EO 10A-10AA-3

ROYAL CANADIAN AIR FORCE

REPAIR AND OVERHAUL INSTRUCTIONS PRATT & WHITNEY R985AN-5, -14B ENGINES

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LIST OF RCAF REVISIONS

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FOREWORD

PURPOSE OF THE ORDER

1 This Engineering Order contains information and instructions for personnel engaged in the repair and overhaul of Pratt and Whitney R 985 engines, Models AN-5 and AN-14B.

METHOD OF USE

2 The information and instructions apply to both Models unless the difference between them is specifically stated.

3 Consult Part 5, Section 3, "Limits", before beginning an assembly operation.

4 Refer to Part 9, "Special Tools" to determine which tools will be required for a particular operation. The number of the tool group appears next to the heading of the paragraph describing the operation.

5 Consult, "List of Products and Suppliers" Part 7, to determine the commercial name of a product with an R.C.A.F. Specification number.

6 The explanation of symbols, codes and abbreviations is given in the Section in which they appear.

7 A description of the engine is given in EO 10A- 10AA-2, "Description and Maintenance Instructions". Reference to other Engineering Orders is made where pertinent.

8 Directional references such as right and left, clockwise and counter clockwise, upper and lower, apply to the engine as viewed from the rear on anti-propeller end, with the crankshaft horizontal and No. 1 cylinder at the top. The direction of rotation of each accessory drive is specified as it appears to an observer facing the accessory mounting pad.

9 Revisions and Amendments issued after the date of publication of this Order will supersede information contained herein.

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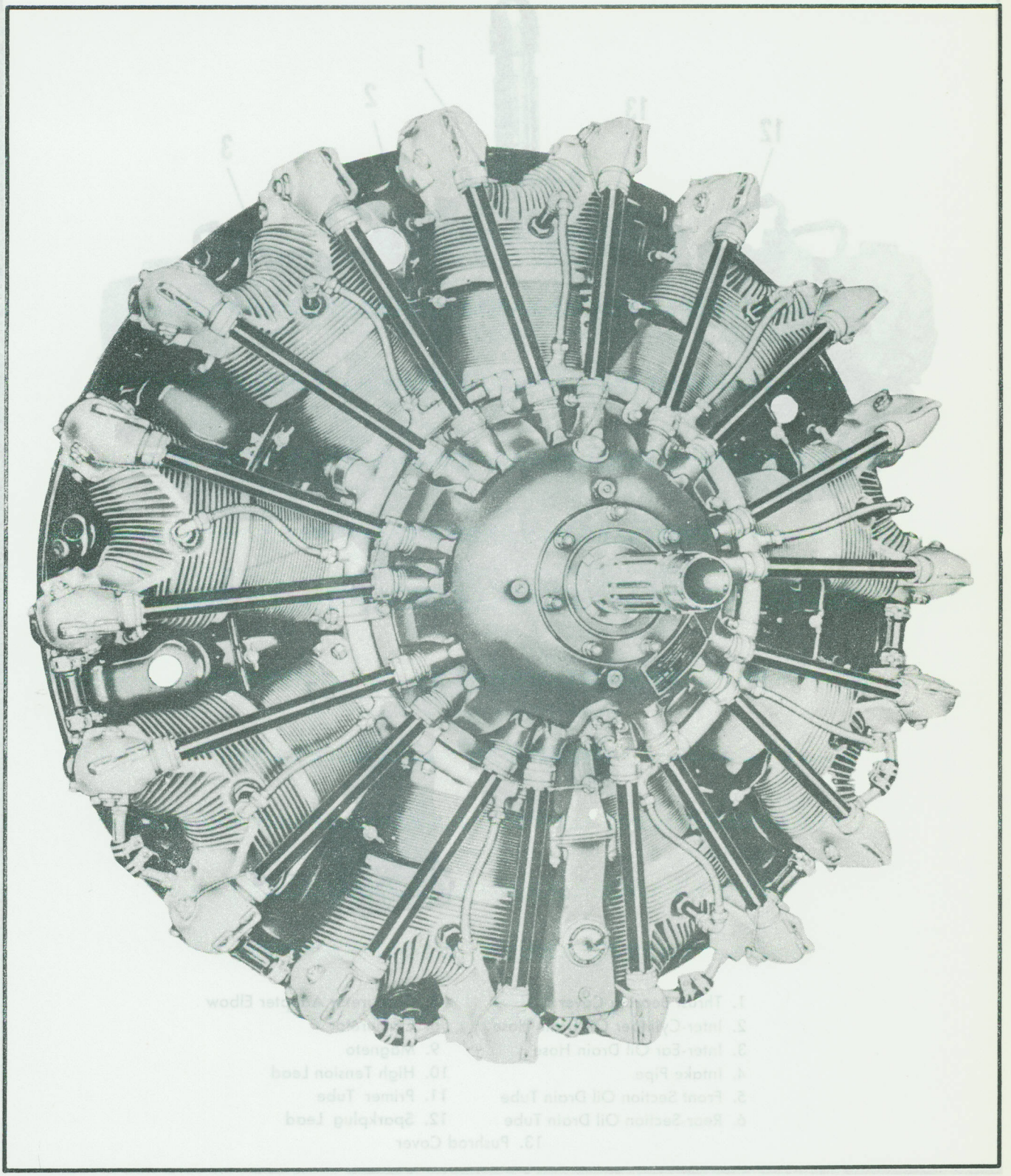
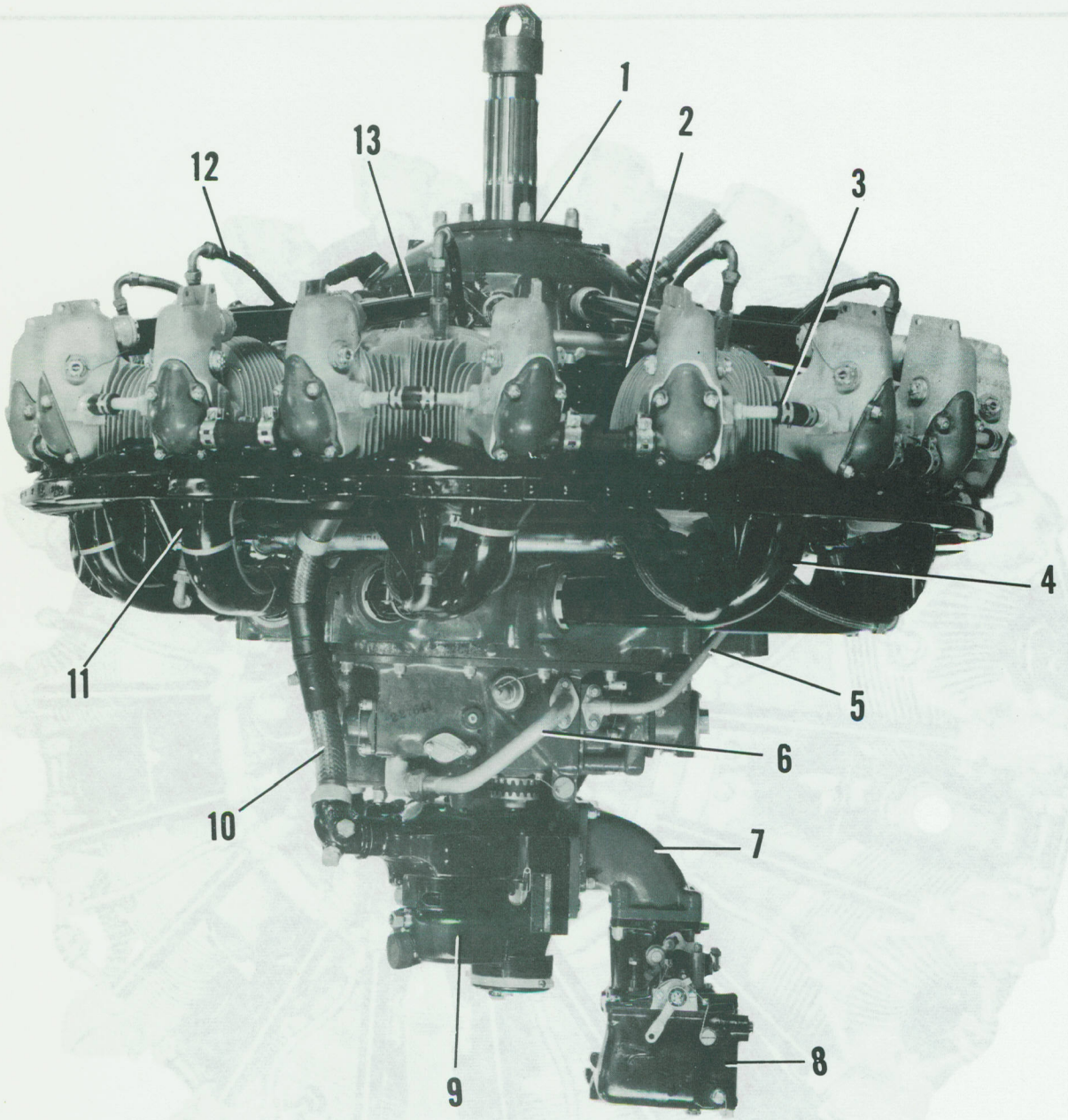


Front View



1. Thrust Bearing Cover
2. Inter-Cylinder Oil Drain Hose
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4. Intake Pipe
5. Front Section Oil Drain Tube
6. Rear Section Oil Drain Tube
7. Carburetor Adapter Elbow
8. Carburetor
9. Magneto
10. High Tension Lead
11. Primer Tube
12. Sparkplug Lead
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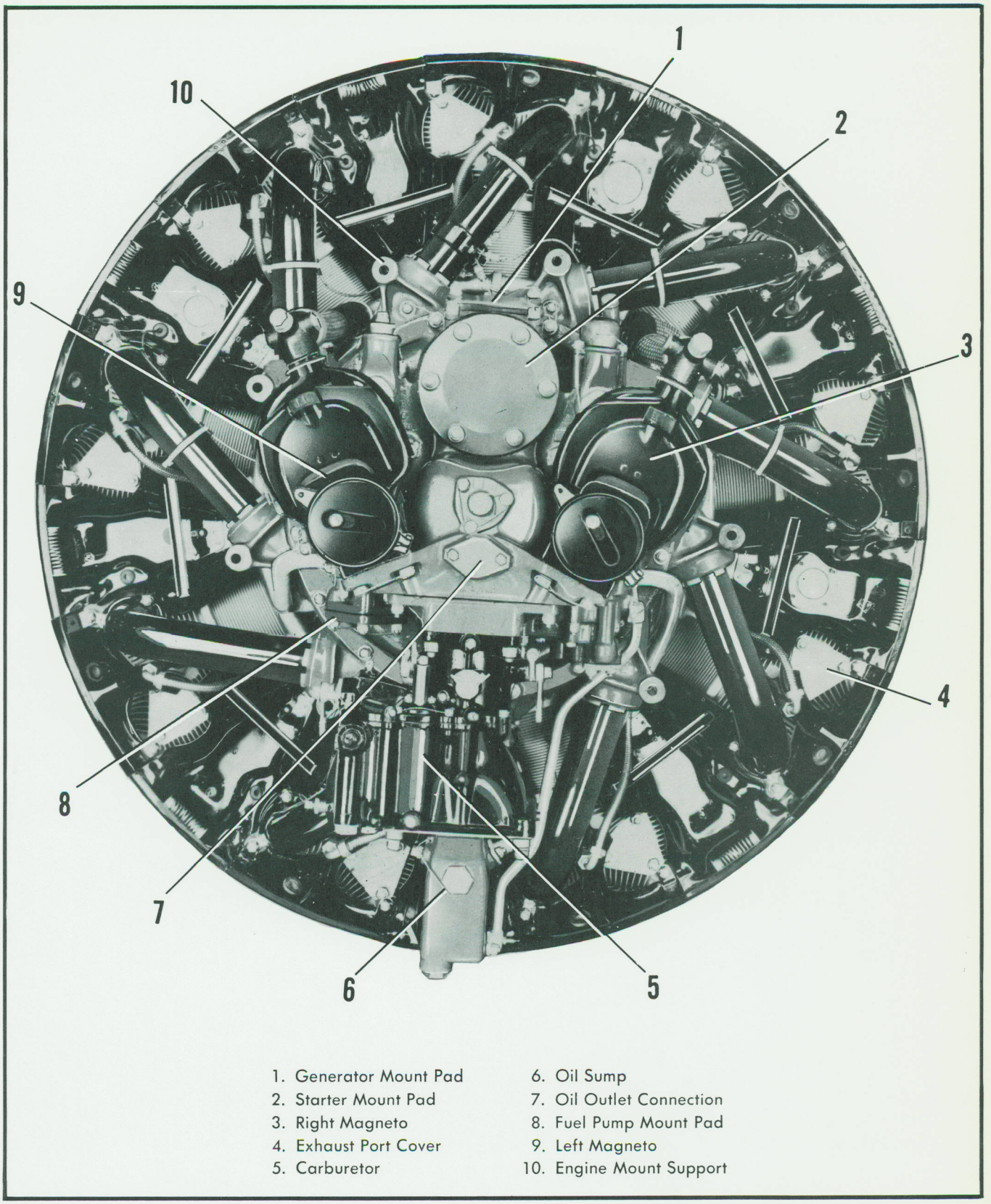
Side View



1. Generator Mount Pad
2. Starter Mount Pad
3. Right Magneto
4. Exhaust Port Cover
5. Carburetor
6. Oil Sump
7. Oil Outlet Connection
8. Fuel Pump Mount Pad
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10. Engine Mount Support

Rear View

1. Generator Mount Pad
2. Starter Mount Pad
3. Right Magneto
4. Exhaust Port Cover
5. Carburetor
6. Oil Sump
7. Oil Outlet Connection
8. Fuel Pump Mount Pad
9. Left Magneto
10. Engine Mount Support

Rear View

PART 1

BASIC CONSTRUCTION

1 The Pratt and Whitney R985 Engine is a single row, nine cylinder radial, air cooled, supercharged engine. The AN-14B is designed for horizontal installation in a conventional aircraft, whereas the AN-5 Model is adapted for vertical installation in a helicopter. The cylinder numbering and firing order is illustrated in Figure 1-1. For ease of description the engine is divided into sections as illustrated in Figure 1-2. The combination of crankcase and cylinders may sometimes be referred to as the Power Section. Figure 1-3 is an exploded view of the engine.

FRONT SECTION

FRONT CASE AN-14B Model

2 The front case supports in its bore a ball bearing which transmits part of the propeller thrust, from the crankshaft to the engine mounting brackets via the main crankcase. The crankshaft is located in the thrust bearing by means of the thrust bearing spacer.

3 Bosses in the front case provide support for the valve tappet guides which accommodate

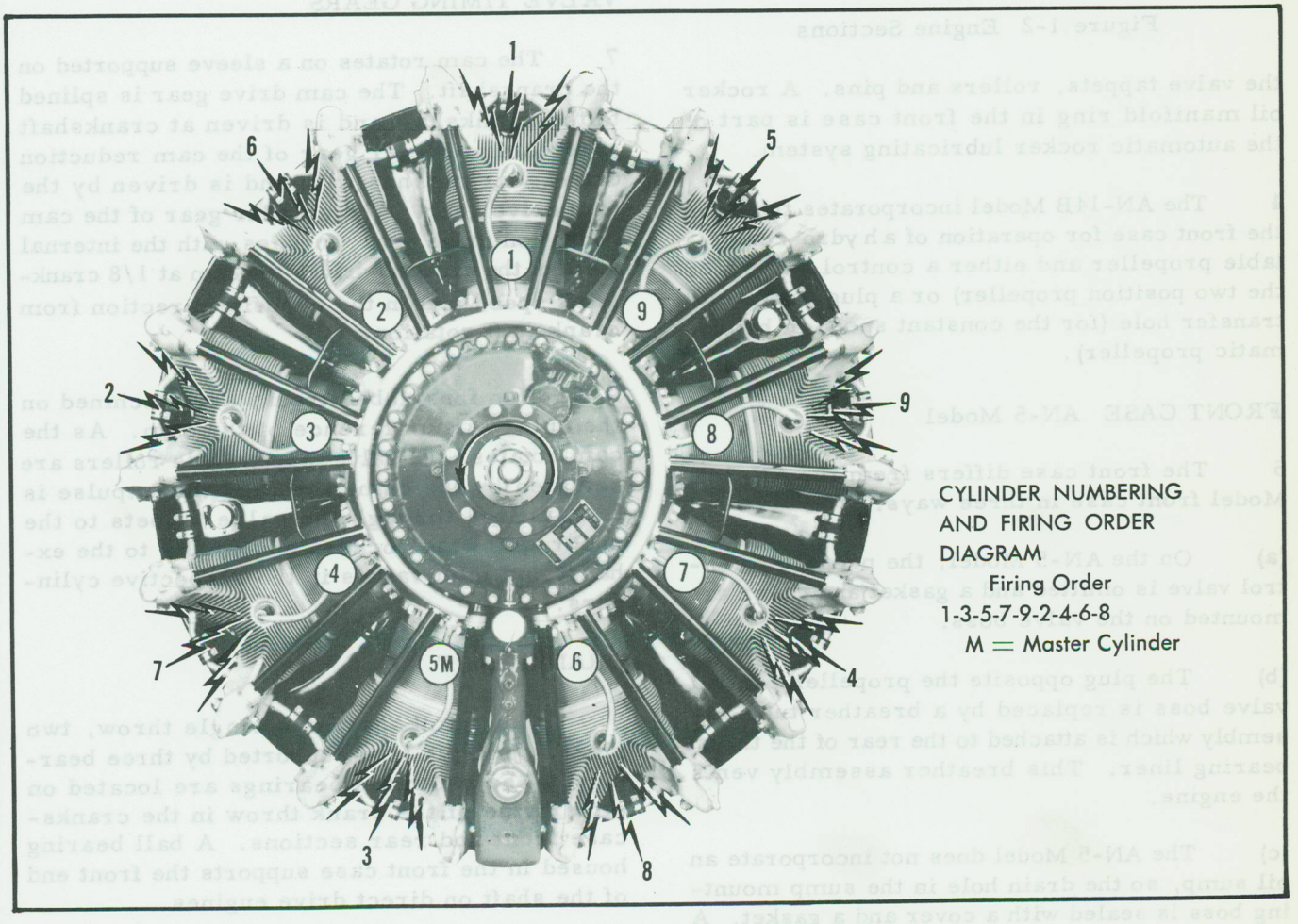


Figure 1-1 Cylinder Numbering and Firing Order

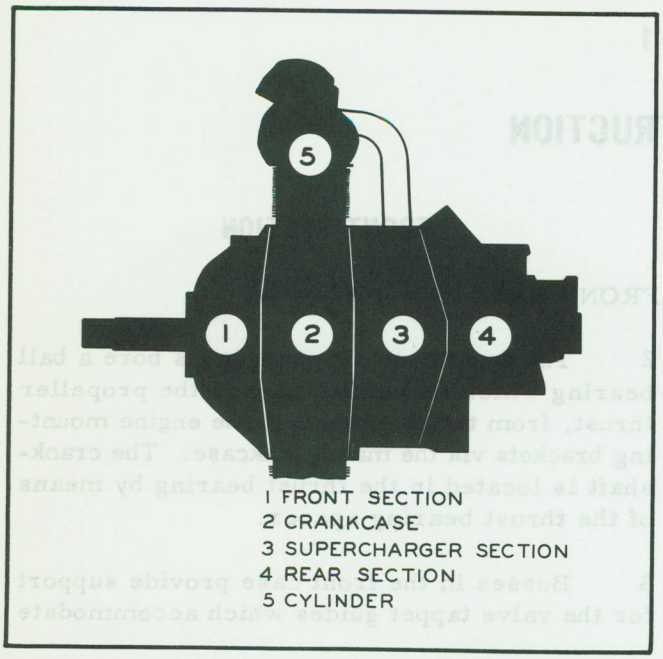


Figure 1-2 Engine Sections

the valve tappets, rollers and pins. A rocker oil manifold ring in the front case is part of the automatic rocker lubricating system.

4 The AN-14B Model incorporates tubing in the front case for operation of a hydro-controllable propeller and either a control valve (for the two position propeller) or a plug with an oil transfer hole (for the constant speed of hydromatic propeller).

FRONT CASE AN-5 Model

5 The front case differs from the AN-14B Model front case in three ways.

(a) On the AN-5 Model, the propeller control valve is omitted and a gasket and cover are mounted on the valve boss.

(b) The plug opposite the propeller control valve boss is replaced by a breather tube assembly which is attached to the rear of the thrust bearing liner. This breather assembly vents the engine.

(c) The AN-5 Model does not incorporate an oil sump, so the drain hole in the sump mounting boss is sealed with a cover and a gasket. A drain hole is provided in the rear face of the boss and two studs are installed to provide for the attachment of the front section to the oil pump oil scavenge tube.

CRANKCASE SECTION

CRANKCASE

6 The crankcase has front and rear sections which are held together by nine crankcase bolts located between the cylinder mounting pads. The sections are machined together and are not interchangeable. The front and rear main bearings, located in the crankcase front and rear sections, respectively, support the crankshaft assembly in the crankcase. A bronze bushing is pinned in the forward face of the crankcase front section to support the rear end of the cam reduction drive gear.

VALVE TIMING GEARS

7 The cam rotates on a sleeve supported on the crankshaft. The cam drive gear is splined to the crankshaft and is driven at crankshaft speed. The larger gear of the cam reduction drive gear meshes with and is driven by the cam drive gear. The smaller gear of the cam reduction drive gear, meshes with the internal teeth of the cam and drives the cam at 1/8 crankshaft speed and in the opposite direction from crankshaft rotation.

8 Two four-lobed tracks are machined on the outer circumference of the cam. As the cam rotates, the valve tappet guide rollers are actuated by the cam lobes and the impulse is transmitted through the valve tappets to the pushrods to the rockers and finally to the exhaust and inlet valves in the respective cylinders.

CRANKSHAFT

9 The crankshaft is a single throw, two piece, split-pin type supported by three bearings. The two main bearings are located on either side of the crank throw in the crankscase front and rear sections. A ball bearing housed in the front case supports the front end of the shaft on direct drive engines.

10 The front section of the crankshaft is

splined to the rear section of the shaft and is held rigid by a through bolt.

11 The reciprocating and rotating parts of the crankshaft are counterbalanced by weights whioh are riveted to the cheeks of the crankshaft. Two flyweights in the rear counterweight ensure vibrationless performance at all speeds.

12 An oil jet in the crankshaft front half rear plug and another on the top of the rear cheek furnish spray lubrication to the pistons, pistonpins and cylinder walls.

MASTER AND LINKRODS

13 The masterod is of one piece construction, incorporating a pressed-in, steel backed, leaded silver bearing. Eight "I" section linkrods, having bronze linkpin and pistonpin bushings, are connected to the masterod by linkpins and to the pistons by full-floating pistonpins.

SUPERCHARGER SECTION

SUPERCHARGER CASE

14 The supercharger case is attached to the rear of the crankcase and is provided with nine bolt bosses for securing the engine in the aircraft. The front end of each magneto drive gear shaft is supported by a bronze bushing set into the front end of the case and the front end of the starter gear is supported by a ball bearing mounting in the front of the case.

15 On the AN-14B Model, a breather tube assembly is located between the No. 2 and 3 intake pipe bosses on the supercharger case. The an-5 Model is vented through the front case so the breather assembly on the supercharger case on this engine is replaced by a recessed head plug.

16 On the AN-5 Model, three duraluminum oil scavenge sleeves are provided in the supercharger case to carry oil from the supercharger case to the rear case which acts as a sump on the engine. The sleeves are a tight fit in the supercharger case.

IMPELLER AND GEARS

17 The impeller is splined to the rear of the impeller shaft with the flat face adjacent to the rear face of the supercharger case. The impeller is driven through the impeller spring drive coupling, a floating gear and the impeller intermediate drive gear at 10 times crankshaft speed.

18 On the AN-14B Model the impeller shaft is supported in the case by three ball bearings whereas on the AN-5 Model the impeller shaft is supported by two steel-backed bronze bushings.

19 In addition on the AN-5 Model, a steel journal is splined on the impeller shaft at the rear of the impeller shaft gear to provide a smooth contact with the rear impeller bearing. The AN-5 Model incorporates a groove in the OD of the rear supercharger bearing cover for the installation of a neoprene oil seal. This seal replaced the gasket used on engines designed for horizontal installation. A spring loaded oil seal is inserted in the bore of the rear supercharger bearing cover on the AN-5 Model.

OIL SUMP

20 An oil sump containing two chambers is located between cylinders No. 5 and 6 on the AN-14B Model. On the AN 14-B Model, the sump is attached to the front and supercharger sections respectively. The AN-5 Model does not have a conventional sump, but uses the rear case as a sump.

REAR SECTION

REAR CASE

21 The rear case attaches to the rear of the supercharger case and supports the accessories and accessory drives. The front face incorporates a vaned diffuser and the rear face an intake duct containing three vanes in its elbow. The case also incorporates an oil pressure chamber containing an oil screen and check valve, a three section oil pump and an oil pressure relief valve.

22 Mounting pads are provided for the carburettor adapter, two magnetos, a fuel pump, starter, vacuum pump adapter, and tachometer.

The AN-14B Model provides drives for a generator whereas the AN-5 Model does not have a generator.

ACCESSORY DRIVES

23 The accessories are driven by three shafts which extend entirely through the supercharger and rear sections. Each shaft carries a spur gear at its forward end which meshes with a gear coupled to the rear of the crankshaft. The upper shaft provides a drive for the starter and for the generator on the AN-14B Model. Each of the two lower shafts drives a magneto through an adjustable flexible coupling. Four vertical drives are provided for by a bevel gear keyed to each magneto drive shaft. Two vertical drive shafts for operating accessories and two tachometers are driven from the upper side of the bevel gears. The under sides of the bevel gears drive an oil pump on the right side and a fuel pump on the left. An additional drive, for a vacuum pump, is located at the lower left of the left magneto drive.

CYLINDERS

CYLINDER HEADS AND BARRELS

24 The cylinders are of steel and aluminum construction. The barrels are machined from steel forgings and have integral cooling fins. The heads are made from aluminum castings and have deep cooling fins and rocker boxes cast integral. The head is threaded and shrunk onto the cylinder barrel, thus forming a semi-permanent assembly. Each cylinder has one inlet valve and one exhaust valve. The inlet valve seats on a bronze seat and the exhaust valve on a steel seat both of which are shrunk into the head. The cylinder also incorporates bronze inlet and exhaust valve guides, bronze bushings for two spark plugs, and four steel bushings for supporting the two rocker shafts. Fins of extreme depth are concentrated on the top and exhaust side of the head and around the exhaust port where the greatest heat dissipation is required. Shallow fins are incorporated on the inlet side. Oil drain tubes are installed in the exhaust and inlet rocker boxes and are connected by a rubber sleeve for inter-cylinder oil drainage. Pressure type deflectors force a high velocity flow of cooling air between and over the cylinder fins.

VALVE MECHANISM

25 All valve operating parts are enclosed and are pressure lubricated. The rocker arms are housed in rockerboxes cast integral with the cylinder head and are supported on double row ball bearings. Eighteen tappets, located in the front case, are actuated by the action of the rollers on the cam lobes and in turn actuate the rocker arms through tubular pushrods. The pushrods are protected by removable oil tight covers. The valve clearance adjusting screw in the front end of each rocker arm has a half ball for self alignment with the valve stem. Rockerbox covers enclose the rocker arms in the rockerboxes.

26 Two concentric valve springs are secured to each valve stem by an upper and lower washer and a split cone. A snapring is installed on each valve stem to prevent the valves from dropping into the cylinder while the split cones are being removed or installed. The inlet valves are solid whereas the exhaust valves are hollow and are sodium filled for cooling. The sodium turns to liquid form under the heat of the exhaust, and dissipates some of the heat assimilated by the exhaust valve in operation. A stellite face prolongs the life of the seating surface of the exhaust valve.

PISTONS

27 The pistons are machined from aluminum alloy forgings and are of the flat-head, full skirt type. Each piston has five ring grooves and is fitted with wedge type compression rings in the first three grooves, dual oil control rings in the fourth groove and an oil scraper ring in the bottom groove The top compression ring is chromium plated on the face which bears against the cylinder wall. Steel piston pins connect the pistons to the master and linkrods.

SYSTEMS

OIL

28 Oil is circulated through the engine by a three section gear pump mounted in the lower right hand side of the rear case. Oil from the tank enters the oil inlet at the bottom of the pump and is directed to the pressure (lower)

section of the pump from where it is forced to the oil screen chamber through a cored passage in the rear case. The oil passes through the screen assembly and the pressure of the oil opens the spring loaded check valve. When the engine is not operating, the check valve prevents oil from seeping into or out of the engine.

29 When the oil emerges from the check valve, it is diverted into two main branches.

(a) In the first branch, the oil is directed through a passage to an annulus around the right magneto drive gear shaft rear bushing. Part of the oil from this annulus is carried by drilled passages to the right accessory drive gear bushing. Here the oil enters the hollow accessory drive gear shaft and flows upward to the starter shaft bushing. Part of the oil from this annulus flows upward through a drilled passage to lubricate the accessory and another part enters the magneto drive gear shaft and flows forward to lubricate the front bushing.

(1) Another passage carries the oil from the annulus encircling the right magneto drive gear shaft rear bushing to the oil pressure relief valve, which regulates the engine oil pressure. By-passed oil is returned to the inlet side of the oil pump pressure section.

(b) In the second branch, oil is directed to the left side of the rear case where the oil flow divides. Part of the oil enters the annulus which encircles the left magneto drive gear shaft rear bushing. Drilled passages from this annulus carry oil to the left accessory drive gear bushing. Here the oil enters the hollow accessory drive gear shaft and flows upward to the starter shaft bushing. Other drilled passages and tubes carry the oil to the vacuum pump, tachometer and starter gears. Oil from the annulus around the left magneto drive gear shaft rear bushing flows upward through a drilled passage to lubricate the accessory; oil also enters the shaft and flows forward to an annulus around the front bushing where it is directed by a drilled passage to the front of the supercharger case. Here the oil provides lubrication for the impeller shaft bearings.

30 Oil for the crankcase and front sections is carried from the left side of the rear case through the rear and supercharger cases by a tube. The supercharger case oil pressure tube bracket supports a tube assembly which transfers the oil to the crankcase and also provides spray lubrication for the floating gear and impeller intermediate drive gear. The oil passes from the pressure tube bracket through a series of tubes and drilled passages in the crankcase to the cam oil feed bracket on the front face of the crankcase.

31 At this point the oil is introduced into the crankshaft by means of the cam oil feed bracket where a drilled passage in the crankshaft directs it to the crankpin for lubrication of the masterod bearing, linkpins, pistonpins, and cylinder walls. The cylinder walls and pistonpins are lubricated by spray from the oil jets- one in the rear of the front crankshaft and the other at the top of the rear cheek - and also from oil which passes the masterod bearing and linkpin bushings.

32 Part of the oil at the cam oil feed bracket is routed to the cam bearing and cam reduction gear bushing to provide lubrication at these points.

33 In the AN-14B Model, oil from the cam oil feed bracket is piped to a two position valve in the nose section from whence it is introduced into the propeller shaft through an oil transfer for the operation of a hydro-controllable propeller. If a constant speed governor is mounted on the rear section of the AN-14B Model engine, a plug is installed in the nose section in place of the two position valve and an external oil line from the rear section is connected to this plug to furnish oil for the operation of the constant speed propeller, in which case oil from the feed bracket is not utilized.

34 In the AN-5 Model, oil from the cam oil feed bracket is piped to a bushing in the front case where the propeller control valve is ordinarily located on R985 engines. The oil flows around the bushing and is directed through a tube to the thrust bearing spacer to provide a constant flow of oil to the thrust bearing.

35 An oil manifold ring, fastened to the tappet bosses in the front section, conducts oil to the tappet guides. Oil from the tappets feeds

through the pushrods to the rocker arms, rocker arm bearings, and valve clearance adjusting screws.

36 In the AN-14B Model, the surplus oil in the engine proper drains into the main sump from where it is pumped back through the scavenge pump. Oil from the rocker boxes drains through the pushrod covers to the front case, or through a system of inter cylinder drains to an additional compartment in the sump where it is returned to the oil tank. The rear oil case drains through a tube into the supercharger case, then into the sump.

37 In the AN-5 Model, the rear case acts as a sump. Drain oil from the rockerboxes is carried by inter-rockerbox and inter-cylinder drain tubes to the rockerbox oil scavenge tube. This tube carries the oil to the rear case. Oil from the main crankcase drains into the rear case through three sleeves extending through the supercharger case. A tube attached to the lower side of the front case carries drain oil to the rear case where it enters the small scavenge section of the oil pump. The large scavenge section of the oil pump scavenges the rear case through an external tube extending from the bottom to the right side of the rear case. The scavenge sections of the pump force the oil through the oil outlet port located in the centre of the carburettor mounting flange.

INDUCTION

38 These engines are equipped with float type carburettors. The carburettor meters fuel in proportion to the mass air flow to the engine. The mass air flow to the engine is determined by the throttle opening. After being metered by the carburettor, the fuel is discharged into the air stream to the impeller where it is thoroughly mixed with the air, vapourized, and then delivered to the cylinders through the intake pipes and inlet valves. On the AN-5 Model, a right angle adapter elbow is provided for the carburettor mounting to bring the carburettor into its normal operating position. Consult EO 15 - 10 AA Series for information on the NA R9B Carburettor.

IGNITION

39 Ignition is furnished by two Scintilla SB9RN - 3 or 4 magnetos located at the rear of the engine. The right magneto fires the front sparkplug and the left magneto fires the rear sparkplug in each cylinder, thus giving two independent sources of ignition. The ignition manifold and sparkplugs are shielded to prevent radio interference. For a diagram of the ignition system see Figure 1-4.

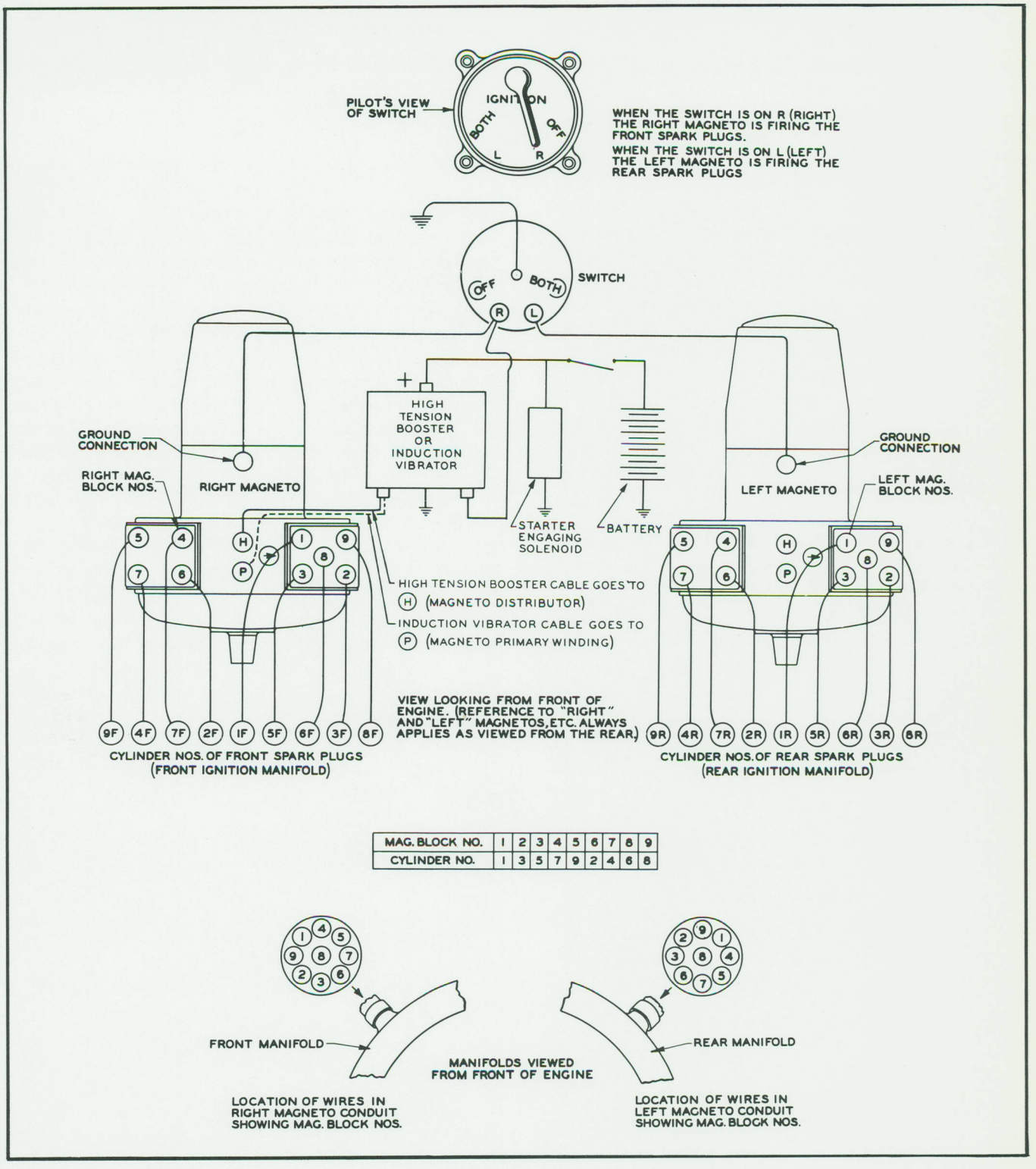


Figure 1-4 Ignition Wiring Diagram

PART 2

DISMANTLING & DISSASSEMBLY

GENERAL

1. The disassembly of each sub-assembly is described immediately following the removal of the sub-assembly from the engine.

2 Immediately after removing each sub-assembly or part from the engine, transfer it to a bench, container, or a part rack, and arrange it so as to protect the assembly or part from damage. In handling sub-assemblies, provide proper covering or support to protect shafts, gears, studs, or any projecting part from being bent, scratched, or otherwise damaged. Exercise extreme care in the handling and disposition of bearings, particularly those with leaded surfaces. Wrap all bearings in moisture-proof paper before placing them in containers. Ball bearings should be wired together in two places to prevent scrambling of their parts during overhaul.

3 During various stages of disassembly, examine all engine parts for signs of scoring, burning, or any other evident damage. Note the presence of loose metal or indications of defects which would not be apparent after cleaning, and tag suspect parts before they are washed and laid out for detailed inspection.

4 Before cleaning any part, refer to Part 3, "Cleaning".

5 For a list of tools to be used in each operation refer to Part 9 under the applicable tool group number.

6 Remove all lockwire, cotterpins, nuts, washers, tablocks, bolts and screws as necessary before attempting to disassemble any part of the engine.

SECTION 1

DISMANTLING

PRELIMINARY OPERATIONS

REMOVAL OF ENGINE FROM CONTAINER

1 Remove the nuts, spacers and lockwashers which secure the engine to the container, then lift the engine carefully from the container using a chain hoist and PWA. -520 Hook.

INSTALLATION IN ENGINE STAND (Tool Group 65)

2 If the engine has just been removed from the airplane or helicopter, remove the carburettor and gaskets. Remove all accessories except the magneto and ignition manifolds before the engine is mounted in the engine stand. Install the lifting eye on the engine, and using a chain hoist in conjunction with the hook, carefully lower the engine into the mounting stand equipped with the mounting plate. Secure the supercharger case to the mounting plate with four bolts, washers and nuts.

EXTERNAL CLEANING

3 Remove all dirt and grease from the external surfaces of the engine by spraying the engine with kerosene or white furnace oil.

CAUTION

Do not allow any of the cleaning fluid to enter the magnetos or ignition manifolds.

OIL DRAIN PLUGS AND OIL SCREENS
(Tool Group 79)

4 Turn the engine to a horizontal position in the stand, and provide screened receptacles under the engine to collect the drail oil. Unscrew the oil drain plug located next to the left accessory drive mounting pad. Use the cover nut wrench to unfasten the oil screen cover nut; then remove the cover, spring, oil screen and check valve assembly. Use the plug wrench to remove the drain plugs from the sump.

5 Examine the plugs and the oil screen, and the screen covering the receptacles, for the presence of metal chips or foreign matter which would indicate a failure or some other unsatisfactory condition in the engine (Figure 2-1).

6 After draining the engine, screw the plugs back into the sump so that they will not be lost.

SPARKPLUGS AND SPARKPLUG LEADS
(Tool Group 115)

7 Using a lead nut wrench, and being careful not to allow the elbows to turn or the wrench to slip, unscrew the nuts which secure the sparkplug lead elbows. Withdraw the connector from each sparkplug and install a suitable protective cap over each connector (Figure 2-2). Remove the sparkplug, using the sparkplug wrench; then

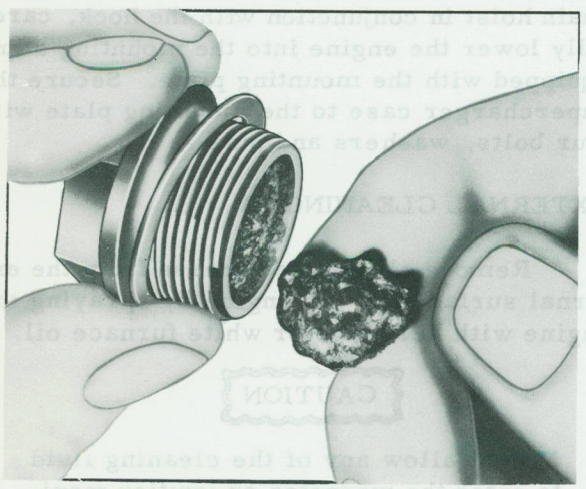


Figure 2-1 Examine Oil Drain Plug

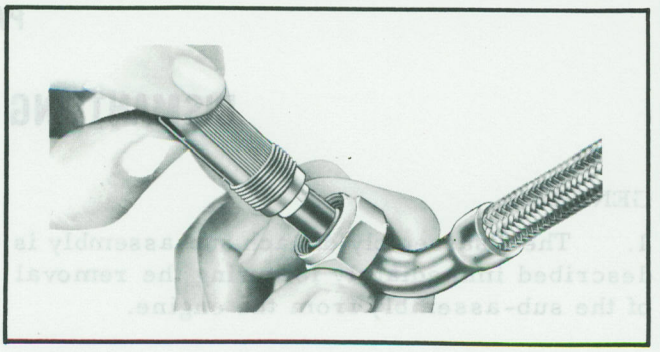


Figure 2-2 Connector Cap

install the plugs in the sparkplug bushings.

MAGNETOS

8 Loosen the knurled coupling which secures each flexible manifold conduit to its distributor block cover elbow. Remove the two screws which secure each elbow to its distributor block cover.

9 Remove the screw which joins the halves of each distributor block cover (Figure 2-3). Remove the two safety pins and disengage the two spring locks on each distributor block cover and remove the cover halves. Lift out the distributor block (Figure 2-4) and warp each distributor block in moisture-proof paper to keep it clean and dry. Remove the three cap screws which attach each magneto to the engine; then lift off each magneto and its rubber coupling (Figure 2-5). Insert a suitable dummy wooden block in place of each distributor block.

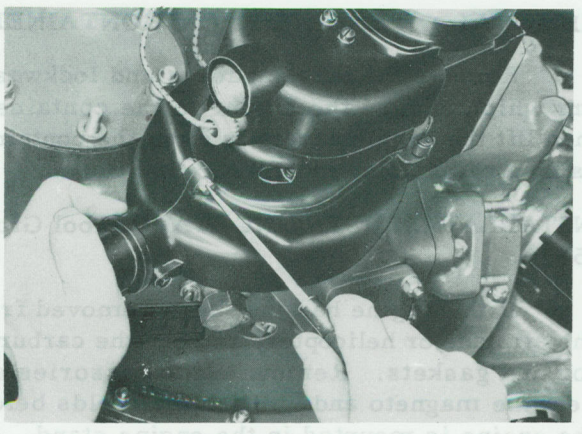


Figure 2-3 Remove Cover

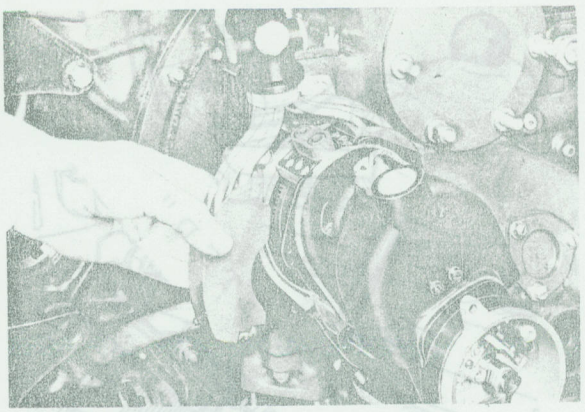


Figure 2-4 Remove Block

MAGNETO COUPLING GEAR SCREWS (tool Group 76)

10 Use the wrench to loosen, but do not remove, the screws which fasten the magneto coupling gears to the rear ends of the magneto drive shaft gears.

PRIMER LINES AND PRIMER DISTRIBUTOR

11 Disconnect all primer lines at the primer distributor and at the Nos. 1, 2, 3, 8 and 9 cylinders to which they are attached. Unfasten the clamps securing the lines to the intake pipes and withdraw each primer line from the cylinder deflector through which it extends. Do not remove the distributor from the No. 1 intake pipe until that intake pipe has been disassembled from the engine.

CRANKSHAFT RUNOUT CHECK

12 Mount a dial indicator on a thrust bearing cover stud with the plunger of the indicator resting on the shaft (Figure 2-6). Rotate the shaft slowly while observing the dial indicator. The runout should not exceed .005 inch and .015 inch full indicator reading on the rear and front cone seats, respectively. In the event that these limits are exceeded, particular note should be made for further investigation after the engine has been completely disassembled.

THRUST BEARING NUT (Tool Group 128)

13 To facilitate later removal of the thrust bearing nut, loosen it one turn, using the applicable wrench and turning bar.

STARTER JAW NUT

14 Remove the starter pad cover plate from the rear case and loosen the starter jaw nut, but do not remove it at this time.

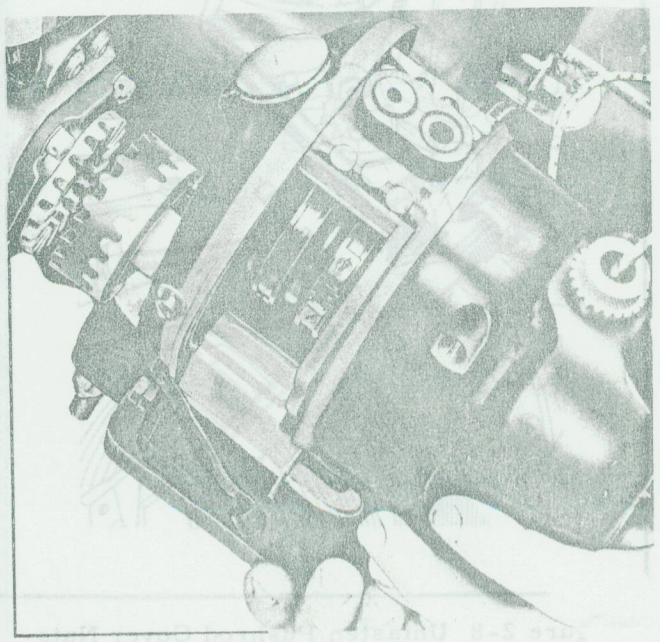


Figure 2-5 Remove Magneto

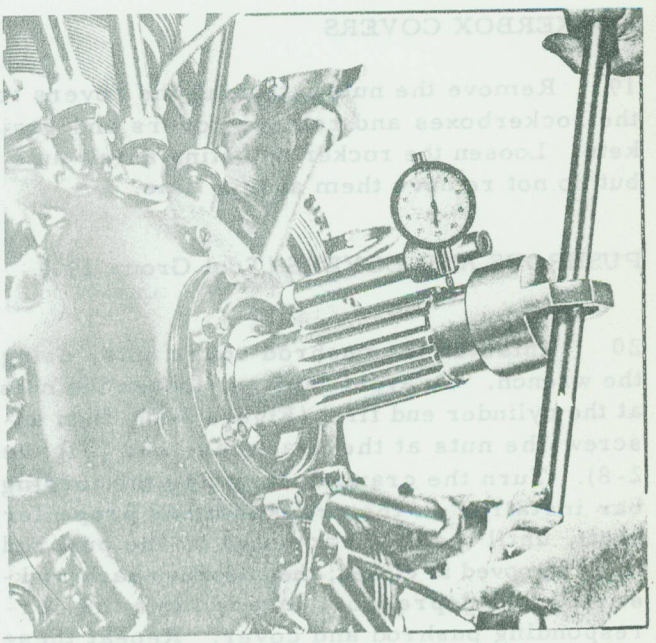


Figure 2-6 Propeller Shaft Runout Check

ACCESSORY DRIVE GEAR NUTS

15 Loosen the accessory drive gear nuts, but do not remove them at this time.

CYLINDER DEFLECTORS

16 Detach the cylinder head deflector nuts. Release the spring-loaded clamp on the rear side of the inter-cylinder deflectors, and remove the cylinder head deflectors. Remove the wing nuts attaching the inter-cylinder deflectors to the retaining clamps and remove the clamps and the deflectors.

17 On the AN-5 Model, the inter-cylinder deflectors between No. 7 and No. 8 cylinders cannot be removed until the clamp underneath the deflector has been loosened and the tee hose connection has been withdrawn from the deflector.

18 On the AN-14B Model, remove the deflector between No. 5 and No. 6 cylinders with the sump.

NOTE

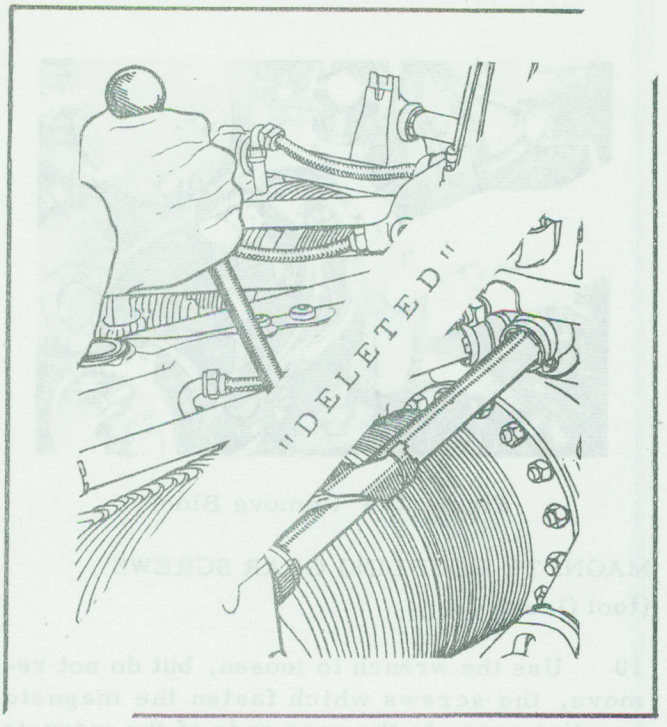
To facilitate assembly of the deflectors, tag each deflector by its location at disassembly.

ROCKERBOX COVERS

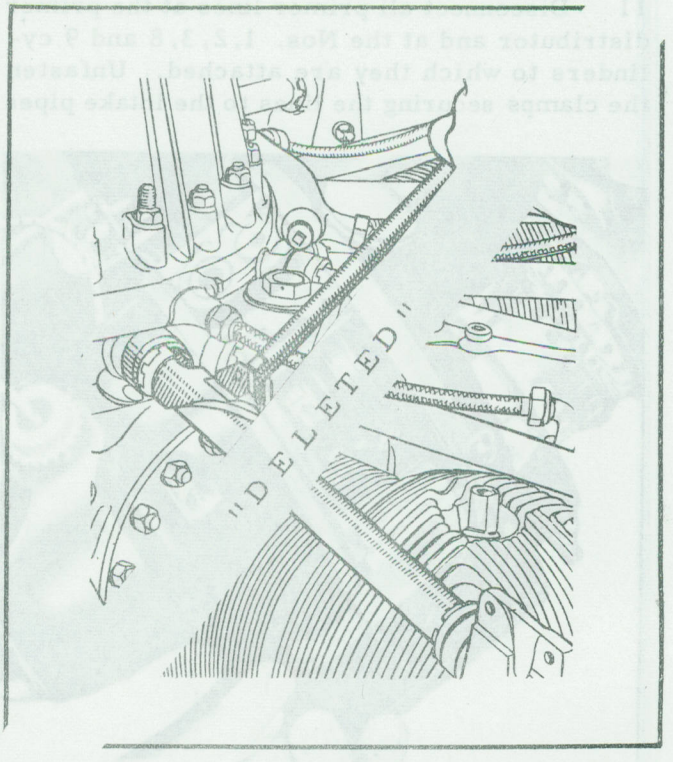
19 Remove the nuts attaching the covers to the rockerboxes and remove covers and gaskets. Loosen the rocker adjusting screw nuts, but do not remove them at this time.

PUSHRODS AND COVERS (Tool Group 100)

20 Unfasten the pushrod cover nuts, using the wrench. To avoid damage, loosen the nuts at the cylinder end first (Figure 2-7), then unscrew the nuts at the crankcase end (Figure 2-8). Turn the crankshaft, using the turning bar installed on the crankshaft or propeller shaft, until the valve actuated by the pushrod to be removed is closed; then depress each rocker with the depressor, and remove the corresponding pushrod and cover. Repeat these operations until all pushrods are removed.



gure 2-7 Unfasten Pushrod Cover Nuts-Cylinder End



gure 2-8 Unfasten Pushrod Cover Nuts-Crankcase End

21 Withdraw the pushrods from the covers and drift the ball ends from the pushrods, using the drift or the puller (Figure 2-9). Tie each ball end and spacer to the corresponding pushrod for correct location at assembly.

22 Remove the packing nuts from the pushrod covers and remove the packings from the nuts.

OIL SCAVENGE TUBES

23 On the AN-14B Model, unfasten the nuts attaching the main oil sump to the oil pump and rocker oil sump to oil pump scavenge tube and remove these tubes. On the AN-5 Model, disconnect the rockerbox to rear case, front case to oil pump, and rear case to oil pump oil scavenge tubes.

OIL SUMP

24 Unscrew the four nuts attaching the sump to the engine and pull the sump straight out from the engine (Figure 2-10). Lift the cylinder deflector off the sump and remove the drain plugs and the oil screen from the sump. The AN-5 Model does not have a sump.

IGNITION MANIFOLD (Tool Group 48)

25 Unfasten the nuts attaching the ignition manifold to the front and supercharger sections. Uncouple the union on the rear manifold, using the strap wrench. Withdraw the manifolds from the engine.

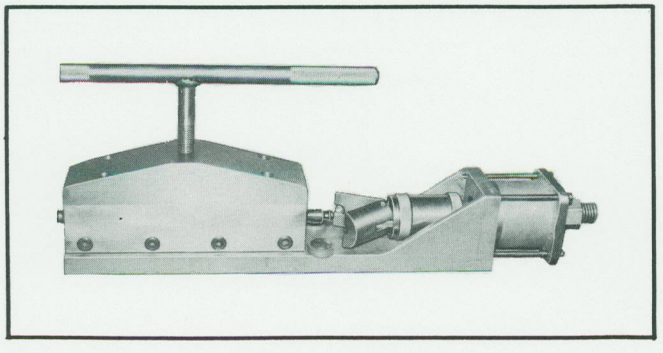


Figure 2-9 Ball End Drift

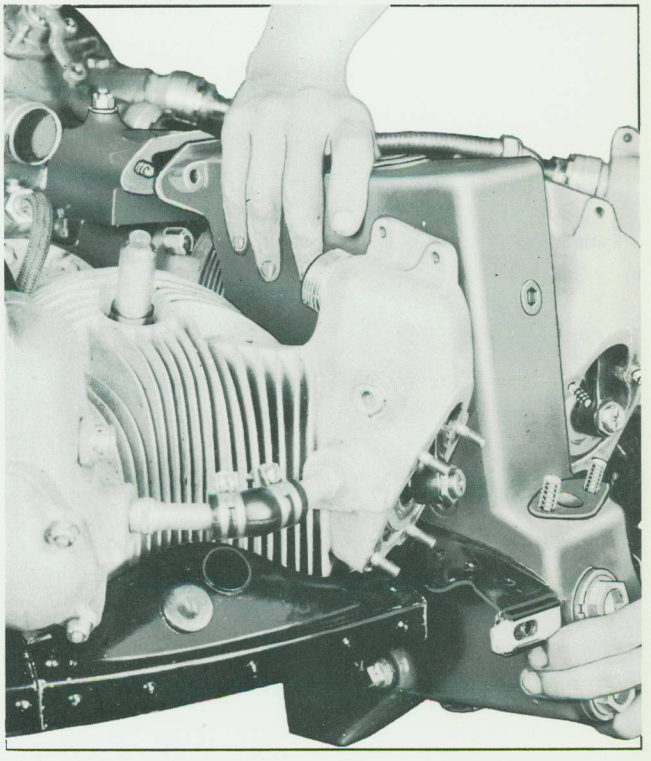


Figure 2-10 Remove Oil Sump

SECTION 2

DISASSEMBLY

FRONT SECTION

FRONT CASE (Tool Group 35)

1 If necessary, use the wrench to loosen the thrust nut. Lift off the nut and the oil slinger. Unfasten the nuts attaching the thrust bearing cover to the case and remove the cover. Mount the puller on the front case and attach the puller to the thrust bearing cover studs. Remove all the nuts which attach the front case to the crankcase front section. Make sure all the valve tappets are in their full outward position. Tighten the screw of the puller until the front case breaks loose and can be lifted off by hand (Figure 2-11).

CAUTION

Do not attempt to remove the front case by hammering on the valve tappet guides or by prying between the parting faces of the front case and the crankcase front section.

TAPPET ROLLERS AND PINS (Tool Group 125)

2 Withdraw the valve tappet assemblies from their guides and remove the pins and rollers from the tappets. Install the protectors over the threads of each tappet guide.

ROCKER OIL MANIFOLD

3 Remove the screws attaching the rocker oil manifold to the bosses in the front case and lift off the ends of the manifold from the case.

BREATHER

4 On the AN-14B Model, remove the plug from the breather assembly aperture. On the AN-5 Model, remove the castellated nuts from the inner breather tube bracket. Remove the cap screw from the outer breather tube and lift out the outer tube. Unscrew the breather plug and remove the inner breather tube.

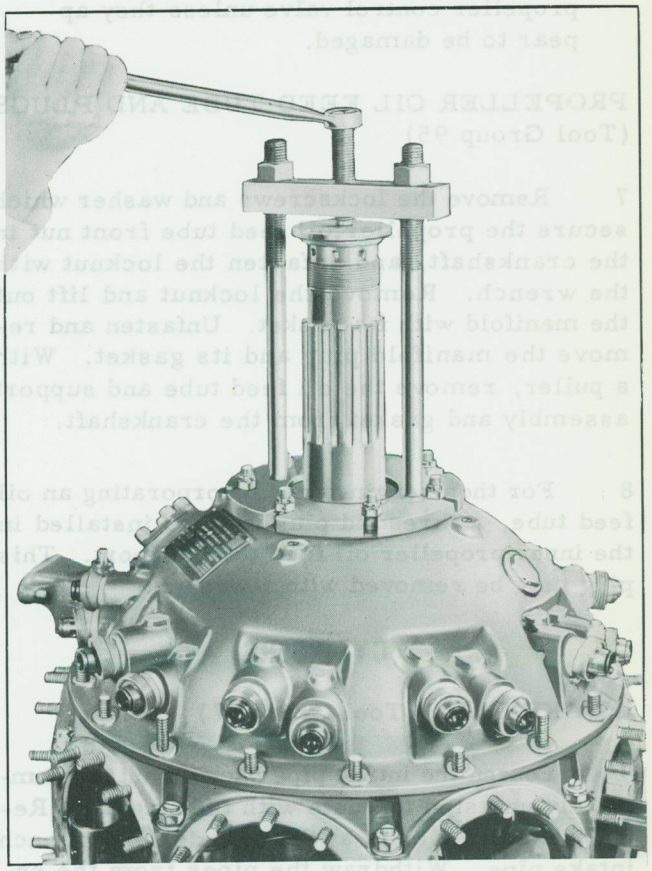


Figure 2-11 Front Case Puller

THRUST BEARING AND RING CARRIER (Tool Group 127)

5 Use a fibre drift and mallet to drive the bearing and crankshaft front oil seal ring carrier from the front case. Remove the rings from the ring carrier with the pliers. Press the ring carrier from the bearing.

HYDRO-PROPELLER CONTROL VALVE ASSEMBLY AN-14B Model (Tool Group 46)

6 Remove the nuts attaching the valve cover to the front case. Lift the complete assembly from the case. Drive out the tapered pin holding the lever to the shaft. Lift the lever and bushing from the shaft. Withdraw the shaft from the cover and, using the wrench, remove

the packing nut from the cover and remove the packing.

NOTE

Do not remove the tubes to and from the propeller control valve unless they appear to be damaged.

PROPELLER OIL FEED TUBE AND PLUGS (Tool Group 95)

7 Remove the lockscrews and washer which secure the propeller oil feed tube front nut in the crankshaft, and unfasten the locknut with the wrench. Remove the locknut and lift out the manifold with its gasket. Unfasten and remove the manifold plug and its gasket. With a puller, remove the oil feed tube and support assembly and gasket from the crankshaft.

8 For those engines not incorporating an oil feed tube, a threaded plug may be installed in the inner propeller oil feed tube support. This plug may be removed with a wrench.

CYLINDERS

INTAKE PIPES (Tool Group 67)

9 Loosen the intake pipe packing nuts. Completely unfasten the nuts with the fingers. Remove the three bolts at the cylinder end of each intake pipe. Withdraw the pipes from the engine. If a pipe sticks in place, use the puller to remove it. Remove the primer distributor from the No. 1 intake pipe. Install protectors in the intake pipe ports in the supercharger case.

CYLINDERS AND PISTONS (Tool Group 24)

10 Loosen the intercylinder hose by removing the hose clamps from the intercylinder drain tubes and slipping the hose to one side.

11 Install the turning bar on the crankshaft. Rotate the crankshaft until the piston of the cylinder to be removed is at the top of its stroke. Remove the palnuts and remove the cylinder flange nuts.

12 Do not remove the top flange nut until just prior to the cylinder removal.

13 Remove the cylinders in the following sequence; No. 6, No. 7, No. 8, No. 9, No. 1, No. 2, No. 3, No. 4, and No. 5. In any case, remove the masterod cylinder last.

14 Support the cylinder with both hands while the top flange nut is being removed; then withdraw the cylinder straight out from the engine. (Figure 2-12). Place each cylinder in an appropriate carrier to prevent damage to the cooling fins and barrel.

15 If a nut is found to be loose or there has been failure of a stud, change that stud and the two adjacent studs in accordance with instructions in Part 8, Section 1.

16 If only two adjacent studs have failed or two adjacent nuts have been found loose, the cylinder may be reused provided the nuts adjacent to the loose nuts are found to be at least to the minimum torque (Part 5, Section 4) and provided the cylinder barrel passes magnetic inspection and the flange flatness check described in Part 4, Section 2, paragraph 13.

17 If more than two adjacent studs have failed or if more than two adjacent nuts are known to have been loose during engine operation, the cylinder should be scrapped or rebarreled and

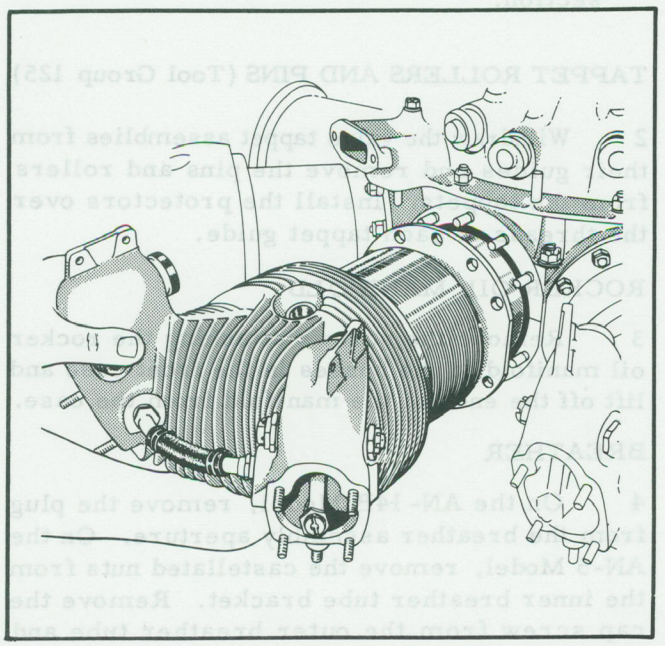


Figure 2-12 Withdraw Cylinder from Engine

all the studs on the cylinder mounting pad changed.

18 Directly after removal of a cylinder, push the pistonpin from the piston, using the pistonpin pusher if necessary. Lift the piston from the linkrod and remove the rings from the piston with the pliers (Figure 2-13). Tag the rings to indicate the piston from which they were removed. Record any stuck, broken or sluggish rings on the Inspection Report.

19 Make certain that the plugs are removed from the pistonpins at disassembly. If difficulty is experienced in taking out the plugs, drill a hole in one plug large enough to accommodate a small brass drift. Insert the drift through the hole and drive out the opposite plug; then drive out the remaining plug.

INLET AND EXHAUST VALVES
(Tool Group 58)

20 Mount and secure the cylinder on the cylinder stand. Compress the valve springs with the swivel arm of the stand and take out the split locks (Figure 2-14). Use the scraper to remove any carbon from the stem of the exhaust valve; then, withdraw the upper washer and the inner and outer valve springs from each rockerbox (Figure 2-15). Remove the safety circlets from the valve stems, then lift out the valve springs

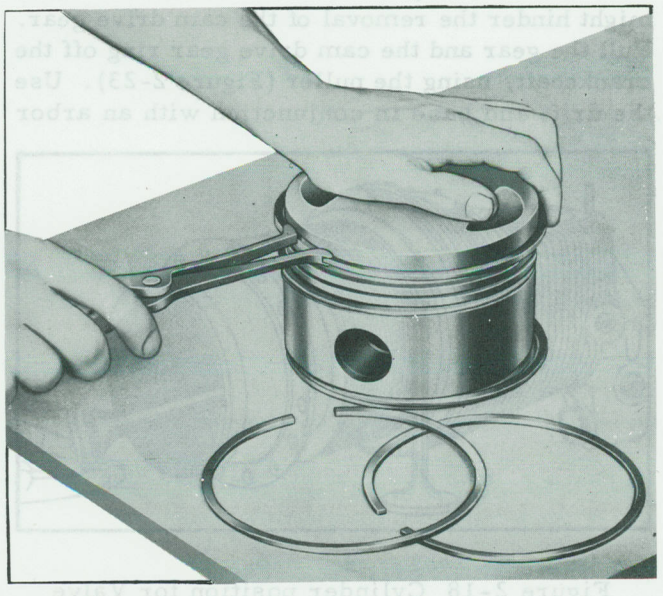


Figure 2-13 Remove Piston Rings

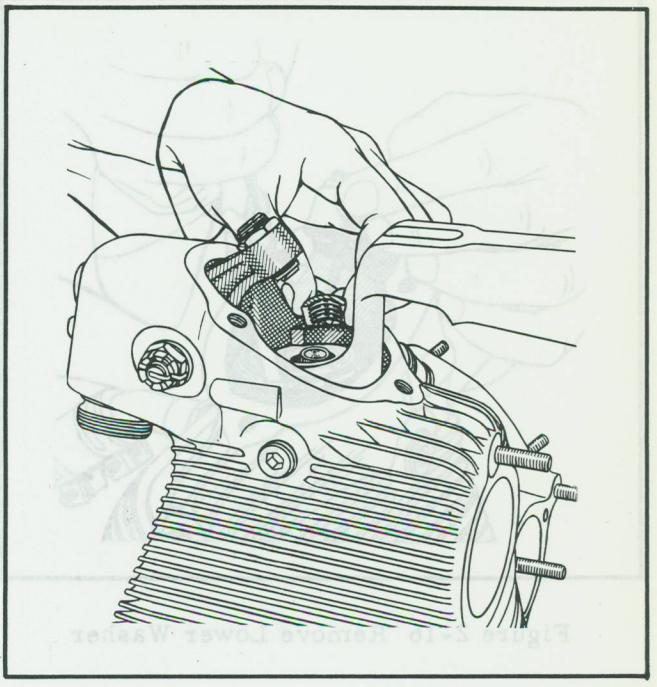


Figure 2-14 Remove Split Locks

lower washer with long nosed pliers (Figure 2-16). Remove the cylinder from the stand, holding the valve stems with the fingers (Figure 2-17) so that the valves will not drop into and damage the cylinder barrel. With the cylinder in a horizontal position on a bench, withdraw the valves (Figure 2-18) and place them in a rack provided with numbered positions.

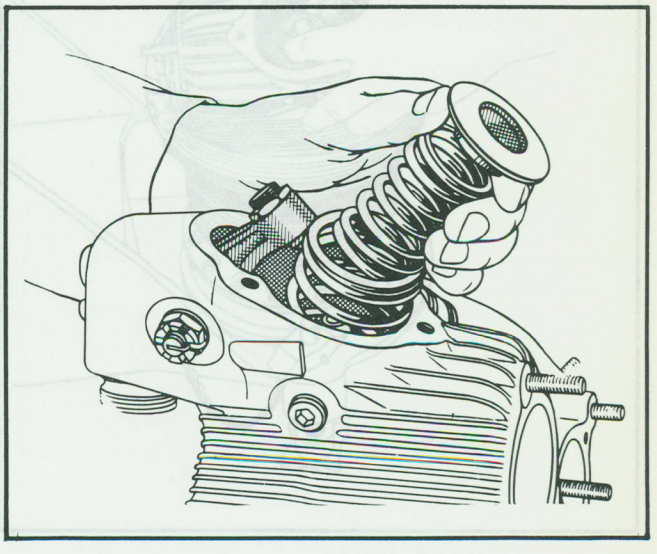


Figure 2-15 Remove Valve Springs

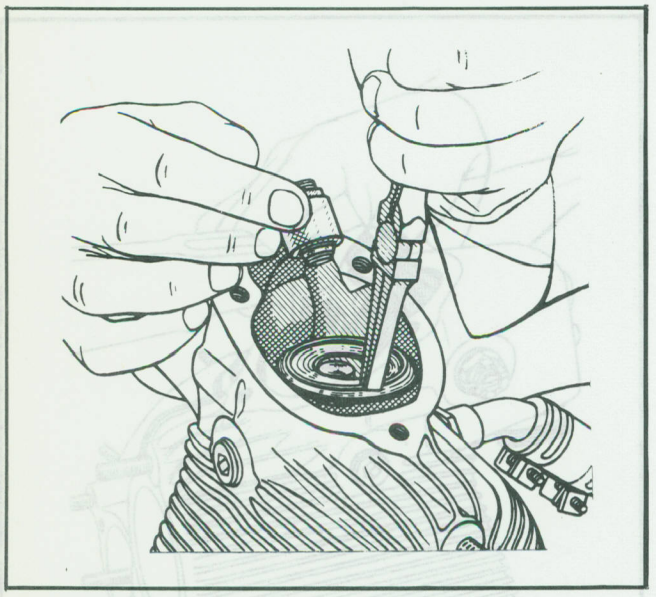


Figure 2-16 Remove Lower Washer

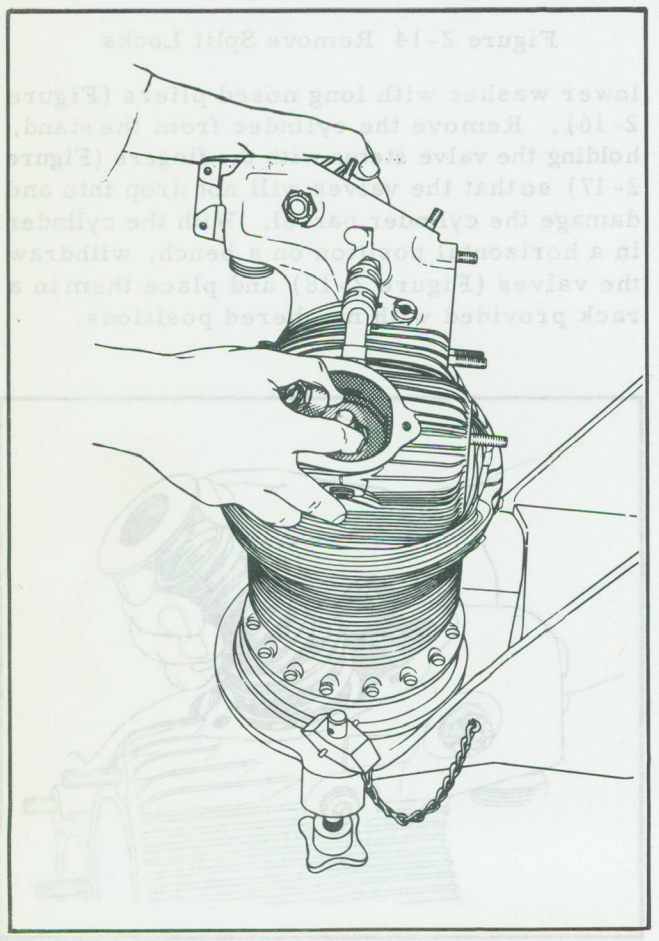


Figure 2-17 Removing Cylinder from Stand

ROCKER SHAFTS

21 Unfasten and remove the inner and outer rocker shaft nuts (Figure 2-19). Drift out the shaft by driving on the smaller end of the shaft with a fibre drift (Figure 2-20). Lift out the rocker. Unscrew the valve adjusting screw and locknut from the rocker (Figure 2-21).

ROCKER SHAFT BEARINGS (Tool Group 113)

22 Use the Drift and Base in conjunction with an arbor press to remove the bearing from the rocker (Figure 2-22).

CRANKCASE SECTION

CAM

23 Lift off the cam.

CAM OIL FEED BRACKET

24 Remove the screws which attach the cam oil feed bracket to the crankcase front section. Detach the oil feed tube at the crankcase front section. Lift the bracket and oil feed tube off the engine as a unit. Disassemble the bracket and remove the oil seal rings.

CAM DRIVE GEAR (Tool Group 13)

25 Stone out any burrs on the crankshaft which might hinder the removal of the cam drive gear. Pull the gear and the cam drive gear ring off the crankshaft, using the puller (Figure 2-23). Use the drift and base in conjunction with an arbor

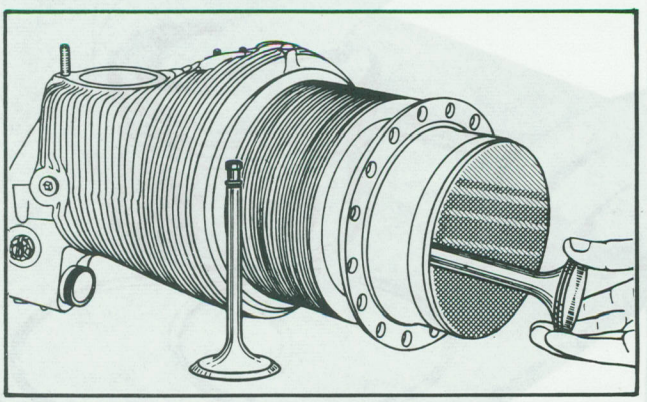


Figure 2-18 Cylinder position for Valve removal

press to separate the gear and the ring. Remove the key from the crankshaft.

CRANKCASE FRONT SECTION

26 Unscrew the long crankcase bolt located between the No. 5 and No. 6 cylinder pads and lift the spacer from the bolt hole. Remove the nuts from the other eight crankcase bolts and drift the bolts downward until they bottom on the supercharger case. Remove the washers from the bolt bosses on the crankcase front section.

27 Remove the crankcase front section from the rest of the engine by lifting evenly on both sides of the crankcase to prevent cramping the front main bearing (Figure 2-24). Remove the front main bearing outer race and the front section of the inner race from the crankshaft.

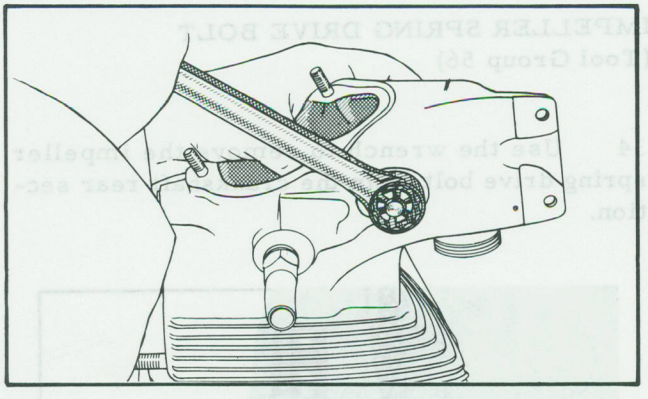


Figure 2-19 Remove Rocker Shaft Nuts

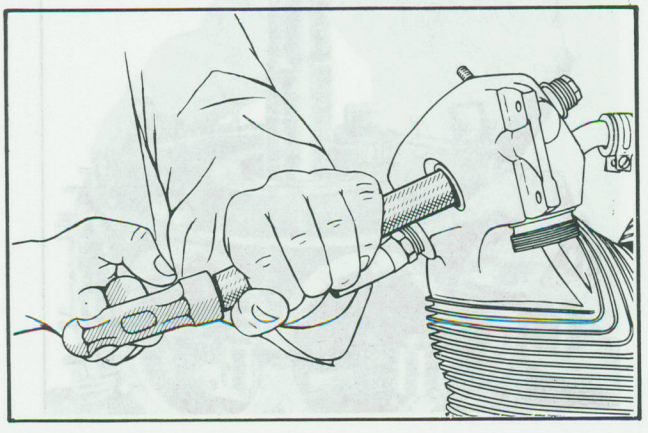


Figure 2-20 Drift out Rocker Shaft

CAM REDUCTION DRIVE GEAR
(Tool Group 15)

28 Place the crankcase front section on a bench. Unfasten the cam reduction drive gear

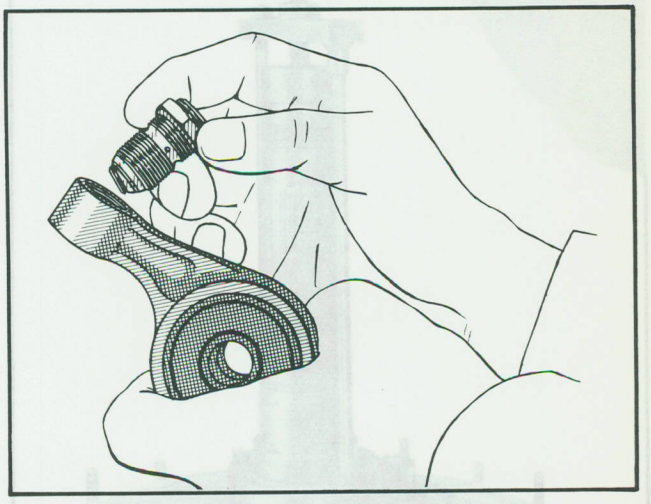


Figure 2-21 Remove Adjusting Screw

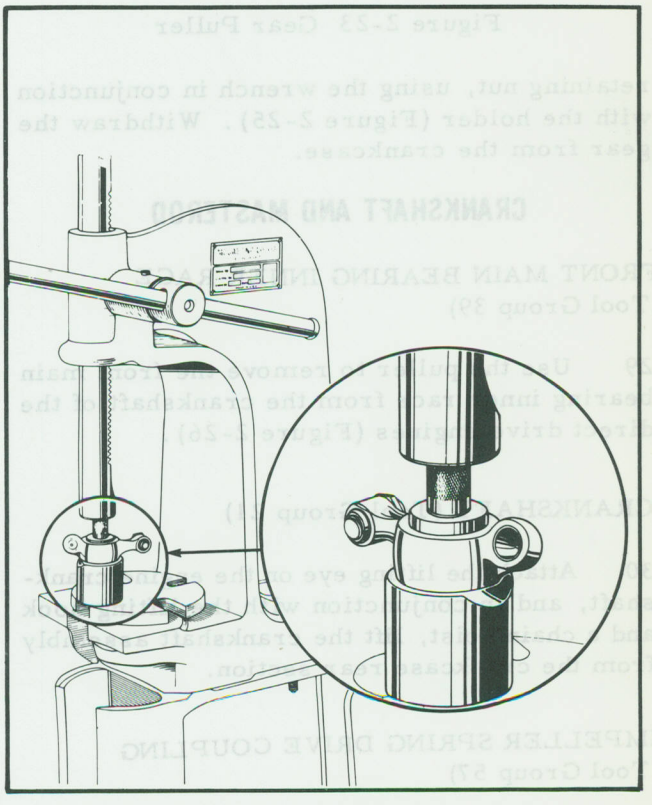


Figure 2-22 Remove Bearing from the Rocker

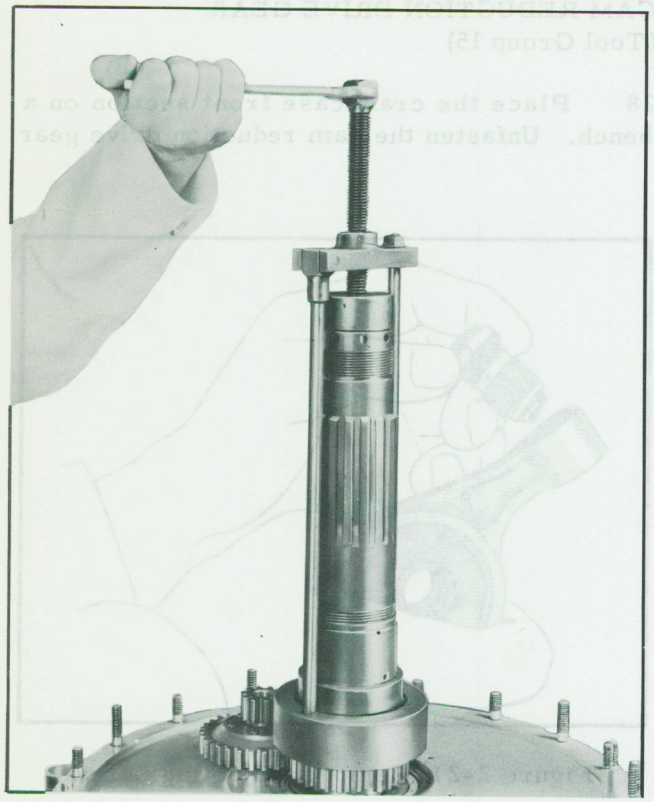


Figure 2-23 Gear Puller

retaining nut, using the wrench in conjunction with the holder (Figure 2-25). Withdraw the gear from the crankcase.

CRANKSHAFT AND MASTEROD

FRONT MAIN BEARING INNER RACE (Tool Group 39)

29 Use the puller to remove the front main bearing inner race from the crankshaft of the direct drive engines (Figure 2-26).

CRANKSHAFT (Tool Group 21)

30 Attach the lifting eye on the engine crankshaft, and in conjunction with the lifting hook and a chain hoist, lift the crankshaft assembly from the crankcase rear section.

IMPELLER SPRING DRIVE COUPLING (Tool Group 57)

31 Mount the splined end of the crankshaft in the fixture equipped with an adapter. Fasten one end of a rubber band to the masterod and the other end to the fixture in order to hold the master and linkrod assembly in position, thus preventing damage to any part of the assembly.

32 Remove the cotterpin, nut and washer which attach the fixed spider of the spring coupling assembly to the crankshaft rear gear. Use the puller to pull the spring drive coupling from the crankshaft rear gear (Figure 2-27). Disassemble the fixed spider, floating spider, floating spider friction band, springs and buttons.

CRANKSHAFT REAR GEAR

33 Unfasten the four retaining screws attaching the crankshaft rear gear to the rear of the crankshaft. Remove the gear.

IMPELLER SPRING DRIVE BOLT (Tool Group 56)

34 Use the wrench to remove the impeller spring drive bolt from the crankshaft rear section.

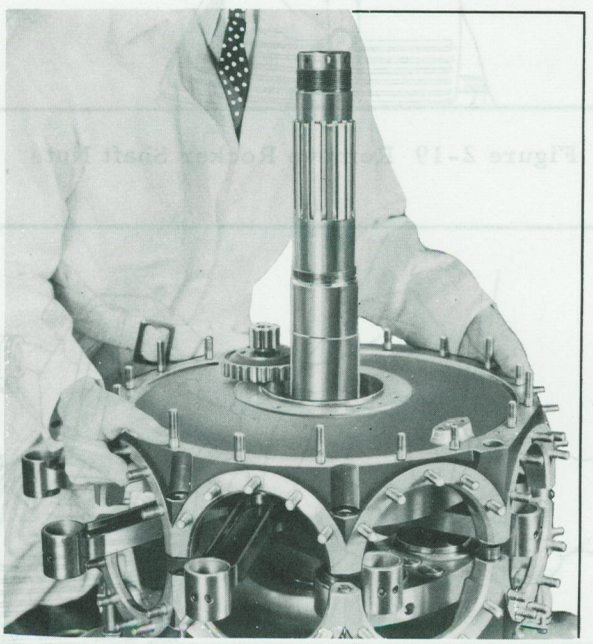


Figure 2-24 Crankcase Front Removal

REAR MAIN BEARING (Tool Group 102)

35 Remove the outer race, rollers and rear section of the inner race of the rear main bearing. Use the puller to pull the reaminder of the inner race from the crankshaft (Figure 2-28).

Figure 2-25 Remove Cam Reduction Drive Gear

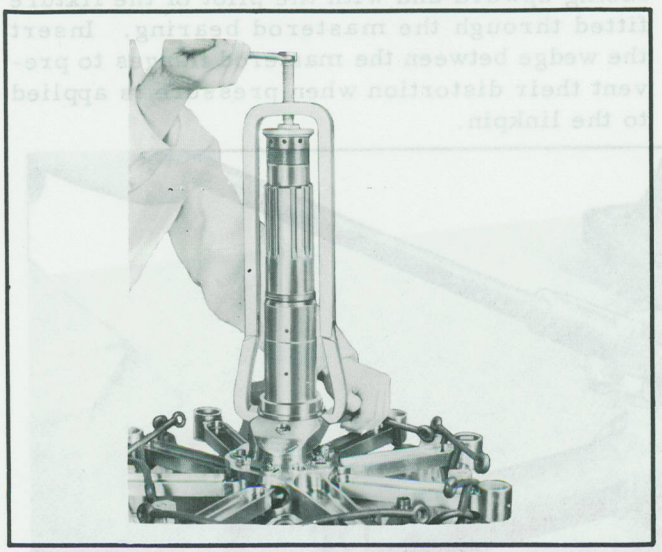


Figure 2-26 Front Main Bearing Inner Race Puller

CRANKSHAFT FRONT AND REAR SECTIONS (Tool Group 23)

36 Remove the cotterpin located near the head of the crankshaft bolt. Use the applicable wrench to unscrew the crankshaft bolt. Coat the threads of the puller with white lead and oil to prevent "picking up" of the threads. Screw the short stud of the puller securely into the bolt hole in the crankshaft rear section, and screw the puller body securely into the bolt hole in the crankshaft front section. Pump the two sections of the crankshaft apart (Figure 2-29).

CAUTION

To prevent damage to the crankshaft splines, support the rear section of the crankshaft when the crankshaft is separated.

37 Install a suitable protector on the spline of the crankshaft front section to avoid damage to the masterod bearing. Remove the master and linkrod assembly (Figure 2-30).

PROPELLER OIL FEED TUBE AND SUPPORT ASSEMBLY (Tool Group 97)

38 On those engines equipped for a hydromatic propeller, and which incorporate the "fix"

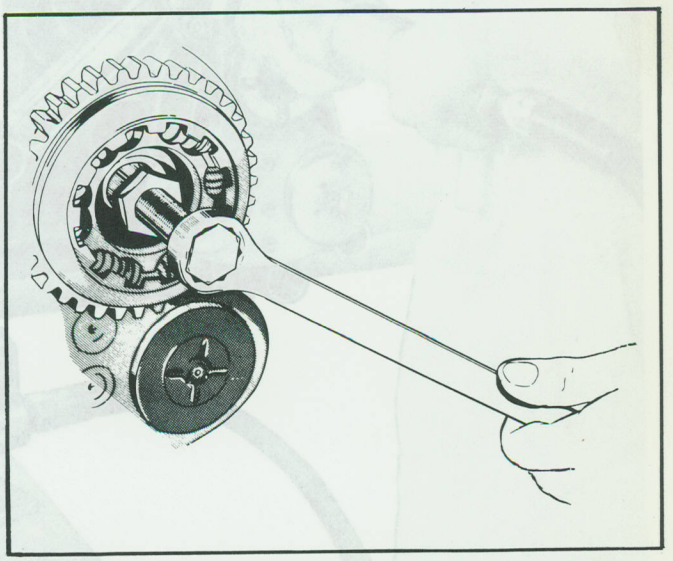


Figure 2-27 Remove Spring Drive Coupling

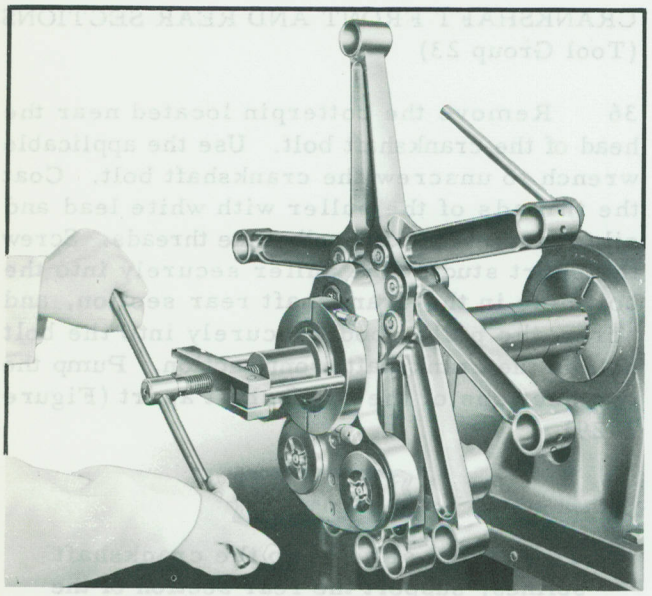


Figure 2-28 Rear Main Bearing Inner Race Puller

type oil feed tube, remove the screws which fasten the lockwasher to the large circular nut at the forward end of the crankshaft and remove the washer. Unscrew the locknut and remove the front plug. Remove the rear nut, tabwasher, and spacer; then remove the oil tube assembly, using the puller, withdraw the gasket, and remove the crankshaft from the fixture.

FLYWEIGHTS (Tool Group 34)

39 Use a long handle allen wrench to loosen the allen plug in the flyweight bolts (Figure 2-31); then unscrew the flyweight bolt. Jack the flyweight sections apart, using the disassembly pusher (Figures 2-32 and 2-33).

OIL PLUGS (Tool Group 80)

40 Remove the crankshaft rear plug from the crankshaft, using the rear plug wrench. Remove the crankshaft front oil plug, using the oil plug wrench.

LINKPINS (Tool Group 69)

41 Remove the two screws which hold the locking bar at the front end of each pair of linkpins; then drift off the locking bars.

42 Rest the masterod assembly on top of the fixture with the forward side of the masterod facing upward and with the pilot of the fixture fitted through the masterod bearing. Insert the wedge between the masterod flanges to prevent their distortion when pressure is applied to the linkpin.

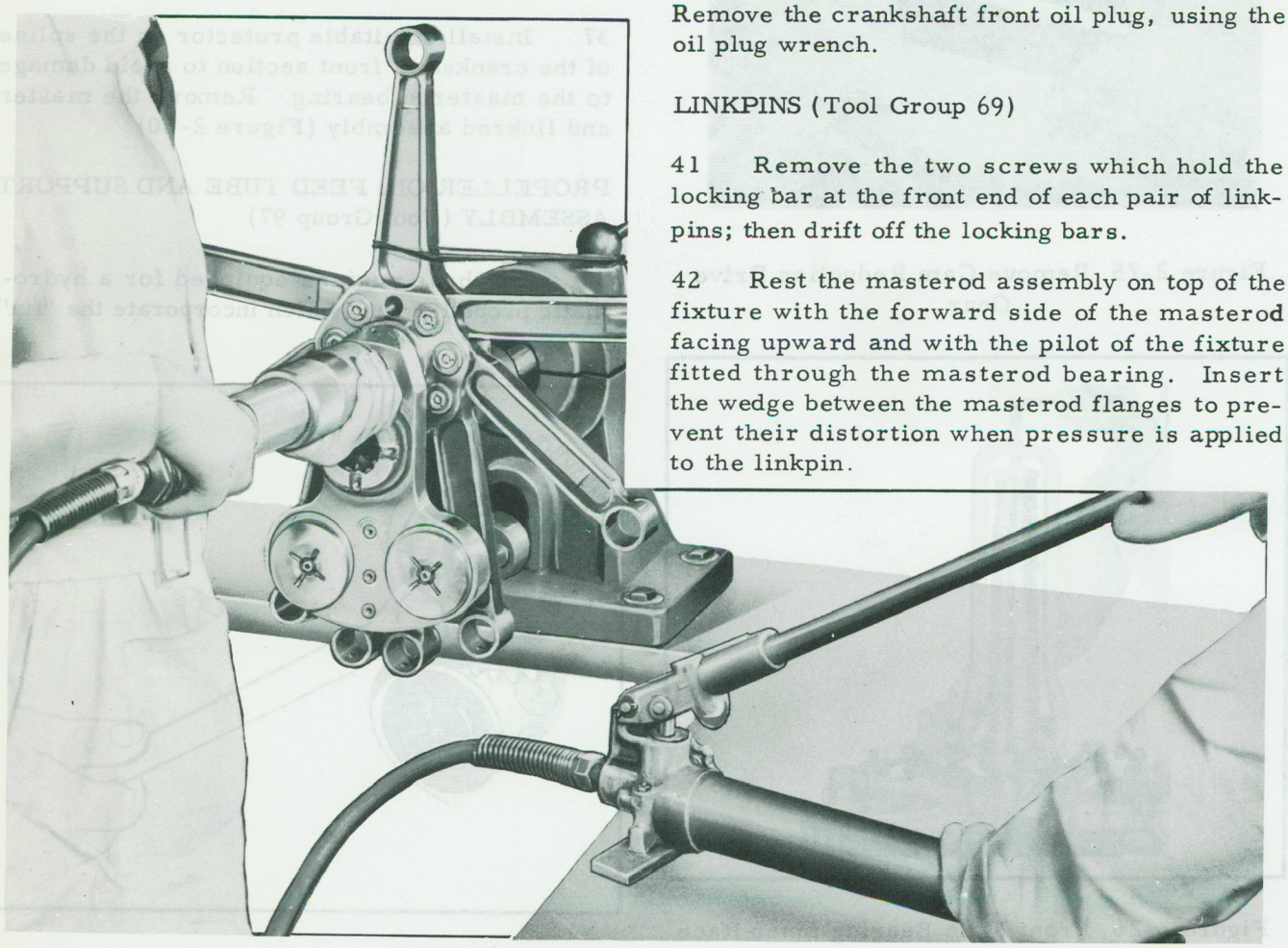


Figure 2-29 Pump Crankshaft Apart

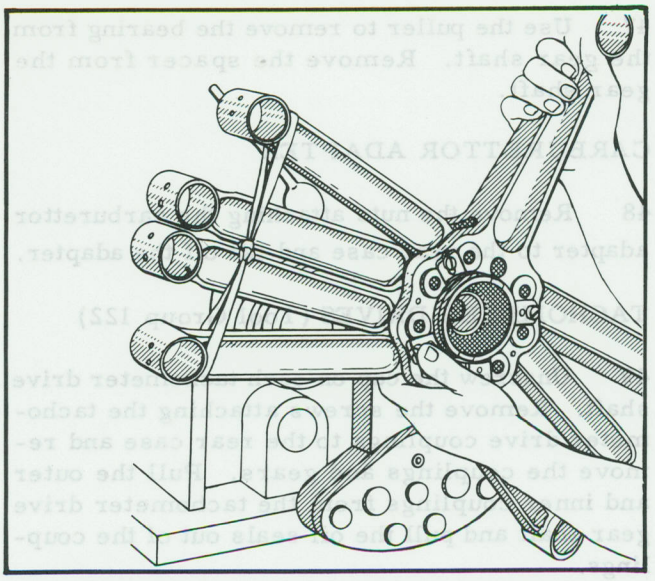


Figure 2-30 Remove Master and Linkrod Assembly

CAUTION

Be extremely careful to avoid damage to the surface of the lead silver masterod bearing when fitting the masterod over the pilot of the fixture.

43 Turn the masterod so that the linkpin to be removed is located directly over one of the slots in the base of the fixture. Locat the L head plunger over the linkpin; then place the drift between the plunger and the linkpin and press the linkpin out by bringing the plunger down (Figure 2-34). If necessary, tap the plunger with a copper hammer until the linkpin starts to move.

NOTE

Care should be taken to insure that the pin to be removed is directly over the slot in the fixture provided to receive it.

CRANKCASE REAR SECTION (Tool Group 19)

44 Unfasten and remove the nuts which attach the crankcase rear section to the supercharger case and lift off the crankcase. It may be necessary to tap the crankcase with a fibre drift to release it from the supercharger case. Use the puller to remove the crankcase bolts from the crankcase rear section.

REAR SECTION

STARTER JAW AND GEAR (Tool Group 117)

45 Crank the bed of the engine stand until the supercharger and rear sections are in a horizontal position.

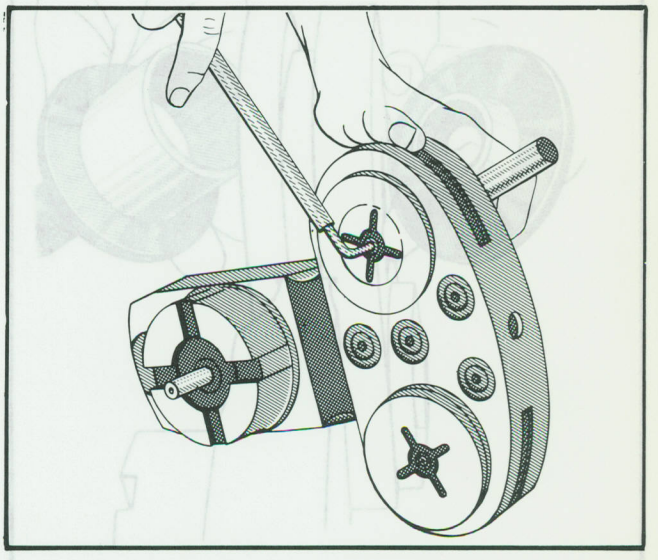


Figure 2-31 Loosen Allen Plug

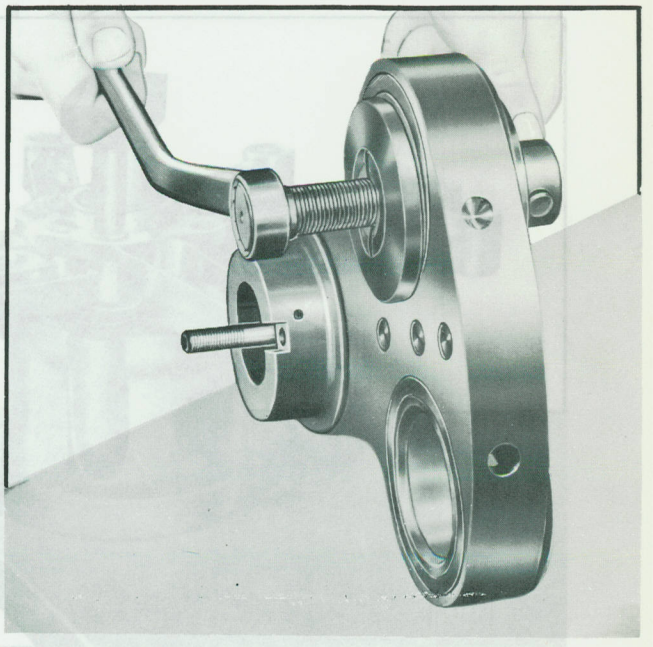


Figure 2-32 Disassembly Pusher

46 Remove the starter jaw nut and starter jaw. Drift the starter gear forward in the supercharger case, using a fibre drift and hammer; then lift the gear free of the case (Figure 2-35).

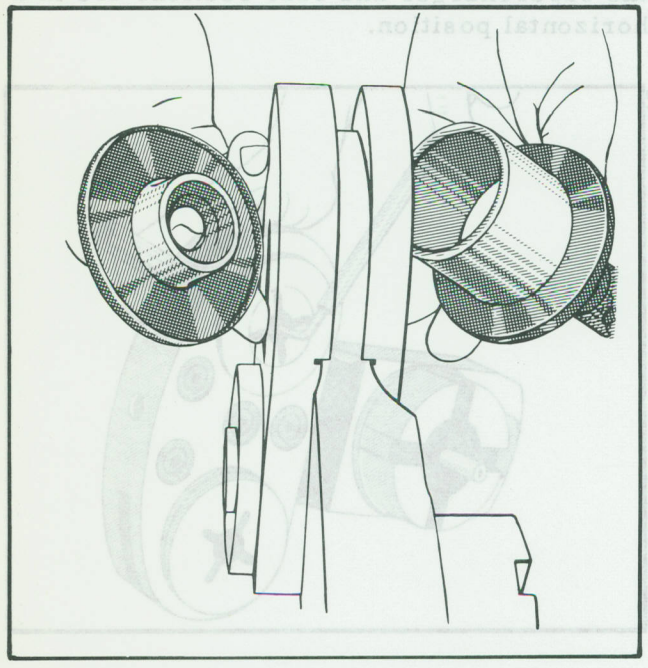


Figure 2-33 Flyweight Sections

47 Use the puller to remove the bearing from the gear shaft. Remove the spacer from the gear shaft.

CARBURETTOR ADAPTER

48 Remove the nuts attaching the carburettor adapter to the rear case and lift off the adapter.

TACHOMETER DRIVES (Tool Group 122)

49 Unscrew the cap on each tachometer drive shaft. Remove the screws attaching the tachometer drive couplings to the rear case and remove the couplings and gears. Pull the outer and inner couplings from the tachometer drive gear shaft and pull the oil seals out of the couplings.

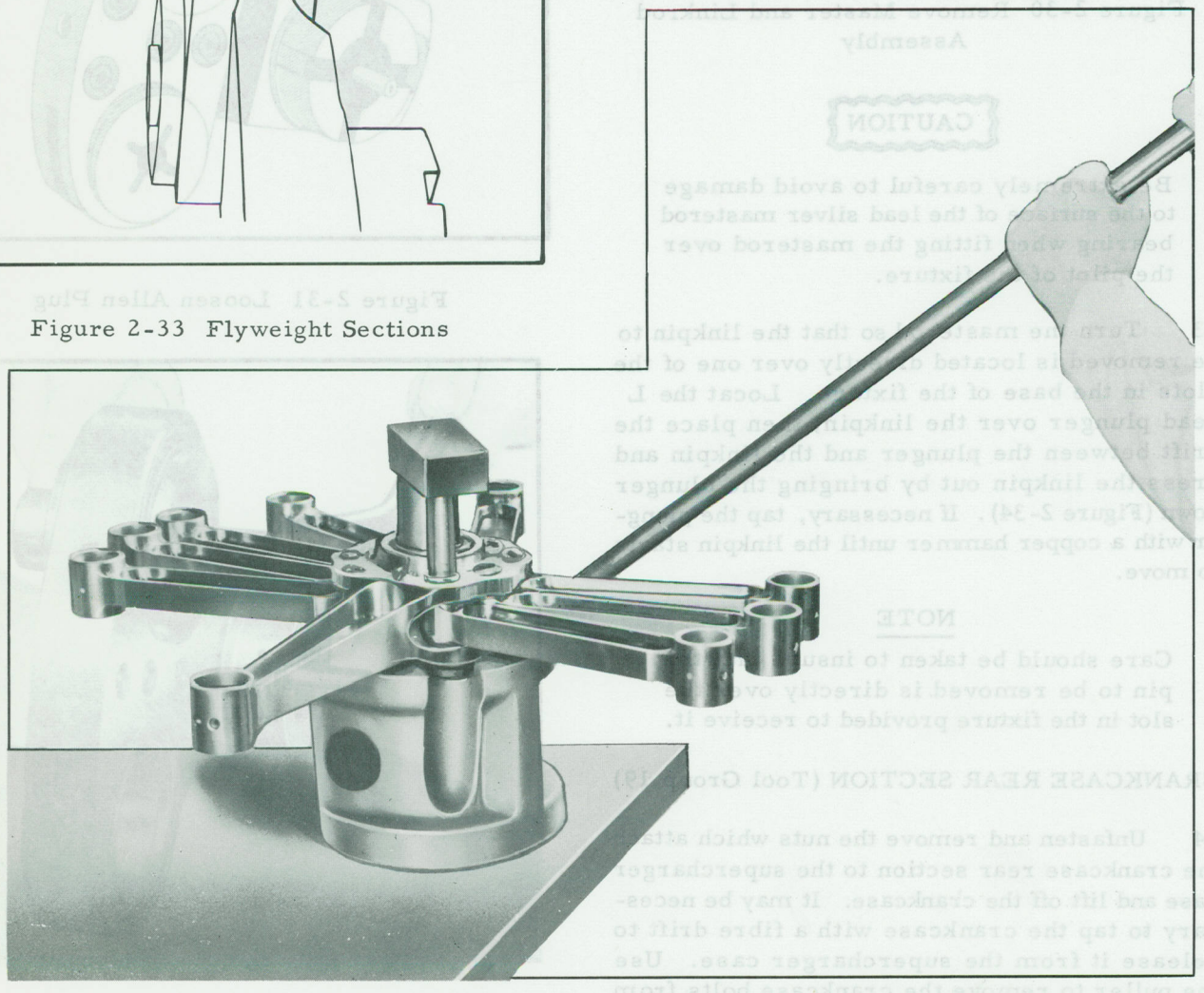


Figure 2-34 Press out Linkpin

FUEL PUMP DRIVE GEAR (Tool Group 41)

50 Remove the nuts attaching the fuel pump drive gear shaft and pull the oil seals out of the gear adapter to the rear case; then withdraw the adapter and gear from the case. Use the puller to facilitate removal of the adapter and gear. Pull the fuel pump drive gear from its adapter. Remove the fuel pump drive gear oil seal.

OIL PUMP (Tool Group 81)

51 Remove the nuts attaching the oil pump to the rear case. Attach the puller to the oil inlet part studs and pull the pump from the rear case.

52 Loosen and remove the four nuts on the four through bolts which hold the pump together. Two of these bolts can be pulled out with the fingers but the other two must be drifted out (Figure 2-36). Lift off the cover, or pressure section (Figure 2-37), and the gears (Figure 2-38) then remove the key from the drive shaft (Figure 2-39). Lift off the first scavenge section and oil seal ring (Figure 2-40). Remove the gears; then, remove the key from the drive shaft. Remove the oil seals from the shaft

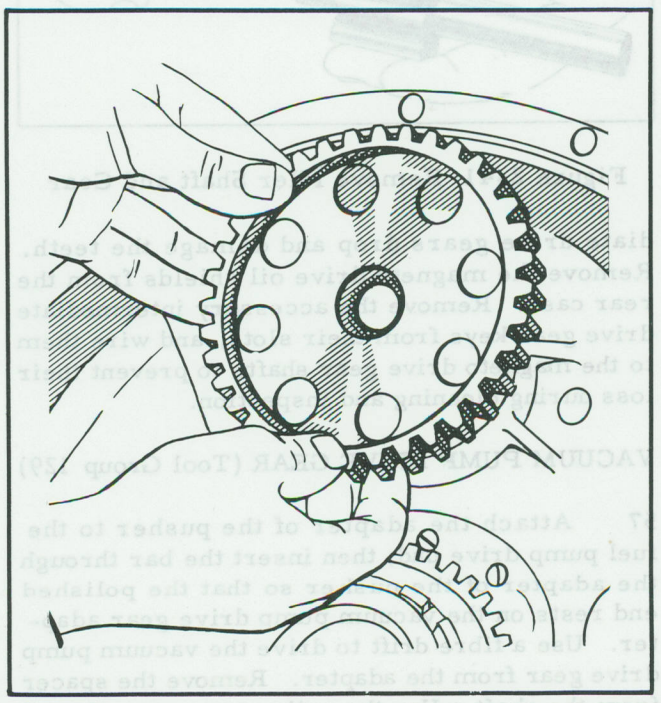


Figure 2-35 Remove Starter Gear

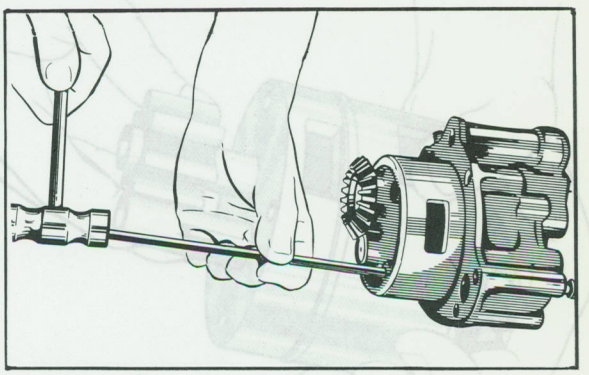


Figure 2-36 Drift Out Oil Pump Bolts

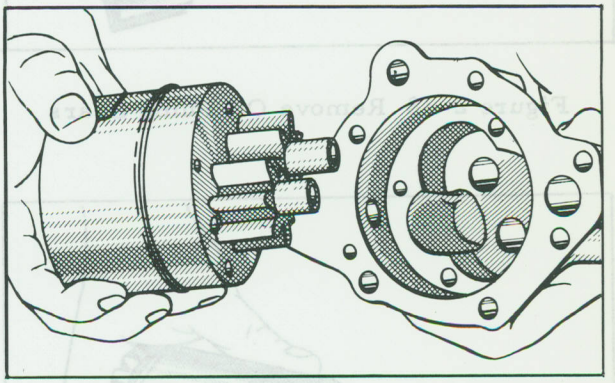


Figure 2-37 Remove Oil Pump Pressure Section

holes in this section. Lift off the second scavenge section and remove the idler shaft and gear (Figure 2-41). Remove the drive gear and key and withdraw the drive shaft from the pump end plate (Figure 2-42). If difficulty is experienced in removing the gears, they may be removed with the puller.

INTAKE DUCT VIEW PORT

53 Remove the intake duct view port plug and cover.

PLUGS

54 Remove the by-pass plug, the oil thermometer connection plug, and all allen plugs from the rear case.

MAGNETO COUPLING DRIVE GEARS (Tool Group 75)

55 Remove the magneto coupling screws.

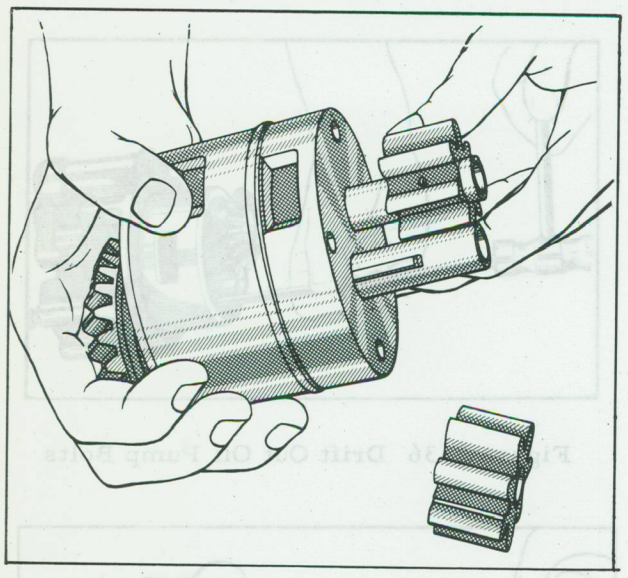


Figure 2-38 Remove Oil Pump Gears

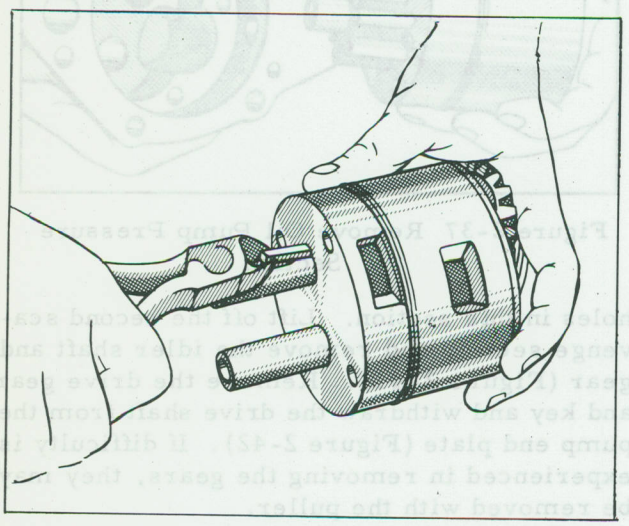


Figure 2-39 Remove Key from Drive Shaft

Pull the coupling gear from each magneto drive gear shaft. Unfasten the screws attaching the magneto drive covers to the rear case and pull off the covers and remove the packings. On engines that incorporate the new oil seal housing, magneto drive coupling and lip type oil seal, remove oil seal using the oil seal puller.

56 Pull the magneto drive gears forward from the supercharger case (Figure 2-43), being careful not to let the accessory intermediate drive gears drop and damage the teeth. Remove the magneto drive oil shields from the rear case. Remove the accessory intermediate drive gear keys from their slots, and wire them to the magneto drive gear shafts to prevent their loss during cleaning and inspection.

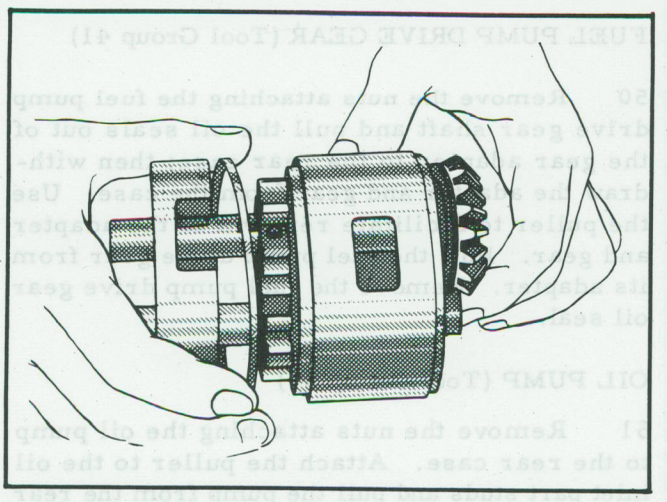


Figure 2-40 Remove Oil Seal Ring

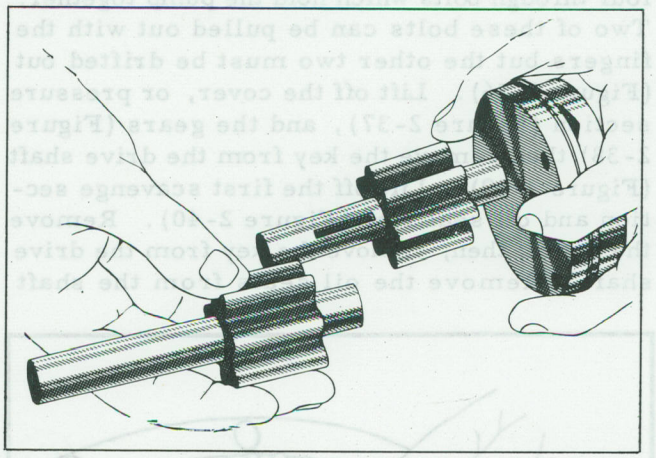


Figure 2-41 Remove Idler Shaft and Gear

VACUUM PUMP DRIVE GEAR (Tool Group 129)

57 Attach the adapter of the pusher to the fuel pump drive pad; then insert the bar through the adapter of the pusher so that the polished end rests on the vacuum pump drive gear adapter. Use a fibre drift to drive the vacuum pump drive gear from the adapter. Remove the spacer from the shaft. Use the puller to remove the oil seal.

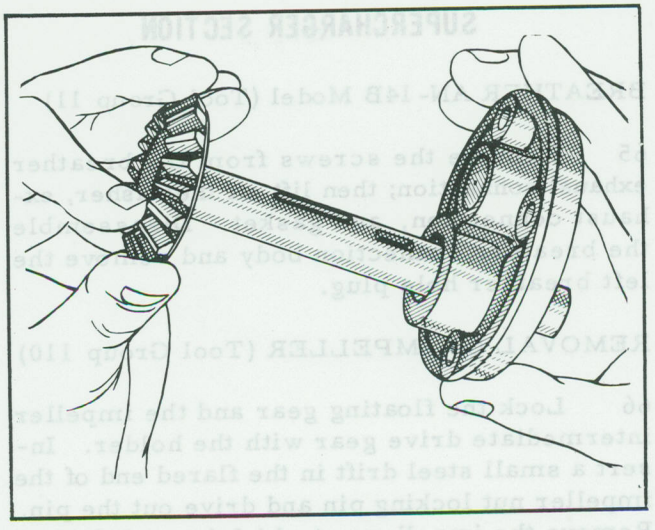


Figure 2-42 Remove Drive Shaft

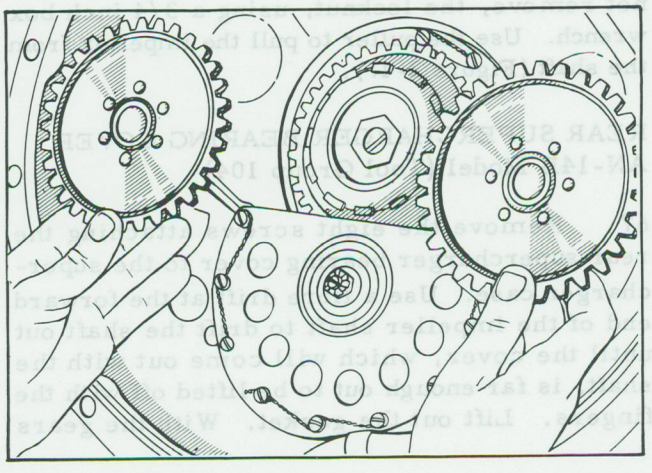


Figure 2-43 Remove Magneto Drive Gears

GENERATOR DRIVE GEAR (Tool Group 42)

58 Unfasten the four nuts which fasten the generator drive assembly to the top of the rear section and remove the assembly.

59 On the single bearing drive assembly (Figure 2-44), remove the screws from the bearing retainer plate. Hold the assembly in a vise having lead padded jaws and remove the spanner nut which has a left hand thread. Withdraw the gear from the housing and drift the bearing from the gear.

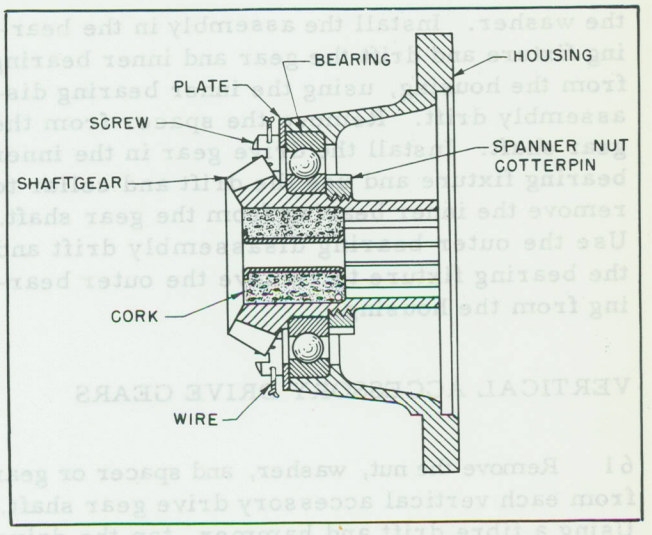


Figure 2-44 Single Bearing Generator Drive

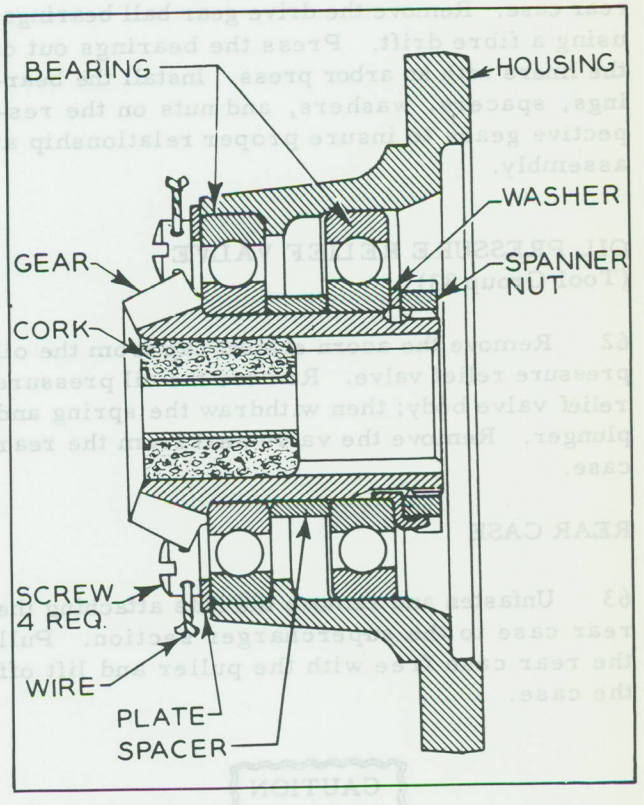


Figure 2-45 Double Bearing Generator Drive

60 On the double bearing drive assembly (Figure 2-45), remove the screws from the retainer plate and drift the cork from the drive gear shaft bore. Install the drive gear in the holding fixture and remove the spanner nut. Lift out

the washer. Install the assembly in the bearing fixture and drift the gear and inner bearing from the housing, using the inner bearing disassembly drift. Remove the spacer from the gear shaft. Install the drive gear in the inner bearing fixture and use the drift and collar to remove the inner bearing from the gear shaft. Use the outer bearing disassembly drift and the bearing fixture to remove the outer bearing from the housing.

VERTICAL ACCESSORY DRIVE GEARS

61 Remove the nut, washer, and spacer or gear from each vertical accessory drive gear shaft. Using a fibre drift and hammer, tap the drive gears downward, but be careful not to let them fall. Remove the drive gear adapters from the rear case. Remove the drive gear ball bearings, using a fibre drift. Press the bearings out of the liners with an arbor press. Install the bearings, spacers, washers, and nuts on the respective gears to insure proper relationship at assembly.

OIL PRESSURE RELIEF VALVE (Tool Group 83)

62 Remove the acorn shaped cap from the oil pressure relief valve. Remove the oil pressure relief valve body; then withdraw the spring and plunger. Remove the valve seat from the rear case.

REAR CASE

63 Unfasten and remove the nuts attaching the rear case to the supercharger section. Pull the rear case free with the puller and lift off the case.

CAUTION

Do not pry the cases apart by inserting an object between the parting faces.

64 Place the case on a bench so that the parting face is up, thus avoiding possible damage to the oil pressure tube or the magneto drive shaft bushings.

SUPERCHARGER SECTION

BREATHER AN-14B Model (Tool Group 11)

65 Remove the screws from the breather exhaust connection; then lift off the washer, exhaust connection, and gasket. Disassemble the breather connection body and remove the left breather hole plug.

REMOVAL OF IMPELLER (Tool Group 110)

66 Lock the floating gear and the impeller intermediate drive gear with the holder. Insert a small steel drift in the flared end of the impeller nut locking pin and drive out the pin. Remove the impeller nut which has a left hand thread (Figure 2-46). Remove the cotterpin from the impeller shaft locknut at the forward end of the impeller shaft and loosen, but do not remove, the locknut, using a 3/4 inch box wrench. Use the puller to pull the impeller from the shaft (Figure 2-47).

REAR SUPERCHARGER BEARING COVER AN-14B Model (Tool Group 104)

67 Remove the eight screws attaching the rear supercharger bearing cover to the supercharger case. Use a fibre drift at the forward end of the impeller shaft to drift the shaft out until the cover, which will come out with the shaft, is far enough out to be lifted off with the fingers. Lift out the gasket. With the gears

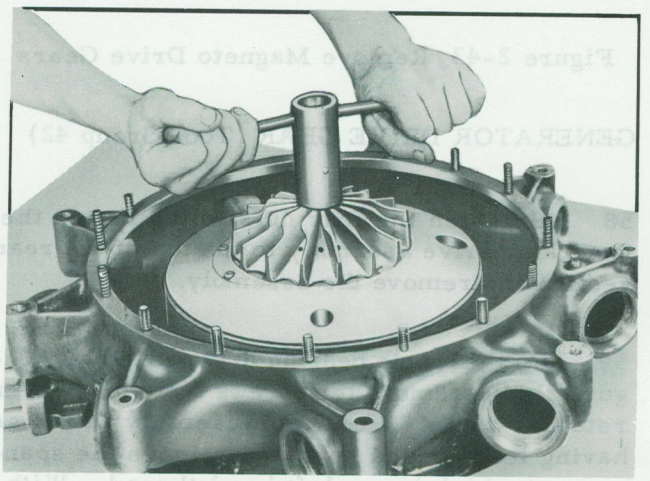


Figure 2-46 Remove Impeller Nut

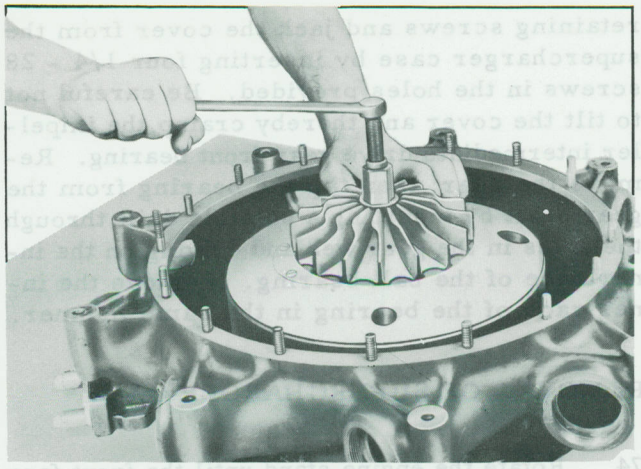


Figure 2-47 Pull Impeller from Shaft

still locked, remove the impeller intermediate drive gear rear bearing and inner liner, using the puller (Figure 2-48). Press the liner from the bearing using an arbor press and a suitable drift.

REAR SUPERCHARGER BEARING COVER AN-5 Model (Tool Group 103)

68 Remove the eight screws attaching the rear supercharger bearing cover to the supercharger case. Use the puller to pull the cover from the case. Lift out the impeller shaft rear spacer. Drift the impeller shaft oil seal from the rear supercharger bearing cover, using the disassembly drift and the holder.

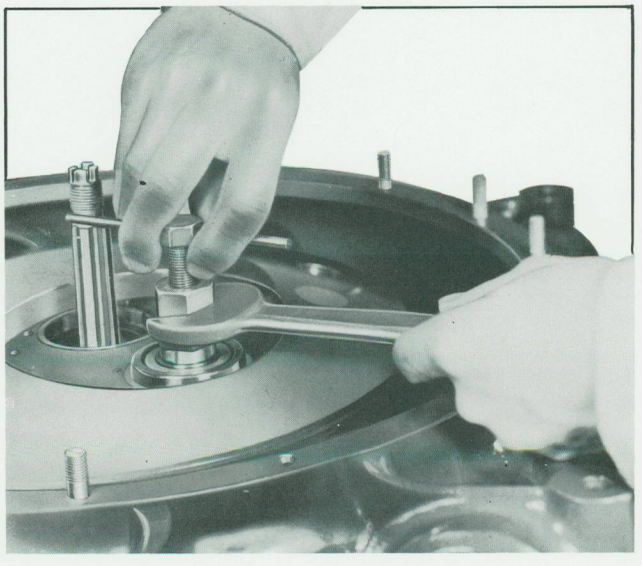


Figure 2-48 PWA-346 Puller

CAUTION

Use extreme care in the removal of the impeller shaft oil seal. Immediately upon removal of the seal, clean it with a kerosene or Varsol spray, and air dry it. The seal should then be protected with a cardboard collar placed around the carbon portion of the seal and individually boxed.

69 With the gears still locked, unscrew the impeller intermediate drive gear nut and remove the rear bearing and inner liner using the puller (Figure 2-48). Press the liner from the bearing using an arbor press and a suitable drift.

FLOATING GEAR (Tool Group 32)

70 Bend down the tab lock and unscrew the floating gear retaining nut (left hand thread) with the retainer nut wrench (Figure 2-49). Remove the front thrust spacer. Remove the floating gear and needle bearings, being careful not to drop the needles into the supercharger section. Remove the rear thrust spacer and floating gear inner race.

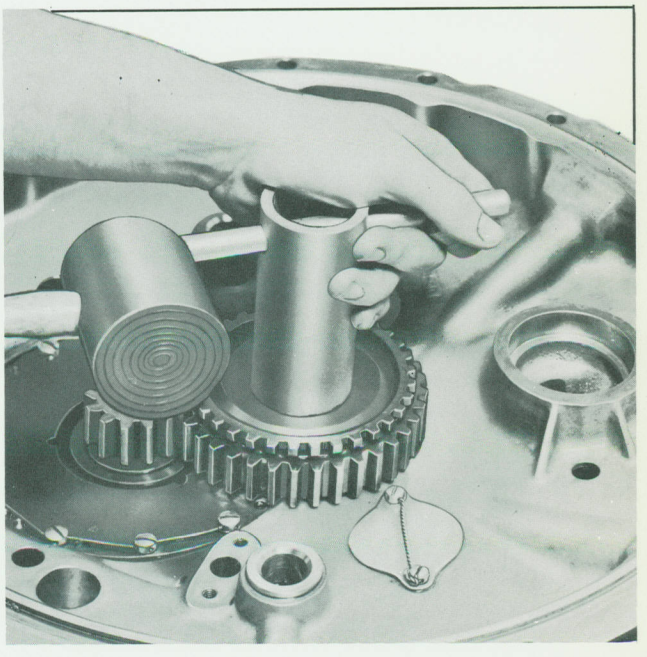


Figure 2-49 Unscrew Floating Gear Nut

IMPELLER SHAFT AN-14B Model
(Tool Group 51)

71 Make sure the nut and the locking pin are removed from the front end of the impeller shaft. Lift off the rear bearing spacer, the oil baffle, the laminated shim, and the oil slinger. Use a fibre drift to tap the impeller shaft from the rear to the front and withdraw the shaft from the supercharger case.

IMPELLER SHAFT AN-5 Model
(Tool Group 50)

72 Make sure the locking pin and the nut are removed from the front end of the impeller shaft. Tap the shaft from the front towards the rear with a fibre drift. Use the sleeve in conjunction with an arbor press to press the impeller shaft journal from the shaft.

IMPELLER INTERMEDIATE DRIVE GEAR

73 Unscrew the front supercharger cover retaining screws and jack the cover from the supercharger case by inserting four 1/4 - 28 screws in the holes provided. Be careful not to tilt the cover and thereby cramp the impeller intermediate drive gear front bearing. Remove the gear; then tap the bearing from the gear shaft by inserting a suitable drift through the holes in the gear web and driving on the inner race of the ball bearing. Remove the inner race of the bearing in the same manner.

REMOVAL OF SUPERCHARGER CASE

74 Rotate the engine stand until the front face of the supercharger case is up. Remove the nuts and bolts which fasten the supercharger case to the stand and lift off the case.

75 On the AN-14B Model, remove the lockwire and screws from the two supercharger section plates and remove the plates.

PART 3

CLEANING

GENERAL CLEANING INSTRUCTIONS

1 After the engine has been completely disassembled, clean all engine parts thoroughly in preparation for inspection. It is very important that all parts listed in "Specific Cleaning Instructions" be cleaned only in accordance with those instructions.

2 Clean all other parts in accordance with the instructions under "Degreasing" or "Decarbonizing" after steel parts have been cleaned, cover them with a thin coat of light oil to protect them from rust and corrosion.

3 Scrupulous cleaning of the engine parts is essential to proper inspection and overhaul. The variety of dirt to be removed from the parts - carbon, sludge, gum, corrosion, oils, and greases - and the variety of metals from which the parts are manufactured precludes the possibility of using a single cleaner. Extensive research by manufacturers has produced numerous satisfactory cleaners for these many types of dirt. Operator preference for various cleaners, plus the fact that volume dictates the amount and type of mechanized cleaning equipment necessary, makes it impractical to set up specific cleaning instructions with the exception of those given for a few parts which require special handling.

4 Degreasing of all parts, with the exception of clutch shafts, will be advantageous as parts which are totally cleaned by this operation will carry less contaminants to dip tanks or spray booths in follow-up cleaning operations.

DEGREASING

5 Degreasing may be accomplished by using any one of the following types of cleaning agents:

(a) Emulsion Type Cleaners - These cleaners, such as Turco Mulsirex, Magnus Emulso-Dip and Emulso-Spray, and Kelite Protexol, are emulsifying compounds and are mixed with petroleum solvents such as varsol or kerosene. The cleaner issued at room temperature in a dip tank or applied as a coarse spray, and followed by a hot water spray rinse. The parts should be dried by air blasting. Emulsion cleaners are safe for all metals, since they are neutral and non-corrosive.

(b) Chlorinated Solvents - These solvents generally perchlorenthylene or aniline inhibited trichlorethylene, are usually utilized in the vapour condensate method. In this method the solvent is vapourized by steam heating in a specially constructed tank. The parts are suspended in this vapour and are degreased by the condensation of solvent on their surfaces. Parts degreased by this method are absolutely dry, and if they are not to be subjected to further cleaning operations, should be sprayed immediately with a light oil to protect them against rusting and corrosion.

(c) Petroleum Solvents-These solvents include white furnace oil, kerosene, varsol and other light petroleum distillates. The solvents may be used in a dip tank or as a spray. When used as a spray they should be used in a spray booth which has positive ventilation to the outside. The flash point of these solvents is relatively high; however, proper fire precautions should be taken.

DECARBONIZING

6 Parts which have hard carbon deposits may be cleaned by soaking in a carbon removing solution or, in the case of some parts, by soft grit blasting or by both methods.

CARBON REMOVERS

7 Carbon removers, generally alkaline or cresol solutions, require careful handling. Goggles and rubber gloves should be standard equipment for personnel using these solutions.

8 Some carbon removers will attack aluminum and magnesium parts, if allowed to stand too long in the solution. For this reason, manufacturer's recommendations - for solution concentration, length of soaking time and, if the solution is heated, the heat range of the solution, should be followed.

9 To avoid any possibility of electrolytic (galvanic) corrosion, parts should be segregated as to metals so that dissimilar metals will not be placed in the same tank at the same time.

10 Immediately upon removal from carbon removing solutions, parts should be rinsed thoroughly with a hot solution of soap and water or with a petroleum solvent. A cold water rinse is not desirable. Air dry the parts and, if they are not to be processed further, coat them with a film of light oil.

SOFT GRIT BLASTING

11 Soft grit blasting for the removal of hard carbon may be accomplished in a standard sandblast cabinet, using air pressures of 65 to 100 pounds, depending on the type of grit material and the size of the nozzle used.

12 Before blasting a part, it should be either degreased or put through a decarbonizing solution and then rinsed and dried thoroughly. After blasting, remove the dust by air blasting and follow with a petroleum solvent or hot water rinse.

13 Many types of grit material are in general use. Among them are Turco Carbonblast, ground apricot and peach pits, walnut shells, clover seed, and cracked wheat.

14 Some types of soft grit leave a light, greasy film on a part, and this film should be removed by degreasing if the part is to be subjected to fluorescent penetrant inspection.

BUFFING

15 An uncharged cloth buffing wheel may be used to remove small hard carbon deposits not removed by other cleaning methods.

SPECIFIC CLEANING INSTRUCTIONS

PARTS WITH LEADED BEARING SURFACES

16 The masterod bearings, the impeller shaft thrust plate and the cam bearings have leaded bearing surfaces and require special care to prevent damage to these surfaces. Clean parts by flowing kerosene or white furnace oil over the bearing surfaces and wiping the bearing surfaces with a soft, smooth cloth.

BALL AND ROLLER BEARINGS

17 Ball and roller bearings are at all time susceptible to magnetization which causes small foreign particles to adhere to the balls or races. In some cases, these particles are so strongly attracted that they are not removed during the soaking and washing operations. To prevent the possibility of foreign particles remaining, completely demagnetize each ball or roller bearing before cleaning.

18 Demagnetize non-demountable ball and roller bearings as an assembly, but demagnetize the component parts of demountable bearings separately, being extremely careful not to mix the parts of one bearing with those of another. Rotate large bearings slowly while passing them through the demagnetizer. Pass the bearings or parts through the demagnetizer at a rate not to exceed 12 feet per minute and remove them from the demagnetizing field before shutting off the switch.

19 After demagnetizing, test the bearings or component parts for residual magnetism, using a magnetic compass. Deviation of the compass needle when the bearing is placed at the east or west points will indicate incomplete demagnetization. After demagnetization reassemble all demountable bearings.

20 Soak bearings that do not have hard carbon deposits in clean hot oil for 4 hours. The bath should consist of No. 10 viscosity lubricating oil heated to a temperature of 77°C - 88°C (170°F-190°F). If equipment for heating the oil is not available, soak the bearings in a cold solvent such as white furnace oil.

21 Clean bearings, having hard carbon de-

posits, by soaking in a carbon removing solution, provided the bearings do not have micarta retainers.

22 After decarbonizing, thoroughly pressure-flush the bearings with hot oil to remove all foreign particles or residue. If oil heating equipment is not available, flush the bearings with a spray of white furnace oil. Turn one of the races slowly while flushing to help dislodge any dirt.

CAUTION

Never allow a bearing to spin freely under the impetus of air or spray pressure, as injury to the bearing will result.

23 If neither a spray or pressure-flushing device is available, hold bearings below the surface of a bath of solvent and rotate them by hand.

24 If the bearing is not to be used immediately, oil the part well; then wrap it in greaseproof wrapping paper and place it in a box or covered container.

CYLINDERS

25 The inside of the heads should be soft grit blasted to remove the hard carbon deposits.

CAUTION

Cylinder barrel muffs must never be blasted.

PARTS TREATED WITH PRESERVATIVE VARNISH

26 To avoid the possibility of removing the varnish, clean these parts with petroleum solvent only. For stripping, consult Part 8 Section 1, paragraph 23.

PISTONS

27 If necessary, during or after soaking in a carbon remover solution, use a soft metal or wood scraper to remove carbon from the ring grooves, being careful not to damage any of the ring lands or to remove any metal from the small radii between the ring lands and the bottom of the ring grooves. Soft grit blast all surfaces of the piston.

28 Ream out any oil holes filled with carbon, using an undersize drill. If necessary, polish the piston with crocus cloth and kerosene, but if this is done, clean it again by spraying with a petroleum solvent. Do not remove glazed surfaces on the piston skirt and the pistonpin.

VALVES

29 Soft grit blasting will remove the hard carbon from the heads of the valves; however, it is permissible to sandblast the exhaust valve heads, provided grade 120 round sand, propelled by air pressure not exceeding 30 psi is used, and provided the valve stem is protected from the sandblasting. Use a cloth wheel free of any abrasive compounds to clean valve stems as scratches will invite cracks, and subsequent failure of the valves. Do not remove the glaze and discoloration on the valve stems.

INTERNAL OIL PASSAGES

30 Clean the internal passages of all parts and blow out the passages with compressed air. Remove oil passage plugs where necessary.

IMPELLER SHAFT OIL SEAL AN-5 Model

31 Clean the impeller shaft oil seal immediately upon removal from the engine using kerosene or varsol spray, then air dry the seal. Do not use degreasing fluids on this seal. Do not wipe it with cloth or lint. Protect the seal with a cardboard collar placed around the carbon portion. Box the seal individually.

PART 4

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PART 4

INSPECTION

GENERAL

1 Thorough inspection of engine parts during overhaul is essential to ensure that unserviceable parts do not continue in service. These instructions will assist the experienced inspector to determine the serviceability of parts. The final responsibility for the disposition of parts rests with the supervisor of inspection.

RECORDS

2 Keep a record of the condition of all parts, including fits, clearances and spring pressures where applicable. When recording unserviceable conditions use standard descriptive terms. Some of the conditions which may be encountered are described in Section 1.

LABELLING

3 Attach a label to parts which require further attention stating the action to be taken to restore them to a serviceable condition. If the repair work affects a fit or clearance the label must remain with the part as a note to the inspector on assembly to check that fit or clearance. Parts which are beyond repair must be rejected, and should be destroyed to prevent their accidental re-installation.

CLEANING

4 Before cleaning the engine, inspect the exterior for signs of oil leaks or damage which would be removed by the cleaning process. After cleaning (refer to Part 3, "Cleaning",) arrange all the parts of one engine on a table so that the inspector can judge the condition of the engine as a whole, and trace the course of wear from one part to another if necessary.

TYPE OF INSPECTION

5 Subject all engine parts to visual and dimensional inspection as described in Section 1. Groups of similar parts are covered under "General", Section 1,while parts which are not easily grouped or which require special procedure are covered under "Specific", Section 2.

6 Subject steel parts to magnetic inspection as described in Section 3.

7 Inspect non-ferrous parts by the "Fluorescent Penetrant" method, Section 4.

SURFACE TREATMENT

8 The surface appearance of a part depends upon the treatment it has been given. The following description of various surface treatments will enable the inspector to distinguish between them and to recognize any condition which is not a result of normal manufacturing process.

(a) Preservative Varnish - Various interior steel parts are coated with a baked phenolic resin or varnish coating to provide resistance to corrosion. The shiny transparent coating, which is of a bluish-green or golden-brown appearance depending on the dye use, need not be replaced at overhaul.

(1) Parts which require magnetic inspection will show a stronger indication if this coating is stripped at overhaul. Parts that do not require magnetic inspection may be continued in service with the resin coating intact. However, any signs of flaking or peeling of the coating is cause for stripping the affected part. Refer to Part 7, "Repairs" for method of stripping Preservative Varnish.

(b) Phosphate Compound Coating - Other steel parts, particularly splined couplings have a phosphate compound coating to reduce galling. This coating accomplished its purpose when the parts were new and need not be replaced where it is worn off. The phosphate coating is dark gray in colour and somewhat granular in texture.

(c) Surface Oxidation Process - This process imparts a very thin oxide finish which aids in holding an oil film and helps prevent galling and corrosion. Smooth surfaced parts with this treatment are a shiny black. Where there has been contact with moving parts, the finish will be partly or entirely rubbed off. In other places the finish will remain intact. It is neither necessary nor desirable to reprocess parts.

(d) Discoloration of Steel Parts - During inspection of steel parts such as crankshaft, propeller shafts, linkrods, gears, cams, and starter jaws, the surfaces may be found to be darkened or stained. Such discoloration is the result of a new method of surface inspection and is not injurious either to the strength or durability of the part.

(e) Shot-Peening - Various steel and aluminum parts are shot-peened to put their surfaces under compression to make them more resitant to fatigue cracks. It is important that shot-peened surfaces should not be marred as a nick, gouge, or other such injury, breaking through the tension layer below the surface compression layer, will set up stresses. Dents which do not break through the surface are not serious. If an area on a shot-peened surface is blended to remove an injury, the area should be shot-peened to restore the surface compression. The character of a shot-peened surface varies with the hardness of the material and size and material of the metal or glass pellets used to peen it. Shot-peened surfaces will all feel more or less pebbled to the fingers even if shot-peening has no greater visible effect than to provide a mat rather than a polished surface. Where only certain portions of a part are shot-peened, nicks and scratches on the portions which are not shot-peened may be cleaned up in the ordinary way.

GAUGES

9 When an inspection procedure requires a very accurate measurement, a micrometer or a dial indicator must be used. If a micrometer is to be used, check it for accuracy before taking a measurement. Make sure that the contacting surfaces of the micrometer are clean, and that the contacting surfaces of the part to be measured are clean and free from burrs. When using a depth micrometer, be sure to hold the anvil tightly and squarely against the contacting surface. If a dial indicator is used, make sure that the indicator support is firmly anchored and any swivel connection tightened securely.

10 When taking a measurement with a feeler gauge, the final size of the feeler must be a reasonable snug fit.

11 Both the plug type and the flat type gauges are used for measuring the amount of wear of bushings and similar parts. Except when otherwise stated, if the "No-Go" end of a plug gauge enters, the part is worn beyond the allowable limit. Because certain parts do not always wear evenly, the flat type gauge must be tried at several different diameters. If the gauge enters at any point, the part is worn beyond the allowable limit.

SECTION 1

VISUAL INSPECTION & DIMENSIONAL CHECKS - GENERAL

BAD CONDITIONS

1 The description of conditions of Engine parts in paragraphs 2 to 39 is mainly to encourage the use of standard terminology when making inspection records. It is the responsibility of the inspector to determine whether a part shall continue in service.

ABRASION

2 A roughened area - Varying degrees of abrasion can be described as light or heavy, depending upon the extent of reconditioning which will be necessary to restore the surface.

(a) Cause: presence of fine foreign material between moving surfaces.

BEND

3 General distortion in structure as distinguished from a local change in contour such as a Dent, Peening, etc.

(a) Cause: forces defined in Stresses, or uneven application of heat.

BLISTERING

4 Raised areas indicating separation of the surface from the base. Usually found on plated, or painted surfaces. Associated with flaking and peeling.

(a) Cause: imperfect bond with the base, usually aggravated by the presence of moisture, gas, heat, or pressure.

BLOW-BY

5 The passage of combustion products, under pressure, past pistonrings, valves, etc. Severe cases indicated by characteristic discoloration and frequently by erosion or guttering. There is usually slight blow-by at the pistonrings during operation. One indication of this is that lead from the fuel is always found in some quantity throughout the engine, particularly in rotating oil cavities which act as centrifuges. Weak or poorly seated pistonrings can permit sufficient blow-by to build up considerable crankcase pressure with possible resultant "heavy breathing" and without the rings showing strong indication of such a condition.

(a) Cause: Improper seating of pistonrings or valves.

BREAK OR FRACTURE

6 Complete separation by force into two or more pieces.

(a) Cause: fatigue; shock; overload.

BRINELLING

7 Indentations sometimes found on the surfaces of ball or roller bearing parts. Bearings which do not have full, constant rotation and are subjected to shock loading, have brinelling tendencies. Propeller thrust bearings have been known to become brinelled when the engine was partially supported at the propeller shaft during transit in a railroad car or truck.

(a) Cause: improper assembly or disassembly technique, such as removing or installing a roller or ball bearing by the application of force on the free race.

BURNING

8 Injury to the surfaces by excessive heat. Evidenced by characteristic discolouration or, in severe cases, by loss or flow of material.

(a) Cause: excessive heat due to lack of lubrication, improper clearance, blow-by, detonation, etc.

BURNISHING

9 Mechanical smoothing of a metal surface by rubbing, not accompanied by removal of material but sometimes by discolouration around the outer edges of the area. Usually found on plain bearing surfaces. Operational burnishing is not detrimental if it covers approximately the area carrying the load, and provided there is no evidence of pile-up or burning.

(a) Cause: normal operation of parts.

BURR

10 A sharp projection or rough edge.

(a) Cause: machining operations; excessive wear; peening.

CHAFING OR FRETTING

11 A rubbing action between two parts having limited relative motion. To be interpreted as an action which produces a surface condition rather than as a description of the injury.

CHIPPING (See Figure 4-1)

12 Breaking out of small pieces of metal. Not to be confused with Flaking.

(a) Cause: concentration of stress due to shock, nicks, scratches, inclusions, peening; careless handling of parts.

CORROSION (See Figure 4-2)

13 Breakdown of the surface by chemical action.

(a) Cause: presence of corrosive agents.

CRACK

14 A partial fracture.

(a) Cause: excessive stress due to shock, or overloading; extension of a nick or scratch; defective material.

CUPPING (See Figure 4-3)

15 Hollowed out areas resulting from repeated contact of two operating parts.

(a) Cause: improper hardness; excessive sliding motion; impact.

DENT

16 Small, smoothly rounded hollow in the surface.

(a) Cause: concentrated overload resulting from peening or the pressure of chips between loaded surfaces; striking of part with dull object through careless handling.

ELECTROLYTIC ACTION

17 Breakdown of the surface by electrical action between parts composed of dissimilar metals.

(a) Cause: galvanic action between dissimilar metals.

EROSION (See Figure 4-4)

18 Carrying away of material by the flow of

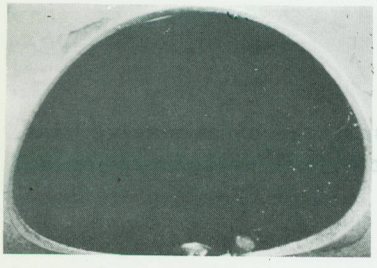


Figure 4-1 Chipping

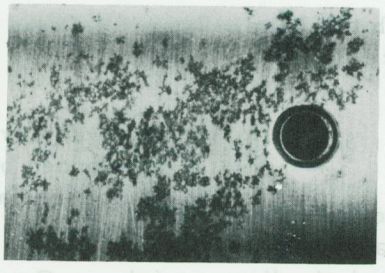


Figure 4-2 Corrosion

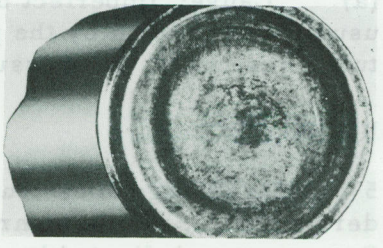


Figure 4-3 Cupping

hot gases, grit or chemicals. (See also GUTTERING.)

(a) Cause: blow-by; flow of corroding liquids, hot gas, or grit laden oil.

FATIGUE FAILURE (See Figure 4-5, 4-6)

19 Progressive yielding of one or more local areas of weakness such as tool marks, sharp indentations, minute cracks, inclusions, etc., under repeated stress. As the working stress on the piece is repeated, cracks develop, at the ends of which there are high concentration of stress. The cracks spread, usually from the surface or near the surface, of the section. After a time, there is so little sound metal left that the normal stress on the piece is higher than the strength of the remaining material, and it snaps. Failure is not due to crystallization of metal. The appearance of a typical fatigue failure is easily explained. As failure proceeds, the severed surfaces rub and batter each other, crushing the grains of the material and producing the dull or smooth appearance; the remaining unfractured portion preserves the normal grain structure up to the moment of failure. The progressive nature of the failure is usually indicated by several more or less concentric lines, the centre, or "focus," of which discloses the origin of the failure.

(a) Cause: tool marks: sharp corners; nicks; cracks; inclusions; galling; corrosion; insufficient tightening of studs or bolts to obtain proper stretch.

FEATHERING

20 A rough, featherlike edge, sometimes found on pistonrings or oil seal rings.

(a) Cause: excessive pressure resulting from insufficient end gap, insufficient lubrication, or excessive temperature; failure to remove all abrasive after lapping.

FLAKING (See Figure 4-7)

21 Breaking away of pieces of a plated or painted surface.

(a) Cause: incomplete bond; excessive load; blistering.

FRETTING CORROSION (See Figure 4-8)

22 Discolouration may occur on surfaces which are pressed or bolted together under high pressure. On steel parts the colour is reddish brown and is sometimes called "cocoa" or "blood." On aluminum or magnesium, the oxide is black.

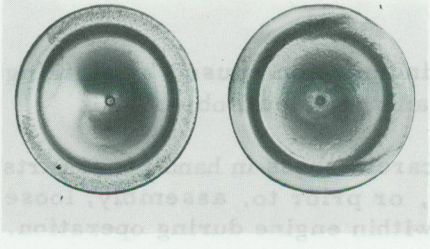


Figure 4-4 Erosion

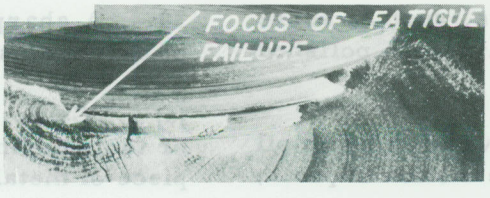


Figure 4-5 Fatigue Failure (Steel)

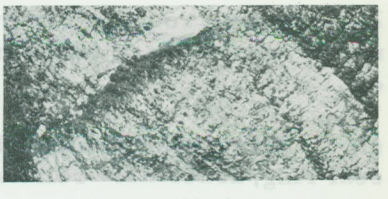


Figure 4-6 Fatigue Failure (Aluminum)

Figure 4-7 Flaking

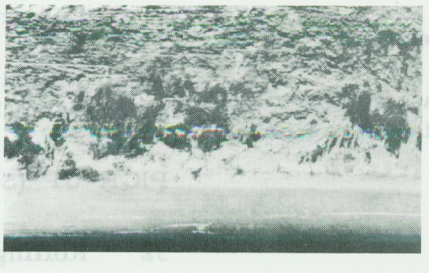


Figure 4-8 Fretting Corrosion

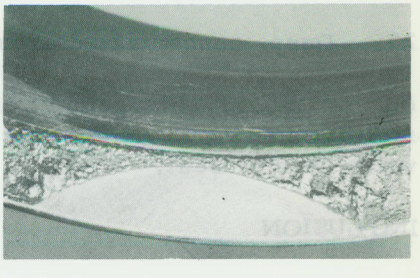


Figure 4-9 Galling

(a) Cause: rubbing off of fine particles of metal by slight movement between parts and oxidizing of these particles.

GALLING (See Figure 4-9)

23 A transfer of metal from one surface to another. Do not confuse with Pickup, Scoring, or Scuffing.

(a) Cause: severe chafing or fretting action caused during engine operation by a slight relative movement of two surfaces under high contact pressure.

GLAZING

24 Development of a hard, glossy surface on plain bearing surfaces or pistons. An often beneficial condition.

(a) Cause: combination of pressure, oil, and heat.

GOUGING

25 Displacement of material from a surface, a cutting, tearing, or displacement effect.

(a) Cause: presence of a comparatively large foreign body between moving parts.

GROOVING

26 Smooth rounded furrows, such as score marks whose sharp edges have been polished off.

(a) Cause: concentrated wear as by an oil seal ring; abnormal relative motion of parts; parts out of alignment.

GUTTERING

27 Deep, concentrated erosion.

(a) Cause: enlargement of a crack or defect by burning of an exhaust flame, as on a valve head or seat.

INCLUSION

28 Foreign material enclosed in the metal. Surface inclusions are indicated by dark spots or lines. Both surface inclusions and those near the surface may be detected during magnetic inspection by the grouping of magnetic particles. Examination of a fatigue fracture may reveal an inclusion at the focal point.

(a) Cause: inherent discontinuity in the material.

LEAD SWEATING (See Figure 4-10)

29 Patches of lead on the surface of a bearing or bushing, the alloy of which contains a relatively high percentage of free lead.

(a) Cause: heat or pressure producing separation of free lead.

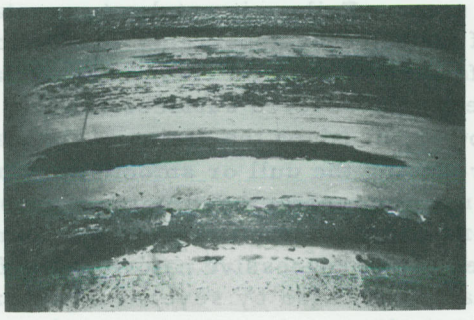


Figure 4-10 Lead Sweating

NICK

30 A sharp indentation caused by striking of part against another metal object.

(a) Cause: carelessness in handling of parts or tools during, or prior to, assembly; loose piece of metal within engine during operation.

PEENING (See Figure 4-11)

31 Deformation of the surface.

(a) Impact of foreign object such as occurs in repeated blows of a hammer on part.

PICK-UP (See Figure 4-12)

32 Rolling up of metal, or transfer of metal from one surface to another.

(a) Cause: rubbing of two surfaces without sufficient lubrication, presence of grit between surfaces during assembly under pressure; unbroken edges of press fitted parts; incipient seizure of rotating parts during operation.

PILE-UP

33 Displacement of particles of a surface from one point to another. Distinguished from pick-up by the presence of depressions at the point from which the material has been displaced.

PITTING (See Figure 4-13)

34 Small, irregularly shaped cavities in a surface from which material has been removed by corrosion or chipping. Corrosive pitting is usually accompanied by a deposit formed by the action of a corrosive agent on the base material.

(a) Cause: (1) corrosive pitting - breakdown of the surface by oxidation or some other chemical or electrolytic action.

(2) Mechanical pitting - chipping of loaded surfaces because of overloading, improper clearances, or the presence of foreign particles.

SCORING (See Figure 4-14)

35 Deep scratches made during engine operation by sharp edges or foreign particles; elongated gouges.

(a) Cause: presence of chips between loaded surfaces having relative motion.

SCRATCHES

36 Narrow, shallow marks caused by the movement of a sharp object or particle across a surface.

(a) Cause: carelessness in handling of parts or tools prior to, or during assembly; sand or fine foreign particles in engine during operation.

SCUFFING (See Figure 4-15)

37 Surface injury resulting from the inci-

Figure 4-11 Peening

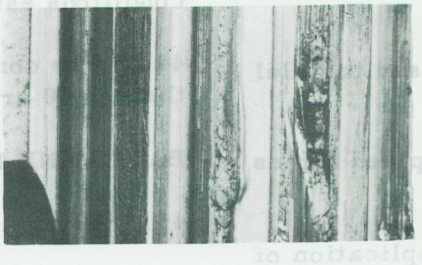


Figure 4-12 Pile-up

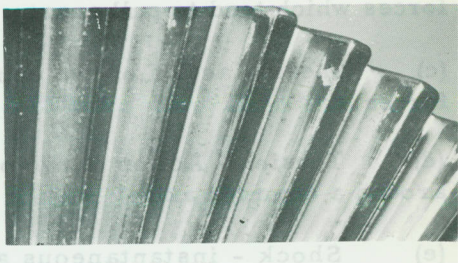


Figure 4-13 Pitting

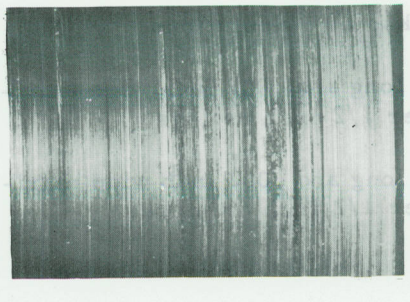


Figure 4-14 Scoring

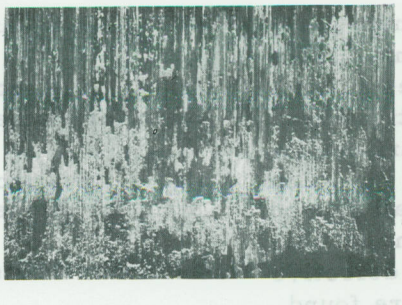


Figure 4-15 Scuffing

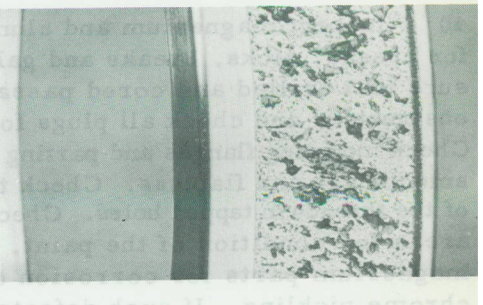


Figure 4-16 Spalling

pient seizure of reciprocating parts. Evidenced by pick-up and pile-up.

(a) Cause: insufficient clearance or lubrication.

SPALLING (See Figure 4-16)

38 Sharply roughened area characteristic of the progressive chipping or peeling or surface material. Not to be confused with flaking.

(a) Cause: surface crack, inclusion, or similar surface injury causing a progressive breaking away of the surface under load.

STRESSES

39 When used in describing the cause of failure of machine parts, stresses are generally divided into five groups - compression, tension, shear, torsion, and shock. These are used to describe the forces as follows:

(a) Compression - action of two directly opposed forces which tends to squeeze a part together.

(b) Tension - action of two directly opposed forces which tend to pull apart.

(c) Shear - action of two opposed parallel forces.

(d) Torsion - Action of two opposed forces around a common axis.

(e) Shock - instantaneous application of stress.

ALUMINUM & MAGNESIUM PARTS

40 Inspect magnesium and aluminum parts for cracks, nicks, breaks and galling. Make sure that drilled and cored passages are not obstructed, and check all plugs for tightness. Check mounting flanges and parting surfaces for smoothness and flatness. Check the condition of the threads in tapped holes. Check all painted areas for condition of the paint. Inspect all magnesium parts for corrosion or defective chrome pickling. If such defects are found, they may be repaired as described under "Chromic Acid Treatment."

BALL & ROLLER BEARINGS

41 Disassemble all demountable bearings, making certain that the parts of one bearing are not mixed with those of another.

42 Bearings often show wear on the bore, outside diameter, or lateral faces due to spinning. External wear appearing on brightly polished surfaces, is not cause for rejection, provided the external dimensions of the bearings are within their specified limits. Scuffed or abraded surfaces should be polished with No. 5 Moco Compound to remove loose material and to reduce high spots. After polishing, check the external dimensions of the bearings. When the contact pressure between the bearing outer race and its seat is not uniform, slight relative motion between the race and its seat often produces corrosion fretting. Generally, this condition is not cause for rejection of the bearing and may be cleaned up with No. 5 Moco Buffing Compound.

43 Circumferential scratches frequently noted on raceways are due to the passage of minute foreign particles through the bearing and are cause for rejection only when they exceed the conditions established above.

44 The conditions defined in paragraphs 45 through 60 are cause for rejection.

BALLS AND ROLLERS

45 Pits.

(a) Larger then .006 inch diameter.

(b) Cluster or chain.

46 Dents, nicks, or indentations.

(a) .010 inch long and .002 inch wide maximum for diameter 1/2 inch or less.

(b) .012 inch long and .002 inch wide maximum for diameter 1/2 inch or more.

47 Scratches.

(a) Single scratch more than half way around diameter.

(b) Multiple scratches one-quarter around diameter.

(c) Scratches that cross each other, if any of them can readily be felt with a .020 inch radius scriber.

48 Scuffs.

(a) Any that can be felt with a .020 inch radius scriber.

49 Discolouration due to heat.

RACES

50 Pits.

(a) Larger than .010 inch diameter and readily felt with a .020 inch radius scriber.

(b) Cluster or chain.

51 Dents, nicks, and indentations.

(a) More than .010 inch across and readily felt with a .020 inch radius scriber.

52 Scratches.

(a) Long single scratches.

(b) Scratches that cross each other and can be readily felt with a .020 inch radius scriber.

(c) Any scratch that crosses the race.

53 Cracks.

(a) Any cracked race unacceptable.

54 Discolouration due to heat.

ASSEMBLIES

55 Damaged or excessively loose retainers.

56 Stains that are not readily removed with light polishing.

57 Spalled load carrying surfaces.

58 Loose or missing rivets.

59 Badly dented or otherwise damaged race shields.

60 Excessive corrosion or rust in the raceways or in the rolling elements.

NOTE

Clean minor pitting or corrosion from the raceways by dry buffing, using Lea Compound No. 305A or No. 4 Moco Buffing Compound on a cloth wheel. Be very careful not to burn or heat the race surface by excessive buffing. Never attempt to polish the raceways with abrasive paper or cloth.

CAUTION

When an abrasive has been used on a bearing, the bearing must be thoroughly flushed as instructed in Part 3, "Cleaning."

BALL BEARING FEEL TEST

61 The feel test is used to judge the condition of the internal bearing surfaces both as to wear and smoothness. All ball bearings, except some double row bearings, have some initial clearance. In installations where the bearings are well protected from dirt, the internal clearance will not change perceptibly during the life of the bearings. The presence of dirt will cause rapid wear which will alter the end play and/ or the radial play, and will also affect the separator fit to a marked degree. Rough running of the bearing may result from failure of the bearing elements or separator, from brinelling, chips, dirt, or corrosion within the bearing.

62 Make sure the bearings are oiled; then spin them by hand, holding them so that the axis of rotation is in a vertical plane, to insure contact between the raceway and each rolling element. Reverse the bearing and repeat the spinning. Thrust bearings should be assembled and given the spin test under a five pound thrust load. Any rough running bearings should be thoroughly cleaned and flushed as described in Part 3, "Cleaning". If, after the recleaning, the bearing continues to run rough, reject the bearing.

BOLTS

63 Inspect for cracks especially under the bolt head and at the base of the threads. Check the condition of the threads.

BUSHINGS & PLAIN JOURNAL BEARINGS

64 Examine for cracks, scoring, looseness, and indications of overheating and lead sweating. Check for concentricity and excessive wear, using the proper maximum wear gauge listed in Part 9, "Special Tools".

COUPLINGS

65 Examine for burrs and check the fit with mating parts. Inspect splined areas for pitting, pick-up, and roughness.

GEARS

66 Examine for evidence of improper tooth bearing, pitting, spalling, excessive wear, and burrs. Examine any splined areas for burrs, galling, and fit with mating parts. Inspect journal surfaces on gear shafts for scoring, roughness, and indications of overheating.

LEADED BEARINGS

67 The masterod bearing has a leaded bearing surface. In most instances the deciding factor in determining whether a leaded bearing surface is fit for further service, is the condition of the lead coating. If the lead coating is in good condition, the bearing will automatically be within the prescribed limits, unless extreme out of roundness or distortion of the bearing shell exists, or unless the bearing is to be used with a part having dimensions other than those of the one with which it was originally used.

68 As the condition of the bearing is determined by visual inspection, the object of the following discussion with the accompanying photographs, is to acquaint the overhaul personnel with the various bearing appearances, and to assist in evaluating them. Limitations of photography prevent the accurate illustration of acceptable and non-acceptable conditions of the leaded bearing surface, and it is impossible to show in the accompanying photographs the difference in appearance which exists between a polished leaded surface and an exposed and polished silver surface. Usually, however, these two conditions are readily distinguishable upon examination of the actual bearing. If there is any doubt as to whether a polished area has a lead or silver surface, it may be tested by running a finger nail lightly over the surface. A leaded surface will scratch readily; a hard, glassy surface indicates polished silver.

69 The two bright streaks down the middle of some of the photographs are the results of reflected light from the curved surface of the bearings and should be disregarded.

70 Figure 4-17 shows a bearing which has had severe usage, as indicated by the highly polished portions of the leaded surface, but which is still satisfactory for continued service. The light area at "A", as well as other light areas, are well covered with polished lead. The light coloured streaks, which have a frosted rather than polished appearance upon examination of the bearing itself, emanating from the oil holes at "B", indicate low spots in the leading coating. Such streaks are not cause for rejection of the bearing. The light colour merely indicates that the lead in this area has not been in contact with the crankpin. Low areas which have not been in actual contact with the crankpin retain the light colour of an unused bearing, whereas the remaining surface normally takes on a much darker appearance after the bearing has been in service. Such indications should not be confused with areas of corrosion which may be similar in appearance and which may also occur around the oil holes. Areas of corrosion may take any shape and may occur at any position adjoining the oil holes. Corrosion spots often have a brownish, pitted appearance. The scratches indicated at "C" are from testing the surface for lead with a finger nail. Obviously, the lead coating of a bearing should not be scratched or otherwise disturbed more than necessary, but light scratching with a finger nail is not detrimental.

71 Figures 4-18 and 4-19 illustrate conditions of the lead surface, commonly called "hen tracking", which consists of a closely-knit group of small, interconnected furrows. Where this

condition is confined to small, well-defined areas, not greater than one half inch square, the bearing may be continued in service, as shown in Figure 4-18. Where the "hen tracking", is extensive or where the condition shows signs of spreading all over the surface as in Figure 4-19, the bearing should be returned to the manufacturer for reprocessing.

72 Figure 4-20 illustrates a bearing with metal particles imbedded in the lead surface. This condition results from foreign matter accumulating in the oil system of the engine. Where a few isolated particles of foreign matter have become imbedded in the leaded surface and the lead has formed a protective coating over and around the particles in such a manner that they cannot damage the crankpin, the bearing may be continued in service. Consideration should also be given as to whether the particles are of steel or of aluminum, since the aluminum particles are less apt to damage the crankpin.

73 Figure 4-21 shows a magnified view of a bearing surface in which a foreign particle has imbedded itself, first scratching a groove in the surface. It can be noted that the lead which was displaced by this particle has blended into the adjoining lead coating; also that a protective coating has formed over the particle itself. In such cases, the bearing is suitable for further use.

CAUTION

Never attempt to remove foreign particles from the lead surfaces as serious damage may result to the lead coating.

74 Figure 4-22 shows a bearing surface which has been seriously corroded. Small isolated corrosion spots, the size of those shown at "A" and "B", are not cause for rejection of the bearing; however, where several spots are grouped together, as in this instance, the bearing should be reprocessed. Corrosion spots in the presence of severe "hen tracking", as illustrated at point "C", are grounds for rejection of the bearing. Obviously, corrosion spots as large as the one at "D" are cause for immediate rejection of the bearing.

75 Figure 4-23 illustrates a condition which is commonly known as "lead washing". Much of the lead coating has disappeared due to acidic attack resulting from high acidity of the lubricating oil. Examination of this bearing shows that the areas, indicated at "A" and "C", are entirely devoid of any lead coating. Any one of these areas is sufficient cause for rejection of the bearing. In cases which are as extreme as this one, it is improbable that the finger nail test would be necessary to determine whether or not the lead coating has disappeared to the extent that the bearing should be reprocessed, but this test might prove necessary if the area at "C" were the only one in question, as the light or polished appearance is similar to that of a bearing which has been subjected to severe load.

76 Indicated at point "B" on this same bearing is a condition which is apt to occur more or less frequently and which is in no way detrimental, namely, a small triangular section, at one side of an oil hole, where lead has been removed from the surface. It is believed that this condition is due to physical removal of the plating by oil under the extremely high pressure which develops when the oil is wedged between the crankpin and the bearing. These triangular areas are always sharply defined and always appear at about the position which is illustrated at "B" of Figure 4-23. The same condition also appears at the left hand oil hole of the bearing illustrated in figure 4-17.

77 Generally speaking, it is safe to continue the use of a leaded silver bearing if no part of the lead coating has disappeared to the extent that the silver beneath can come in contact with the crankpin. Small individual pits or minute areas of incipient corrosion, such as sometimes occur opposite crankpin holes when the engine has been idle with the crankshaft in one position for an extended period, are not considered detrimental. If there is any doubt as to the serviceability of a bearing, however, it should be returned to the manufacturer for inspection and reprocessing, if the latter proves necessary.

LINERS

78 Examine for pitting and galling. If the

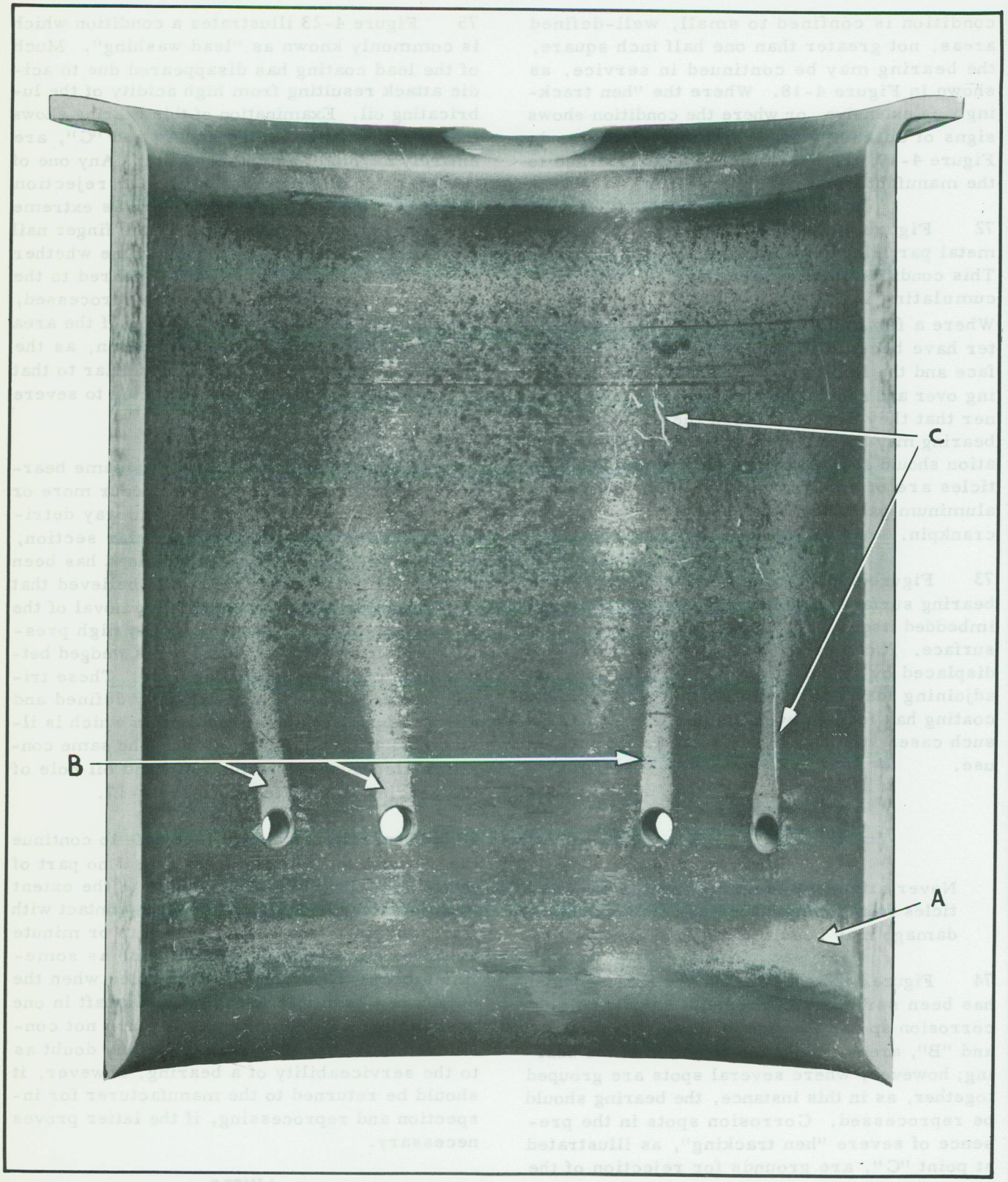


Figure 4-17 Light Coloured Streaks from Oil Holes

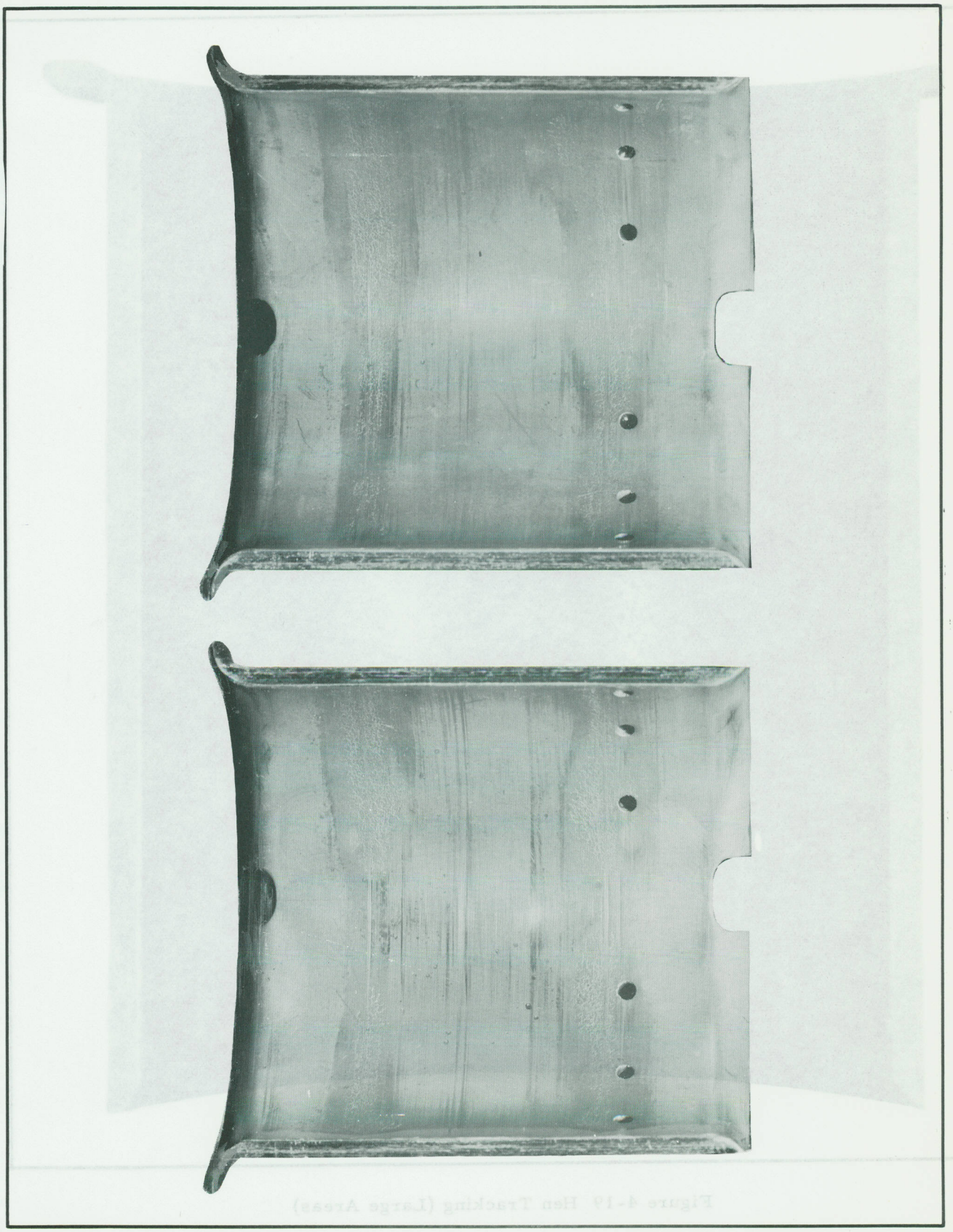


Figure 4-18 Hen Tracking (Small Areas)

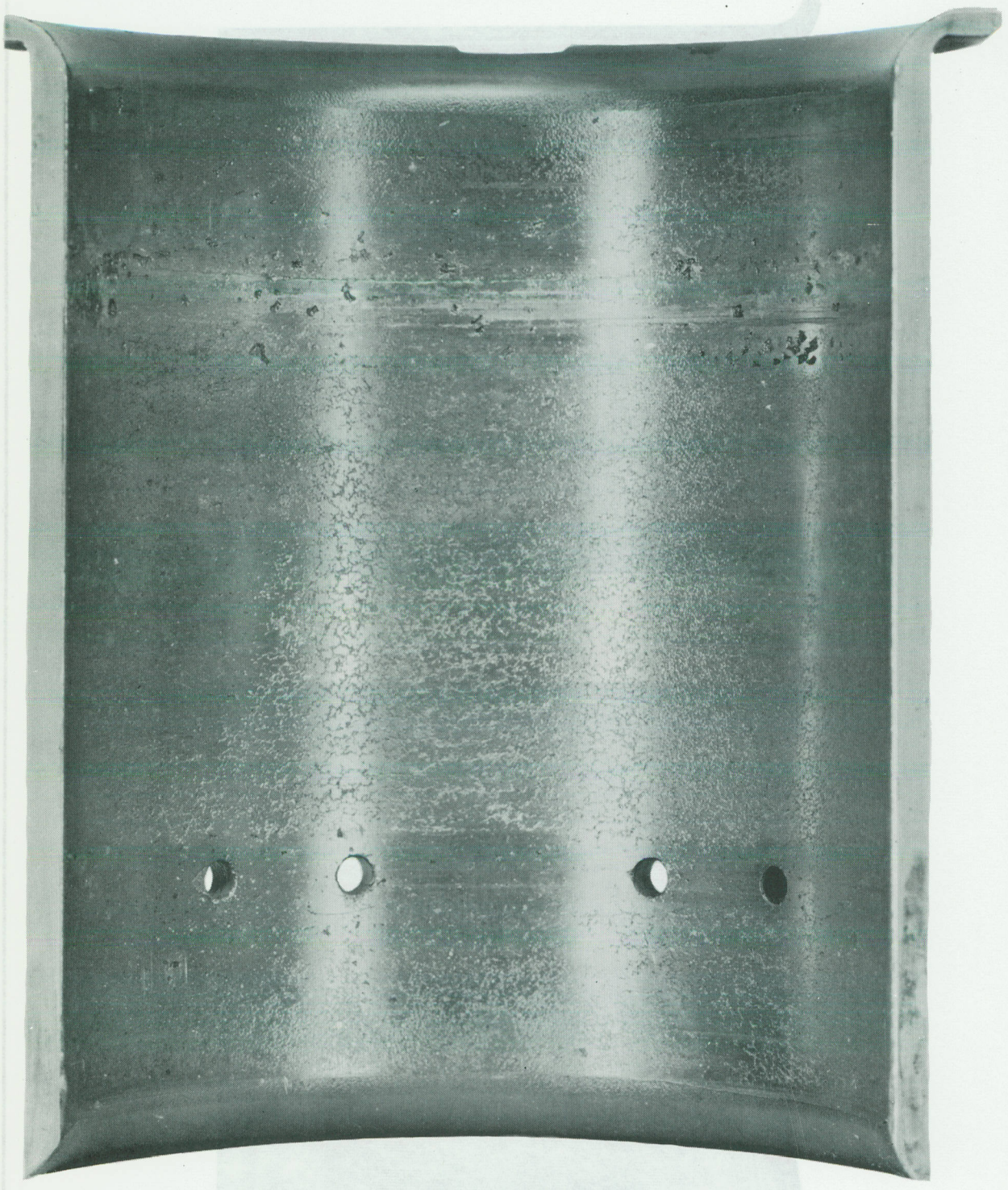


Figure 4-19 Hen Tracking (Large Areas)

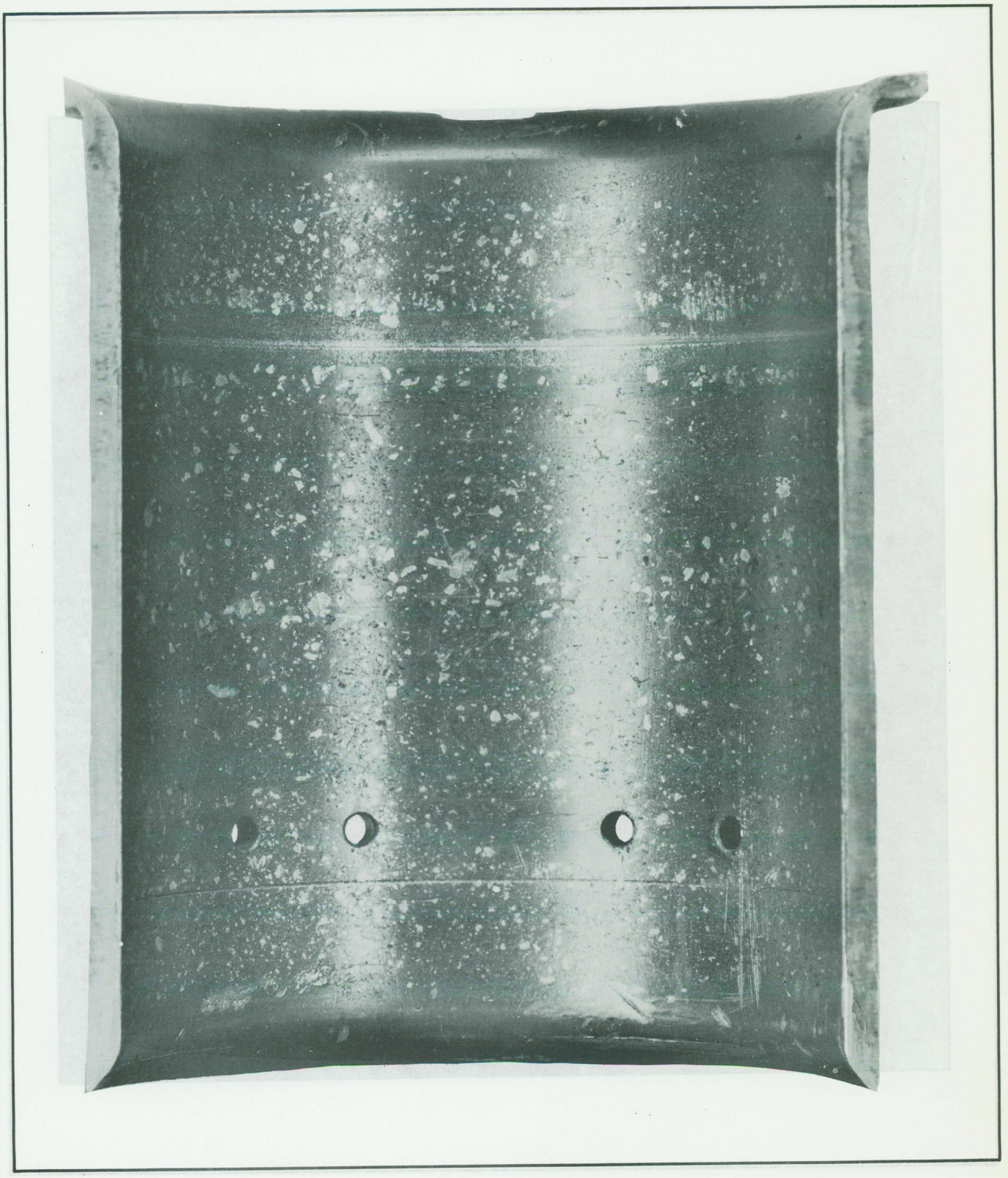


Figure 4-20 Contamination by Foreign Metal Particles

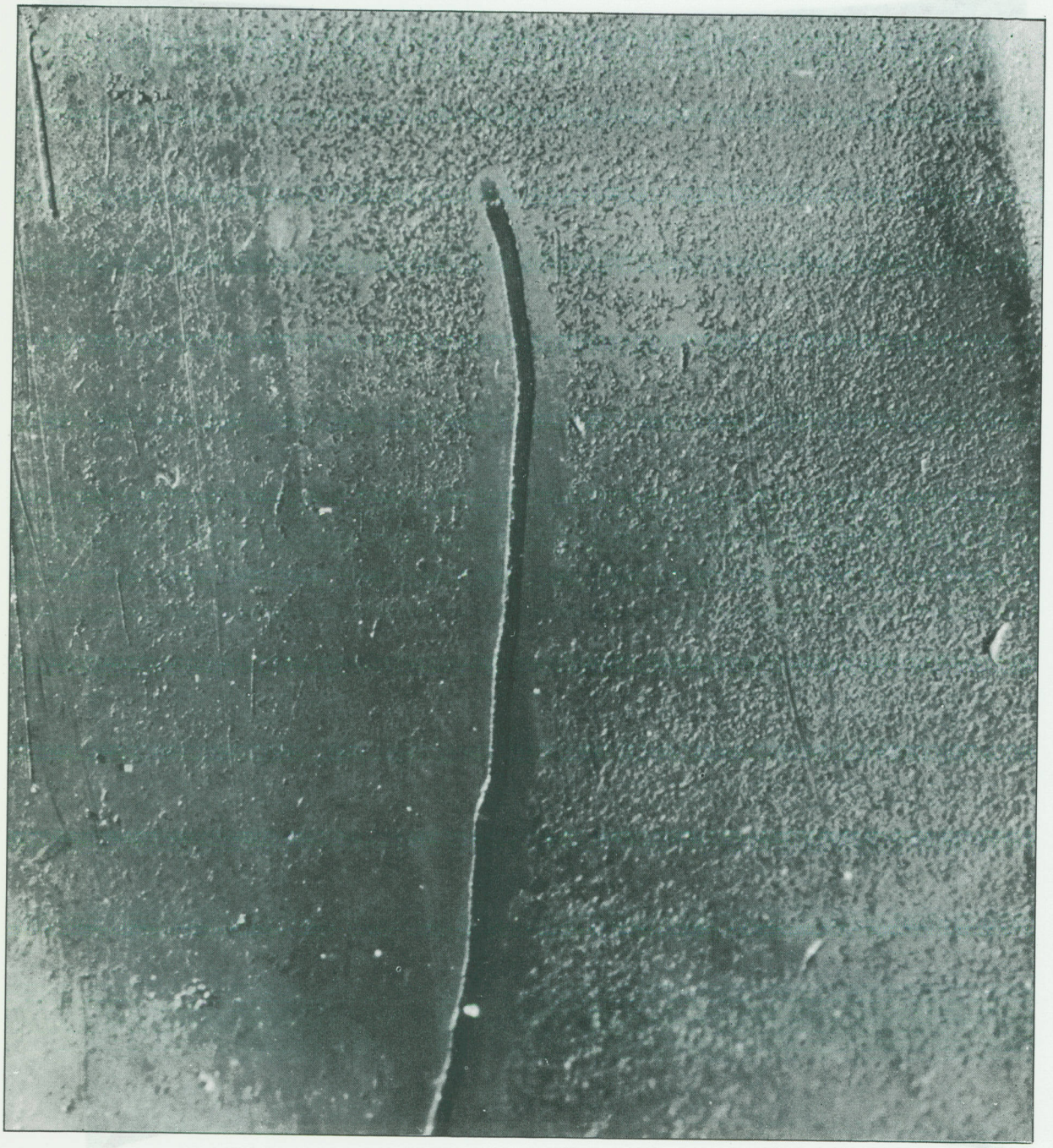


Figure 4-21 Foreign Particles Imbedded in Bearing Surface

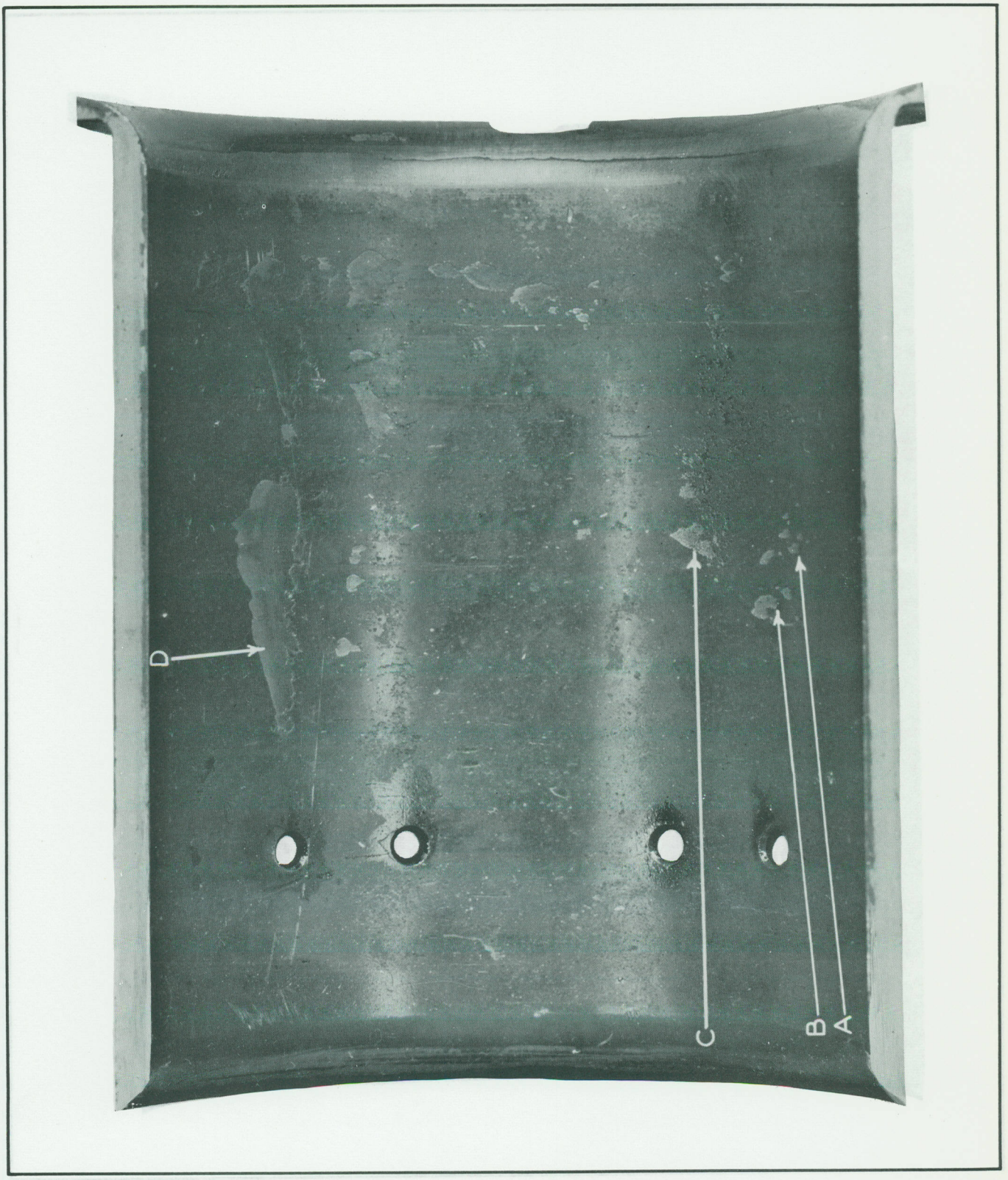


Figure 4-22 Corrosion

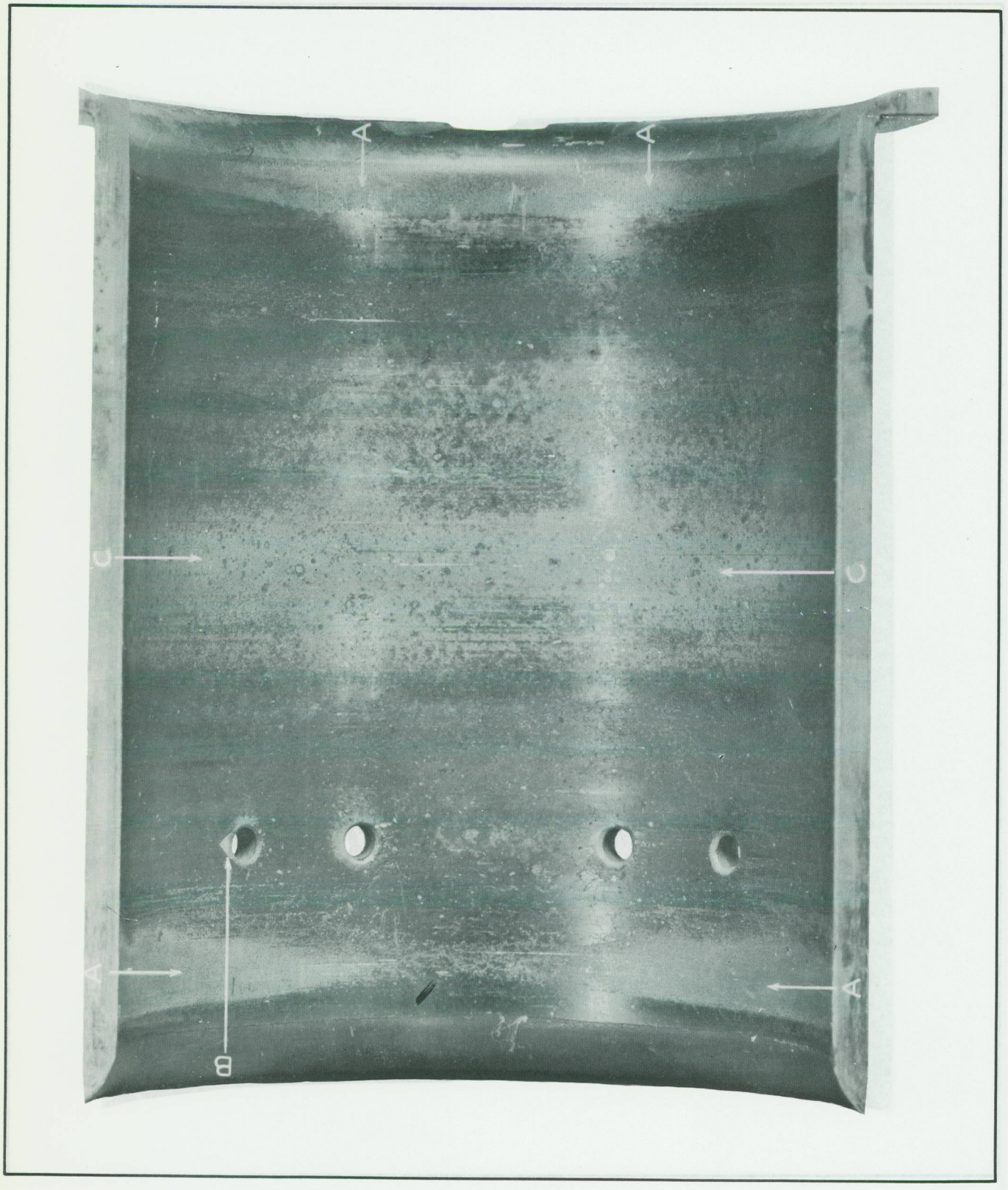


Figure 4-23 Lead Washing

liner accommodates a bearing, check the fit of the bearing in the liner. If the liner accommodates oil seal rings, check the liner for wear and excessive grooving. If the inside diameter of the liner has been worn .003 inch or if a groove of .0015 inch or more has been worn at any one point, change the liner or regrind it to accommodate oversize rings.

NUTS

79 Inspect any wrench slots for cracks and burrs. Check the condition of the threads and check the faces of the nut for galling and pick-up.

OIL SEAL RINGS

80 Exchange all bronze oil seal rings for new rings at every overhaul. Check the old rings for excessive wear and loss of tension. If the rings have been worn excessively or have lost their tension appreciably, carefully inspect their carriers and liners for wear, roughness, and indications of overheating.

OIL SEAL RING CARRIERS

81 Check the condition of the ring grooves and examine any splines for galling and burrs. Check the fit of each carrier with its mating parts.

RIVETS

82 Check for secure anchorage.

SHAFTS

83 Check shafts for straightness by rolling them on a plane surface or by rotating them on vee blocks or lathe centres and checking the runout, using a dial indicator.

84 Inspect for fatigue cracks. Check the condition of threaded areas and examine splines for burrs and galling. Inspect bearing journals for scoring, roughness, and indications of overheating.

SPACERS

85 Inspect for nicks and cracks. Check mating surfaces for smoothness. Examine any splines for galling and burrs.

SPRINGS

86 Inspect for pitting, cracks, rusting, and burrs. Check the spring pressure as illustrated in Figure 4-24. Refer to the TABLE OF LIMITS, Part 5, Section 3.

STUDS

87 Check for looseness, cocking, possible fracture at the base of the threads, and projection length. Inspect the threads for nicks, cracks, and burrs.

TUBES

88 Inspect for dents, cracks, and obstructions. Check the condition of any flanges. Check tubes that fit into mating holes for looseness which might result in loss of any oil pressure.

THREADED INSERTS

89 Check for looseness. Inspect the threads for nicks, cracks, and burrs.

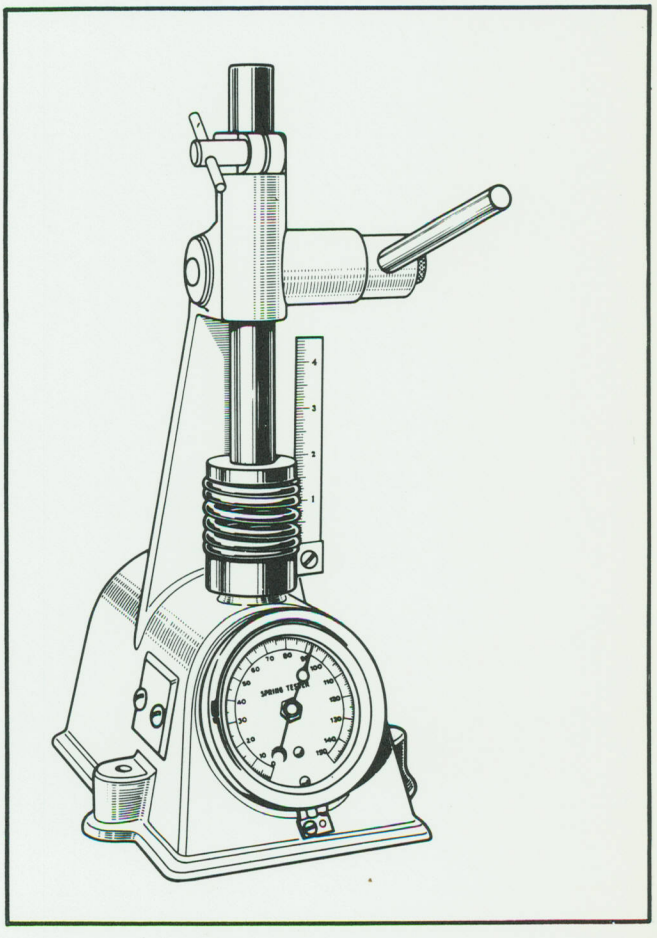


Figure 4-24 Spring Tester

SECTION 2

VISUAL INSPECTION & DIMENSIONAL CHECKS - SPECIFIC

FRONT SECTION

NOTE

Inspect engine data plate for security. Refer to Part 8, Section 2, para. 174.

OIL SLINGER

1 Inspect for galling and distortion.

THRUST BEARING NUT

2 Inspect the front and rear faces for galling. Examine the wrench slots for cracks, burrs and other damage. Check the condition of the threads.

VALVE TAPPETS

3 Examine for cracks and scoring. Check the fit of each tappet in its guide. Inspect the socket in the pushrod end of each tappet for galling, scoring and excessive wear. Change the socket if an area 1/32 inch wide has been worn on the surface of the socket, or if the surface is rough or uneven.

VALVE TAPPET GUIDES (Tool Group 136)

4 Examine for cracks, especially at the slotted ends. Inspect for scoring. Check the tightness of the guide in the front case by tapping the end of the guide with a hide mallet. Check for excessive wear with the maximum wear gauge. Using the aligning gauge check the alignment of the guides. If the gauge does not enter two adjacent guides, place a dial indicator on a straight-edge across the cam shelf and measure the relative difference in height between the sides of the roller slot in the suspected guide. (Fig. 4-25). A maximum difference of .008 inch in the height of the sides is permissible. Re-position, if practicable, otherwise exchange any guides found out of alignment.

VALVE TAPPET ROLLERS AND PINS

5 Check the fit between the rollers and pins. The roller when oiled should turn freely on the pins. Use a magnifying glass to examine the rims of the rollers for pitting, roughness, and cracks, particularly at the edges. Mild pitting is not necessarily cause for rejection, but breaks in the rim surface require exchange. Inspect the roller pins for scoring, pitting, cracks, and signs of overheating.

PROPELLER CONTROL VALVE ASSEMBLY AN-14B Model

6 Examine the valve shaft for mutilations and for freedom of movement and check the fit of the valve assembly in the front case. Inspect the tapered pin and the liner for cracks. Renew the cork packing in the cover and the gasket between the cover and the front case at each overhaul.

PROPELLER AND THRUST BEARING OIL FEED TUBES

7 Check the condition and the fits of the oil

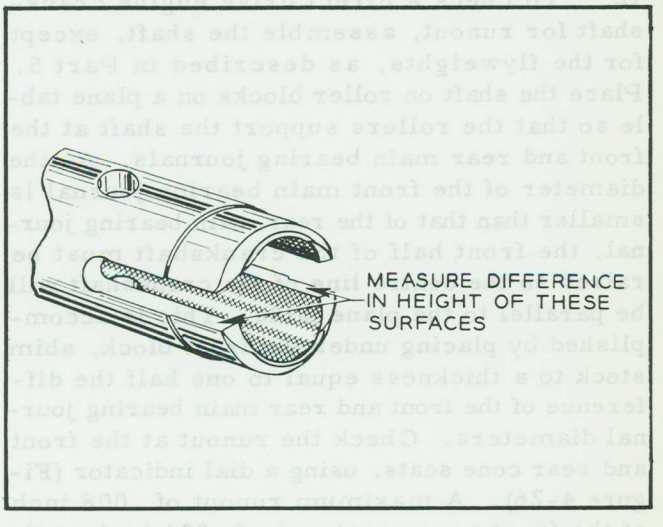


Figure 4-25 Suspected Guide

feed tubes to and from the propeller control assembly. On the AN-5 Model inspect the oil feed tube to the thrust bearing. Change a tube if it is mutilated, cracked, or is a loose fit.

CRANKCASE SECTION

CAM

8 Inspect the gear teeth for wear, pitting and signs of improper contact. Examine the ID for smoothness. Inspect the cam lobes for pitting and uneven wear.

CAM OIL FEED BRACKET

9 Check the fit of the bracket on the cam hub. Examine the steel bushings for smoothness.

CYLINDER FLANGE STUDS OR BOLTS

10 See "Cylinders and Pistons" in the Part 2, and "Cylinder Flange Studs" in Part 8.

ENGINE LIFTING LINKS

11 Inspect for cracks and general condition.

CRANKSHAFT ASSEMBLY

CRANKSHAFT

12 To check a direct drive engine crankshaft for runout, assemble the shaft, except for the flyweights, as described in Part 5. Place the shaft on roller blocks on a plane table so that the rollers support the shaft at the front and rear main bearing journals. As the diameter of the front main bearing journal is smaller than that of the rear main bearing journal, the front half of the crankshaft must be raised so the centre line of the crankshaft will be parallel to the plane table. This is accomplished by placing under the front block, shim stock to a thickness equal to one half the difference of the front and rear main bearing journal diameters. Check the runout at the front and rear cone seats, using a dial indicator (Figure 4-26). A maximum runout of .008 inch at the front cone seat and of .004 inch at the rear cone seat is permissible.

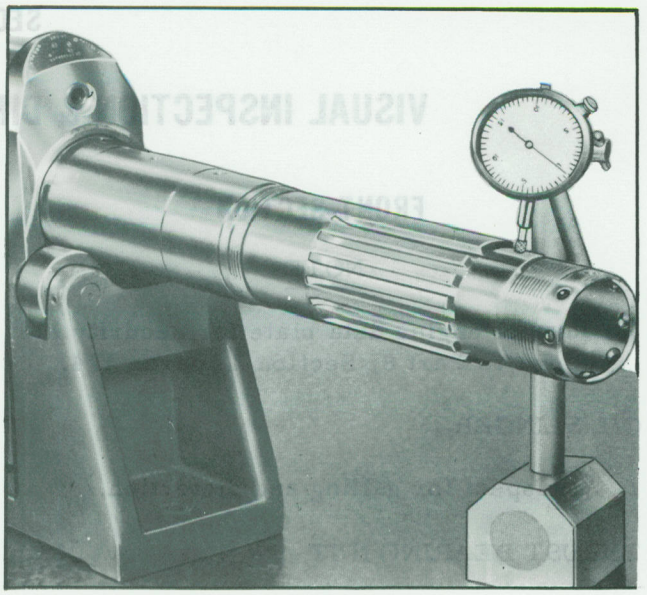


Figure 4-26 Crankshaft Run-out

13 While the crankshaft is on the roller blocks, measure the diameter of the crankpin in four places on the circumference and in each case at three points along the length (Figure 4-27). The diameter should be considered the average of the measurements taken and should be recorded as it will be used in determining the clearance between the master rod bearing and the crankpin. If the measurements show the crankpin is more than .001 inch out of round, or if the crankpin is severely scored, lap the crankpin. In extreme cases, return the crank-

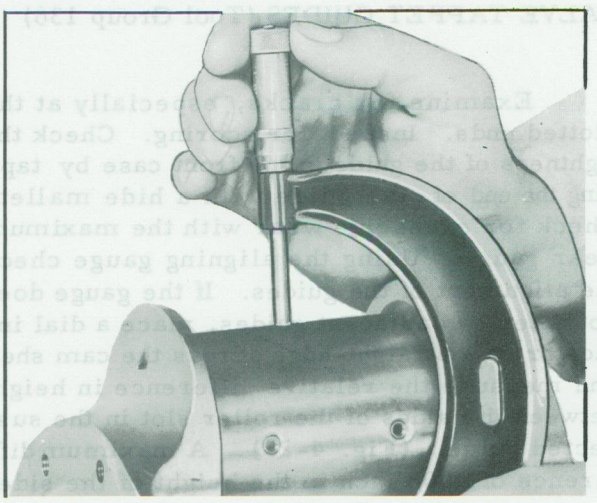


Figure 4-27 Measure Crankpin Diameter

shaft to stoves and hold for return to the manufacturer for repair. Slight scoring or roughness may be cleaned up with crocus cloth and oil.

14 Check for wear on the load side of the crankshaft splines. The worn area is usually defined by a sharp step along the inner and rear edges and the surface may be lightly galled. If such wear exists, measure the thickness of the worn portion of each spline. The minimum permissible width of each spline for SAE No. 30 splines is .2532 inches. It is permissible to use the shaft if three or fewer splines which are not adjacent are below the minimum measurement; but if four or more splines are below the minimum measurement, return the shaft to stoves and hold for return to the manufacturer. If the shaft is to be reused, blend the sharp edges at the bottom and rear of the worn areas to form a fillet of .025 inch radius (Figure 4-28).

15 Disassemble the crankshaft as described in Part 2.

16 Check the conditions of all threaded areas. Threaded portion for propeller thrust bearing nut should be inspected to insure that threads are smooth, and that no cracks or corrosion are present. See that oil jets are unobstructed,

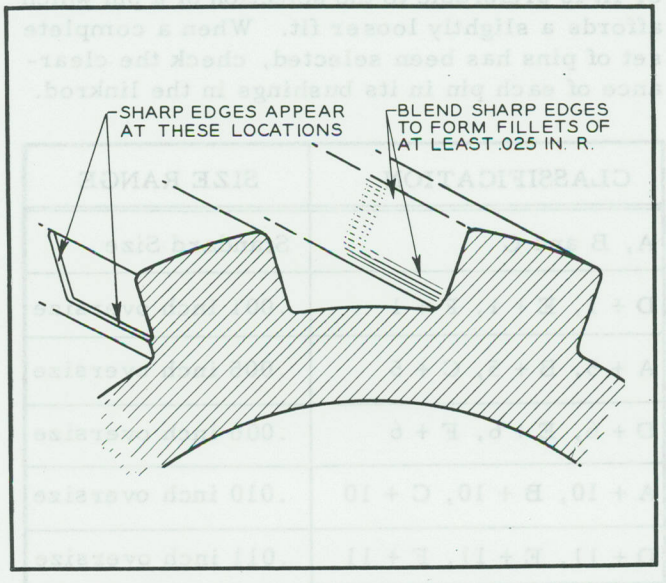


Figure 4-28 Shaft Spline Fillet Radius

and make sure that all oil passages have been thoroughly cleaned. Inspect the flyweight liners for scoring, pitting, and galling. Refer to Part 8 under Flyweight Liner Repair for instructions on cleaning up galled liners.

17 Check the front and rear main bearing journals for galling and wear. If either journal is excessively galled or worn, return the shaft to the manufacturer for repair. Slight scoring or roughness may be cleaned up with crocus cloth and oil.

18 Clean and polish any galled surface before the crankshaft is magnetically inspected.

CRANKSHAFT BOLT

19 Inspect the tin plating on the crankshaft bolt.

FLYWEIGHTS

20 Inspect the flyweights for galling, scoring and excessive pitting. Slight pitting is not cause for rejection of the flyweight for it can be cleaned up by polishing with crocus cloth and oil.

FRONT AND REAR MAIN BEARINGS

21 Inspect the inner and outer races for excessive wear, pitting and flaking. Examination of the inner race will usually show that the load, indicated by a bright line, has been concentrated on a small section of the race. Viewing the shaft from the rear with the crankpin uppermost, this section is located at about the "five o'clock" position. At reassembly of the engine, turn the bearing inner race about 120 degrees from the original position of the shaft. This will allow another turning at the succeeding overhaul.

22 Discard the inner race of the front or rear main bearing if any pitting or flaking of the raceway is visible to the naked eye. Ordinarily the outer race and rollers will be in good condition and may be reused when assembled with a new inner race of the same manufacture. However, exchange the entire assembly if the bearing feels rough when assembled with a new inner race or if the rollers appear pitted or damaged in any way.

23 Use Table 4-1 when ordering inner races, for exchange.

Part No.		Part	Mfg. Mark
32835		Bearing	SKF, MRC or Bower
	37019	Inner Race	MRC
	45058	Inner Race	SKF
11730		Bearing	SKF or MRC
	18014	Inner Race	SKF

Table 4-1 Front and Rear Main Bearing Inner Races.

CRANKSHAFT BEARING LINERS

24 Inspect as directed under Section 1, General. Rework in accordance with instructions in Part 7.

IMPELLER SPRING DRIVE COUPLING

25 Examine the splines and spring retaining webs on the fixed spider for burrs and wear. Examine the spring retaining webs and teeth on the floating spider for wear, burrs and cracks. Check the pressure of each spring. Change a spring if it is worn more than 1/32 inch on the ends. Inspect the bronze friction band for wear. Check the buttons for galling on the ends and stone smooth any galled areas.

MASTEROD ASSEMBLY

LINKPINS

26 Clean up any galled areas, using crocus cloth and oil; then inspect each pin for cracks. Strip old copper flash plating from the linkpins. Renew the copper flash plating on each linkpin at every overhaul.

27 Polish the linkpin holes in the masterod with crocus cloth and oil until they are smooth; then check the fit of each linkpin in its holes. Carefully measure the diameter of each linkpin hole with an indicating plug gauge. The diameter of the hole should be considered the average of the maximum and minimum diameters. Measure the diameters of each end of the linkpin and compare these diameters with the diameters of the corresponding holes in the masterod. If this comparison shows that the fit is not within the proper limits, select a linkpin which will give the proper fit.

28 Linkpins are available in the sizes shown in Table 4-2, the pin diameters increasing in increments of approximately .0003 inch.

29 Masterod linkpin holes are classified in the same way.

30 Be sure that each linkpin is marked with the proper positioning number so that it will be mated with the proper holes at assembly.

31 The two holes for a linkpin may have worn unevenly, but a careful measurement of the two ends of a number of linkpins will aid in the selection of a pin whose diameters vary in the same manner as the diameters of the corresponding holes in the masterod. Reject a linkpin, if it is more than .0015 inch out of round.

32 If difficulty is experienced in selecting a linkpin which will afford the proper fit, the selection of a pin which affords a slightly tighter fit is preferable to the selection of a pin which affords a slightly looser fit. When a complete set of pins has been selected, check the clearance of each pin in its bushings in the linkrod.

CLASSIFICATION	SIZE RANGE
A, B and C	Standard Size
D + 1, E + 1, F + 1	.001 inch oversize
A + 5, B + 5, C + 5	.005 inch oversize
D + 6, E + 6, F + 6	.006 inch oversize
A + 10, B + 10, C + 10	.010 inch oversize
D + 11, E + 11, F + 11	.011 inch oversize

Table 4-2 Linkpin Sizes

LINKRODS (Tool Group 71)

33 Inspect all surfaces of each linkrod for nicks and cracks. Inspect the rods for rust pitting. If rust pitting is present, the linkrod may be reconditioned as described in Part 8 Section 2 Paragraph 36. Check the fit of each pistonpin bushing with the corresponding pistonpin.

34 Check the alignment of the linkrods with the bushing in place, using the fixture. Secure the arbor, detail 33 of the fixture, in the bracket of the fixture so that it is approximately five inches above the surface plate. Indicate the arbor to make sure that it is parallel with the surface plate (Figure 4-29). Insert the expanding sleeve, detail 17, in the pistonpin bushing and expand it with the tapered sleeve, detail 34. Place the expanding sleeve, detail 29, in the linkpin bushing and expand it with the tapered arbor, detail 39. Place the linkrod in position on the fixture, sliding the tapered sleeve, detail 34, onto the arbor, detail 33. Adjust the jack, detail 44, until the rod is level. Using the block and indicator, details 14 and 47, indicate the ground surface on the underside of the tapered arbor, detail 39, at a distance of three inches from the centre of the linkpin bushing (Figure 4-30). Note the maximum indicator reading; then indicate the ground surface on the underside of the opposite end of the arbor at a distance of three inches from the centre of the bushing. The maximum reading represents any misalignment of the linkpin and pistonpin bushings at a total distance of six inches (three inches on each side) from the centre of the linkpin bushing. Remove the jack from under the rod and indicate the tapered arbor at a point at right angles to the former point of indication.

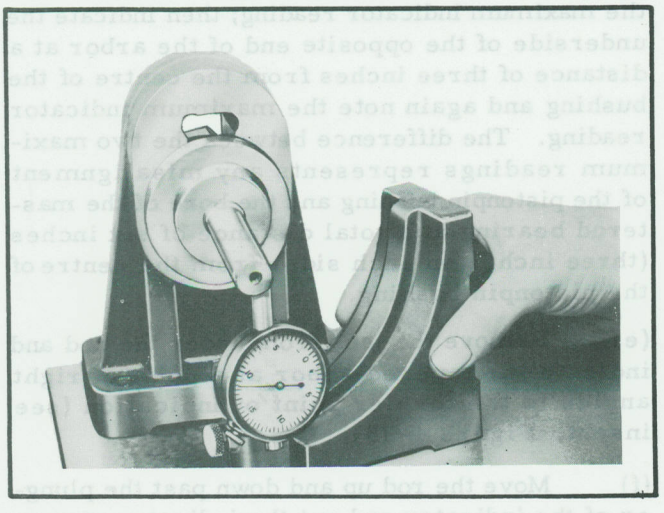


Figure 4-29 Arbor Parallel to Surface Plate

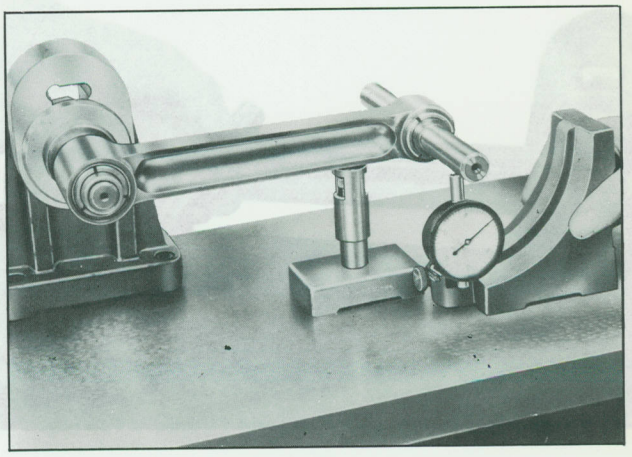


Figure 4-30 Check Linkrod Alignment

35 Move the rod up and down past the plunger of the indicator at zero where the maximum reading is obtained. Without moving the indicator, remove the rod from the fixture and replace it with the sides reversed. Again move the rod up and down past the plunger of the indicator and set the indicator at zero where the maximum reading is obtained. Without moving the indicator, remove the rod from the fixture and replace it with the sides reversed. Again move the rod up and down past the plunger of the indicator and note the maximum indicator reading (Figure 4-31). The maximum indicator reading indicates the amount of bend in the rod at a total distance of six inches (three inches on each side) from the centre of the linkpin bushing. The maximum allowable misalignment of the bushings, as well as the maximum allowable bend in the rod, is .010 inch at a total distance of six inches (three inches on each side) from the centre of the linkpin bushing.

36 If the bushing misalignment or bend in the rod has been found to be excessive, remove the linkpin and pistonpin bushings from the rod in accordance with instructions in Part 8 and check the alignment of the rod without the bushings in place. The procedure is the same as when

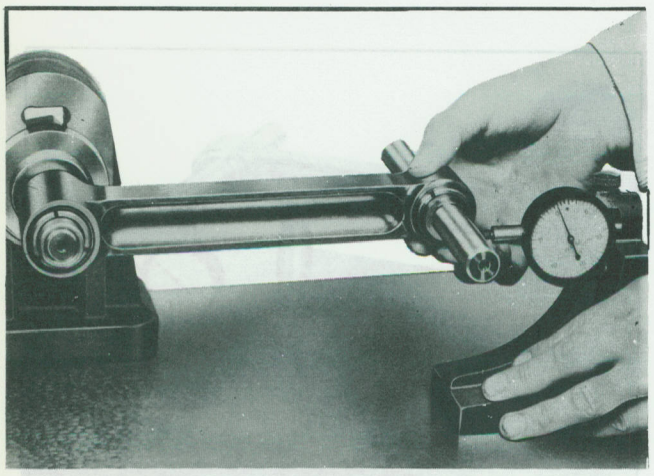


Figure 4-31 Check Linkrod Bend

the bushings are in place, except that the expanding sleeve, detail 19, is placed in the pistonpin end of the rod and the expanding sleeve detail 25, is placed in the linkpin end of the rod and expanded with the tapered arbor, detail 37. If the misalignment or bend is still excessive, reject the rod. However, if checking the alignment of the rod without the bushings in place shows that the misalignment or bend was in the bushings, install new linkpin and pistonpin bushings in the rod and bore to size according to the instructions in Part 8 under Linkpin and Pistonpin Bushing Exchange.

37 It is possible that a buckling of the rod, which would not be indicated by the alignment check, could occur. This buckling would tend to shorten the rod and distort the web of the rod. If this condition does exist, it will usually be found at a point on the flat sides of the rod immediately adjacent to the linkpin bushing. Check for this condition by placing a straightedge along the sides of the rod (Figure 4-32).

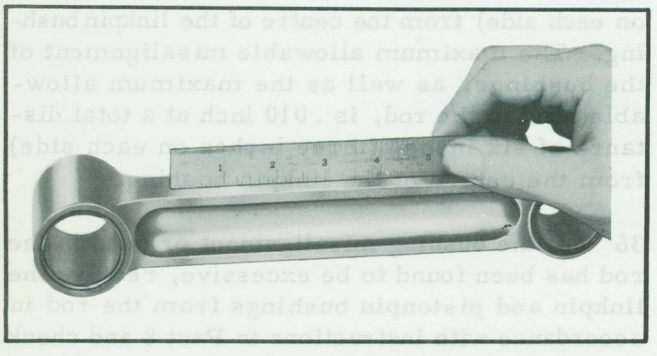


Figure 4-32 Check Linkrod for Buckling

Any noticeable buckling or distortion is cause for rejection of the rod.

MASTEROD (Tool Group 72)

38 Inspect the masterod for nicks, cracks and burns. Check the masterod for rust pitting. If rust pitting is present, the rods may be reconditioned as described in Part 8.

39 Check the alignment of the masterod with the pistonpin bushing in place, using the following method:

(a) Secure the masterod arbor, detail 45 of the fixture, in the bracket of the fixture. Indicate the bearing surfaces of the fixture; then indicate the bearing surfaces of the arbor to make sure that they are parallel with the surface plate.

(b) Insert the expanding sleeve, detail 17, in the pistonpin bushing and expand it with the tapered arbor, detail 41.

(c) Place the masterod in position on the arbor, detail 45, and support it with the jack, detail 44, so that it is approximately horizontal. Be extremely careful not to damage the surface of the masterod bearing.

(d) Using the block and indicator, indicate the underside of the tapered arbor, detail 41, at a distance of three inches from the centre of the pistonpin bushing (Figure 4-33). Note the maximum indicator reading; then indicate the underside of the opposite end of the arbor at a distance of three inches from the centre of the bushing and again note the maximum indicator reading. The difference between the two maximum readings represents any misalignment of the pistonpin bushing and the bore of the masterod bearing at a total distance of six inches (three inches on each side) from the centre of the pistonpin bushing.

(e) Remove the jack from under the rod and indicate the tapered arbor at a point at right angles to the former point of indication (see insert, Figure 4-33).

(f) Move the rod up and down past the plunger of the indicator and set the indicator at zero where the maximum reading is obtained.

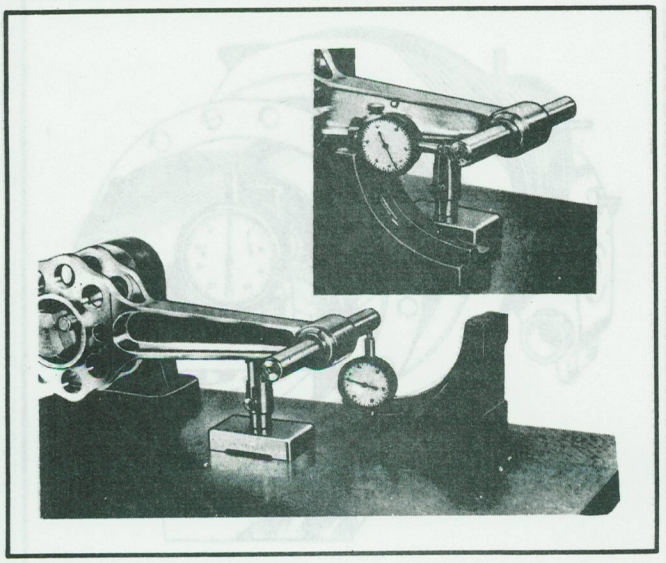


Figure 4-33 Check Masterod Alignment

(g) Without moving the indicator, remove the rod from the fixture and replace it with the sides reversed. Again move the rod up and down past the plunger of the indicator. The maximum indicator reading represents the amount of bend in the rod at a total distance of six inches (three inches on each side) from the centre of the pistonpin bushing.

(h) The maximum allowable misalignment, as well as the maximum allowable bend, is .010 inch at a total distance of six inches (three inches from each side) from the centre of the pistonpin bushing.

40 If the bushing misalignment or the bend in the rod has been found to be excessive, remove the pistonpin bushing from the rod in accordance with the instructions in Part 8, then check the alignment of the rod without the bushing in place. The procedure is the same as when the bushing is in place except that the expanding sleeve, detail 19, is placed in the piston end of the rod and expanded with the arbor, detail 41. If the misalignment or bend is still excessive, reject the rod. However, if checking the alignment of the rod without the bushing in place shows that the misalignment was in the bushing, install a new bushing and bore to size according to the instructions in Part 8.

41 It is possible that buckling of the rod, which would not be indicated by the above check could occur. This would tend to shorten the rod and distort its web. Check for this condition by placing a straightedge along the sides of the rod. Any noticeable buckling or distortion is cause for rejection of the rod.

MASTEROD BEARING

42 Refer to Part 8. It is recommended that the Masterod bearing be removed so that the masterod bore can be magnafluxed at each overhaul in helicopter installations, or at alternate overhauls in conventional installations.

CYLINDERS

CYLINDER BARRELS (Tool Group 25)

43 Using gauge and pencil carbon paper, check the cylinder flange for flatness and squareness. If the flange is uneven or distorted and providing the distortion does not exceed .003 inch, lap the flange as described in Part 8. If the distortion exceeds .003 inch, reject the cylinder.

44 Inspect the spotfaced areas around the stud holes in the cylinder flanges. These areas should be smooth and free from metal spray surface finish or other foreign material. Refer to Part 8, for instructions on re-spotfacing these areas.

45 The greatest wear in a cylinder barrel usually occurs at the rear, slightly toward the thrust side, where the upper pistonring reaches the top of its travel. This wear extends only a short way down the barrel, and the main part of the barrel's choke is not appreciably affected unless the condition is extreme. As wear increases at the top of the barrel, a step is formed. If this step exceeds .006 inch at any part of the circumference, reject the barrel.

46 Check the bore of the barrel for out of roundness. The bore should not be more than .006 inch out of round. It is permissible to let the diameter of the barrel at the step location reach .006 inch over the diameter of a standard bore, providing .006 inch out of roundness is not exceeded. If the diameter of the barrel at the step location or the out of roundness of the barrel is found to be excessive, and

the cylinder head is still in good condition, return the cylinder to stores and hold for return to the manufacturer for rebarreling.

47 Use the bore gauge and indicator to measure the wear and out of roundness of the barrel (Figure 4-34). Set the needle of the indicator at the zero mark in the gauge, which represents the basic diameter of the cylinder barrel. The presence and extend of wear and distortion may be determined by moving the Indicator along the length of the barrel while looking for any fluctuations in positive or negative directions on the indicator in various radial positions. A positive reading at the top of the barrel indicates the amount of choke left in the tapered (preground) type of barrel. By observing any difference in the diameters of the cylinders at a given distance from the end of the barrel, the out of roundness of the cylinder at that location may be determined. A step at the top may be calculated by subtracting the indicator reading obtained above the top of the upper ring travel from that obtained at the exact top of the upper ring travel.

48 Examine the cylinder barrel for cracks, scoring, damaged fins, and other irregularities. Check the condition of metallized surfaces. If a cylinder is to be resurfaced, refer to Part 8.

CYLINDER HEADS

49 Examine the head fins for cracks and breaks. Small cracks in the head fins are not cause for rejection. If more than 8 inches of any one fin in completely broken off or if the total area of fin breakage on one head exceeds approximately 20 square inches, exchange the cylinder. Fin area is defined as the total area exposed (both sides at the fins) to cooling air. Where adjacent fins are broken in the same area, the total permissible length of breakage is 6 inches on any two adjacent fins and 4 inches on any three or more adjacent fins. The length limits given are measured at the base of the fin. Carefully blend any roughness or sharp corners into the adjacent surface to eliminate a possible source of new cracks.

50 Examine the areas adjacent to the spark

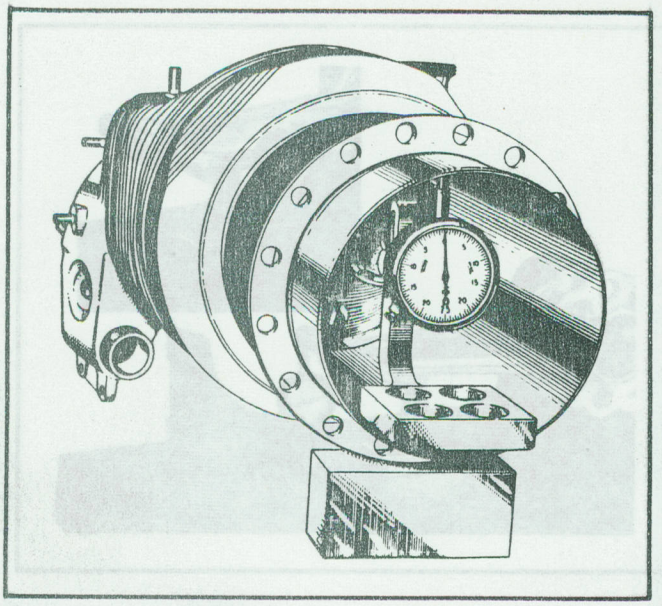


Figure 4-34 Measure Wear of Barrel

plug bushings for cracks. Inspect the outside surfaces of the cylinder heads. If a cylinder is to be resurfaced, refer to Part 8.

51 Inspect the inside surface of the cylinder head and the inlet and exhaust ports for cracks. Examine the heavy strengthening rib on the front of the valve housings for cracks.

52 Inspect the flange at the base of the cylinder head for cracks. Inspect the inside of the rocker box walls for cracks and indications of valve spring chafing.

DEFLECTORS

53 Inspect for cracks and dents. Check the condition of the paint. See that the blast tubes are tight.

EXHAUST VALVES (Tool Group 28)

54 Inspect for burning and pitting. Check the valve lock grooves for galling, scoring and burrs. Use the gauge to check each exhaust valve for stretch (Figure 4-35). A clearance of 1/32 inch or more between the gauge and the radius of the valve head is cause of changing the valve.

55 If an exhaust valve is creased or shows signs of swelling or drawing where the head joins the stem, change the valve regardless of what the radius gauge shows. Inspect the tip of the valve for cupping and wear and stone it flat, if necessary, to avoid possible chipping

around the edge. Check the fit of the valve in its guide, and check the valve stem for taper and out of roundness (Figure 4-36). Change a valve if the stem is tapered or out of round .006 inch or more.

56 Erosion which starts at the edge of the valve head and extends down under the stellite seating surface is not necessarily cause for rejection of the valve. It is permissible to grind away the eroded portion at the edge of the valve head, restore the radius, and reface the valve seating surface. This rework is discussed in Part 8.

CAUTION

To avoid possible injury to personnel, carefully dispose unserviceable sodium, filled exhaust valves as instructed in EO. 00-80-4/24.

INLET VALVES

57 Check the valve lock grooves for galling, scoring and burrs. Inspect the valve heads for excessive pitting and check the fit of each valve in its guide.

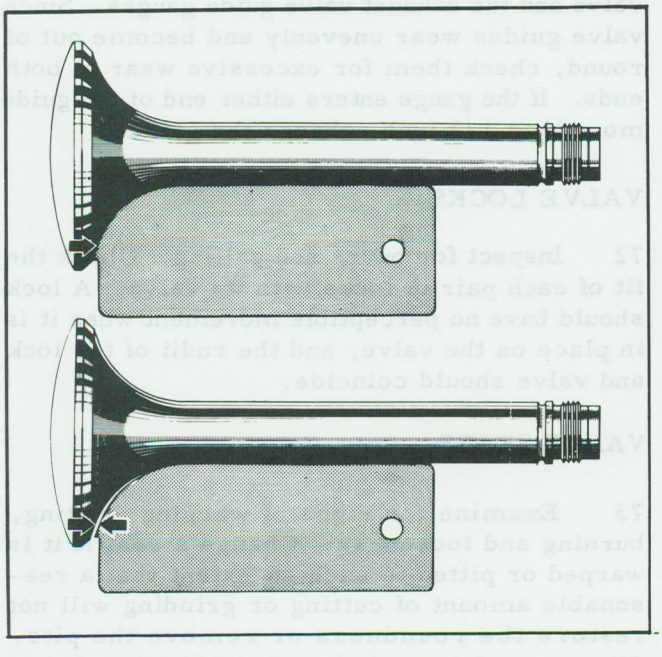


Figure 4-35 Check Valve Stretch

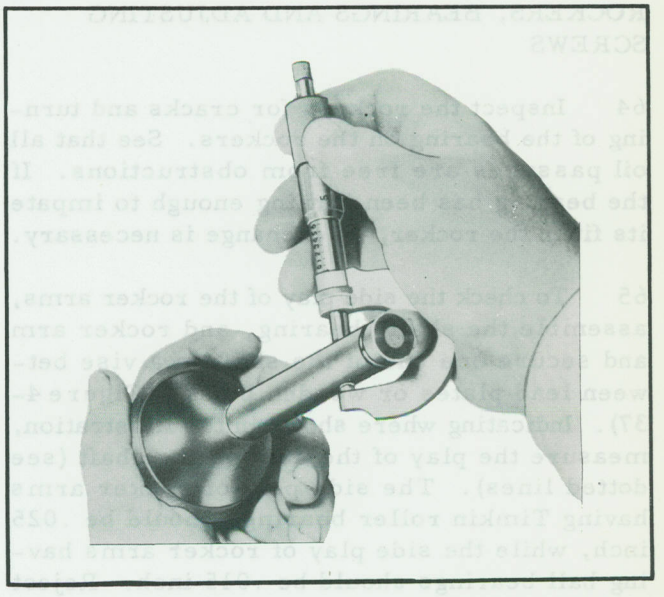


Figure 4-36 Check Valve Stem

INTAKE PIPES

58 Inspect for dents and cracks. If a pipe is questionable, subject it to a pressure test. Check the condition of the paint.

INTAKE PIPE COUPLINGS

59 Inspect for cracks, and check the condition of the threads and anodized surfaces.

PRIMER LINES AND PRIMER DISTRIBUTOR

60 Inspect for dents, cracks, obstructions and breaks. Check the condition of the threads on the elbows, unions, and couplings.

PUSHRODS

61 Inspect for cracks. Check the rods for straightness by rolling them on a plane surface. Check the fit of the ballends on the rod. Change ballends which are loose or worn.

PUSHROD COVERS

62 Inspect for cracks or dents. Check the condition of the paint.

PUSHROD COVER NUTS

63 Inspect for cracks and check the condition of the threads.

ROCKERS, BEARINGS AND ADJUSTING SCREWS

64 Inspect the rockers for cracks and turning of the bearing on the rockers. See that all oil passages are free from obstructions. If the bearing has been turning enough to impate its fit in the rocker, an exchange is necessary.

65 To check the side play of the rocker arms, assemble the shaft, bearing, and rocker arm and secure one end of the shaft in a vise between lead plates or wooden blocks (Figure 4-37). Indicating where shown in the illustration, measure the play of the arm on the shaft (see dotted lines). The side play of rocker arms having Timkin roller bearings should be .025 inch, while the side play of rocker arms having ball bearings should be .015 inch. Reject the bearing if the limit is exceeded.

66 Exhaust rocker bearings are subject to heavier loading and greater heat than those on the inlet side, and consequently are of shorter life. To obtain the maximum bearing life, it is feasible to shift exhaust rocker bearings over to the inlet rockers after one of two overhauls, assuming, of course, that the bearings are still in a serviceable condition. The inlet rocker bearings may, in turn, be transferred to the exhaust rockers.

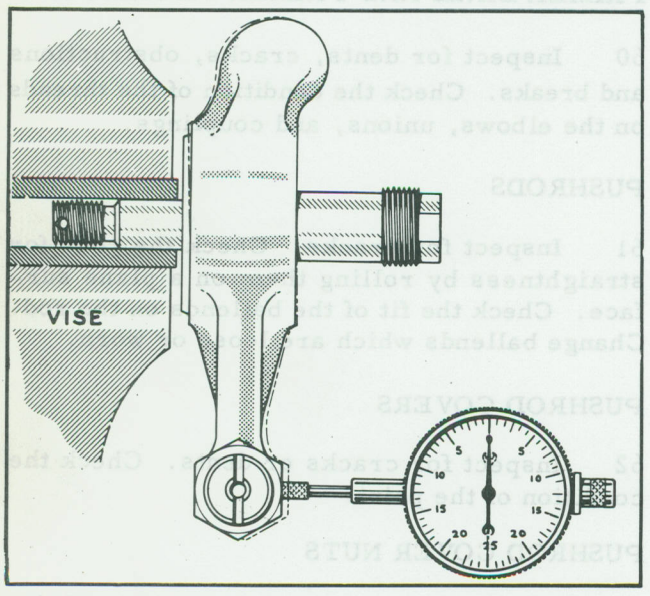


Figure 4-37 Rocker Arm Side Play

67 One side of each bearing is always subjected to a greater thrust load and becomes worn and rough first, particularly at exhaust locations. Reversing a bearing, end for end, is often practicable for prolonging its life. When installing part of a set of new bearings, assembly the new ones in the exhaust rocker.

68 Examine the ball socket in each rocker for looseness and wear. Change a socket if it has a flat of more than 1/32 inch. Check the valve adjusting screw assemblies. Give particular attention to the half ball for unusual wear, looseness in socket, nicks or a pitted condition. Inspect the screws for cracks. Reject damaged locknuts.

ROCKERBOX COVERS

69 Inspect for cracks and check the condition of the paint. Check the condition of the parting surface.

SPARKPLUG BUSHINGS

70 Inspect for burning and check the condition of the threads.

VALVE GUIDES (Tool Group 133)

71 Check for excessive wear, using the inlet valve and the exhaust valve guide gauges. Since valve guides wear unevenly and become out of round, check them for excessive wear at both ends. If the gauge enters either end of the guide more than 1/3 inch, change the guide.

VALVE LOCKS

72 Inspect for burrs and galling. Check the fit of each pair of locks with its valve. A lock should have no perceptible movement when it is in place on the valve, and the radii of the lock and valve should coincide.

VALVE SEATS

73 Examine for signs of warping, pitting, burning and looseness. Change a seat if it is warped or pitted to such an extent that a reasonable amount of cutting or grinding will not restore the roundness or remove the pits. Change a valve seat when the wall at the lower

extremity has been reduced in thickness to a point where further cutting or grinding would cut into the cylinder head.

VALVE SPRING WASHERS

74 Inspect for cracks, pitting and galling.

PISTONS, PISTONPINS AND PISTONRINGS

PISTONS

75 Inspect the skirts and ring lands for cracks and examine pistonpin holes for scoring. Inspect the inside surfaces for cracks, paying particular attention to the underside of the head, the fins, and the pistonpin bosses. If the piston is heated slightly, residual oil will seep from any cracks, and the inspection for cracks will be facilitated.

76 Make sure that all carbon has been removed from the ring grooves; then check the width of the grooves by measuring the side clearance of standard size rings at several points around the piston, making sure that the outer face of wedge type rings is flush with the piston at the point of measurement (Figure 4-38). If the side clearance is excessive, it will be necessary to use oversize pistonrings.

77 Using a mirror to aid in the examination of the grooves between the cooling fins inside the piston, thoroughly inspect each piston for any accumulation of blast material, loose carbon or other foreign material which may have been left after cleaning (Figure 4-39). Such

Figure 4-38 Check Groove Width

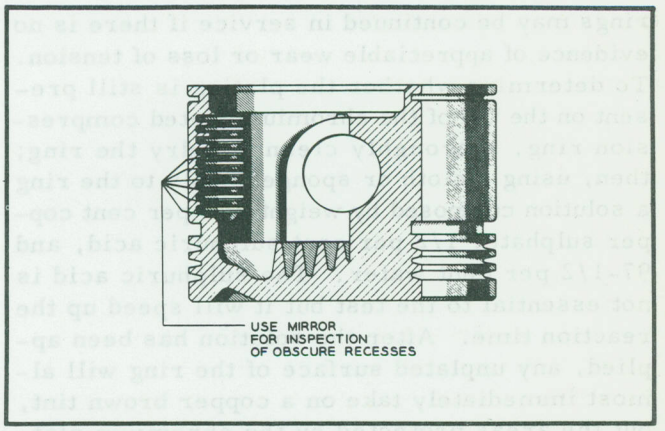


Figure 4-39 Piston Interior

material may cause plugging of oil passages. It is very important that all such material be detected and carefully removed.

78 Examine the top of the piston for flatness. Place the piston on a surface plate; then set up a dial indicator so that the plunger rests on the top of the piston at a point 3/8 inch in from the edge. Set the dial at zero; then move the indicator back and forth across the centre of the piston and note the readings. A depression of .006 inch or more within 3/8 inch of the OD is cause for rejection of the piston.

PISTONPINS

79 Inspect for scoring, cracks and rust pitting. Check the fit of each pin in its bushing in the corresponding linkrod and in its bosses in the corresponding piston. Remove pistonpin plugs from the pin and subject the pistonpin to magnetic inspection.

PISTONPIN PLUGS

80 Check for damage and fit in the pistonpins.

PISTONRINGS

81 Change all plain compression rings at every overhaul. If these rings have feathered edges or show signs of blow-by, check the corresponding cylinder barrels carefully for damage to the bore.

82 Dual oil control rings and stepped scraper

rings may be continued in service if there is no evidence of appreciable wear or loss of tension. To determine whether the plating is still present on the OD of the chromium plated compression ring, thoroughly clean and dry the ring; then, using a cloth or sponge, apply to the ring a solution composed by weight of 2 per cent copper sulphate, 1/2 per cent sulphuric acid, and 97-1/2 per cent water. The sulphuric acid is not essential to the test but it will speed up the reaction time. After the solution has been applied, any unplated surface of the ring will almost immediately take on a copper brown tint, but the areas protected by the chromium plating will remain unchanged. After the test, dip the ring in oil to renew the protective film.

SUPERCHARGER SECTION

FLOATING GEAR BEARING AND INNER RACE

83 Examine the floating gear inner race for roughness or pitting. Check the needles for pit marks or excessive wear, particularly at their extremities.

FRONT SUPERCHARGER BEARING COVER

84 Check the front supercharger cover for condition of the bearing race bores and for tightness in the case.

IMPELLER AND IMPELLER SHAFT

85 Inspect the impeller for nicks, scratches, cracks, or other damage. Inspect the fillets at the base of the blades near the outside diameter of the impeller for fine fatigue cracks. Check for galling on the hub and hub splines. Examine the splines on the impeller shaft for galling and excessive wear. Inspect the impeller shaft gear teeth for pitting and uneven contact pattern.

86 Use local etching to assist in detecting defects. Apply an etching solution consisting of 1 ounce of commercial technical grade caustic soda in 1/2 pint of water to any questionable areas. Using a brush or swab, apply the solution and allow it to stand until the surface is well darkened. Thoroughly wipe off the surface, using a clean cloth dampened with water. Any crack will appear as a dark line.

87 Remove all traces of the caustic solution, using a solution of 1 part of concentrated technical grade nitric acid to 5 quarts of water; then thoroughly wash the impeller in clean water. Dry the impeller; then dip it in kerosene or white furnace oil.

WARNING

As both caustic soda and nitric acid are highly corrosive, take extreme care to avoid their contact with other metal parts or with the skin or clothing. Personnel should wear rubber gloves and a rubber apron.

88 Examine the splines on the impeller shaft for galling and excessive wear. Tin flash plate the impeller shaft at each overhaul. The process of stripping the old tin plate from the shaft in preparation for replating will neutralize any corrosion and clean the surface for magnetic inspection. A moderate amount of corrosive pitting of the bottom areas of the shaft spline is not injurious and no attempt should be made to remove it.

89 Check the spline fit between the impeller and the impeller shaft. There should be no perceptible radial looseness when the impeller is seated in place. If the fit of the impeller on the shaft is slightly loose, the tin plating of the impeller shaft may be increased to a maximum thickness of .0005 inch.

IMPELLER SHAFT OIL SEAL AN-5 Model (Tool Group 55)

90 Use a micrometer to check the operating height of the Part No.87241 Impeller Shaft Oil Seal. The operating height should be .688 inches.

91 Check the spring pressure of the seal which should be 4 pounds at the minimum of 7 pounds at the maximum. If the spring pressure is less than the minimum figure, change the seal. If the spring pressure exceeds the maximum figure, check the seal for foreign material which might hinder its operation. If further cleaning with kerosene or Varsol and air blast is ineffective, change the seal.

92 Inspect the seal for leakage with the testing fixture (Figure 4-40). Connect the fixture, through a shut-off valve, to a source of compressed air at 90 to 100 psi. Connect the flexible vacuum line to location No. 1 inlet as shown in Figure 4-40. Place the impeller shaft oil seal on the fixture seating surface as Location No. 1 using a neoprene pad on the oil seal as illustrated in the insert of Figure 4-40.

93 Open both the air line valve and the vacuum valve and note the reading on the gauge. When the gauge indicates 22 to 29 inches Hg., close the vacuum valve and watch for a loss of vacuum as indicated by the gauge. The seal is satisfactory when the loss of vacuum does not exceed .5 inches Hg. in 30 seconds.

94 If the seal fails to pass this inspection, lap it on a dry cast iron or glass lap, using a figure "8" stroke, then retest the seal.

CAUTION

Limit the lapping to a minimum necessary to produce the desired surface, since lapping will reduce the spring pressure of the oil seal at operating height.

95 As Part No. 80489 Impeller Shaft Rear Spacer mates with the impeller shaft oil seal, the spacer should be checked at the mating surface for leakage. Check the spacer in the same manner that the oil seal was inspected using the same limits.

REAR SECTION

FUEL PUMP DRIVE ADAPTER

96 The face of the fuel pump drive adapter which forms a seat for the gear should be smooth and parallel to the face of the flange

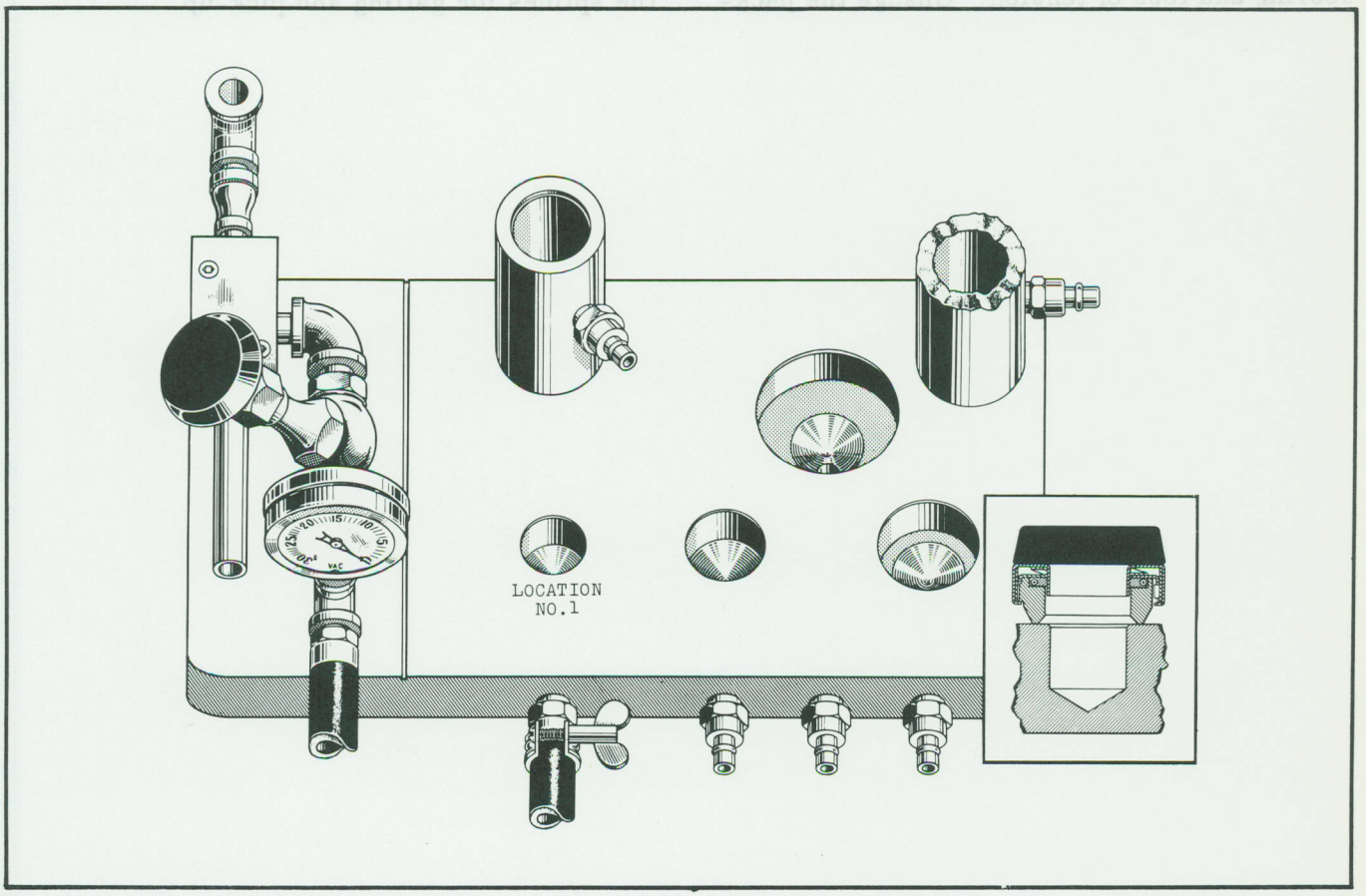


Figure 4-40 Test Fixture

OIL PRESSURE RELIEF VALVE

97 Check the tension of the relief valve spring. Note the condition of the valve in the valve seat. Lap these parts together with a very fine grade of lapping compound to form a perfect seat. The guide surfaces of the valve should have a free sliding fit in the seat. Polish the guide surfaces with crocus cloth and oil.

OIL PUMP

98 Check all gear teeth for pitting and uneven contact. See that the gears turn freely and show no indication of interference with the pump body. Inspect the drive and idler shafts for scoring and roughness. Examine all keys and keyways for burrs and nicks, and check the fit of the keys in the keyways. See that all oil passages are clean. Inspect the sections of the body for cracks, scoring, and condition of the parting surface Check the oil seal rings for scoring and loss of tension. Change the packing in the centre section of the pump body.

OIL SCREEN AND CHECK VALVE ASSEMBLY

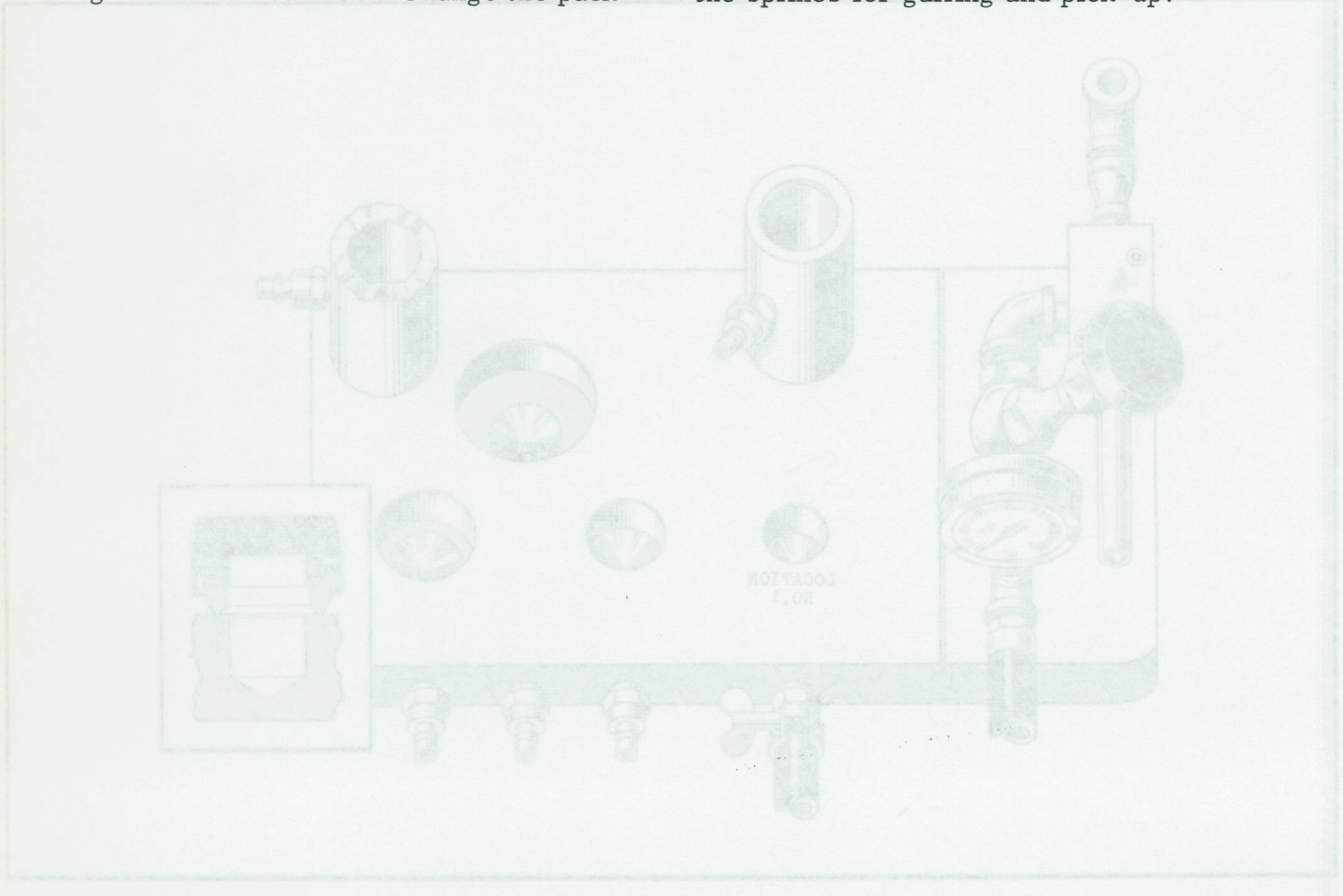
99 Examine the oil screen for distortion or splits at the soldered joints. Check the fit of the screen in its chamber in the rear case. Examine the oil check valve to see that it is free and seats properly. Check the spring pressure and examine the cover for cracks and condition of paint.

REAR CASE

100 Inspect the vanes in the intake duct for nicks and cracks, with particular attention to the welded joints. Inspect the carburettor mounting pad for smoothness. Check the tightness of magneto locating dowels.

STARTER JAW

101 Check for cracks and burrs, and inspect the splines for galling and pick-up.



SECTION 3

CRACK DETECTION

MAGNETIC

THEORY

1 Magnetic Particle Inspection is a non-destructive method of testing most steel parts for "discontinuities" at or near the surface of the part. The term discontinuity refers to a dissimilar substance interrupting the continuity of the magnetic material. A discontinuity is not necessarily a defect. A defect is a discontinuity that is severe enough to cause rejection. That a discontinuity exists is made evident by a pattern of indicating medium, called an "Indication", which conforms generally to the contour or shape of the discontinuity projected on the surface of the part. A discontinuity may be a non-metallic inclusion, an abrupt and local change in surface hardness, or an actual opening or void at, or under, the surface. Non-metallic inclusions are not ordinarily cause for rejection unless located in a highly stressed area. Local areas of variation in hardness of the surface such as are often caused by rough-handling, nicks, etc. are not detrimental, as a rule. Openings or voids such as forging laps, forging bursts, quench cracks or fatigue cracks are cause for rejection unless removal of the defective area can be accomplished without detrimental effect on the part. Cracks developed in grinding or plating may be cause for rejection depending on the part, location and severity. The books "Principles of Magnaflux Inspection" and "Magnaflux Aircraft Inspection Manual" are recommended for study.

2 Magnetic Particle Inspection should be a regular part of the inspection procedure for overhaul shops. The inspection should include the testing of parts using the procedure established for the parts, a tabulation of the nature and extend of the discontinuities indicated and the final decision as to the suitability of the parts for further service, as indicated above. Inspectors in this, particularly those in charge of the disposition of questionable indications, should be specialists who have been thoroughly trained to evaluate correctly the various indications which may be encountered.

3 The process consists of magnetizing the part to be inspected and applying the indicating medium, an especially prepared magnetic iron oxide powder, to the part Magnetization of a part may be accomplished in any one of several ways and that used will depend on the shape of the part and location of type of discontinuity to be found (Figures 4-41, 4-42, 4-43, 4-44). When an electric current flows through a conductor, a magnetic field, whose lines of force take the form of concentric rings is created around the conductor at right angles to the direction of current flow (Figure 4-41). The strength of the magnetic field or flux density depends on the current strength used. That is why low voltage high amperage currents are used for magnetizing parts to be inspected. The current used may be alternating or direct current has been generally accepted as a standard in the aircraft industry. There are, further, two classes of magnetic particle inspection methods; the residual and the continuous method. The residual method makes use of the magnetism remaining in a part after the source of magnetizing current has been removed. The continuous method makes use of the magnetizing force present while the magnetizing current is applied. The continuous method is more sensitive, and will indicate discontinuities further under the surface than will the residual method.

4 When a part such as a shaft, bolt, or any similarly shaped part is magnetized by passing a current directly through the part, it is said to be circularly magnetized and the flux lines of the magnetic field formed are similar to those shown (Figure 4-42).

5 Ring gears, sleeves, and other similarly shaped parts are magnetized by placing a brass or copper rod through the part and passing a current through the rod. In this method the part is circularly magnetized by induction (Figure 4-43).

6 The third method of magnetizing consists of placing the part in an insulating sleeve inside a solenoid and passing a current through the coils of the solenoid. This method is known as longitudinal or bi-polar magnetization and the field produced is parallel to the centreline of the solenoid (Figure 4-44).

7 Simple parts are sometimes magnetized in only one direction, more complex or highly stressed parts are often magnetized in more than one direction and perhaps by using each of the three methods.

8 The two edges of any crack or the two sides of any discontinuity, such as a non-metallic inclusion, at or near the surface, which extends at approximately right angles to the magnetic field of the magnetized part, will assume a north and south polarity and there will be a leakage or external field between them (Figure 4-45). When the indicating medium (powder) is applied to the part the particles of the powder will be attracted by the external magnetic flux field forming an indication. Such indications are strongest when the discontinuity is at 90 degrees to the magnetic field and gradaully decrease in strength as the angle approaches zero.

9 The indicating medium consists of finely divided iron oxide particles. It is available in the form of a dry powder or in the form of a paste which is then mixed with a suspensory liquid. This is referred to as the wet method. The indicating medium may be applied by one of four methods. In the dry residual method the powder is applied in dry form by dusting it on the part which has been magnetized. In the dry continuous method the powder is dusted on the part during the application of the magnetizing current. In the wet residual method, the suspension consists of a low viscosity, high flash point petroleum distillate containing iron oxide particles. This is applied through a hose or

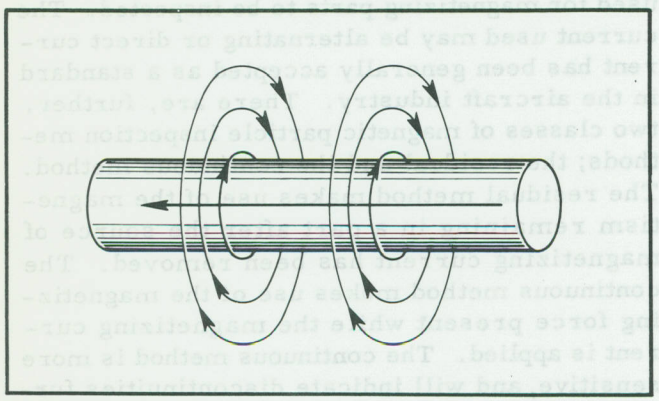


Figure 4-41 Principle of Magnetization

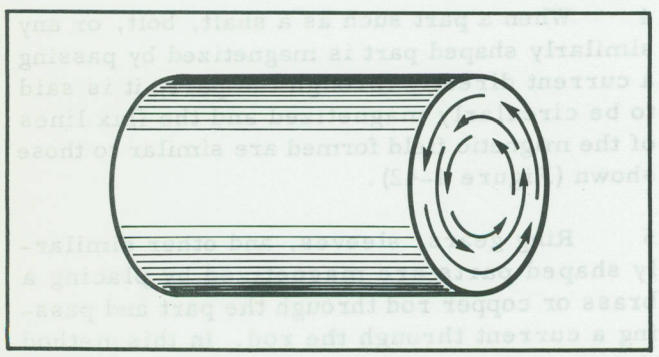


Figure 4-42 Magnetization by Dirent Current

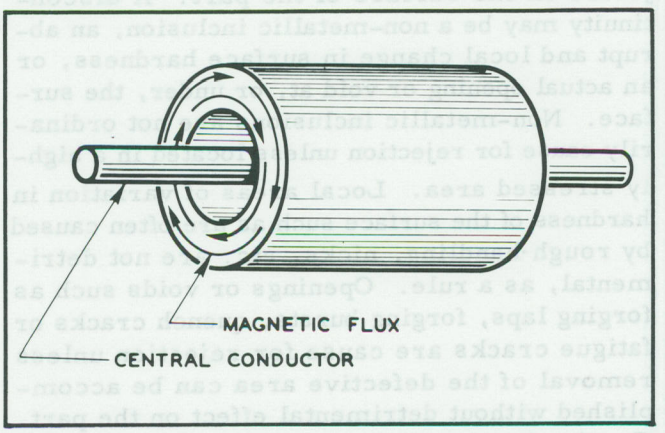


Figure 4-43 Magnetization by Induction

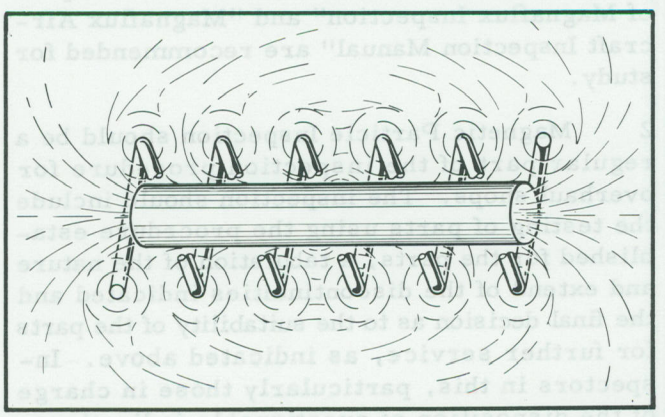


Figure 4-44 Bi-Polar Magnetization

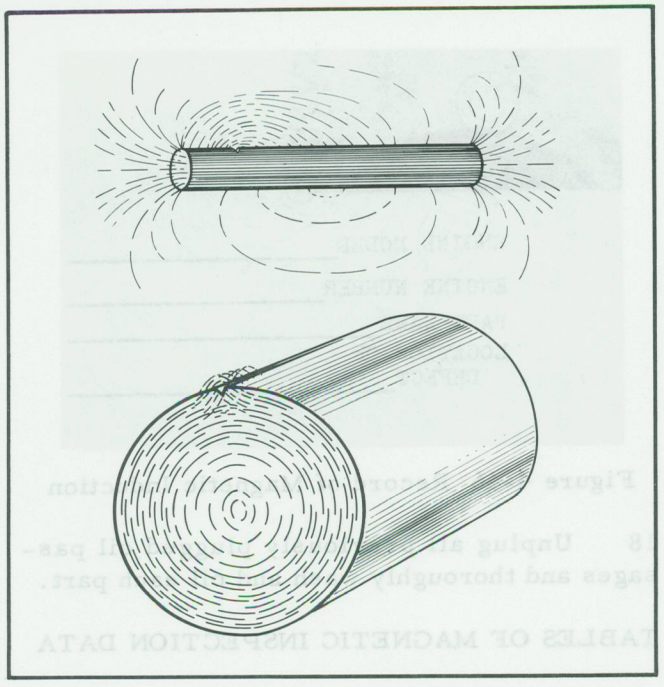


Figure 4-45 Crank indicated by Polarity

by immersing the part in a tank after magnetizing. The oxide is kept in suspension by means of a circulating pump or by forcing air through small holes in air pipes located in the bottom of the tank. Sometimes both methods are combined, especially in the case of integral tanks of older magnetizing units. In the wet continuous method, the suspension is applied while the part is being magnetized, usually by flowing from a hose unless special machines are available.

PROCEDURE

10 The parts to be inspected by the magnetic method are listed in the table on the following pages. Any parts which are not included in the table, with the exception of non-demountable ball or roller bearings, may be inspected in the same manner as that described for similar parts which are included. Exhaust valves are non-magnetic and cannot be inspected by this method. All parts must be completely disassembled, cleaned, degreased, and decarbonized before magnetic inspection.

NOTE

All areas that are scratched, scored, or galled, must be stoned and polished with crocus cloth and oil.

Plug all oil passages which are not easily cleaned with heavy grease or conspicuous fibre or wooden plugs.

11 The horizontal Direct Current type of magnetic inspection machine equipped with 4 inch and 8 inch solenoids and the wet residual method of testing are recommended for overhaul bases. Magnetize the parts in accordance with the instructions on the following pages.

12 To prevent burning of the part at the points of contact, make sure that the machine contact plates are clean and that the part is held tightly. Do not release the pressure on the part until the ammeter needle has returned to zero.

NOTE

Parts treated with preservative varnish, phosphate compound coating, or the surface oxidation process must be polished to a clean bright finish at the points of contact or serious burning will result. Red oxide or fluorescent magnetic powder should be used on parts which have dark grey phosphate compound coating and on parts which have been treated with the black surface oxidation proc3ss. Indications on varnished parts are not so strong as those on bare steel and are easily distorted or removed if not handled carefully.

13 A "shot" or current flow of 1/5 to 1/2 second duration is sufficient to magnetize a part. Longer duration of flow wastes power and incurs greater danger of burning.

14 The suspension used for the wet residual method should contain 2 ounces of black or red magnetic iron oxide to 100 ounces of suspensory liquid in which the parts should be immersed for 3-5 minutes. The suspension used for the wet residual method using fluorescent magnetic oxide should contain 0.3-0.5 ounces of fluorescent magnetic oxide to 100 ounces of fluid in which parts should be immersed about 30 seconds. The parts should then be carefully rinsed in clear liquid to remove any residue of

fluorescent particles before examination under "black light".

15 Remove the parts from the testing bath and subject each one to a thorough visual inspection. Attention should be given to the following general areas where discontinuities are most likely to occur. Inspect gear teeth at the roots and at the pitch line of the thrust side. Inspect splines and mating lugs at the roots. Fillets and sharp angles on stressed parts should be given particular attention. Note galled or roughened areas carefully for indications of fatigue cracks. Fatigue cracks of this source are usually very small and difficult to detect unless preparation of the part is done well. Inspect bolt and shaft threads at the roots. Oil holes and shaft holes in stressed areas should be examined for radial cracks emanating from the holes. In addition to these areas, areas on specific parts where special attention is necessary, are listed in the table on subsequent pages.

16 Indications at corners, steps or radii of any part which, after magnetic inspection and removal of the magnetic powder, can still be seen with the naked eye or a magnifying glass are usually cause for rejection of the part.

NOTE

If a part showing indications is passed for further service, a complete record showing location and extent of the indications should be kept so that the part may receive special attention at the next inspection. Apply a piece of transparent scotch tape to the indication; then stick it on a card, with pertinent information. The pattern is thus transferred from the specimen to the card (Figure 4-46).

17 After each magnetization and inspection, each part should be passed completely through an alternating current demagnetizer at a rate not to exceed 12 feet per minute, (Figure 4-47). The part should be removed from the demagnetizing field before shutting off the demagnetizer switch. After demagnetizing, test each part for magnetization with a compass. A maximum compass needle deflection of 3 degrees at a distance of 6 inches from the part is allowed.

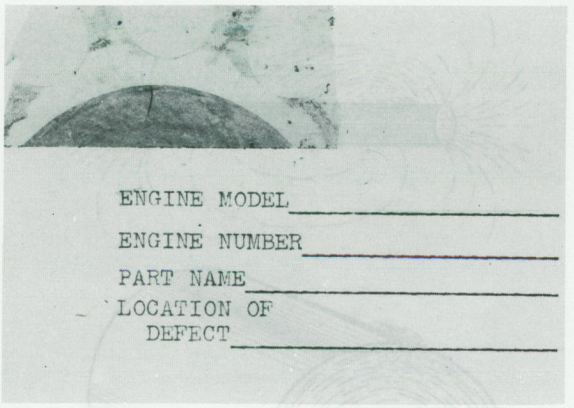


Figure 4-46 Record of Magnetic Induction

18 Unplug all previously plugged oil passages and thoroughly wash and oil each part.

TABLES OF MAGNETIC INSPECTION DATA

19 These tables should be used in conjunction with the instructions on the following pages. The methods of magnetization and the recommended amperages are indicated by a code number listed after the part name. The code number which follows a part name contains a letter plus one or two numerals. The code letter is

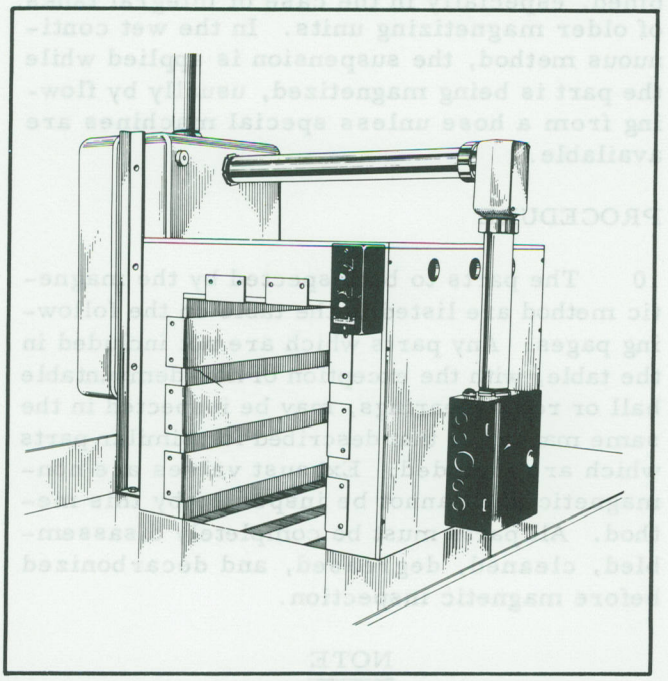


Figure 4-47 A C Demagnetizer

a key to the method of magnetization, and the numerals are the key to the amperages required. If the code letter refers to two methods of magnetization, the first digit of the code number indicates the amperage required for the first methods of magnetization and the second digit indicates the amperage required for the second method. For example, if a part had a code number of E-6-5, according to the following chart the part is to be magnetized circularly, contacting on the ends, using 2500 amperes. After inspection and demagnetization, the part is to be magnetized longitudinally in a solenoid, using 2000 amperes. The amperages given apply only when the wet residual method is used.

Letter	Method of Magnetic Inspection
A	Magnetize circularly, contacting on ends
B	Magnetize circularly, rotating accentrically on a copper rod
C	Magnetize longitudinally in a solenoid

Letter	Method of Magnetic Inspection							
D	Magnetize circularly contacting on ends Magnetize circularly, contacting on OD							
E	Magnetize circularly, contacting on ends Magnetize longitudinally in a solenoid							
F	Magnetize circularly, rotating accentrically on a copper rod Magnetize circularly, contacting on OD							
G	Magnetize circularly, rotating accentrically on a copper rod Magnetize longitudinally in a solenoid							
	1	2	3	4	5	6	7	8
Amps.	200	500	1000	1500	2000	2500	3000	3500

Table 4-3 Code of Methods of Magnetic Inspection

Nomenclature	Method	Item for Special Attention
Ballend - Pushrod	A-2	
Bolt - Crankcase	E-4	Area under bolt head and around thread
Bolt - Crankshaft	E-4-2	Check radius under head
Bolt - Impeller Spring Drive	A-4	Examine threaded area under bolt head
Button - Impeller Spring Drive Gear Spring Retainer	A-1	
Cam	F-7-5	Magnetize and inspect each lobe separately. Any defect on cam follower tracks is cause for rejection (Figure 4-48)
Cage - Impeller Intermediate Drive Gear Shaft Ball Bearing	B-5	
Cage - Impeller Shaft Bearing	F-5-4	

Table 4-4 Methods of Magnetic Inspection For Specific Items

Nomenclature	Method	Item for Special Attention
Cage - Reduction Drive Gear Pinion	F-7-6	Examine pinion shaft races
Carrier - Propeller Shaft Oil Seal Ring	B-5	Check ring lands
Crankshaft - Front		See Specific Procedure
Crankshaft - Rear		See Specific Procedure
Cylinder		See Specific Procedure
Flange - Magneto	F-4	
Flyweight - Outer	G-5-4	
Flyweight - Inner	G-5-4	
Gear and Shaft Assembly - Impeller Intermediate Drive	D-6-5	
Gear - Impeller Spring Drive	F-7-6	
Gear - Cam Drive	D-5-4	
Gear - Cam Reduction Drive	D-6-5	
Gear - Crankshaft Rear	F-6-5	
Gear - Fuel Pump Drive	E-4-3	
Gear - Generator Drive Pinion	E-4-3	
Gear - Vertical Accessory Gear	B-4	
Gear - Oil Pump Drive	E-5-3	Be careful not to burn sharp edges of teeth
Gear - Reduction Drive Pinion	D-6-5	
Gear - Reduction Drive Fixed	F-7-5	
Gear - Magneto Drive	F-7-6	Figure 4-49
Gear - Starter Drive	D-5-4	
Gear - Tachometer Drive	A-4	
Gear - Vacuum Pump Drive	F-4-3	

Table 4-4 Methods of Magnetic Inspection for Specific Items (continued)

Nomenclature	Method	Item for Special Attention
Hub - Reduction Drive	F-7-6	
Jaw - Starter	B-6	
Liner - Front Main Bearing	B-6	
Liner - Rear Main Bearing	B-6	
Link - Engine Lifting	A-5	
Nut - Pushrod Tube Packing	B-5	
Nut - Thrust Bearing	F-5-3	
Pin - Link		See Specific Procedure
Pin - Piston	A-5	Any defect in ID is cause for rejection. Non-metallic indications on OD are acceptable except on surface or extreme ends.
Pin - Valve Tappet Roller	A-2	
Race - Inner Floating Gear	F-5-5	
Rod - Link		See Specific Procedure
Rod - Master		See Specific Procedure
Rocker - Inlet Valve Large		See Specific Procedure
Rocker - Exhaust Valve Large		See Specific Procedure
Roller - Valve Tappet		See Specific Procedure
Shaft - Impeller	E-5-4	
Shaft - Reduction Drive Pinion	A-4	
Shaft - Valve Rocker	A-3	
Socket - Pushrod Ball	A-2	
Screw - Flyweight	A-4	
Spacer - Crankshaft Thrust Bearing	B-5	
Spider - Driving Spring Drive Supercharger	F-6-5	

Table 4-4 Methods of Magnetic Inspection for Specific Items (continued)

Nomenclature	Method	Item for Special Attention
Spring - Outside - Intake and Exhaust Valve	A-1	Use a non-metallic wedge in end of coil to magnetize and demagnetize.
Spring - Inner - Intake and Exhaust Valve	A-1	
Spring - Impeller Spring Drive	A-1	
Stud - Cylinder Flange	A-2	
Tappet - Valve	A-3	
Washer - Upper Valve Spring	B-4	

Table 4-4 Methods of Magnetic Inspection for Specific Items (continued)

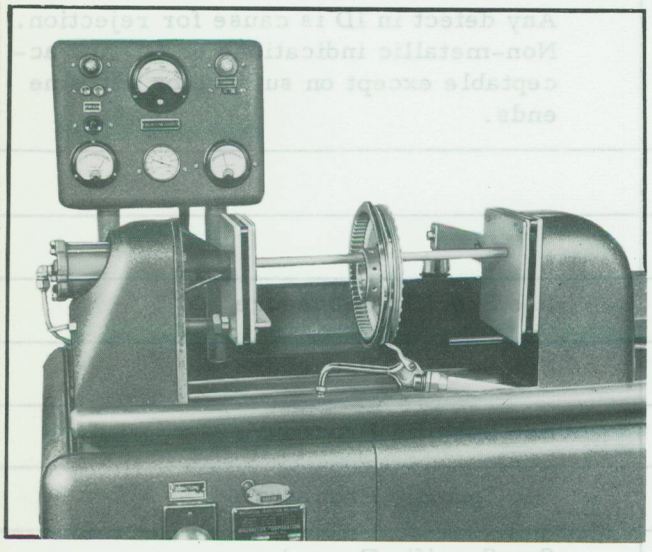


Figure 4-48 Magnetizing Cam by Induction

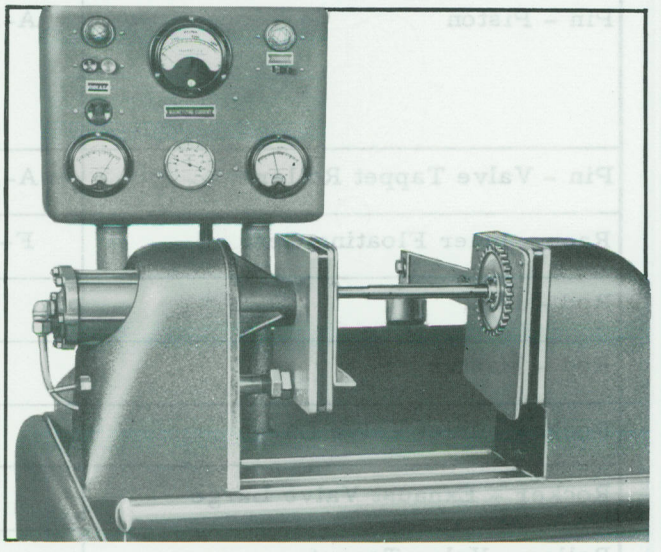


Figure 4-49 Magnetizing Magneto Drive Gear by D C

Nomenclature	Specific Procedure
Crankshaft, Front	3000 amps., circularly, using bronze balls to make contact (Figure 4-50). Examine splines crank pin shoulder, and fillets carefully for defects. 3000 amps., circularly, between plates, contacting crankpin cheek and counterweight radius. 500 amps., longitudinally, by wrapping two turns No. 0000 insulated copper cable around the crankpin and eight turns around the crankshaft (Figure 4-51).

Table 4-5 Specific Procedures of Magnetic Inspection

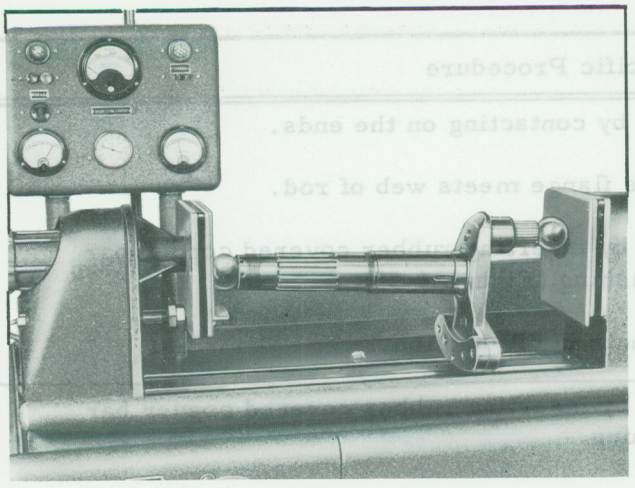


Figure 4-50 Magnetizing Front Crankshaft by DC

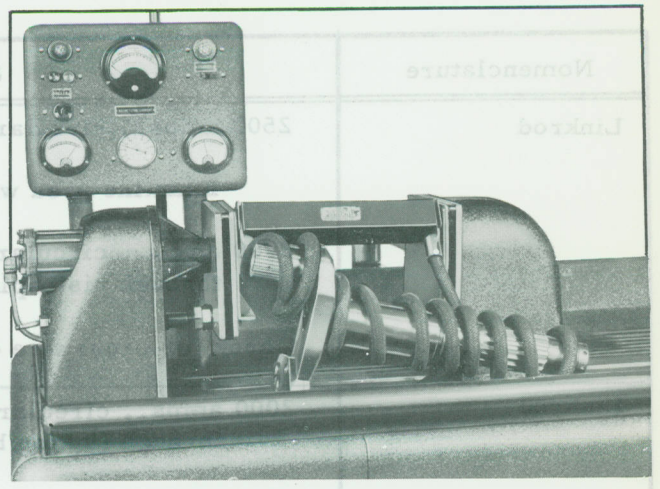


Figure 4-51 Magnetizing Front Crankshaft Longitudinally

Nomenclature	Specific Procedure
Cylinder	1000 amps., longitudinally, by wrapping five turns of No. 0000 insulated cable around barrel (Figure 4-52). Examine bore of cylinder for transverse defects. 2500 to 3500 amps., circularly, by placing length of No. 0000 insulated cable through bore and out the inlet port (Figure 4-53). Examine bore of cylinder for lengthwise defects.
Crankshaft, Rear	3000 amps., circularly, by contacting rear bearing bore and face of crankpin bore, using bronze balls. 3000 amps., circularly, between plates, contacting crankpin cheek and counterweight radius. 2000 amps., longitudinally, by wrapping two turns of No. 0000 insulated copper cable around the crankpin and one turn around the rear main bearing.
	Examine cylinder hold-down flanges particularly around stud holes. NOTE - This check is only necessary if it is known that the cylinder was involved in an accident of any kind, or if failed studs or loose nuts were found.
Linkpin	1500 amps., circularly, by contacting on ends. 1000 amps., longitudinally in 4 in. solenoid (Figure 4-54).

Table 4-5 Specific Procedure of Magnetic Inspection (continued)

Nomenclature	Specific Procedure
Linkrod	2500 amps., circularly, by contacting on the ends. Examine area where flange meets web of rod. 2000 amps., circularly, by inserting rubber covered copper bar through pistonpin bushing (Figure 4-55). Check for crosswire defects in "I" section.
Linkrod	2000 amps., circularly, by inserting rubber covered copper bar through linkpin bushing. 1000 amps., longitudinally, in an 8 in. solenoid.
Masterod	2500 amps., circularly, by contacting on ends (Figure 4-56). Check for cracks in or around linkpin holes. 3000 amps., circularly, on a copper rod through pistonpin hole (Figure 4-57). Check for defects in "I" section. 3000 amps., circularly, by contacting on the faces of the hub. 1500 amps., longitudinally by placing "I" section in 8 in. solenoid.
Rocker, Inlet and Exhaust Valve	1700 amps., circularly, by contacting on ends.
Rollers, Tappet	1500 amps., circularly, by magnetizing 15 to 18 at a time on a 19/64 in. copper rod. Check faces and bores. 1000 amps., longitudinally, by placing in solenoid.

Table 4-5 Specific Procedure of Magnetic Inspection (continued)

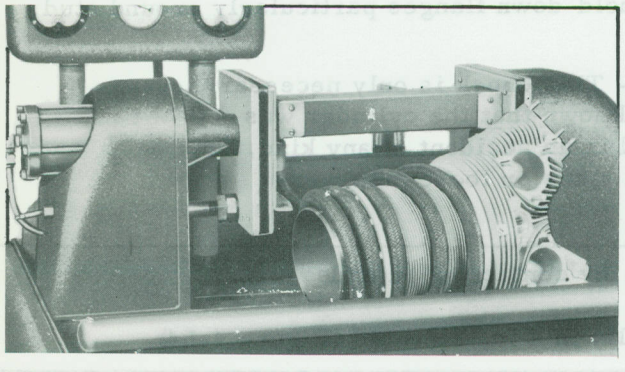


Figure 4-52 Magnetizing Cylinder Longitudinally

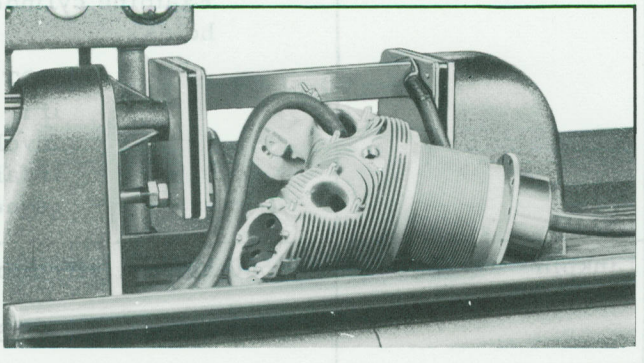


Figure 4-53 Magnetizing Cylinder Circularly

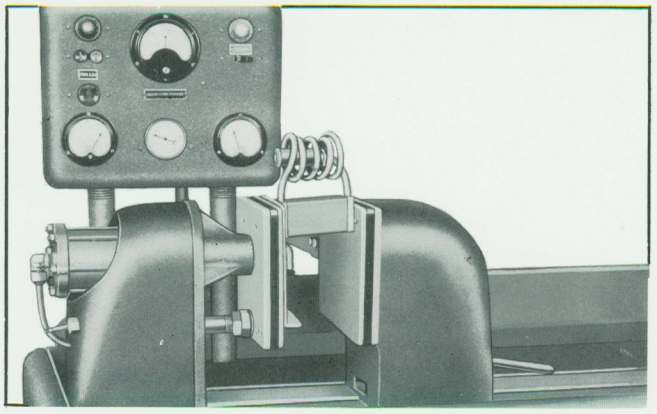


Figure 4-54 Magnetizing Linkpin Longitudinally

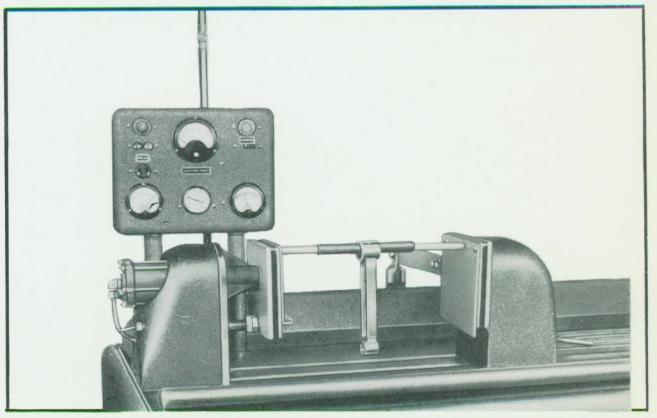


Figure 4-55 Magnetizing Linkrod Circularly

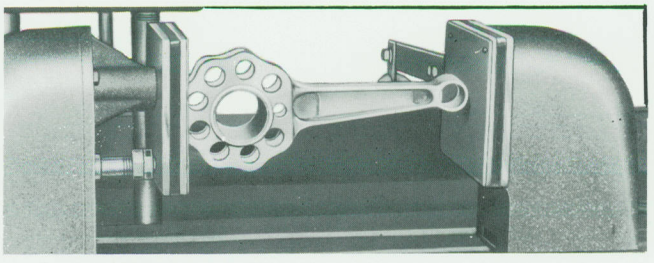


Figure 4-56 Magnetizing Masterod by D C

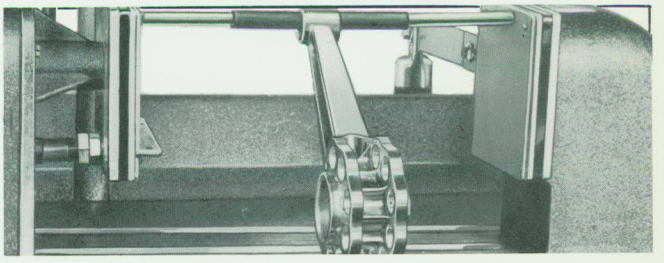


Figure 4-57 Magnetizing Masterod by Induction

FLUORESCENT PENETRANT

20 Engineering Order 105-1-2R "Surface Defect Detection", when issued, will refer to the Dye Penetrant method of inspection.

PART 5

RE-ASSEMBLY

SECTION 1

GENERAL

LOCKWIRING

TYPE OF WIRE

1 To determine the proper wire to be used in conjunction with a certain part, refer to EO 10A - 10AA-4 Part List. The part number of the wire appears by the number of the part which it locks.

PROCEDURE

2 Check the units to be lockwired to make sure that they have been correctly torqued and that the wiring holes are properly positioned in relation to each other. When there are two units, the hole in the first unit should be between the three and the six o'clock position and the hole in the second unit between the nine and twelve o'clock position (Figure 5-1). Positioning the holes in this manner insures that the wiring will have a positive locking effect on the two units, since the braid will always exert a tightening pull on both units. Never over torque or loosen units to obtain proper alignment of the holes. It should be possible to align the wiring holes when the units are torqued within the specified limits. However, if it is impossible to obtain a proper alignment of the holes without either over or under torquing, another unit should be selected which will permit proper alignment within the specified torque limits.

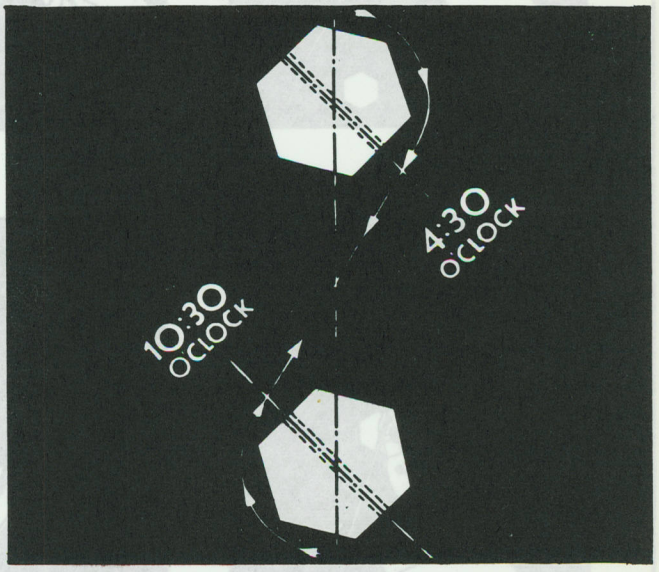


Figure 5-1 Proper Position of Lockwire Holes

LOCKWIRING BOLTS (See Figure 5-2)

3 Insert wire of the proper gauge through the hole which lies between the three and the six o'clock position on the bolt head (Sketch A). Grasp the left end of the wire with the fingers and bend it clockwise around the head of the bolt and under the other end of the wire (Sketch B). Pull the loop very tightly all around the head of the bolt with the pliers. Grasp the wire only at the end in order not to mutilate any portion which is to be twisted. Holding the wire ends apart and keeping the loop tight around the head of the first bolt, twist the wires around each other in a clockwise direction to form the braid. Continue twisting the wires by hand toward the second bolt until the end of the braid is just short of the hole in the second bolt which lies between the nine and twelve o'clock position (Sketch C). Make sure that the loop around the head of the first bolt is still tight and in place; then grasp the wires in the jaws of the pliers just beyond the end of the braid and, with the braid held taut, twist in a clockwise direction until the braid is stiff (Sketch D). Twisting the braid in a clockwise direction has the effect of securing the loop down around the head

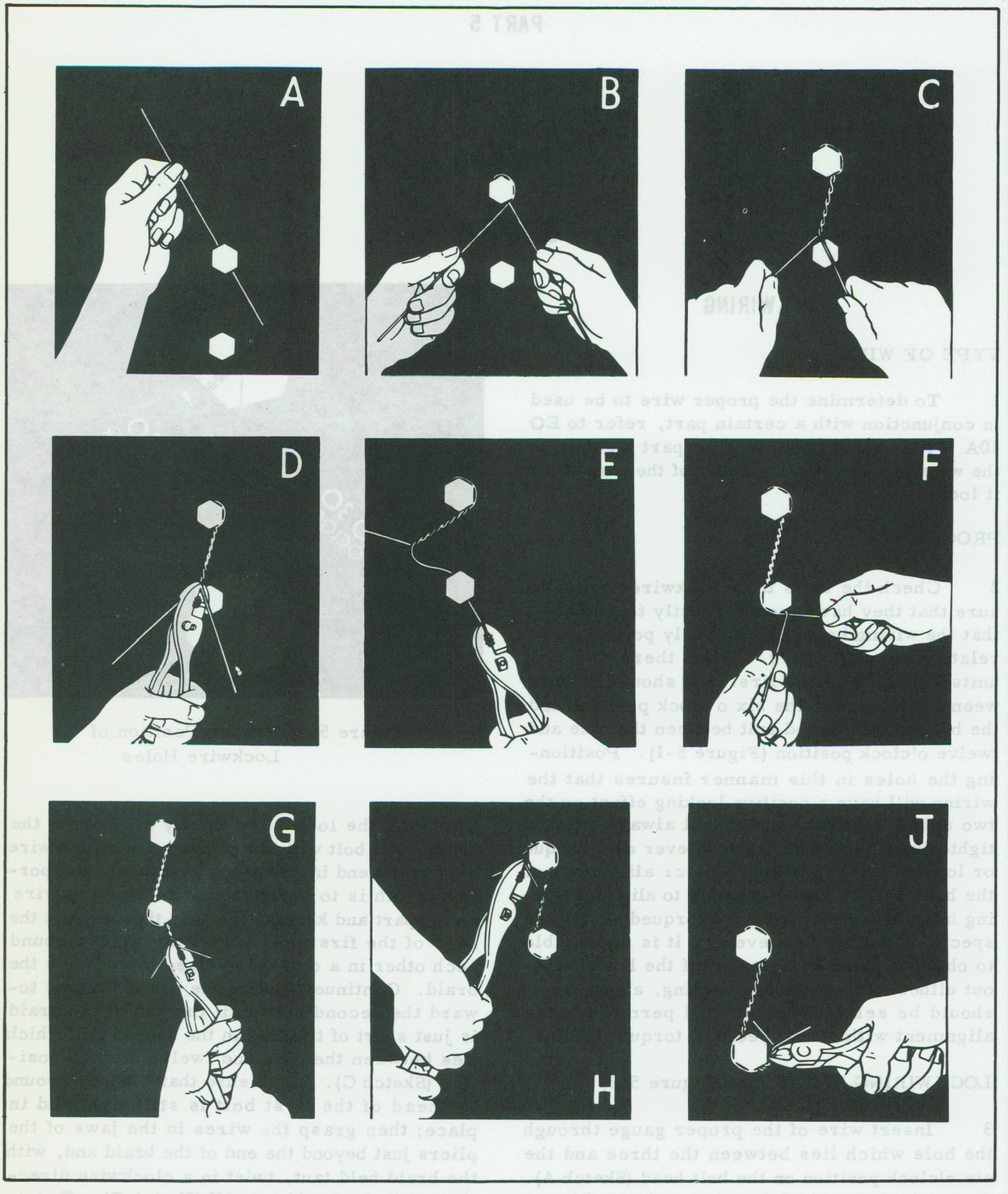


Figure 5-2 Steps in Wire Locking

of the first bolt. The rigidity of the stiff braid reduces vibration and resultant wear. Do not overstress the dires by attempting to twist the braid too tightly. After making sure that the braid is not so long that it cannot be pulled taut between the bolts, insert the end of the wire which is on top at the end of the braid through the hole between the nine and the twelve o'clock positions on the second bolt head. Grasp the end of this wire with the pliers and pull the braid taut (Sketch E). Bring the other end of the wire counterclockwise around the head of the second bolt and under the wire end which protrudes from the bolt hole (Sketch F). Pull the resulting loop tight with the pliers; then twist the wire ends together in a counterclockwise direction (Sketch G). Twisting the wire ends in a counterclockwise direction will keep the wire in place down around the head of the second bolt. Grasping the ends of the wire beyond the braid with the pliers and keeping the wires under tension, twist them tight in a counterclockwise direction. With the final twisting motion of the pliers, bend the twisted wire ends in around the head of the second bolt to the right (Sketch H). Cut off the excessive wire at the ends with diagonal cutters leaving at least three full twists (Sketch J). Avoid sharp or projecting ends. Do not twist off the ends of the wires with pliers.

BASIC TYPES OF LOCKWIRING

4 Many separate lockwiring operations are required, most of which are covered by the seven basic examples illustrated in (Figure 5-3). Examples 1 and 5 illustrate the proper method of wiring bolts, fillister head screws, square head plugs, and similar parts which are wired diagonally in pairs. Example 2 is similar to that used between certain rockershaft caps and pushrod gland nuts. Example 3 shows how to wire three or more units together diagonally. Note that the braid between the second and third units should be twisted counterclockwise so that the wire from the hole in the second unit will be on top of the loop around the second unit to hold it down in place. The wire inserted in the lockwire hole in the third unit should be the lower wire of the braid and beyond the third unit this wire should be brought over the other wire to secure the loop in place around the head of the third unit. Example 4 illustrated the proper method of lockwiring together studs and castellated nuts. Examples 6 and 7 show the way to wire a screw or a plug to a fixed point, such as a lug on a boss.

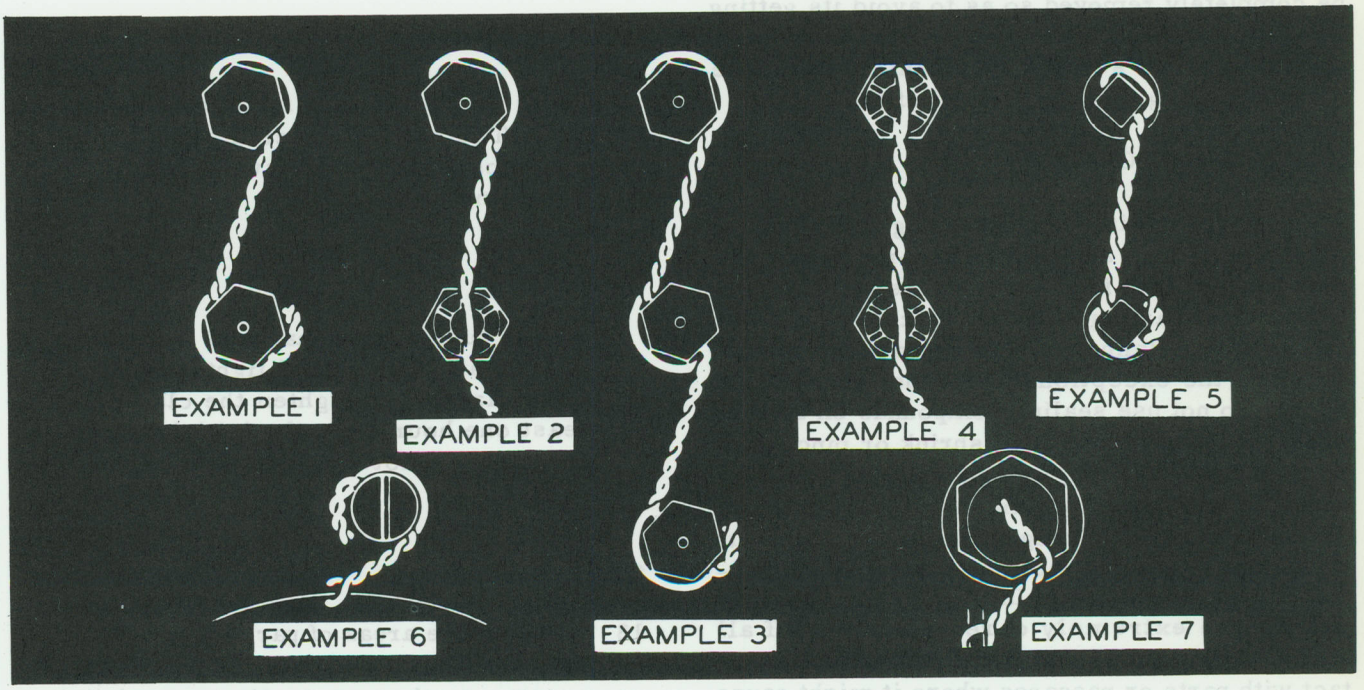


Figure 5-3 Examples of Wire Locking

PROCEDURES AND PRECAUTIONS

FOREIGN MATTER

5 Care should be taken to prevent dirt, dust, cotterpins, wire, nuts, washers, or other foreign material from entering the engine. Before assembling any part, be sure that all chips and other foreign matter resulting from repair operations have been cleaned from the part. Use suitable plugs or covers for all engine openings.

LUBRICANTS

6 Coat with engine lubricating oil all bearing surfaces, gears, and other areas subject to friction. Do this before assembling the parts. Before splines of any kind are mated, they should be properly lubricated. Norm Paste No. 30, is recommended for tight fit splines, and engine lubricating oil is recommended for loose-fit splines. Lubriplate No. 130A is recommended for all crankcase mating surfaces and all accessory drive splines. Fel-Pro No. C-5 is recommended for high temperature threaded parts. The Norm Past, Lubriplate, and Fel-Pro No. C-5 must be very carefully applied in thin, even coats, and all excess compounds must be completely removed so as to avoid its getting into or onto parts, passages or surfaces where the presence of surplus lubricant might cause malfunctioning or even failure of the engine.

SEALING COMPOUND

7 Apply a thin coat of sealing compound to threaded fittings and plugs, non-metallic gaskets (except fuel feed valve gaskets), and metal to metal parting surfaces (except crankcase and cylinder flange parting surfaces). In addition to the exceptions parenthetically noted above, do not use sealing compounds on splined areas, on parts which have shrink or pinch fits, on metal oil seal rings or parts which are assembled with them, or magneto, carburettor, or fuel feed valve parting surfaces, or any parts which have relative motion to each other during engine operation. In using sealing compounds, be extremely careful to wipe off all excess compound so that it will not come in contact with parts or passages where it might cause damage.

8 Glyptal may be used to seal the inner ends of those cylinder flange studs which protrude into the interior of the crankcase, but only when applied after the studs have been installed in the case.

9 Sealing compounds which may be used are Dow-Corning No. 4, Permatex No. 3, Permatex No. 2 (for threaded core plugs only), Tite Seal BR, Sumtex MM-50, Parker Sealube, Wellseal Jointing Compound, Gredag (gaskets only), and Lubriplate (gaskets only).

NEW PARTS

10 When a new part is to be installed and it is important that it be identified as to engine number or position in the engine, it should be marked in the same manner and the same location as the part which it is exchanged.

PARTS NOT REUSABLE

11 Do not reinstall used gaskets, packings, rubber parts, bronze oil seal rings, lockwashers, rivets, cotterpins, or wire. Locknuts may be reused if their locking action as determined at installation is still satisfactory.

HOSE (Tool Group 45)

12 Use the compressor for tightening all hose clamps. The hose-connected parts should be properly positioned and secured before the final tightening of the clamps.

NOTE

As the rubber hose material takes a set shortly after the initial tightening of the hose clamps, retighten the clamps at least one hour after the initial tightening, but do not exceed the maximum torque.

TAPE

13 Tape those areas of parts over which clips or brackets are to be installed and for which grommets or other protective coverings are not provided.

OIL PASSAGES

14 Check all oil passages with wire, air pressure, or oil pressure to make sure they are clean and not accidentally blocked because of improper assembly or installation of parts. Perforated or cutaway gaskets, in particular, should be checked after assembly to make sure they do not restrict passages intended to be open.

COTTERPINS

15 Cotterpins should fit snugly in their holes, with the head or loop end well into the castellation of the nut. Unless a different treatment is described or illustrated by the detailed assembly instructions, bend one end of each cotterpin back over the stud or bolt and the other down flat against the nut.

LIMITS (Tool Group 68)

16 Check fits, clearances, backlashes, spring pressures, and torques to make sure they are within the tolerances specified in Sections 3 and 4. When using a backlash arbor, make sure the dial indicator plunger is on the scribed mark of the arbor arm. Use the proper calibrated torque for tightening nuts to the recommended torques. Check all moving parts to see that they do not bind. The assembly of parts for which the LIMITS tables indicate a tight fit may be facilitated, if the outer part is expanded by heating it in an oil bath. If a magnetic chuck is used in grinding a part to obtain a desired fit, make sure the part is demagnetized before assembling it in the engine.

GEAR TEETH ALIGNMENT

17 Paint applied to the non-meshing faces of the gear teeth marked for timing will render the marked teeth more distinguishable for alignment at assembly.

ETCHING MARKS

18 Part numbers etched by electric pencil on steel parts may sometimes be clarified by swabbing the marks with a nital solution of 3 to 5 per cent nitric acid in alcohol.

SECTION 2

SPECIFIC

SUPERCHARGER SECTION

SUPERCHARGER CASE (Tool Group 119)

1 Crank the bed of engine stand to a horizontal position and place the supercharger case, front face up, on the mounting plate. Attach the case to the mounting plate with four bolts, washers and nuts.

IMPELLER INTERMEDIATE DRIVE GEAR

2 Install the large ball bearing on the intermediate drive gear, thrust side facing outward (Figure 5-4). Insert the intermediate drive gear shaft through the bore in the supercharger case from the front side of the case. Using a suitable drift and a mallet, install the impeller intermediate drive gear rear bearing inner liner into the rear bearing, with the thrust side of the bearing opposite the flange end of the liner. Drift the rear bearing and liner onto the shaft, thrust side up, and screw the retaining nut finger tight on the shaft.

FLOATING GEAR (Tool Group 32)

3 Install the floating gear inner race on the front supercharger bearing cover, making sure the dowel on the cover engages the notch in the inner race. Install and attach the cover in the supercharger case.

4 Insert the needles in position in the floating gear, using the heavy oil to keep them in place. There are 79 of these needles and, when installed, there should still be a space equal to slightly less than an additional needle.

5 Place the rear thrust spacer, bevel side down, over the front of the cover. Install the floating gear. Next install the front thrust spacer with the bevel side up, the tab lock, and the floating gear retaining nut which has a left hand thread. Lock the impeller intermediate drive and floating gears with the holder. Tighten the floating gear retaining nut.

6 Check the end clearance between the floating gear and the rear thrust spacer. See reference 619, Section 3. If the clearance is ex-

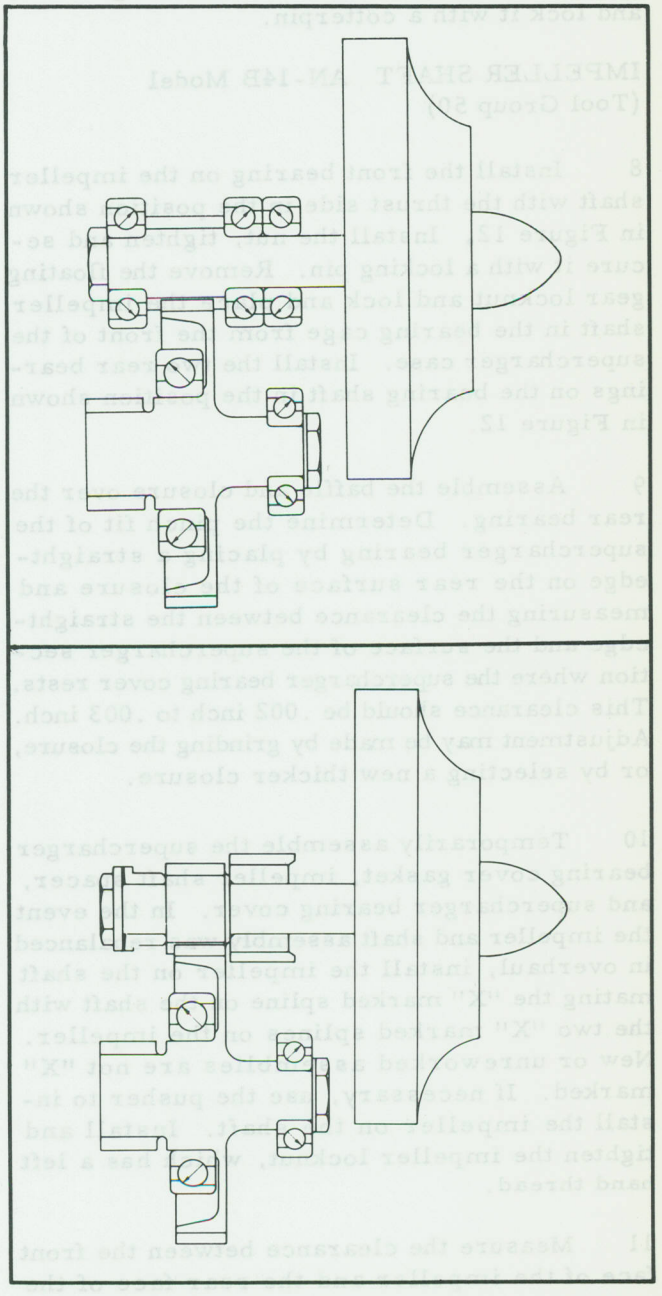


Figure 5-4 Floating Gears

cessive, the use of selective thrust spacers should bring the clearance within the specified limits. If the clearance is insufficient, grind the necessary amount from the rear face of the gear.

7 Turn the supercharger case over and tap the intermediate drive gear rear bearing with a fibre drift to insure that it is seating properly; then tighten the intermediate drive gear nut, and lock it with a cotterpin.

IMPELLER SHAFT AN-14B Model
(Tool Group 50)

8 Install the front bearing on the impeller shaft with the thrust side in the position shown in Figure 12. Install the nut, tighten and secure it with a locking pin. Remove the floating gear locknut and lock and place the impeller shaft in the bearing cage from the front of the supercharger case. Install the two rear bearings on the bearing shaft in the position shown in Figure 12.

9 Assemble the baffle and closure over the rear bearing. Determine the pinch fit of the supercharger bearing by placing a straightedge on the rear surface of the closure and measuring the clearance between the straightedge and the surface of the supercharger section where the supercharger bearing cover rests. This clearance should be .002 inch to .003 inch. Adjustment may be made by grinding the closure, or by selecting a new thicker closure.

10 Temporarily assemble the supercharger bearing cover gasket, impeller shaft spacer, and supercharger bearing cover. In the event the impeller and shaft assembly was rebalanced in overhaul, install the impeller on the shaft mating the "X" marked spline on the shaft with the two "X" marked splines on the impeller. New or unreworked assemblies are not "X" marked. If necessary, use the pusher to install the impeller on the shaft. Install and tighten the impeller locknut, which has a left hand thread.

11 Measure the clearance between the front face of the impeller and the rear face of the supercharger case (Figure 5-5). See reference 640, Section 3. Adjustment may be made by grinding the impeller shaft spacer or by selecting a new spacer.

NOTE

If a spacer has been ground, re-install it on the shaft and check it with a dial indicator to ascertain if it is running true within .001 inch full indicator reading. Try the spacer at various positions on the shaft until this condition is obtained.

12 Check the end clearance of the impeller shaft and bearing assembly (Figure 5-6). An end play of .010 inch with new bearings is permissible; if the play exceeds this limit, select different bearings.

13 Remove the impeller locknut and pull the impeller from the shaft.

14 Tighten the screws in the supercharger bearing cover. Use the feeler gauge to check the clearance between the supercharger bearing cover and the impeller shaft spacer. Lockwire the supercharger bearing cover screws (Figure 5-7).

15 Install the impeller, using the pusher. Install the locknut and tighten it with the wrench and lock it with a lockpin, using the riveter.

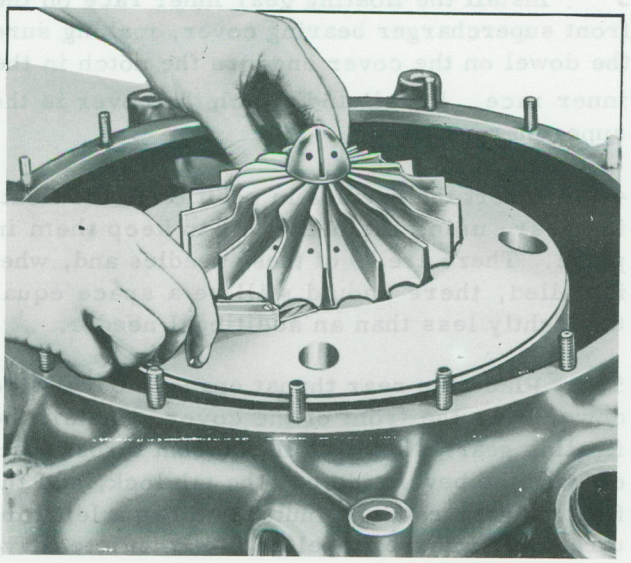


Figure 5-5 Measure Front Clearance

IMPELLER SHAFT AN-5 Model
(Tool Group 50)

16 See Figure 5-8. Press the journal on the impeller shaft, using the sleeve. Insert the impeller shaft in the bearing cage from the rear of the supercharger case. Screw on the retaining nut and lock the nut with a cotterpin. Place the rear spacer on the impeller shaft. Exercise extreme care in installing the impeller shaft oil seal in the impeller shaft bore of the rear supercharger bearing cover, using the drift and holder. Place a new rubber seal in the groove around the OD of the cover. In the event the impeller and shaft assembly was rebalanced in overhaul, install the impeller on the shaft mating the "X" marked spline on the shaft with the two "X" marked splines on the impeller. New or unreworked impeller and shaft assemblies are not "X" marked. If necessary, use the pusher to install the impeller on the shaft. Screw the impeller nut, which has a left hand thread, on the shaft using the holder and wrench.

17 Check the clearance between the impeller and the supercharger case (Figure 5-5). See reference 640, Section 3. Adjustment may be made by grinding the impeller shaft spacer or by selecting a new spacer.

NOTE

If a spacer has been ground, reinstall it on the shaft and check it with a dial indicator to ascertain if it is running true within .001 inch full indicator reading. Try the spacer at various positions on the shaft until this condition is obtained.

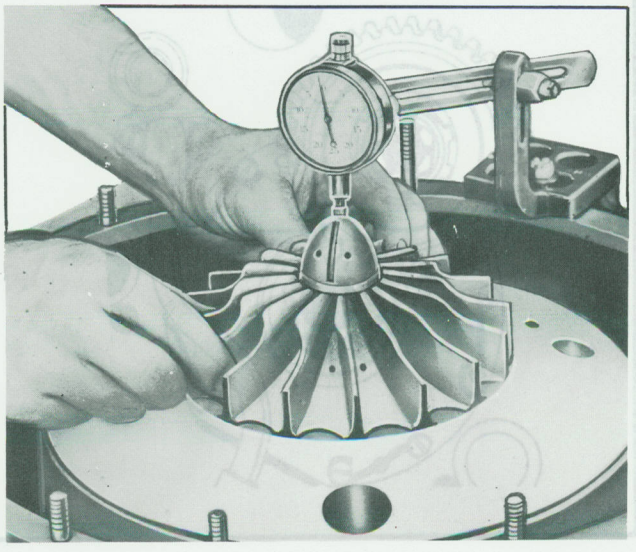


Figure 5-6 Measure End Clearance

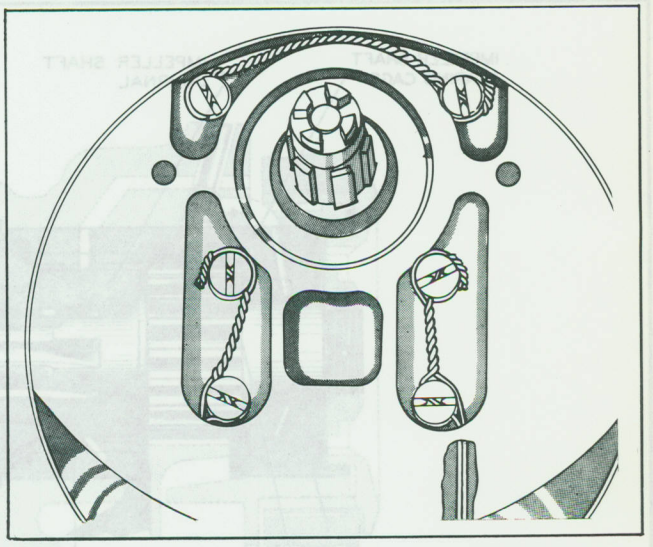


Figure 5-7 Wirelock Cover Screws

18 Using a dial indicator, check the impeller shaft end play (Figure 5-6). If the end play is insufficient, face the flange of the impeller shaft small bearing, using the facing cutter and holder. If the end play is excessive, disassemble the impeller, impeller shaft, floating gear, and impeller intermediate drive gear according to the instructions in Part 2 disassembly; then change the impeller shaft bearings according to the instructions in Part 8 repair under "Impeller Shaft Bearings", paragraphs 111 through 116.

19 If the clearances are within the specified limits, tighten the impeller nut, and lock the nut with a lockpin, using the riveter.

SUPERCHARGER CASE BREATHER PLATES
AN-14B Model

20 Attach the supercharger section breather plates to the supercharger case. Lockwire the screws in the plates.

OIL PRESSURE TUBE

21 Insert one end of the tube in its aperture

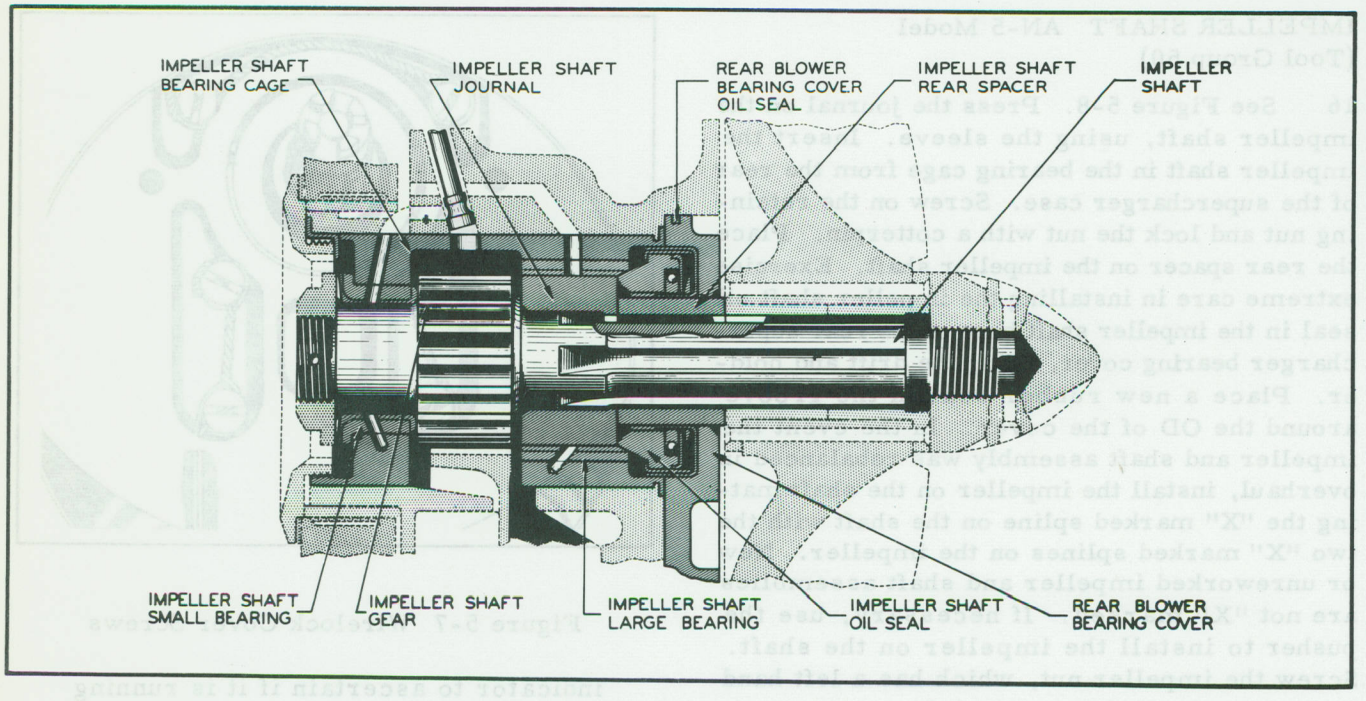


Figure 5-8 Impeller Shaft

in the supercharger case. Attach the bracket on the other end of the tube to the case with two screws. Lockwire the screws (Figure 5-9).

BREATHER AN-14B Model

22 Place a rubber seal under the breather body in the supercharger case. Tighten the body in the case with the body wrench. Place a gasket on the breather body and install the breather pipe. Secure the breather pipe with a screw and lockwire the screw.

23 Coat the left breather plug with a thread compound. Place a rubber seal on the plug. Install and tighten the plug, using the plug wrench.

INTAKE PORT PROTECTORS (Tool Group 67)

24 Install the protectors in the intake pipe ports in the supercharger case.

REAR SECTION

ASSEMBLY OF REAR TO SUPERCHARGER CASE (Tool Group 10)

25 Apply a thin coating of Fairpreen Neoprene Cement No. 5128 to the OD of the starter and magneto drive bushings and to the oil scavenge sleeves on the AN-5 Model. Apply this coating from the base of the bushing or sleeve to approximately 1/2 inch from the end.

26 On the AN-5 Model, use the pressure oil tube drift to install the spacer on the oil pres-

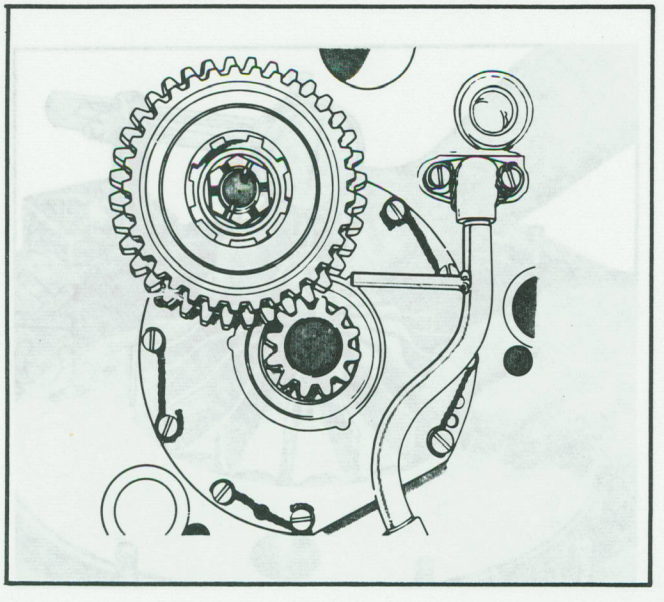


Figure 5-9 Oil Pressure Tube

sure tube. Drive the spacer until it is seated against the rear case. Install an oil seal over the tube and place it adjacent to the forward end of the spacer. Use the puller to install a spacer over each magneto drive gear shaft bushing in the rear case. Seat the spacers against the rear case and install an oil seal on each spacer. Use the puller to install a spacer over the starter drive gear shaft bushing in the rear case. Seat the spacer against the rear case and install an oil seal over the spacer. Install oil seals in the cutout positions on the three oil scavenge sleeves extending from the rear face of the supercharger case.

NOTE

If an oversize bushing was installed in the rear case, a corresponding oversize spacer should be installed.

27 Fit a new gasket on the parting surface of the supercharger case, and assemble the rear case to the supercharger case. Be careful to align the cases to prevent damage to the oil pressure tube, drive shaft bushings, and oil scavenge sleeves on the AN-5 Model. It may be necessary to tap the rear case with a fibre drift at the magneto and starter shaft bushings. Secure the cases with washers and nuts. Tighten the nuts to the required torque (Section 4).

PLUGS

28 Install the allen plugs in the rear case, using a 1/8 inch allen wrench and tighten with an allen socket ratchet. Install the small square-head oil plugs, using a 1/8 inch box wrench. Install a wooden cover over the carburettor mounting flange and secure it with two washers and two nuts. Install the plugs beneath the magneto drives. Install any other plugs which may have been removed from the rear section during disassembly.

STARTER SHAFT AND GEAR

29 Check the fit of the shaft in the bushing in the rear case. Grind the shaft, if necessary, to conform with the limits, reference 614 or 105, Section 3; then install the shaft spacer, bevel side against the radius on the shaft. Press the bearing into position on the shaft.

30 Insert the starter gear through its bushings from the forward face of the supercharger case (Figure 5-10). If necessary, tap the gear with a fibre drift to drive the ball bearing completely into the recess in the supercharger case. Install the starter jaw over the spline end of the starter shaft, holding the starter gear so the shaft will not push out of the supercharger case. Install the starter jaw washer and nut and tighten the nut with a 3/4 inch socket wrench.

31 Use a feeler gauge to check the clearance between the starter jaw and the face of the starter gear bushing. See reference 611 or 178, Section 3. Ordinarily this clearance will not be excessive unless all new parts have been installed or unless a gasket of abnormal thickness has been used between the supercharger and rear cases. If less than the minimun clearance is found with the original parts installed, check to see that the bushing is properly seated in the rear case.

32 If the desired clearance is not obtained, install a thicker starter gear spacer or grind the original spacer.

GENERATOR DRIVE GEAR ASSEMBLY
(Tool Group 42)

33 Use a depth micrometer to measure the

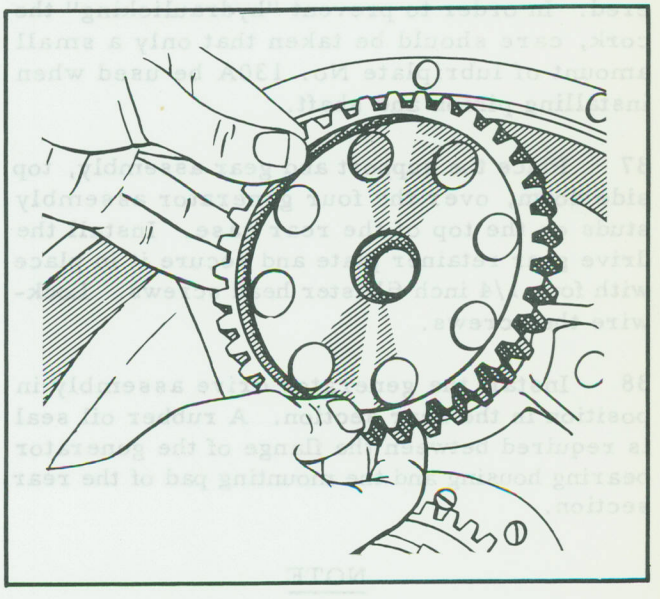


Figure 5-10 Insert Starter Gear

depth of the ball bearing boss in the housing of single bearing assemblies or the bosses in double bearing assemblies. Use an outside micrometer to measure the width of the bearings. If the width of the bearing is less than the depth of the boss, lap the inner face of the support housing to obtain the proper fit.

34 On single bearing assemblies, use an arbor press to install the bearing on the gear shaft. Install the gear and bearing assembly in the housing. Install the washer and spanner nut, which has a left hand thread, using the teneragor drive gear nut wrench. Cotterpin the nut.

35 On double bearing assemblies (Figure 5-11), hold the drive gear with the holding fixture and drift the inner bearing on the shaft, using the bearing drift. Install the spacer on the gear shaft and install the gear and inner bearing in the housing, using the assembly drift. With the assembly held with the fixture, install the outer bearing in the housing, using the bearing drift. Install the washer and spanner nut, which has a left hand thread. Cotterpin the nut. Shellac a new Part No. 50681 cork and install it in the gear shaft from the anti-spline end of the shaft.

36 If desired a solid cork, Part No. 7435, may be installed if much oil leakage past the generator drive pinion splines has been encountered. In order to prevent "hydraulicking" the cork, care should be taken that only a small amount of lubriplate No. 130A be used when installing pinion and shaft.

37 Place the support and gear assembly, top side down, over the four generator assembly studs on the top of the rear case. Install the drive gear retainer plate and secure it in place with four 1/4 inch fillister head screws. Lockwire the screws.

38 Install the generator drive assembly in position in the rear section. A rubber oil seal is required between the flange of the generator bearing housing and the mounting pad of the rear section.

NOTE

It is important that the correct generator drive gear and starter jaw assembly be used with the different generator drive and shaftgear assemblies. Refer to EO 10A - 10AA -4 Part List, for the appropriate part number of the various assemblies.

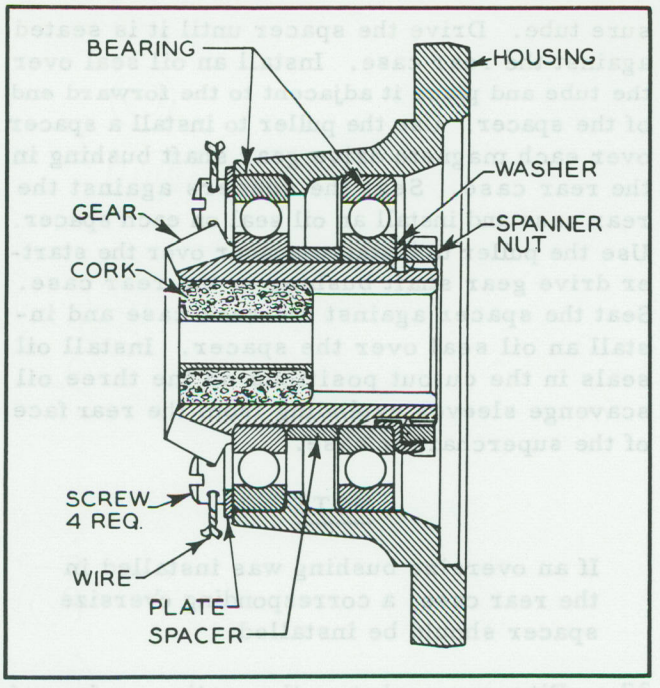


Figure 5-11 Generator Drive Gear Assembly

39 Check the backlash between the generator drive gear and the starter jaw gear, using a dial indicator and the backlash arbor. See reference 605, Section 3. First check the backlash with the starter jaw contacting the flange of the starter shaft rear case bushing and again with the starter jaw as far to the rear as possible. In the forward position the backlash should not be less than the minimum specified, while in the rear position, the backlash should not exceed the replacement limit.

40 Tighten the four nuts on the generator drive cover and lockwire the nuts.

41 Install the starter drive cover and gasket and secure it in place with six 3/8 inch self-locking nuts.

VERTICAL ACCESSORY DRIVE GEARS
(Tool Group 140)

42 To assemble the right vertical accessory

drive gear and shaft, install the adapter on top of the shaft housing with the flanged side down. Temporarily secure the adapter with two washers and a nut.

43 Press the shaft bearing into the cover liner with the manufacturer's number on the bearing upward. Push the drive shaft and gear upward through the oil pump housing. Hold the shaft in place with the assembly stop through the magneto drive shaft housing. Press the cover liner and bearing over the end of the shaft (Figure 5-12). Install the bevel gear on the end of the shaft and secure it in place with a washer and nut Tighten the nut finger tight.

44 Install the left vertical accessory drive gear and shaft upward through the fuel pump housing. Mount the cover liner, with the bearing installed, over the shaft. Install the spacer, washer and nut on the shaft. Tighten the nut finger tight.

45 If an accessory is to be installed, substitute a gear for the spacer on the upper end on the shaft.

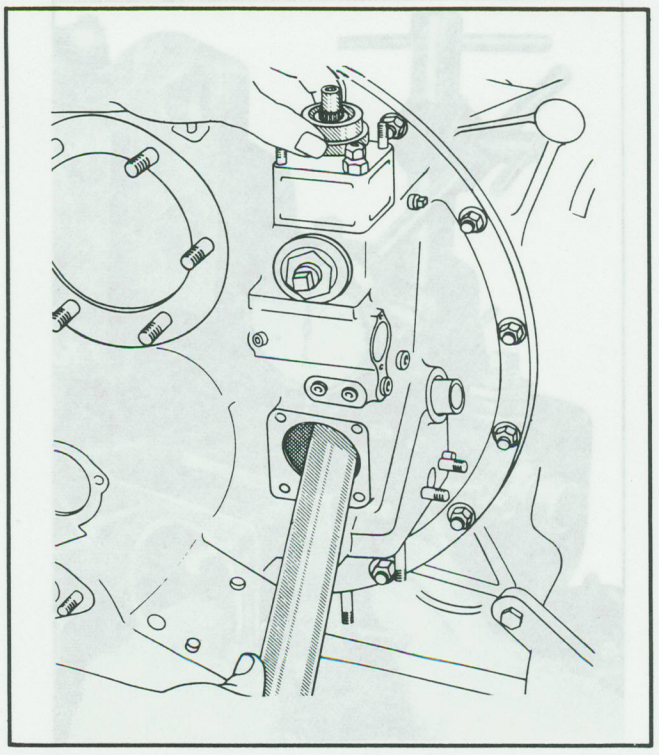


Figure 5-12 Install Bearing

46 The plug in the end of the shaft may be removed if an accessory requiring lubricating oil, such as a vacuum pump, is to be installed. A propeller governor or hydraulic pump does not require additional lubrication.

TACHOMETER DRIVE (Tool Group 123)

47 Install new oil seals in the outer couplings of the left and right tachometer drive gears, using the assembly drift. Place the inner and outer couplings on the shaft of the tachometer drive gears. Place a gasket on the face of each inner coupling and install the tachometer drive assemblies in the right and left sides of the rear case. Mesh the tachometer drive gears with the worm gears on the vertical accessory drive shafts.

NOTE

It is important to install each tachometer drive coupling on its particular side of the engine. Each coupling has a spiral oil groove in its bore to provide a return for the oil which leaks past the bushing. If a coupling is installed on the wrong side, this groove will assist oil leakage rather than prevent it.

48 Use a dial indicator to check the end clearance of each tachometer drive gear. See reference 659, Section 3. If the end clearance is insufficient, lap the inner face of the inner coupling. If the end clearance is excessive, change the inner coupling.

49 Lockwire the tachometer drive assembly retaining screws (Figure 5-13). Install a gasket in each outer coupling cap and screw the caps onto the couplings.

MAGNETO DRIVE GEARS AND SHAFTS AND ACCESSORY INTERMEDIATE DRIVE GEARS (Tool Group 77)

50 Hole the right accessory intermediate drive gear against the face of the corresponding magneto drive gear shaft rear bushing. Insert the right magneto drive gear from the front face of the supercharger section, through the bushings and through the accessory intermediate drive gear. Align the keyways in the ac-

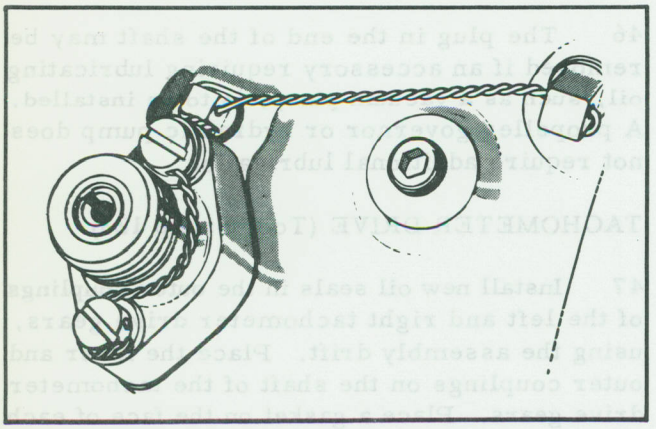


Figure 5-13 Tachometer Drive

cessory intermediate drive gear and the magneto drive shaft and install the keys with a brass drift and a hammer. Assemble the left magneto drive gear and shaft and the left accessory intermediate drive gear in the same manner.

51 Tighten the nut on the upper end of both vertical accessory drive gears. Use a dial indicator to check the end clearance of each magneto drive gear. See reference 664, Section 3. If the clearance is insufficient, face off the flange of the magneto drive gear shaft front bushing. If the end clearance is excessive, change the magneto drive gear shaft bushing.

52 Use a dial indicator having a right angle attachment to check the backlash between the right and left accessory intermediate drive gear and the corresponding vertical accessory drive gear (Figure 5-14). See reference 672, Section 3. If the backlash is excessive, face off the flange of the magneto drive gear shaft front bushing, using the facer. If the backlash is insufficient, change the magneto drive gear shaft bushing.

53 Cotterpin the nuts on the vertical drive gear and shafts. Install a cap on each vertical drive gear and shaft housing. Secure the caps with washers and nuts. Lockwire the nuts.

OIL PUMP

54 See Figure 5-15. Insert the drive gear shaft through the end plate of the oil pump (Figure 5-16). Fit the key in the keyway of the drive shaft and assemble the large gear on the shaft. Place the idler gear and shaft in the end plate. Install the large scavenge section over the drive and idler shafts and fit it to the end plate.

55 Insert new leather packings in the shaft holes of the small scavenge section, and install the section over the shafts, making sure the shafts do not bind in the packings. Fit the key in the keyways of the drive gear shaft and assemble the drive and idler gears on their respective shafts (Figure 5-17). Install the cover or pressure section of the pump over the drive and idler shafts and fit it to the scavenge section (Figure 5-18).

56 Insert the two loose fitting bolts and install and tighten their nuts, finger tight. Insert the two tight fitting bolts; then tighten all four nuts securely. Lockwire the nuts (Figure 5-19).

57 Do not tighten the through bolts excessively as the pump sections will be distorted and bind on the gears. The gears will turn freely by hand if the pump is correctly assembled.

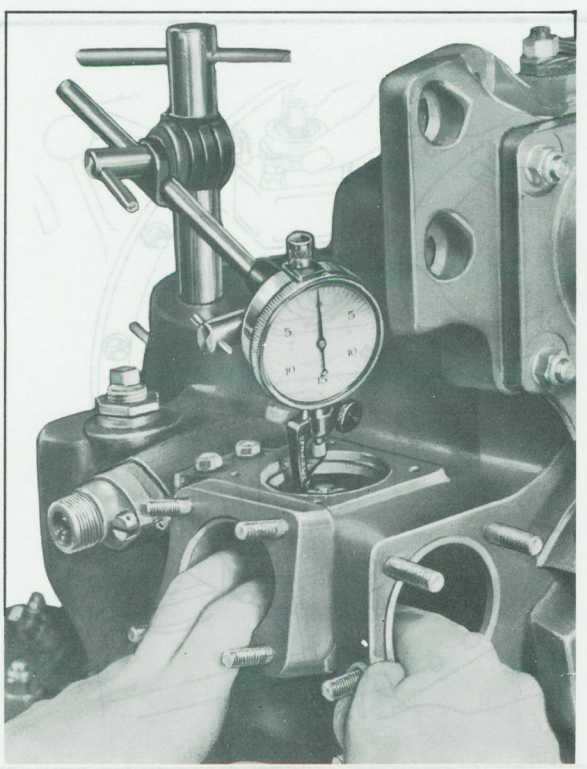


Figure 5-14 Measure Backlash

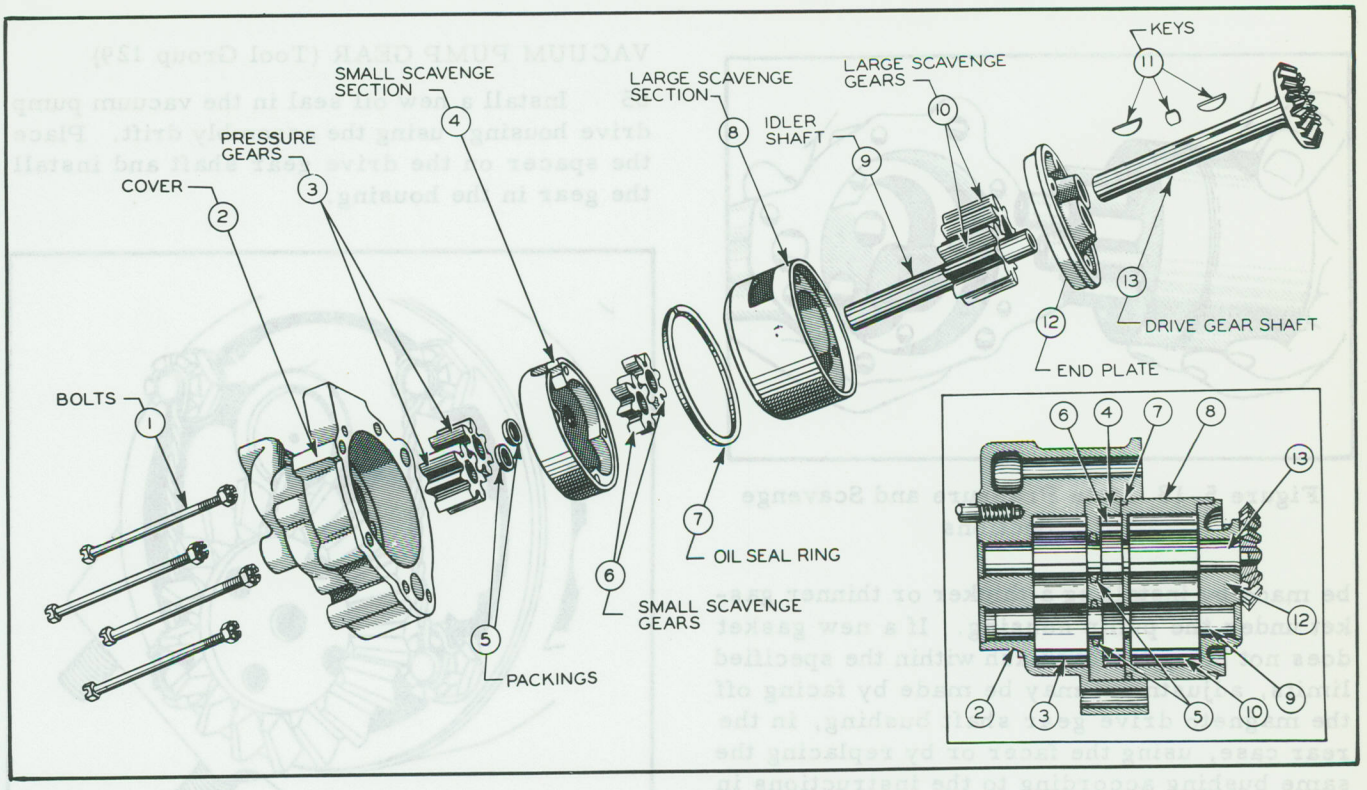


Figure 5-15 Exploded View of Oil Pump

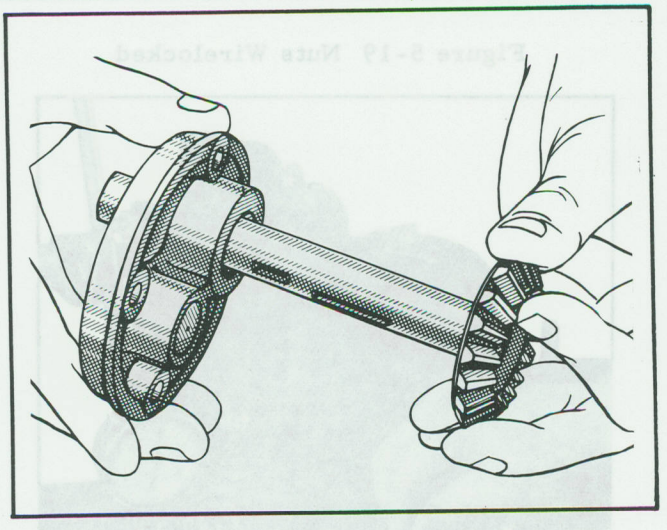


Figure 5-16 Insert Drive Gear Shaft

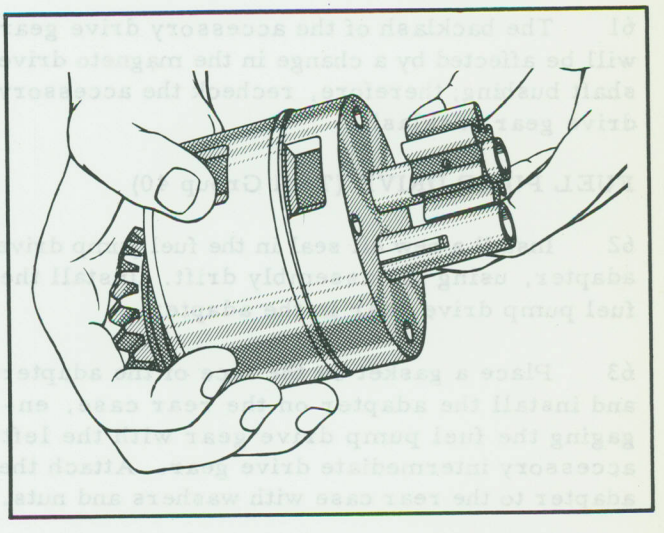


Figure 5-17 Install Pump Gears

58 Install the oil seat rings in position on the OD of the pump body and check the inside clearance of the rings. See reference 750, Section 3. If the side clearance is insufficient, grind the rings on a surface grinder.

59 Fit a new gasket over the mounting flange on the oil pump housing. Install the oil pump in the rear case, engaging the drive gear with the accessory intermediate drive gear. Attach the pump to the rear case with washers and nuts.

60 Use a dial indicator to check the backlash between the oil pump drive gear and the accessory intermediate drive gear. See reference 697, Section 3. Adjustment of the backlash may

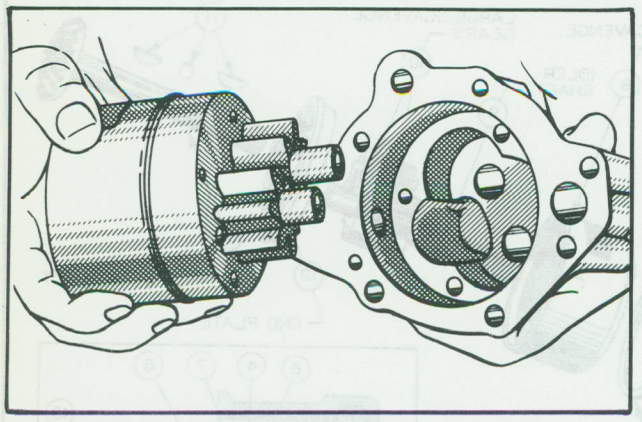


Figure 5-18 Mate Pressure and Scavenge Sections

be made by installing a thicker or thinner gasket under the pump housing. If a new gasket does not bring the backlash within the specified limits, adjustment may be made by facing off the magneto drive gear shaft bushing, in the rear case, using the facer or by replacing the same bushing according to the instructions in Part 8.

61 The backlash of the accessory drive gear will be affected by a change in the magneto drive shaft bushing; therefore, recheck the accessory drive gear backlash.

FUEL PUMP DRIVE (Tool Group 40)

62 Install a new oil seal in the fuel pump drive adapter, using the assembly drift. Install the fuel pump drive gear in the adapter.

63 Place a gasket on the face of the adapter and install the adapter on the rear case, engaging the fuel pump drive gear with the left accessory intermediate drive gear. Attach the adapter to the rear case with washers and nuts.

64 Use a dial indicator and the backlash-arbor to check the backlash between the fuel pump drive gear and the left accessory intermediate drive gear (Figure 5-20). See reference 674, Section 3. As described in the preceding paragraph for the oil pump, adjustment may be made by facing the magneto drive gear shaft front bushing or by replacing the same bushing. Install the cover on the adapter with washers and nuts. Lockwire the nuts (Figure 5-21).

VACUUM PUMP GEAR (Tool Group 129)

65 Install a new oil seal in the vacuum pump drive housing, using the assembly drift. Place the spacer on the drive gear shaft and install the gear in the housing.

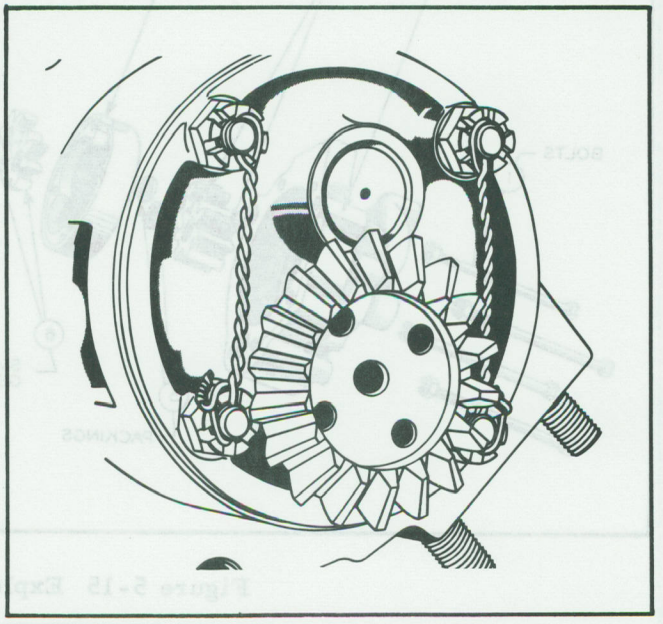


Figure 5-19 Nuts Wirelocked

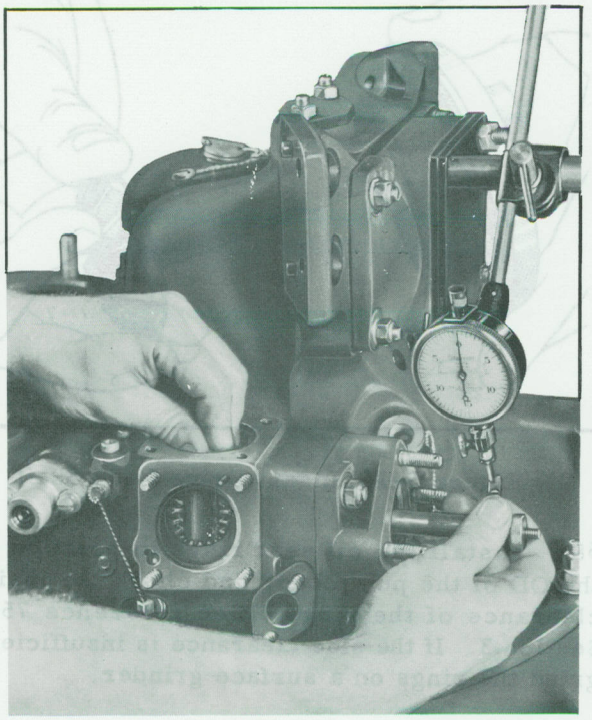


Figure 5-20 Measure backlash

66 Place the proper gasket (Figure 5-22) over the mounting flange of the vacuum pump drive adapter, and install the housing in the rear case. Use a dial indicator and the backlash arbor to check the backlash between the vacuum pump drive gear and the fuel pump drive gear. See reference 741, Section 3.

67 Adjustment to the backlash may be made by installing a thicker or thinner gasket between the vacuum pump drive housing and the rear case. If changing the gasket does not bring the backlash within the specified limits, the drive shaft spacer may be around or a thicker spacer may be installed. Install the proper gasket and the vacuum pump or cover and secure it with washers and nuts.

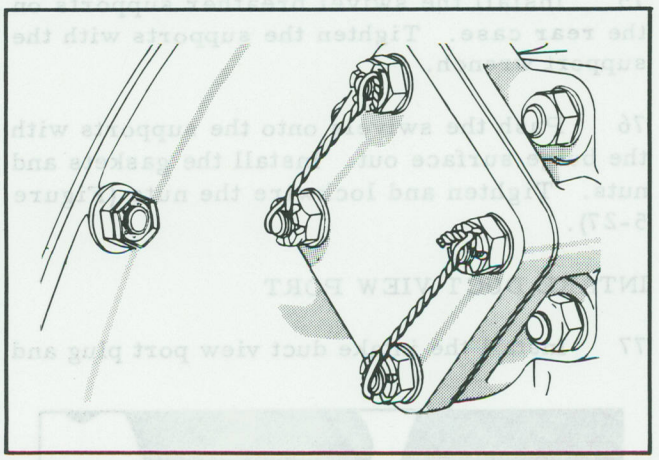


Figure 5-21 Cover and Nuts

MAGNETO COUPLING DRIVE GEARS (Tool Group 75)

68 Install the magneto coupling drive gear oil shields in the right and left magneto coupling drive gear housings with the small slot in the shield fitting over the small dowel pin in the housing.

69 Press the springs into the covers using the spring drift, and install the covers and gaskets on the drive gear housings. Attach the covers to the housings with three cap screws and washers, leaving the fourth screw out.

70 On engines that incorporate the new lip type oil seal, a new magneto drive coupling and magneto drive oil seal housing; install the lip type seal in the housing (Figure 5-23), using the drift and base. Install the assembly in the

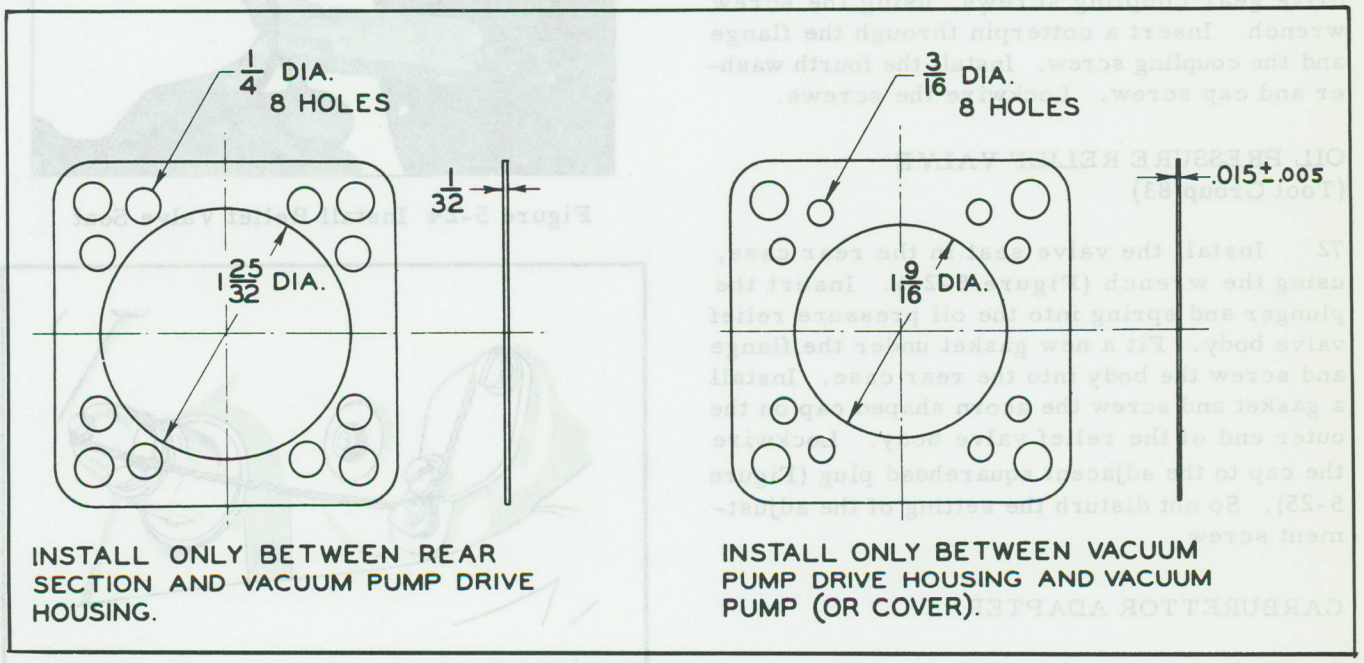
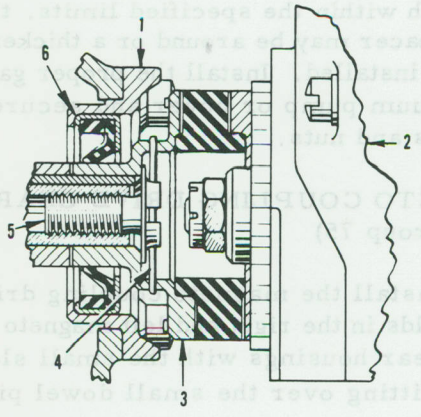


Figure 5-22 Vacuum Pump Gaskets



1. Seal Housing (164315)
2. Magneto
3. Coupling (164316)
4. Cotterpin (#3)
5. Screw (1175)
6. Seal (164314)

Figure 5-23 Magneto Drive and Coupling

engine, using a new gasket and secure with three cap screws and washers, leaving the fourth screw out.

71 Install and tighten right and left magneto drive gear coupling screws, using the screw wrench. Insert a cotterpin through the flange and the coupling screw. Install the fourth washer and cap screw. Lockwire the screws.

OIL PRESSURE RELIEF VALVE (Tool Group 83)

72 Install the valve seat in the rear case, using the wrench (Figure 5-24). Insert the plunger and spring into the oil pressure relief valve body. Fit a new gasket under the flange and screw the body into the rear case. Install a gasket and screw the acorn shaped cap on the outer end of the relief valve body. Lockwire the cap to the adjacent squarehead plug (Figure 5-25). So not disturb the setting of the adjustment screw.

CARBURETTOR ADAPTER

73 Attach the carburettor adapter to the rear case with washers, nuts, and lockwire.

OIL SCREEN AND CHECK VALVE (Tool Group 86)

74 Insert the check valve assembly, oil seal and oil screen into the chamber in the rear case. Install the cover and gasket. Tighten the cover with the wrench and lockwire (Figure 5-26).

SWIVEL BREATHER AN-14B Model (Tool Group 121)

75 Install the swivel breather supports on the rear case. Tighten the supports with the support wrench.

76 Push the swivels onto the supports with the bulge surface out. Install the gaskets and nuts. Tighten and lockwire the nuts (Figure 5-27).

INTAKE DUCT VIEW PORT

77 Install the intake duct view port plug and

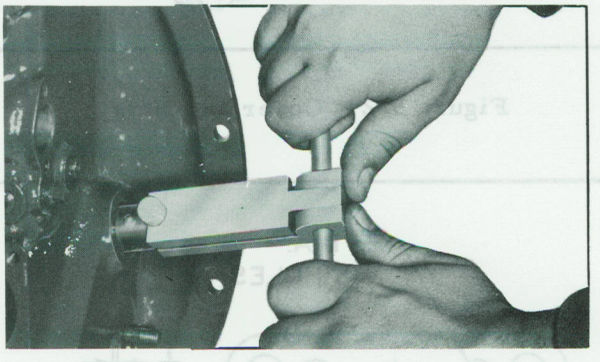


Figure 5-24 Install Relief Valve Seat

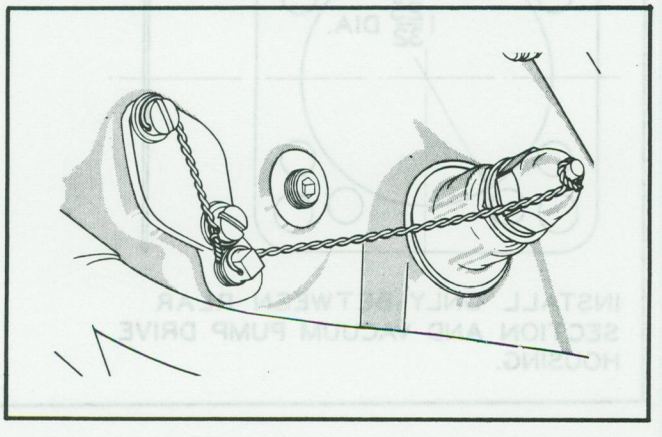


Figure 5-25 Relief Valve Cap

cover in position in the rear case. Lockwire the plug (Figure 5-28).

OIL OUTLET TEMPERATURE BULB CONNECTIONS

78 Install the connection and gasket on the lower right side of the rear case. Lockwire the connection (Figure 5-29).

CRANKSHAFT AND MASTEROD

MASTERODS AND LINKRODS (Tool Group 73)

79 Check the engine mating numbers of the masterod assembly. Check the size marking of each linkpin as compared with the size marking of the corresponding linkpin hole. Set the linkrods on a bench with the rear side up, left to right, in the following sequence 4, 3, 2, 1, 9, 8, 7, and 6. Wipe the masterod, linkrods and linkpins dry with a clean, lint-free cloth.

80 Place the masterod, front face down in the fixtures. Place the linkrods in position in the masterod. Install the wedge between the flanges of the masterod to prevent their distortion during the pressing operation. Apply a generous coating of oil to the linkpins and set each pin in the proper position in the masterod.

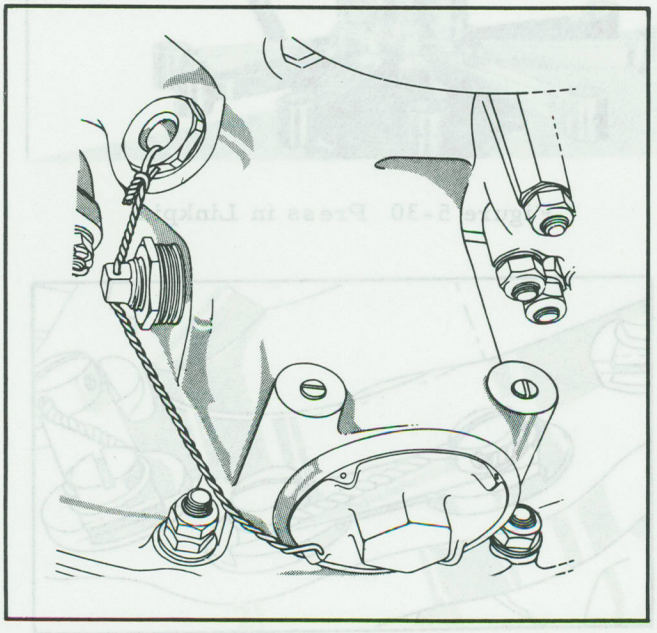


Figure 5-26 Oil Screen Cover

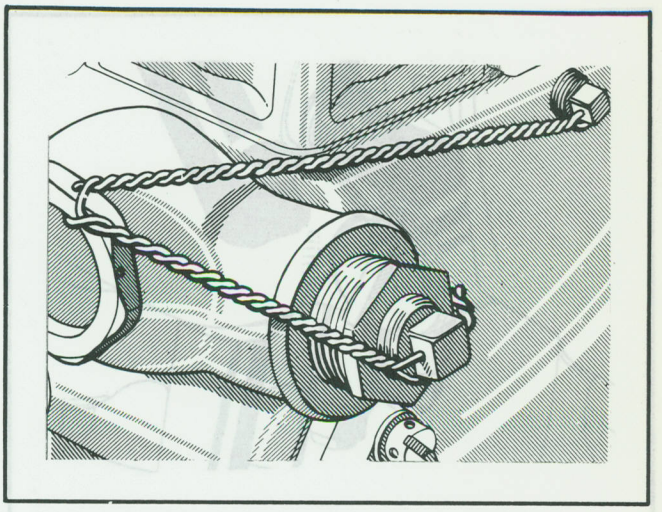


Figure 5-27 Locking of Swivel Nut

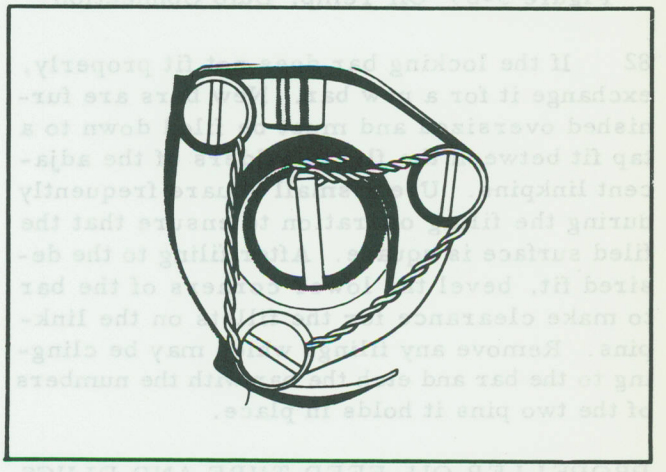


Figure 5-28 Intake Duct View Port Cover

Align the slot in the linkpin with the projecting tongue of the fixture. Place the "L" head plunger through the centre guide holes of both figures and, in conjunction with the drift, bring the plunger down to press in the linkpin (Figure 5-30). Rotate the plunger to the next linkpin, and change the position of the wedge until all the pins are assembled.

LINKPIN LOCKING BARS

81 Remove the masterod assembly from the fixture and install the locking bars on the rear of the linkpins. The locking bars are marked with the position numbers of the two adjacent linkpins. Secure the locking bars with the two fillister-head screws and lockwire the screws (Figure 5-31).

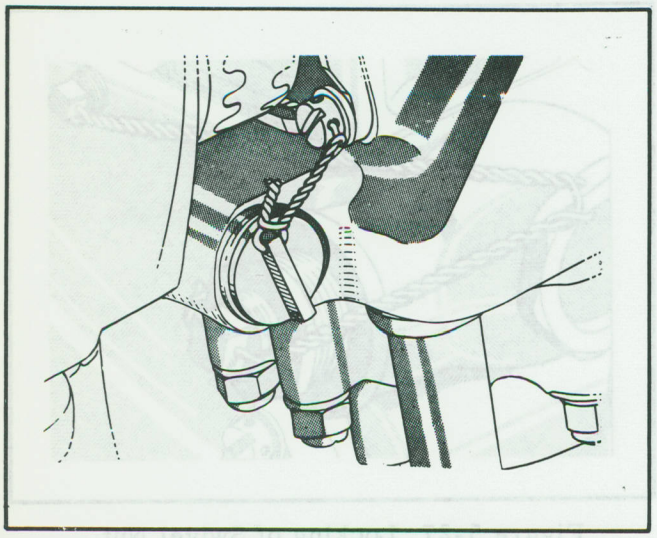


Figure 5-29 Oil Temp. Bulb Connection

82 If the locking bar does not fit properly, exchange it for a new bar. New bars are furnished oversized and must be filed down to a tap fit between the flat shoulders of the adjacent linkpins. Use a small square frequently during the filing operation to ensure that the filed surface is square. After filing to the desired fit, bevel the lower corners of the bar to make clearance for the fillets on the linkpins. Remove any filings which may be clinging to the bar and etch the bar with the numbers of the two pins it holds in place.

PROPELLER OIL FEED TUBE AND PLUGS (Tool Group 96)

83 Install the oil feed tube assembly and gasket in the crankshaft, piloting the tube carefully into the rear plug.

84 Install the manifold with its gasket over the tube support and secure this assembly with the locknut. Tighten the locknut to the recommended torque (Section 4) and secure with washer and lockscrews. Lockwire the screws; then install and secure the manifold plug with the gasket.

CRANKSHAFT FRONT SECTION (Tool Group 22)

85 Mount the splined end of the crankshaft front section in the fixture equipped with the appropriate adapter.

86 Screw the crankshaft front plug in place on the rear face of the crankshaft front throw. If the plug has been previously used in the same opening, tighten it beyond the previous staking point. Use a punch and a light hammer to stake the plug in the crankshaft.

87 Leave the crankshaft front section in the fixture until the crankshaft rear section has been assembled.

SUPERCHARGER SPRING DRIVE BOLT (Tool Group 120)

88 Install the supercharger spring drive bolt

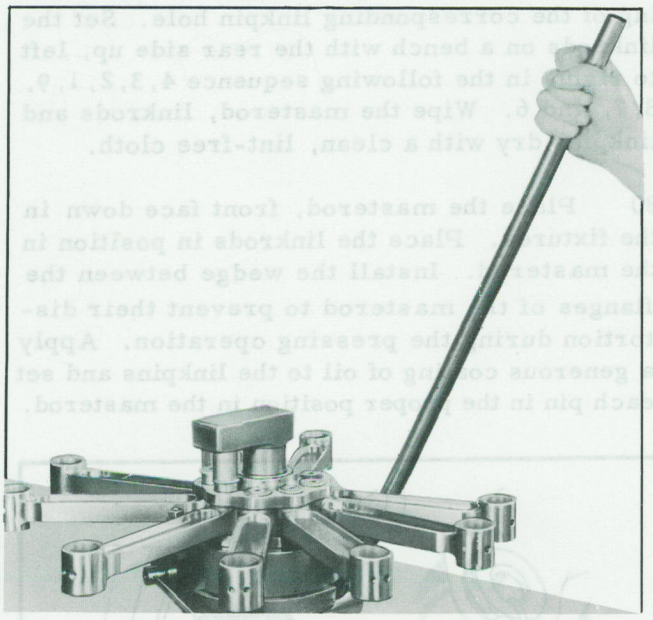


Figure 5-30 Press in Linkpin

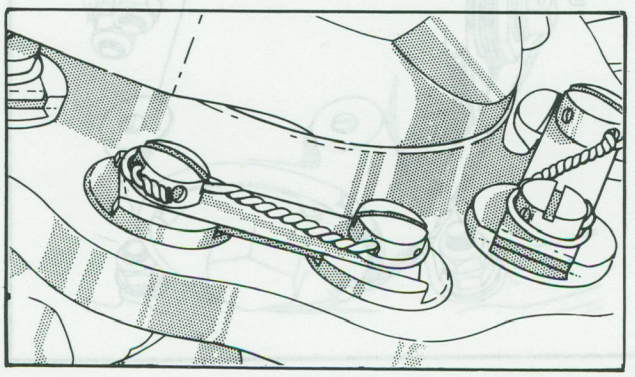


Figure 5-31 Linkpin Locking Bars

from the front side of the crankshaft rear section. Use the wrench to tighten bolt in the crankshaft.

FLYWEIGHTS (Tool Group 34)

89 Place the counterweight on a bench with the rear side up. Coat the flyweight mating surfaces with white lead and oil. Match the mating numbers of the flyweight outer and inner sections. Install the outer flyweights from the rear of the counterweight.

90 Turn the counterweight on its edge and press the inner halves of the flyweights on by hand (Figure 5-32). If the flyweights do not fit together easily, rest the outer cage of the counterweight on a bench and tap the flyweight lightly with a rawhide mallet. Screw the shaft of the puller through the outer flyweight into the internal threads of the inner flyweight. Hold the end of the shaft with a suitable wrench, and press the flyweights together by turning the knurled handle.

91 Apply a coating of white lead and oil to the flyweight bolt expanding plugs. Use an allen wrench to screw the expander plugs into the flyweight bolts several times to make sure they turn freely; then leave the plugs loose in the bolts. Install the bolts on the bevel side of the flyweights and screw the flyweights bolts in snugly by hand (Figure 5-33). Install the bolt wrench over one flyweight. Use a 1/2 inch bar to turn the wrench and screw the flyweight bolt all the way in (Figure 5-34). Repeat the procedure to install the second flyweight.

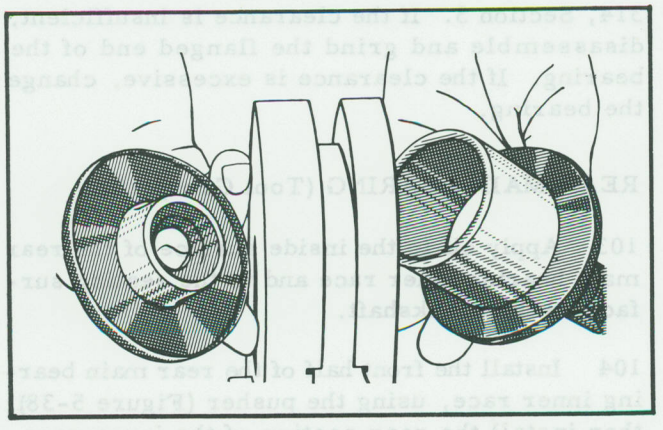


Figure 5-32 Inner Halves of Flyweights

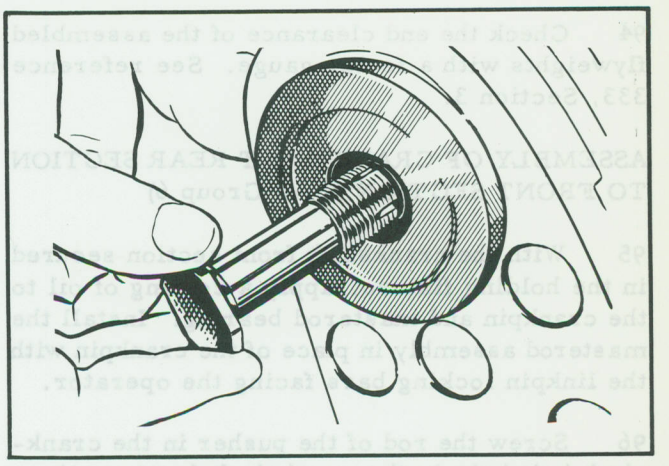


Figure 5-33 Insert Flyweight Bolts

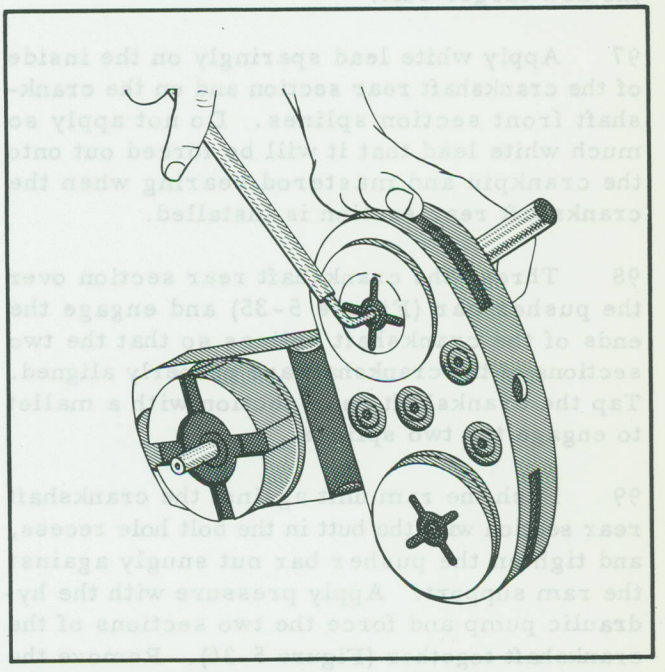


Figure 5-34 Screw Home Flyweight Bolts

92 Torque the expander plugs to 200 to 225 inch pounds, using an allen wrench with a long handle and the torque wrench. The expander plug should in no case project more than 1-1/2 threads.

93 Measure and record the length of the flyweight bolt, using an outside micrometer. Torque the flyweight bolt to approximately 1300 inch pounds. Measure the flyweight bolt stretch. The recommended flyweight bolt stretch is .001 to .0015 inch.

94 Check the end clearance of the assembled flyweights with a feeler gauge. See reference 333, Section 3.

ASSEMBLY OF CRANKSHAFT REAR SECTION TO FRONT SECTION (Tool Group 6)

95 With the crankshaft front section secured in the holding fixture, apply a coating of oil to the crankpin and masterod bearing. Install the masterod assembly in place of the crankpin with the linkpin locking bars facing the operator.

96 Screw the rod of the pusher in the crankshaft bolt hole in the crankshaft front section. Use the modified pusher for crankshafts using the new larger bolt.

97 Apply white lead sparingly on the inside of the crankshaft rear section and on the crankshaft front section splines. Do not apply so much white lead that it will be forced out onto the crankpin and masterod bearing when the crankshaft rear section is installed.

98 Thread the crankshaft rear section over the pusher bar (Figure 5-35) and engage the ends of the crankshaft splines so that the two sections of the crankshaft are properly aligned. Tap the crankshaft rear section with a mallet to engage the two splines.

99 Push the ram unit against the crankshaft rear section with the butt in the bolt hole recess, and tighten the pusher bar nut snugly against the ram support. Apply pressure with the hydraulic pump and force the two sections of the crankshaft together (Figure 5-36). Remove the pusher from the crankshaft.

100 Apply oil or white lead and oil to the crankshaft through bolt and screw the bolt into the shaft. Measure and record the length of the bolt, using ball ends and a 7 inch outside micrometer (Figure 5-37). Alternately tighten and gauge the bolt, using the micrometer, ball ends, and the wrench intil the bolt is stretched .009 inch to .011 inch. While tightening the through-bolt, line up the cotterpin hole. Fit the cotterpin through the holes in the bolt and crankshaft rear cheek and anchor the cotterpin in place.

101 If the cotterpin holes cannot be lined up within the prescribed through bolt stretch, it may be necessary to drill a new hole in the bolt to accommodate the pin, but not more than three holes should be drilled in a crankshaft through bolt head and these holes should be logically spaced.

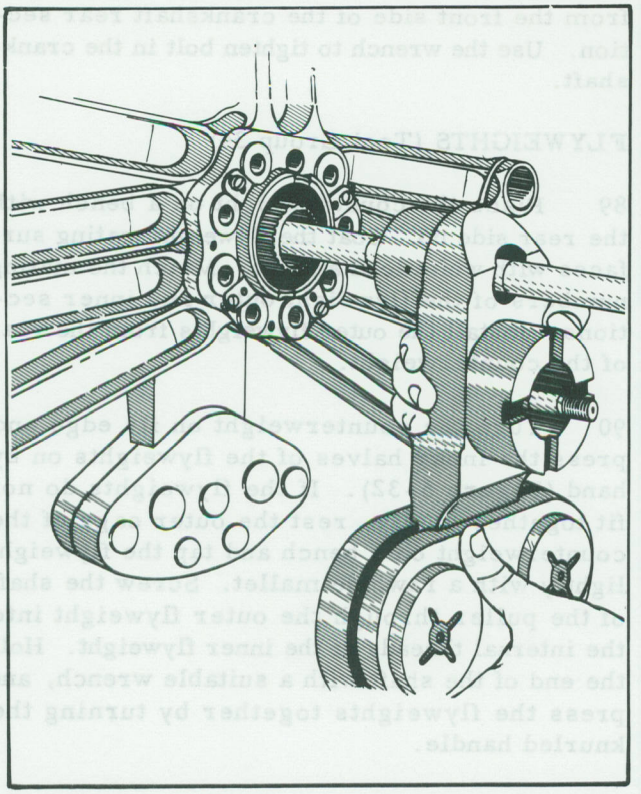


Figure 5-35 Mate Crankshaft Sections

102 Use a feeler gauge to check the end clearance of the masterod bearing. See reference 314, Section 3. If the clearance is insufficient, disassemble and grind the flanged end of the bearing. If the clearance is excessive, change the bearing.

REAR MAIN BEARING (Tool Group 102)

103 Apply oil to the inside surface of the rear main bearing inner race and to the seating surface on the crankshaft.

104 Install the front half of the rear main bearing inner race, using the pusher (Figure 5-38); then install the rear section of the inner race. Install the rollers and the bearing outer race.

105 If the inner race pusher is not available, heat the inner race in an oil bath to 175° to 204° (347° to 400°F) for 3 minutes. Allow the race to drain and install it on the crankshaft, using lint-free asbestos gloves.

CRANKSHAFT REAR GEAR

106 Use a depth micrometer to measure the distance from the rear face of the rear main bearing inner race to the bottom of the lug slots in the crankshaft. Measure the height of the lugs on the crankshaft rear gear. The depth of the slots should be .002 inch to .004 inch greater than the height of the lugs. If the distance is not within the limits, grind the lugs to obtain the proper dimensions.

107 Align the "O" markings on the gear and crankshaft and install the gear on the crankshaft. It may be necessary to tap the gear with a fibre drift in order to install it. Recheck the clearance between the gear and the crankshaft, using a feeler gauge. If the clearance is insufficient, grind the lugs on the gear. Secure the gear to the crankshaft with four screws.

IMPELLER SPRING DRIVE COUPLING (Tool Group 57)

108 Place the buttons and springs in place in the fixed spider of the impeller spring drive coupling, using the compressor. Install the friction band on the floating spider and insert the flosting spider in the crankshaft rear gear. Drift the fixed spider into place. Make certain that the fixed and floating spiders are properly aligned so as not to damage the springs in the fixed spider. Secure the spiders in position with the washer and nut. Cotterpin the nut.

109 Place the crankshaft rear gear over the friction band with the two small etched "X's" on adjacent lugs (Figure 5-39). Install the gear and coupling assembly on the rear of the crankshaft aligning the etched "O's" on the gear and crankshaft. Install the washer end nut on the spring drive coupling bolt. Cotterpin the bolt.

FRONT MAIN BEARING (Tool Group 38)

110 Withdraw the crankshaft assembly from the holding fixture and place it on a bench. Apply oil to the front main bearing inner race and to the seating surface on the crankshaft.

111 Install the rear section of the front main

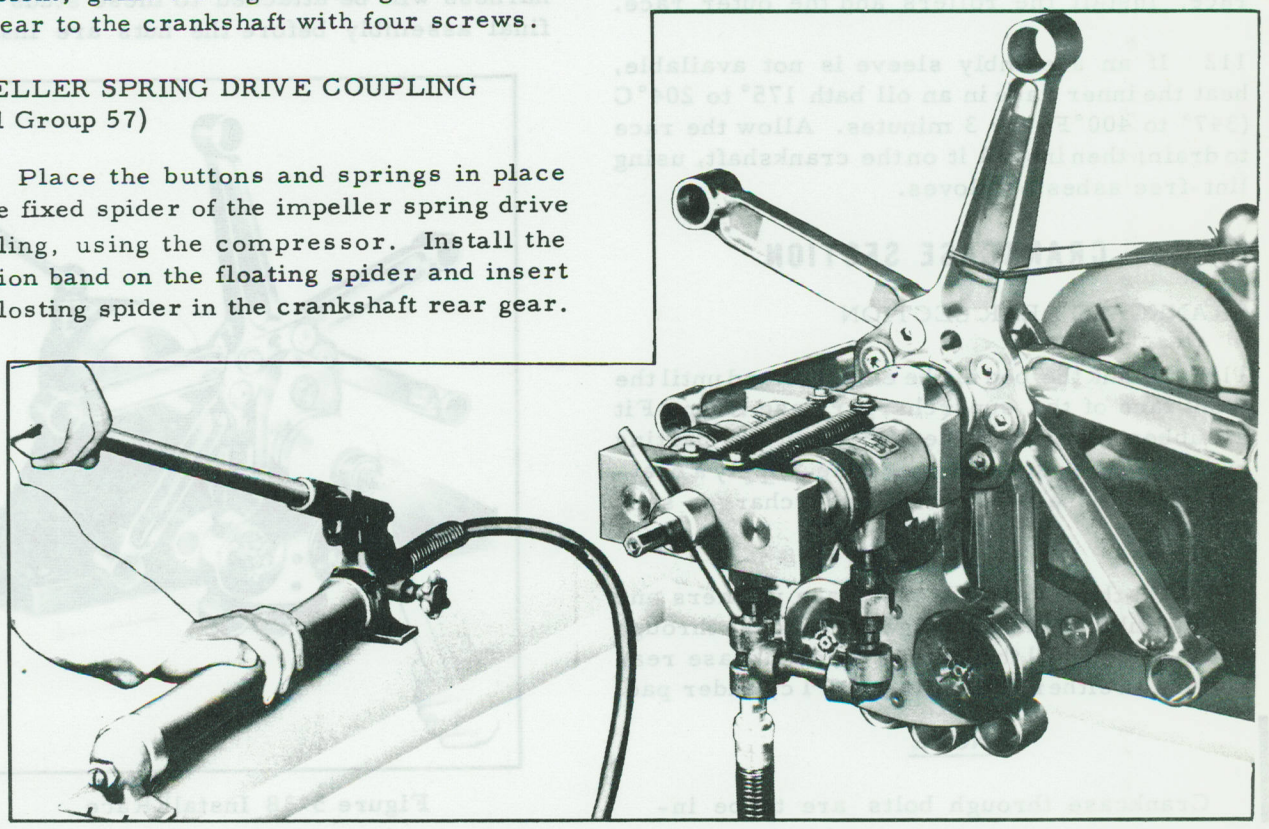


Figure 5-36 Use Hydraulic Pressure

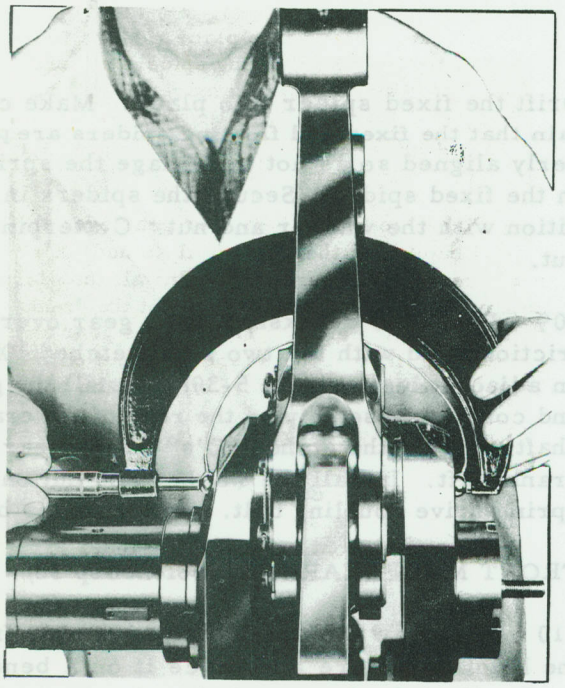


Figure 5-37 Measure Through Bolt

bearing inner race on the crankshaft, using the sleeve; then install the front section of the inner race. Install the rollers and the outer race.

112 If an assembly sleeve is not available, heat the inner race in an oil bath 175° to 204°C (347° to 400°F) for 3 minutes. Allow the race to drain; then install it on the crankshaft, using lint-free asbestos gloves.

CRANKCASE SECTION

CRANKCASE REAR SECTION

113 Crank the bed of the engine stand until the front face of the supercharger case is up. Fit a rubber oil seal in the groove in the parting surface of the supercharger case. Apply a coating of oil to the gears in the supercharger section.

114 On the AN-14B Model place washers and lifting links on the two longer crankcase through bolts, and install the bolts in the crankcase rear section on either side of the No. 1 cylinder pad.

NOTE

Crankcase through bolts are to be installed with the head of the bolt towards the front of the engine.

115 On the AN-5 Model place washers and lifting links on the four longest crankcase through bolts, and install the bolts in the crankcase rear section between the cylinder pads of Nos. 7 and 8, Nos. 8 and 9, Nos. 9 and 1, and Nos. 1 and 2 cylinders.

116 Place washers on the remaining crankcase through bolts and install the bolts in the crankcase. Place a rubber band around the protruding bolts in the crankcase to prevent their dropping from the case. Install a rubber oil seal around the oil transfer ferrule between Nos. 5 and 6 cylinder pads.

117 Mount the crankcase rear section on the supercharger section, being careful not to damage the oil transfer tube. Attach the crankcase rear section to the supercharger section with washers and nuts. Install each washer with the radius adjacent to the counterbore in the crankcase. Do not install washers and nuts on studs Nos. 1 and 5 clockwise and 4 and 7 counterclockwise from the sump mounting pad. The ignition harness will be attached to these studs during final assembly before the nuts are installed.

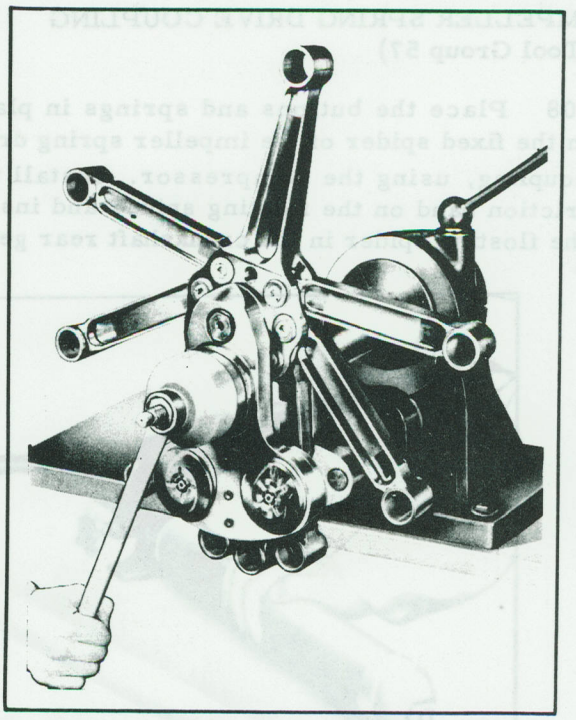


Figure 5-38 Install Race

Install palnuts on the crankcase rear section studs.

NOTE

Washers installed under the head of the crankcase through bolts are to be fitted with the flat side to the crankcase.

ASSEMBLY OF CRANKSHAFT AND MASTEROD ASSEMBLY TO ENGINE (Tool Group 4)

118 Oil the impeller spring drive coupling and the crankshaft rear gear. Attach the lifting eye to the front end of the crankshaft, and in conjunction with the hook and a chain hoist, lower the crankshaft and masterod assembly into the crankcase rear section. Fit the crankshaft rear main bearing through the crankcase bore, engaging the crankshaft rear gear with the starter gear and the magneto drive gears and the impeller spring drive coupling with the floating gear. Be certain that the masterod fits in the opening for the No. 5 cylinder and the 8 linkrods fit into the openings for their respective cylinders. Install the supports over the masterod and each linkrod. Pull the No. 1 linkrod to its full outward position.

CRANKCASE FRONT SECTION (Tool Group 18)

119 Temporarily install the cam reduction gear locknut on the cam reduction gear to make sure that the nut seats properly on the gear. Remove the nut and install the gear in its bushing. Re-install the nut on the gear and tighten

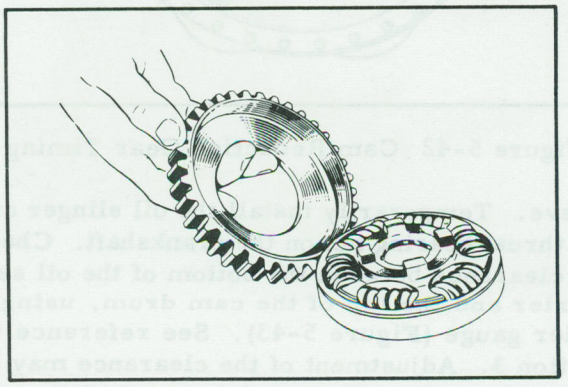


Figure 5-39 Gear and Coupling Assembly

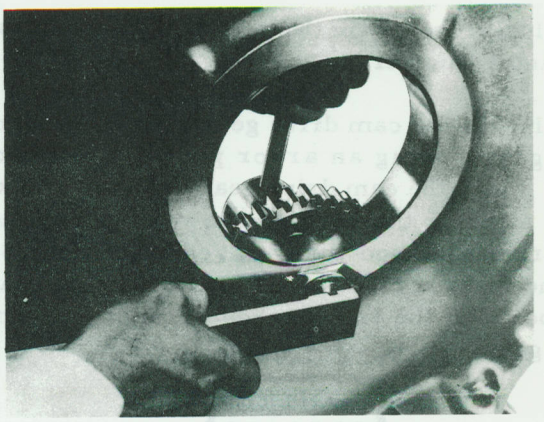


Figure 5-40 Tighten Cam Reduction Gear Locknut

it with the wrench in conjunction with the holder (Figure 5-40). Check the clearance between the nut and the bushing. See reference 310, Section 3. If the clearance is insufficient, face off the bushing with the facer. When the clearance is satisfactory, tighten and cotterpin the nut in the gear.

120 Remove the lifting eye from the front end of the crankshaft. Lower the crankcase front section, in a level position, over the crankshaft to the parting surface of the crankcase rear section.

121 It may be necessary to tap the crankcase front section downward with a fibre drift.

122 Being careful not to pry against the supercharger case, force the crankcase bolts up through their respective holes in the crankcase. Secure the bolts in position with washers and nuts, making sure that each washer is installed with its radius next to the counterbore in the crankcase. Install the special crankcase bolt and washer in the recess between Nos. 5 and 6 cylinder mounting pad. Tighten the bolt nuts to the recommended torque (Section 4) then cotterpin the nuts.

CAM DRIVE GEAR

123 Check the fit of the cam drive gear key in the keyway in the crankshaft. See reference 3, Section 3. If the clearance is insufficient, grind down the key in a surface grinder, or select a new key.

124 Insert the key in the keyway, using a brass drift and a hammer.

125 Install the cam drive gear ring on the cam drive gear, using an arbor press, drift and base. Place the cam drive gear over the crankshaft, aligning the key and keyway. Mesh the cam drive gear and the cam reduction gear so that the marked tooth of the cam reduction gear falls between the two marked teeth of the cam drive gear.

CAUTION

The No. 1 linkrod should still be in its full outward position. Do not turn the crankshaft until after the cam is installed.

CAM OIL FEED BRACKET

126 Install the two floating rings in the oil feed bracket. Assemble the halves of the bracket using tow bolts and nuts. Cotterpin the nuts. Place the cam oil feed bracket over the crankshaft, and install a gasket under the oil feed tube bracket. Attach the oil feed tube and the cam oil feed bracket to the crankcase front section with fillister head screws. Lockwire the screws (Figure 5-41).

CAM AND CRANKSHAFT FRONT OIL SEAL RING CARRIER

127 Make sure that the floating rings in the cam oil feed bracket are properly centred. Oil the bore of the cam, and place the cam over the end of the crankshaft and seat it on the sleeve of the cam drive gear.

128 The two marked teeth on the cam rim must engage with the marked tooth on the pinion of the cam reduction gear while No. 1 linkrod is at top dead centre position (Figure 5-42).

129 Install the two oil seal rings on the front oil seal ring carrier. Use a feeler gauge to check the side clearance and gap clearance of each ring. See references 13 and 14, Section 3. Adjust the clearances to conform to the specified limits. Oil the bore of the ring carrier and install the ring carrier over the crankshaft so that it seats on top of the cam drive gear

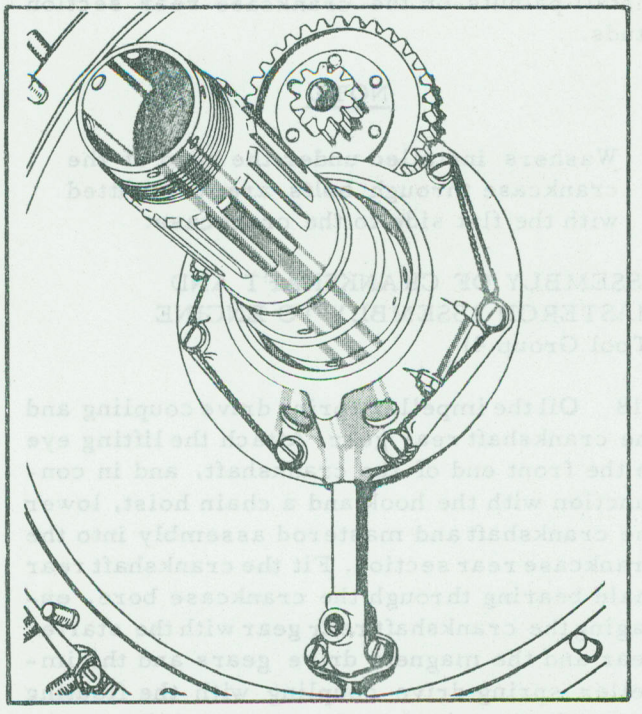


Figure 5-41 Cam Oil Feed Bracket

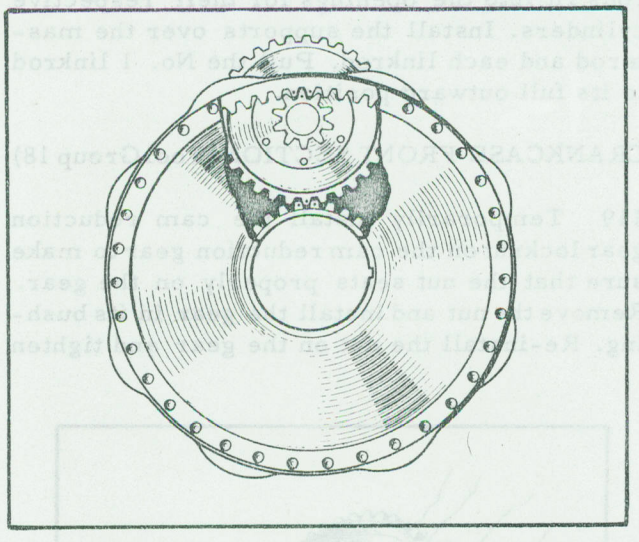


Figure 5-42 Cam Reduction Gear Timing

sleeve. Temporarily install the oil slinger and the thrust bearing nut on the crankshaft. Check the clearance between the bottom of the oil seal carrier and the top of the cam drum, using a feeler gauge (Figure 5-43). See reference 9, Section 3. Adjustment of the clearance may be made by grinding the cam drive gear ring or by installing a thicker ring. Remove the oil slinger and the thrust bearing nut.

FRONT SECTION

FRONT BREATHER

130 On AN-14B Model, install the gasket and plug in the breather aperture in the front case.

131 On the AN-5 Model, install a gasket on the breather plug; then screw the plug into the front case. Place the inner breather tube inside the case, inserting the breather extension body end into the plug. Place the outer tube on the breather plug and secure it in place with the cap screw. Do not fully tighten the cap screw. Install the inner breather tube brackets on the studs of the case, securing them with castle nuts. Tighten the cap screw and lockwire the screw and nuts.

ROCKER OIL MANIFOLD

132 Insert the ends of the manifold in the front case. Attach the manifold to the case with screws. Lockwire the screws (Figure 5-44).

Figure 5-43 Check Carrier to Drum Clearance

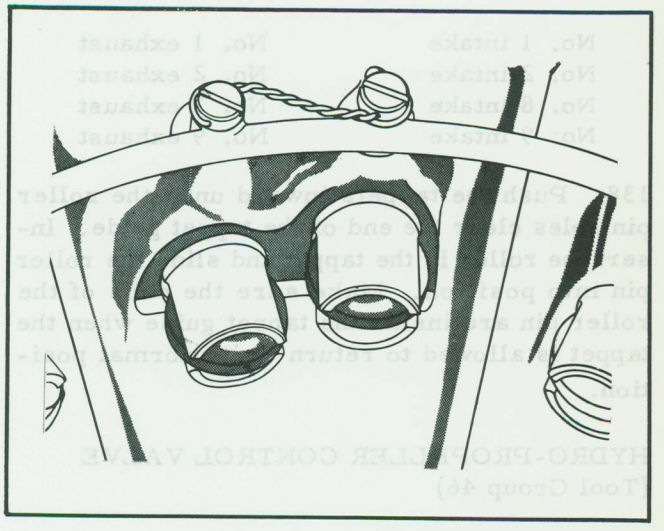


Figure 5-44 Secure Rocker Oil Manifold

THRUST BEARING COVER PINCH FIT

133 Install the thrust bearing cover on the front case and secure it with nuts. Use a feeler gauge to measure the distance between the shoulder of the thrust bearing liner, where the outer race of the thrust bearing seats, and the shoulder of the cover at several points. The distance should be considered the average of the measurements taken.

134 Measure the combined thickness of the thrust bearing outer race and the thrust bearing cover spacer ring at several points, using an outside micrometer. The thickness should be considered the average of the measurements taken.

135 The pinch fit is the difference between the average distance and the average thickness measured. See reference 7, Section 3. If the pinch fit is not within the specified limits, adjust it by grinding or exchanging the thrust bearing cover spacer ring.

TAPPETS, ROLLERS AND PINS

136 Coat the tappets, rollers and pins with oil and install the tappets in their guides.

137 On the AN-14B Model, install the draining tappets, which have oil holes drilled in them, in the following guide locations:

No. 1 intake	No. 1 exhaust
No. 2 intake	No. 2 exhaust
No. 8 intake	No. 3 exhaust
No. 9 intake	No. 9 exhaust

138 Push the tappets inward until the roller pin holes clear the end of the tappet guide. Insert the roller in the tappet and slide the roller pin into position. Make sure the ends of the roller pin are inside the tappet guide when the tappet is allowed to return to its normal position.

HYDRO-PROPELLER CONTROL VALVE (Tool Group 46)

139 On the AN-14B Model, install the oil feed tube leading from the control valve boss to the thrust bearing liner. Insert a new packing in the valve cover by twisting it in the direction of the thread until it is bottomed. Slide the valve shaft through the valve cover from the bottom and install the oil control valve packing nut, using the valve nut wrench. Secure the valve lever in position with the taper pin. Apply oil with the finger to the inside of the control valve opening; then install a gasket and the control valve in the front case.

140 On the AN-5 Model, install a gasket and plug in the control valve aperture.

ASSEMBLY OF FRONT CASE TO ENGINE

141 Insert the propeller control valve vertical oil feed tube in position.

142 Stagger the front crankshaft oil seal rings and oil the ring carrier rings and the cam lobes. Install a rubber oil seal on the parting surface of the front case. Place a single strand cotton thread gasket on the parting surface of the crankcase front section with the ends of the thread overlapping.

143 Push the valve tappets to their outermost position, and being careful not to damage the oil tube extending from the cam oil feed bracket, install the front case in position over the crankshaft. It may be necessary to seat the front case by dribing alternately on opposite sides of the case, using a fibre drift and a hammer.

144 Coat the threads of the studs and the washer seats at the front case with a small amount of Permatex No. 2 or its equivalent. Secure the case in position with washers and nuts.

THRUST BEARING (Tool Group 126)

145 Place the crankshaft adjusting spacer in position on the crankshaft front oil seal ring carrier.

146 Install the thrust bearing in its liner in the front case.

147 Screw the lifting eye on the front end of the crankshaft and in conjunction with the hook and a chain hoist, raise the crankshaft slightly and insert a piece of fibre between the crankshaft rear counterweight and the front face of the crankcase rear section.

148 Remove the eye and chain hoist, then drive the thrust bearing into its liner, using the sleeve. Install the oil slinger, making sure it is centred over the shoulder on the crankshaft.

THRUST BEARING NUT (Tool Group 128)

149 Screw the thrust bearing nut on the crankshaft and tighten it securely, using the wrench and turning bar to keep the crankshaft from turning.

NOTE

Remove the fibre which was inserted under the crankshaft rear counterweight.

CYLINDERS & PISTONS

ROCKER ARM, ROCKER ARM BEARINGS, AND ADJUSTING SCREWS (Tool Group 111)

150 Screw the valve adjusting screw into the rocker (Figure 5-45) and install the locknut on the adjusting screw.

151 Press the rocker bearing into the rocker, using an arbor press and the drift and base.

152 Place the rocker in position in the rocker box on the cylinder (Figure 5-46), and install the shafts, small end first, through the bush-

ings and the bearing, from the inside outward. Install the rubber oil seal, washer, and nut on the small (outer) end of the rocker shaft. Tighten the nut to the recommended torque, (Section 4).

153 Install the copper covered gasket, with the smooth side adjacent to the nut, and the nut. Tighten the nut to the recommended torque (Figure 5-47).

154 Insert a cotterpin through each nut and bend the upper end of the cotterpin back through the hollow shaft.

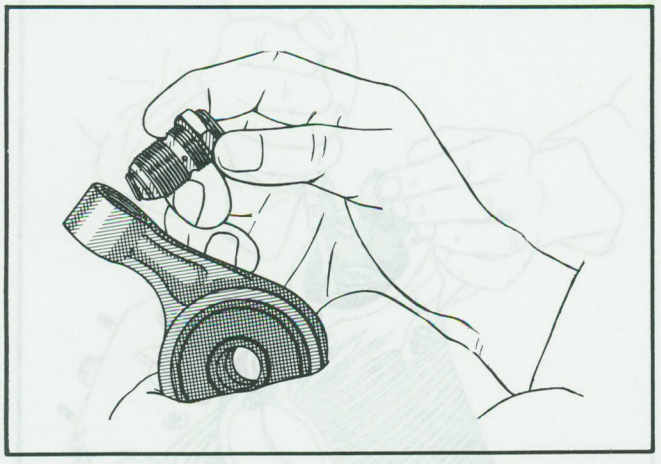


Figure 5-45 Valve Adjusting Screw

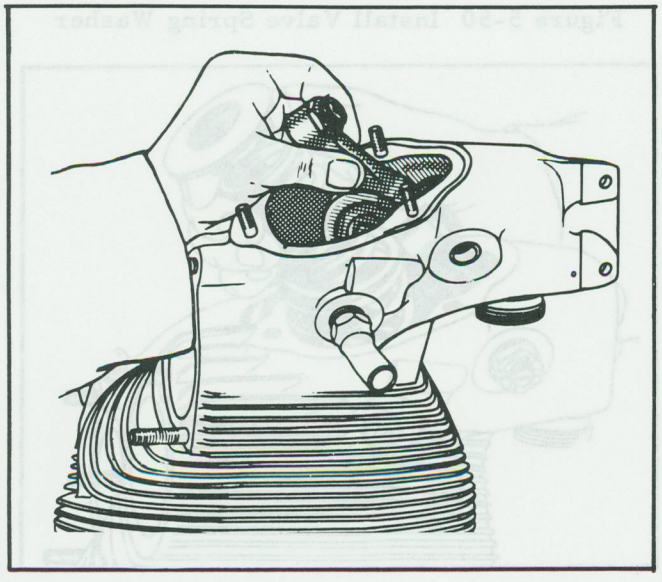


Figure 5-46 Install Rocker Arm

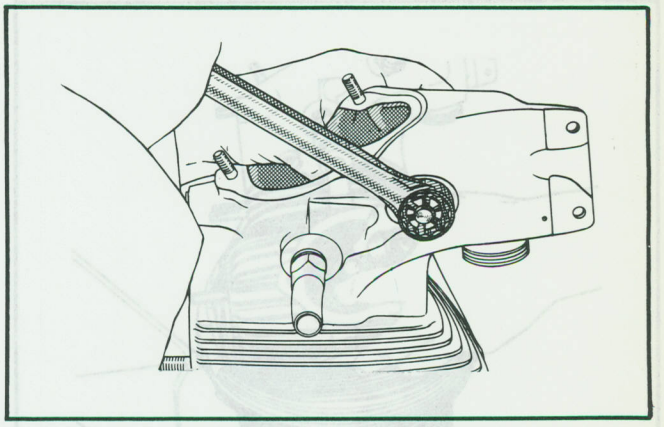


Figure 5-47 Tighten Nut on Rocker Shaft

VALVES AND VALVE SPRINGS (Tool Group 131)

155 Prior to assembling the valves in the cylinders, clean and oil the valve stems and valve guides.

156 Set the cylinder on its side on a clean bench. Install the inlet and exhaust valves in their respective guides (Figure 5-48). Hold the valves in place with the forefingers while setting the cylinder on the stand (Figure 5-49).

157 Install a safety circlet on each valve stem. Using a pair of long nose pliers, install the valve spring lower washers in position (Figure 5-50). Install the valve outer springs and the

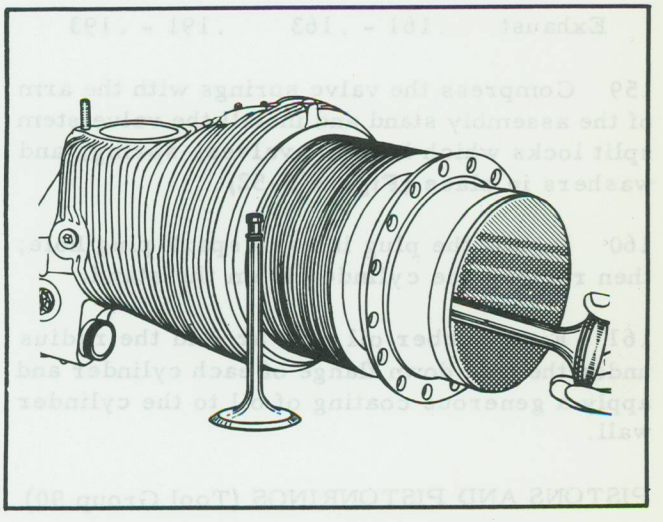


Figure 5-48 Install Valves

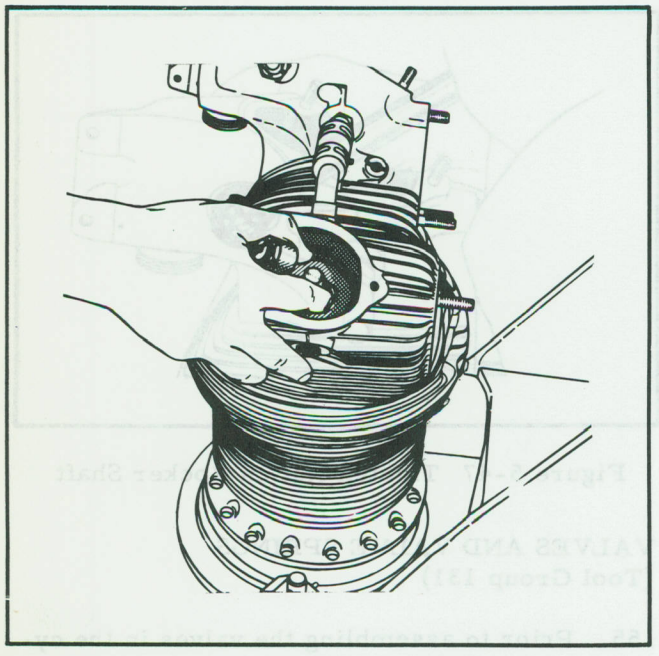


Figure 5-49 Set Cylinders on Stand

inner springs (Figure 5-51). Place the valve spring upper washers in position.

158 The inlet and exhaust valve springs are not interchangeable because of a difference in spring pressures. They may be distinguished by their wire diameters which are:

	Inner Spring	Outer Spring
Inlet	.153 - .155	.182 - .184
Exhaust	.161 - .163	.191 - .193

159 Compress the valve springs with the arm of the assembly stand and install the valve stem split locks which lock the valves, spring, and washers in place (Figure 5-52).

160 Install the plug in each spark plug hole; then remove the cylinder from the stand.

161 Fit a rubber oil seal around the radius under the hold down flange of each cylinder and apply a generous coating of oil to the cylinder wall.

PISTONS AND PISTONRINGS (Tool Group 90)

162 Using the pliers, install each set of piston rings on the piston of the cylinder in which the rings were lapped (Figure 5-53). Expand the rings just enough to clear the piston OD.

PISTONPINS AND PLUGS

163 If the plugs which were removed at disassembly are undamaged, they may be reinstalled in the piston pin. Heavy wall pistonpin plugs are used currently on all engines. If new plugs are to be installed, turn down the plug to the desired fit. Install the plugs in the piston pin, using an arbor press and a drift shaped to fit the contour of the plug dome. A swelling

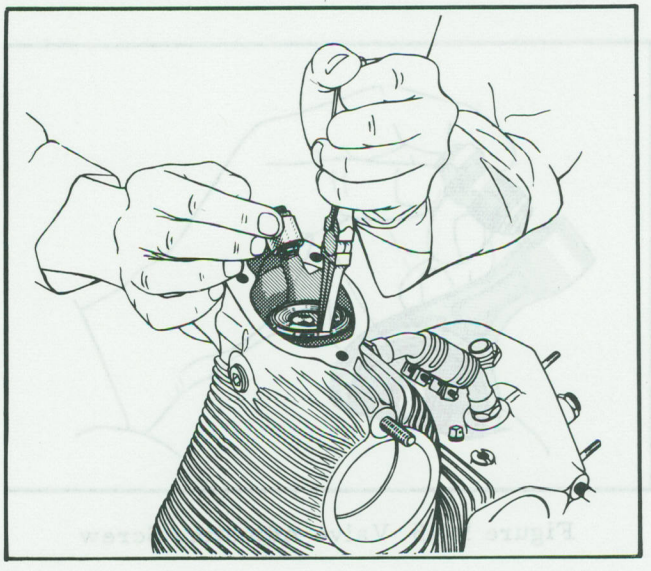


Figure 5-50 Install Valve Spring Washer

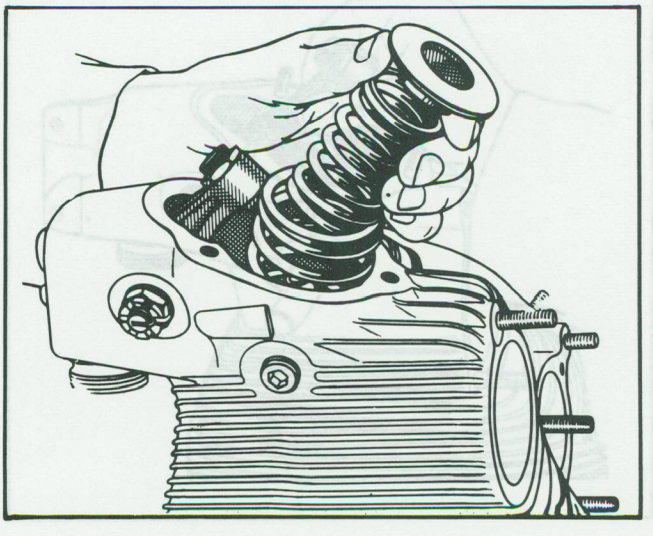


Figure 5-51 Install Valve Springs

of the piston pin up to .0008 inch is permissible. Stamp the cylinder number next to the OD of the dome of one of the plugs in each pin.

NOTE

If the operators service experience, using the old fit of .0000 inch to .0015 inch tight between the piston pin and piston-pin plug, has been unsatisfactory, it is recommended that a new fit of .0015 inch tight to .002 inch tight be maintained at next and subsequent overhauls. The use of a tighter fit occasionally results in a slight swelling of the ends of the piston pin. A .001 inch tolerance for taper and out-of-round on the piston pins permits pin end swelling up to .0008 inch.

ASSEMBLY OF PISTONS AND CYLINDERS (Tool Group 7)

164 Install the turning bar on the engine crankshaft and turn the crankshaft until the masterod, No. 5, is at the top dead centre position. Remove the rubber rod protector.

165 Hold the piston stamped "5" in place over the masterod with the number up. Insert the pistonpin, with the number up, through the piston and pistonpin bushing. Stagger the gaps of the piston rings and apply a generous coating of oil to the rings.

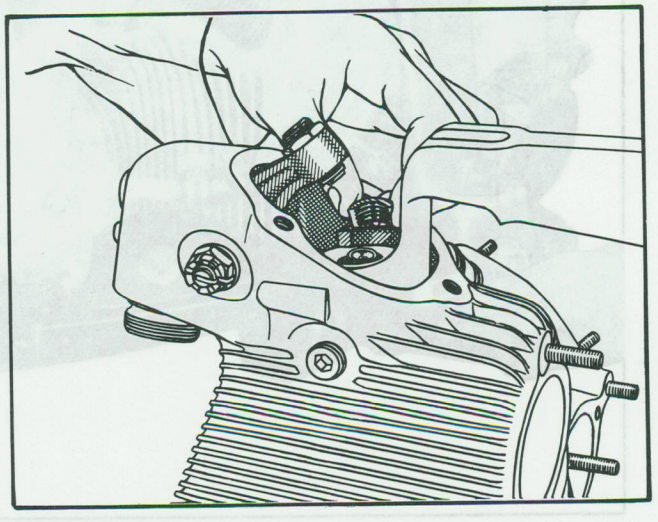


Figure 5-52 Install Split Locks

Figure 5-53 Install Piston Rings

166 Lock the clamp over the piston rings. Hold the cylinder with two hands in a level position and slide the cylinder over the piston and first four rings; then relocate the clamp over the fifth or scraper ring and push the cylinder into position against the mounting pad (Figure 5-54).

167 Center the cylinder with two locating nuts and install washers and nuts on the other studs. (Consult Part 2, Paragraphs 15, 16, and 17). Tighten the nuts uniformly with the proper wrench and handle. Torque the nuts to the recommended torque (Section 4). Install palnuts and tighten them 1/4 turn. Make sure that the palnuts fit properly and are properly tightened.

INTERCYLINDER OIL TUBE HOSE

168 On the AN-14B Model install new rubber hoses on the intercylinder drain tubes of cylinder numbers 3, 4 and 5 and 6, 7 and 8. On the AN-5 Model, install new rubber hoses on intercylinder drain tubes of all cylinders.

169 Secure each hose in place with two clamps. Tighten the clamp bolts.

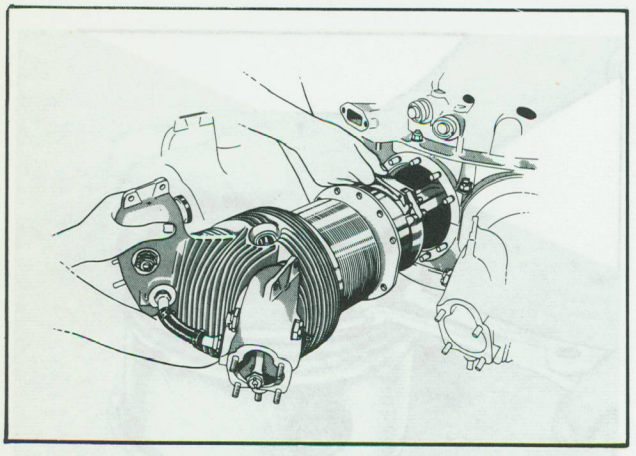


Figure 5-54 Install Cylinder

FINAL OPERATIONS

IGNITION MANIFOLD (Tool Group 48)

170 Mount the front ignition manifold over the crankshaft and front case or reduction gear housing. Attach the manifold to the crankcase front section with five cap screws. Lockwire the cap screws.

171 Uncouple the union on the rear ignition manifold and install the manifold on the supercharger section. Tighten the union on the manifold with the wrench. Fasten the manifold to the supercharger section with five cap screws. Lockwire the cap screws. Install the washer and nuts on the supercharger case studs supporting the ignition manifold.

OIL SUMP (Tool Group 87)

172 Place the intercylinder sump deflector on the sump while the sump is still on the bench. Use a 3/8 inch box wrench and a screw driver to attach the deflector to the sump.

173 Check the clearance between the sump and the deflector. If necessary, bend the deflector to provide approximately 3/16 inch clearance between the sump and the deflector.

174 On the AN-14B Model, install the strainer and retainer in the sump, using the driver to make sure they are in as far as possible.

175 Screw the oil drain plugs into the sump and tighten them with a 1 inch box wrench.

176 Place a gasket on each sump mounting flange. Install the sump on its mounting pads (Figure 5-55). Install a fibre locknut on each stud and tighten the nuts with a 1/2 inch socket and a speed handle.

OIL SCAVENGE TUBES

177 On the AN-14B Model, insert gaskets under the connecting brackets and install the main oil sump to the oil pump and rocker oil sump to oil pump scavenge tubes on the engine.

178 On the AN-5 Model, install the rocker box to rear case, front section to oil pump, and rear case to oil pump scavenge oil tubes on the engine, inserting gaskets under the connecting brackets.

CYLINDER DEFLECTORS

179 Unless a shroud is used for cooling pur-

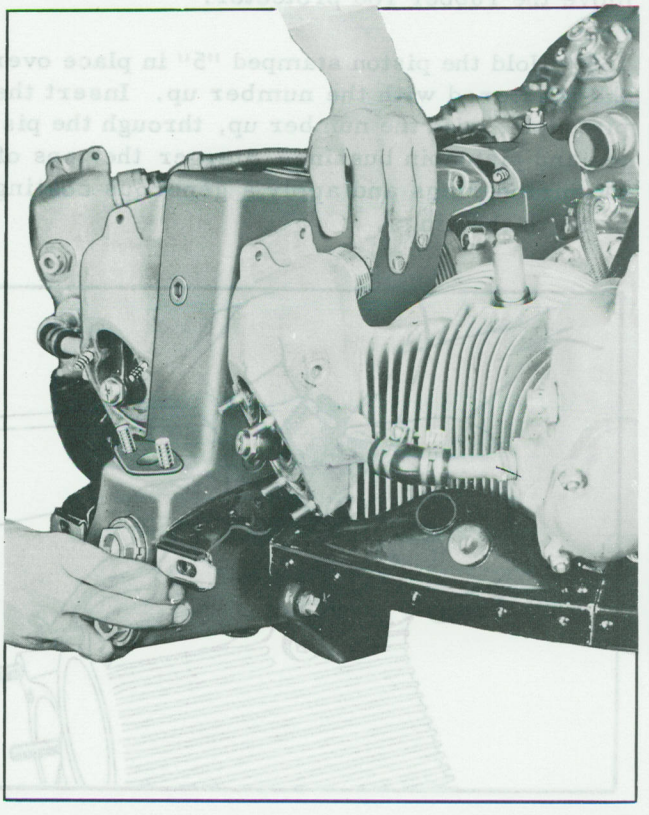


Figure 5-55 Install Main Oil Sump

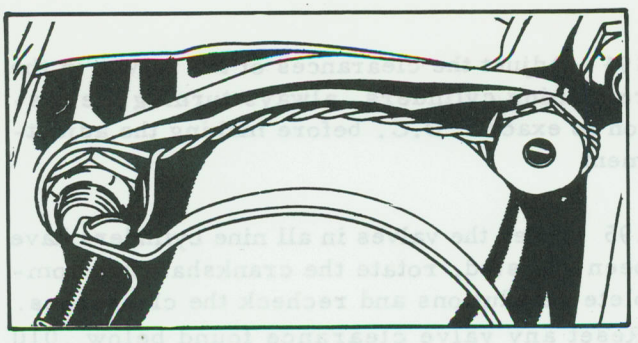


Figure 5-56 Intake Pipe at Cylinder

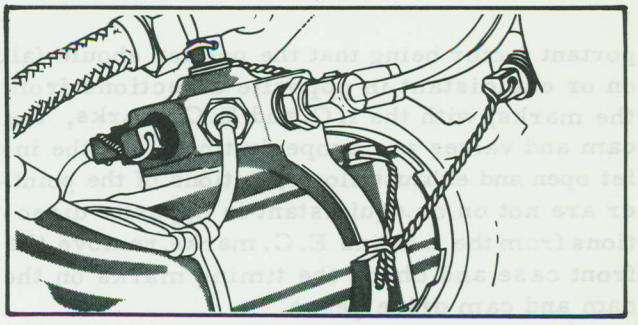


Figure 5-57 Primer Distributor Clamp

poses during the post overhaul run-in of an engine, it is recommended that the cylinder deflectors be left off until after the run-in has been completed. If deflectors are installed, first install the head deflectors; then install the intercylinder deflectors and secure them with retaining clamps and nuts.

PRIMER DISTRIBUTOR

180 Clamp the primer distributor to the No. 1 intake pipe. Lockwire the clamp screws.

INTAKE PIPES (Tool Group 67)

181 Remove the port protectors from the supercharger case. Install the flange gland nut and rubber packing on each intake pipe and place the pipe in position. Screw the gland nut finger tight in the supercharger case. Install the gasket at the cylinder intake ports with the split side towards the port. Secure the pipe flange to the cylinder heads with cap screws and nuts and tighten and lockwire the nuts (Figure 5-56). Tighten the gland nut at the supercharger end of each pipe, using the wrench Use care in tightening the nuts to avoid damaging the pipes.

PRIMER TUBES

182 Attach the primer tubes to the primer distributor and insert the tubes through the deflectors and attach them to cylinders, No. 8, No. 9, No. 1, No. 2, and No. 3. Clamp the tubes to the corresponding intake pipes with two clamps on each pipe. Secure each clamp with a bolt, washer and nut. Lockwire the primer distributor (Figure 5-57).

VALVE TIMING CHECK (Tool Group 139)

183 Refer to Pushrods in the following paragraph and install the inlet and exhaust valve pushrods for the No. 1 cylinder.

184 Mount the pointer over the crankshaft. Install the proper tutning bar on the crankshaft and turn the crankshaft counterclockwise until the piston of No. 1 cylinder is at the top dead centre position of the compression stroke; - both valves should be closed.

185 Set the clearance of the intake and exhaust valve at .060 inch. Continue to turn the crankshaft counterclockwise nearly one complete revolution until the pointer is near the inlet open (I.O.) mark on the front case. Insert a .0015 inch feeler gauge between the valve adjusting screw and the stem of No. 1 inlet valve, and tap the handle of the turning bar in a counterclockwise direction until a slight pressure is exerted on the feeler gauge. At this point the inlet valve is just opening and the timing pointer should align approximately with the I.O. mark.

186 Continue turning the bar counterclockwise until the pointer passes the exhaust valve closing (E.C.) mark on the front case. Insert a .0015 inch feeler gauge between the valve adjusting screw and the stem of No. 1 exhaust valve and turn the crankshaft clockwise until the pointer is in a vertical position. Tap the handle of the turning bar in a counterclockwise direction until the pressure on the feeler gauge begins to release. The exhause valve is now just closing and the pointer should align approximately with the E.C. mark.

187 If the pointer aligns properly (the im-

portant factor being that the pointer should fall on or equidistant in opposite directions from the marks) with the I.O. and E.C. marks, the cam and valves are properly timed. If the inlet open and exhaust close positions of the pointer are not on or equidistant is opposite directions from the I.O. and E.C. marks, remove the front case and check the timing marks on the cam and cam drive gears.

PUSHRODS (Tool Group 99)

188 One of the ball ends on each pushrod bears the number of the cylinder into which it fits. The exhaust rods are marked with an "Ex" after the cylinder number and the intake rods are marked "In".

189 Coat the ball ends of each pushrod with oil and insert the rod into its cover.

190 Depress the rocker, using the depressor and fit the pushrod and cover into position. If a valve tappet is out too far to allow installation of the pushrod, turn the crankshaft until the tappet can be pushed far enough into its guide to permit installation of the pushrod.

VALVE CLEARANCE ADJUSTMENT
(Tool Group 132)

191 The valve clearances are adjusted in a sequence which conforms to the firing order of the cylinders; 1, 3, 5, 7, 9, 2, 4, 6, 8.

192 Back off all the valve clearance adjusting screws until at least six threads are visible above the rocker. Turn the crankshaft counterclockwise until No. 1 piston is at T.D.C. (top dead centre) of the compression stroke. Insert a .010 inch leaf of the clearance gauge between the valve adjusting screw and valve stems on No. 1 cylinder, and tighten the adjusting screw until a .010 inch clearance is obtained. Tighten the valve adjusting screw locknut to a torque of 300 to 350 inch pounds.

193 After the valves in No. 1 cylinder have been adjusted, rotate the crankshaft until No. 3 piston is at T.D.C. of the compression stroke. Adjust the valves in the same manner as described for No. 1 cylinder.

194 Adjust the clearances of the valves in the remaining cylinders, always turning the piston to exact T.D.C. before making the adjustment

195 After the valves in all nine cylinders have been adjusted, rotate the crankshaft two complete revolutions and recheck the clearances. Reset any valve clearance found below .010 inch. Do not disturb a greater clearance unless it is in excess of .025 inch.

ADJUST LENGTH OF PUSHRODS
(Tool Group 2)

196 If more than five threads of the valve adjusting screw can be seen above the locknut, the pushrod is too long. If the adjusting screw shows fewer than two threads, the pushrod is too short. In either case, adjust the pushrod to the proper length. This adjustment is accomplished be removing the pushrod ball and and washer and changing the washer for a thicker or thinner washer to establish the proper length.

197 The packing for the pushrod cover gland nuts should be arranged as shown (Figure 5-58). Tighten the gland nut at the crankcase end first; then tighten the gland nut at the cylinder end, using the proper torque wrench. Tighten the nuts to the recommended torque (Section 4).

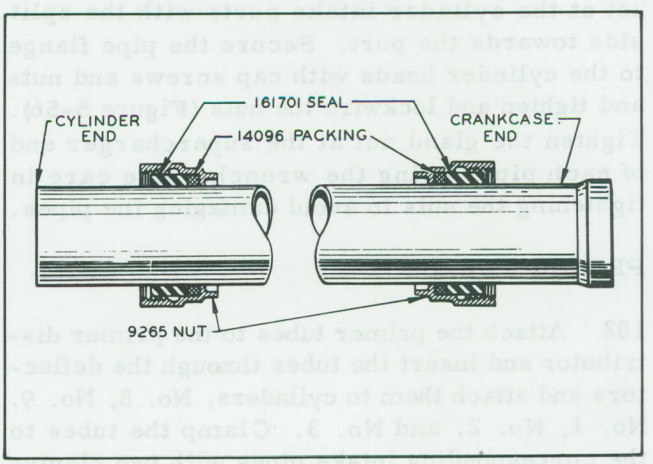


Figure 5-58 Pushrod Cover Coupling Arrangement

ROCKER BOX COVERS

198 Place a new gasket on each rocker box. Place the covers on the rocker boxes and install the fibre nuts or screws. Tighten the nuts or screws to the recommended torque, (Section 4).

INSTALLATION AND TIMING OF MAGNETOS (Tool Group 63)

199 Crank the bed of the engine stand until the engine assumes a horizontal position. Rotate the crankshaft until the timing pointer aligns with the spark advance mark on the front case, (Figure 5-59).

200 To check the internal timing of each magneto, rotate the magneto shaft until the two marks on the distributor gear align with the two marks on the right side of the housing. In this position a locking tool is to be locally manufactured, (see EO 15-5ADB-2), and used in lieu of a straightedge placed across the step in the cam should coincide with a line between the marks on the breaker housing, (Figure 5-60). If the internal timing is correct, a white dot will be visible through the hole under the cap in the top of the breaker housing.

201 Mount the left or right magneto on the engine without installing the rubber coupling.

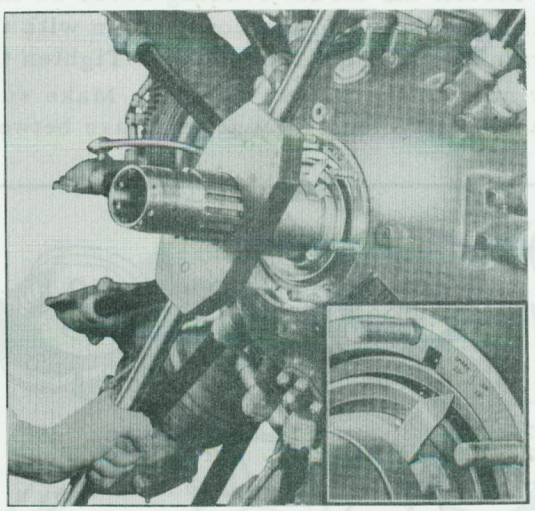


Figure 5-59 Align Pointer And Mark

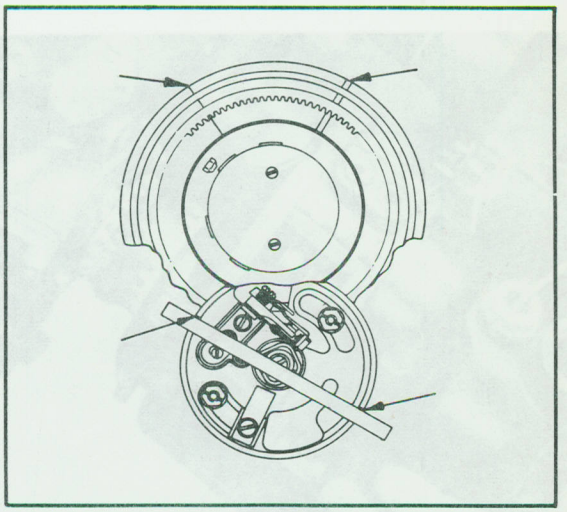


Figure 5-60 Magneto Internal Timing

Measure the distance between the magneto drive shaft and the magneto shaft couplings, making sure that the two shafts are at their maximum distance apart. Rubber couplings are provided 1/32" oversize, identified by "B + 1/32" moulded on the face. The rubber coupling used should be .020" to .030" less in thickness than the distance between the two metal couplings. Remove the magneto from the engine.

202 Hold the magneto in place and rotate the rubber coupling between the two metal couplings until the rubber coupling can be engaged with the metal couplings without causing the magneto shaft to turn, (Figure 5-61). Fit the magneto over the dowel pins on the mounting pad and secure the magneto to the mounting pad with cap screws, (Figure 5-62). Remove the magneto locking tool, (see EO 15-5ADB-2).

203 The two magnetos must synchronize - that is, both sets of breaker points must open simultaneously so that the timing of the two magnetos is identical. To determine whether or not the magnetos are synchronized, proceed in the following manner:

204 Rotate the crankshaft until #1 piston is at T.D.C. of the compression stroke. Connect the two red leads of the indicator to the ground connections of the magnetos, the ground the black wire to the engine.

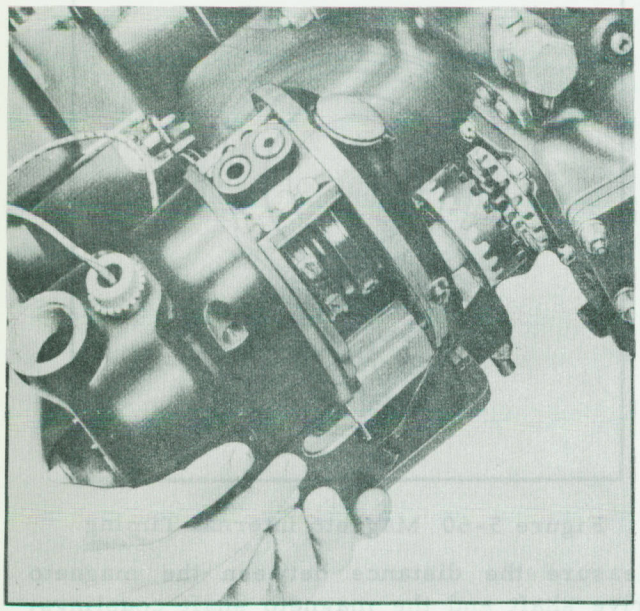


Figure 5-61 Install Rubber Coupling

205 Turn the propeller about 90 degrees in the opposite direction to that of normal rotation; then turn it back in the normal direction of rotation until the indicator lights just flash on. At this point, the timing pointer should line up with the 25 degree S.A. mark on the front case. If the two lights do not flash on simultaneously and at the proper point, one or both of the magnetos must be retimed to the engine.

206 If the indicator light shows that the breaker points are opening before the pointer aligns with S.A. mark, remove the magneto and rubber coupling, then turn the rubber coupling clockwise one or two notches on the magneto couplings. Reinstall the magneto and recheck the timing. If the indicator light flashes on when the pointer has passed the S.A. mark, turn the rubber coupling counterclockwise one or two notches on the magneto coupling.

NOTE

The two magnetos must be synchronized so that both lights of the indicator flash on simultaneously when the timing pointer is on the S.A. mark on the template.

207 As an alternate method for positioning the No. 1 piston 25 degrees before top centre, turn the propeller shaft in the normal direction of rotation to bring the No. 1 piston at the beginning of the compression stroke, then install the indicator (Time-Rite) in the front spark plug hole of No. 1 cylinder (Figure 5-63, Sketch A). Align the cap of the indicator so that the slide slot lines up with the vertical axis of the cylinder and the pivot arm is at the top of the slot. Push the slide pointer up close to the pivot arm (Sketch B). Turn the propeller shaft in the direction of rotation until the pivot arm pushes the slide pointer to its farthest point (Sketch C). Turn the propeller shaft about 90 degrees in the opposite direction. This will return the pivot arm to the top of the slot.

208 Adjuct the proper engine scale (the scale marked R985) so that the zero degree mark on the scale aligns with the reference mark on the slide pointer (Sketch D). Move the slide pointer up to align with the 25 degree mark on the scale (Sketch E).

209 Turn the propeller shaft in the normal direction of rotation until the pivot arm just contacts the slide (Sketch F). At this point the lower light on the indicator should flash on. The No. 1 piston is now positioned 25 degrees before top centre.

THRUST BEARING COVER

210 Install the thrust bearing cover so that the oil drain holes in the cover align with the oil drain holes in the front case. Tighten the cover nuts to the proper torque. Make sure that a .004 inch feeler gauge will pass between

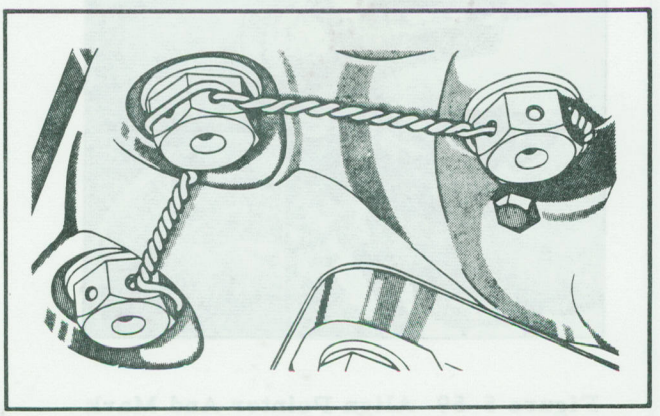


Figure 5-62 Secure Magneto

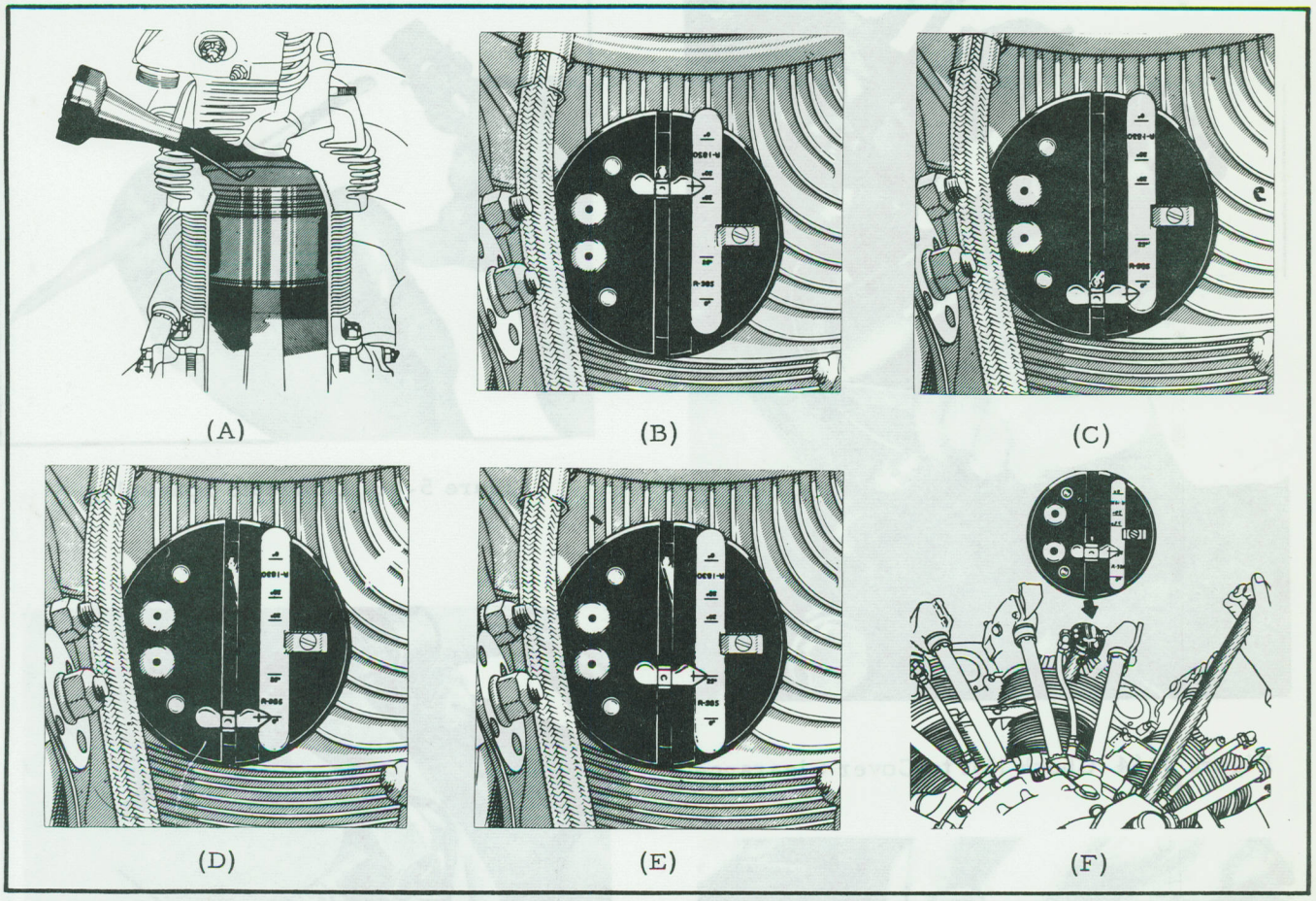


Figure 5-63 Alternate Procedure to follow in Timing and Synchronizing Magnetos

the thrust nut and the cover at all points (Figure 5-64).

SPARKPLUGS (Tool Froup 115)

211 Remove the breather plug from each sparkplug hole just prior to installing the sparkplug.

212 Examine the sparkplugs to be certain they are of the approved type.

213 Install a serviceable solid copper gasket (Figure 5-65). Lightly lubricate the first two threads of the sparkplug shell with anti-seize compound Spec 3GP-802, Ref 34A/58 (Figure 5-66).

214 Insert the sparkplug in its bushing and screw it down with the fingers until the gasket is seated. If this cannot be done, use an 18 by 1.5 millimeter tap to clean the bushing threads.

215 Using the sparkplug wrench, tighten the sparkplug to a torque of 300 to 360 pound-inches.

216 Make certain that the inside of each sparkplug barrel is clean and dry. Wipe the connector clean; then apply a thin coating of Dow corning No. 4 Compound Ref 33G/49 with a clean cloth to the connector. Do not place any compound in the sparkplug barrel.

NOTE

Do not apply the compound with the fingers because moisture from the hands tends to make the compound inefficient

217 Remove any compound from the threads of the sparkplug to ensure an electrical bond between the sparkplug and its lead and to pre-

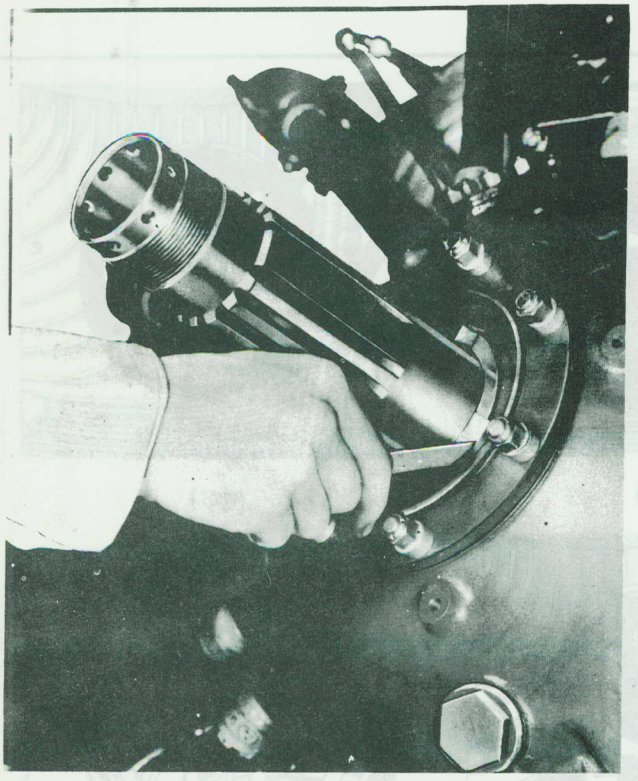


Figure 5-64 Check Nut to Cover Clearance

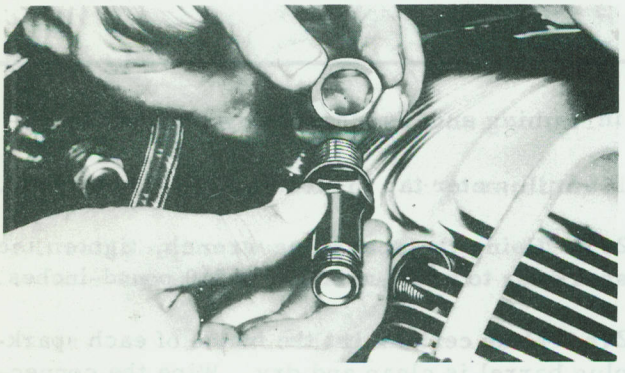


Figure 5-65 Install Copper Gasket

vent radio interference from this source. Install the sparkplug lead (Figure 5-67). Be sure the .062 hole drilled in the sparkplug lead ferrules for Nos. 5 and 6 cylinders is at the bottom when the manifold is in place on the engine. Tighten the lead nut fingertight and then a half turn using the lead nut wrench while holding the sparkplug with the holder.

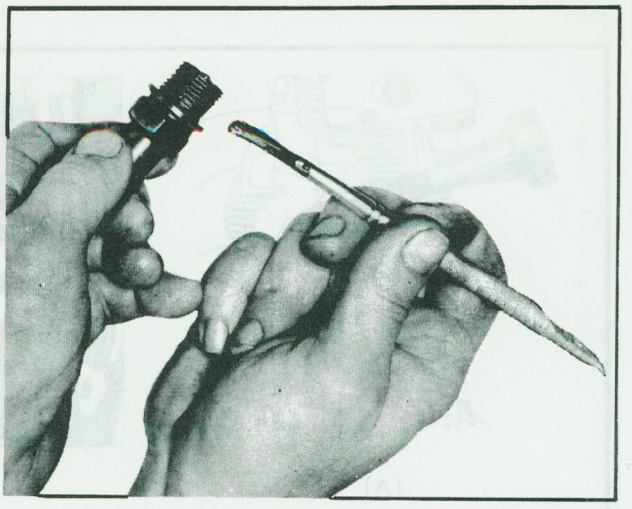


Figure 5-66 Lubricate Sparkplug

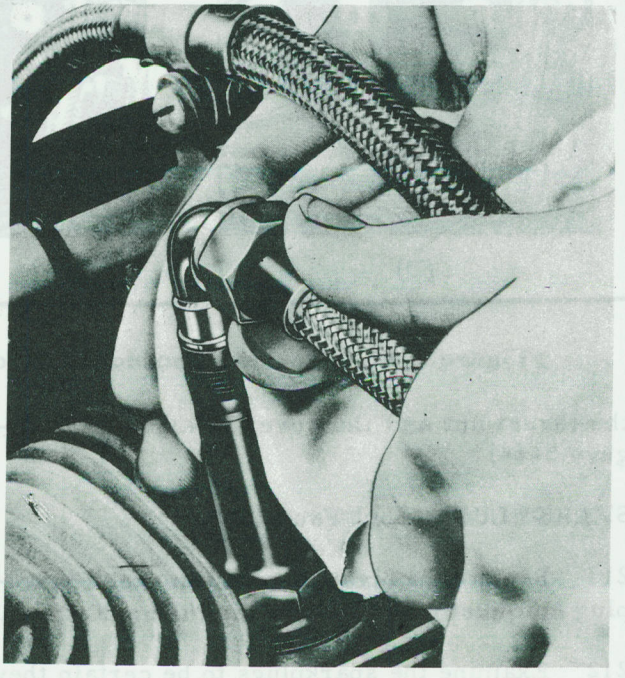


Figure 5-67 Install Sparkplug Lead

INSPECTION OF ASSEMBLED ENGINE

218 Make a thorough visual inspection of the assembled engine. See that all external nuts and fittings are tight and that no gaskets or lockwire have been omitted.

SECTION 3

LIMITS

INTRODUCTION

TABLES AND CHARTS

1 Figures 5-68 through 5-71 are to be used in conjunction with the table in this Part. Consult the Figures first, then the table.

REFERENCE NUMBERS

2 Reference numbers on the figures indicate parts for which fits, clearances, torques, or spring pressures are specified. A description of, and limits of these fits, clearances, backlashes, torques, and spring pressures are located in the table by corresponding reference numbers. Reference numbers in the charts for which there are no corresponding reference numbers in the table are not applicable to the engine Models covered by this Order.

VALUES

3 The Minimum and Maximum columns indicate the tolerances for new parts. The figures in the Exchange column indicate the allowable limit to which parts except springs may wear before exchange is necessary. Spring exchange is necessary when the spring rate is less than the limit in the Exchange column. Unless otherwise specified, all fits and clearances involving circular configurations are diametrical except spline fits and clearances, which are calculated from chordal dimensions.

TERMS AND SYMBOLS

4 The symbol "T" in the Minimum and Maximum column indicates a tight fit. An asterisk (*) in the Exchange column indicates that the parts should be exchanged if any looseness is found. The symbol < preceding a limit in the Exchange column indicates that, contrary to the column heading, the spring should be changed when its rate is less than the limit. The term "Fit To" means that a grinding, filing, or other fitting operation may be necessary to obtain the desired fit at assembly.

UNITS

5 The figures in the Minimum, Maximum, and Exchange columns should be interpreted as follows: torques in pounds-inches, spring pressures in pounds and all other limits in inches.

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
1	5-70	Hydromatic Control Valve Body-Front Case (AN-14B Model) (Fit To)	.0005		.0015
2	5-68,5-70	Front Case Oil Feed Tube - Front Case	.001T	.0025T	*
3	5-68,5-70	Key - Crankshaft, Front (Fit To)	.000	.0015T	*
3	5-68,5-70	Key - Cam Drive Gear	.0015	.0045	.006
4	5-68,5-70	Thrust Bearing Liner - Front Case	.002T	.006T	*

Table 5-1 Table of Limits

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
5	5-68, 5-70	Thrust Bearing - Bearing Liner	.0002	.002	.004
7	5-68, 5-70	Thrust Bearing Cover Spacer Ring Pinch (Fit To)	.004T	.008T	*
8	5-70	Propeller Control Oil Feed Tube - Thrust Bearing Liner	.000	.0015	.003
9	5-68, 5-70	Cam Drum End Clearance (Fit To)	.008	.010	.015
11	5-68, 5-70	Crankshaft Oil Seal Ring Carrier - Crankshaft	.0005	.0025	.004
12	5-68, 5-70	Thrust Bearing - Crankshaft Oil Seal Ring Carrier	.0002T	.0014T	.0005
13	5-70	Cam Drive Gear Ring - Cam	.0005T	.0025T	*
13	5-70	Oil Seal Ring Carrier Ring Side Clearance	.003	.008	.015
14	5-70	Oil Seal Ring Carrier Gap (Mitre Cut)	.010	.018	.030
14	5-70	Oil Seal Ring Carrier Gap (Double Ring - Butt Type)	.005	.015	.020
15	5-68, 5-70	Cam Drive Gear - Crankshaft	.0005	.0025	.004
16	5-68, 5-70	Cam Drive Gear - Cam Drum	.003	.0045	.006
17	5-68, 5-70	Cam Oil Feed Bracket Ring - Cam Drum	.004	.008	.010
19	5-68, 5-70	Cam Drive Gear Backlash - Cam Reduction Gear	.004	.012	.020
20	5-68, 5-70	Cam Reduction Pinion Backlash - Cam Rim	.009	.019	.030
21	5-68, 5-70	Cam Reduction Pinion - Cam Reduction Gear	.0005T	.0015	.003
22	5-68, 5-70	Valve Tappet Roller Side Clearance - Tappet	.008	.020	.025
22	5-68, 5-70	Valve Tappet Roller Side Clearance - Guide	.008	.010	.018
23	5-68, 5-70	Valve Tappet Roller Pin - Tappet (Fit To)	.0005	.002	.003
24	5-68, 5-70	Valve Tappet Roller Pin - Roller	.001	.0025	.004
25	5-68, 5-70	Valve Tappet Guide - Front Case	.0015T	.004T	*
26	5-68, 5-70	Valve Tappet - Guide (By Selection)	.0005	.0015	.003

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
28	5-68, 5-70	Push Rod Ball Socket - Valve Tappet	.0005T	.0025T	*
29	5-68, 5-70	Push Rod Ball End - Socket (See Assembly)			
30	5-68, 5-70	Cam Drum - Cam Rim	.0025T	.0005	.0015
31	5-68, 5-70	Cam Oil Feed Bracket Oil Feed Tube - Feed Bracket	.0005T	.0035T	*
32	5-68, 5-70	Cam Oil Feed Bracket Tube - Tube Bracket	.0015T	.0045T	*
33	5-68, 5-70	Hydromatic Control Valve Oil Feed Tube - Tube Bracket	.000	.0015	.003
34	5-68, 5-70	Front Case - Crankcase, Front Section	.000	.004	*
35	5-68, 5-70	Push Rod Ball Socket - Valve Rocker	.000	.0025T	*
36	5-68, 5-70	Push Rod Ball End - Push Rod	.0015T	.0035T	
37	5-68, 5-70	Inlet Valve Spring (Inside) Dia. Wire .154 at 1-1/2"	53	56	< 48
38	5-68, 5-70	Inlet Valve Spring (Outside) Dia. Wire .183 at 1-1/2"	68.5	72.5	< 64
39	5-68, 5-70	Inlet Valve Guide - Valve	.0015	.004	.010
40	5-68, 5-70	Inlet Valve Guide - Cylinder Head	.0005T	.003T	*
41	5-68, 5-70	Inlet Valve Seat - Cylinder Head (Shrink)	.0065T	.010T	*
42	5-68, 5-70	Valve Adjusting Screw Ball - Socket (Fit To)	.0005	.007	.020
43	5-68, 5-70	Cold Valve Clearance (Inlet and Exhaust)	.010	.010	
44	5-68, 5-70	Exhaust Valve Spring (Inside Dia. Wire .162 at 1-1/2"	62.25	65.25	< 58
45	5-68, 5-70	Exhaust Valve Spring (Outside) Dia. Wire .192 at 1-1/2"	79.5	83.5	< 75
46	5-68, 5-70	Exhaust Valve Guide - Valve	.003	.0055	.010
47	5-68, 5-70	Exhaust Valve Guide - Cylinder Head	.0005T	.003T	*
48	5-68, 5-70	Exhaust Valve Seat - Cylinder Head (Shrink)	.0065T	.010T	*
49	5-68, 5-70	Rocker Bearing - Valve Rocker	.0005T	.0015T	*

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
50	5-68, 5-70	Rocker Bearing - Rocker Shaft	.000	.0008	.0015
51	5-68, 5-70	Rocker Shaft Small Bushing - Shaft	.000	.001	.002
52	5-68, 5-70	Rocker Shaft Small Bushing - Cylinder Head	.001T	.004T	*
53	5-68, 5-70	Rocker Shaft Large Bushing - Shaft	.000	.001	.002
54	5-68, 5-70	Rocker Shaft Large Bushing - Cylinder Head	.001T	.004T	*
55	5-68, 5-70	Rocker Oil Manifold - Crankcase Front Section	.000	.002	.004
56	5-68	Front Crankcase Oil Vent Connection - Front Crankcase	.001T	.003T	*
57	5-68	Propeller Shaft Thrust Bearing Oil Transfer Tube - Front Case	.001T	.0025T	*
58	5-68	Propeller Shaft Thrust Bearing Oil Transfer Tube - Thrust Bearing Liner	.000	.0015	.003
59	5-68	Propeller Control Oil Transfer Seal Ring Gap	.010	.018	.030
60	5-68	Propeller Control Oil Transfer Seal Ring Side Clearance	.003	.008	.015
61	5-68	Front Crankcase Oil Vent Connection Bushing - Insert	.001T	.003T	*
301	5-68, 5-70	Piston Rings - End Clearance (Rectangular and Wedge Type Rings)			
		Top Groove	.052	.062	
		2nd Groove	.0515	.0585	
		Five Groove Piston, 3rd Groove	.0515	.0585	
		Tapered Bore 4th Groove	.0515	.0585	
		5th Groove	.0115	.0185	
		(With Chrome-Moly Barrels Using Compression Ring in Place of Scraper Ring) 5th Groove	.0515	.0585	

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
302	5-68, 5-70	Piston Ring Side Clearance			
		Top Groove	.002	.006	
		2nd Groove	.002	.006	
		Five Groove Piston,			
		3rd Groove	.002	.006	
		4th Groove	.0035	.007	
		5th Groove	.001	.0035	
		(Wedge Type Ring Clearance is Measured with Outer Face of Ring Flush with Piston)			
303	5-68, 5-70	Piston Pin - Piston (Light Hand Push Fit When Parts are Oiled and at Room Temperature	.0003		.003
304	5-68, 5-70	Piston Pin Plug (Heavy Wall) - Pin (Service Fit)	.0015T	.002T	
305	5-68, 5-70	Piston - Cylinder Barrel	.018	.022	.028
306	5-68, 5-70	Piston Pin Bushing - Pin	.0017	.0033	.005
307	5-68, 5-70	Piston Pin Bushing - Master and Linkrod	.0045T	.006T	*
308	5-68, 5-70	Cam Reduction Gear Bushing - Gear	.001	.003	.005
309	5-68, 5-70	Cam Reduction Gear Bushing - Crankcase, Front Section	.001T	.003T	*
310	5-68, 5-70	Cam Reduction Gear End Clearance (Fit To)	.006	.012	.016
311	5-68, 5-70	Front Main Bearing Liner - Crankcase Front Section (Shrink)	.008T	.012T	*
312	5-68, 5-70	Front Main Bearing - Front Main Bearing Liner	.0002	.0017	.004
313	5-68, 5-70	Front Main Bearing - Crankshaft	.001T	.0003	.001
314	5-68, 5-70	Masterod Bearing End Clearance Crankshaft (Fit To)	.009	.015	.024
314	5-70	Masterod Bearing End Clearance - Crankshaft (Bronze Bearing)	.010	.014	.024

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
315	5-68, 5-70	Masterod Bearing Pinch - Masterod	.001T	.002T	*
315	5-70	Masterod Bearing Pinch - (Bronze Bearing)	.0008T	.0022T	*
316	5-70	Masterod Bearing Diametrical Clearance - Crankshaft (Prefitted Bearing)	.003	.007	.009
316	5-68, 5-70	Masterod Bearing Diametrical Clearance - Crankshaft (Bronze Bearing) (Fit To)	.004	.0045	.0065
317	5-68, 5-70	Crankshaft Front Splines - Crankshaft Rear Splines	.001T	.002T	*
318	5-68, 5-70	Linkrod Side Clearance	.008	.014	.018
320	5-68, 5-70	Linkrod Bushing - Rod	.0015T	.0025T	*
321	5-68, 5-70	Linkrod Bushing - Linkpin	.0013	.0033	.004
322	5-68, 5-70	Linkpin - Masterod	.0004T	.001T	*
323	5-68, 5-70	Oil Transfer Ferrule - Crankcase Rear Section	.000	.003T	*
324	5-68, 5-70	Oil Transfer Ferrule - Crankcase Front Section	.000	.003	
325	5-68, 5-70	Rear Main Bearing Liner - Crankcase Rear Section	.008T	.012T	*
326	5-68, 5-70	Rear Main Bearing - Rear Main Bearing Liner	.0002	.0017	.004
327	5-68, 5-70	Rear Main Bearing Pinch - Crankshaft Rear Gear (Fit To)	.002T	.004T	*
328	5-70	Rear Main Bearing - Crankshaft	.0012T	.0001	.001
328	5-68	Rear Main Bearing - Crankshaft	.0007T	.0021T	.001
329	5-68, 5-70	Spring Drive Fixed Spider Splines - Crankshaft Splines	.0005T	.0005	
330	5-68, 5-70	Oil Pressure Tube - Crankcase Rear Section	.000	.002	
331	5-68, 5-70	Flyweight Liner - Crankshaft	.001T	.003T	*
332	5-68, 5-70	Inner Flyweight - Outer Flyweight	.000	.001T	.001
333	5-68, 5-70	Flyweight End Clearance	.008	.012	.018
347	5-68, 5-70	Magneto Drive Oil Seal Housing - Rear Crankcase	.000	.012	
348	5-68, 5-70	Magneto Drive Oil Seal Housing - Oil Seal	.001T	.007T	*

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
601	5-68, 5-70	Starter Shaft Ball Bearing - Supercharger Case	.0004T	.0014	.004
602	5-68, 5-70	Starter Shaft Spacer - Shaft	.000	.004	.006
603	5-68, 5-70	Starter Shaft Ball Bearing - Shaft	.000	.001T	.001
604	5-70	Generator Drive Pinion Splines - Generator (On Width)	.001	.006	.030
605	5-70	Starter Jaw Gear Backlash - Generator Drive Gear	.002	.030	.035
606	5-70	Generator Drive Shaft Bearing - shaft	.0006T	.0002	.001
607	5-70	Generator Drive Housing - Rear Case	.000	.004	.006
608	5-70	Generator Drive Shaft Bearing - Housing	.0004T	.0011	.004
609	5-70	Generator Drive Shaft Bearing Pinch - Retainer (Fit To)	.000	.0077T	*
610	5-68, 5-70	Rear Case - Supercharger Case	.000	.006	
611	5-68, 5-70	Starter Jaw End Clearance	.012	.015	.020
612	5-68, 5-70	Starter Jaw Splines - Starter Drive Shaft	.001	.005	.007
613	5-68, 5-70	Starter Shaft Bushing - Rear Case	.0005T	.0025T	*
614	5-68, 5-70	Starter Shaft Bushing - Shaft (Fit To)	.0025	.0035	.004
615	5-68, 5-70	Starter Shaft Bushing - Supercharger Case.. (By Selection)	.000	.001	.0015
616	5-68, 5-70	Starter Gear Backlash - Crankshaft Rear Gear	.004	.012	.020
617	5-68, 5-70	Impeller Spring Drive Spring Rectangular Wire at 7/8"	95	105	< 85
618	5-68, 5-70	Spring Drive Coupling Floating Spider - Floating Gear	.011	.019	
619	5-68, 5-70	Floating Gear End Clearance (Fit To)	.006	.008	.012
620	5-68, 5-70	Needle Bearings End Clearance	.0085	.0225	
621	5-68, 5-70	Floating Gear - Needle Bearings	.0016	.0032	.005

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
622	5-68, 5-70	Floating Gear Inner Race - Front Supercharger Bearing Cover	.000	.002	.005
623	5-68, 5-70	Front Supercharger Bearing Cover - Impeller Shaft Bearing Case	.0005	.0035	
624	5-70	Impeller Shaft Front Bearing - Impeller Shaft Bearing Cage	.0002T	.0011	.003
625	5-70	Impeller Shaft Front Bearing - Shaft	.0002T	.0005	.001
626	5-68, 5-70	Impeller Shaft Oil Jet - Supercharger Case	.000	.004T	*
627	5-68, 5-70	Impeller Shaft Bearing Cage - Supercharger Case	.000	.002T	*
628	5-68, 5-70	Impeller Intermediate Drive Gear Backlash - Floating Gear	.003	.015	.020
629	5-68, 5-70	Impeller Inter. Drive Gear Backlash - Impeller Shaft Gear	.004	.013	.020
630	5-68, 5-70	Impeller Inter Drive Gear Front Bearing - Front Supercharger Bearing Cover	.0005T	.0009	.002
631	5-68, 5-70	Impeller Intermediate Drive Gear Front Bearing - Shaft	.0004T	.0012T	.0005
632	5-68, 5-70	Impeller Intermediate Drive Gear End Clearance	.011		
633	5-68, 5-70	Supercharger Case Oil Pressure Tube - Tube Bracket	.0025T	.0005	.001
634	5-68, 5-70	Oil Pressure Tube - Tube Bracket	.000	.002	.004
635	5-68, 5-70	Supercharger Case Oil Pressure Tube Bracket Supercharger Case	.0005T	.0015	
636	5-70	Impeller Shaft Rear Front Bearing - Impeller Shaft Bearing Cage AN-14B Model	.008	.014	
637	5-70	Impeller Shaft Rear Bearings - Shaft	.0004T	.0003	.001

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
638	5-70	Impeller Shaft Rear Gear Bearing - Impeller Shaft Bearing Cage	.0002T	.0011	.003
639	5-70	Clamp - Impeller Shaft Bearing (Fit To)	.002T	.004T	*
640	5-68, 5-70	Impeller Flat Clearance (Fit To)	.025	.035	.045
641	5-68, 5-70	Impeller Throat Clearance (Fit To)	.025	.035	
642	5-70	Impeller Spacer - Impeller Shaft Bearing Cover (Fit Per Side)	.0012	.0023	.003
643	5-70	Impeller Shaft Spacer - Impeller Shaft	.0002T	.0013	.004
644	5-68, 5-70	Impeller Splines Shaft Splines (On Width)	See Assy.		
645	5-68, 5-70	Impeller Inter. Drive Gear Rear Bearing Inner Liner - Gear	.0005T	.001	.002
646	5-68, 5-70	Impeller Intermediate Drive Gear Rear Bearing - Inner Liner	.0005T	.0003	.001
648	5-68, 5-70	Impeller Intermediate Drive Gear Rear Bearing - Outer Liner	.0008	.0021	.003
649	5-68, 5-70	Impeller Intermediate Drive Gear Rear Bearing Outer Liner - Supercharger Case	.000	.002T	*
650	5-68, 5-70	Rear Supercharger Bearing Cover - Supercharger Case	.007	.015	.022
652	5-68, 5-70	Oil Return Check Valve - Valve Guide	.0005	.0035	
653	5-68, 5-70	Oil Return Check Valve Spring Dia. Wire .038 at 13/16 in.	2.25	2.75	1.75
654	5-68, 5-70	Oil Screen Retaining Spring Dia. Wire .069 at 1-3/32 in.	9	13	5
655	5-69, 5-71	Internal Breather Tube - Supercharger	.001T	.003T	
655	5-69	Tachometer Drive Coupling Gear	.001	.003	*
656	5-69, 5-71	Tachometer Drive Gear Oil Tube - Rear Case	.001T	.003T	*

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
657	5-69, 5-71	Tachometer Drive Gear - Rear Case	.001	.003	.005
658	5-69, 5-71	Tachometer Drive Gear Backlash - Accesory Drive Gear	.008	.016	.020
659	5-69, 5-71	Tachometer Drive Gear End Clearance (Fit To)	.008	.016	.030
660	5-69, 5-71	Tachometer Drive Gear Inner Coupling - Rear Case	.000	.004	.006
661	5-71	Tachometer Drive Gear Inner Coupling Bushing - Gear	.001	.003	.005
662	5-71	Tachometer Drive Shaft Insert - Shaft	.0008T.	.0023T	*
663	5-69, 5-71	Magneto Drive Gear Backlash - Crankshaft Rear Gear	.004	.012	.020
664	5-69, 5-71	Magneto Drive Gear Shaft End Clearance (Fit To)	.012	.045	.060
665	5-69, 5-71	Magneto Drive Gear Shaft Front Bushing - Supercharger Case	.0005T	.0025T	*
666	5-69, 5-71	Magneto Drive Gear Shaft Bushings - Gear Shaft	.001	.003	.0045
667	5-69, 5-71	Magneto Drive Gear Shaft Rear Bushing - Supercharger Case	.000	.001	.0015
668	5-69, 5-71	Key - Magneto Drive Gear Shaft	.001T	.002	.004
668	5-69, 5-71	Key - Magneto Coupling Gear	.0005	.0035	.005
668	5-69, 5-71	Key - Accessory Intermediate Drive Gear	.0005	.0035	.005
669	5-69, 5-71	Accessory Drive Gear Oil Metering Plug - Gear	.000	.004T	*
670	5-69, 5-71	Accessory Drive Shaft Bushing - Shaft	.001	.003	.005
671	5-69, 5-71	Accessory Drive Shaft Bushing - Rear Case	.001T	.003T	*
672	5-69, 5-71	Accessory Drive Gear Backlash - Accessory Intermediate Drive Gear (Fit To)	.004	.012	.020

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
673	5-69, 5-71	Accessory Inter. Drive Gear - Magneto Drive Gear Shaft	.000	.002	.004
674	5-69, 5-71	Accessory Inter. Drive Gear Backlash - Fuel Pump Drive Gear	.004	.012	.020
675	5-69, 5-71	Fuel Pump Drive Shaft - Pump Bracket	.002	.004	.0045
676	5-69, 5-71	Fuel Pump Drive Gear Adapter - Rear Case	.000	.004	
679	5-69, 5-71	Vertical Accessory Drive Shaft Bearing - Shaft	.0005T	.0003	.001
680	5-71	Vertical Accessory Drive Shaft Bearing - Accessory Drive Cover	.0006	.002	.004
682	5-71	Auxiliary Drive Cover Rear Case	.0005T	.0025	.005
683	5-71	Vacuum Pump Drive Oil Seal Housing - Rear Case	.000	.004	.007
684	5-71	Vacuum Pump Drive Oil Seal Housing - Oil Seal	.0015T	.0045T	*
685	5-71	Vacuum Pump Drive Bearings - End Clearance	.002		
686	5-71	Vacuum Pump Drive Liner - Rear Case	.000	.002T	*
687	5-71	Vacuum Pump Drive Liner - Bearings	.0003	.0018	.003
688	5-71	Vacuum Pump Drive Gear Bearings - Gear	.005T	.0003	.0015
689	5-71	Vacuum Pump Drive Gear Backlash	.004	.012	.020
690	5-69, 5-71	Oil Pump Idler Shaft - Gears	.000	.0015	.003
691	5-69, 5-71	Oil Pump Idler Shaft - Bodies	.001	.003	.005
692	5-69, 5-71	Oil Pump Gears Backlash	.003	.013	.020
693	5-69, 5-71	Keys - Oil Pump Drive Shaft	.0005T	.0015	*
693	5-69, 5-71	Keys - Oil Pump Gear	.000	.0005	
694	5-69, 5-71	Oil Pump Drive Shaft - Bodies	.001	.003	.005
695	5-69, 5-71	Oil Pump Drive Shaft - Gears	.000	.0015	.003
696	5-69, 5-71	Oil Pump Gears End Clearance	.003	.0055	.0085

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
697	5-69,5-71	Oil Pump Drive Gear Backlash - Accessory Inter. Drive Gear	.004	.012	.020
698	5-69,5-71	Oil Pump Body End Plate - Body	.000	.004	
699	5-69,5-71	Oil Pump Gears - Oil Pump Bodies	.003	.007	.010
700	5-69,5-71	Oil Pump Body - Rear Case	.001	.003	.005
701	5-69,5-71	Oil Pump Cover - Body	.0015	.0045	.006
702	5-69,5-71	Oil Pressure Relief Valve Piston - Seat	.002	.006	.010
703	5-69,5-71	Oil Pressure Relief Valve Spring Dia. Wire. .0625 at 1-7/16 in.	19	21	<15
704	5-69,5-71	Supercharger Case Oil Pressure Tube - Tube Bracket	.005T	.0025	
705	5-69,5-71	Supercharger Oil Pressure Tube - Supercharger Case	.000	.002	.003
706	5-69,5-71	Supercharger Oil Pressure Tube - Rear Case	.0005T	.0025T	*
707	5-69,5-71	Rear Case Oil Pressure Tube - Rear Case	.001T	003T	*
727	5-71	Accessory Drive Gear Bearing Liner - Rear Case	.000	.002	.005
731	5-71	Accessory Drive Gear Bearing Liner - Bearing	.000	.0015T	.0015
732	5-71	Accessory Drive Gear Bearing - Gear	.0005T	.0003	.001
737	5-69,5-71	Vacuum Pump Drive Gear Oil Seal - Pump Adapter	.0015T	.0065T	*
738	5-69,5-71	Vacuum Pump Drive Adapter - Rear Case	.000	.003	
739	5-69,5-71	Vacuum Pump Drive Gear Bushing - Gear	.0015	.0035	.005
740	5-69,5-71	Vacuum Pump Drive Gear Bushing - Pump Adapter	.001T	.003T	*
741	5-69,5-71	Vacuum Pump Drive Gear Backlash - Fuel Pump Drive Gear (Fit To)	.004	.012	.020
742	5-71	Tachometer Drive Gear Coupling Oil Seal - Coupling	.0015T	.0065T	*
743	5-69,5-71	Fuel Pump Drive Gear Oil Seal - Pump Adapter	.0015T	.0065T	*

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
749	5-69, 5-71	Oil Screen By-Pass Valve Plug - Rear Case	.000	.0025	
750	5-69, 5-71	Oil Pump Body Oil Seal Ring Side Clearance (Fit To)	.0005	.0025	
751	5-71	Tachometer Drive Inner Coupling Bushing - Coupling	.005T	.0025T	*
760	5-68	Impeller Shaft Front Bearing - Liner	.001T	.003T	*
761	5-68	Impeller Shaft Front Bearing - Shaft	.005	.007	.009
762	5-68	Impeller Shaft End Clearance	.006	.010	.015
763	5-68	Impeller Shaft Liner - Bearing	.001T	.003T	*
764	5-68	Impeller Shaft Journal - Bearing	.005	.007	.009
766	5-68	Impeller Shaft Journal - Shaft	.0015T	.0005	.001
767	5-68	Impeller Shaft Oil Seal - Bearing Cover	.001T	.006T	*
768	5-68	Impeller Shaft Journal and Spacer Splines - Shaft Splines (By Selection)	.0026	.0084	
769	5-68	Oil Drain Sleeve - Supercharger Case	.001T	.003T	*
770	5-68	Oil Drain Sleeve - Rear Crankcase	.000	.0015	.0025
771	5-68	Oil Drain Sleeve - Supercharger Case	.001T	.003T	*
772	5-68	Oil Drain Sleeve - Rear Crankcase	.000	.0015	.0025

Table 5-1 Table of Limits (continued)

REFERENCE NUMBER	FIGURE NUMBER	NAME	MINIMUM	MAXIMUM	EXCHANGE IF OVER
749	5-69,5-71	Oil Screen By-Pass Valve Plug - Rear Case	.000	.0025	
750	5-69,5-71	Oil Pump Body Oil Seal Ring Side Clearance (Fit To)	.0005	.0025	
751	5-71	Tachometer Drive Inner Coupling Bushing - Coupling	.005T	.0025T	*
760	5-68	Impeller Shaft Front Bearing - Liner	.001T	.003T	*
761	5-68	Impeller Shaft Front Bearing - Shaft	.005	.007	.009
762	5-68	Impeller Shaft End Clearance	.006	.010	.015
763	5-68	Impeller Shaft Liner - Bearing	.001T	.003T	*
764	5-68	Impeller Shaft Journal - Bearing	.005	.007	.009
766	5-68	Impeller Shaft Journal - Shaft	.0015T	.0005	.001
767	5-68	Impeller Shaft Oil Seal - Bearing Cover	.001T	.006I	*
768	5-68	Impeller Shaft Journal and Spacer Splines - Shaft Splines (By Selection)	.0025	.0084	
769	5-68	Oil Drain Sleeve - Supercharger Case	.001T	.003T	*
770	5-68	Oil Drain Sleeve - Rear Crankcase	.000	.0015	.0025
771	5-68	Oil Drain Sleeve - Supercharger Case	.001T	.003T	*
772	5-68	Oil Drain Sleeve - Rear Crankcase	.000	.0015	.0025

SECTION 4

TORQUE VALUES

INTRODUCTION

1 The following torque values, in pound-inches unless otherwise specifiec, are recommended for use during assembly of the Pratt & Whitney Aircraft R985 engine. The torque values for all nuts, bolts and screws, are based on the use of a thread lubricant, such as engine oil or equivalent, except where otherwise specified or where the applicable overhaul instructions recommend a special lubricant or surface coating. Torque values for interference fit applications such as studs, pushrod cover cylinder connectors and pipe plugs may be obtained with or without lubrication, unless otherwise specified.

2 Torque indicating devices should be checked daily and calibrated by means of weights and a measured lever arm to make sure that inaccuracies have not crept in. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive to the way they are supported during a tightening operation, and every effort should be made to adhere to the instructions furnished by the respective manufacturers. Tightening should be done slowly and evenly for consistency and the best possible accuracy.

3 There may be certain instances other than those included under "Specific Recommendations", where it is obvious that the torque recommended for tightening a nut on a bolt or stud of given size should not be used, due to the kind of material or the design of the engine part involved. Common sense and good judgment must be used in such cases.

4 After a castle nut, screw, or bolt has been tightened to the proper torque, it should not be loosened to permit the insertion of lockwire of a cotterpin. If the slots in a nut or the lockwire holes in a bolt or screw are not properly aligned at the minimum torque limit, the nut screw, or bolt should be further tightened to the next aligning position, but the maximum torque limit, if any, must not be exceeded. If this alignment cannot be accomplished without exceeding the maximum torque limit, back off the nut, screw, or bolt half a turn, then retighten. Occasionally, it may be necessary to select a new part.

5 Because of the unconventional design of cylinder flange nut wrenches, particular care should be exercised in tightening cylinder flange nuts. Whenever special extensions and adapter wrenches are used to tighten cylinder hold down nuts, the torque specified in this bulletin is at the nut.

GENERAL RECOMMENDATIONS

NUTS, BOLTS, AND SCREWS (Table 5-2)

6 A standard nut has a height approximately equal to the diameter of the bolt. Unless otherwise specified, for thin nuts, where the height of the nut is approximately half the sixe of the bolt diameter, reduce the listed torque values fifty percent. Castellations are additional and do not affect torque.

Thread Size	Limits		Thread Size	Limits	
	Minimum	Maximum		Minimum	Maximum
8-32	15	20	3/8-24	225	300
8-36	15	20	7/16-14	325	430
10-24	20	30	7/16-20	360	480
10-32	20	30	1/2-13	500	650
12-24	35	45	1/2-20	560	750
12-28	35	45	9/16-12	700	950
1/4-20	50	70	9/16-18	800	1050
1/4-28	65	85	5/8-11	1000	1300
5/16-18	110	150	5/8-18	1150	1500
5/16-24	125	170	3/4-10	1700	2300
3/8-16	200	270	3/4-16	2000	2600

Table 5-2 Torque Recommendations for Nuts, Bolts, and Screws.

STEPPED STUDS (Table 5-3)

7 If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum recommended, select another stud.

STEPPED STUDS

PLAIN NECKED

Thread Size (Nut End)	Driving Torque Limits		
	Minimum Plain and Necked	Maximum Plain	Maximum Necked
8-36	10	30	30
10-32	15	50	45
12-28	20	75	65
1/4-28	40	125	115
5/16-24	85	260	240
3/8-24	160	500	450
7/16-20	200	800	700
1/2-20	250	1300	1150
9/16-18	425	1800	1600
5/8-18	625	2600	2400
3/4-16	1100	4600	4200

Table 5-3 Torque Recommendations for Stepped Studs.

STANDARD STUDS (Table 5-4)

8 If the torque required to drive a stud to the correct projection length should not come up to the minimum or should exceed the maximum recommended, select another stud.

STANDARD STUDS

PLAIN NECKED

Thread Size	Driving Torque Limits		
	Minimum Plain and Necked	Maximum Plain	Maximum Necked
8-32	10	30	30
10-24	15	45	40
12-24	20	70	65
1/4-20	40	105	95
5/16-18	85	230	210
3/8-16	160	425	375
7/16-14	200	675	600
1/2-13	250	1050	950
9/16-12	425	1500	1400
5/8-11	625	2100	1900
3/4-10	1100	3800	3500

Table 5-4 Torque Recommendations for Standard Studs.

STEEL PIPE PLUGS IN ALUMINUM AND MAGNESIUM CASES (Table 5-5)

9 If a pipe plug is found to leak after it has been tightened to these limits, it should not be tightened further, but should be removed, and more sealing compound (JAN-A-669) applied to the threads. The plug should then be reinstalled and retightened to the desired limits.

10 When plugs are tightened in a hot engine, the torques recommended should be reduced about 20%, owing to the different expansion characteristics of the steel plugs and the aluminum or magnesium cases.

HEX HEAD STRAIGHT THREADED FLANGED PARTS

11 Tighten a hex head straight threaded plug or connector until the under side of the head or flange makes contact with its mating face and then tighten to a maximum of 50 pound-inches additional torque, unless otherwise specified.

FLEXIBLE TUBE CONNECTIONS (Table 5-6)

12 The seals must be wet with engine oil immediately prior to installing and tightening. Make certain that the tube is properly aligned and that the seal has bottomed before applying the listed torque.

Thread Size	Torque Limits	
	Minimum	Maximum
1/16 in. A.N.P.T.	30	40
1/8 in. A.N.P.T.	30	40
1/4 in. A.N.P.T.	70	85
5/16 in. A.N.P.T.	70	85
3/8 in. A.N.P.T.	95	110
1/2 in. A.N.P.T.	140	160
3/4 in. A.N.P.T.	210	230

Table 5-5 Torque Recommendations for steel Pipe Plugs in Aluminum & Magnesium Cases.

HOSE, TUBE AND THREADED CONNECTORS (Table 5-7)

13 All locknuts on connectors, elbows and fittings shall be tightened to 1/2 the values given under General Recommendations for Nuts, bolts and Screws. The torque value for the nut on all hose fittings and tubes (not covered under Flexible Tube Connections) shall be in accordance with the following table. No attempt should be made to correct any leakage of the joint by overtightening. The fitting should be disassembled and checked for nicks, burrs, dirt, etc. If necessary use new parts.

14 If either of the mating sealing surfaces are aluminum, the required torque limits for aluminum fittings apply.

INSTALLATION OF CRUSH TYPE ASBESTOS FILLED GASKETS (Table 5-8)

15 Install all crush type gaskets except the self centering type, with the unbroken surface against the flange of the plug or part being tightened against the seal. Turn mating part until sealing surfaces are in contact and tighten to the angle of turn shown below for the appropriate thread pitch.

HOSE CLAMPS

16 Tighten thumb-screw type hose clamps to 10 pound-inches minimum to 20 pound-inches maximum. Retighten after a period of 1 hour or immediately following the next operation of the engine to 10 pound-inches minimum to 20 pound-inches maximum.

Tube Size	Single Wall Tubes	Double Wall Tubes
	Limits	Limits
1/8 in.	25 to 30	
3/16 in.	25 to 30	
1/4 in.	25 to 30	
5/16 in.	30 to 35	
3/8 in.	30 to 35	
1/2 in.	90 to 100	
5/8 in.	90 to 100	
3/4 in.	90 to 100	
7/8 in.	90 to 100	
1 in.	90 to 100	245 to 255
1-1/8 in.	100 to 110	245 to 255
1-1/4 in.	100 to 110	245 to 255
1-1/2 in.	100 to 110	245 to 255

Table 5-6 Torque Recommendations for Flexible Tube Connections.

HOSE	TUBE	THREAD	ALUMINUM FITTINGS (Liquid or Air) STEEL FITTINGS (Air)	Steel FITTINGS (Liquids)
Size	O.D.	Size	Limits	Limits
3	3/16 in.	3/8-24	30 to 50	70 to 800
4	1/4 in.	7/16-20	40 to 65	90 to 100
5	5/16 in.	1/2-20	60 to 80	135 to 150
6	3/8 in.	9/16-18	75 to 125	270 to 300
8	1/2 in.	3/4-16	150 to 250	450 to 500
10	5/8 in.	7/8-14	200 to 350	650 to 700
12	3/4 in.	1-1/16-12	500 to 700	900 to 1000
16	1 in.	1-5/16-12	600 to 900	2200 to 2400
18	1-1/8 in.	1-1/2-12	600 to 900	2200 to 2400
20	1-1/4 in.	1-5/8-12	600 to 900	2200 to 2400
24	1-1/2 in.	1-7/8-12	600 to 900	2200 to 2400

Table 5-7 Torque Recommendations for Hose, Tube & Threaded Connectors.

Thread Pitch on Part to be Tightened	Angle of Turn	
	Aluminum Asbestos	Copper Asbestos
8 Threads per Inch	135°	67°
10 Threads per Inch	125°	67°
12 Threads per Inch	180°	90°
14 Threads per Inch	180°	90°
16 Threads per Inch	270°	135°
18 Threads per Inch	270°	135°
20 Threads per Inch	270°	135°
24 Threads per Inch	360°	180°
28 Threads per Inch	360°	180°

Table 5-8 Crush Values for Asbestos Filled Gaskets.

USE OF TORQUE WRENCHES WITH EXTENSIONS OR ADAPTERS

17 On occasion it is necessary to use a special extension or adapter wrench together with a standard torque wrench (Figure 5-68). In order to arrive at the resultant required torque limits, the following formula should be used:

T = Desired torque on the part.

E = Effective length of special extension or adapter (See Figure 5-68).

L = Effective length of torque wrench (See Figure 5-68).

R = Reading on scale of dial of torque wrench.

A = Distance through which force is applied to part.

$$R = \frac{LT}{A} = \frac{LT}{L+E}$$

Example: A torque of 1440 pound-inches is desired on a part using a special extension having a length of 3 inches from centre to centre of its holes, and a torque wrench measuring 15 inches from centre of handle or handle swivel pin to centre of its square adapter.

$$\text{Then: } R = \frac{LT}{L+E} = \frac{15 \times 1440}{15+3} = 1200$$

With the axis of the extension or adapter and the torque wrench in a straight line, tightening to a wrench reading of 1200 pound-inches torque will provide the desired torque of 1440 pound-inches on the part.

ADVANCE REVISION

Serial #1 dated 18 Mar 60
(Sheet 1 of 1)

The sheet of this Advance Revision is to be inserted in the EO as follows:-

Sheet 1 facing page 149

Part 5, Section 4, page 149, para. 19(c)

Delete present para. 19(c). Insert new para. 19(c) as follows:-

Propeller shaft thrust bearing nut.

Tighten to 250 foot-pound; then turn to tighten through an angle of 25 to 30 degrees.

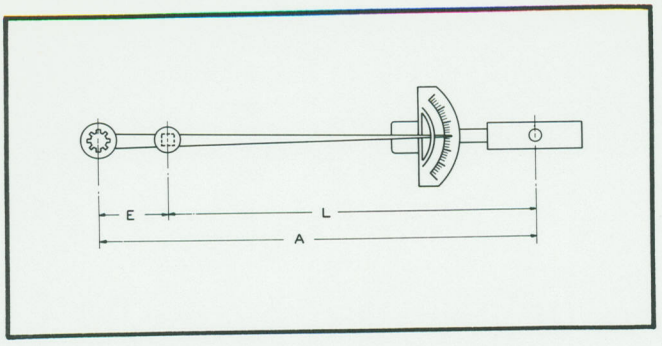


Figure 5-68 Extension on Torque Wrench

SPECIFIC RECOMMENDATIONS

18 The following values are exceptions to those contained in paragraphs 6 through 17.

19 FRONT SECTION

(a) Dehydrator Plugs; 3/4 and 1 in. dia thread	35 to 45
(b) Propeller Shaft Thrust Bearing Cover nuts	100 to 150
(c) Propeller Shaft Thrust Bearing nut	Tighten to 250 pound-feet; then turn to tighten through an angle of 15° to 20°

20 POWER SECTION

(a) Crankcase Through - bolt 7/16 in. hollow type bolt	350 to 400
(b) Crankshaft Bolt	.009 to .011 inch stretch
(c) Crankshaft Flyweight Through Bolts Expander (Through Bolt)	.001 to .0015 inch stretch
	200 to 225
(d) Cylinder Flange nuts	300 to 350
(e) Dehydrator Plugs	
(1) Cylinder	20 to 25
(2) 3/4 and 1 in. dia. thread	35 to 45
(f) Rocker Box Cover nuts	60 to 75
(g) Rocker Shaft Caps and nuts (aluminum)	65 to 100
(h) Rocker Shaft nuts	200 to 250
(j) Sparkplugs	300 to 360
(k) Sparkplug Lead Coupling	
(1) 5/8-24 thread	100 to 120
(2) 3/4-20 thread	140 to 160
(m) Valve Adjusting Screw Lock-nuts	300 to 350

21 SUPERCHARGER AND ACCESSORY SECTION

(a) Supercharger Intermediate Gear Shaft Nut	600 to 675
(b) Starter and Starter Cover Nuts (two top nuts only)	175 to 200
(c) Dehydrator Plugs 3/4 in. and 1 in. dia. thread	35 to 45

L
e
A

PART 6

TESTING

INTRODUCTION

CAUTION

Personnel in charge of engine testing must be experienced. This Part does not contain basic information with which experienced test operators are familiar.

PURPOSE OF TEST AFTER OVERHAUL

1 Run-in of an engine after overhaul is essential as a means of seating the piston rings, burnishing certain other new engine parts which may have been installed, and generally checking the performance of the engine.

HORSEPOWER CHECK

2 There are many variables which affect horsepower and it is not feasible for the average overhaul base to maintain the complete equipment and personnel necessary for close horsepower measurement. When an engine has been overhauled as recommended in the preceding sections of this Order, it should develop essentially the same horsepower as when new, provided the carburettor and magneto have also been overhauled and tested correctly. A check on manifold pressure and rpm, using a calibrated test propeller and correcting for carburettor air inlet temperature, will provide a sufficiently close check on horsepower for most purposes.

PREPARATION OF ENGINE FOR TEST

HORIZONTAL TEST ALTERATIONS AN-5 Model (Tool Group 44)

3 For a post-overhaul run-in of a AN-5 Model in a horizontal position, it is necessary to make the following alterations.

4 Remove the intercylinder deflector from between No. 5 and No. 6 cylinders and the No. 5 intake and No. 6 exhaust rockerbox covers with their intercylinder oil drain pipe. Loosen the three clamps on the T hose connection between No. 7 and No. 8 cylinders and remove the hose. Remove the cover plates and gaskets from the sump mounting bosses on the front and supercharger cases. Remove the rockerbox to rear case oil scavenge pipe, the front case to oil pump oil scavenge pipe, and the rear case to oil pump oil scavenge pipe. Remove the breather plug from between the No. 2 and No. 3 intake pipe bosses on the supercharger case. Remove the square headed plug forward of the left accessory drive mounting pad on the rear case; then remove the 90 degree carburettor adapter from the rear case. Remove the nut securing the rear ignition manifold brace to the rear case directly behind the No. 2 cylinder.

5 Install a standard carburettor adapter on the rear case, securing it with washers, nuts, and lockwire. Attach an improvised gasket and blind cover on the rear face of the sump mounting boss on the front case. Install a sump between the No. 5 and No. 6 cylinders using gaskets between the sump and the sump mounting bosses on the front and supercharger cases. Secure the sump with washers, nuts, and lockwire. Assemble rockerbox covers to an oil sump drain T fitting, using rubber hoses and clamps. Install the assembly on the engine, placing gaskets between the rockerbox covers and the rockerboxes, and a gasket between the T fitting and the sump. Install the oil sump to oil pump scavenge tube assembly, and the rockerbox oil sump to the oil pump oil scavenge tube assembly. Remove the cover plate located on the supercharger case behind the No. 7 cylinder and install the rear to supercharger case oil drain tube assembly. Install an intercylinder oil drain tube between the No. 7 and No. 8 cylinders.

6 To supply additional oil to the rear surface of the impeller shaft rear bearing at the point of contact with the impeller shaft oil seal, install the impeller shaft seal oil feed connection on this engine as shown in Figure 6-1.

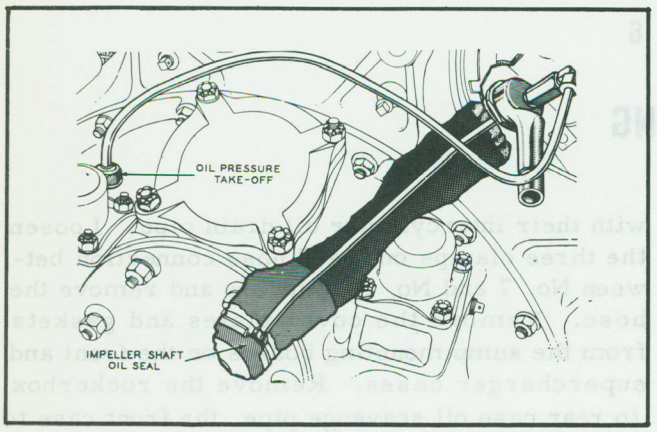


Figure 6-1 Impeller Shaft Oil Feed Connection

Install this connection (refer to Figure 6-2), and insert the tube (8) into the breather aperature between the No. 2 and No. 3 intake pipe bosses in the supercharger case. Direct the end of the tube into an oil drain hole located 20 degrees off-centre at the rear of the impeller shaft boss in the supercharger case. Line up the additional oil drain holes in the impeller shaft bearing cage liner and the impeller shaft bearing cage with the supercharger case oil drain hole to from a direct passage to the impeller shaft rear bearing and impeller shaft oil seal. Install the connection body (2) in the breather hole. From a point directly behind the No. 2 cylinder push the rear ignition manifold forward until the manifold brace rests against the No. 2 cylinder; then screw the hollow transfer screw (5) into the connection body, controlling its extended length with the hex nut. Install the exhaust connection (1) over the hollow transfer screw; then install the fitting (4) on the screw and tighten the fitting. Screw the elbow (3) into the top of the fitting (4). Screw the nipple (10) into the oil pressure take-off on the left side of the rear case and connect the nipple to the elbow (3) by means of the copper tubing with fittings (9).

INSTALLATION OF ENGINE IN TEST STAND (Tool Group 64)

7 With the engine in a horizontal position, suspend a Lifting Sling from a chain hoist in the engine compartment of the test cell and attach the hooks of the sling to the two lifting links on the top of the engine. Draw up the hoist just enough to relieve the Engine Stand of the weight of the engine; then unfasten the Mounting Plate from the stand and withdraw the engine and plate from the stand. Hoist the engine to the proper level; then back the engine and mounting plate into the test stand and secure the plate to the stand.

INSTALLATION OF STARTER AND FUEL PUMP

8 Put a new gasket on the starter pad; then mount the starter in position and secure it with the nuts.

NOTE

Starters must be adjusted for a maximum torque no greater than 450 pounds-feet.

Mount the fuel pump on the fuel mount pad, using a new gasket, and install the fittings needed for connecting the fuel lines.

INSTALLATION OF CARBURETTOR

9 Install the carburettor on the engine, us-

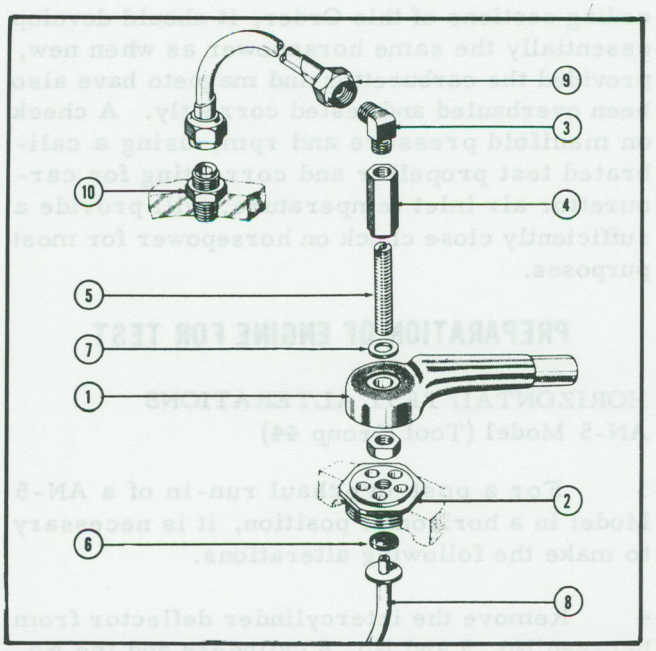


Figure 6-2 Connection Assembly

ing a new gasket and secure it with bolts. Lockwire bolts in position.

CAUTION

Use no grease or sealing compounds on the gasket between the engine and the carburettor. Grease or sealing compound so used might cause stoppage of some of the passages within the carburettor. Take particular care when installing the gasket to line up correctly the mating holes in the gaskets, the engine, and the carburettor.

10 Set the airscreen on the throttle body, using one new gasket underneath it and another new gasket on the top; then mount the air scoop over the screen and secure it with the bolts.

PRE-OILING OF ENGINES

10 To insure sufficient lubrication of certain bearings in the engines immediately after initial starts on the test stand, pre-oil the engines to force all air from the internal oil passages. To accomplish this, connect an oil pump to the pressure oil gauge takeoff on the left rear face of the rear case. The pump should be capable of building up an oil pressure of 45 to 60 pounds per square inch. Connect a pressure gauge in the line between the pump and the engine. Incorporate a screen (50 mesh) to keep the oil clean in the pre-oiling system. Remove the oil sump drain plug; then build up the oil pressure within the engine to 45 to 60 pounds and flow until the oil starts to run out of the sump drain.

INSTRUMENT AND CONTROL CONNECTION

12 Connect the lines, controls, and leads in the following list. Refer to Figures 6-3 and 6-4 to identify the location of the various connections on the engine and carburettor.

(a) Supercharger rim manifold pressure manometer line. (Item 1).

(b) Thermocouple lines on at least four cylinders. Refer to "Cylinder Temperatures", paragraph 25.

(c) Breather line at the breather outlet on the rear case. (Item 3).

(d) Throttle control. (Item 4).

(e) Mixture control. (Item 5).

(f) Fuel pressure gauge line to the carburettor. (Item 6).

(g) Fuel lines to the fuel pump and carburettor; and a fuel pressure relief valve, if the fuel pump does not incorporate one.

(h) Main oil pressure gauge lines to the pressure oil gauge take-off on the left rear face of the rear case. (Item 8).

(j) Tachometer. (Item 9)

(k) Fuel pump drain line.

(m) Oil inlet and oil outlet lines. See EO 45-1-2 for a list of oils approved for use in Pratt & Whitney Aircraft engines. (Item 11).

(n) Install the exhaust stacks. (Item 12).

(p) Magneto ground wires. (Item 13).

(q) Install the carburettor air intake duct to the air scoop on the carburettor.

(r) Air intake thermometer line in the air intake duct.

(s) Starter control; and any other connections which the particular type of starter used may require.

TEST PROPELLERS

GENERAL

13 Four-bladed wooden test propellers (test clubs) are recommended for use on the average test stand because of their convenience, economy, and cooling efficiency. Since the desired diameter for a test propeller depends to a considerable extent on the location and characteristics of the test house in which it is to be used, test propellers as furnished are somewhat larger in diameter than will normally be necessary.

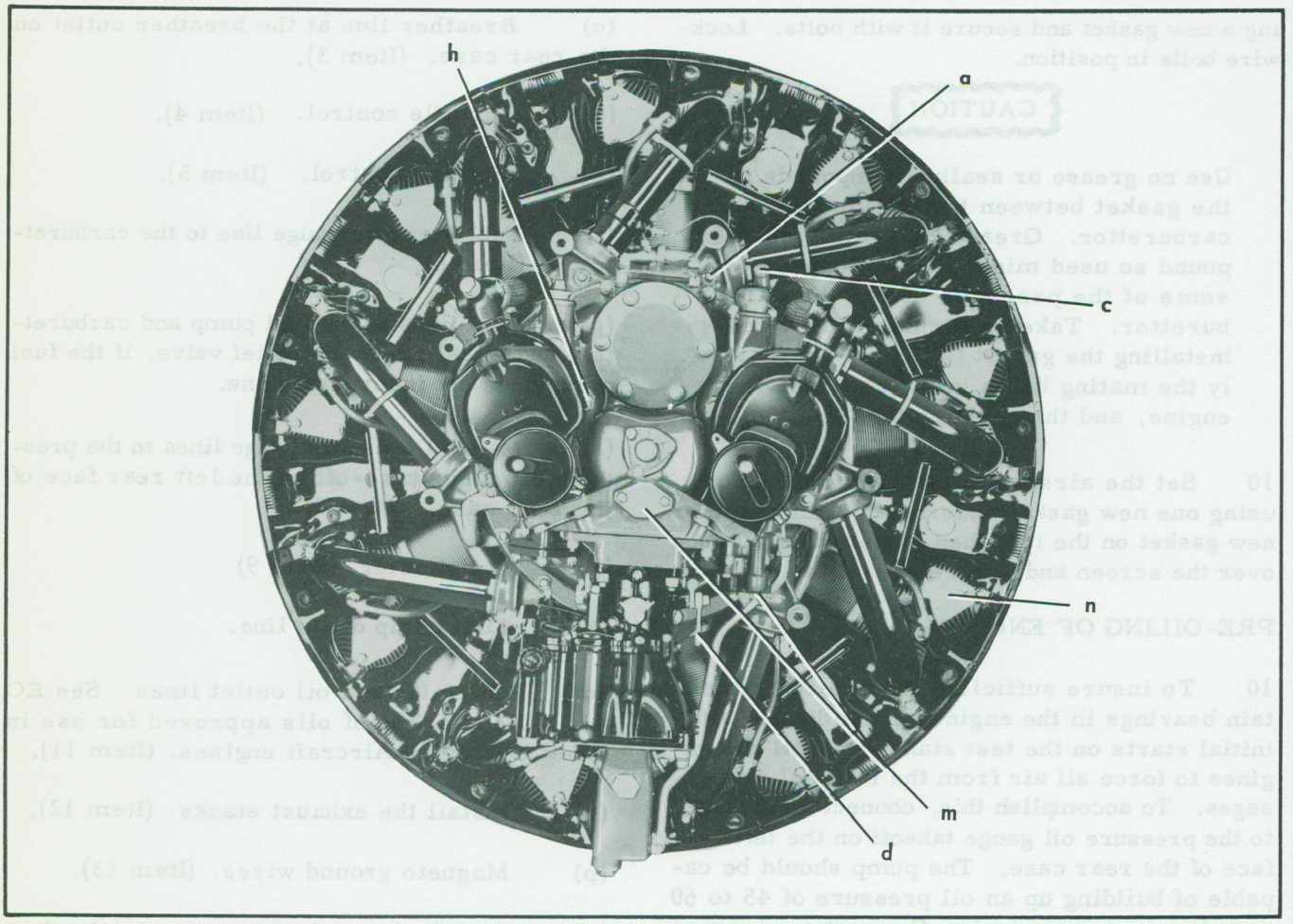


Figure 6-3 Connections

They must therefore be calibrated by trimming the blades for use on the particular engine model and in a particular test stand. Before a new propeller is calibrated it should be checked for static balance and, if necessary, the heavy blade or blades should be trimmed to correct the balance as directed under "Rebalancing". A correctly calibrated propeller should cause an engine to turn out its normal rated rpm at normal rated manifold pressure for the altitude at which the test stand is located. It is permissible for the manifold pressure at the normal rated rpm to exceed the normal rated by 3 percent, and at normal rated manifold pressure for the altitude the rpm may very ± 59 rpm from the normal rated rpm.

COLD WEATHER

14 If a propeller is being calibrated in cold weather, the blades should be trimmed so that the engine will turn out the minimum permissible rpm at the maximum permissible manifold pressure. If the test stand is located where there is a wide difference between winter and summer temperatures it is desirable to have two test propellers available for use, one correctly calibrated for winter temperatures and another for summer. The same engine model may require a test propeller as much as 2 inches smaller in diameter in winter than in summer in order to obtain the proper relation of manifold pressure and rpm. If a test propeller becomes too small to use, even in winter, because of additional trimming to remove nicked and splintered stock, it can often be recalibrated for use with less powerful engines.

15 When wooden propellers are not in use

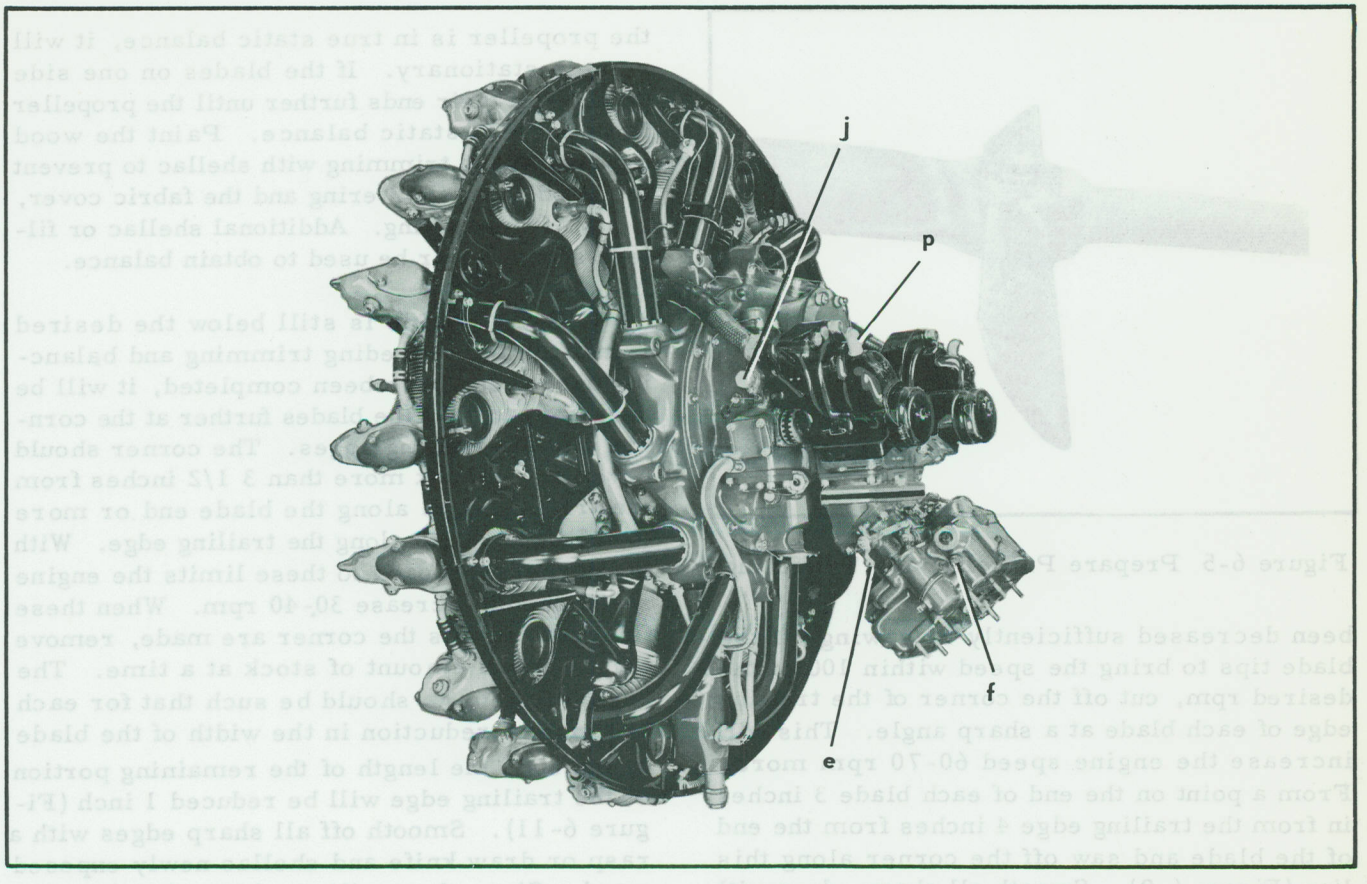


Figure 6-4 Connections

they should be protected from the weather.

CALIBRATION

16 New propellers should be calibrated on a new engine, or on one known to be normal in every respect, under the average atmospheric conditions of the locality. Install the test propeller on the engine; then run the engine up to the normal rated manifold pressure for the altitude and note the rpm. This will indicate the approximate amount of trimming which will be required. An increase of 30 to 50 rpm per inch reduction in propeller diameter can usually be expected; but this will vary with the temperature, the atmospheric pressure, and the shape of the particular test house. It is advisable therefore to take off 1 inch (1/2 inch per blade) in the first trimming operation and note the resultant increase in rpm. This figure will then serve as a guide in determining how much trimming will be needed to complete the calibration.

17 To prepare the propeller for trimming, rest it firmly on a bench or stand and mark a point three inches in from the trailing edge on the end of each blade; then draw lines connecting the points on opposing blades (Figure 6-5). If the points were correctly marked on the blade ends, these lines will bisect the hub exactly. Do not use a hard pencil or sharp pointed tool to draw the lines if the propeller has a fabric covering. Mark off the desired blade length along these lines, measuring out from the edge of the hub flange (Figure 6-6). At the point marked, scribe a line across the width of the blade. Because of the angle of the blade, a gauge 1/16 inch thick and 1/2 inch wide should be inserted between the square used to draw this cross line and the trailing edge of the blade between the 4 and 4 1/2 inch marks on the square (Figure 6-7). Saw off the tip of the blade along the cross line and smooth all sharp edges with a rasp or draw knife (Figure 6-8).

18 After the diameter of the propeller has

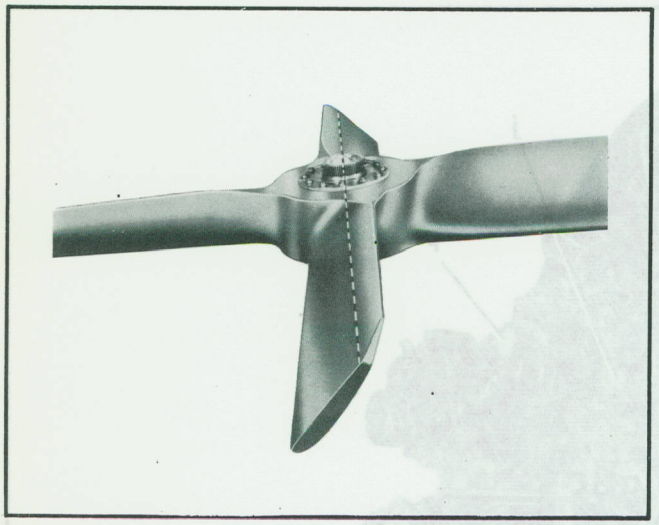


Figure 6-5 Prepare Propeller for Trimming

been decreased sufficiently by sawing off the blade tips to bring the speed within 100 of the desired rpm, cut off the corner of the trailing edge of each blade at a sharp angle. This will increase the engine speed 60-70 rpm more. From a point on the end of each blade 3 inches in from the trailing edge 4 inches from the end of the blade and saw off the corner along this line (Figure 6-9). Smooth all sharp edges with a rasp or draw knife.

REBALANCING

19 After a test propeller has been trimmed it must be rebalanced. Make sure the hub and cone are perfectly clean; then mount the propeller on a regular propeller static balancing stand located where there is no vibration or drafts. Use the correct arbors and centering cone and make certain they are installed tightly; then rotate the propeller slowly forward and back to position the rollers on the balancing stand and to make sure that nothing is affecting their free movement.

20 Set the propeller so that the two blades horizontal. If one blade drops, bevel the end of that blade on the curved side with a rasp or draw knife (Figure 6-10). Set the other pair of blades in a horizontal position and, if one blade drops, bevel the end of that blade on the curved side. After both pairs have been separately balanced, set the propeller so that the blades are 45 degrees from the vertical. If the propeller is in true static balance, it will remain stationary. If the blades on one side drop, trim their ends further until the propeller is in perfect static balance. Paint the wood exposed by the trimming with shellac to prevent the wood from splintering and the fabric cover, if any, from peeling. Additional shellac or fillers should never be used to obtain balance.

21 If the engine is still below the desired rpm after the preceding trimming and balancing operations have been completed, it will be necessary to trim the blades further at the corners of their trailing edges. The corner should never be cut back more than 3 1/2 inches from the trailing edge along the blade end or more than 5 inches back along the trailing edge. With the corners cut back to these limits the engine speed should increase 30-40 rpm. When these final cuts across the corner are made, remove only a small amount of stock at a time. The angle of the cuts should be such that for each 1/2 inch of reduction in the width of the blade at the end, the length of the remaining portion of the trailing edge will be reduced 1 inch (Figure 6-11). Smooth off all sharp edges with a rasp or draw knife and shellac newly exposed wood. Since the trailing edges of the blades are uniform in thickness, only a minimum of rebalancing is necessary after the final trimming.

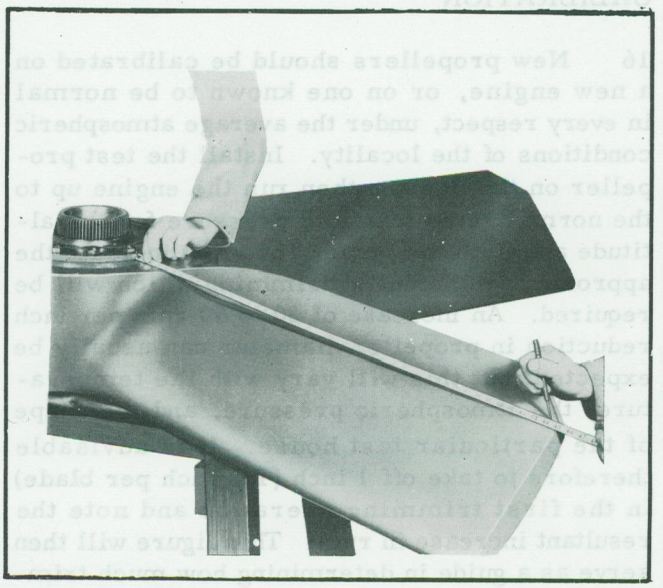


Figure 6-6 Mark off Blade Length

INSTALLATION OF TEST PROPELLER

22 Before installing the test propeller on the propeller shaft of the engine to be tested, make sure the hub splines and the attaching nut are free from burrs or dirt which might damage the propeller shaft. Cover the shaft with a light oil, mount the propeller on the shaft, and screw on the attaching nut. Tighten the nut, using a bar 4 feet long and apply a weight of between 160 and 190 pounds to the end of the bar at right angles to the ground. Do not strike the bar with a hammer or other heavy instrument to tighten the nut. After the nut has been torqued, a 2 1/2 pound hammer may be used to strike the bar near the nut in order to check its tightness. Do not exceed a normal swing of the hammer.

TEST PROCEDURE

23 An experienced test operator should be in charge of the run-in of an overhauled engine. The test operator should keep the engine and instruments under constant observation, recording gauge readings and other data and comments at 15 minute intervals in a log of the test run. File the completed log with the inspection and overhaul records of the engine. The operator should watch for oil and fuel leaks and make the necessary corrections during the run-in when possible. Oil and fuel pressure relief valve adjustments may also need to be made

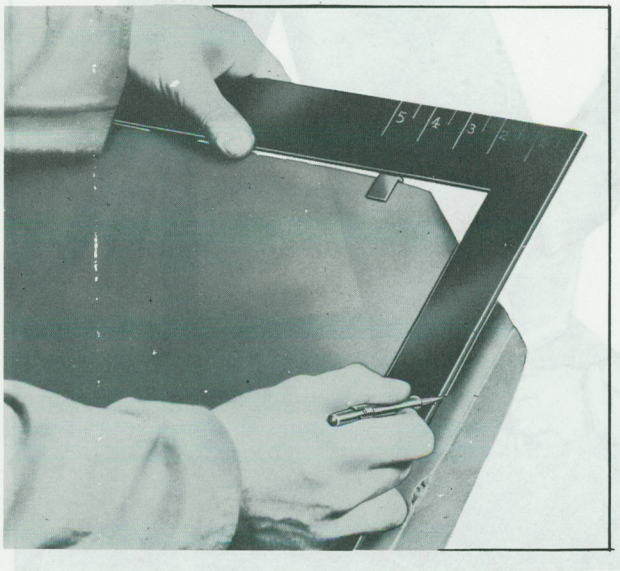


Figure 6-7 Scribe Cross Line

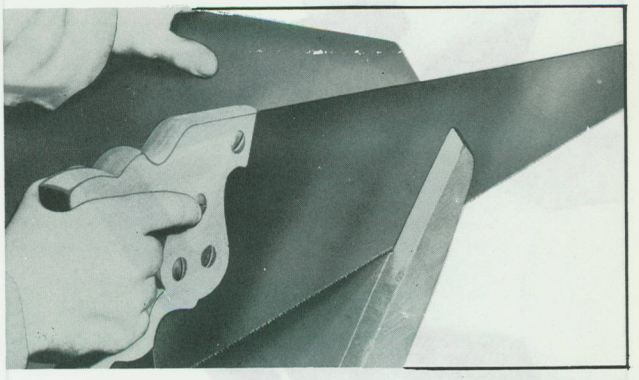


Figure 6-8 Saw off Blade Tip

during the test run. If the engine is equipped with short exhaust stacks so that the exhaust flames from the cylinders are visible, the operator should note any differences or changes in the colour of the flames. Misfiring spark plugs, mixtures that are too lean or too rich, and other discrepancies can often be diagnosed from flame colour.

AIR TEMPERATURE

24 It is desirable to maintain the carburetor air inlet temperature between 21°C and 32°C (70°F and 90°F). Under normal conditions the engine will not require preheated air during the run-in. However, when the outside air is at temperatures between 0°C and 20°C (32°F and 68°F), and is full of moisture, sleet, or heavy wet snow, preheat is necessary to insure against icing. Preheat will frequently be desirable also while measuring fuel consumption.

FUEL GRADE

25 Consult EO 45-1-2 for the proper grade of fuel to use.

CYLINDER TEMPERATURES (Tool Group 27)

26 A survey of all cylinder head and barrel temperatures should be made on the first engine run in a new test house, or on the first engine to be run in an old test house. The head temperatures should be determined by a bayonet type thermocouple inserted in each thermocouple well located near the rear sparkplug of each cylinder, and the barrel temperatures should be determined by a rivet type thermo-

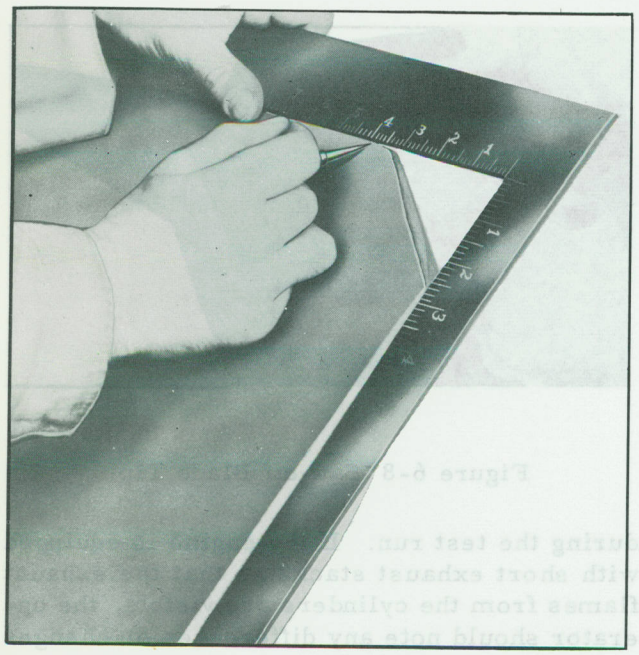


Figure 6-9 Corner Cut

couple embedded in the fillet of the hold-down flange at the rear of the barrel.

27 Unless cylinder barrel thermocouples have already been installed in the cylinders, holes, must be drilled for them. Drill two holes at an angle of 45 degrees to the centre line of the cylinder in the middle of the fillet above the cylinder barrel flange. The holes should be between two stud holes on the rear side of the barrel and should be approximately 1/8 inch deep and 1/4 inch apart. Drive in the rivet type thermocouples, using a drift, upsetting them to secure them in place.

28 From this temperature survey, the four hottest cylinder locations can be determined and cylinder head temperatures can be taken at these locations for all future tests. Cylinder barrel temperature measurement is unnecessary after the initial check has shown barrel temperatures to be within the limits, providing the maximum outside air temperature which is apt to be encountered has been given due consideration. Cylinder head temperature should not exceed 260°C (500°F).

STARTING THE ENGINE

29 Remove the front spark plugs from cylinders 4, 5, 6, and 7. Check all controls carefully and make certain that the magnetos are properly grounded and that the ignition switch is OFF; then pull the engine through several times by hand. Make sure that no oil has collected inside the cylinders from which the spark plugs were removed; then reinstall the spark plugs and attach the spark plug leads.

30 Operate the wobble pumps in the oil system until the engine pump is supplied with oil. In extremely cold weather the old feed line should be disconnected at the pump so that the cold oil may be forced out of the line with the wobble pump before the engine is started.

ENGINE RUN-IN SCHEDULE

31 The following is the run-in schedule recommended for seating piston rings and burnishing newly installed bushings, etc., in an overhauled engine. Operate the carburettor in the FULL RICH position.

(a) Start the engine and warm up.

(b) Run for two hours with speed increasing in approximately 100 rpm increments from 1000 rpm to 89% normal rated speed on propeller load. The 70% normal rated speed point should not be reached in less than one hour,

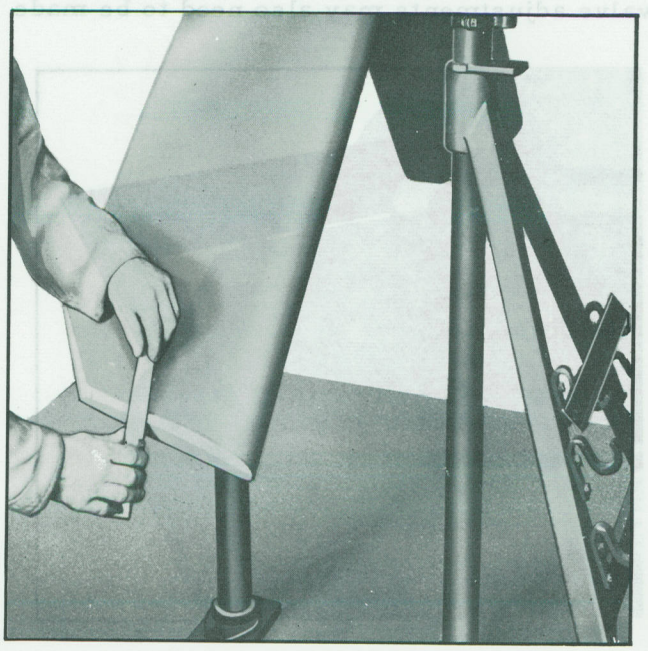


Figure 6-10 Bevel Glade End

and the 89% normal rated speed point should not be reached in less than one and one-half hours.

(c) Run for one-half hour at 89% rated speed on propeller load.

(d) Shut down engine and inspect for oil leakage.

(e) Start engine and warm up.

(f) Run for one-half hour at 89% normal rated speed on propeller load. Include oil consumption measurement.

(g) Continue run for one-half hour at normal rated manifold pressure and normal rated speed.

(h) Operate at 50% normal rated speed for not less than one minute prior to take-off.

(j) Run the engine for one minute at take-off manifold pressure and speed.

CAUTION

The engine may be operated at take-off power for no longer than five minutes at the discretion of an authorized Engineering Officer provided that the test facilities are such that the engine can be operated at take-off power without exceeding cylinder head temperature limits.

(k) If oil consumption, taken during the one-half hour run at normal rated speed is not within the limits specified, run for one-half hour more at 89% normal rated speed. Include oil consumption measurement.

(m) Shut down the engine.

SPECIFIC REQUIREMENTS

32 Take fuel consumption readings in increments of 100 rpm beginning at 1400 rpm. See "Checking Fuel Consumption", paragraph 42.

33 Take fuel readings at not more than fifteen minute intervals.

Figure 6-11 Final Adjustment

34 The idling and accelerating characteristics of the engine should be checked when practicable.

35 Use actual horsepower to calculate specific oil and fuel consumptions. Horsepower may be determined by referring to the proper operating curve. The horsepower used to compute specific fuel and air consumption should be corrected for barometer and carburettor air temperature existing at time of test.

36 Fuel oil pressures, fuel consumption, oil temperatures, cylinder temperatures and manifold pressure should be recorded at all speeds.

37 The barometer reading, corrected for brass scale, should be used to calculate absolute manifold pressure.

OIL PRESSURE AND TEMPERATURE

CAUTION

If the oil pressure does not register almost immediately after starting, STOP the engine and investigate the cause.

38 When the engine is running at rated speed and oil temperatures as in paragraph 40, the

oil pressure should be as follows:

(a) Range.....70 to 90 psi

(b) Desired..... 85 psi

(c) Fluctuation..... 5 psi

39 Oil pressure while idling should be:

(a) For an An-5 Model tested in a vertical position.

At 1000 rpm.....40 psi

(b) Others (Minimum)..... 15 psi

40 When the engine is running at rated speed the oil temperature should be as follows:

(a) Range 60°C to 75°C (140°F to 167°F)

(b) Desired 73°C (165°F)

(c) Maximum rise 22°C (40°F)

FUEL PRESSURE

41 If the fuel pressure is not within the desired range at 3-6 psi at 1000 rpm and above, adjust the fuel pressure relief valve.

CHECKING FUEL CONSUMPTION

42 After the engine has been run-in, check the gross fuel consumption in pounds or gallons per hour. The metering characteristics of the carburettor should be determined on a flow bench after the carburettor has been overhauled. However, it is advisable to make an additional check on the gross fuel consumption when the carburettor is actually mounted on and furnishing fuel to an operating engine. It is recommended that the fuel consumption be measured at several points within the cruising range and also at rated power and speed of the engine.

43 The gross fuel consumption may be determined readily at all times if a fuel flow meter accurately calibrated for the specific gravity of the fuel is installed in the fuel line to the engine. A flow meter of this type should be calibrated once every two months and should be accurate to plus or minus 1 percent throughout its usable range. Gross fuel consumption may also be found by timing a given weight of fuel that the engine consumes from a weight tank mounted on a scale. A third method of finding the gross fuel consumption is by timing a given volume of fuel consumed. The volume fuel flow tank should be accurately calibrated for the specific gravity of the fuel.

44 When determining gross fuel consumption, by the volume or weight method, the longer the duration of the check the more accurate the result will be. In any case, the time interval should not be less than one minute.

45 Fuel flow in pounds per hour is computed by means of the formula:

$$\text{Flow} = \frac{\text{lb.} \times 3600}{\text{sec}}$$

Thus, if it takes 108 seconds to empty 9 pounds of gas out of the weigh tank:

$$\text{Flow} = \frac{9 \times 3600}{108} = 300 \text{ lb./hr.}$$

46 If the fuel flow does not fall within the limits, all factors which might affect engine fuel consumption should be taken into consideration before rejecting the carburettor (or engine)

CHECKING OIL CONSUMPTION

47 The specific oil consumption should be determined at a definite speed and time. During this interval, the oil temperature in the circulating system should be stabilized and no oil should be added. The consumption is ascertained by subtracting the weight of oil, as indicated on the weigh tank scales at the end of the period, from the weight indicated at the beginning of the period.

48 During the run-in, determine the specific oil consumption during the one hour run at 2050 rpm. If the specific oil consumption at maximum cruising rpm is .015 pounds of oil per

horsepower hour less and decreasing, the condition of the newly fitted piston rings should be considered satisfactory. If the specific oil consumption is more than .015 pounds of oil per horsepower hour, the run-in should be continued to seat the piston rings further, after the run at rated speed is completed. The specific oil consumption at rated speed or above should not exceed .025 pounds of oil per horsepower hour. If the condition is not corrected after this extended run, remove the cylinders and investigate the condition of the rings. The oil flow should not exceed 30 to 50 pounds per minute at normal rated speed.

FINAL ENGINE CHECK

49 Since the test propeller does not have the same fly-wheel effect as an airplane propeller, it is impractical to make a final idle adjustment of the carburettor on the test stand. However, at the completion of the run-in, check the engine for idling, acceleration, and operation of the magneto. The operation of the engine and magneto on each of the breaker assemblies should be determined by checking the speed of the engine and noting the loss in rpm when operating each breaker assembly separately. The loss in rpm for either magneto should not be over 100, with about 70 rpm as the customary speed drop. If the engine speed drops more than 100 rpm when the magneto switch is turned to either "L" or "R", or if the difference between the two drop-offs exceeds 40 rpm, recheck the timing of the magneto to the engine. If one of the breaker assemblies still gives a high drop, check the internal timing of the magneto.

ENGINE SHUT-DOWN

50 If the engine is to be placed in storage after the test has been completed, consult EO 10A-10AA-9 for applicable preservation procedures.

REMOVAL OF HORIZONTAL TEST EQUIPMENT AN-5 Model

51 At the completion of the post-overhaul run-in of the AN-5 Model in a horizontal position, remove the test equipment and install the original parts.

NOTE

Do not reuse non-metallic gaskets; exchange each gasket removed for a new gasket.

52 Remove the starter and gasket from the rear case and install the starter drive cover plate and gasket. Remove the fuel pump and gasket and secure the fuel pump mounting pad cover and gasket in place. Remove the carburettor test adapter and re-install the original 90 degree adapter, securing it with washers, nuts, and lockwire. Remove the nuts securing the No. 5 intake and No. 6 exhaust rockerbox covers to the rockerboxes and loosen the nuts securing the T fitting to the sump; then remove the covers and T fitting intact. Remove the main oil sump to oil pump oil scavenge tube assembly, the rockerbox oil sump to oil pump oil scavenge tube assembly, and the rear case to supercharger case oil scavenge tube assembly. Remove the nuts securing the sump to the front and supercharger cases and remove the sump. Remove the blind cover and gasket from the rear face of the sump mounting boss on the front case.

53 Install gaskets and covers on the sump mounting bosses on the front and supercharger cases, and install covers and gaskets on the No. 5 intake and No. 6 exhaust rockerboxes. Remove the intercylinder drain hose from between the No. 7 and No. 8 cylinders and reinstall the T hose connection. Install the rockerbox to rear case oil scavenge tube, the front case to oil pump oil scavenge tube, and the rear case to oil pump oil scavenge tube, using gaskets and nuts. Re-install the gasket and cover plate on the supercharger case behind the No. 7 cylinder. Install the intercylinder deflector between the No. 5 and No. 6 cylinders.

54 Remove the tubing connecting the nipple at the oil pressure take-off on the rear case to the elbow (3); then remove the nipple and the rest of the impeller shaft seal oil feed connection from the engine. Re-install the square headed plug in the oil pressure take-off hole and the breather plug in the breather opening. Re-install the previously removed nut on the rear ignition manifold brace and secure it in place.

SERVICE INSTRUCTIONS

55 Instructions for preparing the engine for installation in an aircraft are contained in EO 10A-10AA-2 Description and Maintenance Instructions.

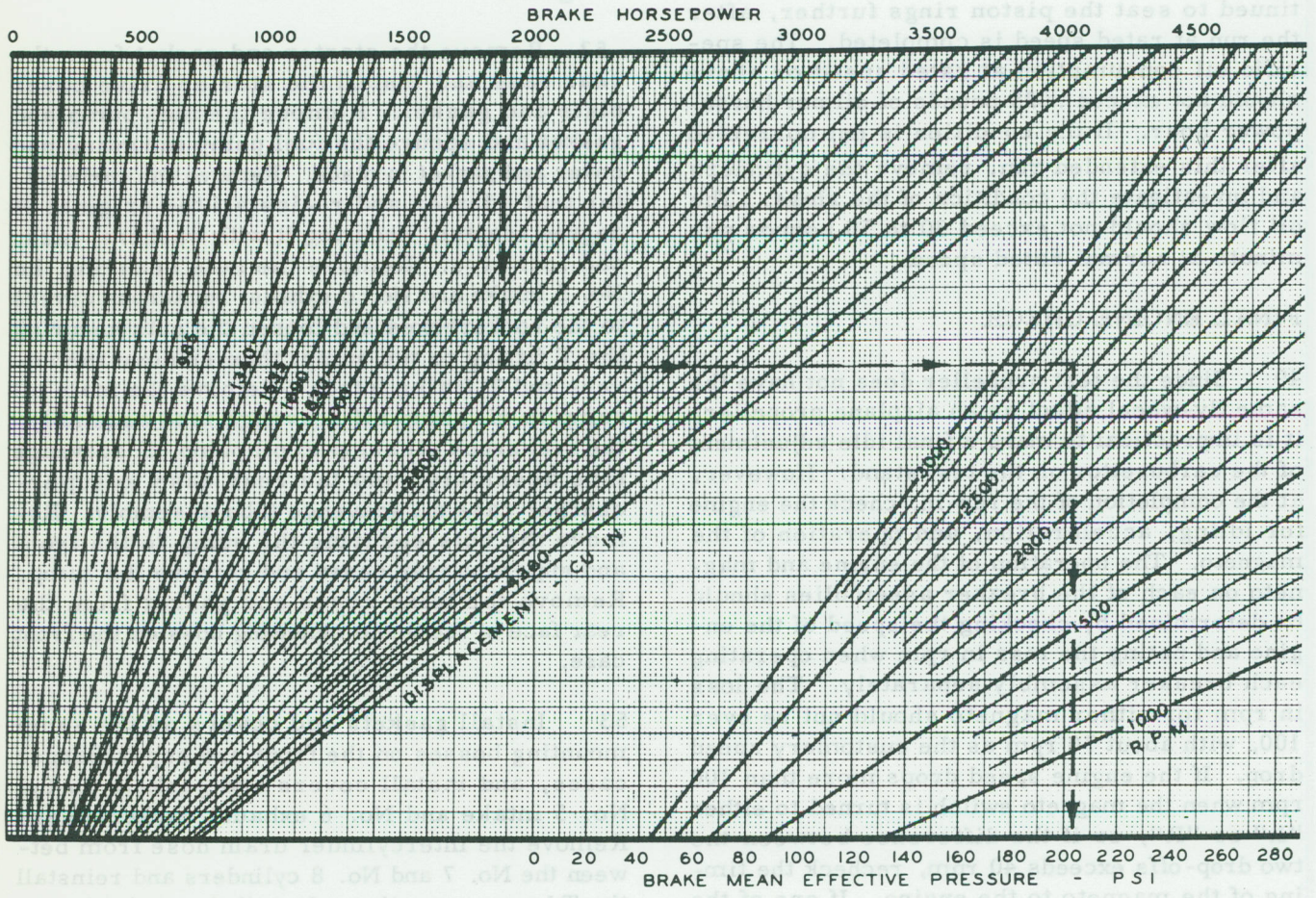


Figure 6-12 BMEP Chart for All Engine Displacements

PART 7

REPAIR MATERIALS

PRODUCT	RCAF REF. NO.	VENDOR	VENDOR'S ADDRESS
Anodex		McDermid, Inc.	526 Huntingdon Ave. Waterbury, Conn., USA
Champion No. 119 Graphite	See EO 15-5F-2A	Champion Spark Plug	8525 Butler Ave. Detroit, Michigan, USA
Clover 2A Compound		Clover Mfg. Co.	328 Main St., Norwalk, Conn., USA
Dow Corning No. 4 Compound	See EO 15-5E-2L	Dow Corning Corp.	Midland, Michigan, USA
Fairpreen Neoprene Cement No. 5128		E.I.duPont de Nemours & Co., Fabric Div.	New York, N.Y. USA
Lea Compound No. 305A		Lea Mfg. Co.	Maple & Cherry Sts., Waterbury, Conn., USA
Lubriplate No. 130A		Fiske Bros. Refining Co.	129 Lockwood St., Newark, N.J., USA
Metex No. 5	No. 33A/456 Paint Remover 1-GP-78	McDermid, Inc.	526 Huntingdon Ave., Waterbury, Conn., USA
No-Ox-Id		Dearborn Chemical Co.	Chicago, Ill., USA
Norm Paste No. 30		Specialty Sales,	530 Commonwealth Ave. Buena Park, Cal. USA
Norton 38601BE Grinding Wheel		Norton Co.	50 New Bond St., Worchester, Mass., USA
Okite	No. 33C/589 Cleaner Oil Tank Mil-C-7122 Type II	Oakite Products Inc.	22 Thames St., New York, N.Y. USA
Penetrol		Turco Products, Inc.	48th & So. Halstead Sts., Chicago, Ill, USA
Pennsalt K-7		Penn. Salt Mfg. Co.	Philadelphia, Pa. USA
Permatex No. 3		Permatex Co., Inc.	1720 Avenue Y, Brooklyn, N.Y. USA
Plastilube No. 3	3-GP-690 Mil AN-6-5A Grease	Warren Refining & Chemical Co.	750 Prospect Ave., Cleveland, Ohio, USA
Rust Ban		Penola, Inc.	Chicago, Ill., USA

Table 7-1 List of Products and Suppliers

PART 7

REPAIR MATERIALS

PRODUCT	RCAF REF. NO.	VENDOR	VENDOR'S ADDRESS
Anodex		MedDermid, Inc.	526 Huntingdon Ave., Waterbury, Conn., USA
Champion No. 119 Graphite	See EO 15-5F-2A	Champion Spark Plug	8525 Butler Ave., Detroit, Michigan, USA
Clover 2A Compound		Clover Mfg. Co.	328 Main St., Norwalk, Conn., USA
Dow Corning No. 4 Compound	See EO 15-5E-2L	Dow Corning Corp.	Midland, Michigan, USA
Fairpreen Neoprene Cement No. 5128		E.I.duPont de Nemours & Co., Fabric Div.	New York, N.Y. USA
Lea Compound No. 305A		Lea Mfg. Co.	Maple & Cherry Sts., Waterbury, Conn., USA
Lubriplate No. 130A		Fiske Bros. Refining Co.	129 Lockwood St., Newark, N.J., USA
Metex No. 5	No. 33A/456 Paint Remover 1-GP-7B	MedDermid, Inc.	526 Huntingdon Ave., Waterbury, Conn., USA
No-Ox-Id		Dearborn Chemical Co.	Chicago, Ill., USA
Norm Paste No. 30		Specialty Sales	530 Commonwealth Ave. Buena Park, Cal. USA
Norton 38601BE Grinding Wheel		Norton Co.	90 New Bond St., Worcheater, Mass., USA
Okite	No. 33C/589 Cleaner Oil Tank Mil-C-7122 Type II	Okite Products Inc.	22 Thames St., New York, N.Y. USA
Penetrol		Turco Products, Inc.	465th & So. Halstead Sts., Chicago, Ill. USA
Permalt K-7		Penn. Salt Mfg. Co.	Philadelphia, Pa. USA
Permatex No. 3		Permatex Co., Inc.	1720 Avenue Y, Brooklyn, N.Y. USA
Plastilube No. 3	3-GP-690 Mil AN-6-5A Grease	Warren Refining & Chemical Co.	750 Prospect Ave., Cleveland, Ohio, USA
Rust Ban		Penola, Inc.	Chicago, Ill., USA

Table 7-1 List of Products and Suppliers

PART 8

REPAIR

SECTION 1

GENERAL

1 Parts to be repaired should be marked to show the exact location of the damage, and bear a tag stating the reason for unserviceability. Markings must be removed from the part before re-installation.

2 When a new part is to be installed, and it is important that it be identified as to engine number or position in the engine, it should be marked in the same manner and the same location as the part with which it is exhanged.

3 Use the Table of Limits, Part 5 Section 3, as a guide in all repair and exchange operations involving fits, clearances, backlashes, spring pressures, and the application of torque.

4 Repair and exchange instructions covering groups of similar parts and general repair procedures are given in the paragraphs in this Section. Repair instructions covering parts which require special procedures and parts which cannot be readily grouped are given in Section 2.

ALUMINUM AND MAGNESIUM PARTS

5 Burrs or scratches which do not impair the serviceability of a part should be smoothed over or removed. If the paint on a part is excessively flaked, chipped, or scratched, the part should be completely repainted; refer to paragraph 20 of this Section under "Painting". Clean up galling, scratches, burrs, or unevenness of mating or parting surfaces with crocus cloth and oil. Remove corrosion from magnesium as directed under "Chronic Acid Treatment", paragraph 14 of this Section.

6 Whenever magnesium parts are reworked, care must be taken to remove dust, filings, turnings, and shavings as they are formed, since these types of magnesium burr very rapidly and under certain conditions become explosive. Finely divided scrap magnesium when mixed with water or water soluble cutting oils, also presents a very serious fire hazard.

WARNING

To prevent these dangers, use a liquid coolant of a straight neutral oil type, with a high flash point, such as mineral seal oil or kerosene. As a further safeguard, accomplish magnesium finishing or rework operations away from the vicinity of sparks or open flames.

BUSHINGS AND PLAIN JOURNAL BEARINGS

7 Using crocus cloth and oil, clean up bushings or plain journal bearings which are slightly scratched or scored. Do not disturb the glazed surface of a bushing or bearing which is not scratched or scored.

NOTE

Never touch a leaded bearing with an abrasive of any kind.

8 When replacing a bushing or plain journal bearing, use the tools which are listed in the picture index covering each specific bushing or bearing; see Figure 8-1 and Table 8-1.

9 If the bushing or bearing is pinned in place, remove the lock pins before attempting to remove the bushing or bearing. When a bushing or bearing is pinned in such a way that it is necessary to drill out the lock pin use the proper drill jig where listed. If a drill jig is not list-

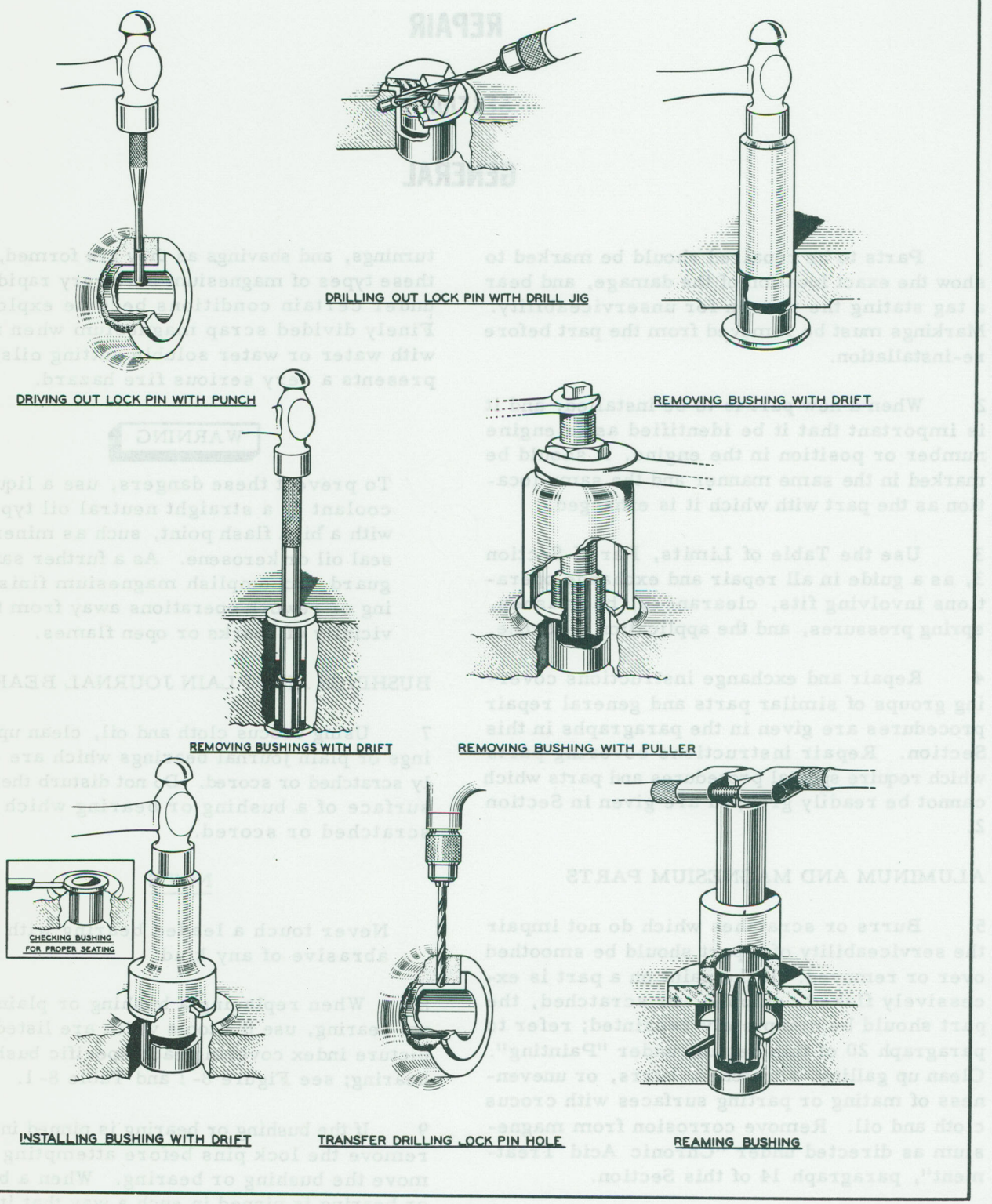


Figure 8-1 Exchanging a Bushing

ed, the lock pin should be driven out with a punch. When driving out a pin, be careful not to damage the bushing boss adjacent to the pin. If damage is likely to occur, the pin should be drilled out after the centre of the pin has been marked with a sharp punch.

10 After the lock pin has been removed, pull or drift out the bushing with the proper puller or drift. When installing a new bushing or bearing, make sure that any oil holes or grooves in the bushing or bearing are lined up properly with oil holes or grooves in the corresponding boss. If the bushing or bearing has a flange, check the flange with a .001 inch gauge to make sure that it is firmly seated. If a drill jig was used in drilling out the lock pin, it should also be used in drilling a new pin hole at least 30 degrees from any existing pin holes. When drilling a new pin hole, be careful not to allow the drill to break into any oil passages.

11 If the old lock pin was driven out with a punch, transfer-drill the new pin hole, using the existing pin hole in the boss as a guide. Drift in new pins with a suitable punch, and peen the hole in the boss if the new bearing or bushing was transfer-drilled. Ream new bushings and bearings to size, polish them with crocus cloth and oil, and check their size with the proper bore gauges. Thoroughly clean bushings or bearings and oil passages after reaming operations.

LEAD-INDIUM PLATED BEARINGS

12 If a leaded bearing is to be exchanged and the new bearing has been in storage, examine the new bearing for oxide film or stain before installing it. Filmed or stained bearings will have spotted areas which are hard and black. It is not considered necessary to remove these stains unless inspection indicates that the staining is unusually severe. If desired, staining may be removed from lead plated surfaces in accordance with the following procedure: Degrease the bearing; then clean it electrolytically in an alkaline cleaner at 82°C to 93°C (180°F to 200°F), with the bearing as the cathode. Line voltage of approximately 6 volts should be used to supply current. Use an alkaline cleaner such as Pennsalt K7, Anodex, or any similar electrolytic cleaner, in the proportion of 9 to 14 ounces of cleaner to each gallon of water. Approximately 4 to 6 seconds will normally be needed to clean the bearing, but if the bearing has been in storage for a long time, up to 10 seconds cleaning time is permissible. After cleaning, rinse the bearing first in cold water and then in hot water. Wipe it dry with a clean cloth or a cotton swab; then oil the bearing with a corrosion preventive compound such as Rust or No-Ox-id.

OIL SEAL RING CARRIER GROOVES

13 If it becomes necessary to grind these grooves to accommodate oversize rings, it should be accomplished as follows:

(a) Using a suitable arbor, hold the carrier in a grinding machine, such as the Brown and Sharpe No. 2 Universal, equipped with a 12 inch x 1/2 inch x 1/4 inch x 5 inch - 80N grinding wheel which has been dressed to have corner radii of .010 x .015 inch, and a two degree taper on the sides. Adjust the carrier to run true within .001 inch full indicator reading. Move the wheel in and grind one side of the groove to a smooth even finish. Grind the other side of the groove in the same manner, and then repeat in the remaining grooves. In grinding the sides of the grooves, no more material should be removed than is necessary to clean up the step and accommodate the next oversize rings.

(b) After grinding the grooves magnaflux the carrier as directed in Part 4, Section 4.

CHROMIC ACID TREATMENT

14 Magnesium parts on which there are signs of corrosion or on which the original chrome pickling is no longer effective may be treated as described in the following paragraphs so that they will be protected against corrosion. A steel tank large enough to submerge any part to be treated is required. Thoroughly clean the part to be treated as described in Part 3, "Cleaning", then remove any paint as described in paragraph 20 of this Section under "Painting".

15 Where close tolerances are not required, remove corrosion with a wire brush or abrasive paper. Where close tolerances are required, swab or brush the surface with a chro-

mic acid solution at a temperature of 60°C to 71°C (140°F to 160°F) containing 1 1/2 pounds of CrO_3 with enough water to make a gallon of solution. If tap water is used, 0.1 percent silver nitrate ($AgNO_3$) should be used to precipitate any soluble chlorides. Dissolve the silver nitrate in distilled water and add it to the chromic acid bath. Rinse the part thoroughly first in cold water, then in water at a minimum temperature of 82°C (180°F). Drain the part and dry it with compressed air.

16 Spot treat areas cleaned of corrosion or the original chrome pickling by swabbing or brushing the areas with a chrome pickling solution containing 1 1/2 pounds of sodium dichromate ($Na_2Cr_2O_7$-$2H_2O$) and 1 1/2 pints of nitric acid (HNO_3-Sp. Gr. 1.42) with enough water to make one gallon of solution. Using an acid resistant container, add approximately 3 quarts of cold water, completely dissolve the sodium dichromate, and then slowly add the nitric acid. Add sufficient water to make one gallon of solution, stirring the solution until it is thoroughly mixed.

WARNING

The operator should wear rubber gloves during this operation.

17 The chrome pickling solution should be maintained at a temperature of 12°C to 29°C (55°F to 85°F) and should not be applied for more than 15 seconds. Immediately following the application of the solution, rinse the part in cold water and then in water at a minimum temperature of 82°C (180°F) and dry the part with compressed air.

EXPANSION OF PARTS BY HEAT

18 When a tight fitting part requires exchanging, it may be necessary to apply heat to the metal surrounding it in order to facilitate removal of the old part and installation of the new part. The method of heating least likely to cause warping is to place the part in an oven and bring the entire part gradually up to the required temperature. However, it is usually more convenient to heat the part with a torch, and this method is satisfactory provided the heat is applied with sufficient care. When applying heat with a torch, use a soft flame gas torch and play the flame over the engine area surrounding the part to be removed. Do not hold the flame too long on any one spot. Never heat a magnesium part with a torch. Immersing magnesium parts in actively boiling water will expand them sufficiently without the fire hazard or danger of warping occasioned by the use of a torch. Except where otherwise specified, magnesium parts should be kept below 120°C (248°F) and aluminum parts should be kept below 150°C (302°F).

19 If a part has been heated or cooled prior to assembly, make sure that sufficient time has elapsed for the temperature of the part to reach that of the surrounding areas before attempting a torque operation intended to secure the retention of the heated or cooled part, either directly or indirectly.

PAINTING

20 Before parts are repainted at overhaul, their surfaces must be properly prepared to receive the paint.

21 If the original finish is to be removed, any one of three methods of stripping may be used. The most effective method is to dip the painted part in a heated stripping solution. A second method is to brush a heavy coat of paint remover on the paint and then wipe the old paint from the metal. A third method is to remove the paint with a stiff wire brush. If paint is removed from magnesium parts with a stiff wire brush, treat the parts as described in paragraph 14 of this section, "Chromic Acid Treatment," to prevent corrosion. If the old paint is not to be removed, the surface of the part should be smoothed with emery or crocus cloth before the part is repainted.

CAUTION

If a section that incorporates a specially processed leaded bearing is to be repainted, carefully protect the bearing from the paint stripper.

22 Thoroughly degrease and dry the surfaces to be painted. Plug all holes and mask all areas not to be painted. First apply one coat of zinc

chromate primer; then bake the part for 1/2 hour at 120°C (248°F). Next apply two coats of grey or black enamel and bake each coat for 1 3/4 hours at 135°C (275°F). Paint may be applied either with a spray gun or with a brush.

NOTE

If baking equipment is not available, a type of enamel which may be air dried must be used. Be sure that each coat is completely dry before applying the next coat.

STRIPPING PRESERVATIVE VARNISH

NOTE

Before stripping an engine part of resin coating in a mechanized cleaning system, ascertain from the vendor of the cleaning fluid that the resin coating will not have a deleterious effect upon his product.

23 To strip an engine part of resin coating procede as follows:

(a) Pour into a clean steel tank of suitable shape and size sufficient tap water to cover the part to be stripped.

(b) Add from 4 to 6 ounces of RCAF Reference No. 33A/456 Paint Remover 1-GP-78 (contractors may use Metex No. 5) for every gallon of water.

WARNING

The solution is a strong alkali. Personnel must wear rubber gloves and apron, and avoid spilling it.

(c) Heat the solution to 93°C (200°F).

(d) Mask off any lead or silver surfaces of the part with rubber stoppers.

(e) Immerse the part in the solution until all resin coating has been removed. Removal can be facilitated by scrubbing with a fibre brush.

(f) Rinse the part thoroughly in a tank of cold, air-agitated water to remove all traces of alkali.

(g) Remove the rubber stoppers if fitted and rinse the part again in clean water heated to 82° to 93°C (180° to 200°F).

(h) Dry the part with an air hose and apply a light covering of oil to protect the surfaces from corrosion.

24 If the paint remover specified in paragraph 23 (a) is not available, an alternative stripping solution can be made, using commercial materials, as follows:

(a) Mix together -

1 part, by weight, of Sodium Resinate.
3 parts, by weight, of Sodium Metasilicate.
1 part, by weight, of Trisodium Phosphate.
2 parts, by weight, of Sodium Carbonate.
4 parts, by weight, of Sodium Hydroxide.

(b) Dissolve the mixture in tap water in the proportions of 8 ounces of mixture to every gallon of water.

RIVETS

25 Any loose rivet should be tightened if possible; otherwise, it should be renewed.

RUBBER PARTS AND PACKINGS

26 All rubber parts and packings should be changed at every overhaul.

STEEL PARTS

27 Clean up and smooth over any burrs and minor galling, pitting, or scratches with crocus cloth and oil or with a fine stone. Be sure to smooth over all bearing journals. It is usually advisable to use a fine flat stone when cleaning up gear teeth.

NOTE

After steel parts have been reworked in any way, they must be given a complete magnaflux inspection.

STUDS

28 Studs which are stretched, loose, or have damaged threads should be exchanged for oversize studs. Whenever a stud which is already oversize requires changing, use the next oversize. Where the threads of a stud hole have become damaged or stripped, it is possible, if there is sufficient material around the hole, to drill and re-tap the hole for a special stepped stud. Use the proper standard stud drivers to install new studs, see Part 9, "Special Tools", and Table 8-1.

NOTE

When installing a stud which has a cotterpin or a lockwire hole, the projection length should be measured to the bottom of the hole. (Figure 8-2).

29 Table 8-2 illustrates the various methods of marking oversize studs for identification. The identifying mark is on the anchor end of the stud. The conical projection or green dye for .004 inch oversize studs, the conical cup or red dye for .008 inch oversize studs, and the drilled hole or purple dye for .012 inch oversize studs are the Pratt & Whitney Aircraft Standard identifying marks. The other marking methods are illustrated because they are used by various vendors and may be encountered in the field.

30 When installing an oversize stud in a stud hole which goes completely through a part, make sure that the anchor end of the stud does not project sufficiently to interfere with other parts. If necessary, file off the anchor end enough to prevent such interference; then reidentify the stud with the proper oversize mark.

SCREW BUSHINGS

31 If a screw bushing needs changing, drill out any lock pins; then remove the bushing, using the proper tools. Install new bushings with the proper driver, drilling new lock pin holes if necessary and installing new lock pins.

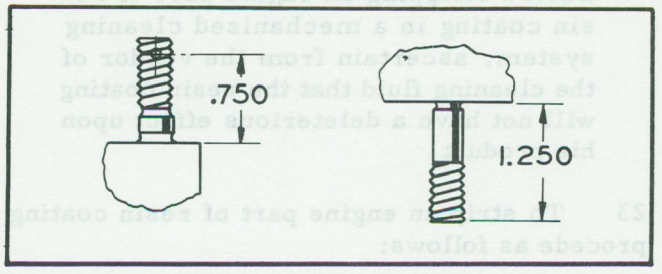


Figure 8-2 Stud Projection Measurement

Part No.	Description	Number of Units Per Assembly	Notes- Projection length
FRONT SECTION (AN-5 Model)			
58843	Propeller Regulator Valve	2	.646- .666 inch
28255	Propeller Regulator Valve Cover Stud	4	.615- .635 inch
109454	Propeller Regulator Valve Housing	1	Refer to tool group No. 17. Change both front and rear bushing if either needs changing.
109453	Propeller Regulator Valve Housing Bushing	1	See page 45, and refer to tool group No. 93.
90106	Sump Attaching Stud	2	1.240- 1.260 inch
62	Thrust Cover Dowel	1	Drive in dowel until it bottoms.
77765	Thrust Cover Stud	2	1.271- 1.291 inch
42419	Thrust Cover Stud	5	1.271- 1.291 inch

Table 8-1 Stud, Dowel, and Bushing Exchange Data

Part No.	Description	Number of Units Per Assembly	Notes- Projection length
FRONT SECTION (AN-14B Model)			
12088	Propeller Regulator Valve Cover Stud	2	.834- .854 inch
12089	Propeller Regulator Valve Cover Stud	2	.615- .635 inch
12055	Sump Attaching Stud	2	1.240- 1.260 inch
62	Thrust Cover Dowel	1	Drive in until dowel bottoms.
42419	Thrust Cover Stud	7	1.271- 1.291 inch
CRANKCASE			
15	Bushing Pin	1	Drill .125 inch for pin.
5670	Cam Reduction - Gear Bushing	1	Refer to tool group No. 16
12081	Cylinder Flange Stud	90	.803- .823 inch
42422	Front Case to Crankcase Stud	1	.834- .854 inch
54610	Front Case to Crankcase Stud	11	.990- 1.010 inch
38300	Front Case to Crankcase Stud	6	1.396- 1.416 inch
12085	Supercharger to Crankcase Stud	1	.865- .885 inch
12057	Supercharger to Crankcase Stud	17	1.178- 1.198 inch
SUMP ASSEMBLY (AN-14B Model)			
12317	Rear Oil Pump Oil Scavenge Pipe Stud	4	.678- .698 inch
39079	Rocker Oil Drain Fitting Stud	2	.802- .822 inch
SUPERCHARGER CASE			
5025	Impeller Intermediate Shaftgear Bearing Liner	1	Finish ground ID 2.0485 plus or minus .0005
24	Locking Pin	1	Drill .218 deep using a No. 43 drill.
1172	Magneto Drive Shaft Bearing	2	See tool group No. 78 Line ream at assembly .750 plus or minus .0005
12054	Oil Drain tube Stud	2	.615- .635 inch
90105	Oil Sump Attaching Stud (AN-5 Model)	2	1.459- 1.479 inch
9252	Oil Sump Attaching Stud (AN-14B Model)	2	1.459- 1.479 inch
11345	Supercharger to Rear Case Stud	2	.928- .948 inch; AN-14B Model uses 4
7959	Supercharger to Rear Case Stud	3	1.209- 1.229 inch
625	Supercharger to Rear Case Stud	9	.865- .885 inch; AN-14B uses 7
9385	Supercharger to Rear Case Stud	1	1.646- 1.666 inch
9085	Supercharger to Rear Case Stud	1	.740- .760 inch

Table 8-1 Stud, Dowel and Bushings Exchange Data (continued)

Part No.	Description	Number of Units Per Assembly	Notes- Projection Length
REAR CASE			
1171	Accessory Drive Shaft Bushing	2	Ream .9995- 1.0005
11345	Carburettor Flange Stud	4	.927- .947 inch
626	Carburettor Flange Stud (Centre)	2	.724- .744 to wire hole.
656	Fuel Pump Pad Stud	4	.990- 1.010 inch
9085	Generator Pad Stud (AN-5 Model)	4	.740- .760 inch
12086	Generator Pad Stud (AN-14B Model)	4	1.365- 1.385 inch
1174	Magneto Drive Shaft Long Bushing	2	Refer to tool group No. 78.
11051	Magneto Locating Dowel	4	.178- .198 inch
62	Oil Pump Dowel	1	.302- .322 inch
23299	Oil Pump Stud	2	2.490- 2.510 inch
19868	Oil Pump Stud	4	1.740- 1.760 inch
12317	Oil Scavenge Tube Studs	2	.678- .698 inch
25	Pin (Accessory Drive Shaft Bushing)	2	Stake in pin.
43567	Pin (Tachometer Drive Liner Coupling Bushing)	2	
77913	Side Auxiliary Drive Pad Stud (Left and Right)	8	.865- .885 inch
12082	Starter Pad Stud (Top)	2	.990- 1.010 inch
12091	Starter Pad Stud	4	1.021- 1.041 inch
1191	Starter Shaft Bushing	1	Temporarily assemble Supercharger and rear cases and line ream bushing hole if an over-size bushing is installed: Cuts on bushing flange should be vertical. Slot from oil hole on bushing stem should be on right side as viewed from the rear.
76366	Tachometer Drive Inner Coupling Bushing	2	See paragraph 159, and refer to tool group No. 124.
28834	Vacuum Pump Adapter Dowel	1	.115 to .135 inch
35139	Vacuum Pump Drive Gear Bushing	1	Refer to tool group No. 130
123423	Vacuum Pump Pad Stud	4	1.090- 1.110 inch
CYLINDER			
12054	Deflector Fastening Stud	2	.615- .635 inch
625	Exhaust and Intake Flange Stud	5	.865- .885 inch
15072	Rockerbox Cover Stud	8	.615- .635 inch

Table 8-1 Stud, Dowel and Bushings Exchange Data (continued)

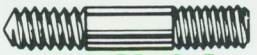
OVERSIZE	+.004 in.	+.008 in.	+.012 in.
P. & W. A. STANDARD	 OR GREEN DYE	 OR RED DYE	 OR PURPLE DYE
STAMPED NO. WITH PREFIX +			
STAMPED NO. WITHOUT PREFIX			
STAMPED OR SCRIBED LINE			
STAMPED OR SCRIBED LINE			

Table 8-2 Oversize Stud Identification

OVERSIZE	+.004 in.	+.008 in.	+.012 in.
P & W.A. STANDARD	OR GREEN DYE	OR RED DYE	OR PURPLE DYE
STAMPED NO. WITH PREFIX +	+4	+8	+12
STAMPED NO. WITHOUT PREFIX	4	8	12
STAMPED OR SCRIBED LINE			
STAMPED OR SCRIBED LINE			

SECTION 2

SPECIFIC

THRUST BEARING LINER EXCHANGE (R985 Engine)

1 Refer to "Expansion of Parts by Heat" paragraph 8 section 1. Heat the portion of the case adjacent to the liner to a temperature of 93° to 121°C (200° to 250°F). Shrink the liner with dry ice and drift the liner from the case. Check the bore of the case for galling, roughness, and out of roundness, and clean up any roughness or galling.

2 Chill the new liner with dry ice; reheat the case to the same temperature as above and insert the liner in the case. Making certain, while the case is still hot, that the oil holes in the liner coincide with those in the case, and that the liner is properly bottomed. Check the seating of the liner with a .001 inch feeler gauge.

3 Mount the case in a lathe, and true it up to within .001 inch full indicator reading, taken on both the face and the bore of the liner (Figure 8-3).

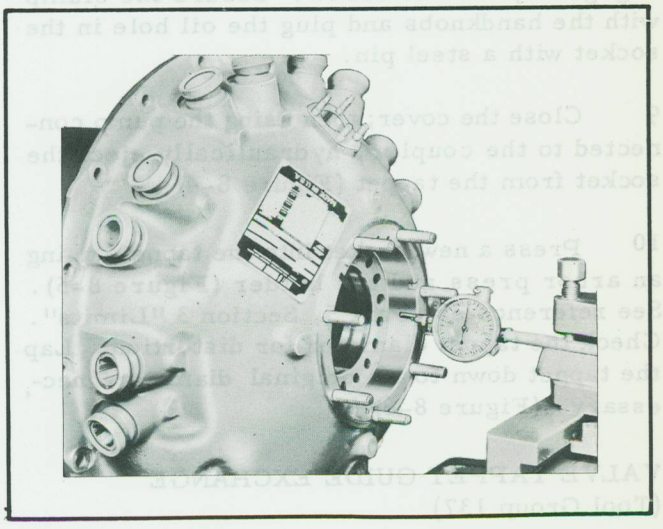


Figure 8-3 True Case in Lathe

4 Using the portable grinder mounted on the tool rest, grind the bore of the liner to 5.5120-5.5130 inch diameter and depth grind the thrust bearing seating surface from rear flange to front face of liner to 1.217 inch plugs or minus .002 inch. Use the wet grinding method, if possible. After grinding, break all sharp edges with a fine file and polish the bore of the liner with crocus cloth and oil.

CAM REPAIR

5 If a cam track has become pitted, remove the pit marks with an oil stone when the removal of the pit marks can be accomplished without taking more than .005 inch of material from the cam track. Blend the resulting depression into the contour of the surrounding surface. If the damaged area cannot be removed within the above working limits, and it is believed that the original cam track form can be restored by the removal of not more than .005 inch of material from the entire cam track, return the cam to the manufacturer for regrinding.

6 To change the cam hub proceed as follows:

(a) Start the rivets with a round nose punch; then remove them with a rivet puller. Separate the hub and the cam, using a leather mallet. Clean up the rivet holes and their countersunk areas.

(b) Install the new hub on the cam and transfer drill the rivet holes with a No. 22 (.157 inch) drill; then countersink the drill holes and clean up with crocus cloth and oil. Install the rivets, and upset the ends, using a riveting machine or a round nose punch. Grind the rivet ends flush with the rear surface of the cam, using a surface grinder.

CAM OIL FEED TUBE AND BRACKET (R985 Engine)

7 If the oil feed tube is loose in the bracket, tighten it by coating the end of the tube with solder.

VALVE TAPPET BALL SOCKET EXCHANGE
(Tool Group 135)

8 Place the tappet between the clamp and holder of the pusher so that the oil hole can be engaged by the set screw. Secure the clamp with the handknobs and plug the oil hole in the socket with a steel pin.

9 Close the cover; then using the pump connected to the coupler, hydraulically eject the socket from the tappet (Figure 8-4).

10 Press a new socket into the tappet, using an arbor press and the holder (Figure 8-5). See reference 28, Part 5, Section 3 "Limits". Check the tappet diameter for distortion. Lap the tappet down to its original diameter if necessary (Figure 8-6).

VALVE TAPPET GUIDE EXCHANGE
(Tool Group 137)

11 Refer to "Expansion of Parts by Heat", Paragraph 18, Section 1 and heat the case adjacent to the guide to 120°C (248°F); then remove the old guide, using the drift Clean up the guide hole with corcus cloth and oil.

12 If a standard size guide will not give the desired fit, .005 inch, .010 inch and .015 inch oversize guides are available. When an oversize guide is to be installed, ream the hole only enough to ensure roundness. (Figure 8-7); then turn down the OD of the oversize guide to give the desired fit (Figure 8-8). Prior to installation, coat the guide and the case hole with graphite grease. Heat the case again to 120°C (248°F), chill the guide if necessary, and install it in the case.

CAUTION

Do not allow the flame to reach the area around the crankshaft bearing liner. Apply heat to the boss only and do not heat the crankcase section above 120°C (248° F).

Part No.	Cylinder No.	Position	Type
39493	8, 9, 1, 2, 3	Inlet	Drain
39494	4, 5, 6, 7	Inlet	No Drain
39495	8, 9, 1, 2, 3	Exhaust	Drain
39496	4, 5, 6, 7	Exhaust	No Drain

Table 8-3 Valve Tappet Guide Data

NOTE

If the AN-5 Model does not already incorporate the new type draining tappet guides, install them at all locations. Drill eight 1/4 inch diameter drain holes through the tappet guide bosses in the front case at the locations shown (Figure 8-9) and install the new guides.

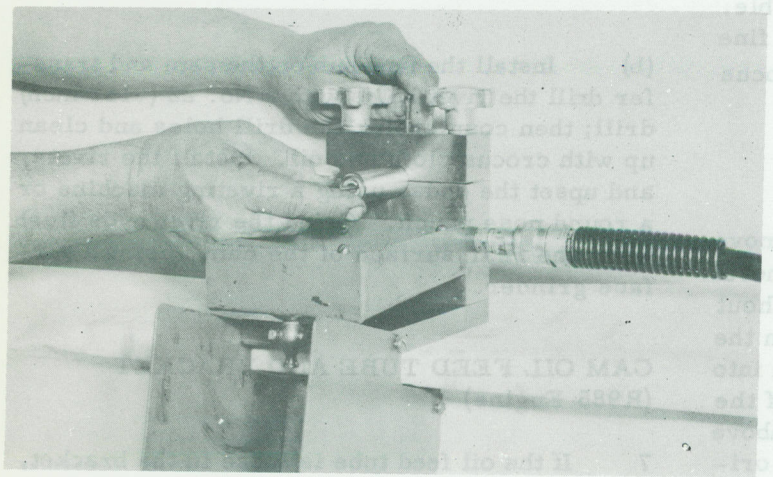


Figure 8-4 Eject old Socket

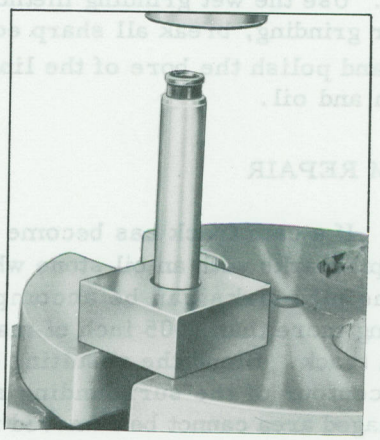


Figure 8-5 Press in new Socket

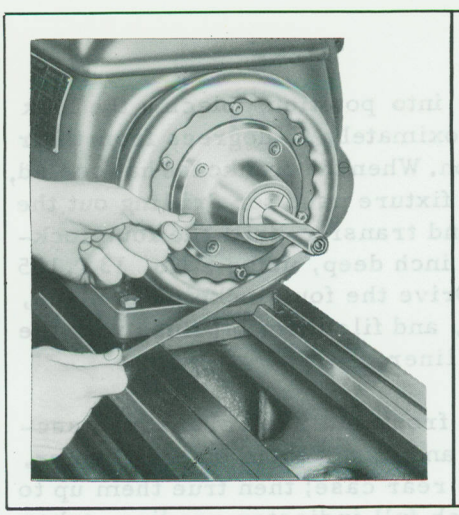


Figure 8-6 Lap Tappet

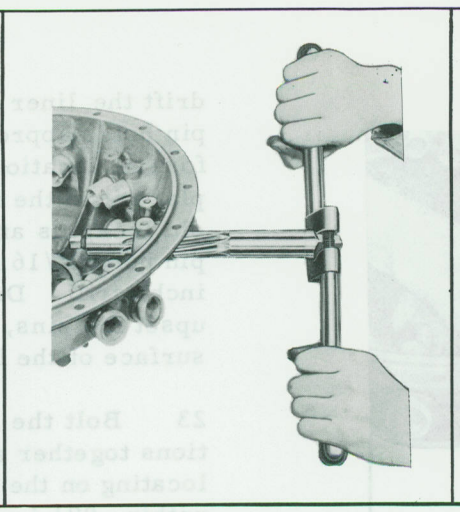


Figure 8-7 Ream Hole

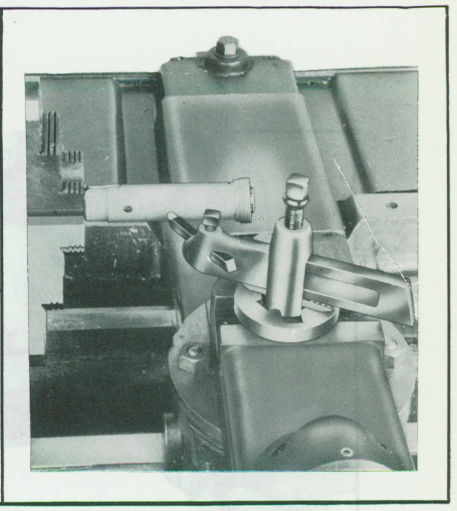


Figure 8-8 Turn down Guide

13 If two adjacent valve tappet guides are to be installed, insert the aligning plug in one guide hole; then place the aligning bar in the slotted end of the plug to align the adjacent inlet or exhaust guide while it is being installed. Drive the guide into position, using the drift (Figure 8-10). If only one guide is to be installed, place the aligning bar in the slotted end of the installed guide and drift the new guide into position.

14 After all the guides have been installed and before the case has cooled, drive each guide solidly into position, using the drift and a mallet; then check the alignment of all guides, using the aligning bar. If the aligning bar does not slide freely in the guide slots, the guides are not parrallel and must be repositioned.

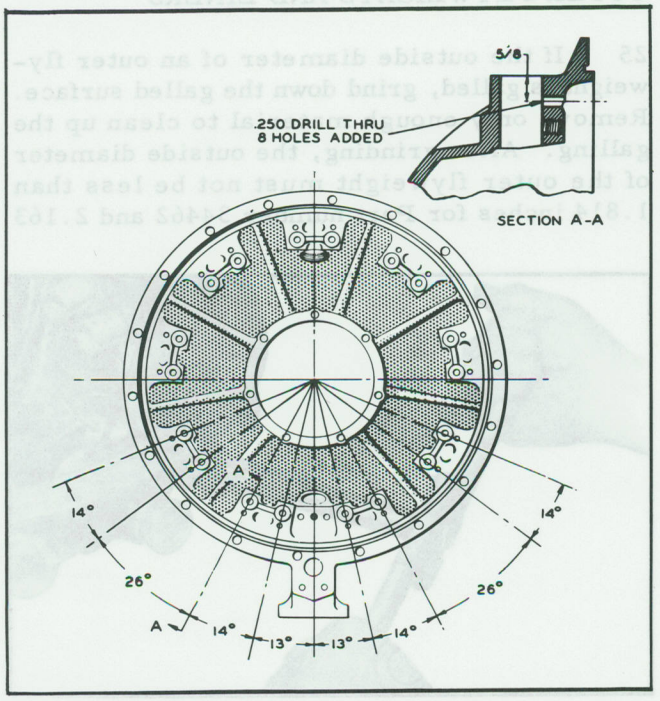


Figure 8-9 Drain hole Locations

15 Tap the screw holes in each newly installed guide with a 5/16-24 NF-3 tap. Install the reaming clamp on the slotted end of the guide to prevent expansion; then finish ream the guide, using the spiral reamer (Figure 8-11).

PROPELLER AND THRUST BEARING OIL FEED TUBE, BUSHING AND LINER AN-5 Model (Tool Group 93)

16 To exchange the oil feed tube that directs oil to the thrust bearing oil ring carrier, first remove the inner bushing from the liner in the front case, using the puller, then withdraw the oil feed tube. Remove the bushing liner from the front case, using the drift.

17 Clean up the liner hole in the front case and, using the assembly drift, install a new Part No. 109454 bushing liner in the case.

18 Secure the drill Jig to the two thrust bearing cover studs adjacent to the control valve pad on the case. Use detail No. 2 bushing of the jig to drill a .302 diameter ("N" size drill) hole through the ID of the newly installed bushing This hole should be in line with the oil feed tube hole in the case. Use detail No. 3

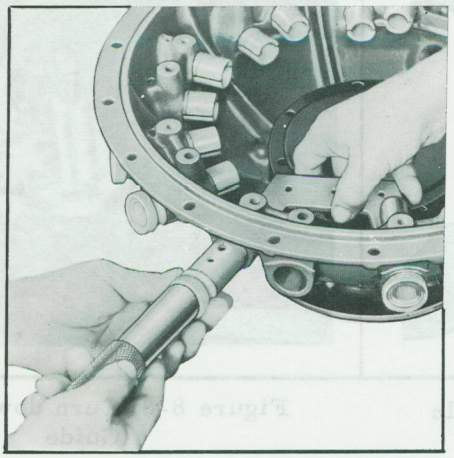


Figure 8-10 Install new Tappet Guide

bushing and ream the hole to a .3215 diameter hole. Clean all chips from the hole with an air blast or flushing oil.

19 Install the oil feed tube, bleed end first, through the hole in the bushing until it engages the hole in the thrust bearing liner. If the oil feed tube is properly seated in the thrust bearing liner, the outer end of the tube will not project into the ID of the liner.

20 Install a Part No. 109453 bushing in the bushing liner, using the assembly drift.

CRANKSHAFT FRONT AND REAR BEARING LINERS

21 If either of these liners requires changing, mount the front or rear crankcase section, parting face down, on a suitable fixture so that it is at an angle of 60 degrees to the bed of a drill press; then spot drill the four lockpins 1/8 inch deep using a No. 52 (.062 inch) drill. Drill out the pins with a No. 15 (.180 inch) drill, making sure that all of the pin is removed from the hole before attempting to drift out the liner. After referring to Section 1 paragraph 18, heat the crankcase to 120°C to 150°C (248°F to 320° F); then drive out the liner. Clean up the bore of the case.

22 Reheat the crankcase to 120° to 150°C (248° to 302°F), and chill the new liner; then drift the liner into position, placing the lock pin holes approximately 45 degrees from their former location. When the crankcase has cooled, place it in the fixture used for drilling out the old lockpins and transfer-drill the four lockpin holes 7/16 inch deep, using a No. 13 (.185 inch) drill. Drive the four lockpins in place, upset the pins, and file them off flush with the surface of the liner.

23 Bolt the front and rear crankcase sections together and mount them on the adapter, locating on the rear case; then true them up to within .001 inch full indicator reading, taken on both the front parting face and the OD of the crankcase front section. Grind the liners to the prescribed diameter (Figure 8-12).

24 Data for wet grinding crankcase liners is:

(a)	Surface Speed	5859 ft/min.
(b)	Wheel Speed	5500 rpm.
(c)	Work Speed	100 rpm.
(d)	Type of Wheel	3880 18BE

OUTER FLYWEIGHTS AND LINERS

25 If the outside diameter of an outer flyweight is galled, grind down the galled surface. Remove only enough material to clean up the galling. After grinding, the outside diameter of the outer flyweight must not be less than 1.814 inches for Part number 34462 and 2.163

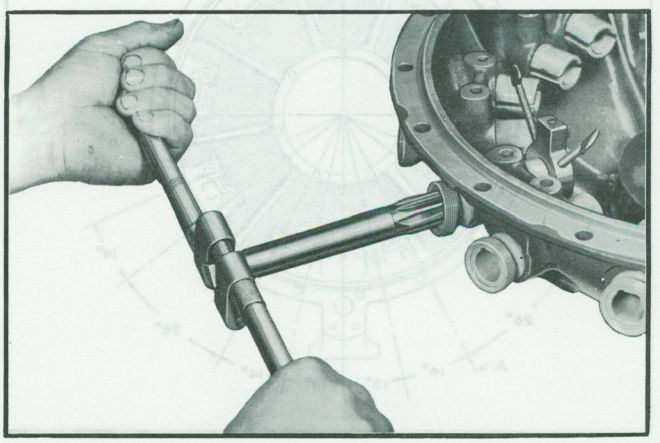


Figure 8-11 Finish Ream Tappet Guide

inches for Part No. 34463. The ground surfaces must be treated with Parco-Lubrite.

26 If the inside diameter of the flyweight liner is galled, grind down the galled surface to a 20-40 RMS finish. Remove only enough material to clean up the galling. After grinding, the inside diameter of the liner must not exceed 2.310 inches.

CRANKPIN LAPPING (Tool Group 20)

27 Plug the holes in the crankpin with heavy grease or soft wax; then lap the crankpin (Figure 8-13). After lapping, polish the crankpin with crocus cloth and oil, and wash the crankshaft thoroughly. If the crankpin is too badly scored or too much out of round to be reconditioned by lapping, return the crankshaft to the manufacturer for reconditioning.

MASTEROD BEARING EXCHANGE (Tool Group 74)

28 The prefitted type of lead silver masterod bearing, with which these engines are equipped, requires no boring or fitting to the masterod. The tolerances of prefitted masterod bearings are held to extremely close limits and when they are assembled in the masterod, they should not be altered in any way.

29 Masterod bearings are available in from .002 inch to .020 inch undersize and from .005 inch oversize on the OD and .002 inch undersize on the ID, to .010 inch oversize on the OD and .006 inch undersize on the ID. In ordering the special undersize bearings, specify the diameter of the crankpin rather than the size of the bearing.

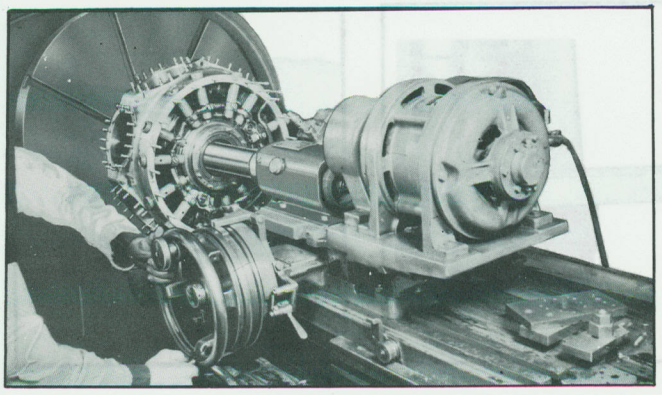


Figure 8-12 Grind Main Bearing Liners

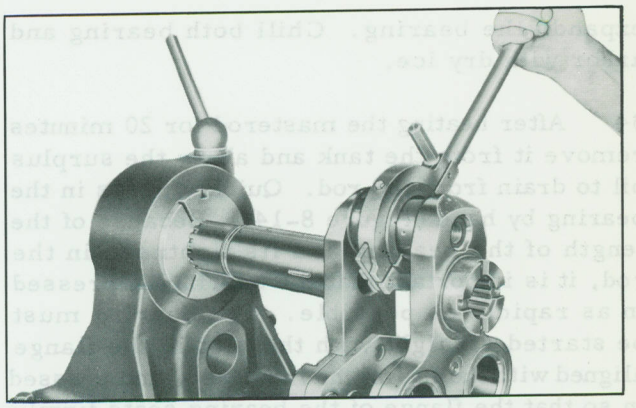


Figure 8-13 Lap Crankpin

30 To remove the masterod bearing, heat the masterod assembly in an oil bath, using a heat transfer and baking oil having a minimum flashpoint of 330°C (626°F) at 218° to 232°C (425° to 450°F). Place the masterod, bearing flange side down, on a wooden block incorporating a hole large enough to receive the bearing. Install the drift, in the bearing, apply water, and drift out the bearing with a heavy hammer.

31 After the bearing is removed, measure the bore of the masterod. Reinstall the linkpins in their holes as the press fit is apt to affect the rod bore measurement. If the bore is enlarged so that a standard size bearing will not give the proper fit, return the masterod to the manufacturer for reoperation.

32 Inspect magnetically the bore of the masterod whenever a bearing is removed. It is recommended that the bearing be removed and the rod bore inspected magnetically at every overhaul for helicopter installations and alternate overhauls for conventional installations. See Section 3, Part 4.

33 To install a bearing, heat the masterod in the oil bath to 218° to 232°C (425° to 450°F). Place the bearing in position on the assembly arbor. Insert a piece of paper between the arbor and the bearing to protect the bearing surface. Tighten the arbor handle lightly to avoid difficulty in removing the arbor after the heat

expands the bearing. Chill both bearing and arbor with dry ice.

34 After heating the masterod for 20 minutes remove it from the tank and allow the surplus oil to drain from the rod. Quickly press in the bearing by hand (Figure 8-14). Because of the length of the bearing and its tightness in the rod, it is important that the bearing be pressed in as rapidly as possible. The bearing must be started straight with the slot in the flange aligned with the lug on the masterod, and pressed in so that the flange of the bearing seats firmly against the rear face of the masterod. After the masterod has cooled to room temperature, place the rod and bearing under an arbor press and, using the arbor, press the flange of the bearing against the face of the rod.

LINKPIN HOLES IN MASTEROD

35 The masterod linkpin holes may be ground oversize if the proper equipment is available or the masterods may be returned to the manufacturer for this rework. Oversize linkpins are available. Refer to Part 4, "Inspection".

REMOVAL OF RUST PITTING ON MASTERODS AND LINKRODS

36 In order to salvage rust-pitted master and linkrods, the rod must first be cleaned in an alkali bath; then polished and buffed.

37 The amount and severity of pitting which may remain after the rods have been polished, must to a great extent, be left to the judgment and discretion of the inspector. In considering the surface condition it should be borne in mind that a pitted condition is least acceptable in that area of the rod where the channel section merges into the pistonpin or linkpin strap.

PISTONPIN BUSHING EXCHANGE (Tool Group 89)

38 Drill through the lockpin using a small drill (No. 30 approximately) then press out the old bushing, either solid or split type, using the drift and an arbor press(Figure 8-15). Drift the sheared lockpin out of the linkrod(Figure 8-16).

39 Press a new bushing into the linkrod, using the drift (Figure 8-17). In case a split bushing is used, install the bushing so that its ends are as nearly flush with the faces of the bushing boss as possible and so that the split is toward the pistonpin end of the rod and 60 degrees from the centreline of the rod. Slide the pistonpin bushing end of the linkrod over the expanding arbor and lock in place. Using a drill press with the stop set to contact a 0.040 inch gauge placed on the expanding arbor, transfer drill into the bushing. A 0.1625 to 0.1655 inch dia. drill which has the point ground to within 7 degrees off flat should be used. Drive in the locking pin (Figure 8-18) and peen slightly, then smooth to bushing boss contours.

40 Bore the bushing to size, using a Wadell Rod Borer or equivalent (Figure 8-19). Align the rod against the plates of the fixture, stoning the edges of the rod lightly, if necessary.

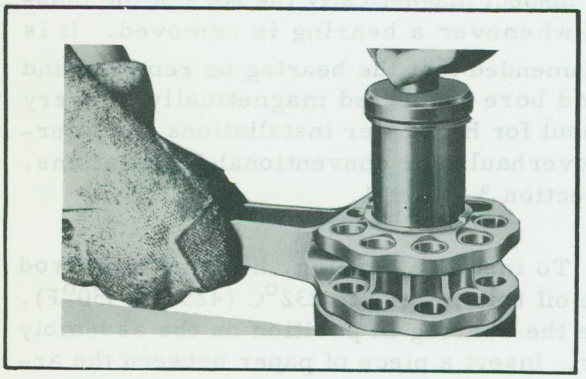


Figure 8-14 Press in Masterod Bearing

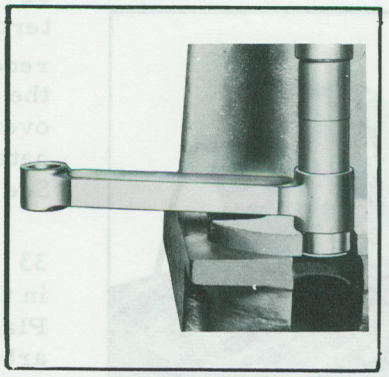


Figure 8-15 Press out Linkrod Bushing

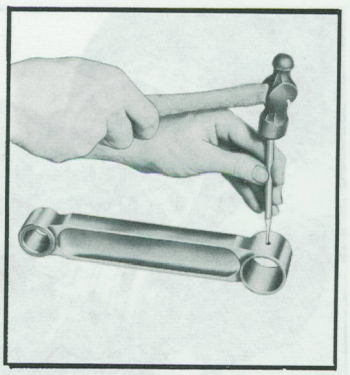


Figure 8-16 Drift out Lockpin

41 Check the size of the bore of the bushing (Figure 8-20). Recheck the rod alignment as directed in paragraphs 33 through 41, Section 2, Part 4.

LINKPIN BUSHING EXCHANGE
(Tool Group 70)

42 Press out the old bushing, using the disassembly drift and an arbor press. Heat the linkrod in an oil bath to 175°C to 205°C (347°F to 401°F) and install the new bushing so that its ends are as nearly flush as possible with the faces of the bushing boss, using the assembly drift and an arbor press (Figure 8-21).

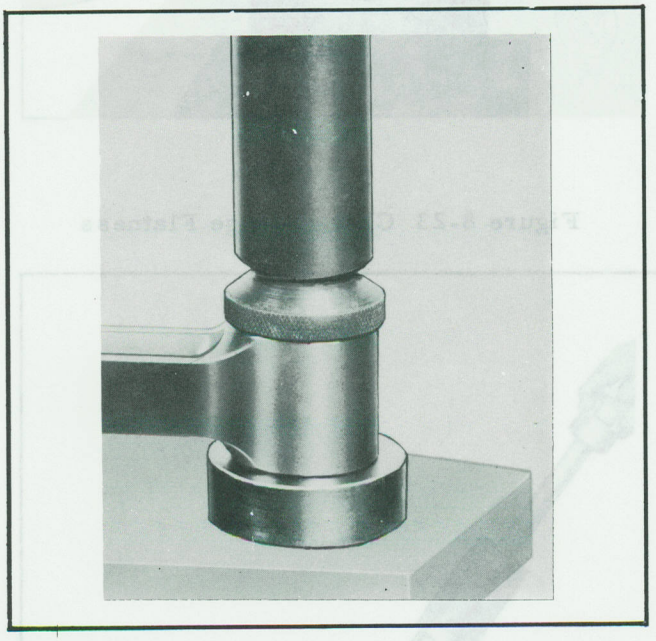


Figure 8-17 Press in Linkrod Bushing

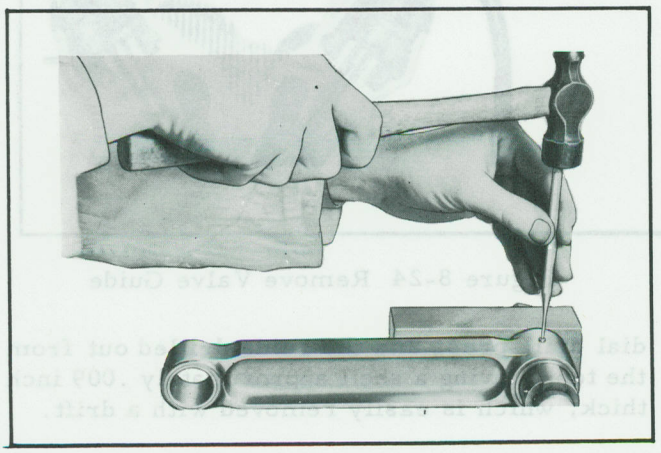


Figure 8-18 Drive in Lockpin

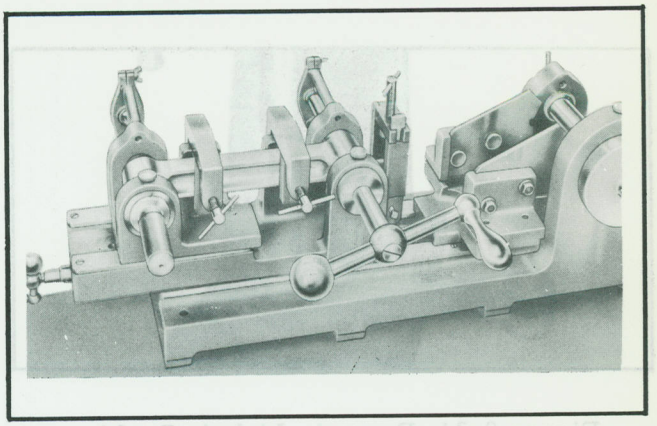


Figure 8-19 Linkrod Borer

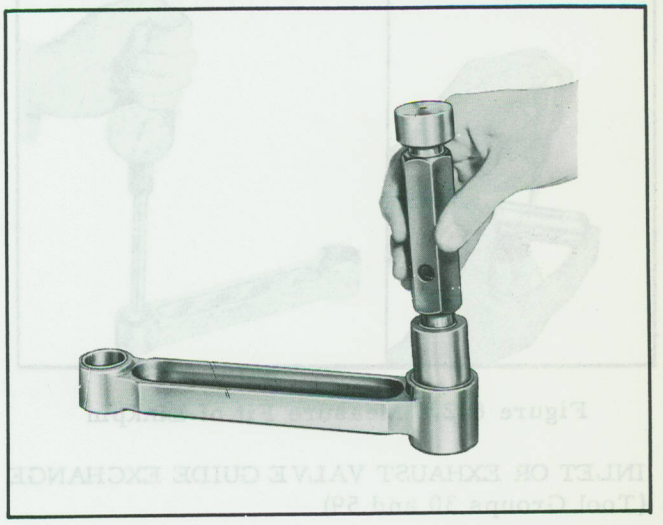


Figure 8-20 Pistonpin Bushing Gauge

43 Bore the bushing, using a Wadell Rod Borer or equivalent; then check the size of the bore of the bushing. Check the fit of the corresponding linkpin in the new bushing (Figure 8-22).

CYLINDER FLANGE REPAIR (Tool Group 26)

44 Lap the cylinder barrel parting surface until it is flat. Check the flange for flatness, using the surface plate and pencil carbon paper (Figure 8-23).

45 If it is necessary to re-spotface the areas where the cylinder hold down nuts contact the cylinder barrel flange, use a back cutter .750 inch in diameter, having a corner radius of .046 to .056 inch. The spindle should be .406 inch in diameter. Remove a minimum of material to provide a smooth, even surface, but in no case exceed .015 inch below the surface of the flange.

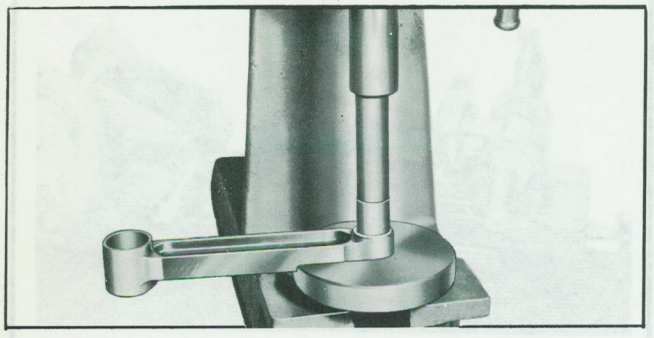


Figure 8-21 Press in Linkpin Bushing

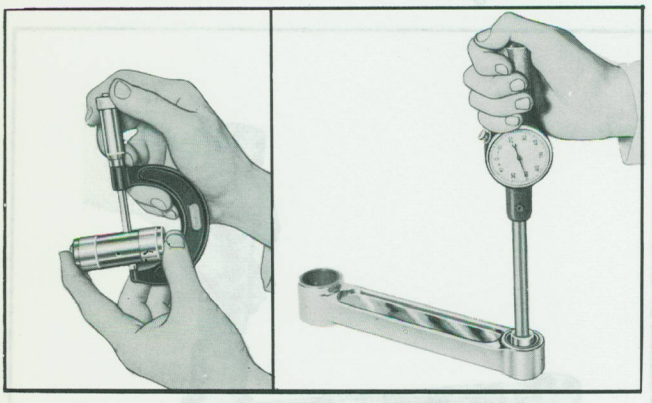


Figure 8-22 Measure Fit of Linkpin

INLET OR EXHAUST VALVE GUIDE EXCHANGE (Tool Groups 30 and 59)

46 Heat the cylinder in an oven to 230° to 260°C (450° to 500°F); then place it on a suitable cylinder stand. Install the exhaust valve guide puller or inlet valve guide puller in the old guide and turn the knob on the end of the tool to expand the collect within the guide.

47 Attach a cold water line to the valve of the tool; then open the valve, allowing the cold water to come in to contact with the valve guide. At the same time, remove the guide, using the knocker of the tool (Figure 8-24).

NOTE

If a valve seat and also a valve guide are to be removed, do not remove the valve guide until after the removal of the seat.

48 As an alternate method of removing the exhaust and inlet valve guides, the cylinder may be placed on a holding fixture attached to a radial drill press and the guide drilled out from the top, leaving a shell approximately .009 inch thick, which is easily removed with a drift.

Figure 8-23 Check Flange Flatness

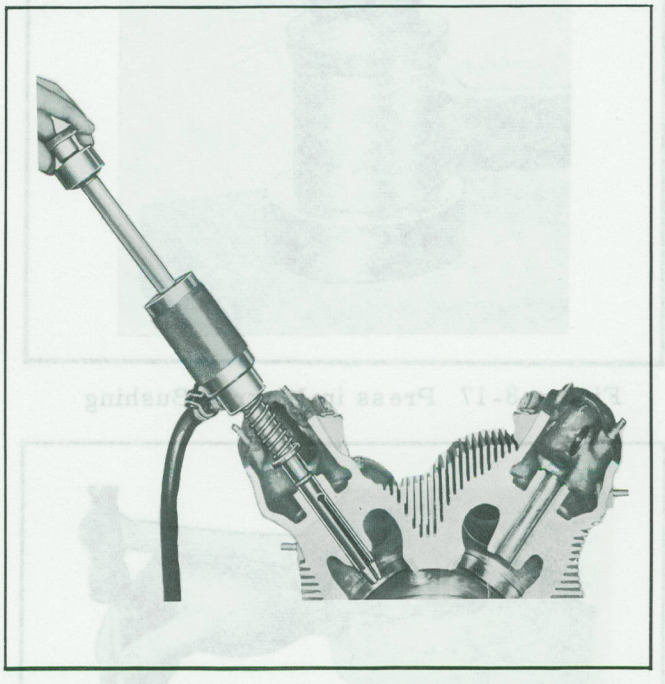


Figure 8-24 Remove Valve Guide

49 After removing the old guide, allow the cylinder to cool; then check the hole in the cy-

linder head for damage and out-of-roundness, particularly at the bottom. If it is necessary to clean up the valve guide hole, and power reaming fixture and power reamers are to be used, mount the cylinders on the reaming fixture. Insert a free fitting locating pin, a detail of the fixture, in both the inlet and exhaust valve guide holes and extend each pin into respective corresponding holes in the fixture in order to locate accurately the cylinder on the fixture. With the cylinder in this position, tighten the two hand clamps at the base of the cylinder; then remove the locating pin from the valve guide hole which is to be reamed. Ream the valve guide hole, using the proper reamer.

50 If power reaming is not available and hand reamers are used, adjust the reamer so that the hole is enlarged only enough to make it round; then turn the OD of an oversize guide to obtain the desired fit in the cylinder head (Figure 8-25).

51 Heat the cylinder head in an oven to 232° to 260°C (450° to 500°F). Smear the new guide with a light coating of oil and graphite grease; then install the inlet or exhaust valve guide with the proper drift (Figure 8-26).

52 After installation of the guide and, if power reaming is to be sued, mount the cylinder on the reaming fixture as described in the paragraph relating to the reaming of valve guide holes. Ream the inlet or exhaust valve guide, using the proper reamer. Check the inlet or exhaust valve guide, using the appropriate gauge (Figure 8-27).

53 Face off exhaust valve guides and bosses to bring the lower end of each guide flush with the lower end of its boss and to remove any burned portions. The end of the valve guide must be flush with the face of the boss within ± .010 inch.

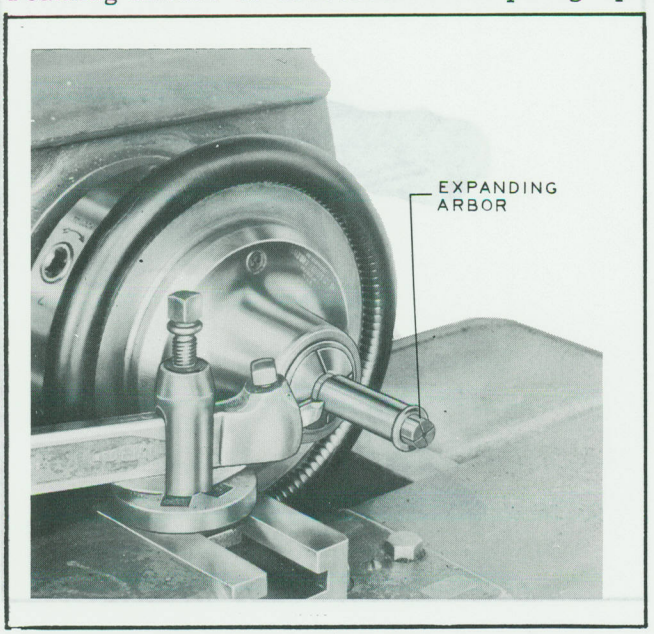


Figure 8-25 Turn down Oversize Guide

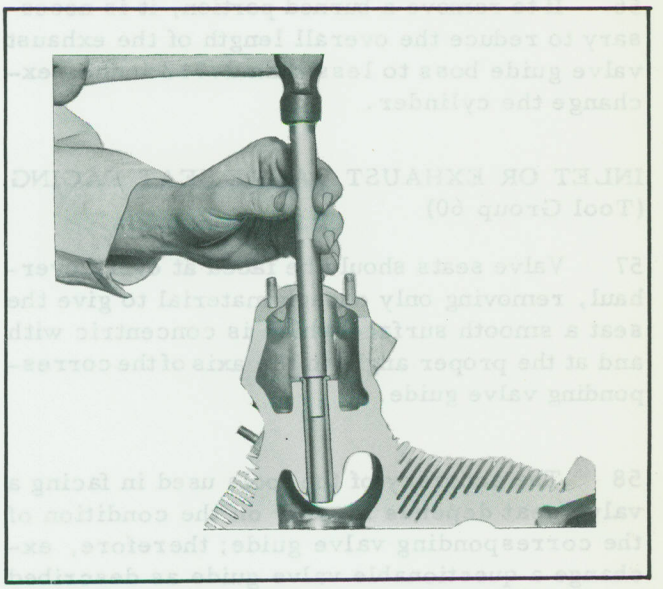


Figure 8-26 Install Valve Guide

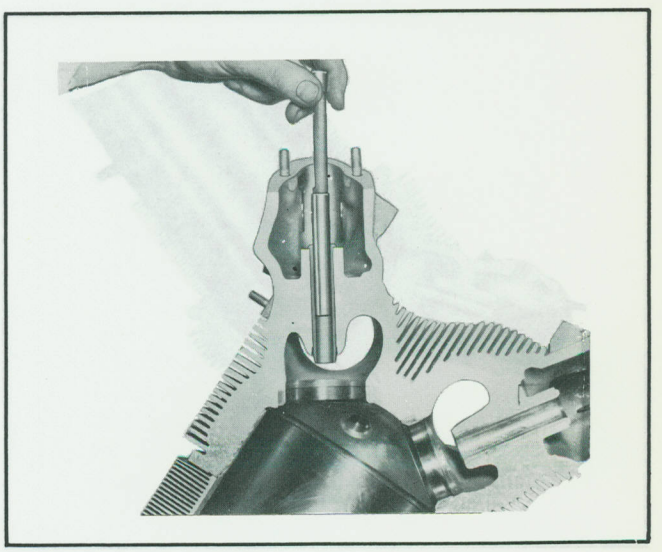


Figure 8-27 Check Bore with Gauge

54 Place the base, detail 1 of the fixture, on the table of the drill press and insert the spindle, detail 2, through the base and engage it with the chuck of the drill press.

55 Invert the cylinder and place it on the base with the spindle inserted through the valve guide. Attach the cutter, detail 5, with its bayonnet lock to the projecting end of the spindle (Figure 8-28).

56 If to remove a burned portion, it is necessary to reduce the overall length of the exhaust valve guide boss to less than 2.312 inches exchange the cylinder.

INLET OR EXHAUST VALVE SEAT FACING (Tool Group 60)

57 Valve seats should be faced at every overhaul, removing only enough material to give the seat a smooth surface which is concentric with and at the proper angle to the axis of the corresponding valve guide.

58 The accuracy of the tools used in facing a valve seat depends largely on the condition of the corresponding valve guide; therefore, exchange a questionable valve guide as described in paragraphs 46 through 56.

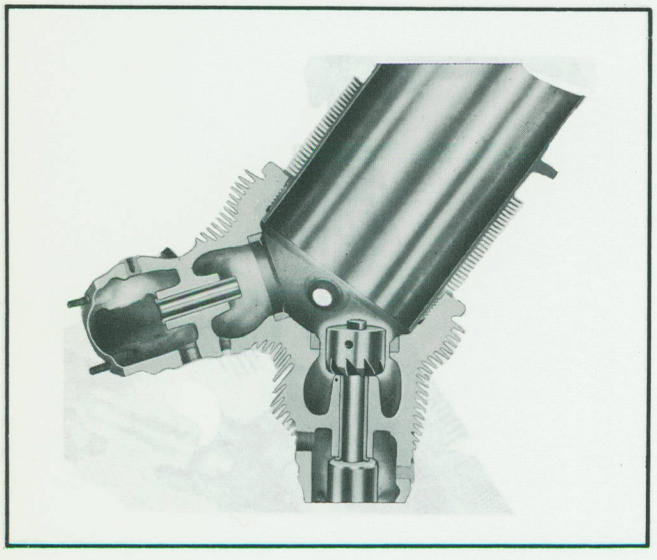


Figure 8-28 Face off Valve Guide and Boss

CAUTION

Ensure that no more material is removed than is necessary to clean up the seating surface, because excessive removal seriously affects the life of the seat.

59 To face the inlet valve seat, first take a light cut, using the adapter, holder and cutter; then take a finish cut, using the finish cutter (Figure 8-29). When the wall thickness of the lower extremity of an inlet valve seat has been reduced to a point where further cutting would damage the cylinder head, exchange the seat.

60 In cleaning up an exhaust valve seat it is not necessary to remove small isolated dark spots completely, particularly if they are not at the edge of the valve seating area.

61 Face off the exhaust valve seat, using a grinding wheel which has been dressed to exactly 45 degrees (Figure 8-30). Where further grinding or cutting would damage the cylinder head, exchange the seat.

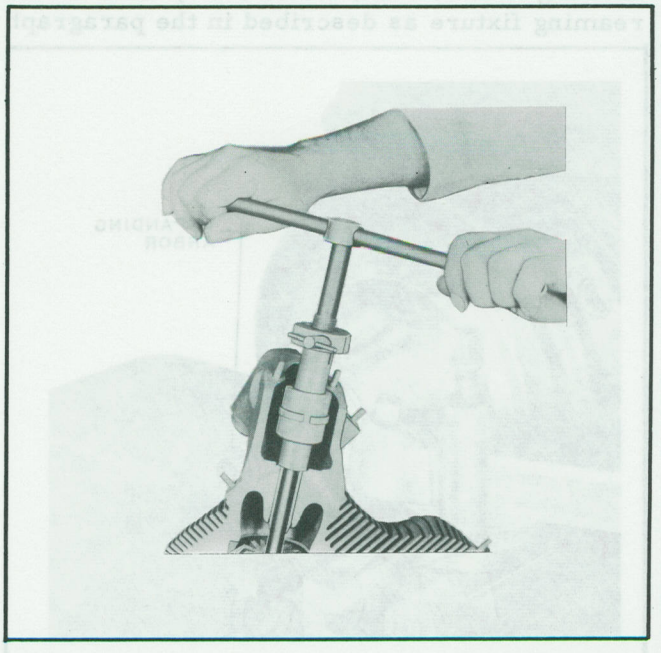


Figure 8-29 Face Inlet Valve Seat

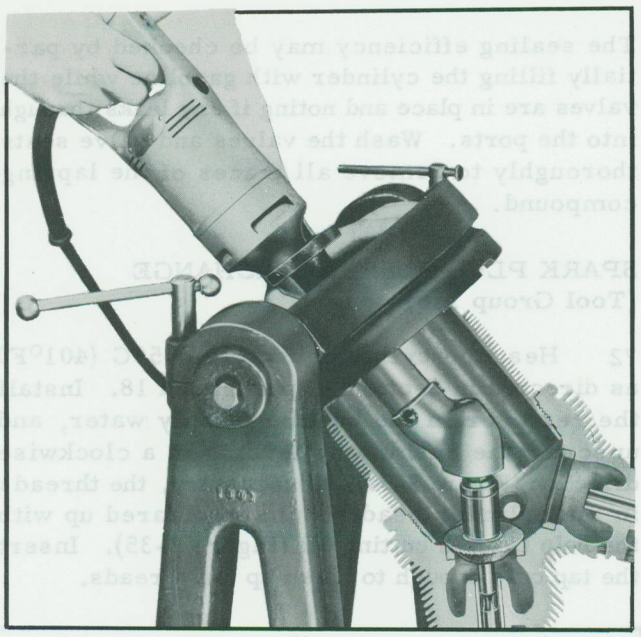


Figure 8-30 Face Exhaust Valve Seat

INLET OR EXHAUST VALVE SEAT EXCHANGE (Tool Group 31 and 61)

62 Heat the cylinder in an oven to 230° to 260°C (450° to 500°F); then place it on a suitable cylinder stand. Depressing the plunger of the proper remover for either the inlet or exhaust valve seat, install the pilot rod of the tool into the valve guide from the barrel end of the cylinder until the body of the tool seats against the valve seat. Release the plunger, making sure the pins are embedded in the valve seat.

63 Attach a cold water line to the valve of the tool. Install the drift in the valve guide from the rockerbox end. Open the water valve, allowing the cold water to come into contact with the valve seat. At the same time, drive the valve seat from the cylinder by striking the drift with a hammer (Figure 8-31).

64 If necessary, remove the corresponding valve guide as described in paragraphs 46 and 47, or in paragraph 48, after the removal of the valve seat. Clean up the valve seat bore in the cylinder with crocus cloth and oil.

65 Heat the cylinder head in an oven to 232° to 260°C (450° to 500°F). Install a new inlet valve seat, using the holder or a new exhaust valve seat, using the drift, being careful to prevent the cylinder head from turning on the barrel while the cylinder is hot.

66 If the valve guide has been removed, install a new guide as described in paragraphs 49 through 56. Face off the intake or exhaust valve seat as described in paragraphs 57 through 61.

VALVE REFACING

67 The seating surface of a valve should be dressed on a valve refacing machine at each overhaul (Figure 8-32). The refacing machine should be set for an angle cut of exactly 45 degrees.

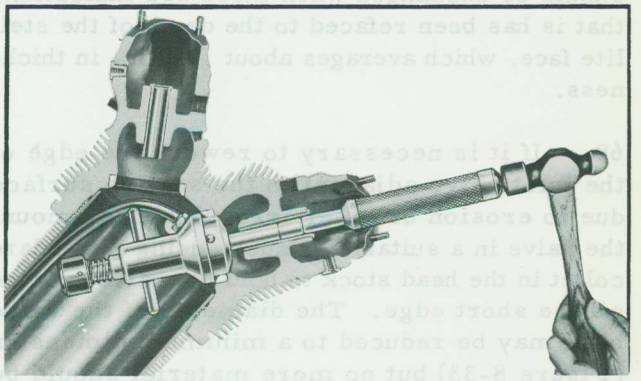


Figure 8-31 Remove Valve Seat

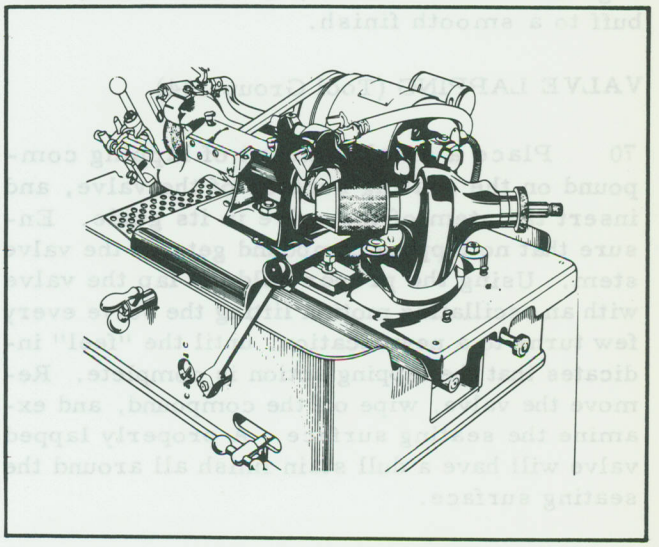


Figure 8-32 Valve Refacing Machine

68 The most important factor in the use of this machine is the proper dressing of the grinding wheel to ensure the accuracy of the 45 degree face angle and the desired condition of the ground surface. The wheel should be run across the valve surface, evenly, and only enough material should be removed to clean up the sruface. This is particularly true on the exhaust valve, as the stellite coating is relatively thin and it is desirable to retain as thick a coating as possible. To ensure a smooth surface and decrease the time necessary for lapping, the wheel should be run across the valve after the final cut, without increasing the depth of the cut, until the stone fails to remove any more material. An inlet valve should be exchanged when further facing will cause a sharp edge to be formed at the outer rim of the head. An exhaust valve should be exchanged when there are indications that is has been refaced to the depth of the stellite face, which averages about .040 in. in thickness.

69 If it is necessary to rework the edge of the inlet valve adjacent to the seating surface due to erosion or other irregularities, mount the valve in a suitable grinder, using a standard collet in the head stock to hold the valve. Grind off the short edge. The diameter of the valve head may be reduced to a minimum dimension (Figure 8-33) but no more material should be removed than is necessary. With the valve turning in the grinder blend the ground valve edge of the valve to a 1/16 inch radius; then buff to a smooth finish.

VALVE LAPPING (Tool Group 134)

70 Place a small amount of lapping compound on the seating surface of the valve, and insert the stem of the valve in its guide. Ensure that no lapping compound gets on the valve stem. Using the proper holder, lap the valve with an oscillating motion lifting the valve every few turns to a new location, until the "feel" indicates that the lapping action is complete. Remove the valve, wipe off the compound, and examine the seating surface. A properly lapped valve will have a dull stain finish all around the seating surface.

71 After lapping, pencil carbon may be used to determine if the valve is seating properly. The sealing efficiency may be checked by partially filling the cylinder with gasoline while the valves are in place and noting if any leaks through into the ports. Wash the valves and valve seats thoroughly to remove all traces of the lapping compound.

SPARK PLUG BUSHING EXCHANGE (Tool Group 116)

72 Heat the cylinder head to 205°C (401°F) as directed in Section 1, paragraph 18. Install the remover in the bushing, apply water, and unscrew the bushing by turning in a clockwise direction (Figure 7-34). If necessary, the threads in the cylinder head should be cleared up with the hole tax and cutting oil (Figure 7-35). Insert the tap only enough to clean up the threads.

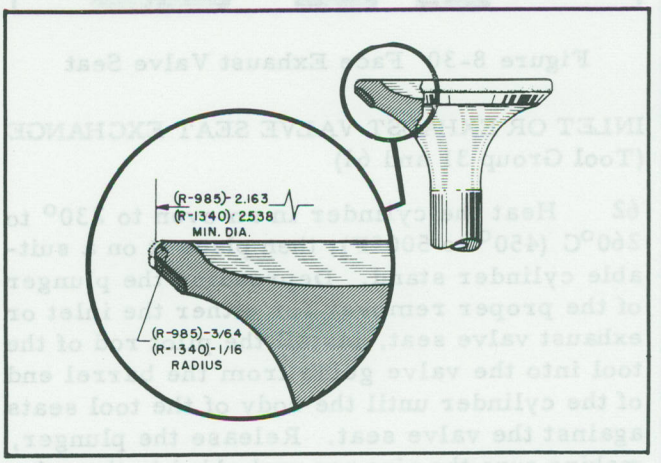


Figure 8-33 Valve Grinding Limits

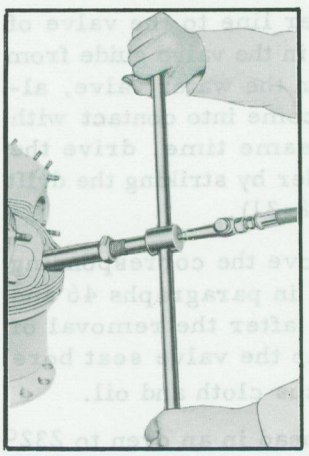


Figure 8-34 Remove Spark Plug Bushing

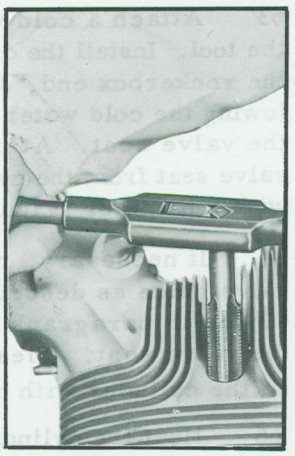


Figure 8-35 Clean up Thread in Cylinder

73 Again heat the cylinder head 205°C (401°F). Cover the threads with a suitable lubricant and install the bushing which has a left hand thread on the OD, using the driver (Figure 8-36).

CAUTION

While the cylinder head is hot, take care that it does not turn on the barrel.

74 If the engine is equipped with bronze bushings, the counterbore may be used to bore the bushings to a thin shell which may be easily collapsed and removed.

75 If a bronze bushing is not flush with the recess in the cylinder head, face it off with the proper facer for the front or rear bushing (Figure 8-37). After the cylinder has cooled to room temperature clean up the threads in the bushing with the tap.

ROCKER SHAFT BUSHING EXCHANGE
(Tool Group 114)

76 If it is necessary to change one of the bushings at a rocker shaft, both bushings must be changed. After referring to Section 1 paragraph 18, heat the section of the cylinder adjacent to the bushings to 120°C (248°F). Remove the old bushings using the drifts. Remove the small bushing before the large bushing. Clean up the bushing holes in the cylinder head, using crocus cloth and oil. Reheat the part of the cylinder head adjacent to the rocker shaft bushing holes to 120°C (248°F); then install the new bushings using the proper drift. Do not install the large bushing until the small bushing

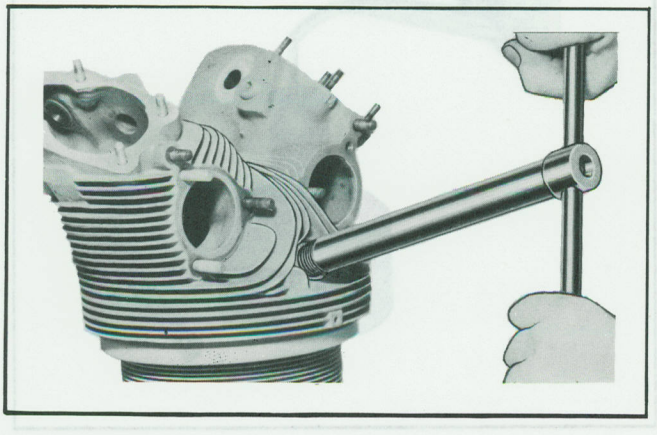


Figure 8-36 Install New Bushing

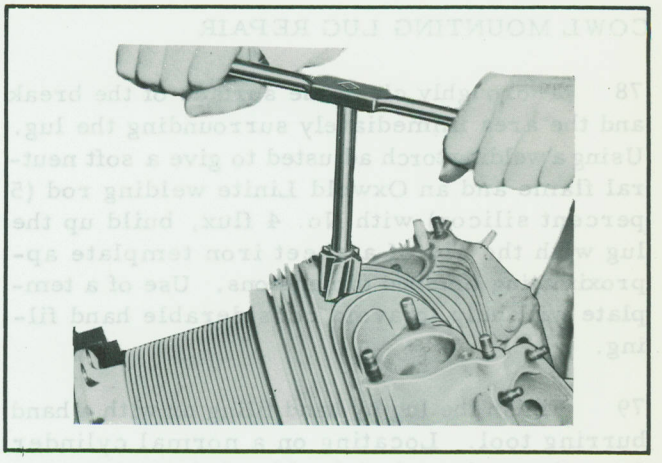


Figure 8-37 Face off Bushing

has been installed in the thicker wall section of the rocker box. Line ream the bushings, (Figure 8-38), then check the bushings for size.

ROCKER BALL SOCKET EXCHANGE
(Tool Group 112)

77 Insert a tapered pin in the oil hole in the ball socket (Figure 8-39). With the rocker bearing removed, place the rocker arm on the pilot of the pusher (Figure 8-40). Fill the plunger guide about half full of heavy oil and insert the plunger (Figure 8-41). Using a hammer or an arbor press drive or press the plunger to drive the socket from the rocker (Figure 8-42). Install a new socket, using the assembly fixture and arbor press (Figure 8-43).

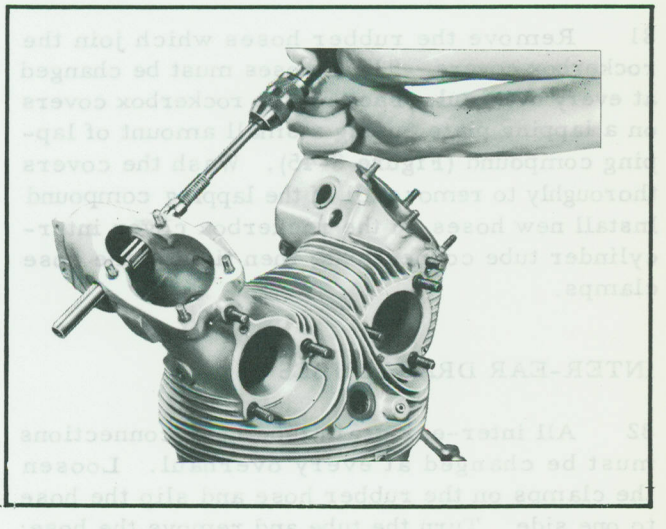


Figure 8-38 Ream Rocker Shaft Bushing

COWL MOUNTING LUG REPAIR

78 Thoroughly clean the surface of the break and the area immediately surrounding the lug. Using a welding torch adjusted to give a soft neutral flame and an Oxweld Linite welding rod (5 percent silicon) with No. 4 flux, build up the lug with the aid of a sheet iron template approximating finished dimensions. Use of a template will help to avoid considerable hand filing.

79 Finish the lug by hand filing or with a hand burring tool. Locating on a normal cylinder from the rocker shaft bushing holes, the valve guide bushing holes, or both, make a simple drill jig. Using a hand drill and this jig, drill the holes in the rebuilt lug. It is unnecessary to bake or reheat the head after the repair has been made.

PUSHROD COVER NUT CONNECTOR EXCHANGE (Tool Group 101)

80 To change a pushrod cover nut connector, first remove the old connector, using the disassembly driver (Figure 8-44). If a standard size exchange connector will not give a sufficiently tight fit to prevent oil leakage, use a .004 inch oversize connector. Install a new connector, using the assembly driver.

ROCKERBOX COVERS AND INTER-CYLINDER DRAIN TUBES

81 Remove the rubber hoses which join the rockerbox covers. These hoses must be changed at every overhaul. Face off the rockerbox covers on a lapping plate, using a small amount of lapping compound (Figure 8-45). Wash the covers thoroughly to remove all of the lapping compound Install new hoses on the rockerbox cover inter-cylinder tube connections; then tighten the hose clamps.

INTER-EAR DRAIN TUBES

82 All inter-ear drain tube hose connections must be changed at every overhaul. Loosen the clamps on the rubber hose and slip the hose to one side. Turn the tube and remove the hose; then install a new hose and tighten the clamps.

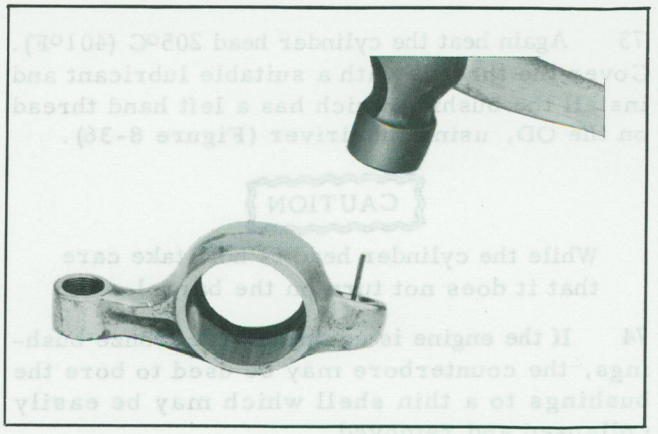


Figure 8-39 Insert Pin in Oil Hole

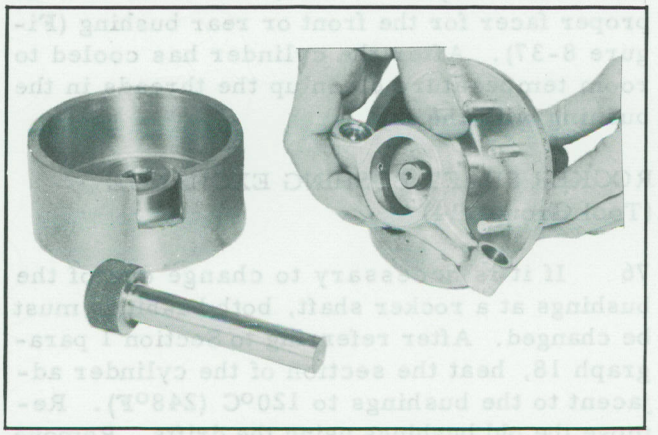


Figure 8-40 Rocker Arm on Pusher

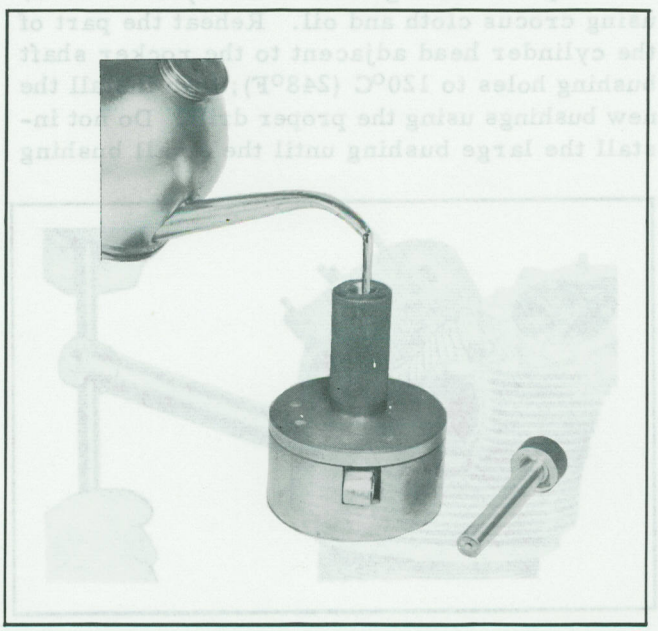


Figure 8-41 Half Fill Plunger Guide

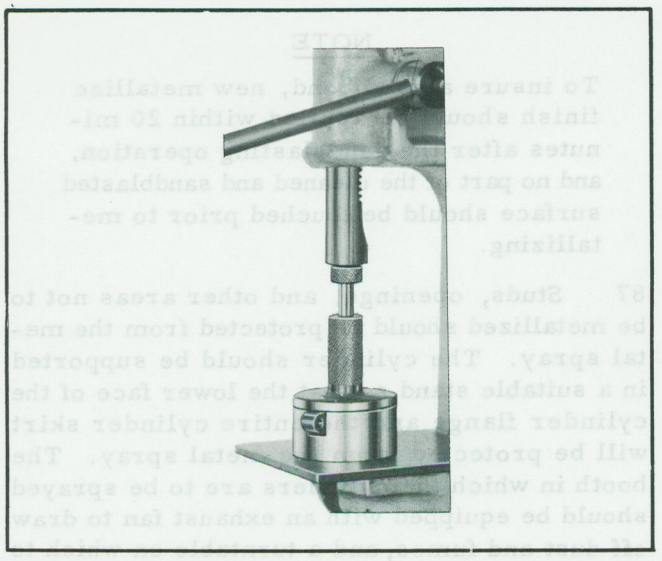


Figure 8-42 Remove Socket from Rocker Arm

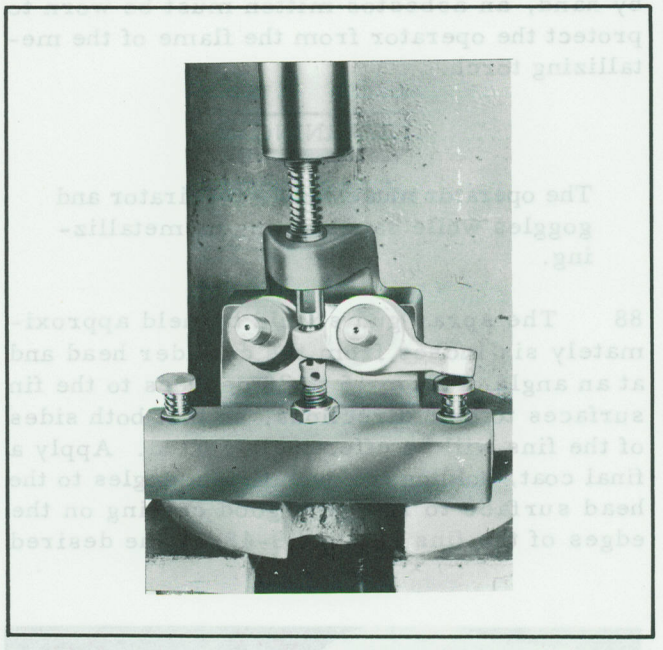


Figure 8-43 Install New Socket

83 If an inter-ear drain tube requires changing, remove the rubber hose connection; then back out the damaged tube. Coat the new tube thread with a thread lubricant; then install the tube. Metallize the new tube as described in paragraphs 84 through 89; then install a new rubber hose connection and secure it with clamps.

METALLIZING CYLINDERS

84 It is not anticipated that frequent remetallizing of cylinders will be necessary although this will depend largely upon conditions of operation and the kind of treatment to which the cylinders are subjected. Normally, remetallizing should not be necessary for at least two or three overhauls.

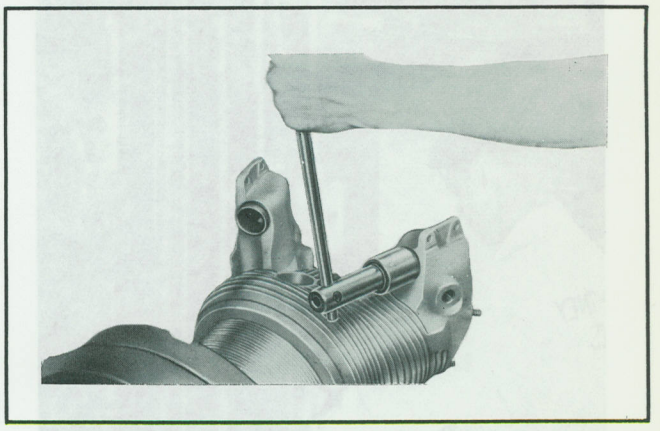


Figure 8-44 Remove Connector

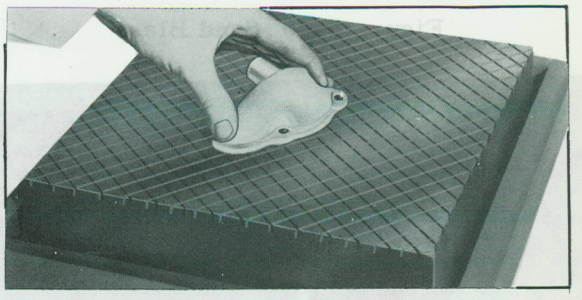


Figure 8-45 Lap Rockerbox Cover

NOTE

Cylinder heads on later cylinders are sandblasted, not metallized, and intake pipe couplings and rockerbox covers are anodized, not metallized.

85 If a cylinder is to be remetallized, the external surfaces should be thoroughly cleaned. Refer to Part 3, "Cleaning".

86 Sandblast the surfaces of the cylinder which are to be metallized (Figure 8-46 and 8-47). All studs openings and other areas not to be sandblasted should be covered with masking tape, metal plates, rubber stoppers, rubber hose, copper tubing, or other suitable protective coverings. The anodized intake pipe couplings

Figure 8-46 Sand Blast

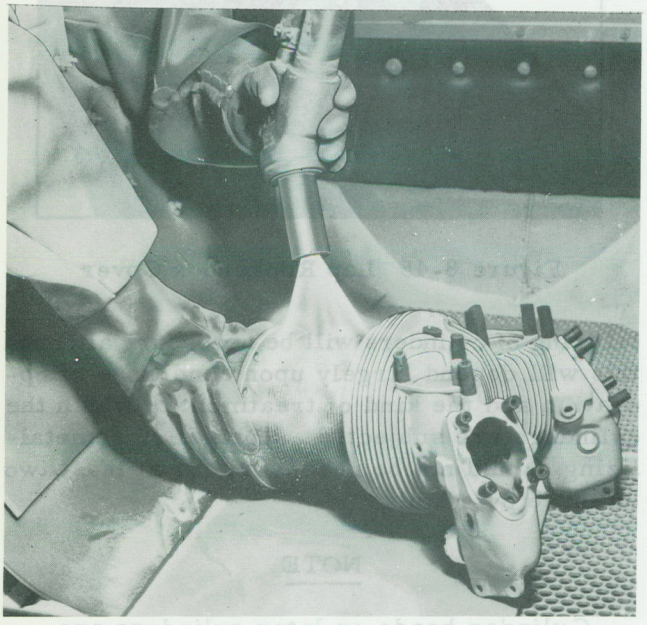


Figure 8-47 Sand Blast

of later cylinders should be protected with masking tape during any sandblasting or metalizing operations. Unmetallized cylinder heads may be metallized or left unfinished. Old metallize finish need not be entirely removed, as the well bonded portions make a satisfactory base for the new finish. Continual sandblasting will cause excessive erosion of the metal and may impair the cooling efficiency of the fins. A fine grade of sand should be used, as the use of steel grit or coarse sand is dangerous. Anodized rocker box covers should not be sandblasted or metallized.

NOTE

To insure a good bond, new metallize finish should be applied within 20 minutes after the sandblasting operation, and no part of the cleaned and sandblasted surface should be touched prior to metallizing.

87 Studs, openings, and other areas not to be metallized should be protected from the metal spray. The cylinder should be supported in a suitable stand so that the lower face of the cylinder flange and the entire cylinder skirt will be protected from the metal spray. The booth in which the cylinders are to be sprayed should be equipped with an exhaust fan to draw off dust and fumes, and a turntable on which to rotate the cylinder. The turntable may be power driven, if desired. If the table is rotated by hand, an asbestos mitten must be worn to protect the operator from the flame of the metallizing torch.

WARNING

The operator must wear a respirator and goggles while sandblasting or metallizing.

88 The spray gun should be held approximately six inches from the cylinder head and at an angle of from 15 to 20 degrees to the fin surfaces to both directions, so that both sides of the fins will be effectively coated. Apply a final coat, holding the gun at right angles to the head surface to insure a good coating on the edges of the fins (Figure 8-48). The desired

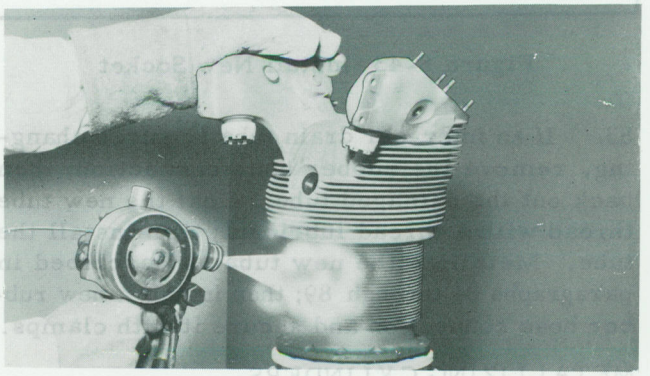


Figure 8-48 Metallize

thickness of the finish is .003 in. and the maximum thickness should not exceed .005 in. Excessively thick coating will have a rough finish and a tendency to flake off. After metallizing, inspect the finish for uniformity.

PAINTING CYLINDERS

89 When cylinders are to be stored after metallizing, they should be completely coated with a corrosive preventive mixture consisting of one part Rust Ban 606, and three parts of engine lubricating oil.

(a) As an alternative to metallizing, the steel barrel and other steel components on the cylinders may be protected by a coating of aluminum heat resistant enamel.

(b) If the cylinders received are painted, rather than metallized, normal cleaning (which removes the paint) is all that is required for the barrel. The head can be lightly sandblasted to remove surface stains. However, if the cylinders received are metallized the metallizing should be removed by sandblasting. Over blasting should be avoided as continued sandblasting will cause excessive erosion of the metal and may impair the cooling efficiency of the fins.

(c) Prior to painting any residue of grease or oil should be removed from the cylinder by degreasing (unless the cylinder has just been blasted and is clean and dry). The attaching nut spot faces should be suitably masked to prevent being coated with paint.

(d) The exposed surfaces of the steel cylinder barrel and other steel components on the cylinder must be coated with a special heat resistant aluminum enamel meeting PWA Specification 577. Any thinner used must be specifically for and compatible with this enamel.

PISTON RING GROOVE REWORKING
(Tool Group 88)

90 If the lands between the compression ring grooves are found to be warped from .0005 to .002 inch, the adjacent grooves should be cleaned up to remove the warpage. If a land is found to be warped more than .002 inch, the piston should be exchanged.

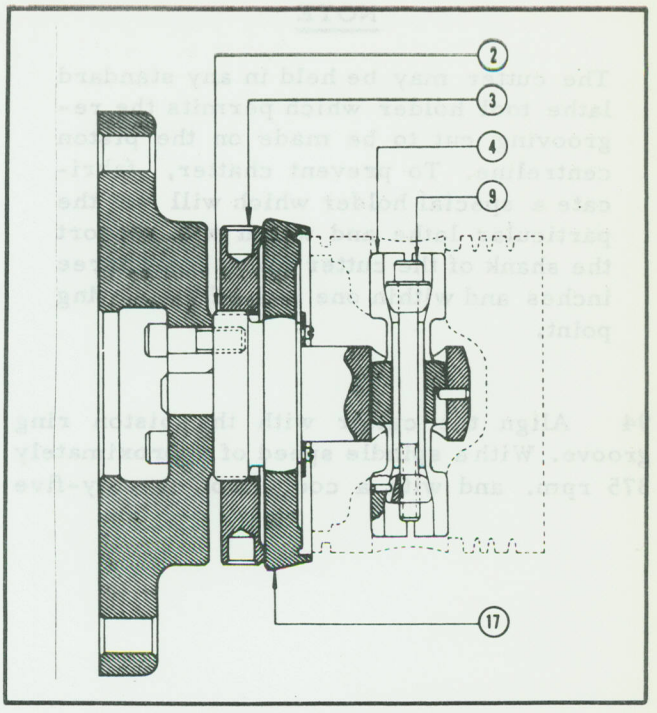


Figure 8-49 Piston and Fixture on Lathe

NOTE

Do not confuse warpage with wear. If a groove is worn evenly, re-operation may not be required.

When necessary, the grooves may be cleaned up by the procedure described in paragraphs 91 through 95.

91 Mount the piston to be worked on the piston regrooving fixture which has been bolted to the face plate of a lathe (Figure 8-49). Mount the detail 17 Adapter on the fixture; place the detail 4 plug in the piston pin hole in the piston and through the hole in the detail 2 Shaft. Tighten the detail 9 Wedge Screw and secure the piston pin securely in place by tightening the detail 3 Ring.

92 Check the piston runout within .001 FIR at both ends.

93 Place the regrooving cutter in a tool holder at right angles to the piston, at zero rake, and on the horizontal centreline of the piston.

NOTE

The cutter may be held in any standard lathe tool holder which permits the regrooving cut to be made on the piston centreline. To prevent chatter, fabricate a special holder which will suit the particular lathe and which will support the shank of the cutter for at least three inches and within one inch of the cutting point.

94 Align the cutter with the piston ring groove. With a spindle speed of approximately 375 rpm. and with a coolant of seventy-five percent kerosene and twenty-five per cent paraffin oil flowing on the cutter, feed the cutter slowly by hand until it reaches the bottom of the groove; then cut an equal amount from each side of the ring groove until it will accommodate the nearest oversize ring with the proper side clearance.

CAUTION

When moving the cutter from one side of the groove to the other side, do not back off the cutter. This precaution avoids cutting a step in the bottom of the groove.

95 The correct oversize pistonring for each groove may be determined by installing in each groove a series of gauges made from sections of the oversize rings which are available and then selecting the ring which provides the proper side clearance.

PISTONRING ARRANGEMENT AND FITTING

96 Install the pistonring assemblies in accordance with the arrangements shown in Figure 8-50). Nitralloy cylinder barrels and pistons with straight-sided grooves are involved in some cases, and the recommended arrangement for each particular combination of piston and cylinder barrel will be used in these cases. The illustration shows ring types, pistons, and type of cylinder barrels. The letters on the rings denote the type of ring, as explained in the legend.

97 Nitralloy barrels may be identified by "139" stamped on the base flange. Current chrome-molybdenum barrels have no identification mark. Early chrome-molybdenum barrels were identified by "185" stamped on the base flange.

98 Check the end clearance or gap of all pistonrings. Insert each pistonring in the inspection gauge and measure the end clearance or gap with a feeler gauge (Figure 8-51). If the gap is insufficient, it should be increased by filing the butt ends with a fine file. After filing, remove sharp edges with a fine stone. If the gap is excessive, the ring should be exchanged.

99 Install the pistonrings, numbered side down, on the pistons; then check the side clearance of each ring with a feeler gauge.

CAUTION

When installing rings expand only to the minimum opening required, as a permanent set may occur without actual ring breakage on "K" spun rings.

100 In measuring the side clearance of wedge-type rings, the outer face of the ring must be flush with the piston (Figure 8-52). In installing a stepped cut scraper ring, it is imperative that the ring be installed with the step toward

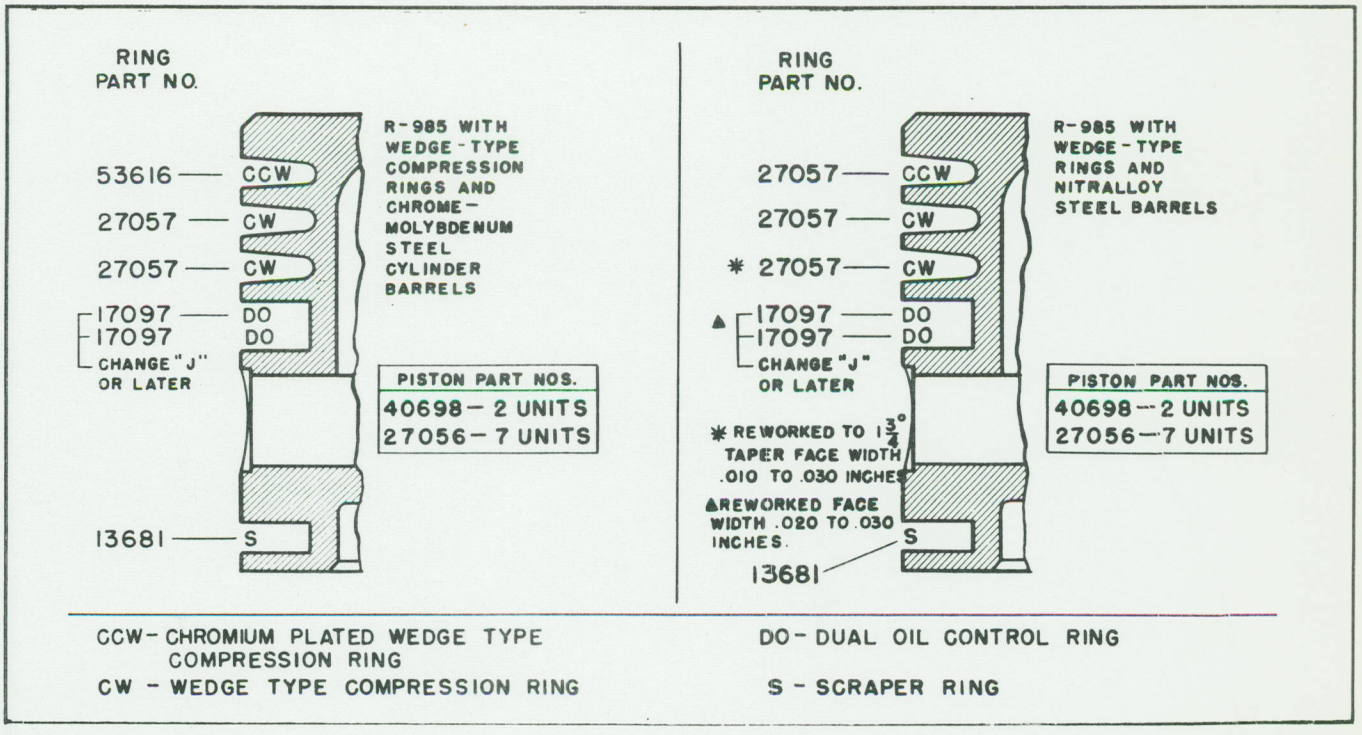


Figure 8-50 Pistonring Arrangement

the bottom of the piston and that it be lapped sufficiently to ensure a wiping surface of .025 inch.

PISTONRING LAPPING

101 To ensure proper seating, it is important that new pistonrings be lapped in the cylinder barrel in which they are to be installed.

CAUTION

Never lap a chromium-plated ring.

102 The number of cycles required for seating rings properly varies with the method employed and the consistency of the lapping compound. Therefore, it will be necessary for each operator to develop the proper technique for the equipment and method in use. The condition of the ring surface, rather than the inside surface of the cylinder, determines the amount of lapping. Rings should be lapped until the original tool marks on the OD have practically disappeared and the surface has a smooth satin finish around the OD of the ring. If the ring does not appear to have a true surface after a normal amount of lapping, a new ring should be used. Use a suitable lapping machine (Figure 8-53) and Clover 2A lapping compound, or its equivalent, diluted in the ratio of two parts kerosene to one part of compound. A satisfactory ring condition can usually be obtained by lapping scraper and dual oil control rings 30 to 50 cycles and by lapping plain compression rings either 100 cycles in a chrome-molybdenum barrel or 200 cycles in a nitralloy barrel.

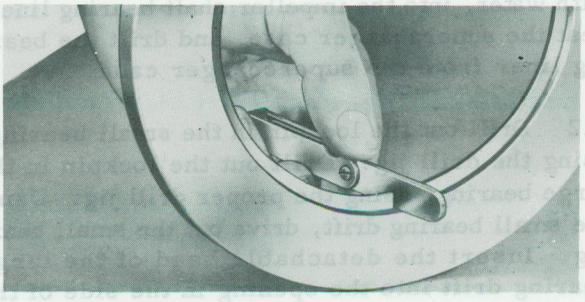


Figure 8-51 Measure Pistonring Gap

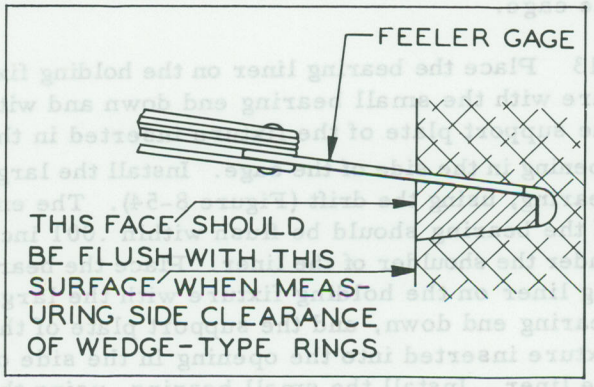


Figure 8-52 Measure Side Clearance

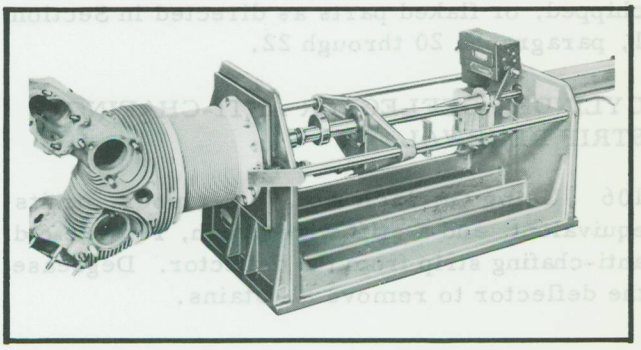


Figure 8-53 Cylinder on Lapping Machine

103 It is common practice to use a discarded .010 in. oversize piston for holding the rings. In some cases, a special lapping plug is made up for this purpose. In any case, a lapping piston should have a guided skirt equal in length to the skirt of the conventional piston. Do not use a piston or lapping plug after its diameter is reduced to a point where the piston or plug is a very loose fit in the cylinder or where the ring grooves have worn excessively. Worn pistons or plugs will not hold the pistonrings in proper alignment for lapping and the rings will tilt back and forth with each stroke, causing them to become crowned.

104 During the lapping operation, the valves should be in place in the cylinder. During the subsequent washing operation, hold the cylinder in a vertical position and make every effort to remove all of the lapping compound without permitting any of it to be washed up into the head of the cylinder. After lapping, wash the rings thoroughly and remove any feather edges

with a fine stone or crocus cloth, being careful not to form a radius on the edge of the ring.

NOTE

Piston ring end clearances may exceed the recommended high limit by 50% after lapping provided the ring gaps are staggered on assembly.

REPAIRING INTAKE PIPES, PUSHROD COVERS, AND DEFLECTORS

105 Smooth out any dents. Repair cracks in deflectors by welding. Repaint scratched, chipped, or flaked parts as directed in Section 1, paragraphs 20 through 22.

CYLINDER DEFLECTOR ANTI-CHAFING STRIP RENEWAL

106 Using Gerlach No. 70 Stripper, or its equivalent, and a stiff wire brush, remove old anti-chafing strip from the deflector. Degrease the deflector to remove all stains.

107 Mask the area not to be coated with anti-chafing compound; then thoroughly mix 1 part Exp. 71103A Compound manufactured by the Minnesota Mining and Mfg. Co., 1 to 2 parts of Ethylene Dichloride (Commercial Grade), and 8% Exp. 55509A Accelerator (by weight based on the weight of undiluted Exp. 71103A Compound). Using a spray gun, apply heavy coats of compound to the deflector until a coating thickness of .018 to .028 inch is obtained. Allow compound to dry for 10 to 15 minutes between coats.

108 Make sure that the deflector is clean and free from oil, kerosene, etc., then bake in an oven for 4 hours at a temperature of 79°C to 88°C (175°F to 190°F) and 1/2 hour at a temperature of 143°C to 154°C (290°F to 310°F). Remove the deflector and cool it to room temperature.

PRIMER LINE SPAGHETTI REPAIR

109 If the spaghetti on the primer lines is worn through or cut by the primer line clamps, repair it by wrapping it in friction tape. Coat the tape with shellac to make it oil and moisture resistant.

IMPELLER SHAFT BEARING CAGE EXCHANGE AN-14B Model

110 Bend back the lugs of the retaining screw and remove the screw, using the driver. After referring to "Expansion of Parts by Heat," heat the case, chill the bearing cage and drift out the cage, using a suitable drift. Reheat the case, chill the bearing cage, and install a new cage, using the assembly drift and guide. Transfer drill a new hole in the cage and tap it with a 1/4-28 N.S. tap. Install a new retaining screw and bend the lugs to lock it in place.

PLAIN IMPELLER SHAFT BEARING EXCHANGE AN-5 Model (Tool Group 91)

111 To change one of these bearings, both bearings must be changed. To change the bearings the impeller shaft bearing liner must be removed from the supercharger case. Bend back the lugs of the retaining screw, and, using the driver, remove the retaining screw. After referring to "Expansion of Parts by Heat", Section 1, paragraph 18, insert a sponge, saturated with water, into the impeller shaft bearing liner, heat the supercharger case, and drift the bearing liner from the supercharger case.

112 Drill out the lockpin in the small bearing, using the drill jig. Drill out the lockpin in the large bearing, using the proper drill jig. Using the small bearing drift, drive out the small bearing. Insert the detachable head of the large bearing drift into the opening in the side of the cage and insert the shaft of the drift through the small bearing end of the liner into the detachable head. Drift the large bearing from the cage.

113 Place the bearing liner on the holding fixture with the small bearing end down and with the support plate of the fixture inserted in the opening in the side of the cage. Install the large bearing, using the drift (Figure 8-54). The end of the bearing should be flush within .001 inch under the shoulder of the liner. Place the bearing liner on the holding fixture with the large bearing end down, and the support plate of the fixture inserted into the opening in the side of the liner. Install the small bearing, using the small bearing drift. Drill the oil and lockpin holes in the small bearing, using the drill jigs.

The lockpin hole should be drilled 45 degrees from any existing hole. Transfer-drill the oil hole in the large bearing, and drill the lockpin hole 45 degrees from any existing holes, using the large bearing drill jig. Install the lockpins.

114 Reheat the supercharger case, and using the assembly drift, reinstall the bearing liner. Install a new retaining screw, and bend down the lugs.

115 Attach the reaming fixture to the rear face of the supercharger case. Insert the bushing, detail 5, into the fixture, and ream the impeller shaft large bearing. Insert the bushing, detail 6, into the fixture, and ream the small bearing

116 Check the impeller shaft bearings for size with the reaming gauges. Check the bearings for concentricity and squareness, using the aligning gauge. Without removing the aligning gauge, check the face of the small bearing flange for flatness by placing the pilot of the aligning gauge on the shaft of the gauge in the small bearing. Using a dial indicator, indicate a point near the outside diameter of the top face of the pilot. Set the dial needle at zero, and rotate the pilot. If the small bearing flange is not flat it should be faced, using the facing cutter and holder.

NOTE

Remove only enough material to square up and smooth the face of the flange.

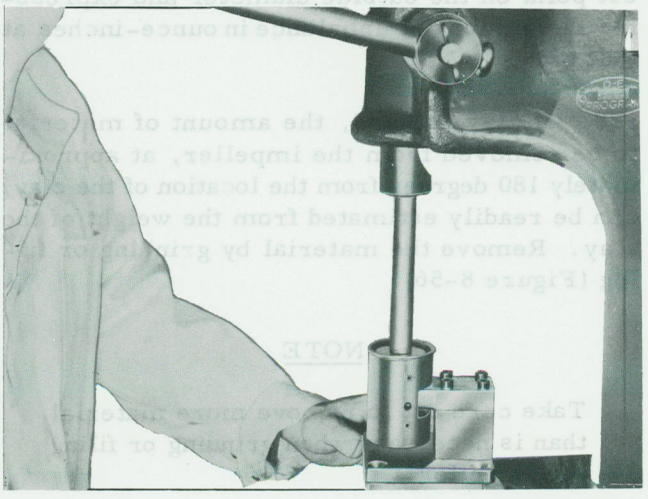


Figure 8-54 Install Impeller Bearing

IMPELLER AND SHAFT

117 The impeller and shaft are originally installed in the engine as a matched , balanced set. It is desirable, although not imperative, that these parts be retained as a matched assembly once they have been used together.

118 If it is necessary to remove nicks, scratches, cracks, damaged corners, or other minor defects from the impeller, the feasibility of their removal should be appraised by reference to the minimum permissible dimensions shown (Figure 8-55).

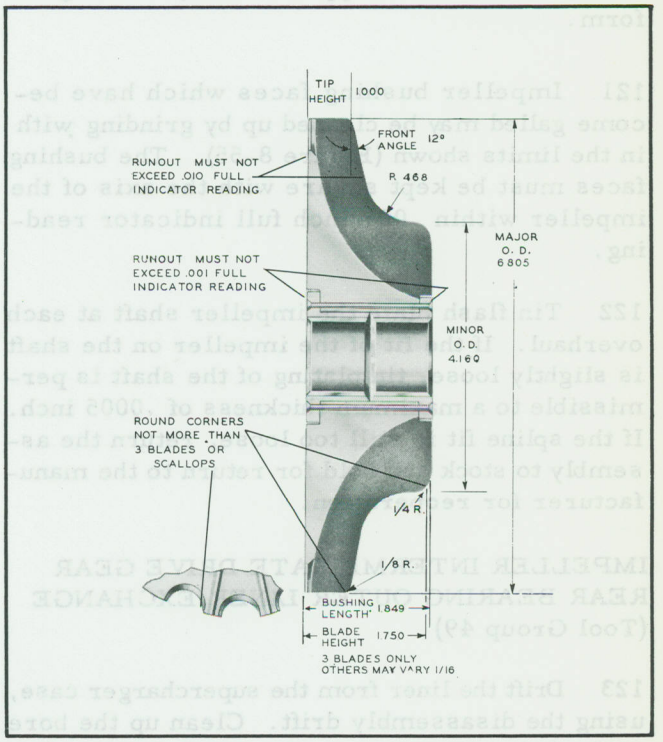


Figure 8-55 Impeller Rework Limits

119 Nicks, scratches, cracks, or damaged corners should be carefully blended to round any sharp corners or high spots. Blending must be kept within the limits shown (Figure 8-55), and no attempt should be made to relocate metal by cold working. After blending, the depression of the blended defect should not exceed .025 inch in depth, .250 inch in width, or .500 inch in length. If damage is grouped in a way which impairs the strength of the remaining material, change the impeller.

NOTE

To assist in determining the extent of the defects while blending, use an etching solution as described in Part 4, "Inspection", Section 2, paragraphs 86 and 87.

120 To remove the nicks from the impeller blade edges, mount the impeller on an expanding arbor of a lathe and true it up to within .001 inch full indicator reading; then machine off the edges of the blades. Do not machine below the limits shown (Figure 8-55). If material is machined from the leading edges, restore the contour of the blades to approximately the original form.

121 Impeller bushing faces which have become galled may be cleaned up by grinding within the limits shown (Figure 8-55). The bushing faces must be kept square with the axis of the impeller within .001 inch full indicator reading.

122 Tin flash plate the impeller shaft at each overhaul. If the fit of the impeller on the shaft is slightly loose, tin plating of the shaft is permissible to a maximum thickness of .0005 inch. If the spline fit is still too loose, return the assembly to stock and hold for return to the manufacturer for reoperation.

IMPELLER INTERMEDIATE DRIVE GEAR REAR BEARING OUTER LINER EXCHANGE (Tool Group 49)

123 Drift the liner from the supercharger case, using the disassembly drift. Clean up the bore of the hole; then line up the notch in the edge of the new liner with the staking pin in the case. Drift in the liner, using the assembly drift.

BALANCING IMPELLER AND SHAFT ASSEMBLY

124 The original balance of an impeller and shaft assembly may be affected by the exchange or repositioning of parts, or by the removal of surface injuries. If any rework other than tin plating the shaft has been done on the impeller or shaft, inspect the assembly for static balance before using it.

125 A satisfactory balance check requires special equipment for the accurate measurement of unbalance and an understanding by personnel of the principles of balancing. The following balancing procedures and limits of unbalance are based on the use of Gisholt Type S Dynetric Balancing Machine. This equipment may be adjusted to measure either static or dynamic unbalance in terms of ounce-inches and to indicate the angle of unbalance.

126 Install the impeller and shaft assembly in the balancing machine, using cradle detail 81058-T-1 and 1-1/8 inch diameter pulley. It is important that the impeller shaft bearings be properly lubricated throughout the test A single coat of grease is sufficient for the average test. It is suggested that spare impeller shaft bearings be used. Enclose the impeller with an 8 inch shroud. Adjust the balancing machine in accordance with the instructions of the machine manufacturer to measure ounce-inches of static unbalance.

127 Set the impeller in motion and observe any static balance. If unbalance exceeds .035 ounce-inches, change the spline relationship of the impeller to the impeller shaft and again check for unbalance. When the most favorable position has been found, mark the splines to indicate the final arrangement. If the unbalance still exceeds .035 ounce-inches, indicate the location and amount of unbalance by applying sufficient modeling clay to the impeller to correct the unbalance, or by indicating the heaviest point on the outside diameter and expressing the amount of unbalance in ounce-inches at that point.

128 If clay is used, the amount of material to be removed from the impeller, at approximately 180 degrees from the location of the clay, can be readily estimated from the weight of the clay. Remove the material by grinding or filing (Figure 8-56).

NOTE

Take care not to remove more material than is necessary when grinding or filing the impeller.

129 Place the impeller and shaft assembly

in the balancing machine and again check the static unbalance. If the assembly is still unbalanced, remove more material from the outer edge of the impeller until balance is restored or until it is evident that the impeller cannot be repaired.

SUPERCHARGER CASE MOUNTING BOLT HOLES

130 To repair worn mounting bolt holes, first drill the holes with a 9/16 inch drill and ream them to .5780 ± .0005 inch. Mount the supercharger case in a lathe, true it up to .003 inch full indicator reading as measured at the rear faces of the mounting lugs and machine the lugs to a thickness of 2.688 inches. Chamfer the holes and insert bushings fabricated from A.M.S. 5022 steel to the dimensions shown (Figure 8-57). Press the bushings in place, using a piloted drift. The desired fit of bushing to lug is .001 inch to .003 inch tight. If necessary, reoperate the bushing flange faces so that they lie within .003 inch of the same plane.

OIL SCAVENGE SLEEVES AN-5 Model (Tool Group 84)

131 To remove the small oil scavenge sleeve, Part No. 121203, ream the sleeve to a thin shell and collapse the shell.

132 If an oversize small oil scavenge sleeve is required, ream the holes in the supercharger and rear cases to the proper oversize, using the fixture and the proper oversize reamer. Counterbore the hole in the rear case.

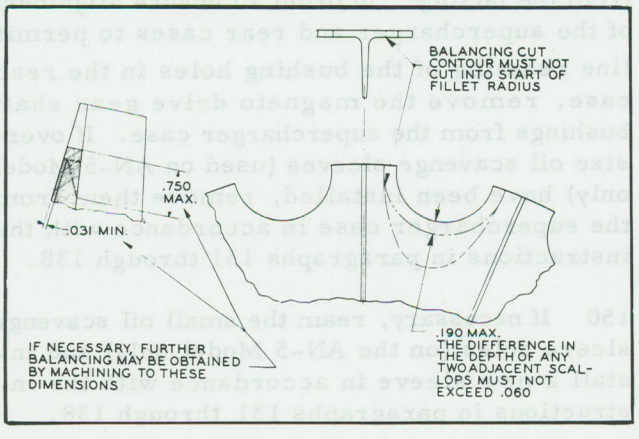


Figure 8-56 Filing Limits for Balancing

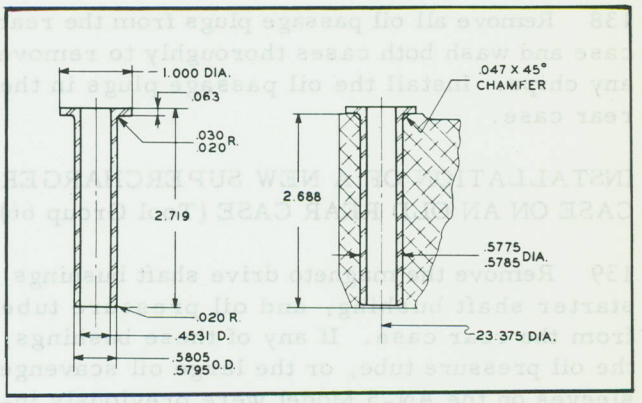


Figure 8-57 Mounting Bolt Hole Bushing

133 Before installing a small oil scavenge sleeve in the supercharger case, refer to "Expansion of Parts by Heat," Section 1, paragraph 18. Heat the supercharger case, and using the assembly drift, drift the larger end of the sleeve into the case until it bottoms in the case.

134 If a large oil scavenge sleeve Part No. 121202, is to be changed, drill out the lockpin, using the lockpin drill jig; then, after referring to "Expansion of Parts by Heat," Section 1, paragraph 18, heat the supercharger case and drift the sleeve from the case.

135 If an oversize large oil scavenge sleeve is to be installed, mount an oiled gasket on the rear parting surface of the supercharger case and align and assemble the supercharger and rear cases. Line ream the oil scavenge sleeve hole, or holes, using the fixture and the proper oversize reamer. Separate the cases and ream the holes in the supercharger case again, using proper oversize of the reamer. Counterbore the holes in the rear case.

136 After referring to "Expansion of Parts by Heat," (Section 1, paragraph 18) heat the supercharger case and, drift the sleeve, small end first, with the cutout towards the inside of the case, into the supercharger case until the sleeve projects from the rear face of the supercharger case to the required amount as measured with the gauge.

137 Using the jig, drill a .125 inch lockpin hole through the newly installed oil scavenge sleeve into the supercharger case to a depth of .480 inch. Install a lockpin in the hole.

138 Remove all oil passage plugs from the rear case and wash both cases thoroughly to remove any chips. Install the oil passage plugs in the rear case.

INSTALLATION OF A NEW SUPERCHARGER CASE ON AN OLD REAR CASE (Tool Group 66)

139 Remove the magneto drive shaft bushings, starter shaft bushing, and oil pressure tube from the rear case. If any of these bushings, the oil pressure tube, or the large oil scavenge sleeves on the AN-5 Model were previously installed oversize, the corresponding holes in the supercharger case must be line reamed with the rear case to accommodate the oversize.

140 To accomplish the reaming operations, install an oiled gasket on the supercharger case parting surface and assemble the supercharger and rear cases loosely. Install the aligning bars in the magneto drive gear shaft bushing holes and tighten the nuts attaching the cases together. Remove the aligning bars and line ream the magneto drive gear shaft holes from the front face of the supercharger case, using the reamer and adapter. Line ream the oil pressure tube hole, using the tube hole reamer and line ream the starter shaft hole from the rear face of the rear case using the bushing hole reamer and the adapters. On AN-5 Model line ream the large oil scavenge sleeve holes from the front face of the supercharger case, using the drain hole reamer and fixture.

141 Disassemble the cases and ream the large oil scavenge sleeve holes in the supercharger case of the AN-5 Model. Ream the small oil scavenge sleeve hole in the supercharger and rear cases of the AN-5 Model, using the sleeve hole reamer and the proper fixture.

142 Remove all oil passage plugs from the rear case and wash both cases thoroughly. Do not reinstall the plugs at this time.

143 Refer to "Bushing and Bearing Exchange". Line up the oil holes in the starter shaft bushing with the oil holes in the rear case and install the bushing, using the assembly drift. Line up the oil holes in the magneto drive gear shaft bushings, with the oil holes in the rear case, and install the bushings in the case, using the bushing drift.

144 Reassemble the supercharger and rear cases. Line up the oil holes in the magneto drive gear shaft bushings with the oil holes in the supercharger case and install the bushings in the case, using the drift. Line ream the magneto drive gear shaft bushings from the front face of the supercharger case, using the reamer and adapter and check the installation with the gauge. Line ream the starter shaft bushing reamer and adapters and check the bushing with the gauge.

145 Face off the starter shaft bushings using the facer and adapter and flush pin gauge. Face off the magneto drive gear shaft bushings, using the facer and gauge.

146 Break all sharp edges of bushings which have been faced.

147 Disassemble the cases and wash both cases thoroughly to remove all chips.

148 Refer to "Oil Scavenge Sleeves," paragraphs 131 through 138 and install the sleeves in the AN-5 Model. Install the oil pressure tube in the rear case, using the pipe drift. Install all previously removed oil passage plugs.

INSTALLATION OF A NEW REAR CASE ON AN OLD SUPERCHARGER CASE (Tool Group 66)

149 Bushings and the pressure oil tube are not installed in the new rear case as received from the factory. In order to ensure alignment of the supercharger and rear cases to permit line reaming of the bushing holes in the rear case, remove the magneto drive gear shaft bushings from the supercharger case. If oversize oil scavenge sleeves (used on AN-5 Model only) have been installed, remove them from the supercharger case in accordance with the instructions in paragraphs 131 through 138.

150 If necessary, ream the small oil scavenge sleeve holes (on the AN-5 Model only) and install a new sleeve in accordance with the instructions in paragraphs 131 through 138.

151 Install an oiled gasket on the supercharger

case rear parting surface and assemble the supercharger and rear cases loosely. Install the aligning bars in the magneto drive gear shaft bushing holes and tighten the nuts attaching the cases together. Remove the aligning bars.

152 Refer to "Installation of a New Supercharger Case on an Old Rear Case," paragraphs 139 through 148 for instruction on line reaming bushing holes, installing bushings, and line reaming the bushings in the supercharger and rear cases. Refer to "Oil Scavenge Sleeves," paragraphs 131 through 138, for instructions on installing the oil scavenge sleeves on the AN-5 Model.

OIL PUMP

153 If, on inspection, any one of the oil pump housing sections is rejected, exchange the entire housing assembly. Small scratches and burrs in any section of the housing, not serious enough to cause rejection of the housing, should be removed with a small triangular scraper. Do not use emery. Where insufficient clearance between the gears and the housing has caused the gear to rub on the housing and the rubbing is not the result of some abnormal condition, scrape enough material from the housing to give the proper clearance at this point. Remove scratches and burrs on the shafts, by polishing with emery. After polishing, check the fit of the shaft in the housing.

154 To change the idler shaft, shear the pin from the inside of the shaft, using a solid steel drift which fits snugly into the hollow idler gear shaft. Drift out the part of the pin that extends through one side of the gear. Mount the gear and shaft in a drill press, and using a No. 31 (.120 inch) drill, drill the remaining part of the pin, in the opposite side of the gear, to a depth of approximately 3/16 inch. The hole through the gear and shaft is used as a guide for the drilling operation. Remove the gear and clean up the pin holes. Install the idler gear on the new shaft. Align the pin holes in the gear and shaft and install the pin.

OIL PUMP SHAFT AND GEAR KEYWAYS REPAIR

155 Oil pump shaftgears and driving gears, having keyways with worn edges, may be reworked to accommodate oversize flat or stepped type keys.

156 The flat type keys are available in standard + 2 and + 5 oversizes for use where the shaftgear or gear keyways are only slightly worn. Larger oversizes of + 10, + 20, and + 30 keys are available, for shaftgears and gears where it is necessary to enlarge the keyway, using the proper cutter or broach (refer to Table 8-3).

157 Stepped keys are available for use when it is necessary to install a new gear on an old shaftgear, or where wear in the keyway in the gear is negligible and rework of the keyway in the shaftgear is necessary. Stepped keys are available in + 20, + 30, + 40, + 50, and + 60 oversize steps and the necessary cutters required for reworking the shaftgear are listed in Table 8-3.

158 Fit the keys to the tight side of the limits but in no case should the tightness exceed the limit.

CAUTION

The fitting of keys must be done with precision machine tools. Hand filing is not permissible. The length and depth of the keyway must not be changed. Use extreme caution when reworking the keyway to remove an equal amount of material from each side.

TACHOMETER DRIVE INNER COUPLING BUSHING (Tool Group 124)

159 If it is necessary to change this bushing, drill out the lockpin to a depth of .100 inch, using a No. 51 (.067 inch) drill. Press out the old bushing, using the disassembly drift and an arbor press. Install a new bushing, using the assembly drift and an arbor press. Drill the lockpin hole 90 degrees from any existing hole, using the drill jig, and install the lockpin. Transfer drill the oil holes in the bushing, using a No. 42 (.0935 inch) drill. Using fixture and reamer, ream the bushing. Check the bushing for size. Refer to Table 8-1.

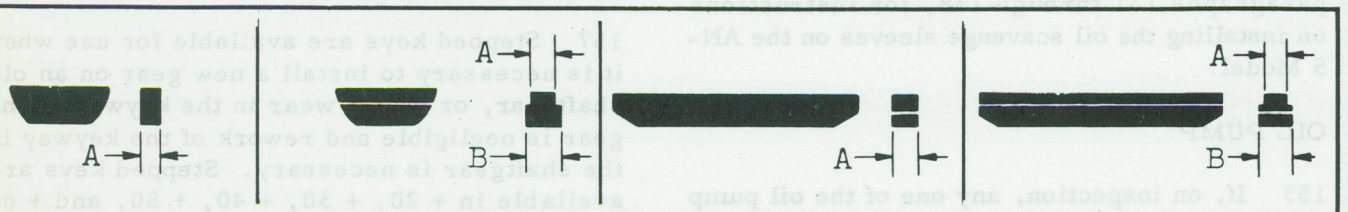
REWORK OF CRANKSHAFT THREADS (Service Bulletin 1488)

CAUTION

This rework must not be done on crankshafts which are marked both "SB 1488" and "14F-56" adjacent to the locking pin holes at the front end of the crankshaft.

160 After the front section of the crankshaft has been inspected and approved for service, mount it in a soft-jawed vise, holding it by the sides of the crank-cheek.

161 Using PWA-5776 Dial Indicator Gauge or equivalent mounted on the rear cone seat of the shaft (see Figure 8-58), set the indicator dial to "0" when the indicator needle is in the root of the first thread.



TYPE 1-FLAT		TYPE 2-STEP	TYPE 3-FLAT	TYPE 4-STEP	
PART NO.	TYPE	DIMENSION "A"	DIMENSION "B"	Cutter PWA NO.	Broach PWA NO.
224887 224884 224886	1 FLAT	.127- .128 (Std.) .129- .130 (+2) .132- .133 (+5) .137- .138 (+10) .147- .148 (+20) .157- .158 (+30)		5556 5556-10 5556-11 5556-12	5573 5554-10 5554-11 5554-12
224885 224884R	2 STEP	.127- .128 .127- .128 .127- .128 .127- .128 .127- .128 .127- .128	.147- .148 (+20s) .157- .158 (+30s) .167- .168 (+40s) .177- .178 (+50s) .187- .188 (+60s) .187- .188 (+10H+60s)	5556-11 5556-12 5556-13 5556-14 5556-15	
224883 224882	3 FLAT	.127- .128 (Std.) .129- .130 (+2) .132- .133 (+5) .137- .138 (+10) .147- .148 (+20) .157- .158 (+30)		5556 5556-10 5556-11 5556-12	5573 5554-10 5554-11 5554-12
	4 STEP	.127- .128 .127- .128 .127- .128 .127- .128 .127- .128 .127- .128	.147- .148 (+20s) .157- .158 (+30s) .167- .168 (+40s) .177- .178 (+50s) .187- .188 (+60s)	5556-11 5556-12 5556-13 5556-14 5556-15	

Table 8-4 Keys and Cutters

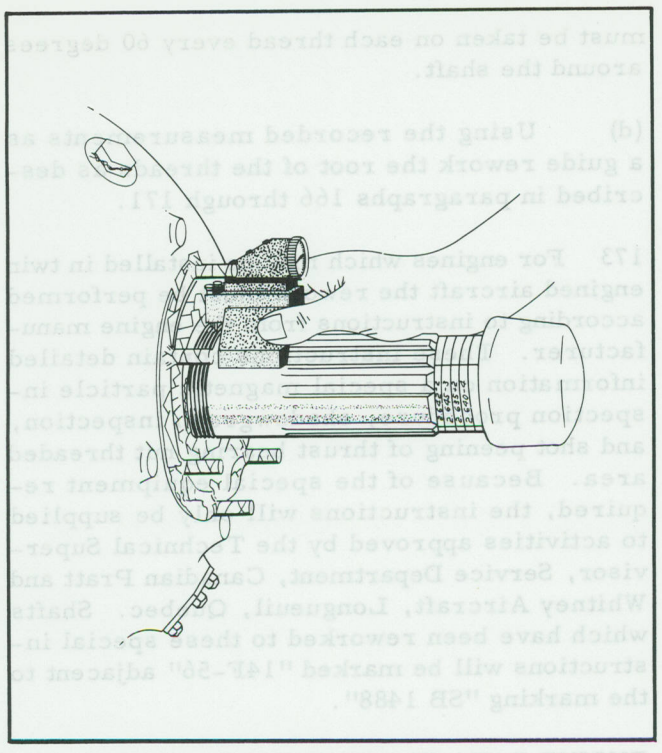


Figure 8-58 Use of Trial Indicator

CAUTION

The needle on the dial indicator is a standard phonograph needle (78 rpm) which has a uniform taper from the OD and a .003 inch spherical radius on the tip. Damaged or worn needles must be changed.

162 To establish a reference point, move the indicator forward and record the reading when the needle contacts the rear cone seat.

NOTE

By measuring the OD of the rear cone seat, and comparing that measurement with the difference between the rear cone seat and the thread root, the minor diameter of the thread can be obtained. After completion of the thread rework the minimum diameter is 2.623 inches. For shafts marked 14F-56 the minimum minor thread diameter is 2.620 inches.

163 To facilitate recording measurements apply masking tape to the front cone seat and mark it with four circumferential lines. Six or seven sets of readings must be recorded on this tape in line with their locations.

164 Measure the location of the root of each thread, recording on the tape on the front cone seat in line with the location of the gauge the plus or minus variation from the "0" reading of the dial.

165 Measure and record the location of the four thread roots at 60 degrees removed circumferentially from the place of the first measurement. Repeat this operation until 6 or 7 sets of readings around the shaft have been recorded.

166 Using lapping compound, such as Clover Grade B Grit 240, applied to No. 55 Emery Cord (.018 inch diameter) or equivalent, undercut the existing thread root .0025 to .0035 inch below the dimension originally recorded. It is preferable that a minimum amount of material be removed and the .0035 maximum must not be exceeded. To assure uniformity the emery cord must be held so that an arc 120 degrees or greater is contacted by the cord. After undercutting the shaft at this location, rotate the shaft in the vise approximately 60 degrees and continue the process. The rate of removal of the material is dependent upon the hardness of the metal which may vary from one shaft to another. After about 50 strokes of the cord, clean the shaft and measure the amount of material removed. This will assist in estimating the number of strokes to be taken.

167 When material has been removed to the desired depth, polish the root by about 10 strokes of the bare cord without lapping compound.

168 Blend the edges of the new cut by about 15 strokes of No. 54 Emery Cord (.025 inch diameter).

169 Carefully wash the reworked shaft and remove all masking tape.

170 Magnetic Particle Inspection should be used to inspect the area of the rework. Magnetize the shaft at 450 Amperes by the use of

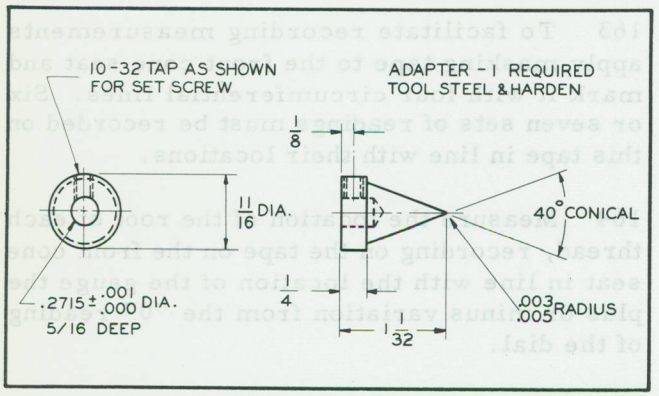


Figure 8-59 Adapter for Micrometer Caliper

four turns of No. 0000 cable or by a box solenoid.

171 Finally, mark the crankshaft "SB 1488" at the front end between the locking holes for the propeller retaining nut and in line with the master spline.

CAUTION

This rework must not be done twice on the same crankshaft.

172 If PWA -5776 Dial Indicator Gauge is not available a Micrometer Caliper can be adapted for use as follows:

(a) Make an adapter to the specifications shown in Figure 8-59 so that it fits the spindle of a four or five inch micrometer caliper. Rework a removable anvil for the same micrometer caliper to a 40 degree inclusive taper having a spherical radius of .003 to .005 inch on the tip. The radius must be carefully maintained by periodic inspection.

(b) Using the adapter and the special anvil, measure and record the minor diameter of the thread. A crankshaft having a minor diameter of less than 2.623 inches at any part of the threads after completion of this rework is not serviceable. For shafts marked "14F-56" the minimum minor thread diameter is 2.620 inches.

(c) Using the adapter only, measure and record the distance from the root of the thread at each desired point to the top of the diametrically opposite threads. These measurements must be taken on each thread every 60 degrees around the shaft.

(d) Using the recorded measurements as a guide rework the root of the threads as described in paragraphs 166 through 171.

173 For engines which may be installed in twin engined aircraft the rework must be performed according to instructions from the engine manufacturer. These instructions contain detailed information on a special magnetic particle inspection procedure, shadowgraph inspection, and shot peening of thrust bearing nut threaded area. Because of the special equipment required, the instructions will only be supplied to activities approved by the Technical Supervisor, Service Department, Canadian Pratt and Whitney Aircraft, Longueuil, Quebec. Shafts which have been reworked to these special instructions will be marked "14F-56" adjacent to the marking "SB 1488".

ENGINE DATA PLATE (SB 871)

174 If the engine data plate is secured by drive screws remove the plate, extend the four holes through the crankcase using a No. 43 drill (.090 inch dia.), and reinstall the plate using Part No. 85039 Chromseal Sheet, four Part No. 156 Rivets, four Part No. 179 Washers and four Part No. 53203 Washers. See Figure 8-60.

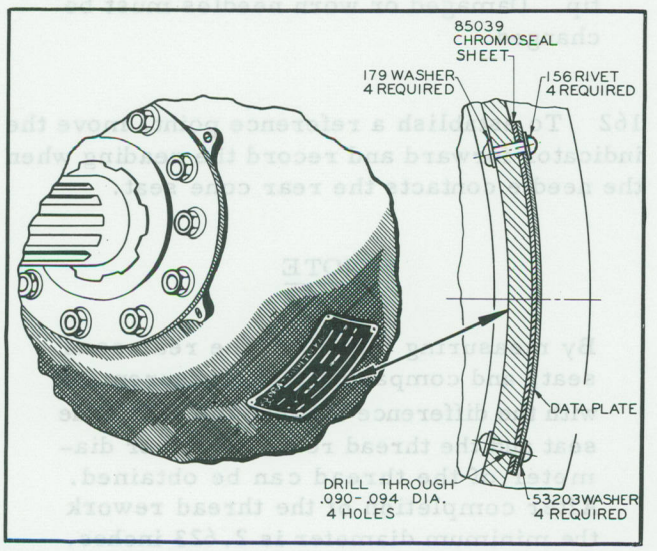


Figure 8-60 Engine Data Plate

LIP TYPE MAGNETO DRIVE SEALS AND RELATED PARTS

175 To improve sealant qualities, Service Bulletin 1266 calls for the installation of a new type seal, drive coupling, and seal housing in the magneto drive assembly. To install the new seals proceed as follows:

(a) Cut off the two Part No. 28 pins flush with the seal housing mounting pad.

CAUTION

These pins were used to position the old Part No. 1108 seal shield. Do not pull them out as this would cause leakage.

(b) Using PWA-4153 Drift and Base, install a new Part No. 164314 Seal in the new Part No. 164315 Housing. Install the assembly in the engine using a new Part No. 809 Gasket and the four old Part No. 171 Washers and Part No. 202 Screws.

(c) Install a new Part No. 164316 Coupling in place of the old Part No. 11049 Coupling and secure it with the old Part No. 1175 Screw and a Part No. 3 Cotterpin. See Figure 5-23.

PART 9

SPECIAL TOOLS

INTRODUCTION

1 The functional tool list in this Part indexes the names and numbers of the special tools used for the overhaul work described in this manual. Each tool number appears by the group name of the engine part, engine assembly, or function with which the tool is identified. These group names are in alphabetical order and are numbered. Reference in the test to the tools in the functional list is made by group number. Revision material involving the addition to tool groups is indicated by the insertion of tool group numbers with alphabetical suffixes (e.g. Tool Group 7A), thereby providing both numerical and alphabetical continuity to the list.

FUNCTIONAL TOOL LIST

TOOL GROUP	NAME	NUMBER
1	Accessory drive shaft bushing	
	Assembly and disassembly drift	PWA-1800
	Maximum wear gauge	PWA-1451-61
	Reaming gauge	PWA-1805-36
	Reaming Fixture	1171-T-1 Det. 2
	Reamer	TAM-3575-26
2	Adjust length of push rods	
	Gland nut wrench	PWA-4531
3	Assembly crankcase front section to engine	
	Crankcase bolt nut wrench	PWA-2239
	Wrench adapter	PWA-2240
	Sump bolt holding wrench	PWA-2768
4	Assembly of crankshaft and masterod to engine	
	Crankshaft lifting eye	PWA-520
	Lifting hook	PWA-2388
	Masterod and linkrod supports	PWA-2488
6	Assembly of crankshaft rear section to front section	
	Pusher	PWA-2422
	Pusher (large bolt)	PWA-2424-102
	Crankshaft bolt wrench	PWA-1914
	Crankshaft bolt wrench (large bolt)	PWA-5192
7	Assembly of pistons and cylinders to the engine	
	Turning bar	PWA-112
	Pistonring clamp	PWA-249
	Cylinder flange nut wrench	PWA-2397
	Handle (use with PWA-2397)	PWA-2411
	Cylinder flange nut wrench	PWA-2006

TOOL GROUP	NAME	NUMBER
7	Assembly of pistons and cylinders to the engine (cont'd)	
	Cylinder flange nut wrench	PWA-2399
	Handle (use with PWA-2006 and PWA-2399)	PWA-2398
	Locknut wrench	PWA-3923
	Locknut wrench (spinning)	PWA-5003
9	Assembly of reduction gear housing to crankcase	
	Propeller shaft lifting eye	PWA-1332
	Lifting hook	PWA-2388
10	Assembly of rear to supercharger case	
	Pressure oil tube drift	PWA-4661
	Magneto drive bushing spacer puller	PWA-4660
	Starter drive bushing spacer puller	PWA-4659
11	Breather (AN-14B)	
	Body wrench	PWA-3482
	Plug wrench	PWA-2373
12	Breather assembly	
	Body connection wrench	PWA-3482
	Breather hole plug wrench	PWA-2373
13	Cam drive gear	
	Puller	PWA-2298
	Drift and base	PWA-3215
15	Cam reduction drive gear	
	Gear nut wrench	TAM-255
	Gear holder	PWA-248
16	Cam reduction gear bushing	
	Assembly and disassembly puller and pusher	PWA-220
	Maximum wear gauge	PWA-1451-61
	Reaming gauge	PWA-1805-36
	Reaming fixture	PWA-1621-T-17
	Reamer	TAM-3575-45
	Facer	PWA-62
18	Crankcase front section	
	Cam reduction gear nut wrench	TAM-255
	Gear holder	PWA-248
	Bushing facer	PWA-62
19	Crankcase rear section	
	Bolt puller	PWA-1285
20	Crankpin lapping	
	Crankpin lap	PWA-981-1
	Lap holder	PWA-980

TOOL GROUP	NAME	NUMBER
21 Crankshaft		
	Lifting eye	PWA-520
	Hook	PWA-2388
22 Crankshaft front section		
	Holding fixture	TAM-206
	Adapter	PWA-1919-2
	Crankshaft front plug wrench	PWA-1647
23 Crankshaft front and rear sections		
	Crankshaft bolt wrench	PWA-1914
	Bolt puller	PWA-2423-100
	Pump assembly	PWA-3755
24 Cylinders and pistons		
	Turning bar	PWA-112
	Flange nut wrench	PWA-2006
	Flange nut wrench	PWA-2397
	Flange nut wrench	PWA-2399
	Wrench handle (PWA-2006 wrench)	PWA-2398
	Wrench handle (PWA-2397 wrench)	PWA-2411
	Wrench handle (PWA-2399 wrench)	PWA-2398
	Torque wrench adapter	PWA-2240
	Torque wrench (0-600 inch lbs)	PWA-2239
	Pistonpin pusher	PWA-4251-10
25 Cylinder barrels (Inspection)		
	Bore gauge	3472-T-3
	Bore indicator	PWA-312-11
	Cylinder barrel flange gauge	PWA-2630-20
26 Cylinder flange repair		
	Lap	PWA-2898
	Flange checking plate	PWA-2630-20
27 Cylinder thermocouples		
	Drill	PWA-3064
	Drift	PWA-2747
28 Exhaust valves (Inspection)		
	Stretch gauge	PWA-737
29 Exhaust valve guides and bosses		
	Fixture	PWA-3149-24
30 Exhaust valve guide exchange		
	Guide puller	PWA-4002-101
	Guide hole reamer (manual)	PWA-302
	Guide reamer (manual)	PWA-2766-8
	Guide reaming gauge	PWA-4189-12
	Guide maximum wear gauge	PWA-4327
	Power reaming fixture	PWA-4700-505

TOOL GROUP	NAME	NUMBER
30 Exhaust valve guide exchange (cont'd)		
	Guide hole reamer + 3	PWA-4699-6
	Guide hole reamer + 5	PWA-4699-7
	Guide hole reamer + 10	PWA-4699-8
	Guide hole reamer + 20	PWA-4699-9
	Guide hole reamer + 30	PWA-4699-43
	Guide reamer	PWA-4701-1
31 Exhaust valve seat exchange		
	Seat remover	PWA-4000-30
	Assembly drift	PWA-2782-10
32 Floating gear		
	Floating gear retaining nut wrench	PWA-345
	Holder	PWA-338
34 Flyweights		
	Disassembly pusher	PWA-1068
	Assembly puller	PWA-1067
	Bolt wrench	TAM-1773
	Expander plug torque wrench	PWA-2239
	Bolt torque wrench	PWA-2238
35 Front case		
	Wrench	PWA-1093
	Wrench (hydraulic)	PWA-5187-30
	Puller	PWA-67
38 Front main bearing		
	Inner race sleeve	PWA-79
39 Front main bearing inner race		
	Puller	PWA-470
	Assembly sleeve	PWA-622
40 Fuel pump drive		
	Oil seal assembly drift	PWA-2285
	Backlash arbor	PWA-2127
41 Fuel pump drive gears		
	Drive gear bracket puller	PWA-2374
	Oil seal puller	PWA-3762
42 Generator drive gear assembly		
	Inner bearing assembly and disassembly fixture	PWA-4638
	Inner bearing disassembly drift	PWA-4639
	Collar	PWA-4640
	Spanner nut wrench	PWA-174
	Inner and outer bearing drift	PWA-4636
	Holding fixture	PWA-4635
	Inner bearing assembly drift	PWA-4637
	Backlash arbor	PWA-2003

TOOL GROUP	NAME	NUMBER
43 Governor drive gear		
	Pliers	PWA-2188
	Governor drive gear holder	PWA-2403
	Snap ring drift	PWA-2126
44 Horizontal test alterations (AN-5)		
	Wrench	PWA-2373
	Wrench	PWA-3482
45 Hose		
	Clamp compressor	PWA-3372
46 Hydro-propeller control valve assembly (AN-14B)		
	Valve nut wrench	PWA-2754
47 Ignition leads		
	Sparkplug holder 7/8" hex.	PWA-4632
48 Ignition manifold		
	Coupling wrench	PWA-5770
	Strap wrench	PWA-1886
49 Impeller intermediate drive gear rear bearing outer liner		
	Disassembly drift	PWA-1944
	Assembly drift	PWA-1969
50 Impeller shaft		
	Journal sleeve (assembly)	PWA-3195
	Oil seal drift	PWA-3029
	Seal holder	PWA-3006
	Impeller pusher	PWA-1882
	Impeller puller	PWA-51
	Impeller locknut wrench	PWA-1269
	Shaft holder	PWA-338
	Small bearing cutter	PWA-3164
	Bearing holder	PWA-3012
	Locknut pin drift	PWA-1558
	Disassembly sleeve	PWA-3196
51 Impeller shaft (ball bearing)		
	Shaft retaining nut wrench	PWA-345
	Impeller pusher	PWA-1882
	Floating gear holder	PWA-609
	Nut wrench	PWA-1269
	Locknut pin drift	PWA-1558
52 Impeller shaft (plain journal type)		
	Impeller shaft nut	PWA-1269
	Front bearing support wrench	PWA-4726
	Puller	PWA-4722
	Ring carrier puller	PWA-4721

TOOL GROUP	NAME	NUMBER
54 Impeller shaft bearing cage exchange (AN-14B)		
	Retaining screw driver	PWA-3008
	Assembly drift	PWA-64
	Assemoly guide	PWA-620
55 Impeller shaft oil seal (AN-5)		
	Testing cover	PWA-4645
56 Impeller spring drive bolt		
	Wrench	PWA-1195
57 Impeller spring drive coupling		
	Holding fixture	TAM-206
	Holding adapter	PWA-1919-2
	Spring drive plate puller	PWA-448
	Spring compressor	PWA-2792
58 Inlet and exhaust valves		
	Cylinder stand	TAM-3146
	Scraper	PWA-4675
59 Inlet valve guide exchange		
	Guide puller	PWA-4002-100
	Guide hole reamer - (manual)	PWA-301
	Guide reamer (manual)	PWA-2869
	Guide assembly drift	PWA-95
	Reaming fixture (power)	PWA-4700-505
	Guide reamer	PWA-4701-6
	Guide hole reamer + 3	PWA-4699-1
	Guide hole reamer + 5	PWA-4699-2
	Guide hole reamer + 10	PWA-4699-3
	Guide hole reamer + 15	PWA-4699-4
	Guide hole reamer + 20	PWA-4699-5
	Reaming gauge	PWA-4189-15
	Maximum wear gauge	PWA-311
60 Inlet or exhaust valve seat facing		
	Refacing arbor holder	PWA-6
	Seat facer	PWA-226-23
61 Inlet valve seat exchange		
	Seat remover	PWA-4107-30
	Seat assembly holder	PWA-4597-50
63 Installation and timing of magnetos		
	Timing indicator	PWA-2417
	Piston position indicator	PWA-4142
64 Installation in test stand		
	Lifting sling	PWA-37
	Engine stand	TAM-1161
	Mounting plate	TC-51259

TOOL GROUP	NAME	NUMBER
65 Installation of engine in engine stand		
	Lifting eye	PWA-520
	Lifting hook	PWA-2388
	Mounting stand	TAM-1161
	Mounting plate	TC-51259
66 Installation of new supercharger case on an old rear case		
	Magneto drive shaft bushing aligning bar	PWA-1981
	Magneto drive shaft bushing reaming adapter	PWA-820
	Maximum wear gauge	PWA-1451-31
	Bushing assembly drift	PWA-1746
	Bushing disassembly drift	PWA-1747
	Bushing disassembly drift	PWA-1748
	Magneto shaft bushing hole reamer	TAM-3575-7
	Oil pressure tube hole reamer	TAM-3574-51
	Starter shaft bushing hole reamer	TAM-3575-6
	Starter shaft bushing reaming adapter	PWA-815
	Starter shaft bushing reaming adapter	PWA-816
	Starter shaft bushing reaming adapter	PWA-817
	Starter shaft bushing hole reaming adapter	PWA-819
	Reaming fixture	PWA-3302
	Large oil scavenge sleeve hole reamer	PWA-3303
	Large oil scavenge sleeve hole reamer	PWA-3303 + 10
	Large oil scavenge sleeve hole reamer	PWA-3303 + 20
	Large oil scavenge sleeve hole reamer	PWA-3303 + 30
	Large oil scavenge sleeve hole reamer	PWA-3304
	Relieving reamer	PWA-3304 + 10
	Relieving reamer	PWA-3304 + 20
	Relieving reamer	PWA-3304 + 30
	Small oil scavenge sleeve hole reamer	PWA-3373
	Small oil scavenge sleeve hole reamer	PWA-3373 + 10
	Small oil scavenge sleeve hole reamer	PWA-3373 + 20
	Small oil scavenge sleeve hole reamer	PWA-3373 + 30
	Small oil scavenge sleeve hole reaming fixture	PWA-3374
	Starter shaft bushing assembly drift	PWA-762
	Magneto shaft bushing reamer	TAM-3575-5
	Magneto shaft bushing reaming gauge	PWA-1805-6
	Magneto shaft bushing clearance gauge	1320-T-120
	Starter shaft bushing reamer	TAM-3575-8
	Starter shaft bushing reaming gauge	PWA-1805-9
	Starter shaft bushing facer	PWA-538
	Starter shaft bushing flush pin gauge	TAM-1113
	Magneto drive shaft bushing facer	PWA-55
	Oil pressure tube assembly drift	PWA-761
67 Intake pipes		
	Nut wrench	PWA-237
	Puller	PWA-3145
	Port protector	PWA-3800
68 Limits (torque wrenches)		
	Adapter	PWA-2240

TOOL GROUP	NAME	NUMBER
68 Limits (torque wrenches) (cont'd)		
	600 pounds-inches	PWA-2239
	1200 pounds-inches	PWA-5567
	2400 pounds-inches	PWA-2238
	3600 pounds-inches	PWA-5266
69 Linkpins		
	Pressing fixture	PWA-296
	Pressing spacer	PWA-2252
	Linkpin disassembly drift	PWA-4497-10
	Support wedge	PWA-992
70 Linkpin bushing exchange		
	Bushing disassembly drift	PWA-1493
	Assembly drift	PWA-2551-4
	Reaming gauge	PWA-1805-110
71 Linkrods (Inspection)		
	Aligning fixture	PWA-1781-61A
72 Masterod (Inspection)		
	Aligning fixture	PWA-1781-61A
73 Masterod and Linkrods		
	Linkpin assembly and disassembly fixture	PWA-296
	Linkpin assembly fixture	PWA-2557
	Wedge	PWA-992
	Linkpin drift	PWA-2674
74 Masterod bearing exchange		
	Bearing disassembly drift	PWA-5353-100
	Bearing assembly arbor	TAM-315
75 Magneto coupling drive gears		
	Spring drift	PWA-4478
	Oil seal assembly drift and base	PWA-4153
	Drive coupling screw wrench	PWA-789
	Coupling gear puller	PWA-621
	Oil seal puller	PWA-3762
76 Magneto coupling gear screws		
	Wrench	PWA-789
77 Magneto drive gears and shaft and accessory intermediate drive gears		
	Bushing facer	PWA-55
78 Magneto drive shaft bushing		
	Disassembly drift (short bushing)	PWA-1748
	Disassembly drift (long bushing)	PWA-1747
	Assembly drift	PWA-1746
	Aligning bar	PWA-1981
	Facer	PWA-55

TOOL GROUP	NAME	NUMBER
79 Magneto drive shaft bushing (cont'd)		
	Maximum wear gauge	PWA-1451-31
	Clearance gauge	1320-T-120
	Reaming gauge	PWA-1805-6
	Reaming adapter	PWA-820
	Hole reamer	TAM-3575-7
	Bushing hole reamer + 5	TAM-3575-35
	Bushing hole reamer + 10	TAM-3575-36
	Bushing hole reamer + 15	TAM-3575-37
	Bushing hole reamer + 20	TAM-3575-38
	Bushing hole reamer + 25	TAM-3575-39
	Bushing hole reamer + 30	TAM-3575-40
79 Oil drain plugs and oil screens		
	Oil screen cover nut wrench	PWA-228
	Sump drain plug wrench	PWA-1787
80 Oil plugs		
	Crankshaft rear plug wrench	PWA-1647
	Crankshaft front oil plug	PWA-2366
81 Oil pump (disassembly)		
	Pump puller	PWA-1327
	Gear puller	PWA-2569
82 Oil pump (repair)		
	Facing tool	PWA-55
83 Oil pressure relief valve		
	Seat wrench	PWA-671
84 Oil scavenge sleeves (AN-5)		
	Small oil scavenge sleeve hole reaming fixture	PWA-3374
	Reamer	PWA-3373
	Reamer + 10	PWA-3373 + 10
	Reamer + 20	PWA-3373 + 20
	Reamer + 30	PWA-3373 + 30
	Small oil scavenge sleeve drift	PWA-3378
	Large oil scavenge sleeve drift	PWA-3379
	Large oil scavenge sleeve lockpin drill jig	PWA-3375
	Oil drain hole reaming fixture	PWA-3302
	Oil drain hole reamer	PWA-3303
	Oil drain hole reamer + 10	PWA-3303 + 10
	Oil drain hole reamer + 20	PWA-3303 + 20
	Oil drain hole reamer + 30	PWA-3303 + 30
	Large oil scavenge sleeve hole reamer	PWA-3304
	Relieving hole + 10	PWA-3304 + 10
	Relieving hole + 20	PWA-3304 + 20
	Relieving hole + 30	PWA-3304 + 30
	Large oil drain tube projection gauge	PWA-3376

TOOL GROUP	NAME	NUMBER
86 Oil screen and check valve		
	Cover wrench	PWA-228
87 Oil sump		
	Strainer driver (AN-14B)	PWA-1572
88 Pistonring groove reworking		
	Fixture	PWA-4272-30
	Regrooving cutter 8 degrees	PWA-4783
	Ring inspection gauge	PWA-3201-1
89 Pistonpin bushing exchange		
	Assembly and disassembly drift	PWA-1641
	Assembly drift and base	PWA-5488
	Split bushing assembly arbor	PWA-1777
	Bushing reaming gauge	PWA-1805-1
	Bushing maximum wear gauge	PWA-1451-13
91 Plain impeller shaft bearings (AN-5)		
	Retaining screw driver	PWA-3008
	Liner drift	PWA-3007
	Small bearing drill jig	PWA-3191
	Large bearing drill jig	PWA-3190
	Small bearing disassembly drift	PWA-3189
	Small bearing assembly drift	PWA-3188
	Large bearing assembly and disassembly drift	PWA-3187
	Liner holding fixture	PWA-3186
	Bearing reaming fixture	PWA-3009
	Small bearing reamer	TAM-3574-79
	Large bearing reamer	TAM-3574-82
	Small bearing reaming gauge	PWA-1805-51
	Large bearing reaming gauge	PWA-1805-52
	Small bearing maximum wear gauge	PWA-1451-73
	Large bearing maximum wear gauge	PWA-1451-112
	Bearing aligning gauge	PWA-3011
	Bearing facing holder	PWA-3012
	Facing cutter	PWA-3164
93 Propeller and thrust bearing oil feed tube, bushing and liner (AN-5)		
	Bushing puller	PWA-4655
	Bushing liner disassembly drift	PWA-1667
	Bushing liner assembly drift	PWA-1193
	Oil feed tube hole drill jig	PWA-4293
	Bushing assembly drift	PWA-4654
94 Propeller governor drive bushing		
	Assembly puller	PWA-1190
	Disassembly drift	PWA-1191
	Reaming adapter	PWA-1039
	Reamer	TAM-3574-59
	Maximum wear gauge	PWA-1451-104
	Reaming gauge	PWA-1805-12

TOOL GROUP	NAME	NUMBER
95 Propeller oil feed tube and plugs (Disassembly)		
	Front plug nut wrench	PWA-2713
	Puller	PWA-3062
	Drift	PWA-3060
	Oil Plug wrench	PWA-2366
96 Propeller oil feed tube and plugs (assembly)		
	Inner plug assembly drift	PWA-3061
	Tube assembly drift	PWA-3062
	Front plug nut wrench (AN-14B)	PWA-2713
	Oil plug wrench (AN-5)	PWA-2366
99 Pushrods		
	Valve spring depressor	PWA-455
100 Pushrods and covers		
	Turning bar	PWA-112
	Cover nut wrench	DMS-196010
	Valve depressor	PWA-455
	Puller	PWA-4877
	Drift	PWA-2152-1
101 Pushrod cover nut connector		
	Disassembly driver	PWA-849
	Assembly driver	PWA-491
102 Rear main bearing		
	Inner race pusher	PWA-268
	Bearing puller	PWA-1742
103 Rear supercharger bearing cover (AN-5)		
	Cover disassembly puller	PWA-3366
	Disassembly drift	PWA-2873
	Oil seal holder	PWA-3006
	Liner Disassembly puller	
104 Rear supercharger bearing cover (AN-14B)		
	Rear bearing and liner puller	PWA-346
105 Reduction drive gear		
	Spanner nut wrench	PWA-487
	Spanner nut pilot	PWA-1986
	Drive gear puller	PWA-442
108 Reduction drive pinion cage		
	Propeller shaft holding fixture	TAM-206
	Holding adapter	PWA-1919-1
	Locknut wrench	PWA-502
	Pinion cage puller	PWA-472
109 Reduction gear pinion (Inspection)		
	Maximum wear gauge	PWA-1451-30

TOOL GROUP	NAME	NUMBER
110 Removal of impeller		
	Floating gear holder	PWA-338
	Impeller nut wrench	PWA-1269
	Impeller disassembly puller	PWA-51
111 Rocker arm, rocker arm bearings and adjusting screws		
	Rocker bearing drift and base	PWA-614
	Rocker shaft nut wrench	PWA-2399
112 Rocker ball socket exchange		
	Disassembly pusher	PWA-1352
	Assembly fixture	PWA-2450
113 Rocker shaft bearings		
	Drift and base	PWA-614
114 Rocker shaft bushing exchange		
	Small bushing disassembly drift	PWA-1776
	Large bushing disassembly drift	PWA-1466
	Small bushing assembly drift	PWA-757
	Large bushing assembly drift	PWA-758
	Step-rocker shaft bushing reamer (late type)	PWA-1682
	Large bushing maximum wear gauge	PWA-1451-34
	Small bushing maximum wear gauge	PWA-1451-110
	Large bushing reaming gauge	PWA-1805-4
	Small bushing reaming gauge	PWA-1805-3
115 Sparkplug		
	Sparkplug wrench	PWA-3168
	Sparkplug holder	PWA-4632
	Sparkplug bushing plug	PWA-3252
	Lead nut wrench	PWA-1683
116 Sparkplug bushing exchange		
	Bushing remover	PWA-4005
	Hole tap	PWA-334
	Bushing assembly driver	3510-T-16
	Disassembly counterbore	PWA-1799
	Bushing tap	PWA-1526
117 Starter jaw and gear		
	Starter shaft bearing puller	PWA-2044
118 Starter shaft bushing		
	Disassembly drift	PWA-1749
	Assembly drift	PWA-762
	Hole reaming adapter	PWA-819
	Bushing reaming adapter	PWA-815
	Bushing reaming adapter	PWA-816
	Bushing hole reamer	TAM-3575-6
	Bushing reamer	TAM-3575-8
	Bushing hole reamer + 5	TAM-3575-29

TOOL GROUP	NAME	NUMBER
118	Starter shaft bushing (cont'd)	
	Bushing hole reamer + 10	TAM-3575-30
	Bushing hole reamer + 15	TAM-3575-31
	Bushing hole reamer + 20	TAM-3575-32
	Bushing hole reamer + 25	TAM-3575-33
	Bushing hole reamer + 30	TAM-3575-34
	Bushing flush pin gauge	TAM-1113
	Maximum wear gauge	PWA-1451-111
	Reaming gauge	PWA-1805-9
119	Supercharger case	
	Engine stand	TAM-1161
	Mounting plate	TC-51259
119A	Supercharger rear bearing cover.	
	Rear bearing and liner puller	PWA - 627
120	Supercharger spring drive bolt	
	Bolt wrench	PWA-1195
121	Swivel breather (AN-14B)	
	Support wrench	PWA-2318
122	Tachometer drives (Disassembly).	
	Oil seal puller	PWA-1836
123	Tachometer drives (assembly)	
	Oil seal assembly drift	PWA-1462
124	Tachometer drive inner coupling bushing	
	Disassembly drift	PWA-3633
	Assembly drift	PWA-2884
	Drill jig	PWA-2883
	Reaming fixture	PWA-2881
	Reamer	TAM-3574-51
	Reaming gauge	PWA-1805-16
	Maximum wear gauge	PWA-1451-41
125	Tappet rollers and pins	
	Protector	PWA-4885
126	Thrust bearing	
	Lifting eye	PWA-520
	Lifting hook	PWA-2388
	Bearing assembly sleeve	PWA-79
128	Thrust bearing nut	
	Wrench	PWA-1093
	Wrench hydraulic	PWA-5187-30
	Crankshaft turning bar	PWA-112

TOOL GROUP	NAME	NUMBER
129 Vacuum pump drive gear		
	Oil seal assembly drift	PWA-1415
	Backlash arbor	PWA-1443
	Oil seal puller	PWA-3762
	Housing pusher	PWA-1998
130 Vacuum pump drive gear bushing exchange		
	Disassembly drift	PWA-1460
	Assembly drift	PWA-1648
	Reaming fixture	PWA-2284
	Reamer	TAM-3574-7
	Reaming gauge	PWA-1805-12
	Maximum wear gauge	PWA-1451-104
131 Valves and valve springs		
	Cylinder stand	TAM-3146
	Sparkplug hole plug	PWA-3252
132 Valve clearance adjustment		
	Clearance gauge	PWA-4675
133 Valve guides (Inspection)		
	Exhaust valve guide gauge	PWA-4327
	Inlet valve guide gauge	PWA-311
134 Valve lapping		
	Inlet valve holder	PWA-10
	Exhaust valve holder	PWA-11
135 Valve tappet ball socket exchange		
	Disassembly pusher	PWA-5160-100
	Hydraulic pump assembly	PWA-3755
	Ball socket assembly holder	PWA-1974
136 Valve tappet guide inspection		
	Aligning gauge	PWA-827
	Maximum wear gauge	PWA-1451-109
137 Valve tappet guide exchange		
	Disassembly drift	PWA-2362
	Guide aligning bar	PWA-828-3
	Positioning gauge	PWA-827
	Assembly drift	PWA-4234-30
	Reaming clamp	PWA-1369
	Reamer	TAM-20933
	Maximum wear gauge	PWA-1451-109
	Reaming gauge	PWA-1450
139 Valve timing check		
	Timing pointer	PWA-85
	Turning bar	PWA-112
140 Vertical accessory drive gears		
	Shaft stop	PWA-2005