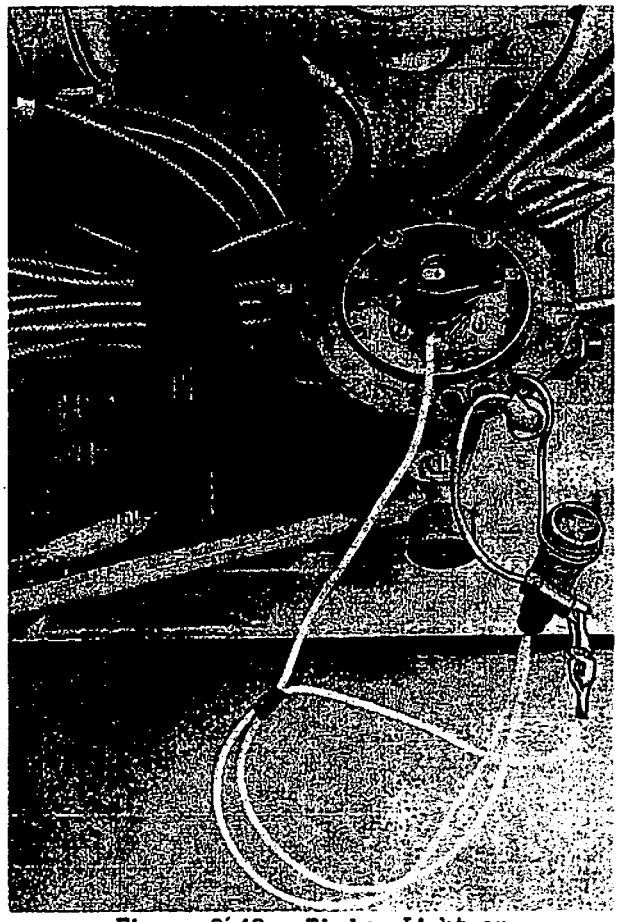


Figure 9-49. Timing Light on Distributor Points

9-51 TIMING WITH AN INDICATOR LIGHT. It is possible to very accurately determine when the breaker points are just opening or just closing by connecting a 24 volt light in series with the breaker point set under consideration. With the ignition switch "on" the lamp will glow when the points are closed and go out when the points are open. When a slight pressure one way or the other, on the breaker arm, will either light or extinguish the lamp one can be certain that the points are at the correct position for timing as mentioned in paragraph 9-47.

9-52 IGNITION TIMING, LH Engine No. 2269 Stock List No. 1906AAF200 100. To set the ignition timing on a left hand engine (LH Engine No. 2269 Stock List No. 1906AAF200 100) the same procedure is followed as outlined in paragraphs 9-42 through 9-50 with the following exceptions:

a. In paragraph 9-42 remove the exhaust side spark plug from number one cylinder in the right hand bank and rotate the crankshaft until this cylinder is on its compression stroke and the flywheel mark "T.C. 1 & 6 R.H. BANK" comes directly opposite the notch in the flywheel housing inspection hole as shown in figure 9-50.

b. In paragraph 9-48 rotate the flywheel in its normal running direction 60 degrees until the mark "T.C. 1 & 6 L.H. BANK" is directly in line with the notch in the flywheel inspection hole as shown in figure 9-43.

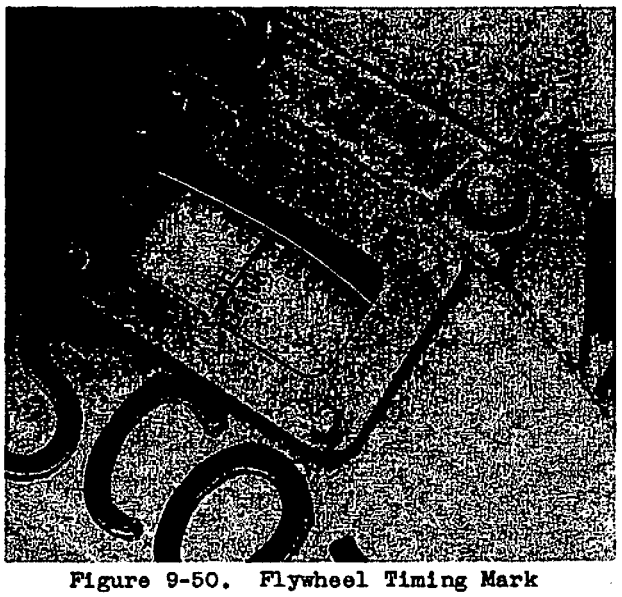


Figure 9-50. Flywheel Timing Mark

9-53 OIL COOLER INSTALLATION. See that the mounting face of the oil cooler and cylinder block are clean, smooth and flat. See that all the studs are in good condition. Replace any studs that are defective. Stick a new gasket to the oil cooler face with gasket cement per Army specification 62-5. Coat the opposite face of the gasket with light cup grease per speci-

fication AN-G-14 (Symbol GRG). Fit the cooler to the engine and secure with nuts and copper washers. Draw it down into place evenly and tight. Replace water circulation pipes. Fit oil and water circulation pipes.

9-54 MECHANICAL FUEL PUMP INSTALLATION. Clean off the mounting face of the fuel pump and cylinder head. See that these surfaces are clean, smooth and flat. See that the pilot diameter of the fuel pump is clean as well as the driving tongue. See that the pump by-pass valves are arranged so they come on the inside of the engine "V" per figure 9-54. The valve cap marked with a "V" has the by-pass valve under it. See that the oil passage hole in the cylinder head is clean. Use a new fuel pump flange gasket and stick it to the fuel pump with gasket cement per Army specification 62-5, being careful not to plug up the oil hole. Be sure there is an oil hole in the gasket. Coat the cylinder head side of the gasket with light cup grease per specification AN-G-14 (Symbol GRG). Rotate the fuel pump drive tongue so it will line up with the slot in the end of the camshaft. Fit the pump to the engine and secure with 5/16 in. nuts and lockwashers. Make sure the driving tongue is properly entered into the camshaft slot. Connect the fuel pipes if they are in good condition. Open the main fuel valve and fill the system with fuel through the use of an electric fuel pump or other auxiliary means. Make a final check for fuel leaks and correct any found.

9-55 OIL FILTER INSTALLATION. See that the mounting faces of the oil filter and sprocket housing are clean and smooth. Coat a gasket with cement per Army specification 62-5 one side and stick it to the filter base. Coat the other side of the gasket with soft cup grease AN-G-14 (Symbol GRG). Assemble the oil filter to the engine and secure with nuts and washers. Fit oil pipes.

9-56 OVERSPEED GOVERNOR INSTALLATION. The first step in the installation of the overspeed governor is to fit the drive cable connection to the overspeed governor assembly. Be sure that the driving tongue enters the slot properly so it does not bind. Now connect the electrical lead to the back of the overspeed governor assembly. Set the overspeed governor assembly with its bracket and drive cable on the engine and secure with two 3/8 in. cap screws and lockwashers. Attach the other end of the drive cable to the front end of the distributor drive housing. Make certain that the driving tongue properly enters the driving slot of the distributor drive shaft. Fasten the drive cable supporting clip to the front of the hand starting throw out plate.

9-57 ELECTRIC FUEL PUMP INSTALLATION. Set the electric fuel pump on the engine and fasten with two 3/8 in. cap screws in the vertical flange of the flywheel housing and one 1/2 in. cap screw in the horizontal flange of the flywheel housing. Remake the fuel pipe connections to the fuel pressure regulating valve as illustrated in figure 9-54. Connect the fuel supply pipe to the fuel pump. Fasten the electrical connections to the fuel pump as illustrated in figure 9-39.

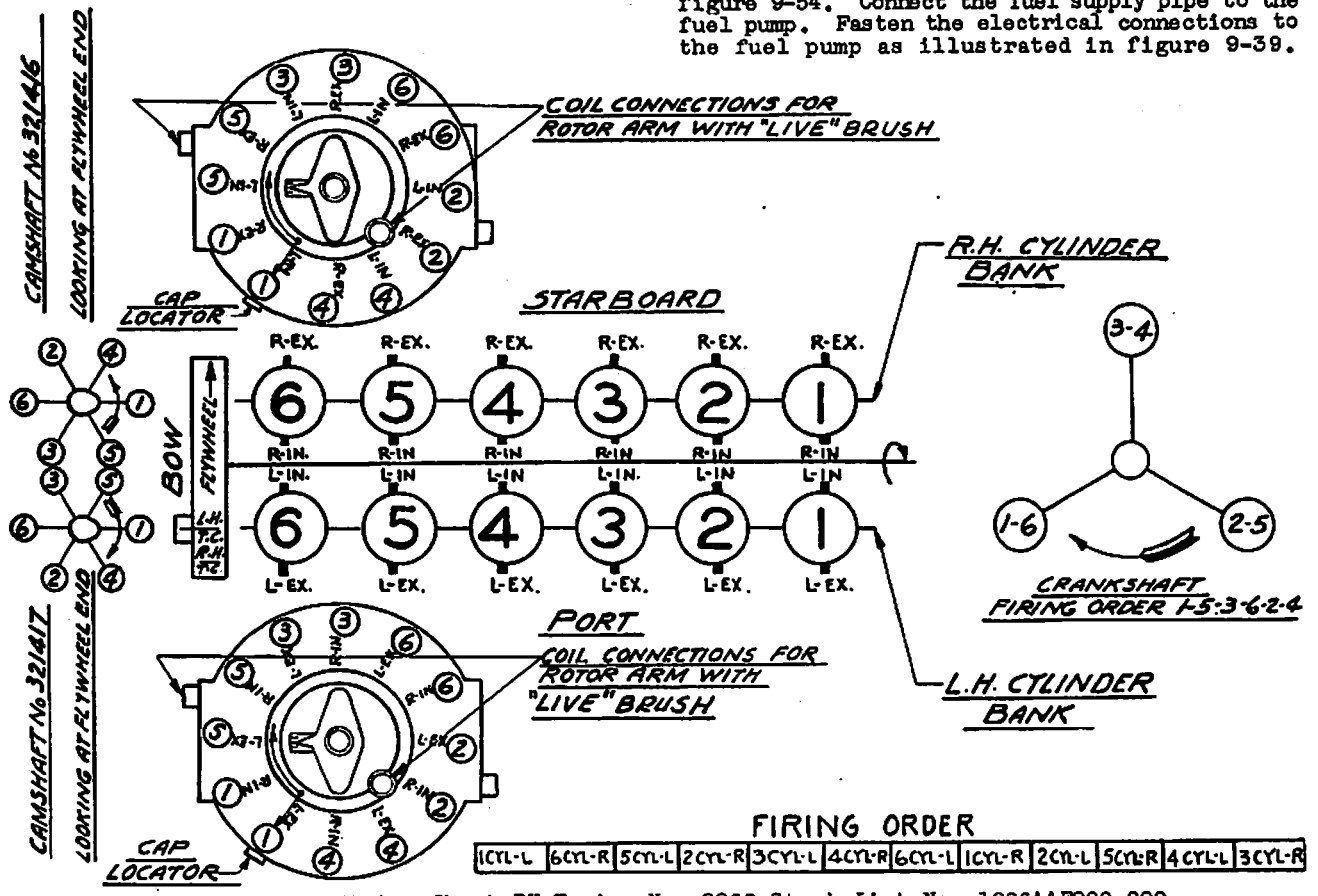


Figure 9-51. Firing Chart RH Engine No. 2268 Stock List No. 1906AAF200 000

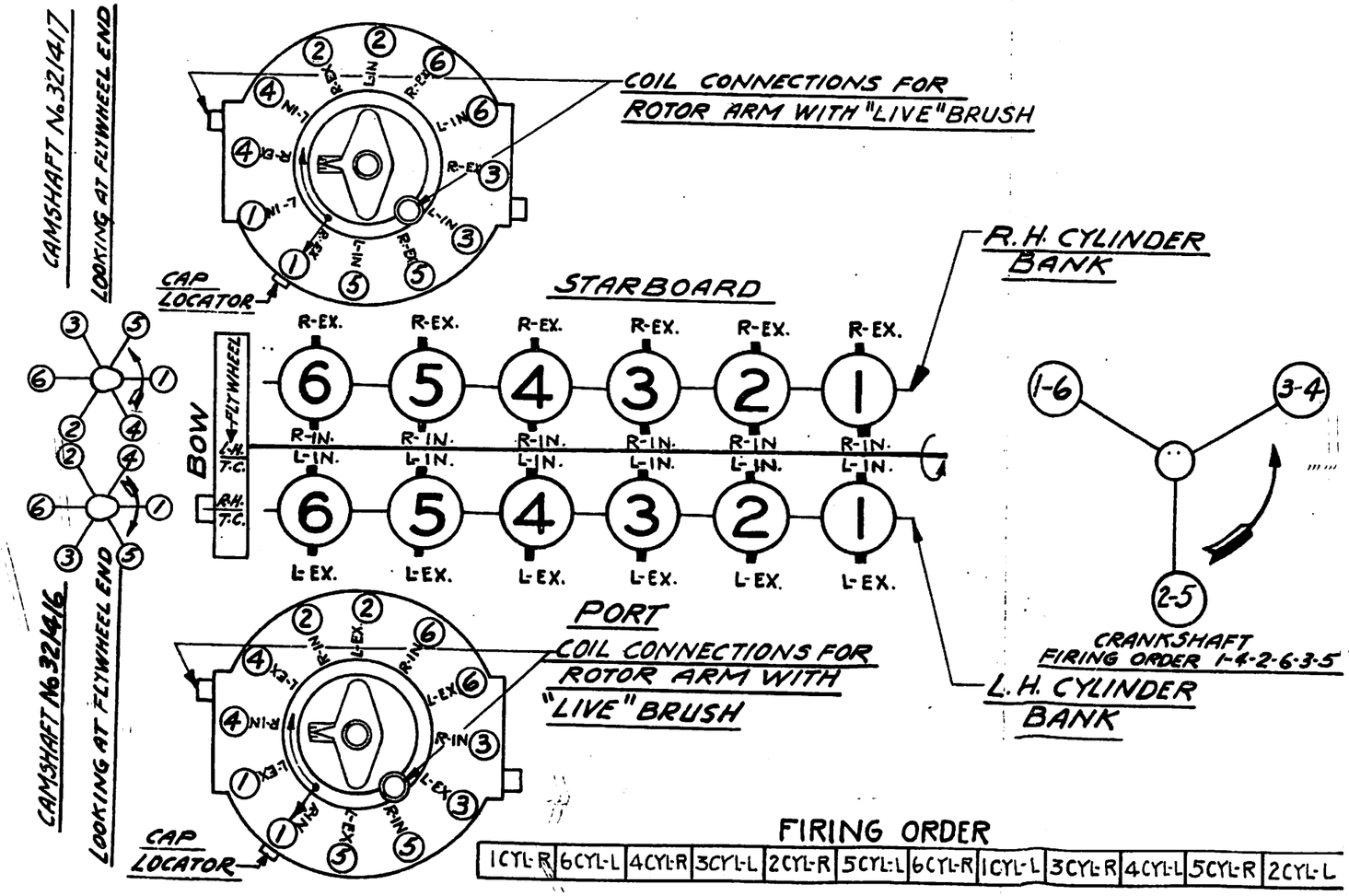


Figure 9-52. Firing Chart LH Engine No. 2269 Stock List No. 1906AAF200 100

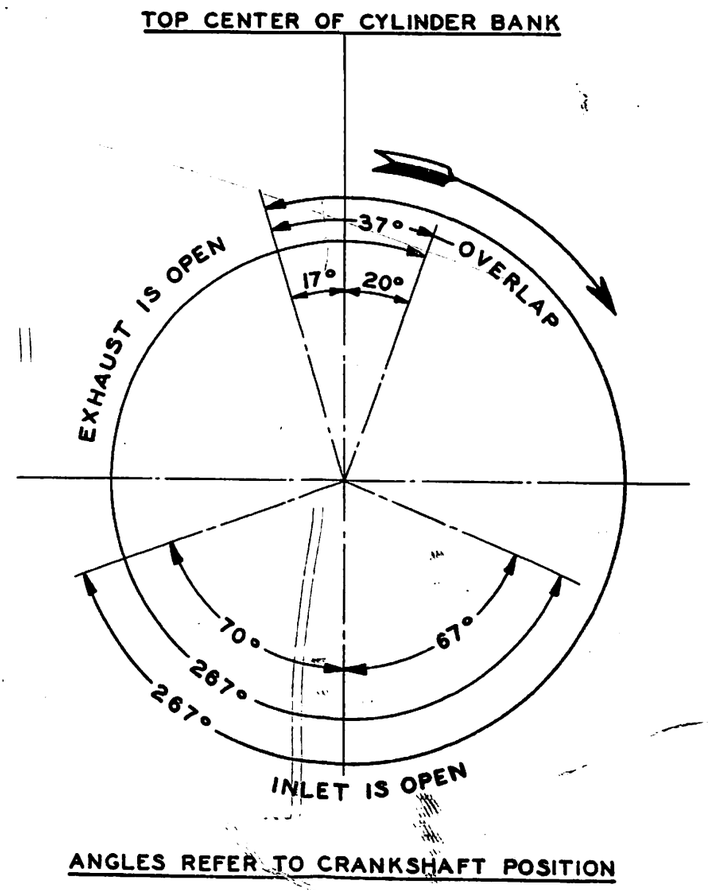


Figure 9-53. Valve Timing Diagram

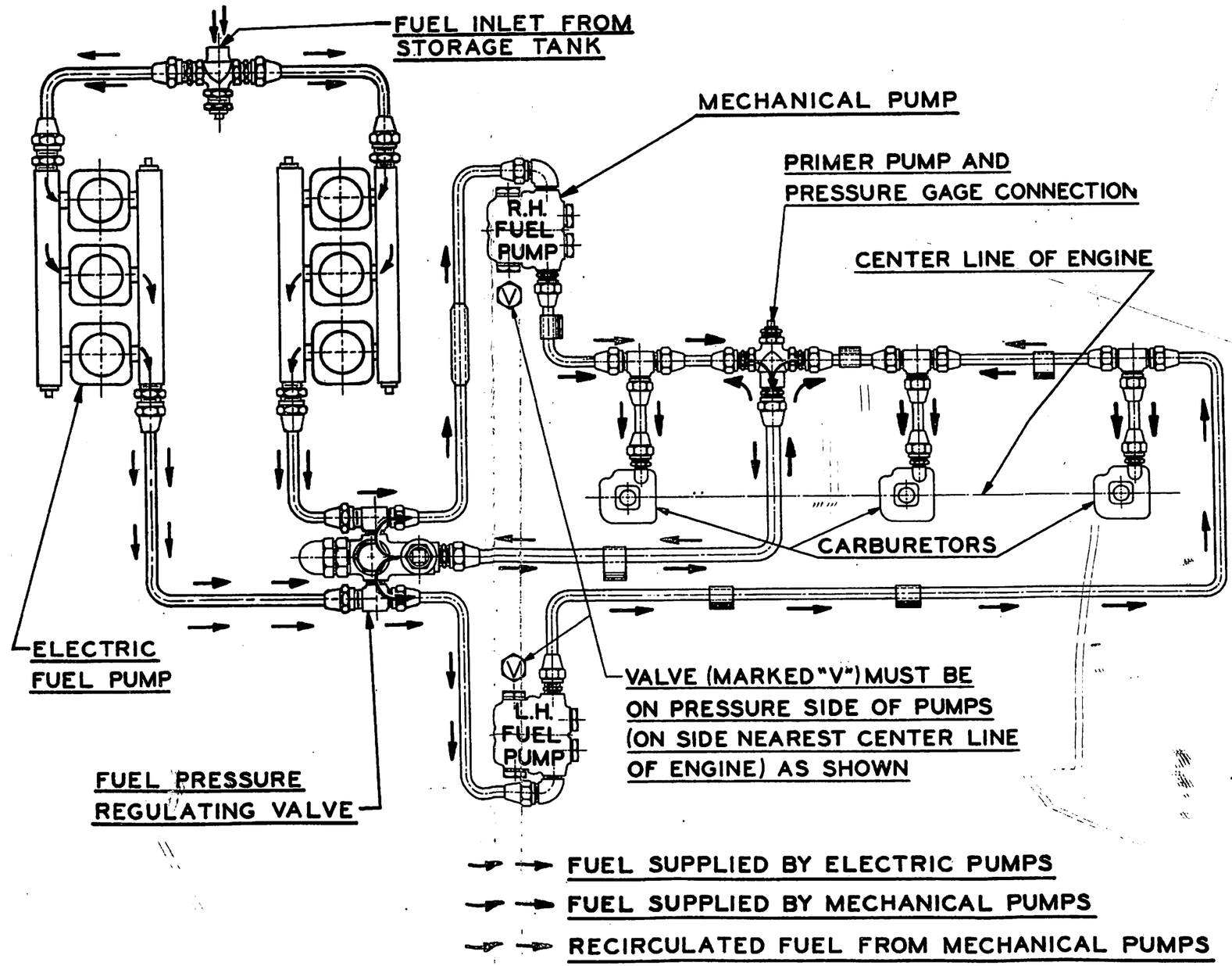


Figure 9-54. Fuel Circulation Diagram

TESTING AFTER OVERHAUL

NOTE

Air Force personnel will follow procedures outlined in Air Force Technical Orders covering this subject. Navy personnel will follow procedure outlined in NavAer 02-1-508.

10-1 GENERAL. It is necessary to carefully test an overhauled engine before returning it to service or storage. The running serves to check the quality of the overhaul work, seats piston rings and burnishes new parts to a good wearing surface. The engine can be adjusted and tuned so that it will operate properly when installed in a boat. Accurate measurements of power, fuel and oil consumption may be made so as to determine the operating efficiency of the unit. During all the outlined run-in tests every precaution must be used to protect the engine from damage. Oil, water and fuel supply must be adequate and circulation assured. Close attention to the instruments will aid in detecting trouble before it becomes serious. Any sudden drop off in engine speed at any given throttle position and dynamometer load is a pretty sure sign of trouble and the engine should be shut down until the cause is determined and corrected. A drop in oil pressure or sudden rise in any temperature is a warning of trouble. An operator can make a quick check of water and oil circulation by laying his hand on the exhaust manifolds and oil pipes each side of the engine. The manifolds should both be of the same temperature and comfortable to the hand. A distinct difference should be detected in the temperature of the oil pipes "in" and the oil pipes "out" of the oil cooler. Every effort should be made to see that the engine is in first class operating condition before it is removed from the test stand for storage or installation. Refer to AN 19-85BHB-2, section IV for storage instructions.

10-2 TEST STAND. A suitable test stand must be provided for rigidly mounting the engine for testing on a dynamometer. Refer to figure 10-6 for mounting dimensions. Provision must be made for aligning the engine with the dynamometer and securely fastening it down so it cannot vibrate or move while under test. Some type of flexible coupling must be made between the engine propeller shaft flange and the dynamometer. This is necessary to avoid any strain and binding in the engine or dynamometer bearings caused by misalignment. In setting the engine up for a running test, care must be used to see that no moving parts are left exposed so that operators clothing can get entangled. Especial attention is called to the engine dynamometer coupling. This part must be protected with a safety guard. No fuel, oil or water leaks must be permitted.

10-3 DYNAMOMETER. Some sort of power absorption device must be used for loading the engine during the running test after overhaul. A water brake or electric dynamometer is most frequently used for this purpose. The dynamometer must be capable of absorbing at least 750 horsepower at 2100 revolutions per minute. It is necessary to have a dynamometer mounted so the loading can be varied and measured, thus the engine output can be accurately determined. The dynamometer must be reversible in rotation so either right or left hand rotation engines may be tested and also so that a reverse gear test can be made. A revolution counter attached to the dynamometer is necessary. Suitable means must be provided for supplying and measuring the fuel and oil consumption of the engine. This is generally done by weighing the fuel and oil used during any given time and at any given horsepower output.

10-4 COOLING SYSTEM. An adequate supply of cooling water must be available to the engine cooling water pumps. The cooling water pipes

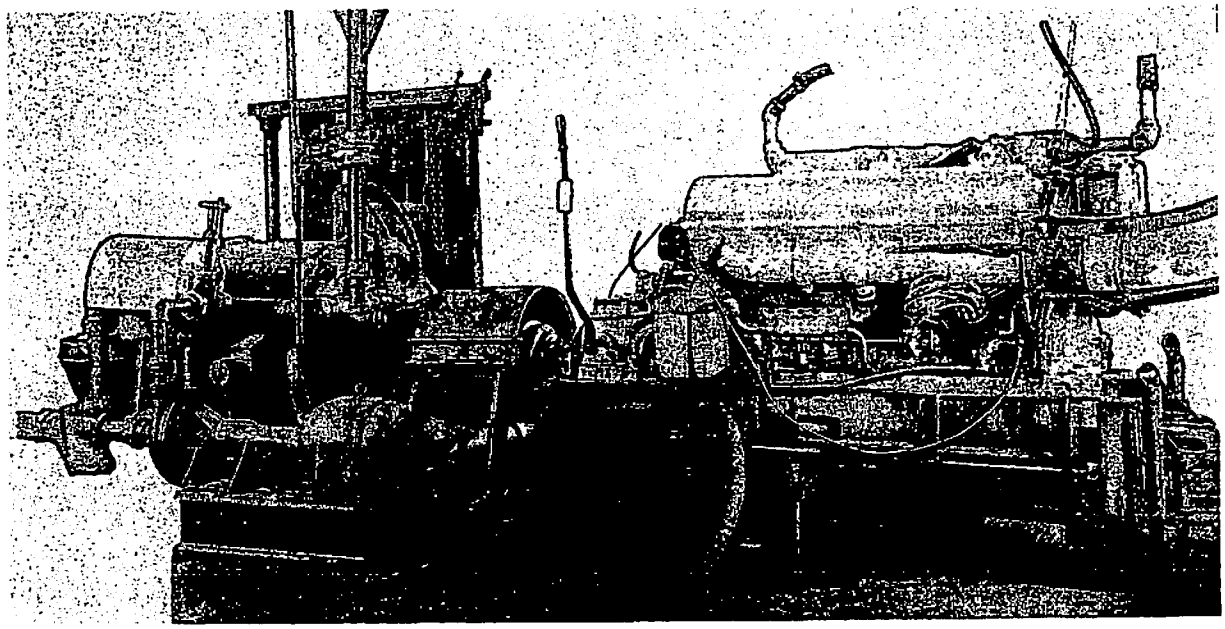


Figure 10-1. Engine Coupled to Dynamometer

must be of sufficient size so that the suction and discharge pressures do not exceed the values shown in figure 10-6. Some visable flow device is necessary in the system to aid the operator in watching the cooling water circulation. An open discharge into a hopper serves the purpose. The water circulation must not be interrupted while the engine is in operation. The highest outlet point in the engine cooling system must be vented to an expansion tank to prevent the accumulation of steam or air pockets in the engine cooling jackets. The cooling radiator for handling the water from the engine must be capable of dissipating 31,500 BTU per minute at a maximum water temperature from the engine of 54°C (130°F). This cooling rate is required for the engine alone. Any cooling load imposed by the dynamometer or additional water jackets on the exhaust pipe beyond the engine manifolds must be added to the above figure. Either fresh or sea water may be used in the engine cooling system, however, it is best to use fresh water in order to reduce deposits and corrosion especially if the engine is to be stored after the dynamometer test.

10-5 STORAGE BATTERY. A source of electric current must be provided for cranking the engine, supplying ignition energy and for absorbing the output of the engine generator. This requirement is usually met by using two lead acid storage batteries of 12 volt rating connected in series to give a combine output of 24 volts. A capacity as follows is satisfactory for this purpose:
20 hour rate of - - - - - - - 147 ampere hours
20 minute rate of - - - - - - - - - 175 amperes
1-1/2 minute rate at 0°C (32°F) of - 850 amperes

10-6 MAXIMUM RATING. The maximum rating of this marine engine is 630 brake horsepower at 2100 revolutions per minute at standard conditions of air temperature and pressure as mentioned in paragraph 10-8. The engine overspeed governor must be adjusted so that the engine speed can never exceed 2100 rpm. The run-in schedule outlined in paragraph 10-10 must be carefully followed. Do not run an overhauled engine at any loads or speed except in the order mentioned in paragraph 10-10.

10-7 NORMAL RATING. The normal rating of this engine is 440 hp at 1800 rpm under standard conditions of air temperature and pressure as mentioned in paragraph 10-8.

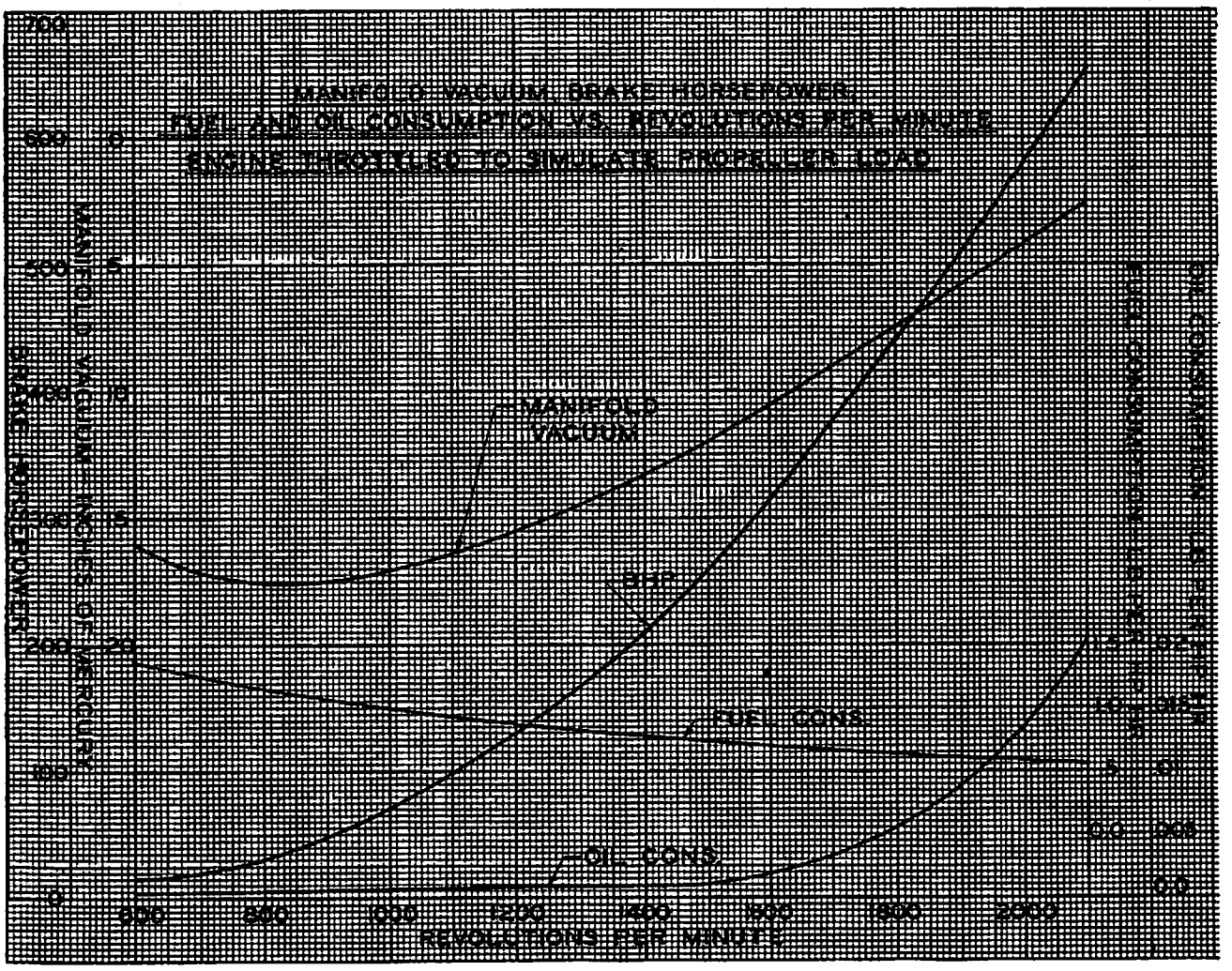


Figure 10-2. Engine Performance Curves

10-8 PERFORMANCE CURVES. The curves shown in figure 10-2 are throttled engine output to duplicate a normal propeller load. These ratings are at standard conditions of 29.92 in. of mercury air pressure and 15.5°C (60°F) air temperature. Test data must be corrected to standard conditions in a manner established by the SAE. When coupled to a dynamometer the engine is capable of greater output than that shown on the curve especially in the intermediate speed ranges. Any variation in the engine over that shown by the curve will also influence the manifold vacuum, fuel and oil consumption. The oil consumption will vary somewhat until the piston rings become seated.

10-9 GENERATOR CONNECTION. The generator must not be run on the engine until it is electrically connected to the apparatus box and battery as shown in the wiring diagram figure 9-39. The generator will be damaged if this is not done. The generator also must be properly polarized before it is run. Refer to applicable Air Force and Navy handbooks.

10-10 RUN-IN SCHEDULE. The run-in schedule is divided into three stages as described below.

10-11 PRELIMINARY RUN-IN.

Duration of run-in minutes	Revolutions per minute propeller drive flange	Reverse gear lever position see figure 4-10	Horsepower load
45	1200	A	120
60	1300	A	150
60	1400	A	185
60	1500	A	225
60	1600	A	270
60	1700	A	320
60	1800	A	380
60	2100	A	630
15	1600	R	250

10-12 DISASSEMBLY, INSPECTION AND REASSEMBLY. At the satisfactory completion of the above preliminary run-in the engine is partially disassembled. Remove the engine from the dynamometer and drain all oil, fuel and cooling water from the engine. Remove the intake manifold, cylinder heads, reverse gear and lower crankcase. All the connecting rods and piston assemblies are next removed. Pull all the main bearing caps off the assembly. From the cylinder heads remove all the rockerarms and valves. The details for disassembly are outlined in section IV. Inspect all the disassembled parts and accept or reject them as mentioned in section VI. Repair or replace any unacceptable parts as mentioned in section VII. Correct any fuel, oil or water leaks revealed in the preliminary run-in. Reassemble the engine as outlined in section IX. Lubricate all parts upon reassembly. Replace all safety wires, cotter pins and lockwashers. Use new gaskets throughout. Replace the engine on the test stand and resume the engine run-in.

10-13 FINAL RUN-IN.

Duration of run-in minutes	Revolutions per minute propeller drive flange	Reverse gear lever position see figure 4-10	Horsepower load
30	2100	A	630
5	2100	A	max
5	1600	R	250

During the test watch the engine and engine instruments for signs of trouble. Any sudden drop off in revolutions per minute at a fixed load and throttle position is a sign of added friction caused by failure of one type or another. Any such difficulties must be located and corrected.

10-14 ENGINE CONNECTIONS FOR TEST OPERATION. In setting the engine up for a running test the following connections must be made. The detail specifications are listed below and their locations are shown in figure 10-3 through 10-6. Do not attempt to operate the engine until all of these items have been provided.

Ref. No.	Description	Size
1	Water outlet connections. Connect both.	Two 1-1/2 in. IPT
2	Generator connections to apparatus box. Refer to wiring diagram figure 9-39.	No. 8 and 10 AWG wire No.8 and 14 shielded AWG. wire
3	Water inlet connection. One each side of engine. Also fit water inlet thermometer to line.	1-1/2 in. IPT
	Thermometer range.	10 to 95°C (50 to 203°F)
4	Oil inlet temperature thermometer.	1/2 in. IPT
	Thermometer range.	10 to 127°C (50 to 260°F)
5	Fuel supply connection. Refer to fuel circulation diagram figure 9-54.	3/8 in. IPT 1/2 in. OD tubing
6	Oil sump thermometer connection.	1/2 in. IPT
	Thermometer range.	10 to 127°C (50 to 260°F)
7	Water recirculation pipes. Connect back into water inlet line per figure 10-6.	1-1/2 in. OD hose connection
8	Overspeed governor connection. Refer to wiring diagram figure 9-39.	No. 14 AWG wire
9	Electric fuel pump connection. Refer to wiring diagram figure 9-39.	No. 14 shielded AWG wire
10	Starter connection. Refer to wiring diagram figure 9-39.	Various

Ref. No.	Description	Size
11	Exhaust manifold outlet. One each side.	3-3/4 ID pipe. Flange drilled with eight 13/32 in. dia equally spaced holes on 6-1/2 in. dia bolt circle
12	Intake manifold vacuum gage connection.	1/4 in. IPT
13	Primer pump connection. (under side of intake manifold)	SAE ball sleeve type 1/8 OD tubing
14	Ignition switch connections. Refer to wiring diagram figure 9-39.	Four No. 14 AWG wires
15	Throttle connection must allow 35° arc of travel on 4-3/8 in. radius at the carburetor.	1/4 in. dia hole
16	Water outlet thermometer. Thermometer range.	1/2 in. IPT 10 to 104°C (50 to 220°F)
17	Fuel pressure gage connection.	1/8 in. IPT 3/16 in. OD tubing
	Range of gage.	0 to 10 lb per square in.
18	Oil pressure gage.	SAE flared type 5/16 in. OD tubing
	Range of gage.	0 to 100 lb per square in.
19	Tachometer sending unit. (Need not be connected for run-in test.)	No. 14 AWG shielded wire
20	Bilge pump inlet and outlet connections.	1 in. IPT
21	Propeller shaft flange. Refer to figure 10-6 for details.	

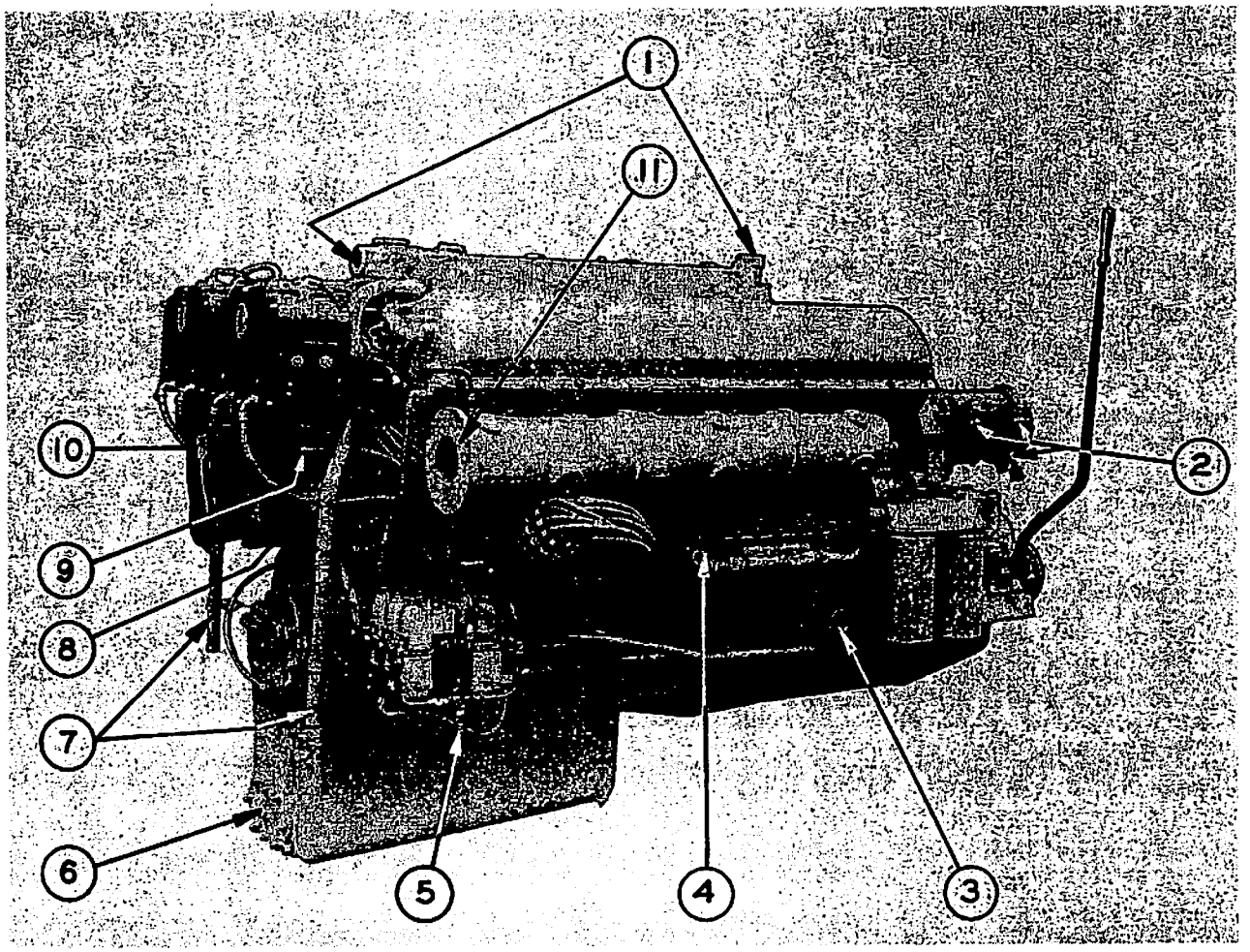


Figure 10-3. 3/4 Front View of Engine Showing Connections for Testing Engine

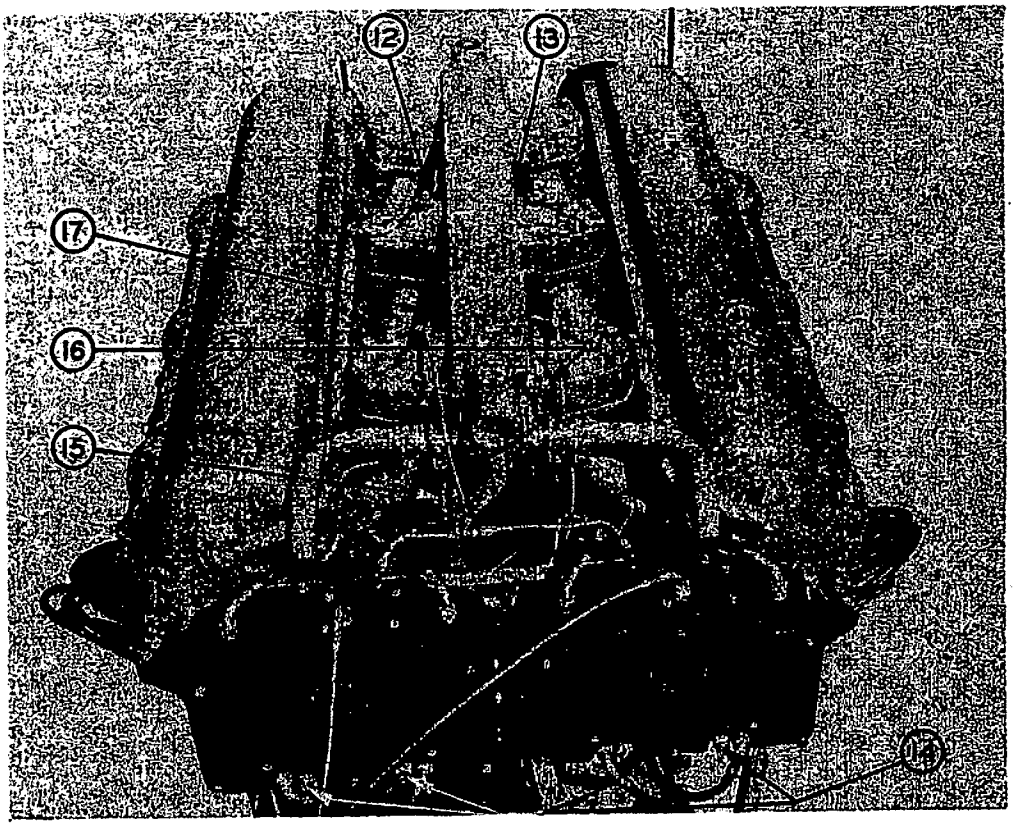


Figure 10-4. Top View of Engine Showing Connections for Testing Engine

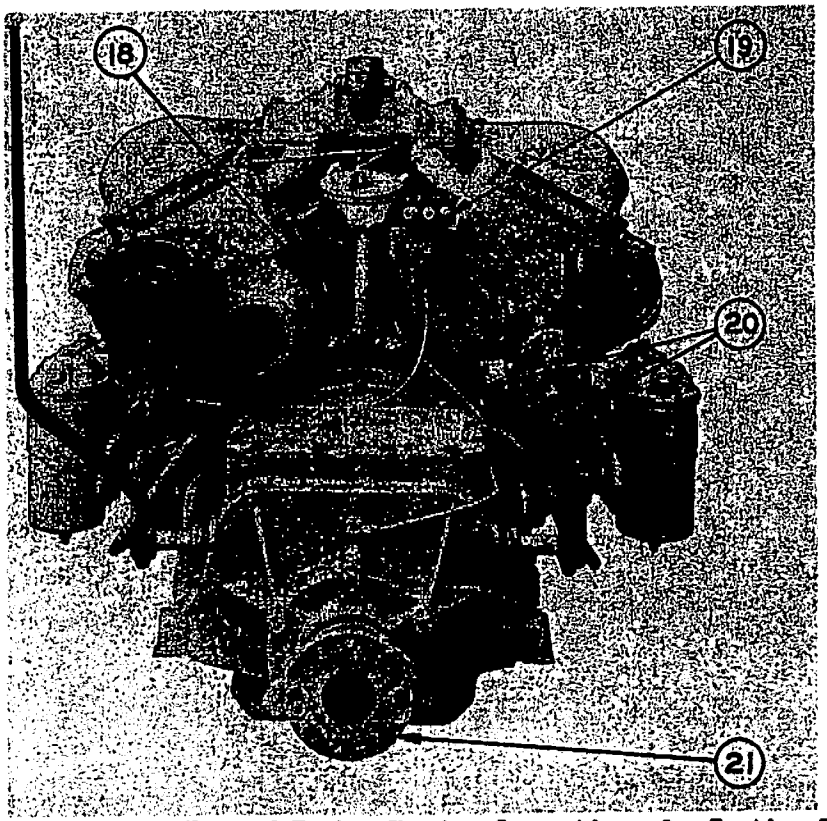


Figure 10-5. Rear View of Engine Showing Connections for Testing Engine

10-15 LUBRICATING SYSTEM. See figure 12-10.

10-16 TYPE OF OIL REQUIRED. Use a motor oil having the oxidation stability, bearing corrosion preventive properties and detergent characteristics necessary to make it generally suitable for use in internal combustion engines under heavy service conditions. It must meet U.S. Army specification 2-104B and U.S. Navy specification 14-0-13 series 9000.

10-17 GRADE OF OIL REQUIRED. Use an SAE 20 oil for very light service and cold climates. Use an SAE 30 oil for moderate service and temperate climates. Use an SAE 40 oil for extremely heavy service and hot climates.

10-18 QUANTITY OF LUBRICATING OIL. 7 U.S. (5.83 Imperial) gallons initial fill. 6 U.S. (5.0 Imperial) gallons refill after draining.

10-19 OIL PRESSURE. With the oil temperature reading 66 to 70°C (150 to 160°F) and the engine running 1600 rpm check the oil pressure reading. 60 to 70 pounds per square inch is correct. If the gage does not show correct pressure, adjust the oil pressure regulating valve until it does. This valve is located between the cylinder banks at the front of the engine. To adjust, remove the large hexagon cap and turn the adjusting screw right or left until the correct pressure is obtained. Always replace the cap, and screw it down tight after the oil pressure is adjusted. Make sure the cap gasket is in place.

10-20 OIL TEMPERATURE. The oil inlet temperature to the engine should never be allowed to exceed 93°C (200°F).

10-21 OIL CONSUMPTION. Refer to paragraph 10-8 and figure 10-2 for oil consumption.

10-22 FUEL SYSTEM.

10-23 GRADE OF FUEL. Use aviation quality gasoline of 87 to 91 minimum octane rating.

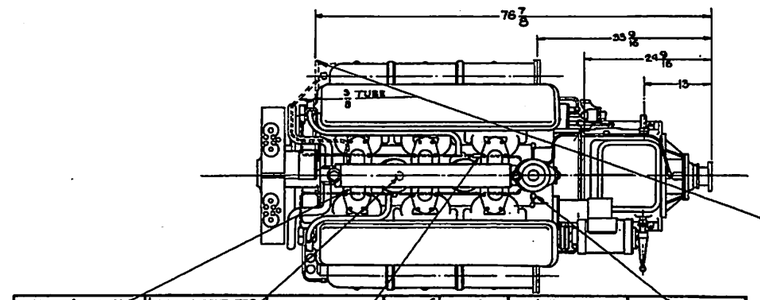
10-24 FUEL PRESSURE. The fuel pressure regulating valve is on the front of the engine on the left hand side. This valve is adjusted by removing the acorn type nut from the bottom of the assembly and then turning the exposed adjusting screw until five pounds per square inch fuel pressure is maintained at both idle and full throttle. Watch the fuel pressure gage on the instrument panel. Be sure to replace the adjusting screw cap after the adjustment has been completed. See that no fuel leaks occur. Refer to figure 11-26.

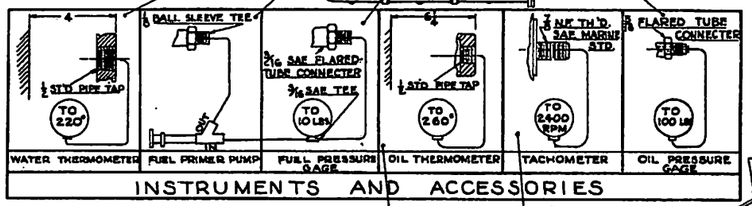
10-25 FUEL CONSUMPTION. Refer to figure 10-2.

10-26 IGNITION CHECK. By proper manipulation of the ignition switches it is possible to get a quick check on misfiring and also on ignition timing. This is done by shutting off one complete distributor (both breaker points) at a time and allowing the engine to idle on the other distributor. This leaves one spark plug operating in each of the 12 cylinders. With the engine idling in this manner, listen to the engine exhaust to detect any misfiring. If there is an uneven beat to the exhaust indicating misfiring, then on the "live" distributor remove one spark plug wire at a time from the distributor cap. Remove and replace all the distributor wires in turn this way, all the while listening to the engine exhaust until the defective plug or plugs are located. Do not disconnect more than one wire at a time and be careful to disconnect the wire from the distributor and not from the spark plug. Correct the defective spark plugs by cleaning, regapping, or replacing. Refer to reference No. 72, figure 12-1 for the proper spark plug gap. Then repeat the process for the other distributor going through the same series of operations as explained before. When all the spark plugs are firing properly, make the following check. See that both distributors are synchronized to fire at the same instant as explained in paragraphs 9-47 and 9-48. Now start the engine up and load it up to 630 horsepower. Switch off one complete distributor (both breaker points) while allowing the engine to operate on the other. If the engine drops off more than 30 rpm under these conditions it is an indication that the general ignition timing is too late and both distributors must be advanced slightly. If the engine picks up more than 30 rpm under these conditions the general ignition timing is too early and both distributors must be retarded slightly. This advance or retard is done externally with the engine running. Loosen the two 1/4 in. hold down bolts and swing each distributor as necessary as measured by the shift of the pointer on the graduations. See figure 9-38. Check both distributors in the above manner and adjust until not more than 30 rpm difference occurs when running on one distributor at a time as compared to running on both. The distributors must be kept in synchronism. Do not shift one distributor more than the other. The position of the pointer on the graduation is no true indication of distributor synchronism. Refer to paragraphs 9-41 through 9-50 for complete details on synchronizing the two distributors.

10-27 AUTOMATIC SPARK ADVANCE CHECK. Each ignition timing distributor is equipped with a mechanical automatic advance mechanism that alters the ignition timing as the engine speed varies. The advance characteristics of each distributor may be given an operating check as follows. Attach a 12 inch diameter metallic disc to the engine propeller drive shaft flange. This disc must be graduated in degrees on its circumference for at least 40 degrees each side of a zero mark. The marks must be conspicuous so they may be viewed with a neon timing light when the disc is rotating at engine speed. An adjustable pointer is to be attached to the dynamometer base. The pointer is to be quite close to the disc on its graduated side. Rotate the engine until the number six piston in the leading cylinder bank is at its top center firing position. Refer to paragraphs 1-22 and 9-42. Now disengage the reverse gear clutch and rotate the propeller shaft until the pointer comes opposite the zero mark on the graduated disc. Engage the clutch again. Now remove the ignition cable from the number six exhaust spark plug in the leading cylinder bank. Attach the timing light leads as follows: high tension lead to the detached spark plug wire, one primary lead to the engine battery and one to ground. See that the attaching wires are clear of rotating parts and protected from coming in contact with operating personnel. See that the timing disc on the propeller drive flange is secure and free of interference. Start the engine up and hold the neon light in such a position that the graduated

HALL-SCOTT DEFENDER
MODEL 2268 & 2269





INSTRUMENTS AND ACCESSORIES

FUEL SYSTEM

TANK VENT PIPE TO BE TAKEN ABOVE DECKS.

PIPES MUST BE LAID WITH A STEADY RISE AND NO AIRLOCKS.

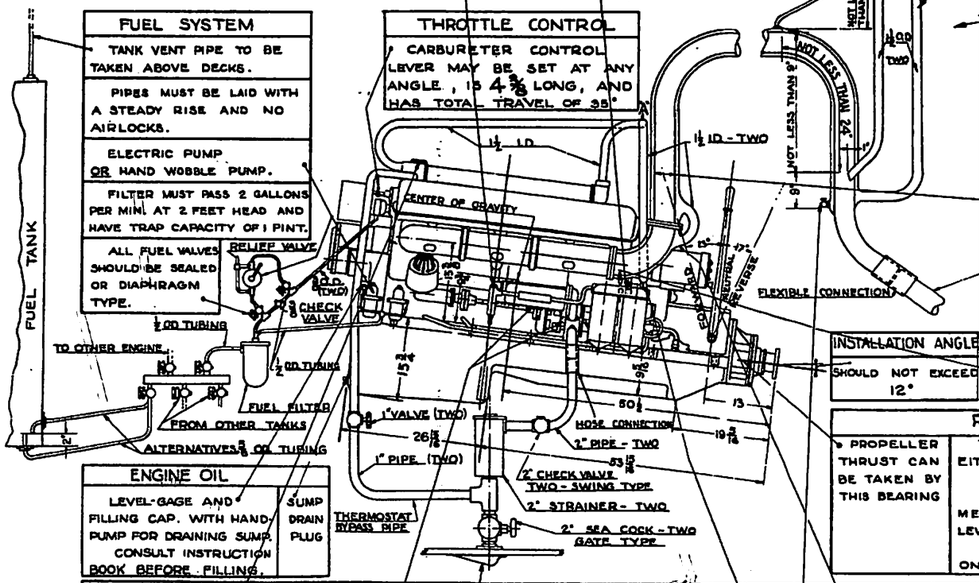
ELECTRIC PUMP OR HAND WOBBLE PUMP.

FILTER MUST PASS 2 GALLONS PER MIN. AT 2 FEET HEAD AND HAVE TRAP CAPACITY OF 1 PINT.

ALL FUEL VALVES SHOULD BE SEALED OR DIAPHRAGM TYPE.

THROTTLE CONTROL

CARBURETER CONTROL LEVER MAY BE SET AT ANY ANGLE, IS 4 3/8 LONG, AND HAS TOTAL TRAVEL OF 35°



ENGINE OIL

LEVEL-GAGE AND FILLING CAP. WITH HAND-PUMP FOR DRAINING SUMP. CONSULT INSTRUCTION BOOK BEFORE FILLING.

SUMP DRAIN PLUG

EXHAUST SYSTEM

EXHAUST GAS PRESSURE IN MANIFOLDS MUST NOT EXCEED 1/2 LBS AT FULL POWER AND SPEED. THIS MUST BE CHECKED DURING TRIALS.

MANIFOLDS MAY BE TURNED AROUND TO DISCHARGE FORWARD. WHEN THIS IS DONE, A 3/8" TUBE MUST BE LED FROM THE 1/4" PLUG IN EACH MANIFOLD TO THE 1/2" PLUG OPPOSITE TO THE WATER THERMOMETER FITTING.

THIS PIPE SHOULD RISE BETWEEN 4' AND 6' ABOVE THE TOP OF THE ENGINE. THE DISCHARGE SIDE SHOULD HAVE A STEADY FALL WITHOUT TRAPS AS SHOWN.

SYSTEM SHOWN IS A RECOMMENDED EXAMPLE OF A SIDE-OUTLET, WET-EXHAUST PIPE WITHOUT A MUFFLER.

THE EXHAUST PIPES MUST BE SUPPORTED IN SUCH A WAY THAT THE MANIFOLD FLANGES ARE RELIEVED OF ALL BENDING OR WRACKING STRESSES AND DO NOT CARRY MORE THAN 300 POUNDS DEAD WEIGHT EACH.

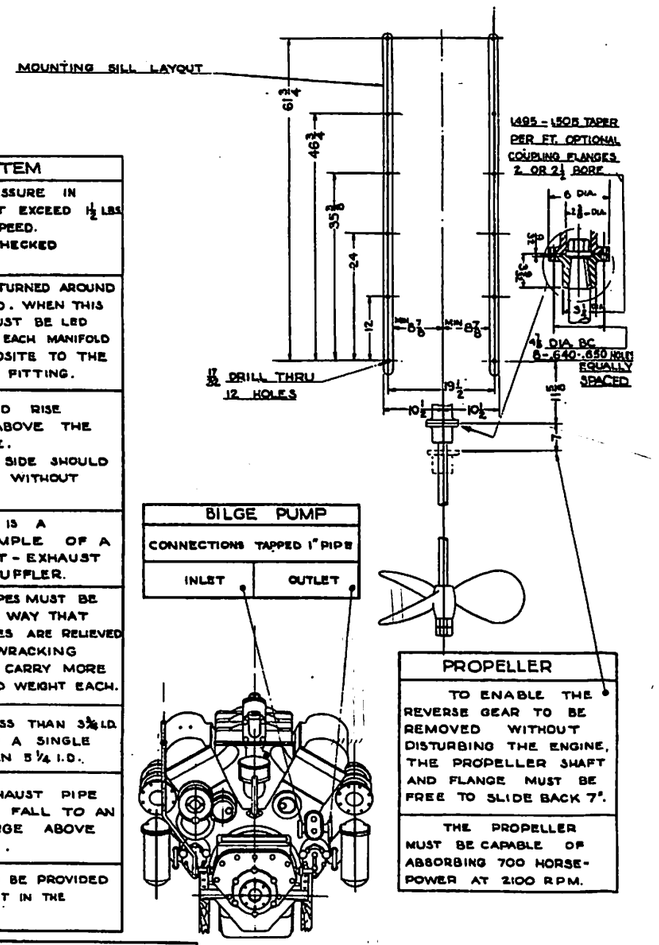
TWO PIPES NOT LESS THAN 3 3/8 I.D. WHICH MAY LEAD INTO A SINGLE PIPE OF NOT LESS THAN 5 1/4 I.D.

FROM HERE, EXHAUST PIPE MUST HAVE A STEADY FALL TO AN OVERBOARD DISCHARGE ABOVE THE WATER LINE.

1/4" DRAIN COCK TO BE PROVIDED AT THE LOWEST POINT IN THE EXHAUST PASSAGE.

INSTALLATION ANGLE

SHOULD NOT EXCEED 12°



BILGE PUMP

CONNECTIONS TAPPED 1" PIPE

INLET	OUTLET

PROPELLER

TO ENABLE THE REVERSE GEAR TO BE REMOVED WITHOUT DISTURBING THE ENGINE, THE PROPELLER SHAFT AND FLANGE MUST BE FREE TO SLIDE BACK 7".

THE PROPELLER MUST BE CAPABLE OF ABSORBING 700 HORSE-POWER AT 2100 R.P.M.

REVERSE GEAR

PROPELLER THRUST CAN BE TAKEN BY THIS BEARING

THE 36" HAND LEVER MAY BE MOUNTED ON EITHER SIDE.

A 16 1/2" LEVER IS SUPPLIED FOR REMOTE CONTROL EXCEPT WHEN SHIFTING, THE REMOTE CONTROL MECHANISM MUST OFFER NO RESTRAINT ON THE LEVER IN EITHER DIRECTION.

THE MAXIMUM MANUAL EFFORT REQUIRED ON THE 36" LEVER IS 160 POUNDS.

IMPORTANT NOTICE

BEFORE STARTING TO INSTALL THE ENGINE, AND BEFORE PLANNING THE LAYOUT OF THE PIPING, ETC., CONSULT THE INSTRUCTION BOOK.

THE MANUFACTURER'S GUARANTEE IS CONDITIONAL UPON STRICT OBSERVANCE OF ALL HIS INSTALLATION INSTRUCTIONS.

CIRCULATING WATER SYSTEM

THE SUCTION SYSTEM, AS SHOWN, FEEDS ONE PUMP ONLY. A DUPLICATE SET OF PIPES AND FITTINGS MUST BE SUPPLIED TO FEED THE SECOND WATER PUMP ON THE OTHER SIDE OF THE ENGINE. THE TWO SIDES MUST BE KEPT ENTIRELY SEPARATE, AND MUST NOT BE CROSS-CONNECTED IN ANY WAY.

THE OUTLET SYSTEM, AS SHOWN, FEEDS ONE EXHAUST PIPE ONLY. FROM THE POINT 'A' ONWARDS A DUPLICATE SET OF PIPES AND FITTINGS MUST BE SUPPLIED TO FEED THE SECOND EXHAUST PIPE ON THE OTHER SIDE OF THE ENGINE.

FILLING PLUG FOR PRIMING THE WATER SYSTEM.

DRAIN PLUGS ARE SITUATED IN EACH PUMP BODY AND UNDERNEATH EACH OIL COOLER CASTING.

EACH SCOOP MUST HAVE AT LEAST 6 SQUARE INCHES WATER PASSAGE THRU THE GRID.

WATER PIPES SHOULD BE LOCATED SO THAT THEY DO NOT INTERFERE WITH ACCESSIBILITY OF THE ENGINE.

1/4" DRAIN COCK TO BE PROVIDED AT THE LOWEST POINT OF THE EXHAUST PIPE JACKETS.

WATER JACKETS MUST BE BELLED OUT AT ALL PIPE CONNECTIONS TO AVOID RESTRICTING THE FLOW OF WATER.

TESTING WATER SYSTEM

THE CAPACITY OF THE TWO WATER PUMPS IS APPROXIMATELY 110 GALLONS PER MINUTE AT 1800 R.P.M.

GAGES MUST BE USED DURING TRIALS TO CHECK, THAT AT 1800 R.P.M:

① THE PRESSURE AT THE ENGINE WATER OUTLET IS BETWEEN 3 AND 6 POUNDS PER SQ. INCH.

② THE VACUUM AT EITHER WATER PUMP INLET CONNECTION IS NOT MORE THAN 10 INCHES OF MERCURY.

Figure 10-6. Engine Installation

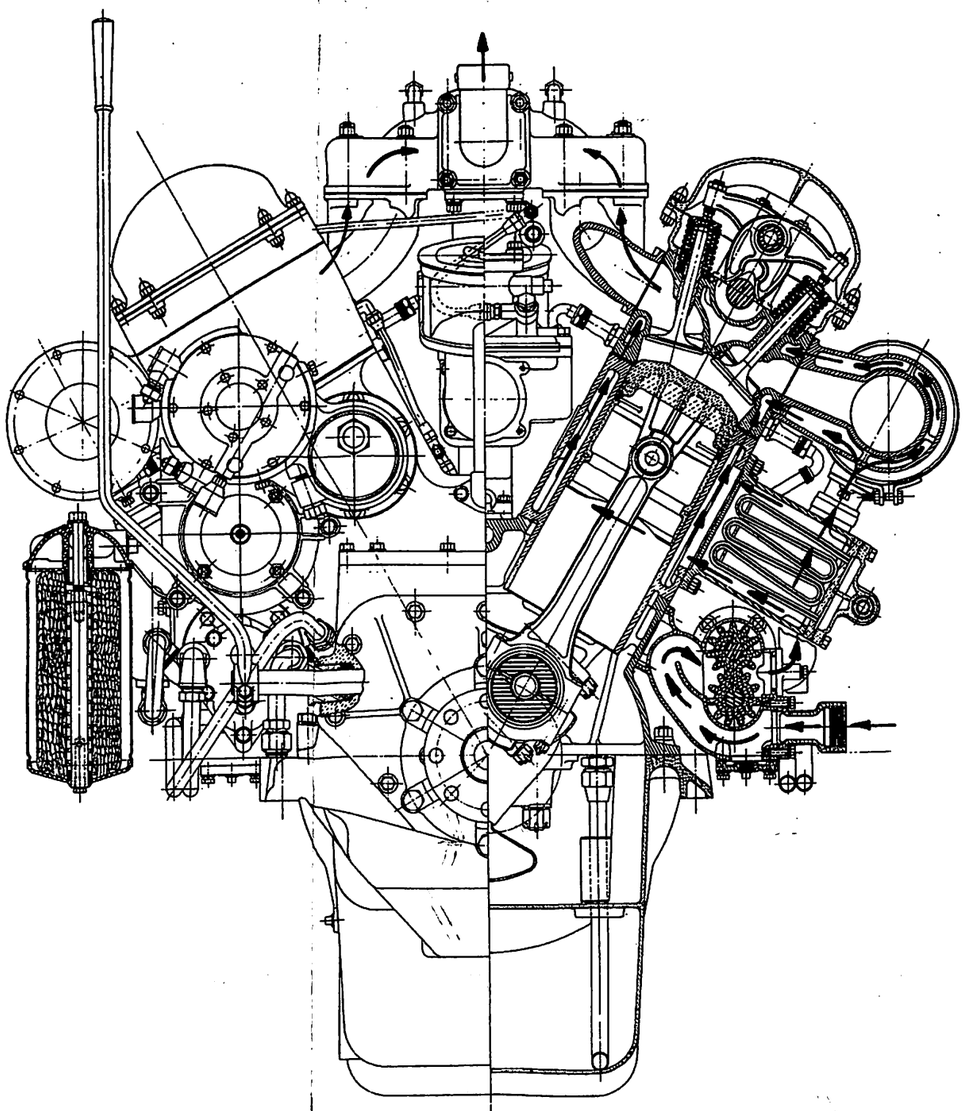


Figure 10-8. Water Circulation Diagram

disc and pointer are illuminated by it. Refer to the engine tachometer and figure 10-7 to determine the amount of spark advance at the various revolutions per minute. If the readings on the disc do not agree with the values given in figure 10-7 take corrective measures. Take readings as the engine is accelerated and also decelerated. Any sluggishness or sticking will cause quite a difference in timing depending on whether the engine is going up in speed or coming down. At the completion of this run check the top center position of the engine again with the pointer on the graduated disc to make certain the reverse gear clutch has not slipped and introduced an error. Reference to the wiring diagram will show that the exhaust bank spark plugs draw their energy from the distributor closest to them. For example, the right hand bank exhaust spark plugs draw their energy from the right hand distributor and the left hand bank exhaust spark plugs draw their energy from the left hand distributor. This being the case it is understood that when the neon light is attached to right hand bank exhaust spark plug wire the right hand distributor is being checked. Similarly when the neon light is attached to the left hand bank exhaust spark plug wire the left hand distributor is being checked. The change from one distributor to the other is made by changing the neon light high tension lead, turning the engine to top center for the number six cylinder in the cylinder bank under consideration and realigning the graduated timing disc with its pointer. Otherwise the test is identical for both distributors.

AUTOMATIC DISTRIBUTOR ADVANCE

Engine RPM	Degrees of Advance on Engine Crankshaft	
	MIN	MAX
0	0	0
200	0	0
400	0	2
600	7	11
800	17	21
1000	26	30
1040 to 2100	28	32

Figure 10-7. Automatic Spark Advance

ACCESSORIES

11-1 SCOPE. This section will deal with the inspection, repair and reassembly of all the engine accessories not dealt with in separate publications as mentioned in paragraph 11-48.

11-2 DEFINITION. Various types of failures will be mentioned in this section in the inspection procedure. All typical failures are described and illustrated in paragraphs 6-2 through 6-12.

INSPECTION

11-3 GENERAL. This section shall outline all inspection procedures that are peculiar to the engine accessories. The methods of inspection shall be described and illustrated where necessary for clarity. Too much importance cannot be placed on the need for careful examination of parts and the use of sound judgment, based upon operating conditions and past performance of similar units, when rendering decisions as to the further useability of parts. No instructions could possibly cover all conditions that may be found in accessory inspection. The section of the building devoted to inspection should have the best possible illumination. Sufficient space should be provided to permit laying out the accessory parts for inspection. The relative wear on the component parts of any one accessory should be compared, and thus it is often possible to determine, at once, the cause of abnormal wear. Unacceptable parts must be conspicuously marked and the details listed.

11-4 INSPECTION TOOLS. Tools and inspection personnel shall be as outlined in paragraph 6-14.

11-5 INSPECTION PROCEDURE. The procedure for accessory inspection shall be as outlined in paragraph 6-15.

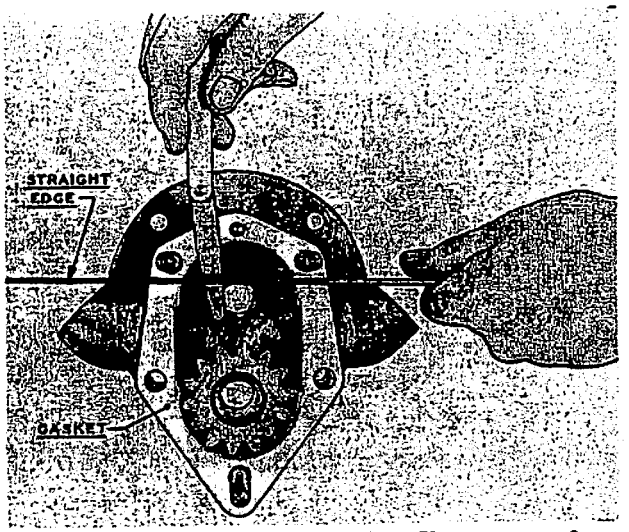


Figure 11-2. Checking End Clearance of Oil Pump Gears

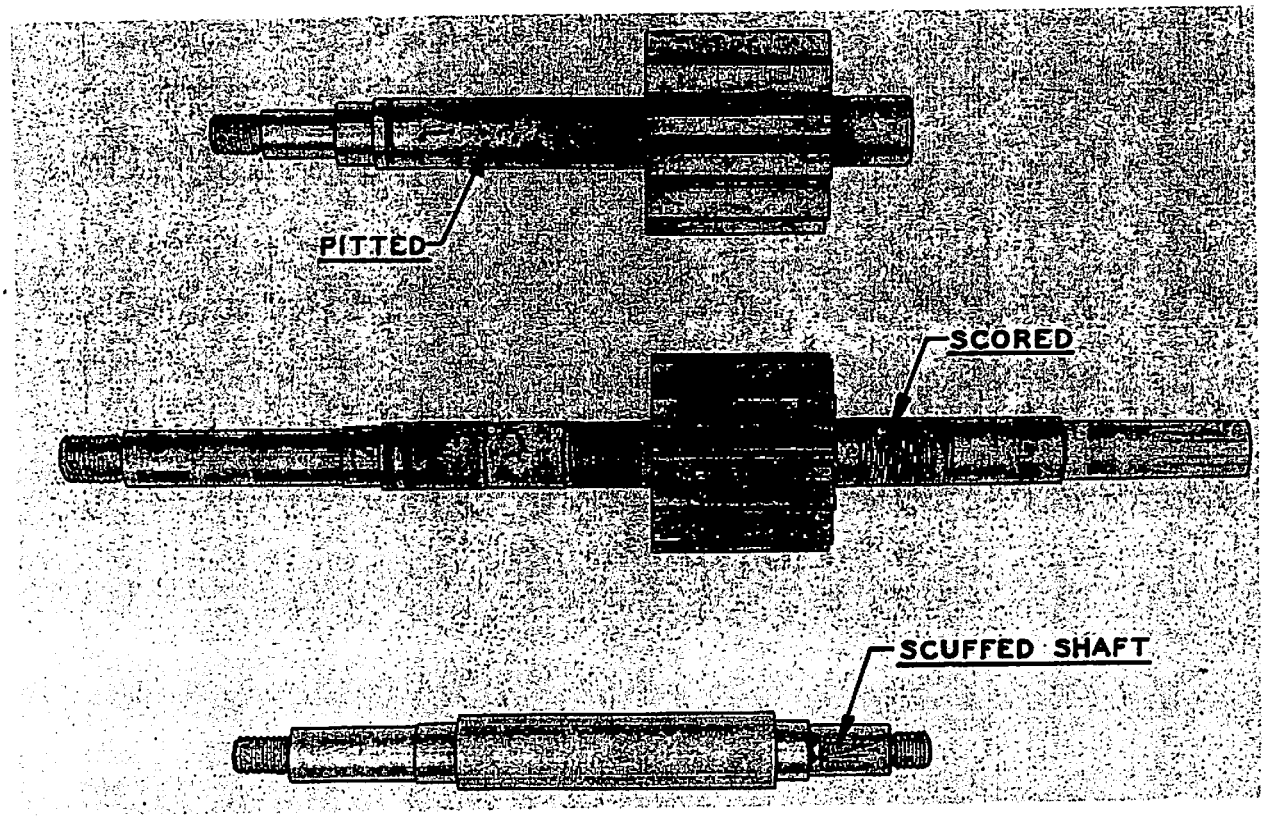


Figure 11-1. Defective Water Pump and Distributor Drive Shaft

11-6 OIL FILTER INSPECTION. Check the general condition of the oil filter bracket to see that gasket faces are in good condition. See that by-pass valve and relief valve are in good condition and clean. Check valve springs for strength. See reference number 105, figure 12-9. Check top edge of oil filter shell to see that it is smooth and top edge is in plane so a tight oil seal can be made. See that all passages are clear. See that shell is not rusted so as to weaken the walls.

11-7 OIL PUMP INSPECTION.

a. Check oil pump gears for radial clearance, end clearance and back lash. See reference numbers 74, 75 and 76, figure 12-1. Back lash must be checked on a fixture. End clearance must be checked with the gasket in place on the face of the housing. Radial clearance is determined by comparing the OD of the gear with the ID of the oil pump housing.

b. Check the general condition of the oil pump housing for wear and cracks. Pipe threads must be in good condition as well as pilot diameter and mounting face. See that the oil pump diaphragm is flat and smooth.

c. Inspect the oil pump idler gear bushings for fit. See reference numbers 78 and 79, figure 12-1. See that the drive shaft and idler shaft are in good condition. Inspect the splines on the drive shaft and in the pump gears.

11-8 OIL COOLER INSPECTION.

a. Make a visual inspection of the oil cooler body. See that the walls, gasket faces or stud bosses are not destroyed by rust. See that all rust and scale are cleaned out of the cooler body.

b. Inspect the oil cooler cover for cracks and corrosion. See that the gasket face is in good condition and is square and true. Examine the by-pass valve and valve spring. See reference number 107, figure 12-9.

c. Assemble the oil cooler cover to the oil cooler body and test for leaks with water at 20 pounds per square inch.

d. Inspect the oil cooler core for general condition. See that all the tubes are clear. See that the gasket faces are smooth and in plane. Clamp an oil cooler cover plate onto the core and test with air pressure at 200 lb per square in. Submerge the core in water and check for leaks.

11-9 OIL PRESSURE REGULATING VALVE INSPECTION. Check the gasket faces to see that they are smooth and true. Check the condition of the valve and see that it is clean. See that all oil passages are clean. Check the tension of the valve spring. See reference number 104 figure 12-9.

11-10 OIL GAGE AND SCAVENGING PUMP INSPECTION. Check the general condition of the pump. See that the ball check valve is free to operate and can seat tightly. See that the oil level gage plate is firmly attached.

11-11 WATER PUMP INSPECTION.

a. Inspect the housing for score marks within the body. See that the threads are all in good shape. See that the packing nuts have not been damaged by poorly fitting wrenches. Check the fit of the pump gears in the body. See that the mounting and gasket faces are smooth and true. All dowels and dowel holes must be in good condition. See that all bores are clean and smooth so new bearings, retainers and packing can be fitted without trouble.

b. Inspect gears for scoring on teeth and end faces. Check gears for back lash, end clearance and radial clearance. See reference numbers 80, 81 and 82, Table of Limits, figure 12-1.

c. Examine water pump shaft for fit in the water pump bushings. See reference number 85, Table of Limits, figure 12-1. Examine pump shafts for scoring and pitting. See that all threads, splines and keyways are in good condition.

d. Check water pump pilot gears for back lash. Inspect the water pump driven pilot gear hub ID for signs of excessive working.

11-12 GENERATOR DRIVE INSPECTION.

a. Examine the generator drive shaft bearing retainer and the generator belt guard for cracks or other damage. See that the pilot diameter and mounting faces are smooth and true. See that all bores are clean and smooth so that oil retainers and bearings may be fitted without difficulty.

b. Inspect the generator drive shaft to see that the splines and threads are all in good condition. See that the ball bearing seat, pilot diameter and mounting face are smooth and true. See that tachometer drive flange is true and accurate. The tachometer spindle must run true with the pilot diameter of the flange. The slot in the tachometer spindle must not be worn.

c. Inspect the generator drive and driven pulleys to see that the grooves are smooth and free from rust. The drive pulley hub must be smooth and concentric to make a good surface for the oil seal. The splines must not be worn.

d. The tachometer adapter plate must not have damaged threads. The pilot diameter and mounting face must be smooth and true.

e. The generator belts must be free of oil and grease and must not show evidence of cracking or splitting.

11-13 DISTRIBUTOR DRIVE INSPECTION.

a. Check the distributor drive housing for cracks and misalignment. See that the mounting face and gasket face are smooth and in plane. See that the steel end plug has not been weakened by rust. Check the internal bores to see that they are smooth and show no signs of the outer ball bearing races having turned. See that the pilot diameter bore and gasket face of cover are smooth and true.

b. Check the shaft and gear for signs of wear. The shaft threads and keyways must be in good condition. See that the steel spacer is smooth and concentric so as to make a suitable surface for the oil retainer. Reject the distributor drive gear if it shows signs of wear. See reference number 94, Table of Limits, figure 12-1. See figure 11-1.

11-14 STARTER INSPECTION.

a. Inspect the starter drive housing and cover for cracks and distortion. See that pilot diameter and gasket faces are smooth and true. Check condition of bushing and needle bearing in drive housing. See reference numbers 66, 67 and 68, Table of Limits, figure 12-1.

b. Check the condition of the starter drive gear, starter idler gear and the starter driven

gear. See that the bores and keyways are in good condition. Check the condition of the gear teeth. Check the gear back lash on reassembly as explained in paragraph 11-44.

11-15 CARBURETOR CONTROL INSPECTION. Inspect the carburetor extension for cracks and damaged gasket faces. See that the control shaft bushing is tight and in good condition. See that the carburetor control shaft is straight and true. See that the ball and socket joints are in good condition and none of the threads is damaged. The control levers must be free from cracks and bends. The clamp ends of the levers must not be bent or broken.

11-16 FUEL PRESSURE REGULATING VALVE INSPECTION. See that all passages and threads are in good condition. Examine the regulating valve to determine if it is free to move in the housing and that the valve stem can move freely in the regulating screw. Check the tension of the valve spring. See reference number 108, figure 12-9.

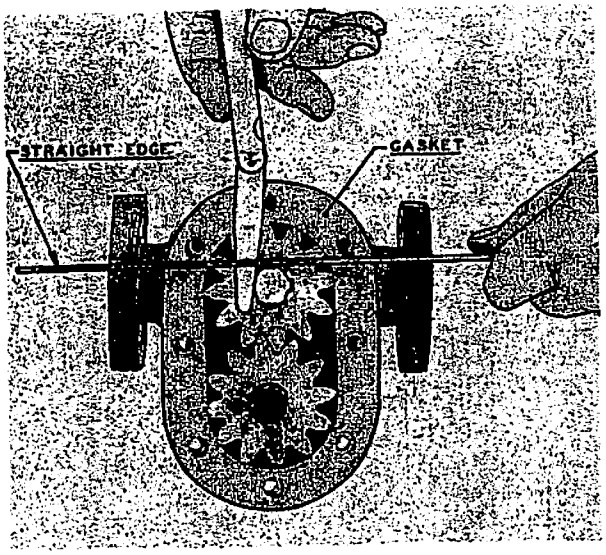


Figure 11-3. Checking End Clearance of Bilge Pump Gears

11-17 BILGE PUMP INSPECTION.

a. Inspect bilge pump housing for cracks, damaged threads, scoring marks from the gears and oversize bushings. Inspect the bilge pump bracket to determine if the pilot diameters and mounting faces are smooth and true. See that the bores are smooth and concentric so that the oil seal and ball bearing may be easily assembled to the bracket.

b. Inspect the bilge pump cover to determine if it has been scored by the gears. See that the gasket face is smooth and true. Check the fit of the bushings on the drive and idler shaft. See reference numbers 92 and 93, Table of Limits, figure 12-1.

c. Check the bilge pump gears for radial clearance, end clearance and back lash. Be sure the pump cover gasket is in place on the housing when checking the end clearance. The radial clearance is determined by comparing the OD of the gear with the ID of the housing. The back lash must be checked on a fixture. Examine the condition of the gear teeth.

d. Check the drive shaft for scoring, wear in the splines and clearance in the bushings. Make certain that the diameters where the oil seal and ball bearing seats are smooth and concentric. Check the condition of the idler shaft keyway and wear in the bushings.

e. See that the bilge pump drive clutch is not scored or worn excessively. The grooves in driving face of the clutch must be sharp and free of carbon and sludge. Check the tension of the bilge pump drive clutch spring. See reference number 102, figure 12-9.

11-18 MAGNETIC STARTER SWITCH INSPECTION. See that all connections are clean and tight. See that the plunger is free to operate under the influence of the spring and electro-magnet.

11-19 FUEL FILTER INSPECTION. Remove the lower casing from the fuel filter and see that all the plates in the element are clean and straight. Check the top face of the casing to see that it is smooth and true. Check the packing and packing nut around the operating stem to see that the operating shaft is not scored.

11-20 OVERSPEED GOVERNOR INSPECTION. Examine the driving end of the overspeed governor drive cable to see that it is in good condition. See that all electrical terminals are clean and serviceable. See that the overspeed governor mounting bracket is not bent, broken or otherwise damaged.

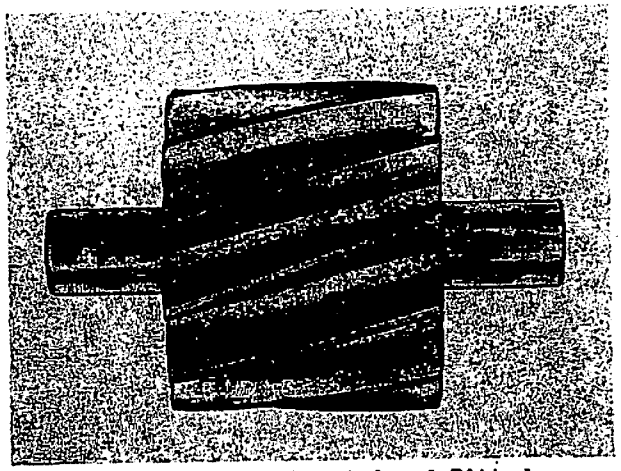


Figure 11-4. Abraded and Pitted Bilge Pump Gear

ACCESSORY REPAIR AND REPLACEMENT

11-21 GENERAL. In this section detailed instructions are given for repair and replacement of parts found unacceptable in the inspection procedure. All possibilities of reclaimation are explained.

11-22 RUST PREVENTION. At the completion of the various repair and replacement operations all steel parts must be adequately protected from rust as outlined in paragraph 5-16.

11-23 TABLE OF LIMITS. Refer to paragraphs 12-5 through 12-9 for an explanation of the Table of Limits found in section XII. This table must be used frequently in the repair and replacement of the engine parts.

11-24 INSPECTION AFTER REPAIR OR REPLACEMENT. All parts, before being considered useable, must be inspected as outlined in paragraphs 11-6 through 11-20 and be acceptable according to these standards.

11-25 OIL FILTER REPAIR AND REPLACEMENT. Replace any defective parts. Retap any holes that show damaged threads. Clean top edge of filter shell and grind it if necessary so that it is "in plane".

11-26 OIL PUMP REPAIR AND REPLACEMENT.

a. Replace any loose or damaged studs or dowels. Where dowel holes are enlarged the parts must be discarded.

b. The oil pump diaphragm may be surface ground to correct any minor imperfections. Do not remove more than a total of .020 in. for reconditioning.

11-27 OIL COOLER REPAIR AND REPLACEMENT. Replace any unacceptable parts. Do not attempt to repair the oil cooler body by welding as this will distort all the machined faces and result in oil and water leaks. Do not attempt to repair leaks in the oil cooler core as it is quite difficult to contain the high oil pressure circulated thru this core and an oil leak is quite serious at this point as it might go undetected until the engine has been seriously damaged.

11-28 OIL PRESSURE REGULATING VALVE REPAIR AND REPLACEMENT. Replace loose or defective dowels. Replace any other defective parts.

11-29 WATER PUMP REPAIR AND REPLACEMENT.

a. Replace any loose or damaged studs. Use white lead as a thread lubricant per Spec. JAN-A-669. Replace any loose or damaged dowels. Retap any holes that have defective threads.

b. Any water pump shafts that are otherwise acceptable should be polished with number 240 grit abrasive cloth. Do not remove any metal from the shaft. This polishing operation is necessary to permit a good seal where the packing rides against the shafts. Also polish the cavities in the water pump body and cover where the packing fits.

c. Replace the bushings in the water pump cover if necessary. These bushings must be reamed after pressing into the cover. Drill 3/16 in. diameter grease holes thru bushing before reaming. Ream to from (.8755 to .8765 in. diameter). These reamed bores must be perpendicular to the face of the cover within the limits mentioned in reference number 83, Table of Limits, figure 12-1.

11-30 GENERATOR DRIVE REPAIR AND REPLACEMENT. Replace any loose or damaged studs. Use white lead as a thread lubricant per Spec. JAN-A-669. Polish the V-belt pulley grooves. Retap any damaged threads.

11-31 DISTRIBUTOR DRIVE REPAIR AND REPLACEMENT. Replace any defective parts. Studs must be

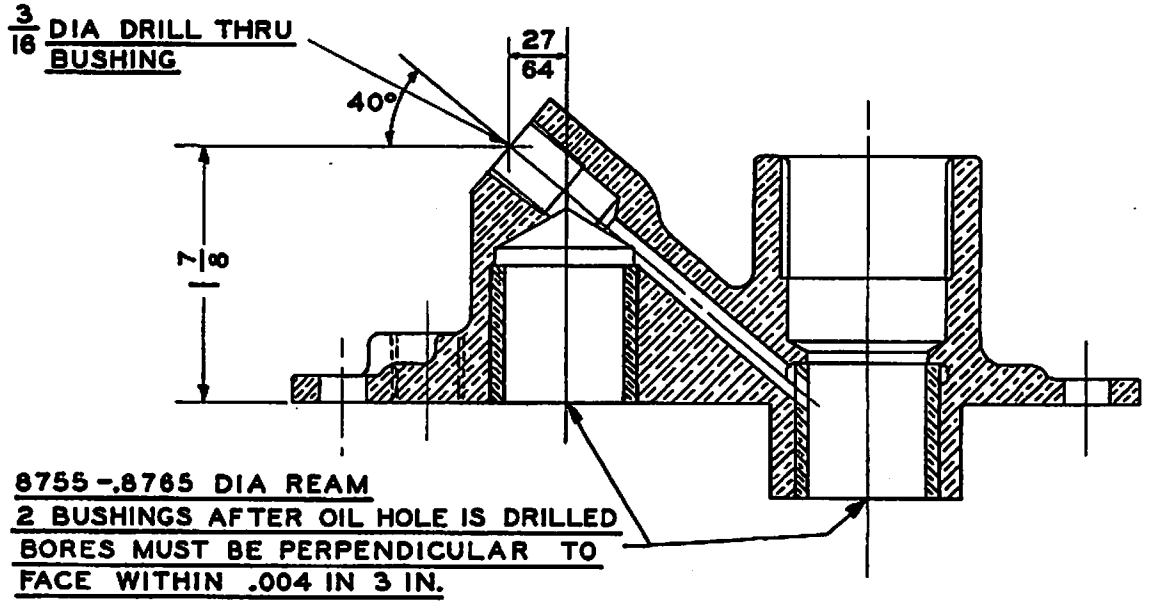


Figure 11-5. Water Pump Cover Assembly

replaced if they are loose or damaged. Use white lead as a thread lubricant.

11-32 STARTER REPAIR AND REPLACEMENT.

a. Press new needle bearing and bronze bushing into the starter drive housing. A close fitting mandrel is necessary in both of these bushings when installing them. Fit bushings into position shown in figure 11-6. This bronze bushing does not require reaming after assembly. The bushing used in the starter drive housing is a porous type. It is to be heated to 82°C (180°F) and then cooled in lubricating oil before installation. Oil must be to Spec. AN-O-6 (Symbol OGP) and of SAE viscosity 50. Also press a new needle bearing into the starter idler gear.

b. Retap any damaged threads and replace any loose or damaged studs.

11-33 CARBURETOR CONTROL REPAIR AND REPLACEMENT. Press new porous bronze bushings into the carburetor extension if the old ones are worn. A close fitting mandrel is used to press these bushings in. A finish ream is not required after assembly for these bushings.

11-34 BILGE PUMP REPAIR AND REPLACEMENT.

a. The bilge pump drive shaft that is otherwise acceptable must be polished with number 240 grit abrasive cloth where the packing runs against the shaft. Remove a minimum amount of metal. Also polish the cavity in the pump body where the packing is fitted.

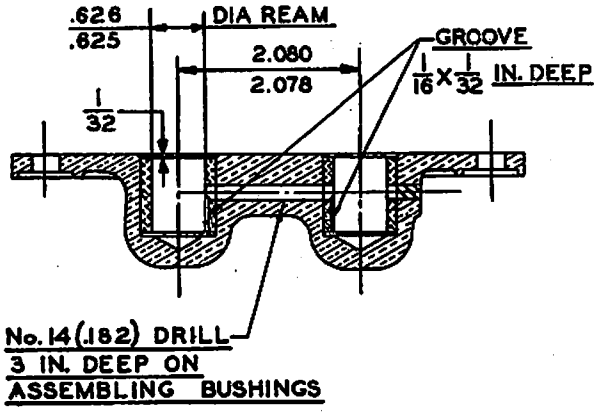


Figure 11-7. Bilge Pump Cover

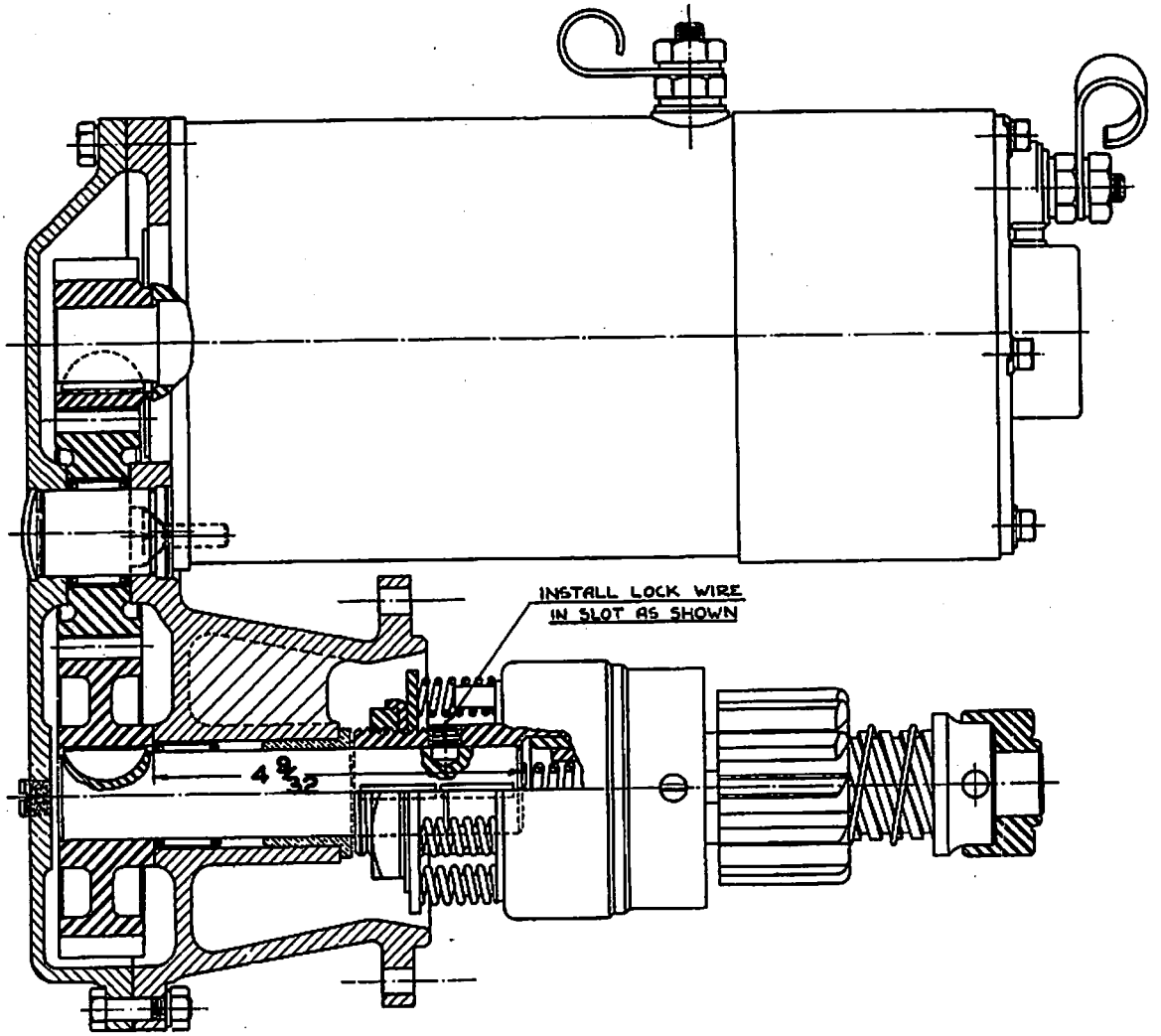


Figure 11-6. Sectional View of Starter Drive

b. Replace the bushings in the bilge pump body and cover if the old ones are unacceptable according to the standards mentioned under reference number 92, Table of Limits, section XII. Drill out grease holes and then finish ream bushings to size shown. The reamed holes must be on centers shown and square with the gasket face within the limits shown under figure numbers 11-7 and 11-8. Plug outer end of grease hole with a piece of brass rod 1/4 in. long and from .190 to .192 in. diameter. Cut oil grooves in bilge pump body bushings.

gasket flange with shellac or similar tacky compound such as Army Spec. 62-5. The opposite gasket face is then coated with grease similar to specification AN-G-14 (Symbol GRG). Such practice allows the assembly to be easily separated at the gasket face. If grease is used against the face carrying the studs it will make "clean up" of the gasket face considerably easier at the next overhaul.

11-37 LOCKING DEVICES. It is assumed that all means used to lock nuts, bolts, screws, etc., to prevent their loosening in service, will be

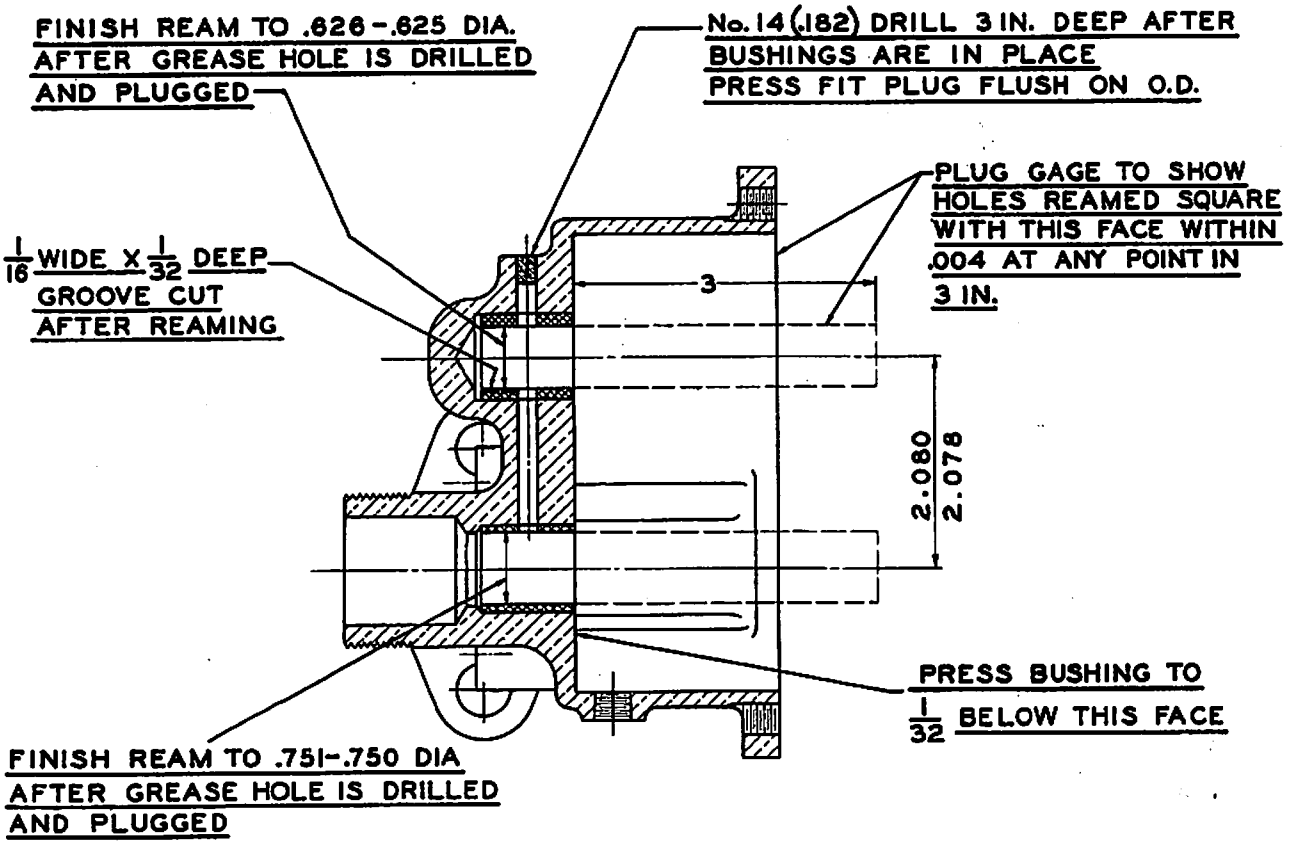


Figure 11-8. Bilge Pump Body

ASSEMBLY OF ACCESSORIES

11-35 GENERAL. Instructions are given below for the assembly of the various accessories. All parts used to make up these assemblies must have been inspected and accepted as outlined in paragraph 11-6 through 11-20. Shop practices and general instructions applying to a number of similar parts are covered in the immediately following paragraphs. It is expected that these instructions will be followed where ever applicable, and are therefore not repeated. All necessary inspection procedures necessary in the course of assembly are explained.

11-36 GASKETS. The reuse of old gaskets and seals is not recommended. It is assumed that all gasket, seals and packing will be installed where required, using new material to replace that removed during disassembly. It is general practice to stick one side of a gasket to the

replaced with new material in the same manner as originally applied by the manufacturer and as shown in illustrations. Cotter pins are usually damaged or destroyed when removed and should not be used a second time. The new pins should be tapped securely in place and the tangs split, one side bent back over end of nut, and the other down along the side. Dowel pins, both tapered and straight, may be used again if they have not been damaged, or if the bore from which they were removed has not enlarged beyond the point where the pins are a tight fit. Safety wiring should be done carefully, following the same grouping as the original installation. Wire should be drawn snugly and then be twisted between nuts, to prevent loosening. Thread the wire thru the nut slots in such a way that it tends to tighten the screw elements as illustrated. Use fully annealed wire for securing parts. Lock washers of the spring type should never bear directly on aluminum.

Plain steel washers should always be used under the lock washers to prevent damage to the aluminum part.

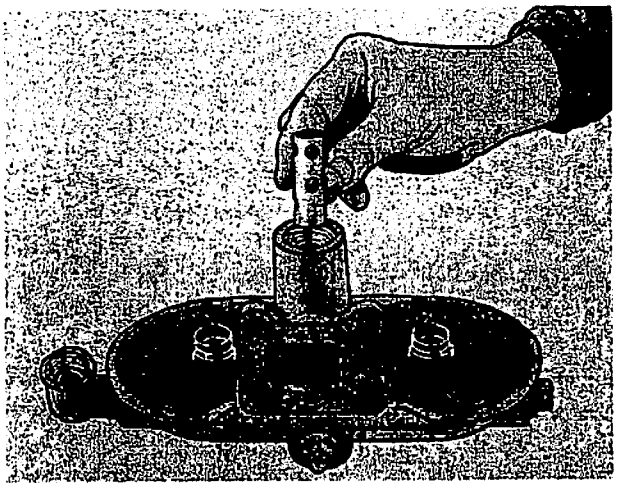


Figure 11-9. Installing Oil Pressure Relief Valve to Oil Filter

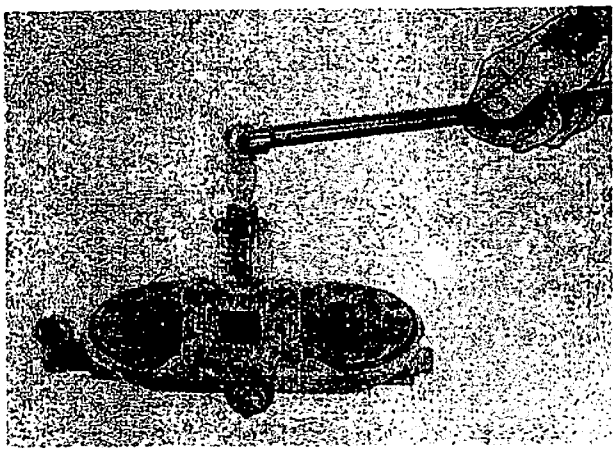


Figure 11-10. Installing Slotted Head Plug to Oil Filter

11-38 OIL FILTER ASSEMBLY. There are two valves in this assembly and they must not be confused. The oil pressure relief valve is near the mounting face of the filter and is controlled by a very stiff spring of 9/16 in. diameter. See reference number 106, figure 12-9. The oil pressure relief valve spring goes into place first and then the valve goes in. It is all held in place with a hollow slotted plug. A wide blade screw driver is necessary to tighten this plug. The oil filter by-pass valve assembles into the top of the oil filter. It is controlled by a softer spring of 45/64 in. diameter. The spring goes into place first followed by the valve and all is retained by a pipe plug. Fit the oil filter element plates and sleeves into the oil filter bracket. Fit new oil filter shell gaskets. Be sure these gaskets are properly placed so they are not twisted. Fit new oil filter elements and shells. Draw the shells up tight with the 1/2 in. cap screws. Use new copper washers under the cap screw heads.

11-39 OIL PUMP ASSEMBLY. Press the oil pump idler shaft into the oil pump scavenge body so that it projects 3-1/2 in. as shown in the illustration. Press the dowels into the oil pump body, pressure side. Press the anti-friction bearing cup to the oil pump body. Do not let this part bind in the bore. Lubricate the idler gear bushing and fit the idler gear and bushing to the idler gear shaft. Set the drive gear, scavenge side, to the oil pump body. Check radial, end clearance and back lash. Coat the oil pump gasket with tacky cement such as Army specification 62-5, both sides. Fit to scavenge pump body and lower the oil pump diaphragm into place. Now coat the other gasket with tacky gasket cement and place on the diaphragm. Place idler gear, idler gear bushing and drive gear in place. Set the oil pump drive shaft into the assembly and then fit the oil pump body, pressure side. Draw the assembly together with nuts and copper washers on the three studs. Cover the drive end of the oil pump with clean cloth or paper to retain the drive shaft and to keep dust and dirt off the anti-friction bearing race. Tubing fittings must be screwed in. The right hand pump is illustrated in figure 11-14.

11-40 OIL COOLER ASSEMBLY. Coat the oil cooler cover gasket with a tacky gasket cement, both sides, such as Army Spec. 62-5, and stick it to the under side of the oil cooler flange. Set the oil cooler core into the oil cooler body. Lay the oil cooler to oil cooler cover gasket in place in the groove provided. This is a rope type gasket or packing. Coat the oil cooler to cover gasket with tacky gasket cement, both sides, such as Army Spec. 62-5. Fit the gasket and oil cooler cover to the assembly. Now run a light ring of non-hardening cement per Army Stock No. 052-C-685-2PX around each stud and then fit new copper washers and draw down tight with nuts. Fit the by-pass valve parts to the oil cooler cover. The spring is inserted first followed by the valve. The whole being retained by the tubing fitting.

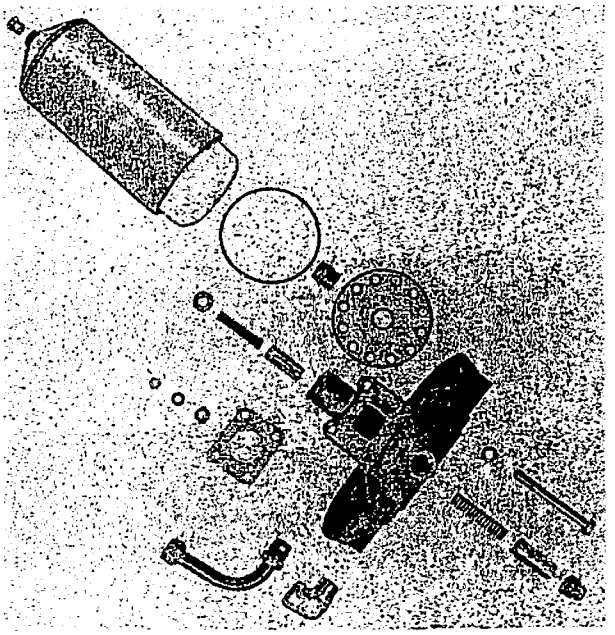


Figure 11-11. Exploded View of Oil Filter

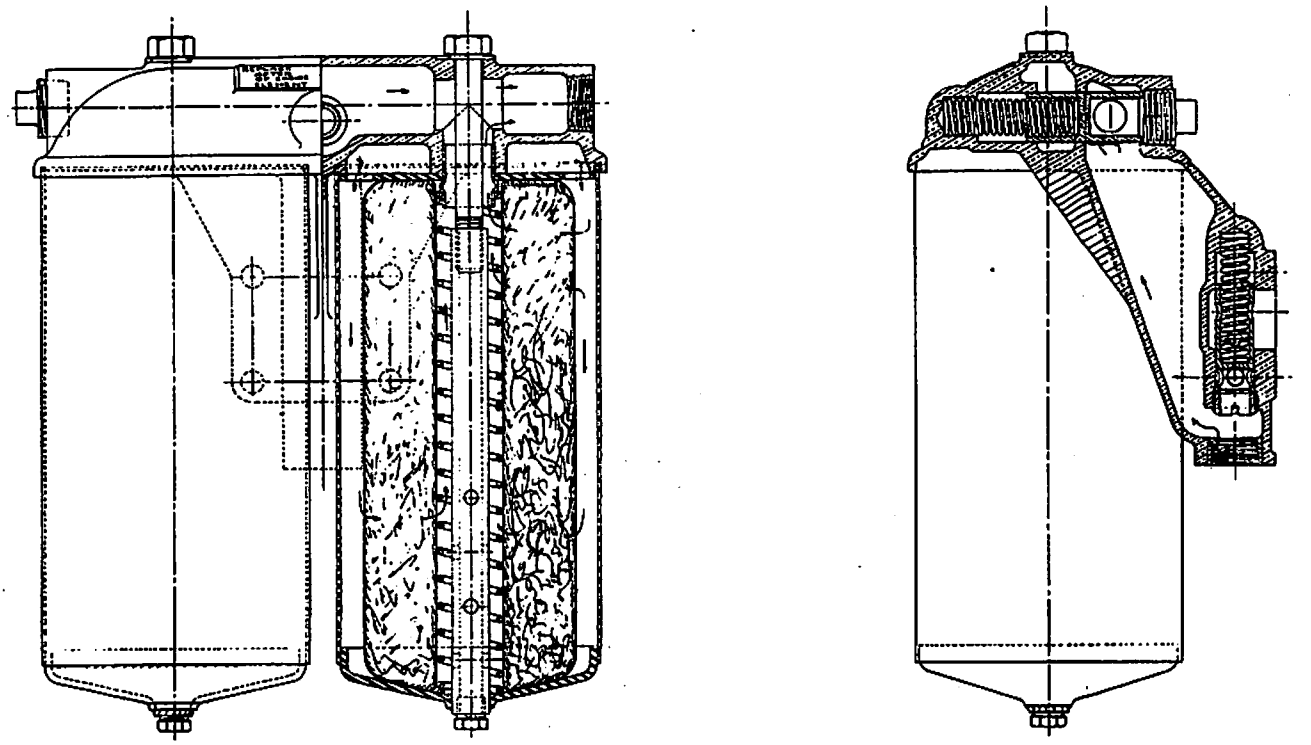


Figure 11-12. Oil Filter Assembly

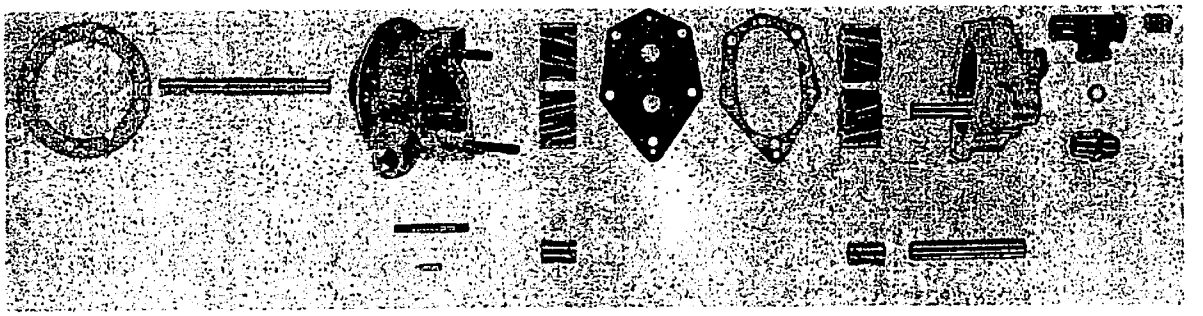


Figure 11-13. Exploded View of Oil Pump

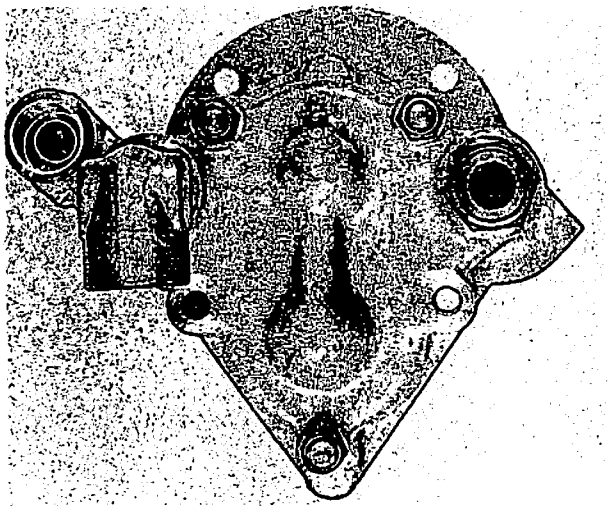


Figure 11-14. Oil Pump Assembly

11-41 WATER PUMP ASSEMBLY. Fit the square keys to the water pump drive shaft and also driven shaft. Lubricate the shafts with white lead per specification JAN-A-669 (Symbol CAS) and press the water pump gears into place on the shafts. Be sure to start the gears so the key way will line up with the key. The counterbored end of the drive gear must be on the same end as the splined end of the drive shaft. Locate the gears on the shafts per illustration. Fit the packing nut spring lock to the water pump body. See figure 11-18 and 11-19. Fit the packing and packing nuts to the water pump body. This is best done by placing the idler gear and shaft assembly temporarily into the body with the short end of the shaft sticking into the packing gland. This makes a convenient pilot for the packing and packing nut. Place four packing washers over the shaft and press down with the nut until the packing nut can be screwed down several threads. Now put the shaft into the other gland and repeat the operation. Withdraw the shaft and gear assembly. Now press the oil seals into the water pump body. The

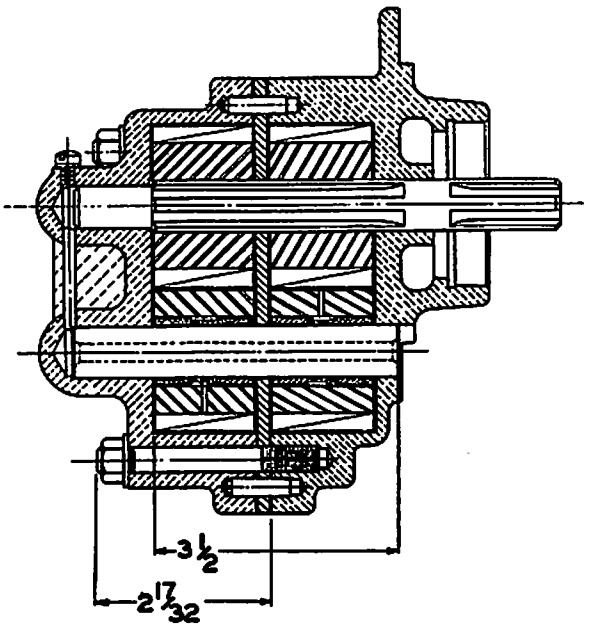


Figure 11-15. Sectional View of Oil Pump

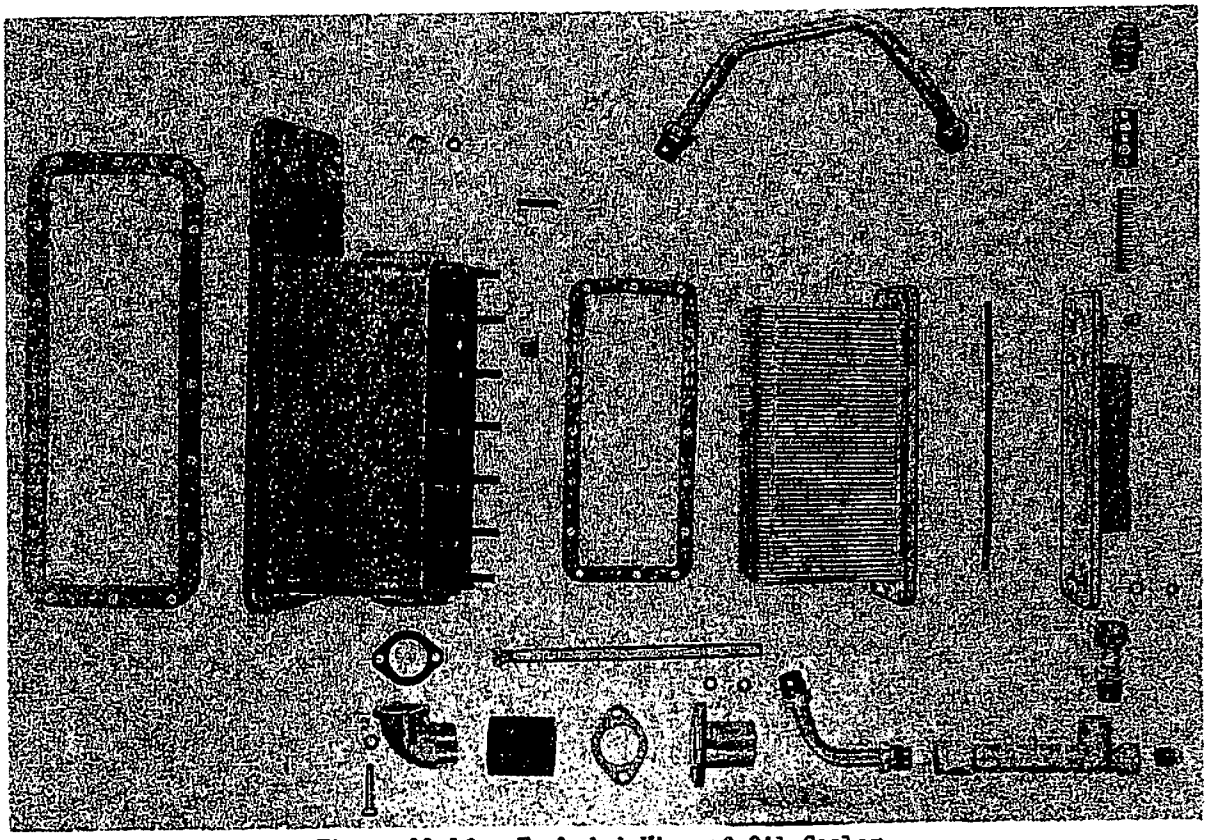


Figure 11-16. Exploded View of Oil Cooler

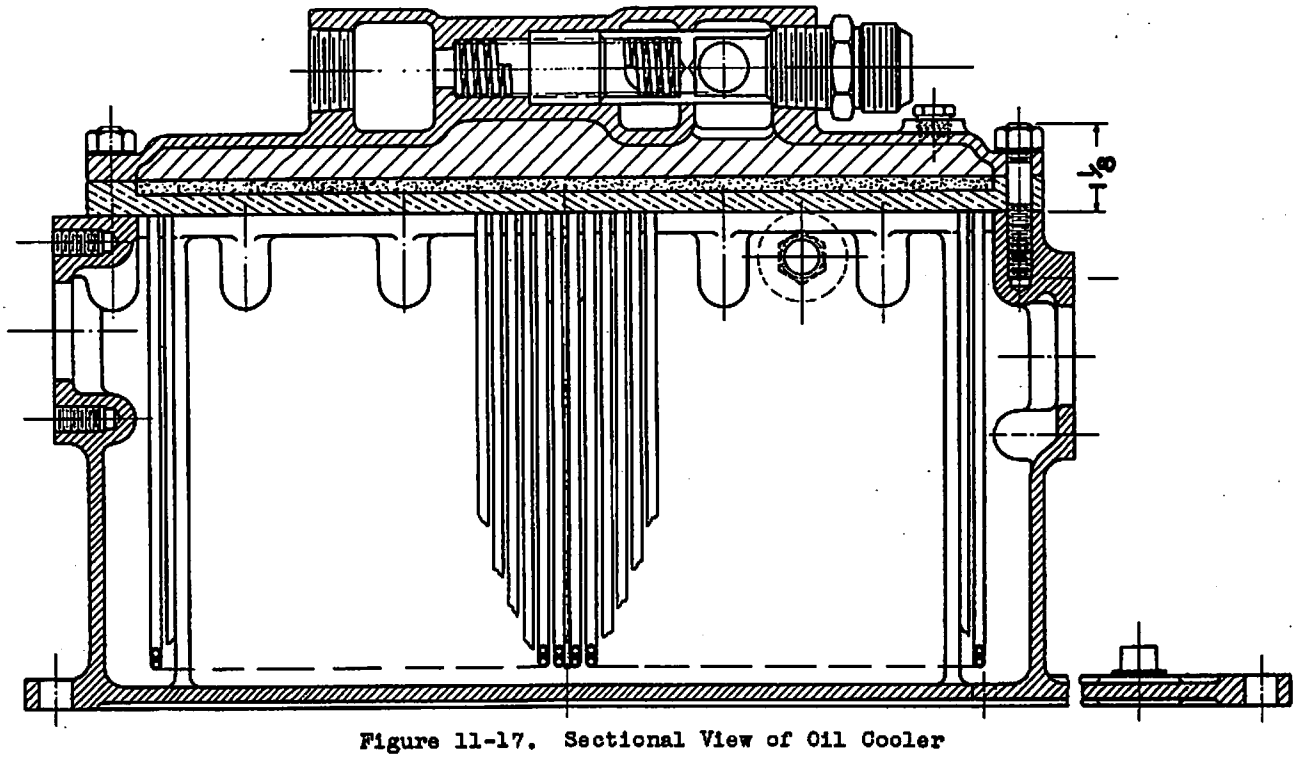


Figure 11-17. Sectional View of Oil Cooler

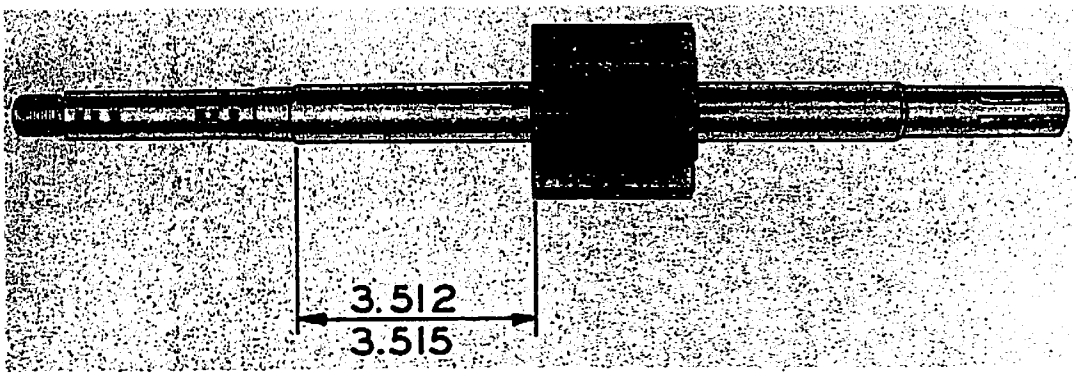


Figure 11-18. Water Pump Drive Shaft Assembly

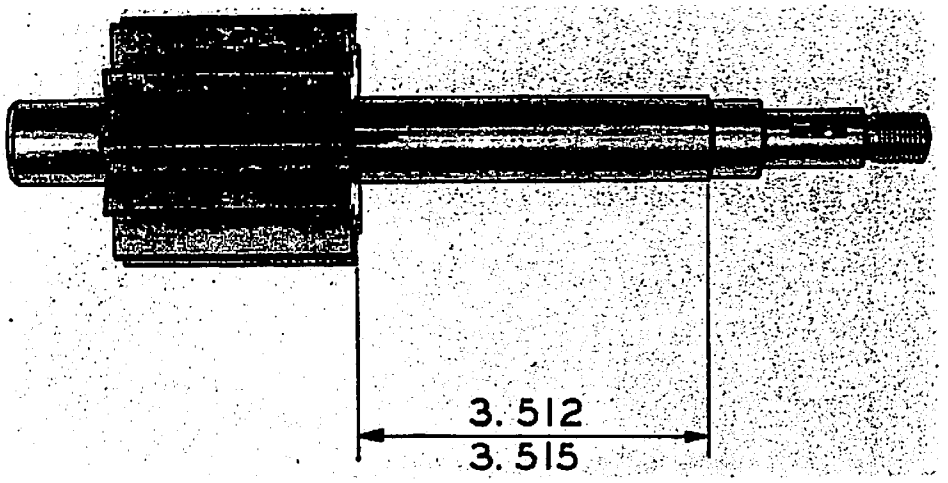


Figure 11-19. Water Pump Driven Shaft Assembly

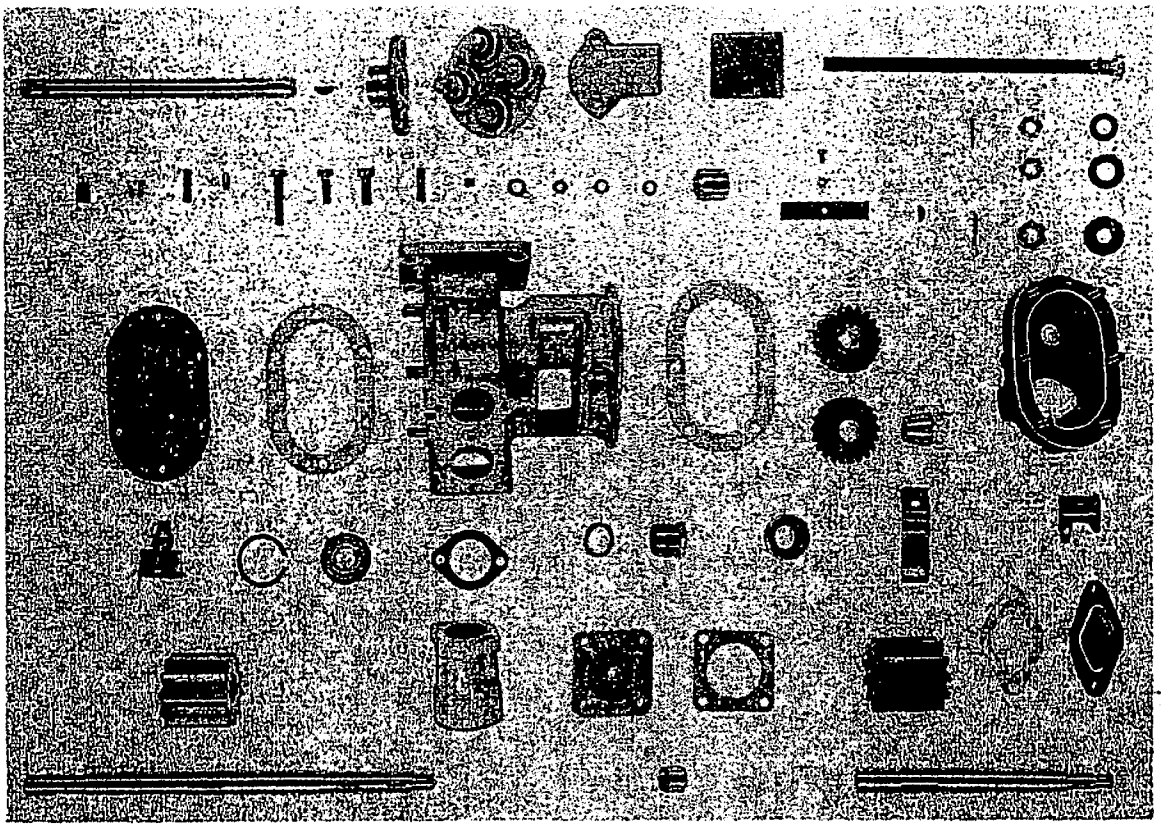


Figure 11-20. Exploded View of Water Pump

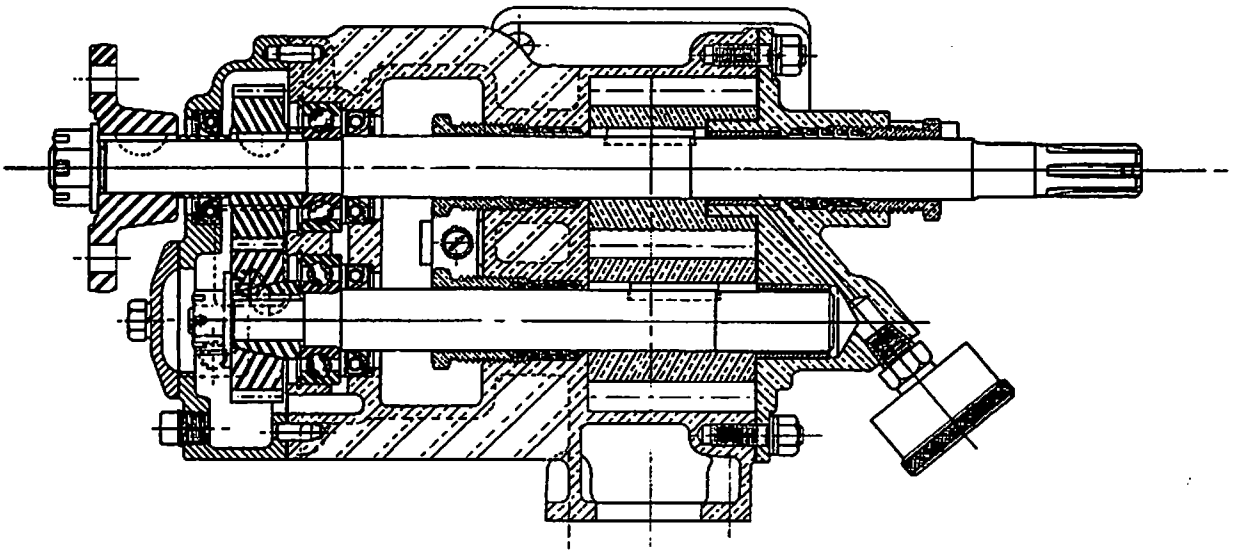


Figure 11-21. Sectional View of Water Pump

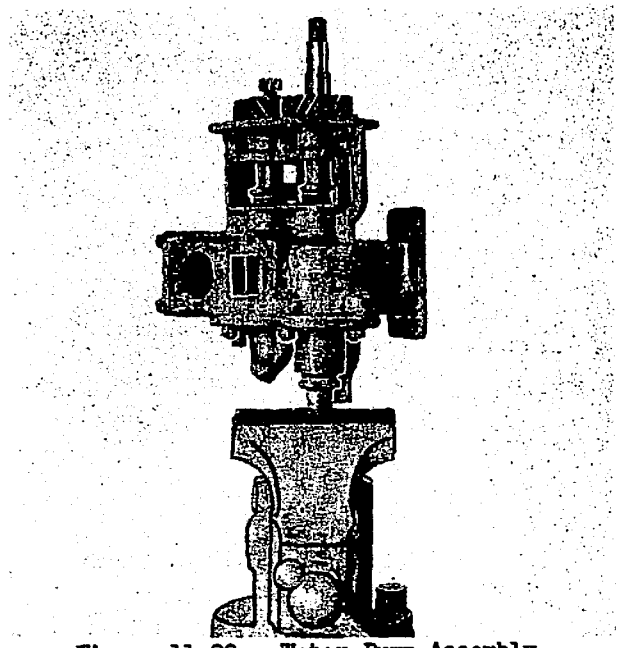


Figure 11-22. Water Pump Assembly with Gear Spacing Strip in Place

sealing lip must point toward the pilot gear end of the assembly. Now fit the ball bearings. Press against the outer race only. Seat the ball bearings firmly and fit the retainer rings. Lubricate the pump shafts and slide them into the water pump body. Fit the keys for the pilot gears and then fit the pilot drive gear. Check radial and end clearance. Then fit the pilot driven gear hub. The taper must be arranged so the pilot driven gear may be added to the assembly. Fit the pilot driven gear and secure lightly with washer and nut. Now roll a piece of .005 in. thick brass strip into the pump gears to hold them clear of one another. Then proceed to tighten the pilot driven gear nut down snug and lock with a cotter pin. The pump drive shaft may be held from turning by placing it in a soft jawed vise. Remove brass strip from pump. Press a new oil seal into the water pump pilot gear cover. The sealing lip is to point in toward the gear so as to retain the lubricating oil in the pilot gear cover. Coat the pilot gear cover gasket with cement per Army Spec. 62-5, both sides. Fit the pilot gear cover to the water pump assembly and tighten nuts. Care must be used in clamping the water pump body in a vise as it is quite easy to distort this soft housing. Now rotate the water pump thru several revolutions to make sure it is free except for the slight drag of the packing. If the pump gears should drag on the housing, bump the shaft end lightly with a soft mallet to shift the shaft in the gear. Lubricate the pump shaft ends. Coat the water pump cover gasket with cement per Army Spec. 62-5, both sides, and fit to the pump body. Fit the pump cover and secure with plain washers, lock washers and nuts. Fit four packing rings, packing nut and packing nut lock to the water pump cover. Do not tighten the packing nut at this stage of the assembly. At the pilot gear end of the pump slide the drive shaft sleeve over the drive shaft thru the oil seal and up against the water pump pilot drive gear hub. Fit the flexible coupling spider and draw down tight with a washer and nut. Lock the nut with a cotter pin. Again rotate the pump to make sure it is free. Coat the inspection cover gasket, both sides,

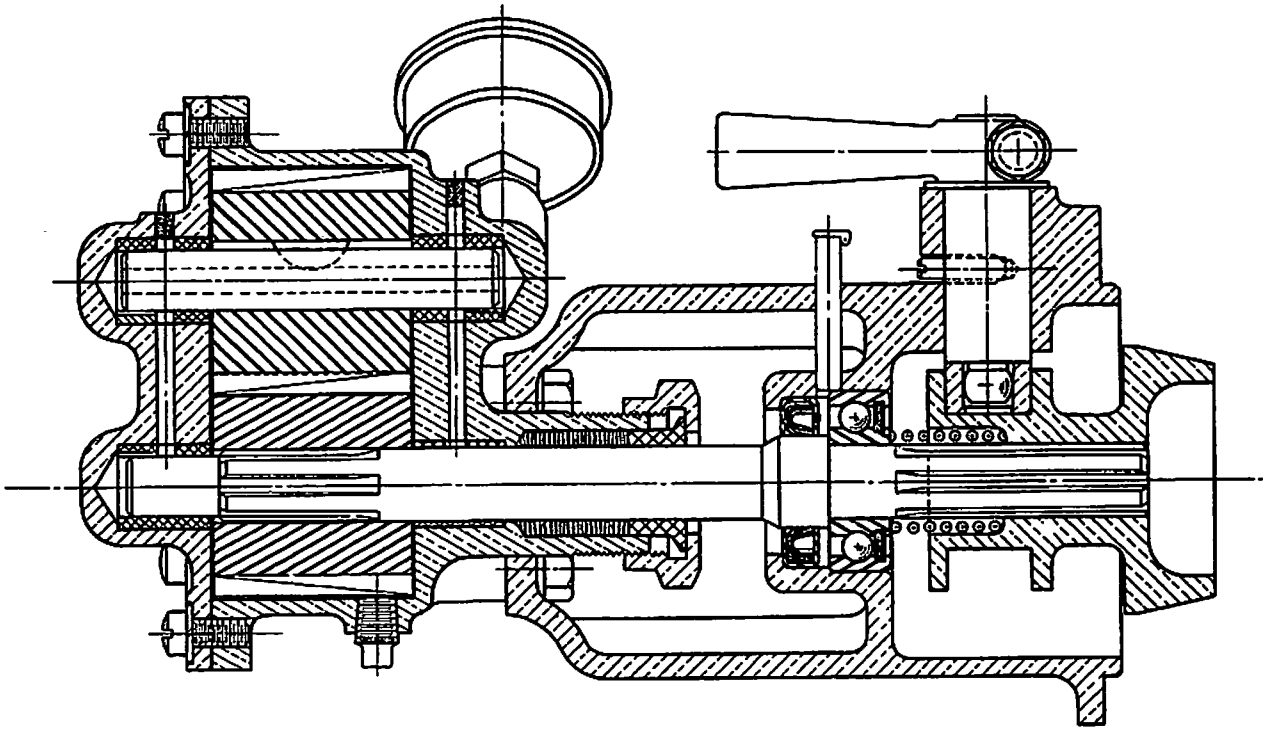


Figure 11-23. Sectional View of Bilge Pump

with a tacky cement such as Army Spec. 62-5. Stick the gasket to the inspection cover. Fit the oil cup to the lower of the two holes provided in the pilot gear cover. Plug the remaining holes with pipe plugs. Now add about one cubic inch of oil to the pilot gear housing thru the inspection hole. Fit the inspection cover plate to the assembly. The oil added must meet specification VV-L-761 (Symbol GO) SAE 90. Fill the water pump grease cup with grease of soda or soda alumina base. Grease must be water resistant but not necessarily water proof and of 177°C (350°F) melting point.

11-42 BILGE PUMP ASSEMBLY. The water pump packing washers are installed in the bilge pump body as the initial step of assembly. Use five new washers. The pump drive shaft should be fitted to the body to act as a pilot for the packing washers. This may be done by installing the shaft end for end to its normal position. Push the packing washers down over the shaft one at a time and force them down to the bottom of the packing counterbore. When all five washers are in place, fit the gland and packing nut. Do not tighten the nut. Now withdraw the drive shaft from the body and packing assembly. Now fit the bilge pump bracket to the bilge pump body and secure with 3/8 cap screws and lockwashers. Be sure that the bracket seats squarely on the body so as to maintain alignment of these

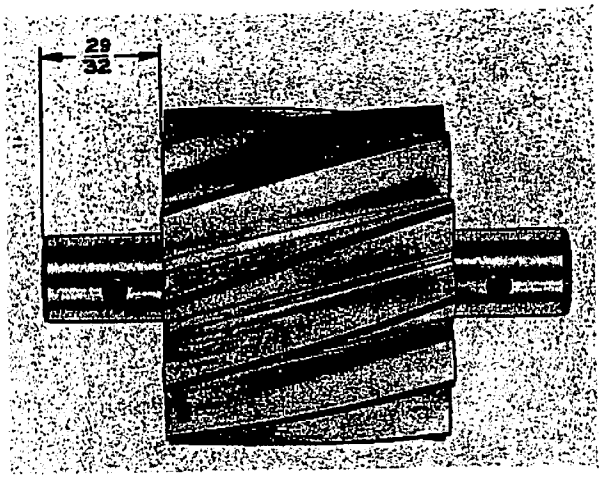


Figure 11-24. Bilge Pump Idler Gear and Shaft Assembly

parts. Press the oil retainer into place in the bilge pump bracket. The sealing lip is to point in toward the mounting flange of the bilge pump bracket. This sealing lip is very delicate so be careful not to damage it. Use white lead per specification JAN-A-669 (Symbol CAS) as a lubricant when pressing the retainer into place. Make sure the retainer is firmly seated against the shoulder and is not cocked in the bore. Press the ball bearing onto the drive shaft. This is a shielded bearing. The shielded side must be on the opposite side from the shaft shoulder as illustrated. Now lubricate the shaft and carefully slide it thru the packing and press the ball bearing into the bilge pump bracket. Install the bilge pump clutch drive spring. Lubricate and fit the bilge pump throw out yoke to the bilge pump drive clutch. Lubricate the bilge pump drive clutch spline and fit it to the drive shaft. See that the throw out yoke is in the proper position to receive the bilge pump throw out shaft. Now press the clutch in, compressing the spring and push the throw out shaft into place to retain it against the spring pressure. Fit the bilge pump throw out stop pin and tighten securely. Fit the bilge pump throw out handle and secure with 3/8 cap screw and lockwasher. Now press the bilge pump idler gear onto the idler shaft to the dimension illustrated. Be sure to use a key in this assembly. Use white lead per specification JAN-A-669 (Symbol CAS) as a lubricant in pressing the gear on. Lubricate the idler gear shaft and set the assembly in the bilge pump housing. Lubricate the drive shaft and set the drive gear over the shaft. Now coat the pump body flange face with tacky gasket cement per Army specification 62-5. Fit new gasket. Coat the flange face of the bilge pump cover with soft cup grease per specification AN-G-14 (Symbol GRG). Fit the cover to the assembly and secure with 5/16 screws and lockwashers. Fit all pipe plugs. Turn the driving clutch by hand to make certain there is no binding. Any binding, other than that caused by the packing washers, must be corrected. When the pump turns freely tighten the packing nuts slightly. As a final step, add several drops of oil per specification AN-O-6 (Symbol OGP) to the oil cup over the pump ball bearing. Also fill the grease cup with grease of soda or soda alumina base and water resistant but not necessarily water proof. The grease must be 177°C (350°F) melting point.

11-43 DISTRIBUTOR DRIVE HOUSING ASSEMBLY. Press the ball bearings on to the shaft. The larger of the two ball bearings goes onto the end of the shaft that is cross drilled for a cotter pin. Fit the small ball bearing to the opposite end. Fit the key and distributor drive gear to the shaft. Secure the gear with a lockwasher and nut. Into the shaft intended for the right hand distributor drive, press the tachometer drive spindle. The spindle must be located as shown in the illustration. Pack the distributor drive housing with grease per specification AN-G-25 (Symbol CLT). Fit the shaft assembly to the distributor drive housing. The shaft with the spindle extension goes into the housing for the right hand side of the engine whereas the plain shaft assembly goes into the housing for the left hand side of the engine. Press a new oil seal into the distributor drive housing cover. The sealing lip is to point toward the pilot diameter on the cover. Coat the cover gasket with tacky gasket cement per Army Spec. 62-5, one side and stick it to the cover. Coat the other side of the gasket with soft cup grease per specification AN-G-14 (Symbol GRG). Place the cover on the distributor drive housing and draw into place with plain washers, lock washers

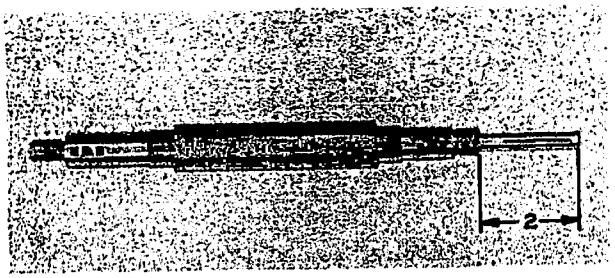


Figure 11-25. Distributor Drive Shaft Assembly

and nuts. On the right hand distributor drive housing, press a new oil seal into place at the front end. See that there are no sharp edges or burrs on the tachometer spindle to damage the sealing lip. The seal lip is to be installed so it will retain the grease in the distributor drive housing. Fit the adapter to the right hand housing. No gasket is used under this adapter. Fit the shaft key and then the flexible coupling dog. Secure with washer and nut. Lock the nut with a cotter pin. Fill the grease cup with grease per specification AN-G-25 (Symbol CLT).

11-44 STARTER DRIVE ASSEMBLY.

a. The assembly of the starting motor is discussed in a separate publication. Refer to paragraph 11-48.

b. The assembly of the Bendix Drive is discussed in a separate publication. Refer to paragraph 11-48.

c. New needle bearings and bushings are assembled to the idler gear and starter drive housing as mentioned in paragraph 11-32a.

d. Fit a key to the Bendix drive shaft and then press the starter driven gear on to this shaft until it just comes flush with the end of the shaft. Now lubricate the shaft and slide it into the starter drive housing. Check for clearance. See reference number 67, Table of Limits, figure 12-1. Fit two keys to the shaft, the meshing spring into the hollow end of the Bendix drive shaft and then slide the Bendix drive into place on the shaft. Make sure the counterbored hole in the shaft comes under the set screw in the Bendix drive. Refer to figure 4-44. Tighten this screw down into the hole in the shaft and then secure the screw with the wire ring in the screw head slot. Press the starter idler gear shaft into place in the starter drive housing. Fit a key to the starting motor shaft and press the starter drive gear firmly in place with the hub of the gear against the starting motor shaft shoulder. Now apply the starter to starter drive housing gasket to the starter after coating it with a tacky gasket cement such as Army specification 62-5. Coat the opposite side of the gasket with soft cup grease per specification AN-G-14 (Symbol GRG). Fit the starting motor to the starter drive housing. Install the two flat head screws and lockwashers to hold this assembly together. Lubricate the idler gear shaft and drop the idler gear into place. Rotate the Bendix drive to see that all parts are free. Check the back lash of the gears. See reference number 69, Table of Limits, figure 12-1. Coat the starter housing drive cover gasket with a tacky gasket cement, one side, and stick to the drive housing.

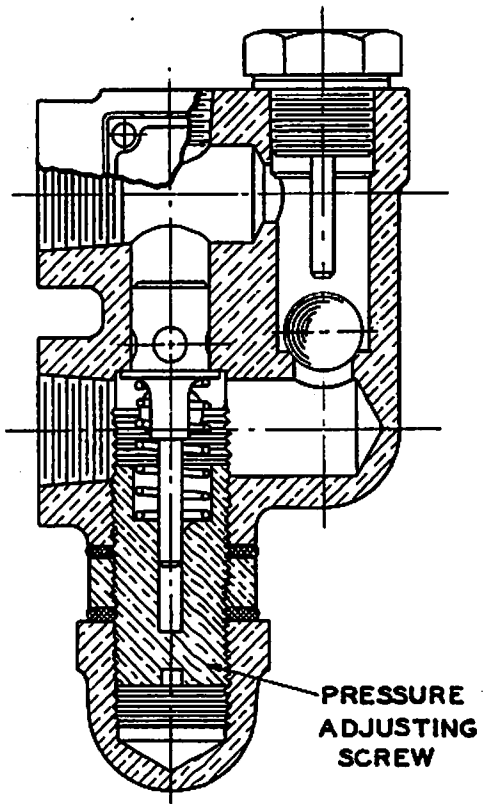


Figure 11-26. Sectional View of Fuel Pressure Regulating Valve

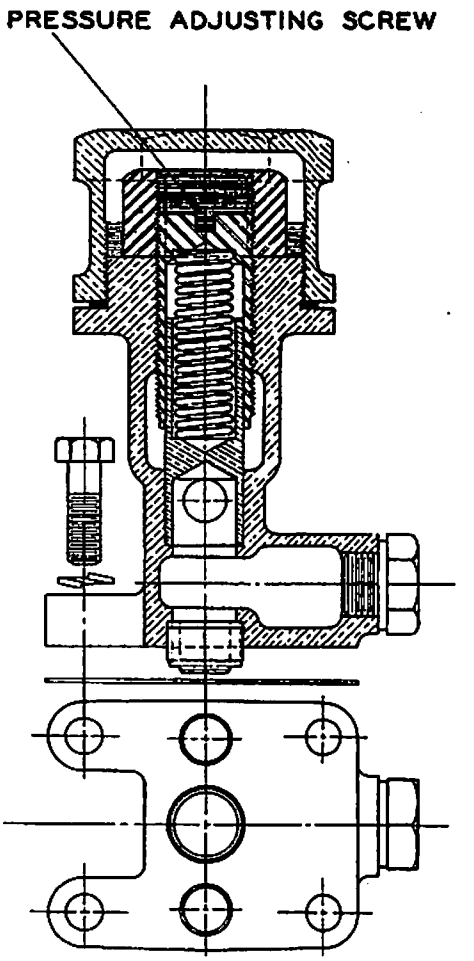


Figure 11-27. Sectional View of Oil Pressure Regulating Valve

Coat the exposed face of the gasket with soft cup grease per specification AN-G-14 (Symbol GRG). Fit the cover into place and secure with cap screws, lockwashers and nuts. Again rotate the Bendix drive to make certain everything is free to rotate. Set the assembly up in its operating position and fill the starter drive housing with oil to the level of the lowest of the two 1/8 in. pipe plugs. Oil must meet specification VV-L-761 (Symbol GO). Viscosity must be equal to SAE 90. Refit the two 1/8 in. pipe plugs. Coat the Bendix drive with rust preventive compound per paragraph 5-16 and set the assembly aside.

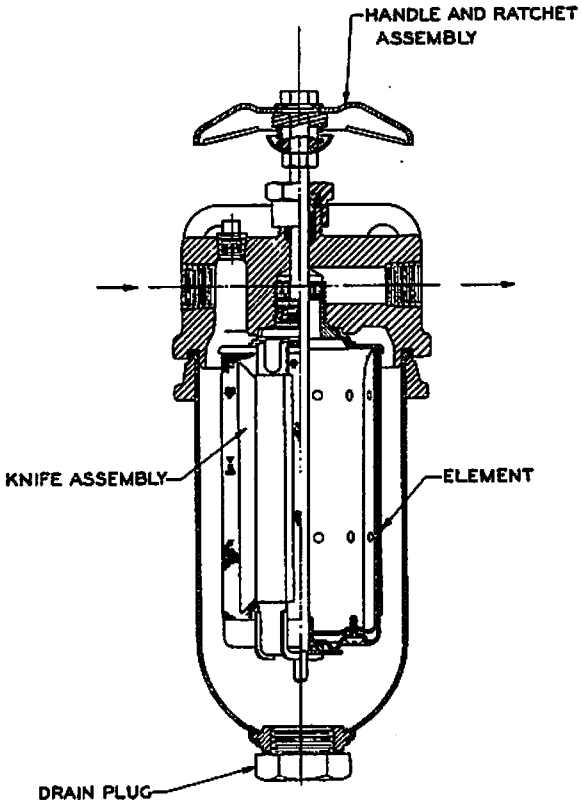


Figure 11-28. Sectional View of Fuel Filter

11-45 FUEL PRESSURE REGULATING VALVE ASSEMBLY. Assemble the fuel pressure regulating valve as shown in the illustration. Use new gaskets throughout and adjust the valve to maintain fuel pressure as mentioned in paragraph 10-24.

11-46 OIL PRESSURE REGULATING VALVE ASSEMBLY. Assemble the valve correctly as shown in the illustrations. Use new gaskets. Keep the valve openings covered to exclude dust until the unit is installed on an engine. Adjust after installing on the engine as mentioned in paragraph 10-19. See figure 11-29.

11-47 FUEL FILTER ASSEMBLY. Assemble the fuel filter as illustrated. Use new gaskets throughout.

11-48 ACCESSORY OVERHAUL. For details in overhauling the more complex accessories such as starting motor, generator, fuel pump, carburetor and other accessories not mentioned in this section refer to applicable Air Force and Navy handbooks.

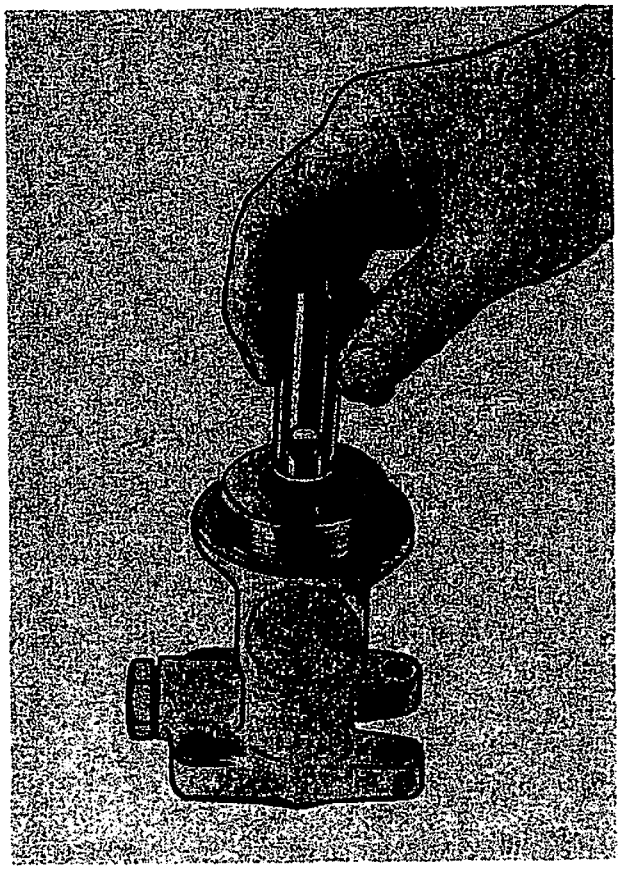


Figure 11-29. Installing Valve in Oil Pressure Regulating Valve Body

HALL-SCOTT DEFENDER
MODEL 2268 & 2269

TABLES OF LIMITS WITH LIMITS AND LUBRICATION CHARTS

INTRODUCTION

12-1 ABBREVIATIONS. All the unusual abbreviations used in this section are explained as follows.

12-2 LIQUID MEASURE ABBREVIATIONS. "U.S. gal" means United States standard gallon of 231 cubic inches. "B. Imp. gal" means British Imperial gallon of 277.42 cubic inches.

12-3 STANDARDS DEFINITION. "AN 0000" means Army-Navy standard. "SAE" means Society of Automotive Engineers. "JAN 00000" means Joint Army-Navy standard. "AGMA" means American Gear Manufacturers Association standard. "AWG" means Standard American Wire Gage. "ASA" means American Standards Association.

12-4 THERMAL DEFINITIONS. "F" means Fahrenheit thermometer scale. "C" means Centigrade thermometer scale. "BTU" means British Thermal Units of heat.

12-5 CRUSH. The term "Crush" as applied to split bearing shells refers to the amount that the bearing shell projects at the parting line above its supporting saddle or cap. The existence of "Crush" permits the shell to be crushed or compressed down into intimate contact with its supporting surface thus assuring good heat transfer characteristics. Specified crush must be present at both ends of both bearing shell halves.

12-6 CLEARANCE FIT. The values given in the following table refers to operating fits between mating parts. This clearance is largely occupied by lubricant. All values are given in inches and are indicated by the letter "L" after the dimension in the Table of Limits.

12-7 TIGHT FIT. Where no relative movement is allowable between mating parts a tight or interference fit is made. All values are given in inches and are indicated by the letter "T" after the dimension in the Table of Limits.

12-8 MISCELLANEOUS ABBREVIATIONS.
"backlash" means the pitch line clearance between mating gear teeth.
"dia" means diameter.
"ID" means inside diameter.
"IND" means total indicated run out.
"L" means loose or free fit. See paragraph 12-6.
"lb" means United States pounds, commercial or avoirdupois.
"max" means maximum.
"min" means minimum.
"OD" means outside diameter.
"T" means tight or interference fit. See paragraph 12-7.
"tol" means tolerance.

12-9 EXPLANATION OF COLUMN HEADING TABLE OF LIMITS.
"Ref. No." means reference number and refers to the numbers shown in the various charts immediately following figure 12-1.
"Chart No." means chart number and refers to the various charts immediately following Table of Limits, figure 12-1.
"Description". In the description column, the mating parts are grouped with the noun name appearing first, followed by the description.
"Minimum" - "Maximum" columns list the manufacturing limits. All values are in inches.
"Maximum Replace", dimensions not exceeding the values given in this column, means the mating parts may be continued in service.

12-10 SPRING SPECIFICATION. Figure 12-9 lists the springs used in the engine, their nominal size and tension. These values are to be used in judging the condition of a spring. The free lengths are important as well as the loads required to compress them to the specified lengths. If any spring does not conform to these specifications it must be discarded and a new spring assembled into the engine.

12-11 TORQUE WRENCHES. The tightness of various nuts and cap screws are given in figure 12-9. These are the more important and sensitive fastenings of the engine and care must be used to follow these recommendations. Common sense and good judgement should be used in tightening any fastening to avoid damage to the engine or service failure. Torque wrenches should always be checked just prior to their use or at least once daily. They must be checked by means of a known weight on a measured lever arm. Checking one torque wrench against another is not accurate. Every effort should be made to follow the instructions furnished with the particular wrench being used. The tightening operation should be done slowly and evenly for best possible accuracy. All values in the accompanying table for torque are in pounds feet.

12-12 TORQUE APPLICATION. After a castle or slotted nut has been tightened to the proper torque, it should not be loosened to permit insertion of a lockwire or cotter pin. If alignment of nut slot and drilled hole in the bolt is impossible at minimum recommended torque, tighten to next aligning position, but do not exceed maximum recommended torque. If this alignment cannot be made within the limits specified try another combination of nut and bolt. However, do not attempt to interchange matched nuts and bolts such as those found on the yoked connecting rod.

12-13 LUBRICATION DIAGRAM. The oil circulation is shown diagrammatically in figure 12-10. The engine has been opened up, so to speak, for in this way the various oil paths can be best shown. Scavenge oil as well as pressure oil is shown. The entire system is duplicated on each side of the engine, including pumps, filters and coolers. A thermometer well is provided on the inboard side of the engine to permit measuring the oil inlet temperature.

12-14 ACCESSORIES. All clearance limits for the various engine accessories may be found in the appropriate Service publication covering the particular accessory under consideration. Refer to section XI for details on reference publications dealing with accessories.

TABLE OF LIMITS

REF. NO.	CHART NO.	DESCRIPTION	FIT MINIMUM	FIT MAXIMUM	FIT MAXIMUM REPLACE
		CRANKSHAFT			
		Journals - Crankshaft main			
1	I	Radial clearance in brg shell	.00355L	.00475L	.005L
2	I	End clearance in center brg	.005L	.015L	.025L
3	I	Crush* - Main brg shell	.0012T	.0012T	.0012T min
4	I	Run out of main journals IND	.000	.001	Straighten
5	I	Run out of rear crankshaft pilot dia and reverse gear drive flange mounting face IND	.000	.001	.001
6	I	Run out of reverse gear drive flange bushing IND	.000	.005	.008
7	I	Tolerance from main journal nominal size (refer to paragraph 7-6d)	-.00325	-.00275	
8	I	Diameter of main journals - undersize			.0015
9	I	Out of round IND			.0015
10	I	Parallelism - In length of journal			.0015
		Journals - Crank pin			
11	I	Radial clearance of yoke rod shell	.003L	.0042L	.0055L
12	I	End clearance of yoke rod shell	.006L	.011L	.015L
13	II	Crush* - Yoke rod brg shell	.00075T	.00120T	.00075T min
14	I	Radial clearance of blade rod shell	.00275L	.0041L	.0055L
15	I	End clearance of blade rod shell	.009L	.014L	.020L
16	II	Crush* - Blade rod brg shell	.00075T	.00150T	.00075T min
17	I	Tolerance from crank journal nominal size (refer to paragraph 7-6d)	-.00325	-.00275	
18	I	Diameter of crank journals undersize			.0015
19	I	Out of round IND			.0015
20	I	Parallelism - In length of journal			.0015
		Gear - Crankshaft and accessory drive			
21	I	Backlash	.004L	.006L	.015L
		FLYWHEEL			
		Gear - Flywheel ring			
22	I	Radial fit	.014T	.024T	.024T
23	I	Out of plane when flywheel is rotated on close fitting mandrel	.000	.005	.005
		UPPER CRANKCASE			
		Face - Bottom flange			
24	II	Out of plane in 42 in.	.000	.0015	.0015
		Faces - Top mounting for cylinder blocks			
25	II	Out of plane in 42 in.	.000	.0015	.0015
26	I	Saddles - Main brg alignment	.000	.0015	.0015
		CYLINDER BLOCK			
27	I	Bore dia tolerance from nominal size	-.0008	+.0005	+.0055
28	I	Out of round in bore as measured in any one plane IND	.000	.002	.002
29	I	Taper of bore in 11-3/4 in. length	.000	.001	.006
30	II	Flange - Bottom mounting face must be perpendicular to cylinder bores in 11-3/4 in. length when checked in a plane parallel to the crankshaft	.000	.002	.002
		CONNECTING RODS			
		Rod - Yoke connecting			
31	I	Twist in 2 in. as indicated on tight fitting mandrels. Figure 7-11.	.000	.002	Straighten
32	I	Bend in 2 in. as indicated on tight fitting mandrels. Figure 7-9.	.000	.001	Straighten
		Rod - Blade connecting			
33	II	Twist in 2 in. as indicated on tight fitting mandrels. Figure 7-11.	.000	.002	Straighten
34	II	Bend in 2 in. as indicated on tight fitting mandrels. Figure 7-9.	.000	.001	Straighten
		*Specified crush must be present at both ends of both bearing shell halves.			

Figure 12-1. (Sheet 1 of 3 Sheets) - Table of Limits

TABLE OF LIMITS

REF. NO.	CHART NO.	DESCRIPTION	FIT MINIMUM	FIT MAXIMUM	FIT MAXIMUM REPLACE
		Pin - Piston			
35	I	Radial clearance in conn. rod	.00055L	.001L	.0023L
36	I	Radial clearance in piston	.00005L	.0005L	.001L
		VALVE MECHANISM			
		Journals - Camshaft			
37	I	Radial clearance in plain brg	.003L	.006L	.012L
38	I	Radial clearance in thrust brg	.004L	.008L	.012L
39	I	Crush* - Camshaft brg shell	.0005T	.0025T	.0005T min
40	I	End clearance in rear brg	.003L	.007L	.020L
		Shaft - Rockerarm			
41	I	Radial clearance of rockerarm on shaft	.001L	.003L	.008L
		Tappets - Valve			
		Clearance for timing both intake and			
42	II	exhaust	.021	.021	Adjust
		Clearance for running (hot)			
43	II	Intake	.021	.021	Adjust
44	II	Exhaust	.030	.030	Adjust
		Valve - Intake			
		Runout of face with respect to			
45	II	stem IND	.000	.001	Regrind
46	II	Radial clearance in guide	.0015L	.003L	.006L
		Seat - Intake valve in cyl. head			
47	II	Eccentricity with respect to guide IND	.000	.015	Regrind
		Valve - Exhaust			
		Runout of face with respect to			
48	II	stem IND	.000	.001	Regrind
49	II	Radial clearance in guide	.002L	.004L	.008L
		Bore - Exhaust valve seat ring			
50	II	Eccentricity with respect to guide IND	.000	.003	Rebore
		Seat - Exhaust valve ring			
51	II	Radial fit in bore	.002T	.0045T	.002T min
52	II	Eccentricity with respect to guide IND	.000	.0015	Regrind
		Guides - Valve (Intake and Exhaust)			
		Clearance - Guide shoulder to			
53	II	cylinder head	.010L	.020L	Adjust Replace pistons at overhaul
		PISTON			
54	VII	Clearance top land	.056L	.060L	.066L
55	VII	Clearance second and third land	.038L	.042L	.048L
56	VII	Clearance fourth land	.090L	.100L	.106L
57	VII	Clearance - Major dia at top of skirt	.012L	.013L	.019L
58	VII	Clearance - Major dia at bottom of skirt	.007L	.008L	.014L
59	VII	Clearance - Minor dia at top of skirt	.028L	.029L	.045L
60	VII	Clearance - Minor dia at bottom of skirt	.023L	.024L	.040L
		Rings - Piston			
61	I	Gap - All rings	.013L	.023L	
62	I	Clearance in grooves 1, 2 and 3	.0035L	.005L	.005L
63	I	Clearance in groove 4	.0015L	.003L	.003L
64	I	Clearance in groove 5	.002L	.0035L	.0035L
		STARTER			
		Gear starter idler			
65	I	Radial clearance on shaft	.0005L	.0029L	.005L
		Shaft - Starter drive			
66	I	Radial clearance in needle brg	.0005L	.0029L	.005L
67	I	Radial clearance in bushing	.0015L	.0035L	.007L
		Sleeve - Starter drive			
		Radial clearance in flywheel housing			
68	I	bushing	.0015L	.0025L	.0075L
69	I	Gears - Starter drive backlash	.002L	.006L	.030L

*Specified crush must be present at both ends of both bearing shell halves.

Figure 12-1. (Sheet 2 of 3 Sheets) - Table of Limits

TABLE OF LIMITS

REF. NO.	CHART NO.	DESCRIPTION	FIT MINIMUM	FIT MAXIMUM	FIT MAXIMUM REPLACE
		IGNITION SYSTEM			
		Points - Ignition distributor			
70	V	Gap	.018	.024	Adjustable
71	V	Cam@angle (degrees of cam rotation while points are closed)	37°	40°	Adjustable
		Points - Spark plug			
72	I	Gap	.020	.020	Adjustable
		ACCESSORY DRIVE			
		Sprocket - Accessory drive			
73	III	End clearance	.001L	.005L	Shim adjust
		OIL PUMP			
		Gears - Oil pump both pressure and scavenge side			
74	III	Radial clearance in body	.002L	.006L	.012L
75	III	End clearance in body	.008L	.014L	.018L
76	III	Backlash	.002L	.006L	.010L
		Shaft - Oil pump drive			
77	III	Radial clearance in housing	.002L	.003L	.006L
		Bushing - Oil pump idler gears			
78	III	Radial clearance on idler shaft	.0005L	.0015L	.006L
79	III	Radial clearance in idler gear bore	.0005L	.002L	.006L
		WATER PUMP			
		Gears - Water pump			
80	IV	Radial clearance in body	.006L	.010L	.020L
81	IV	End clearance in body	.005L	.012L	.025L
82	IV	Backlash	.003L	.007L	.020L
		Cover - Water pump			
83	IV	Bushing bores must be perpendicular to cover face in a distance of 3 in.	.000	.004	.004
		Gears - Water pump pilot			
84	IV	Backlash	.002L	.006L	.008L
		Shaft - Water pump - drive and driven			
85	IV	Radial clearance in cover bushings	.001	.0025	.008
		BILGE PUMP			
		Gears - Bilge pump drive and driven			
86	VI	Radial clearance in body	.005L	.009L	.012L
87	VI	End clearance in body	.003L	.010L	.010L
88	VI	Backlash	.002L	.006L	.015L
		Body - Bilge pump			
89	VI	Bushing bores must be perpendicular to body face in a distance of 3 in.	.000	.004	.004
		Cover - Bilge pump			
90	VI	Bushing bores must be perpendicular to cover face in a distance of 3 in.	.000	.004	.004
		Shaft - Bilge pump - drive			
91	VI	Radial clearance in body	.002L	.004L	.006L
92	VI	Radial clearance in cover	.001L	.0025L	.006L
		Shaft - Bilge pump - driven			
93	VI	Radial clearance in body and cover	.001L	.0025L	.006L
		DISTRIBUTOR			
		Gears - Distributor drive			
94	V	Backlash	.000	.004	.010
		Bushing - Distributor drive housing			
95	V	Radial clearance between distributor shaft and bushing	.0013	.0027	.005

@In cases where the specified cam angle setting gives a point opening below the minimum tolerance, the point opening specification should be given preference.

Figure 12-1. (Sheet 3 of 3 Sheets) - Table of Limits

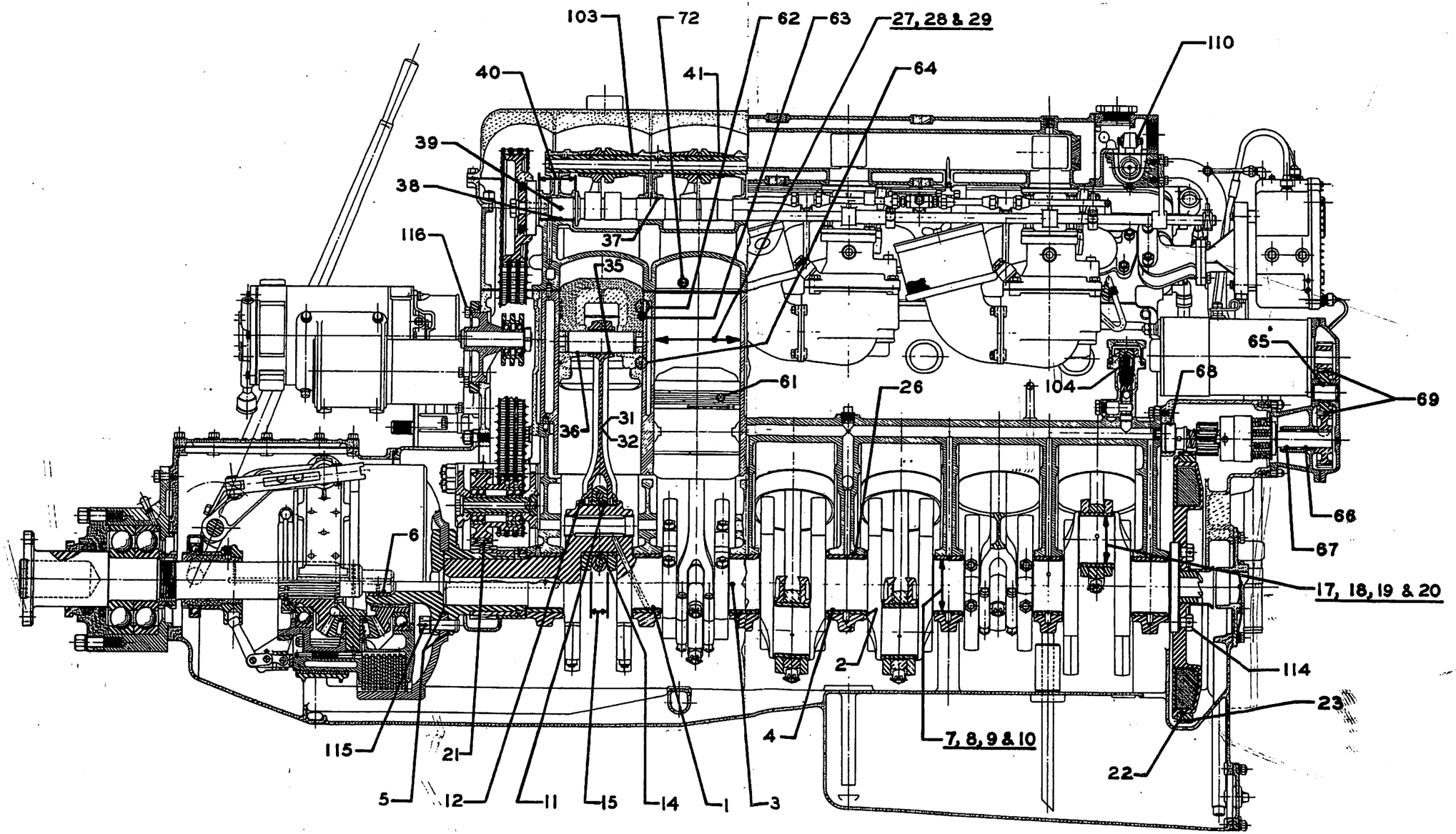


Figure 12-2. Limits Reference Chart No. I

HALL-SCOTT DEFENDER
MODEL 2268 & 2269

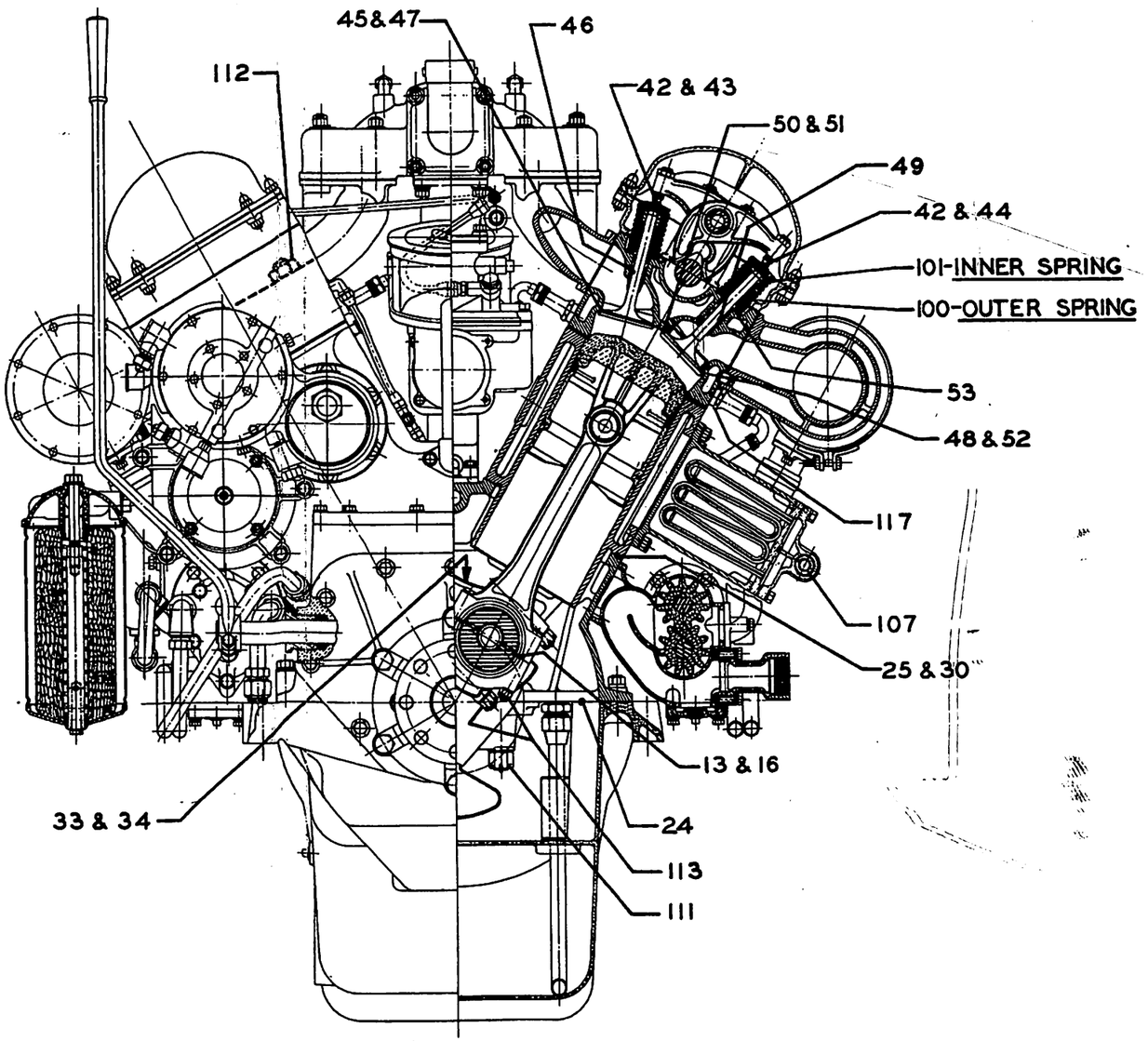


Figure 12-3. Limits Reference Chart No. II

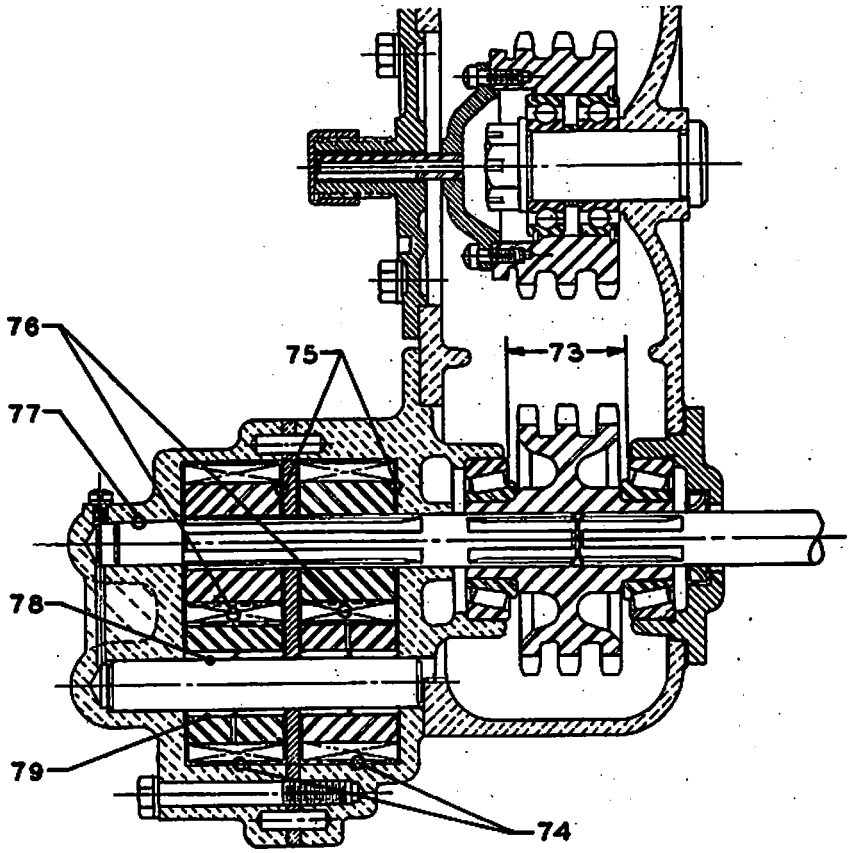


Figure 12-4. Limits Reference Chart No. III

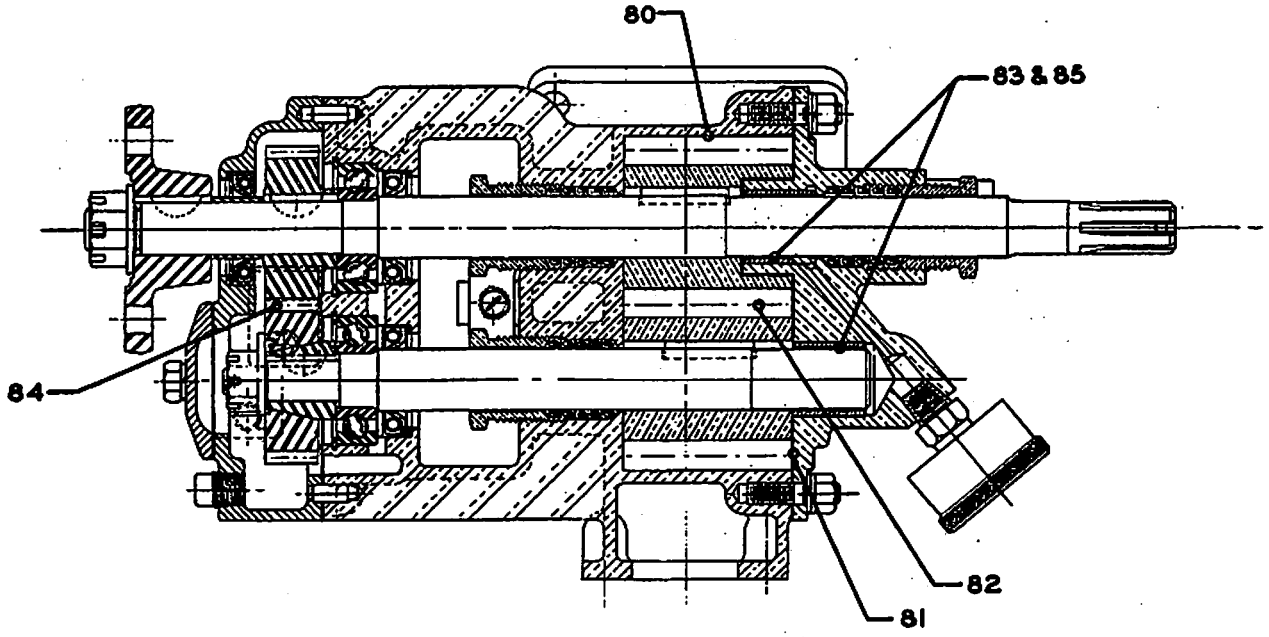


Figure 12-5. Limits Reference Chart No. IV

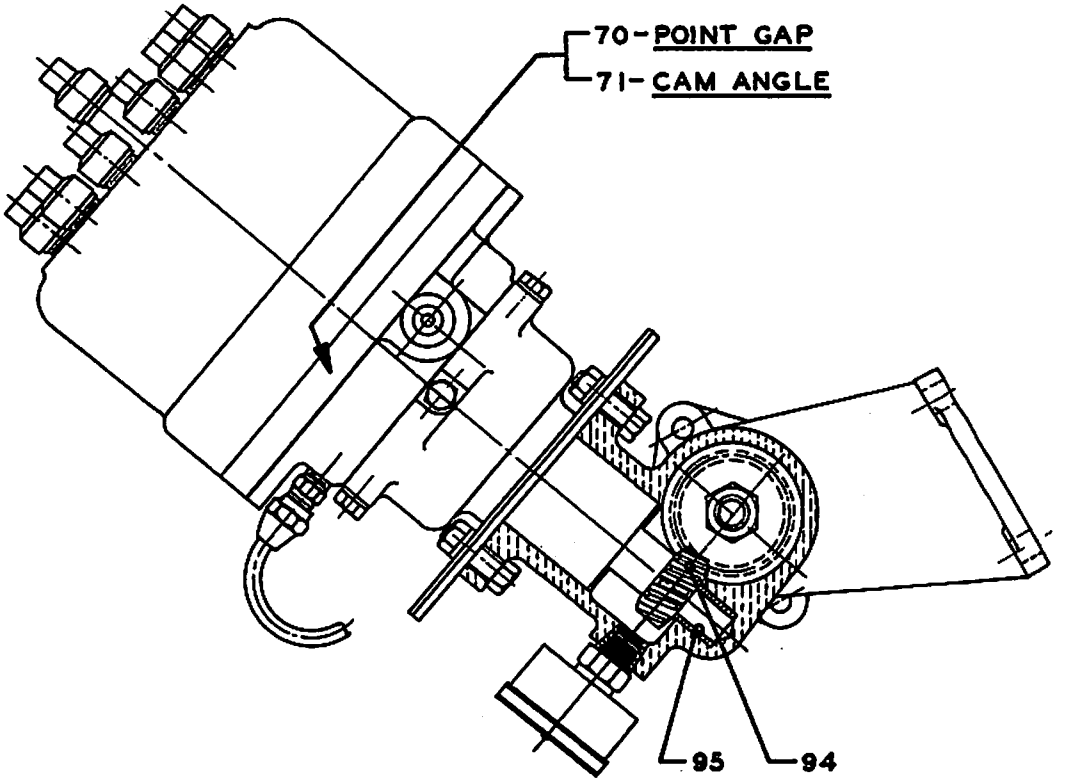


Figure 12-6. Limits Reference Chart No. V

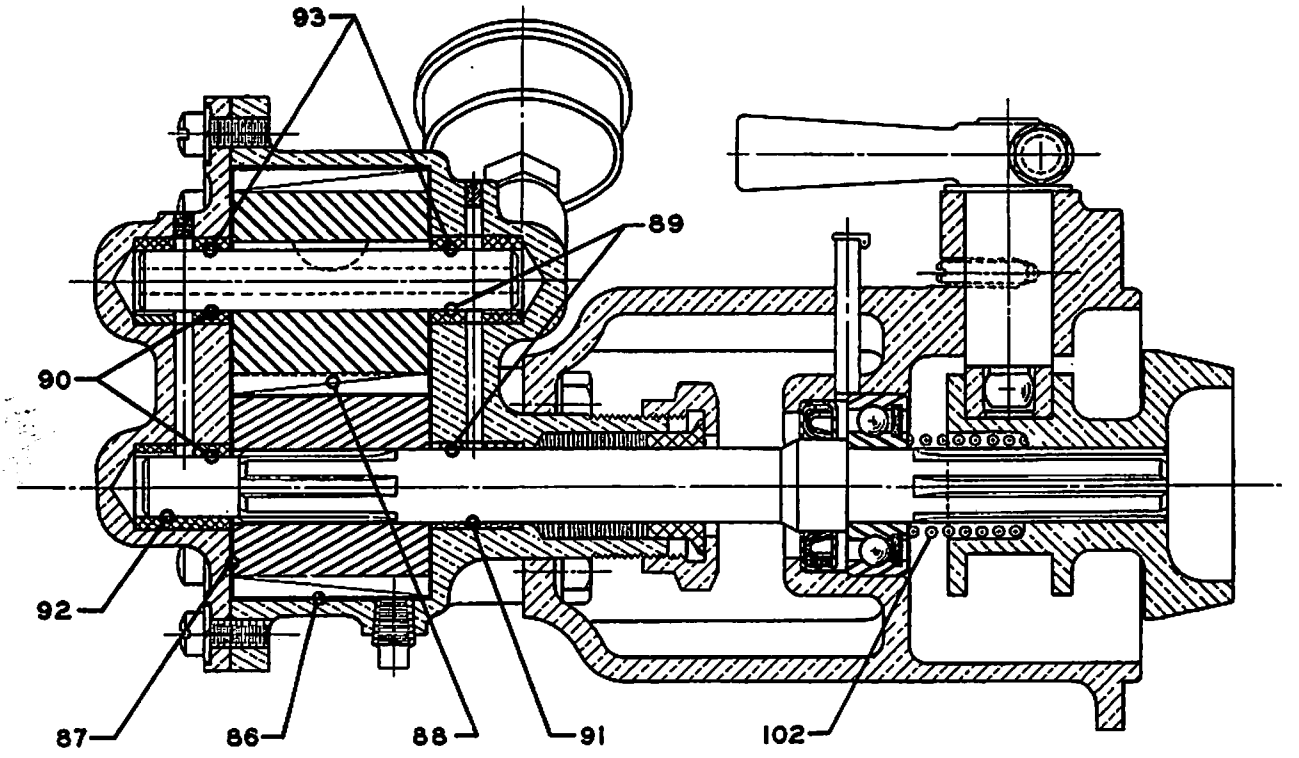


Figure 12-7. Limits Reference Chart No. VI

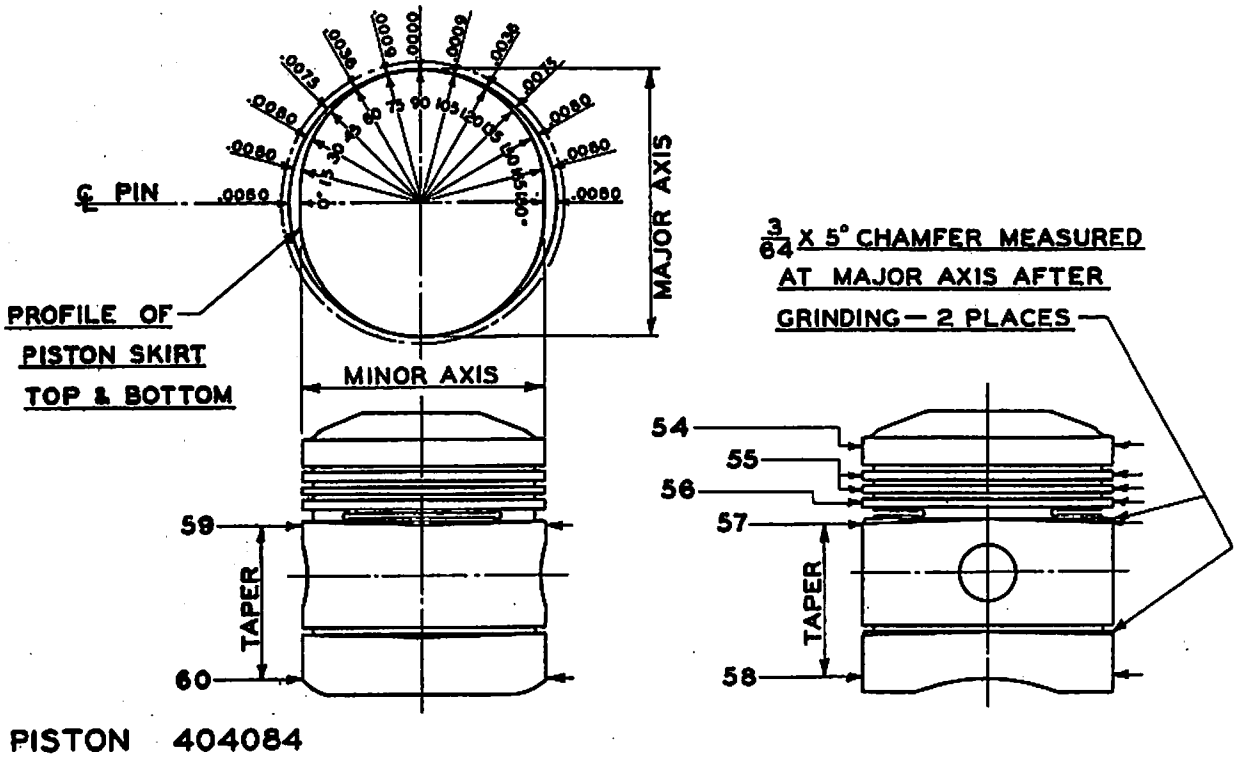


Figure 12-8. Limits Reference Chart No. VII

MISCELLANEOUS TABLE

SPRING SPECIFICATION

REF. NO.	CHART NO.	DESCRIPTION	FREE LENGTH	PRESSURE AND LENGTH	PRESSURE AND LENGTH
100	II	Valve spring - Outer 1-21/32 OD	3-3/16	138 to 148 lb when 2 in. lg	70 to 78 lb when 2-31/64 in.lg
101	II	Valve spring - Inner 1-11/64 OD	2-29/32	105 to 115 lb when 1-15/16 in.lg	45 to 51 lb when 2-27/64 in.lg
102	VI	Bilge pump drive spring 1-11/64 OD	2-1/4	210 to 220 lb when 1-1/2 in. lg	
103	I	Rockerarm spacing spring 1-25/64 OD	1-5/8		
104	I	Oil pressure regulating valve spring 9/16 OD	2-5/8	40 to 50 lb when 1-7/8 in. lg	
105		Oil pressure by-pass valve spring (oil filter) 45/64 OD	3-1/16	12 to 14 lb when 2-1/4 in. lg	7 to 8 lb when 2-9/16 in. lg
106		Oil pressure relief valve spring (oil filter) 9/16 OD	2-5/8	57 to 63 lb when 2-1/16 in. lg	
107	II	Oil pressure by-pass valve spring (oil cooler) 11/16 OD	3-3/8	21 to 23 lb when 2-9/16 in. lg	
108		Fuel pressure regulating valve spring 1/2 OD	1-13/16	2 lb when 1 in. lg	

THERMOSTAT SPECIFICATIONS

110	I	Thermostat valve is to be fully open at 49°C (120°F)

TORQUE TABLE FOR BOLTS, NUTS AND CAP SCREWS

REF. NO.	CHART NO.	DESCRIPTION		Size	Torque in lb - ft min	Torque in lb - ft max
111	II	Main bearing cap nuts		3/4-16	180	200
112	II	Cylinder head hold down nuts	large	3/4-16	230	250
			small	1/2-20	30	40
113	II	Connecting rod cap nuts	large	9/16-18	100	120
			small	3/8-24	30	35
114	I	Flywheel attaching cap screws		5/8-18	140	160
115	I	Reverse gear drum attaching nuts		5/8-18	140	160
116	I	Idler clamp ring and generator support tube nut		3/8-18	15	20
117	II	Spark plugs		18 mm	32	36

Figure 12-9. Miscellaneous Table

INSERT DRAWINGS HERE

Note: These pages appear to be missing in the book without these drawings.

Page 131 Fig. 12-10 Lubrication System

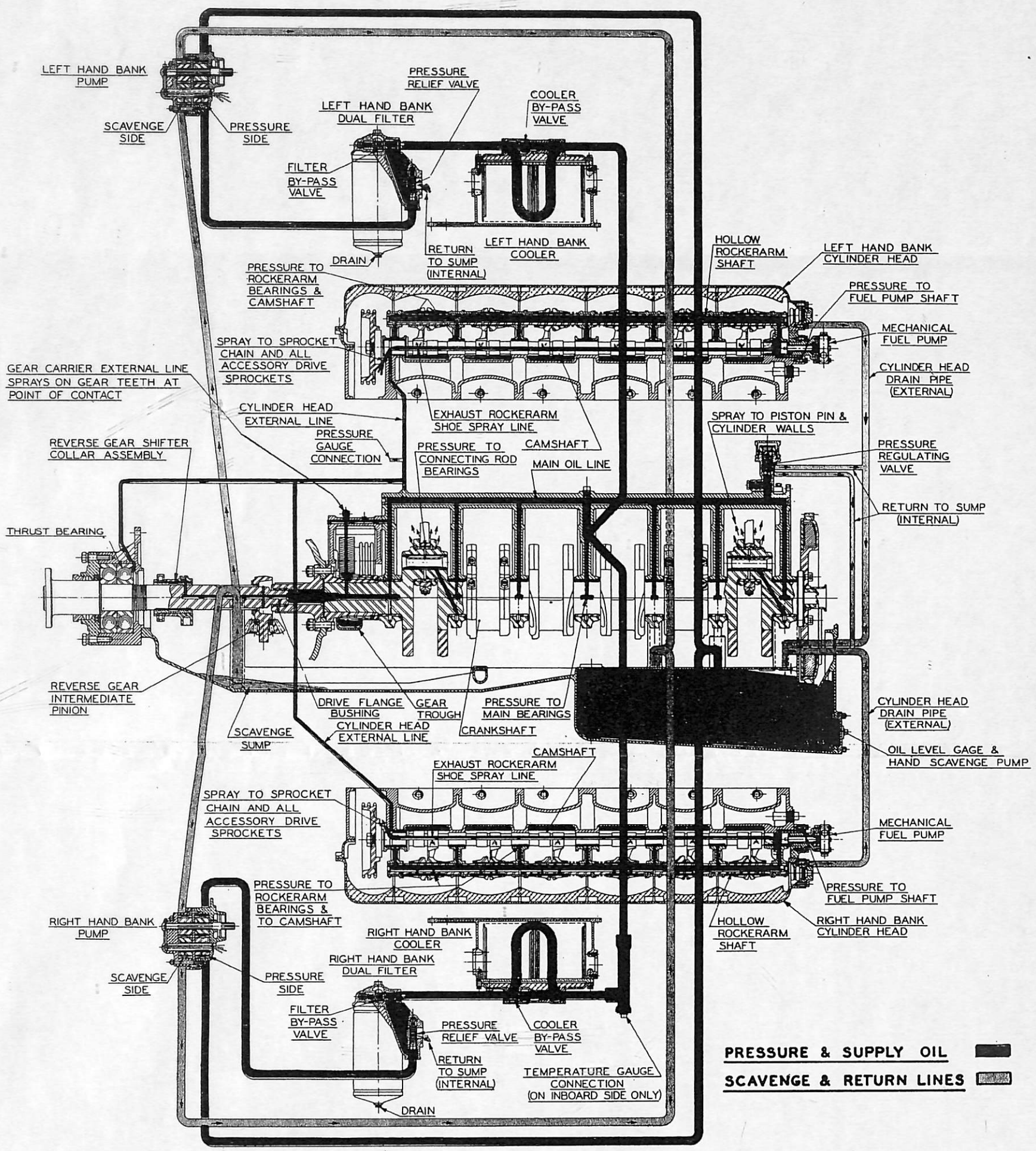


Figure 12-10. Lubrication System